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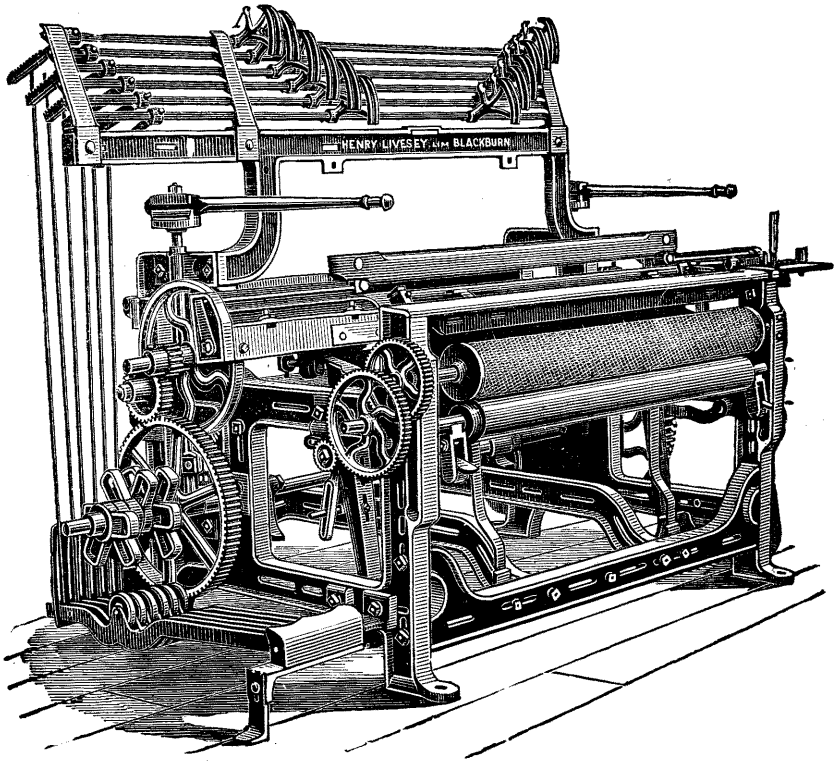

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LECTURES ON

PRACTICAL WEAVING:

THE POWER LOOM

AND

CLOTH DISSECTING,

BY

THOS. R. ASHENHURST,

(Upwards of fifteen years Head Master of the Textile Department, Bradford Technical College; Author of a "Treatise on Weaving and Designing," "Design in Textile Fabrics," "An Album of Textile Designs," "A Treatise on Textile Calculations and the Structure of Fabrics," &c., &c., &c.)

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[ENTERED AT STATIONERS' HALL.]

PREFACE.

If any apology or excuse is necessary for bringing a work of this kind before the public at the present moment, when so many others of a similar kind are being produced, mine must be a desire to present one which, I hope, is as complete as can be conveniently produced, and which will represent machinery and processes up to date.

When I first ventured to bring a book on Weaving before the public 17 years ago (1878) the field was comparatively clear, and the technicalities of the art and science of weaving were not so widely diffused as now. Of works on the subject of weaving there were few. Murphy, Gilroy, White, Watson, and the modest, yet most useful work of Brown, on the "Power Loom," represented practically the whole.

Murphy was the great master, and every writer in the English language, and most Continental writers are indebted to him for much inspiration, whether acknowledged or not, or whether it comes directly or indirectly. Murphy laid down principles with the hand of a master, and although some seventy years have elapsed since his work first saw the light, and the machinery of weaving has been completely revolutionised, yet the principles are the same. The Jacquard was in its infancy, yet the draw loom and contrivances which led to the Jacquard were there, and the figuring machines of to-day are but developments. The power loom was only beginning to see the light; it has now developed into a most important machine. The "Art of Weaving" was well known and lucidly explained by Murphy; the science has been developed since. The science is built upon the art.

During the twenty years I have devoted to teaching, coupled with practical work in the mill, as well as in the years previous when engaged solely in mill work, it has been my lot to be brought in contact with a great variety

of fabrics, and the machinery required for, and the methods of producing them, and to explain such to the students under my care.

The progress which has been made since Technical Schools were first established in this country has, in my opinion, rendered it necessary to make the text books more complete and exhaustive. Several works have appeared since my first; many of them excellent, but none of them, I believe, sufficiently comprehensive.

I cannot claim that everything is embraced within the pages of this work, or that any one item is thoroughly exhausted, but I have endeavoured, at least, to give a sufficiently comprehensive survey to enable the intelligent student to grasp a fairly sound knowledge of Practical Weaving.

Of designing and pattern making I have purposely kept clear so that I might be enabled to deal with the loom and all its parts in detail without confusion of ideas. Pattern making and designing I may deal with when I have completed this work.

Whatever may be the shortcomings, I have endeavoured to reduce to readable form the Lectures and Lessons on the subject it has been my duty and pleasure to give to students during the twenty years I have been endeavouring to teach them, and I trust there may be some information and suggestions in the Lectures which will assist students in advancing themselves, and maintaining the supremacy of British Manufactures.

I have to express my indebtedness to the Machine Makers whose names are mentioned in connection with the various machines dealt with, not only for the loan of many of their blocks, but also for the assistance they have rendered in supplying me with details.

T. R. A.

Bradford, May, 1895.

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PRACTICAL WEAVING: THE POWER LOOM, AND CLOTH DISSECTING.

LECTURE 1.

WINDING, WARPING, BEAMING, AND PREPARING FOR THE LOOM.

To deal with the subject I have taken in hand thoroughly it will be necessary to trace the yarn from the point where it leaves the spinning frame or doubling machine to the loom. As a preliminary we may first take the yarn as being spun upon cops, as would be the case in woollen or cotton, and follow it through the process of warping, sizing, and so forth. Take cotton as the first illustration. It would be necessary to wind from the cop to bobbins. This is done on a machine commonly known as a cop winder, as shown in Fig. 1, the process being to transfer the yarn from the cop to double-headed bobbins. These bobbins are usually built a little fuller in the middle than at the ends, this being attained by the traverse plate travelling a little quicker at the ends of the bobbin than in the centre. This is usually accomplished by the use of a heart-shaped cam, so constructed as to give exactly the motion or variable traverse required. In other cases what is known as the "mangle wheel" motion is employed, that is, a species of skeleton wheel with teeth on the outer rim, and so contrived that the pinion travels first outside the rim and returns on the inner side, so reversing the motion as shewn in the illustration Fig. 2. Recently an

improvement has been introduced entirely dispensing with the double-headed bobbins by winding the yarn upon paper tubes in what are known as cheeses. This is not only economical, but for many purposes gets rid of a difficulty in the regularity of the tension. However well bobbins may be wound there is a tendency to irregularity in tension at the ends of the bobbins, more especially when coming near the bottom, and, as will be shown presently, evenness of tension in warping is an important

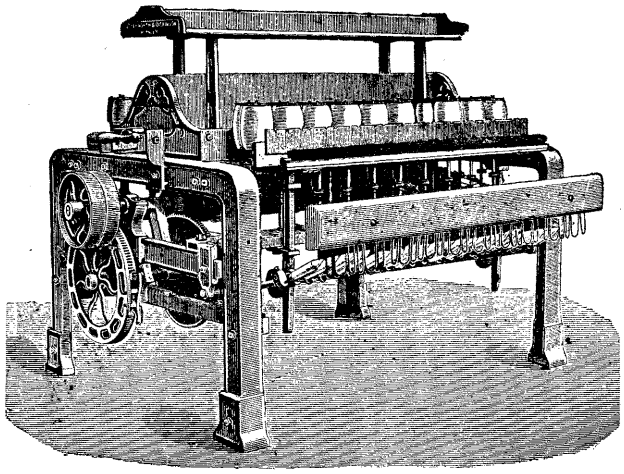


Fig. 1.

factor. Apart from cop winding the yarn has frequently to be wound from hanks in consequence of its being what is termed hank-dyed. Many machines, such as that given in the illustration, Fig. 1, are equipped for either hank or cop winding. The object of hank winding is to prepare for the production of fancy patterns in the warp, as by this means cleaner and better colours are often obtainable, though it is not necessarily the most economical.

Assuming now that the yarn is prepared for the warp, it will be desirable to examine all the various methods

in use, as it does not necessarily follow that the method or process best adapted for one material will be equally suitable for another. To go back to the earliest form of warping, and that which is at present practised in the woollen manufacture to some extent, the general principles may be examined and a theory laid down. Taking the cops as they come from the spinning mule they are placed upon vertical pins, on what is known as a creel as shewn in Fig. 3. From the cops the threads are carried through guide eyes, and gathered together in the

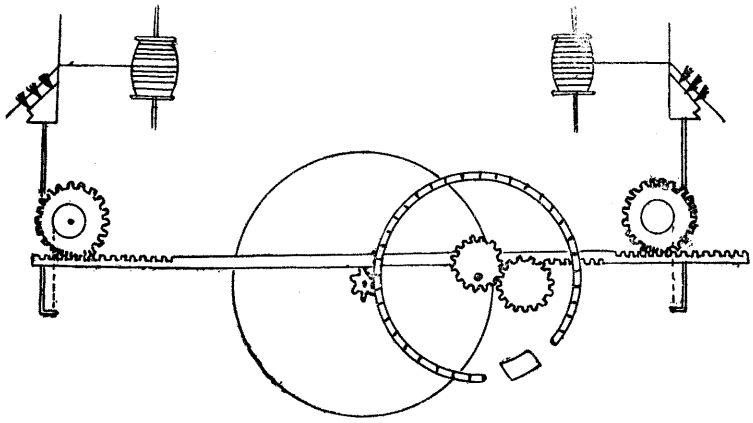


Fig. 2.

hand of the warper. The warp is made upon what is known as the woof, as shewn in Fig. 4, which, although different in some respects from the older forms in use, yet is practically the same. The earlier form simply consisted of a single frame with pins upon one side; the warp threads being taken from the creel the warper picks a "leize" or "lease" with her fingers; taking this "leize" she places the threads on the two pins on the top rail of the frame; then, bringing them from there, they are carried over one of the pins on the

vertical bar at the right, across the frame, over another bar on the left, and so backward and forward till the requisite length of warp is formed, when the threads are carried round to two pins at the bottom to form what is termed the "foot lease;" then carried back in precisely the same manner to the top, when the lease is formed afresh, and so this operation is repeated until the number

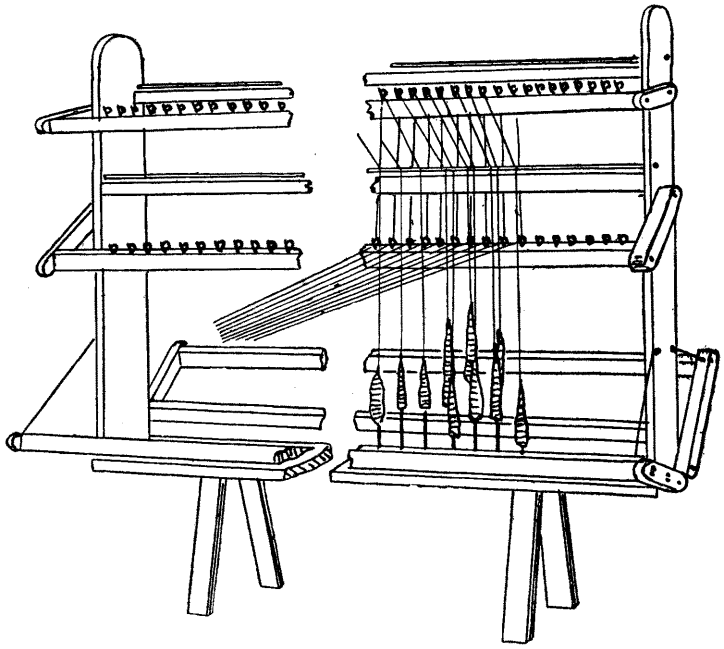


Fig. 3.

of ends required for the warp are put together. The difference between "head leize" and "foot leize" is that every end is leased separately at the top, whereas they are leased in groups at the bottom, these groups forming divisions variously known as "beers" or "porties." The skill of the warper is shewn in this work by keeping all the threads at a perfectly even tension. In the more

modern creel and warping woof a ready means of picking the lease is adopted. Instead of the threads being picked up singly in the fingers from guide-eyes, they are passed through the eyes of a series of needles forming a kind

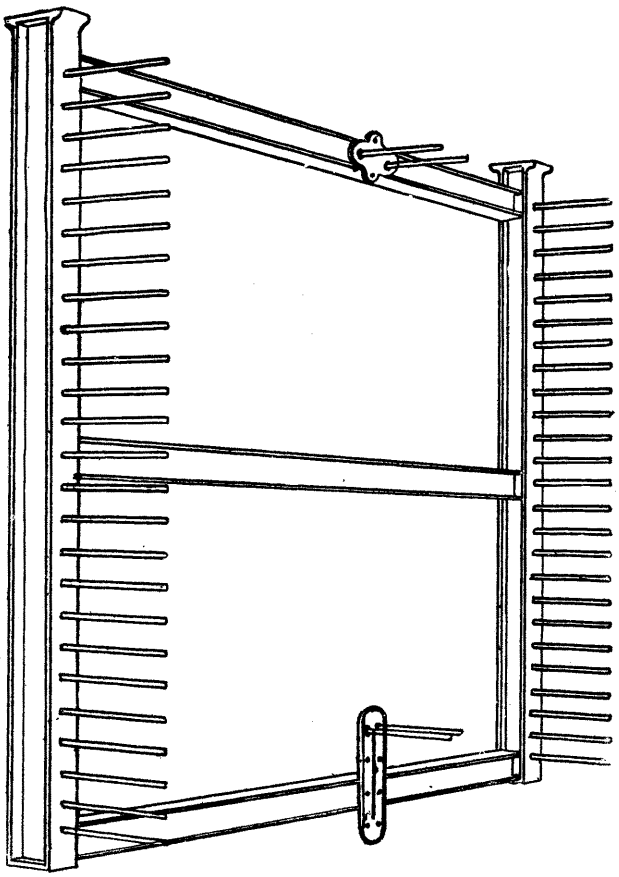


Fig. 4.

of comb, or double comb, and placed in a frame and so arranged that they can be raised and depressed alternately, and so the leize is formed immediately.

The next form of warping mill is what is commonly known as the vertical one, which consists really of a large reel revolving upon a vertical axis, as shewn at Fig. 5. At the head and foot are a pair of lease pins similar to those on the woof, and the yarn is wound round and round upon the reel to the requisite length. For the purpose of distribution of threads upon the reel they are carried through what is known as a heck, precisely similar in character to the combs in the leasing stand.

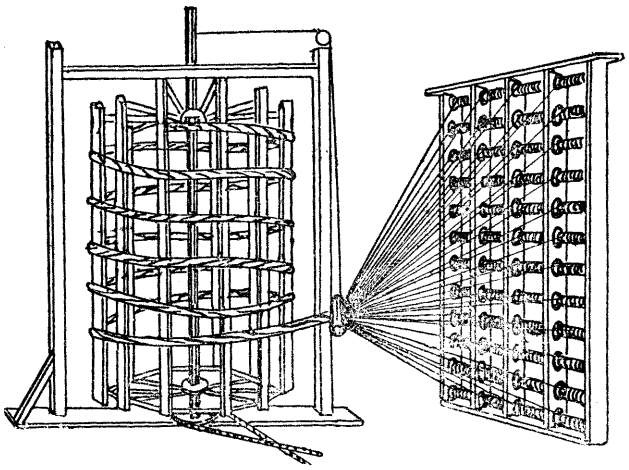


Fig 5.

An illustration of the heck is given at Fig. 6. A few of the needles with eyes, are shewn at each extremity of the bars, one portion being raised and the other depressed, and some of the rollers, or vertical pins, are shewn also for dividing the threads into "leers" or "porties." By an ingenious contrivance of levers, as seen below, the needle frames may be raised by pulling the handle at the end of the horizontal rod on the left of the drawing; the position of the two needle frames can be reversed; so that the warper has only to place her hand between the threads,

place the first lease on the pegs of the warping mill, reverse the position of the needles and place the lease so formed upon the next pin, and so on. There is no need to pick the threads up singly. This heck travels upon a post placed near the reel or mill, and is so arranged that one layer of yarn will not be built upon another more than can be avoided. Should building occur to any great extent the result would be unevenness of tension. The liability to building is probably one of the great

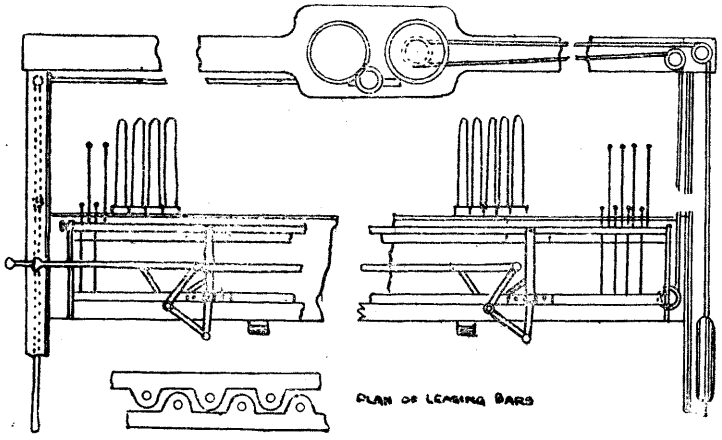


Fig. 6.

causes for the abandonment of the vertical mill in the warping of yarns for many classes of fabrics.

Another feature of this warping mill must be borne in mind; usually the yarn is carried from top to bottom and back, as described in warping on the woof, but this gives rise to serious difficulties in some fabrics, for example in worsted goods. It is well known by all who have carefully observed worsted yarn, that the fibres are laid in one direction in spinning, and were the warp threads carried from top to bottom of the mill and back

again, one half would have the lay of the fibres in one direction and the other half in the opposite direction; then in the process of weaving those fibres laying towards the cloth would be smoothed down in beating up the weft and the others would be ruffled; hence an appearance of defect would be produced. This defect is often brought about in another manner; suppose bobbins are re-wound and are then put in the warping creel as though they had come straight from a doubling frame, they would go into the cloth with the fibres laid in the opposite

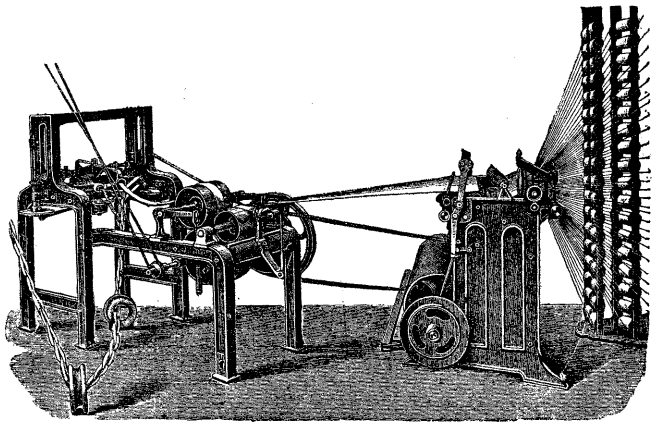


Fig. 7.

direction to the bulk of the warp, and so produce the appearance of a stripe when the goods were dyed and finished.

The next form of warping is what is known as sectional warping; this consists in running all the threads from the creel on to a small section of a beam, as shewn in Fig. 7; those sections are then put together side by side and run direct on to the warp beams for the loom. (Fig. 7 represents a warping machine

from which the warp may be balled, but the principle is the same.) This is a very convenient method of making warps for fancy patterns, and, as will be easily understood, possesses the great advantage of keeping all the warp threads at an even tension as in the horizontal reel. So far as the formation of pattern is concerned as many bobbins would be put in the creel as would form one or more complete patterns, so that all the sections run together side by side would produce the requisite number for the complete warp. In all cases of warping on the vertical mill the warp must be pulled off and balled, or, in the case of woollen or worsted warps, linked for convenience of transport. Sectional warping machines or warps made on sectional machine may be dealt with in the same manner, that is, all the sections may be run together and then drawn off into a ball.

As already said the sectional warping machine has in a very great measure supplanted the warping mill, not only as to the warping of warps where various coloured threads are employed, but also in plain warps, because of the superiority of its work. It must be perfectly clear that warps made upon the sectional machine will not only have an equal tension upon each thread, but there will be a practical freedom from the half beers or groups of thread becoming entangled together. Again, there is the advantage of being able to take sectional warped warps and ball or chain them for the purpose of dyeing or sizing where necessary. For this purpose a chaining machine is in use which meets all the requirements, and is illustrated in Figs. 7 and 8. This machine is made by Messrs. Hurst & Co., of Rochdale. The illustration shews the machine in two parts, the first part consisting of the usual creel, rollers and heck or a sectional warping machine—and the second part of what might be termed a drawing off and chaining machine, so that instead of

the sectional warp being wound from the roller, or made into a "cheese," it is drawn off in the usual manner as from a warping mill and chained, or it may be balled. It will thus be obvious that all the advantages of a sectional machine as regards evenness of tension on the threads is obtained along with the advantages of the ordinary warping mill. Presently it will be necessary to compare the relative cost of ball warping whether on the mill or sectional machine along with warp dyeing and dressing with the other methods in use.

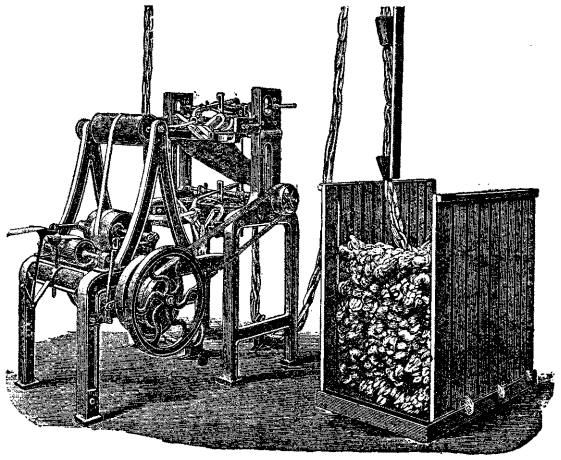


Fig. 8.

The next machine calling for attention is the horizontal warping mill, as shewn in Fig. 9, which really comprises the warping mill and beaming machine.

The mill or reel as will be seen is mounted on a central shaft supported by the end frames of the machine, and the leading feature is the laying of the warp on the reel at each revolution, so as to ensure evenness of tension on all the threads. As seen in the illustration the driving gear is to the left of the machine, there being three

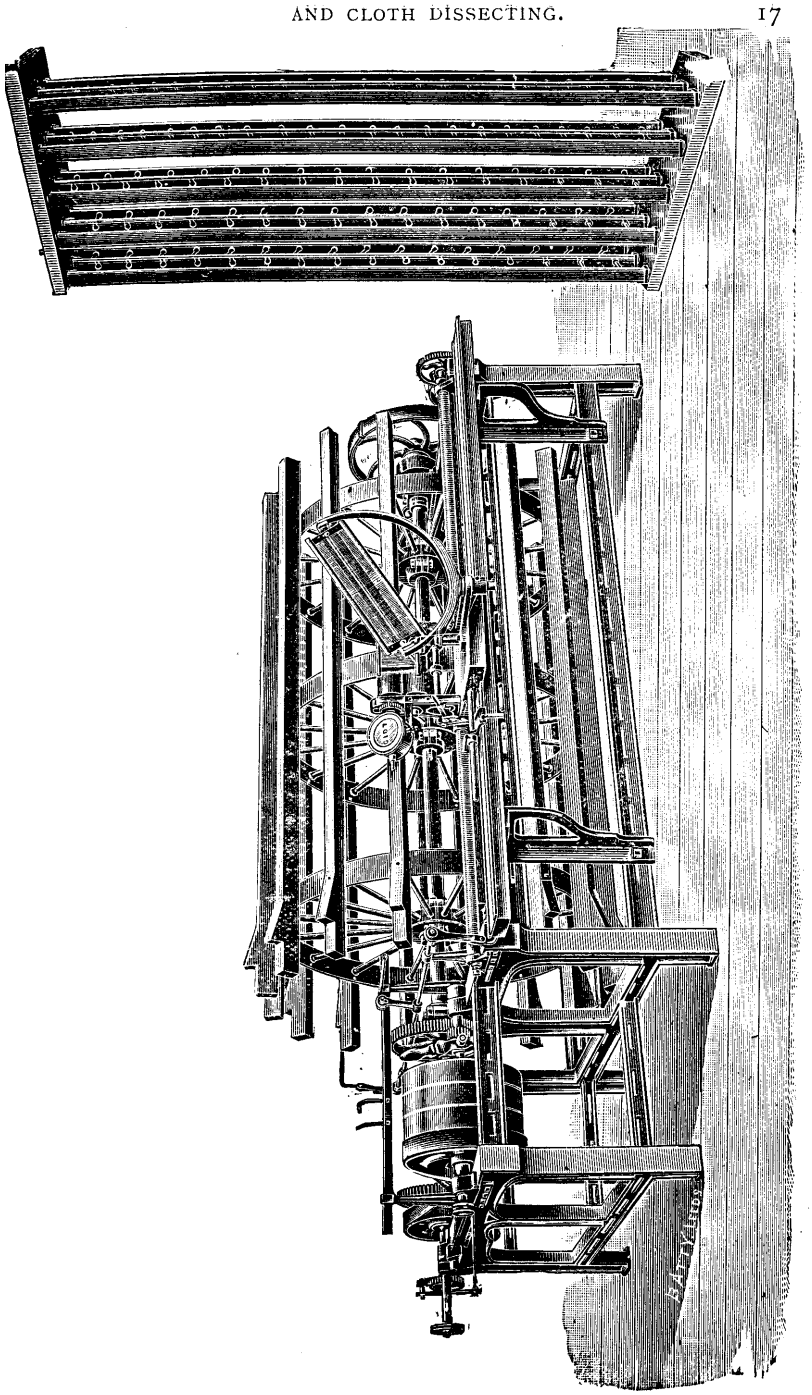


Fig. 9.

pulleys, so that the belt may be either on the loose pulley or the driving pulley at will, or the machine may be reversed for pulling back to find a broken thread. In front of the machine there is a heck differing from the heck already described in having the warp threads carried through a reed to secure perfect distribution. The mode of procedure then is to commence a section of the warp, say for example, 200 ends to the left of the machine and close up to the short inclined planes seen on the staves or bars of the reel to the left; then instead of trying to build the warp in vertical cheeses, or with all the threads laid straight on the top of each other they are gradually moved to the left up the inclined

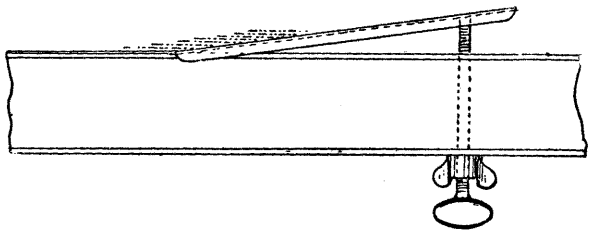


Fig. 10.

plane, forming another with the warp threads on the right and exactly corresponding with that on the left, as suggested in Fig. 9. When one section has been made of the requisite length the heck will be moved to one side and the operation repeated, and so on until the requisite number of threads have been warped.

To ensure accuracy of measurement there is a positive measuring machine attached, the dial of which is seen at the front of the illustration, indicating the exact length put on as the machine is running, and should there be any pulling back the motion registers back, so as to always record the length on the reel. When all the sections have been built the warp can be beamed direct from the reel.

A beaming frame stands in front of the machine, a beam is put in and the flanges adjusted and the warp run direct back, so that all the sections come off together, and at exactly the same tension, thus saving both time and labour.

The machine as shewn here is made by Messrs. Lightowler and Keighley, of Bradford, but the adjustable inclined plate shewn at Fig. 10 is a feature of Messrs.

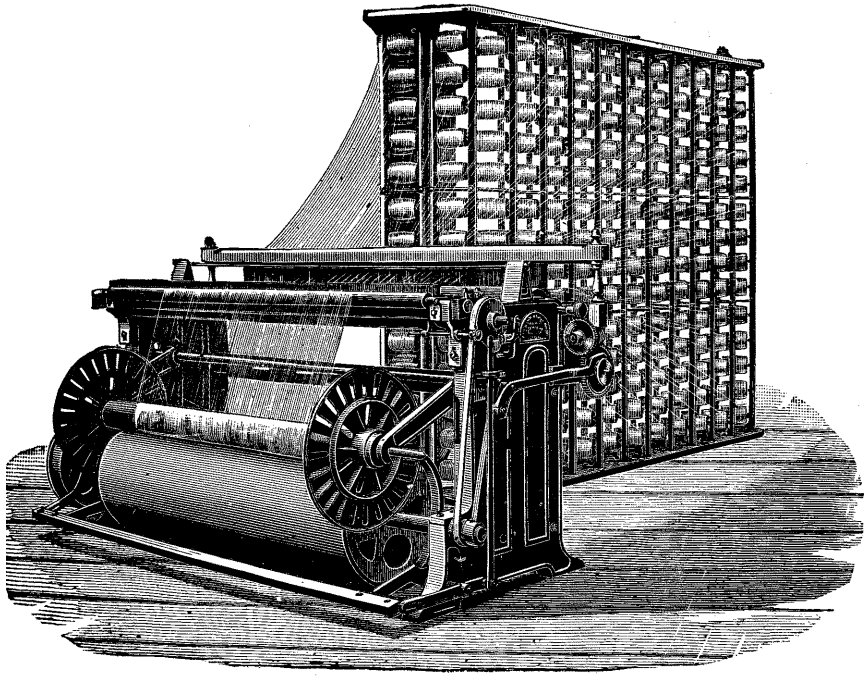


Fig. 11.

Hutchinson and Hollingworth. Messrs. Hutchinson and Hollingworth's Machine differs from this. In the machine just described the heck is made moveable, so as to build the warp up to the inclined plane; but they use a stationary heck and give a traverse to the reel itself, and when one section has been built up the heck is moved a distance corresponding with the width of a section and the process

repeated. As each section is completed of the requisite length, the machine is stopped automatically. Still another machine is shewn at Fig. 11, where the warp threads are run direct from the bobbin to the beam. In this case a comparatively small number of threads would be run on to one beam, but there would be a great length, then a number put together to make up the requisite warp.

Assuming that the warps have been made upon one or other of the mills described, other treatment is then

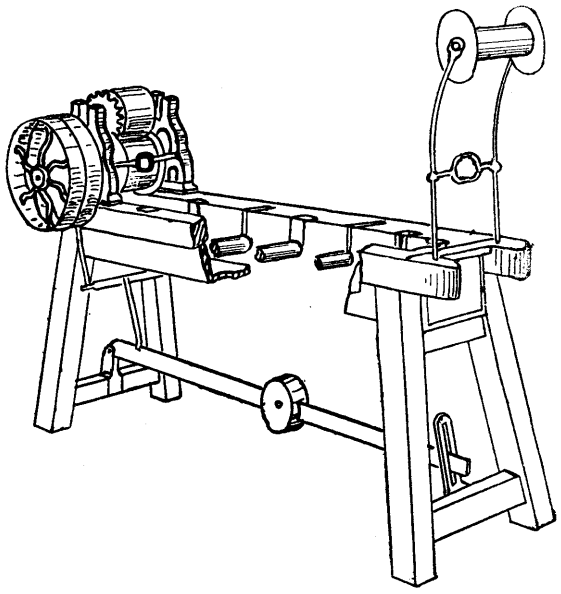


Fig. 12.

necessary. In the case of woollen warps especially they must be sized. As to the nature of the size it is not necessary to enter into the details more than to say that it usually consists of a solution of an animal substance, something of the nature of weak glue. The ordinary process is to pass the warp from the ball through a machine as shewn in Fig. 12. This machine consists of

a long trough containing the hot size and a roller and guide eye and a series of rollers in the bottom of the trough for the purpose of immersing the warp in the size. At the other end are a pair of squeezing rollers. A portion of the trough is shewn with the side cut away. After the warp has passed through the size it is necessary that it should be dried and opened out at the same time. The earliest method of doing this was to stretch the warp over a number of rods in a field, or along a wall side. The warp would be stretched at full length, and a raddle, a species of coarse comb, as shewn at Fig. 13,—where it is shewn both with and without cover,—

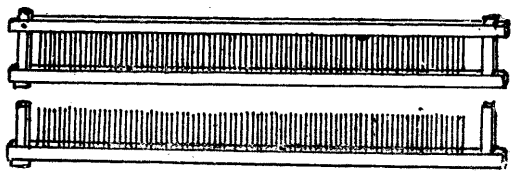


Fig. 13.

would be run through the warp from end to end, so spreading it out to dry and preventing the threads adhering to each other too much with the size. The laying of the warp in the raddle is practically equivalent in beaming to that of slaying in dressing. A given number of threads must be spread over a given width. Then if a raddle is made with a given number of teeth per inch, or per foot, the warp must be spread out to the proper width by filling between a given number of teeth and missing a certain number. This difficulty has been met in a considerable degree by the expanding raddle, which consists of a series of jointed rails or laths, each being pivoted in its centre, one upon one rail and one upon another; these two rails being made to slide upon each other. Upon the laths lying in one direction the raddle teeth

are fixed, and the other blank, so that as the two foundation rails are moved backward and forward the angle of those carrying the raddle teeth is altered, and made finer or coarser as required.

The next method adopted was what is known as the balloon process. In this the warp would be passed through a sizing trough, and through the raddle on to the balloon; the balloon was a skeleton reel placed horizontally with moveable cross bars; these bars being inserted in the radial arms of the reel as it revolved, so that the warp was continually being wound upon a succession of rails; then the balloon made to revolve in hot air until the warp was dry, when it could be wound direct to the weaver's beam and so passed to the loom. The strength of size would of course be varied according to the quality of the material; that which would serve well for coarse goods being altogether unsuitable for fine material.

In goods where the warps would not require to be sized they would be taken direct and beamed, or dressed, on to the weaver's beam. There are many forms of beaming or dressing frame, one of the most convenient being shewn on Fig. 14. As will be seen here the warp ball is placed upon a turn table, this facilitating the revolving of the ball in case of there being any twist, then it is carried through a rack, which enables the dresser to give any degree of tension required. From that it is to be carried over a rail at the opposite end and under a roller and back to the beam, the raddle or sley being placed at any convenient point near the beam; the dresser or beamer's business being to see that the warp threads pass evenly through the raddle, or sley, and are properly built upon the beam. This portion of the work, if not properly carried out, may be the cause of many and serious faults in the cloth, as well as great

trouble in the process of weaving. For instance, if the flanges are not properly and evenly set, or the warp not properly built up to them, there will be irregularity of tension at the edges. In many cases the warps, for convenience, are made into two or more balls, and these have to be put together in beaming or dressing. In putting them together one of two methods may be adopted; the first is to run them both through the rack at the same time, and either lay them side by side on the beam, or in alternate ends, or groups of ends, such as "half

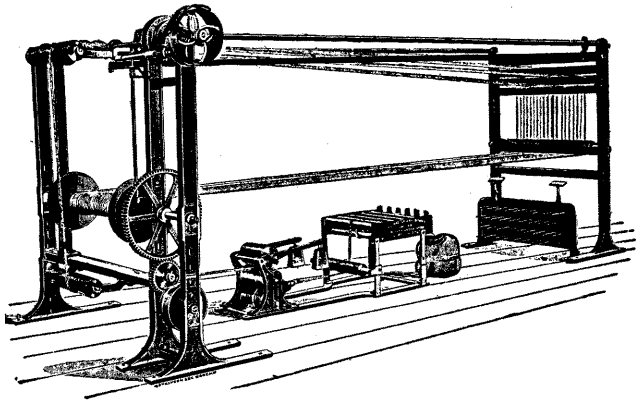


Fig. 14.

beers." In either case every care must be taken to ensure the same tension upon both portions of the warp. Another method is to run one of the warp on to a beam, and then that along with the other half on to a second beam; in that case, the one portion going through the rack and the other being drawn from a beam renders it very difficult to keep the tension even. Another fault often arises from this treatment, in many cases warps are dyed in the warp, and it will be obvious that in process of dyeing the depth of shade at one end of the warp may be slightly different from that at the other.

Supposing two such warps are put together, the light end of one coming to the dark end of the other, and being woven into the piece where alternate threads come to the surface there would be alternate marks of light and dark colour along the piece. Again warps that are dyed in the warp may be so bulky that the colouring matter cannot get evenly through them; they are then split in two and dealt with as two warps after the manner suggested. Very frequently this will obviate any tendency to stripiness, or unevenness, though it can never be looked upon as a perfect remedy.

The slashing machine does its work after the manner of that shewn at Fig. 11, but sizes the warp at the same time.

WARPING FANCY PATTERNS.

We may turn attention for a moment to the warping of fancy patterns, because we have here involved a variety of questions of detail which must receive the most careful consideration. Suppose, for example, we are about to make a warp for a fancy pattern such as a tartan plaid. We should have to determine, first, the number of patterns required in the width of the fabric, then the exact number of threads of each colour required to form the whole warp. Suppose the pattern to be as follows:—a slight modification of the tartan of Campbell, of Loudoun.

16 Black
20 Blue
2 Black
4 Blue
2 Black
20 Blue
16 Black
20 Green
2 Black
6 Yellow

(*Continued.*)

2	Black
20	Green
16	Black
20	Blue
2	Black
4	Blue
2	Black
20	Blue
16	Black
20	Green
2	Black
6	White
2	Black
20	Green
260	ends in the complete pattern.

We should have, say six complete patterns in the entire width of the fabric, with thirty spare threads to be dealt with, those spare threads must be so arranged, that, at least, both sides of the fabric will be alike. Then we must determine how the bobbins should be set on the creel so as to enable us to form the complete warp with the least amount of trouble, such as breaking out threads or introducing extra bobbins. Very often this can be done readily but there are cases such as the pattern in question, where it is practically impossible. Then the warper must arrange the bobbins so that a given number of repeats of the pattern can be warped straightforward with the least possible inconvenience and delay, and the extra threads worked in for the sides conveniently. This system of warping upon the mill is practically abandoned at the present day and the sectional warping machine or the dressing frame has taken its place for this purpose. Suppose for a moment that this warp is being made upon the sectional warping machine, such as

that shewn at Fig. 9. We should begin there by building section upon section on the reel until the warp was completed, then run direct from the reel to the weaver's beam.

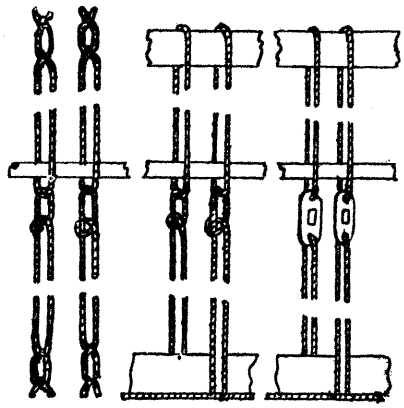
The system of dressing from the ball, as it is termed in the Bradford trade, is a very convenient method of dealing with this subject. The warps would be dyed in the warp, a sufficiently large number of threads in each one to be conveniently split up afterwards. Suppose the pattern mentioned is the one to be dealt with, there are five colours; the threads of each of the colours respectively being for the whole warp, of six patterns, $80 \times 6 = 480$ of black; $88 \times 6 = 528$ of blue; $80 \times 6 = 480$ of green; $6 \times 6 = 36$ each of yellow and white, and if blue be added to each side, that is, beginning in the centres of blue and ending there, plus a half pattern to each side, then four ends would be added to black and twenty-six to blue. One warp would be dyed to each colour, each of such warps containing say ten times the number of threads required for one, so that these could afterwards be split into ten portions, then those several portions would either be wound upon beams in readiness for running together, or they would be passed through the same rack and run directly to the weaver's beam after being drawn through the sley in exact accordance with the required pattern. This is unquestionably the most economical mode of working, as it saves in the first instance the cost of hank dyeing and winding, as well as considerable waste. Suppose we take sectional warping into comparison, we should have at least $2\frac{1}{2}$ per cent. of waste to allow, for there is the cost of hank dyeing and sizing, which at a moderate estimate cannot be less than $\frac{1}{2}$d. per lb. more than warp dyeing and sizing. In addition to that there is the cost of winding on to the warper's bobbins. Of course it may be said there is a disadvantage; inasmuch as warps specially

ordered and dyed for this method of working will involve a loss of time in preparation, as against the readiness with which sectional warps can be prepared, in comparison with sectional warping, where the warp can be immediately prepared from the bobbins in stock. In reality it resolves itself into this, that in the one case coloured yarns wil be kept in stock in warps, which will be of a given length; in the other it would be kept in stock in bobbins where a warp could be prepared *of any length*, so that the balance of convenience in that respect would be with the sectional warping, so that it would be a question for consideration whether economy of cost would not be more than counterbalanced by convenience. So far as perfection in the warp is concerned, that is, evenness of tension upon the threads and perfect distribution upon the beam, the advantage would be with the sectional warping.

DRAFTING AND DRAWING IN.

After the warp is made the next process in preparing for the loom consists in either drawing the warp through the healds or twisting to the remnant of the warp which is already there. We will begin by supposing that we have a complete new set of healds to deal with, so that we can follow the process step by step. First as to the form of heald. Generally speaking they consist of worsted cords mounted, and forming a loop, as shewn in Fig. 16. The lower half of the heald, as will be seen, is a long loop, the upper half is somewhat similar in form with the addition of the small knotted loop in the centre through which the warp thread must pass. This was one of the earliest, and in many respects, one of the most useful forms of healds, it has however has been superseded by what are termed mailed healds, the mail consisting of a metal plate with three eyes, as shewn in Fig. 18, the central eye varying in size and form according to the

nature of, or the bulk of the yarn to be woven, the smaller eyes at the extremities being intended for the heald cords to pass through. The next form adopted is what is known as the wire heald, consisting of a series of twisted wires with a loop formed in the centre for the warp threads and one at each extremity for the purpose of mounting on bars or shafts. One of the great advantages obtained from wire healds is the ready facility with which the set or fineness of the healds can be changed or varied, every heald being loose and moveable, the number per



Figs. 16, 17, 18.

inch can be regulated at will. On the other hand the inconvenience of great weight, tendency to bend on the weavers passing their hands through to take up threads, and in some cases a liability to cut the warp in consequence of roughness or fracture of the wire operate against their general adoption. The advantages of the wire healds so far as convenience of changing is concerned has been met by the introduction of cotton or worsted healds looped and mounted in the same manner as shewn at Fig. 18. The advantage of this class of heald for fancy work will

be apparent presently when dealing with striped or fancy patterns where various degrees of fineness are required, or where striped healds are employed.

The method of mounting the healds should be explained. As they come from the heald knitters the common heald is simply mounted upon what is termed a "rig band" and leased to facilitate the insertion of shafts, so that the mounter of the healds has only to insert the shaft in the lease as given, taking care to tie each end of every shaft in succession with the extremes, or the first heald cord, exactly the same distance from the extremity of the shaft so that in the loom they will be perfectly straight and even. As will be noticed in the section shewn on Figs. 16, 17 and 18, the lower half of the heald is so leased that the shaft goes through every loop, whereas the upper half has the loops on alternate sides of the shaft. The object of this is to facilitate not only the drawing in of the warp in the first instance, but also the taking up of single warp threads afterwards. When the healds are prepared for the warp drawing through, what is termed a looming shaft is inserted in the lower loop of each heald, as shewn in the sections, the object being to ensure the healds being taken in their proper order of succession. The healds being mounted upon their shafts and the looming shafts inserted they are most conveniently hung or suspended in a frame, the lower portion being screwed down or having weights attached to them so as to keep them perfectly straight, without having too much tension upon them. The warp beam is then placed in the frame, the lease rods being immediately behind these, the operation of drawing may be commenced. Two persons are really required for this work, one to pass the hook through the healds in the proper order of succession and the other to hook the threads upon it so that they can be drawn through the healds. In some cases where only

two or three healds are employed the looming shafts may be dispensed with, the drawer-in taking a handful of healds and selecting them with his fingers; in the hands of expert workmen this is looked upon as a quicker method than the other one. The next question is the order of succession in which the threads must be drawn through the healds and also a ready means of conveying to the workman the order and degree of fineness required. Suppose in the first instance, a plain cloth is to be woven, only two healds would be employed and the warp threads drawn upon them alternately, then the draft plan would be shewn in Fig. 19, or in place of the vertical lines numbers might be employed. Now comes the question of variable drafts or variable degrees of fineness. Suppose,

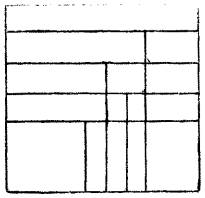


Fig. 19.

for instance, that a cloth is to be made where a stripe is formed, the stripe being of a different material or colour than the ground, and a different degree of fineness in the cloth is involved. For a moment let the ground of the cloth be of cotton, say 60 threads per inch, and the stripe of silk, say of 120 threads per inch; then of course the striped portion will be doubly as fine as the ground. In this case we should simply find an average set for the whole, if the pattern were a small one; suppose, for instance, the pattern consisted of 32 ends of ground and 8 ends of silk, then we should have 40 threads occupying a space which would be equal to 36 of the ground ordinarily, or in other words we should be

increasing the number of threads per inch from the ground in the ratio of 36 to 40 or making an average of $66\frac{2}{3}$ per inch, thus $\frac{40 \times 60}{30} = 66\frac{2}{3}$. Or it may be expressed in another form; the ground threads would be two ends in one dent of the reed, so that in the pattern there would be 16 dents of the ground and 2 dents of the stripe, hence that there would be 40 threads in the 18 dents; thus explaining the formula given above; the crowding or cramming taking place here in small quantities would not prevent the use of healds made with an average of $66\frac{2}{3}$ per inch; but if the pattern is a large one occupying, say 2 inches of ground to 1 inch of stripe then it would be more convenient either to have the healds specially knitted for the purpose or use the loose slips as shewn in Fig. 18. This of course is supposing throughout that the cloth is a perfectly plain one and only two healds are required for it.

I must now deal with the two important questions, viz.:—what is known as casting-out in healds, and the arrangement of drafts for either combined patterns distributed evenly over the cloth or in stripe form, and the calculations connected with the determination of the degree of fineness of the several healds required to form a pattern. Approaching the subject in its simplest form first it must be self-evident that as the warp passes from the warp beam through the reed they should form a perfectly straight line, and consequently that the healds should not drag them to either one side or the other.

Suppose a cloth is to be woven with sixty threads per inch, it is obvious that however many heald shafts there may be in use the heald cords must be distributed over them, so as to give a total of exactly sixty per inch, and if there are either more or less there will be a discrepancy between the reed width and the heald width,

which will cause trouble in weaving, more especially at the edges. I must not be supposed to say, that it is impossible to work with any discrepancy, for in many goods it is no serious disadvantage to have the healds half an inch wider at each side than the sley, but in such case the warp should be proportionately wider in the beam so that the edge threads will not form a kind of V in passing from the beam to the reed. In many cases the warps are systematically put on the beam a little wider than the reed width, but this should not be carried very far.

Then it must be clear that if the healds have too few cords upon them they cannot be adapted; if there are only fifty per inch they cannot be made to carry sixty threads, but the reverse may be the case, by leaving ten out of every sixty empty. We must be careful however how we cast those ten out, it would not do to simply draw fifty threads through the healds and then leave ten empty ones. In many cases it would make a break in the pattern, and in all it would probably give trouble to the weaver in taking up broken threads. Suppose there are eight healds in use the fifty threads would fill up six "gaits" and two ends over; then leaving ten empty would cause the next fifty to commence at No. 5 heald, and there would be a break in the continuity of the pattern represented by the absence of two threads from Nos. 3 and 4 healds, and this would occur every time. Then it is obvious that the healds must be cast out in "gaits" or one complete draft over the heald. The simplest mode of expressing this would be that as there must be ten healds cast out in every sixty there must be ten "gaits" cast out in every sixty, then divide sixty by ten and every sixth "gait" would have to be cast out, and the warp will be kept straight.

The greatest trouble arises when casting out occurs, irregularly to make the healds suit the pattern, and more especially when occurring in odd heald cords upon one or more shafts. This should never be resorted to for regular work, it may be done occasionally to weave a pattern and utilise a set of healds which may be at hand. Suppose a draft such as that shewn at Fig. 20, which is one of the simplest conceivable; the two front healds weaving a plain ground and the back healds perhaps introducing some thread to form a species of stripe. There are two threads on each of the front healds to

Fig. 20.

one on each of the back ones, therefore if an ordinary set of healds upon four shafts be used one half of each of the back shafts would have to be cast out. This would be troublesome to the weaver, but not nearly so bad as if it occurred in irregular order.

In such a case as this the healds should be made specially, then the question would arise as to the method

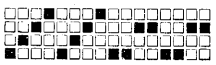


Fig. 21.

of calculating the numbers of threads on such shaft respectively. In this case the matter is easy, as they are in the relation of 2 to 1 throughout, but if the principle is laid down in this it will be intelligible and easily applied to others. I will take a very simple illustration first, so as to make the rule clear, and its application will be more readily grasped. Fig. 21 is a draft for a supposed "hopsack" and twill stripe, on four shafts, and for the purpose of enabling us to weave it on an ordinary tappet loom. There are sixteen threads in the whole pattern,

but each heald does not carry the same number of threads, and in fact the discrepancy is so great that casting out would be out of the question. On the first and third healds there are six threads each, and on the second and fourth two threads each. Then suppose there are 80 threads per inch in the cloth, and 16 threads in each pattern will give $\frac{80}{16} = 5$ patterns per inch, and $5 \times 6 = 30$ threads on Nos. 1 and 3 healds respectively, and $5 \times 2 = 10$ on Nos. 2 and 4, or a total of 80 per inch, distributed over the four in the required proportions. So far this seems very convenient, but it does not go far enough, nor is it handy enough for the majority of cases. It is very seldom that the number of ends in a pattern would

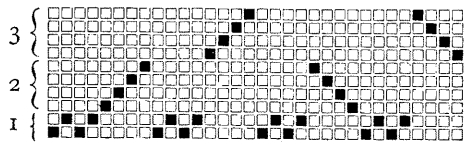


Fig. 22.

be an exact measure of the number per inch. Suppose there are 60 threads per inch instead of 80, then it would not work out; in that case a general formula must come in, and this simply takes the form of a proportion. Thus there are 16 threads in the pattern, 60 per inch; No. 1 heald carries 6 out of the 16; then as $16 : 6 : : 60 : 22\frac{1}{2}$ ends on No. 1 shaft, and as $16 : 2 : : 60 : 7\frac{1}{2}$ ends on 3 shaft, and 3 and 4 are the same, therefore $22\frac{1}{2} \times 2 = 45$ and $7\frac{1}{2} \times 2 = 15$

60

This rule is very simple, and easy to remember, and those engaged in this branch of work should not have to seek for rules and formulæ when wanted, but have them handy.

Take a draft now of a little more elaborate character, but one which can be easily followed. In this the draft is presumably for a stripe, and these are to be their

orders of working, therefore the healds may be divided into three groups, the first two forming one group, the next four the second group, and the last form the third, as shown on the plan. There are 32 threads in the pattern, and suppose there are 72 ends per inch, then on each of the first group there are 8 threads, and on each of the second only two, therefore by the rule laid down, as 32 : 8 : : 72 : 18 for each heald per inch, and as 32 : 2 : : 72 : $4\frac{1}{2}$ for each heald per inch, and $18 \times 2 = 36$

$7\frac{1}{2} \times 8 = 36$

—

72

This pattern approaches a class of striped goods requiring special healds, variously known as striped or spaced healds, and for which a special plan should be made for the heald knitter. I will go back for a moment to the plain cloth in striped form. Suppose we are making a cloth perfectly plain but having a ground say of black or any other colour, of two inches wide, and a stripe of another colour, and of a different material, or a finer thread of the same, one inch wide, and in the stripe we have more threads per inch; say the ground 60 and the stripe 120 ends per inch. It will be quite clear that this could not be woven on two healds only, because of the discrepancy in the degree of fineness of the two parts. Suppose an average number of ends per inch be taken, one pair of healds could certainly carry the threads, but it will be well to see what the result would be, 2 inches by 60 = 120, and 1 inch × 120 = 120, and $\frac{120 + 120}{3 \text{ inches}} = 80$ per inch. Now make the healds with 80 per inch, and the two inches of ground will occupy only $1\frac{1}{2}$ inches in the healds, and the 1 inch of stripe will occupy the same space, or in other words, there would be a "draw" at each side of each stripe of half an inch. This could not be tolerated

in practice. Then the healds must be drawn on four shafts, thus:—

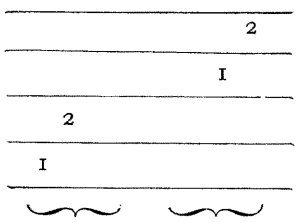


Fig. 23.

and instructions given to the heald knitter after this manner:

2 shafts, 2 inches, 60 sett, 1 inch space.
2 ,, 1 ,, 120 ,, 2 ,,

and also specifying the requisite number of stripes across the piece.

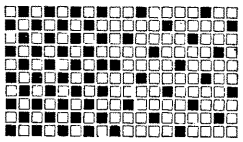


Fig. 24.

Now we come to a question which is a little more intricate, but what has been already said will help to elucidate it, viz.:—stripe healds where there is considerable difference, both in the number per inch and where there may be a great variety of stripe as well as the order of

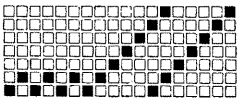


Fig. 25.

interweaving. Take the pattern at Fig. 24, which shews a design for a plain ground with a satin stripe. To begin with, whatever the relative spaces occupied by ground and stripe, or degree of fineness of each, they must be woven on separate sets of healds, therefore, unless the pattern

is very small, there must be striped healds employed. I will endeavour to explain not only the methods of ascertaining the number of threads on each heald shaft, but also the method of giving instructions to the heald knitter. Suppose the following to be the pattern, and to be sleyed with the ground two threads in one dent and the stripe five in a dent.

100	ends	ground
100	,,	stripe
100	,,	ground
20	,,	stripe
10	,,	ground
28	,,	stripe
350	ends	in the total.

Now the two sets of healds are in the relation of 2 to 5 in their degree of fineness, and suppose the ground to be 60 sett, then the stripe would be equal to 150, then the instructions might be given thus,

2 shafts, striped, as follows:—

100	ends	60 sett
100 = 24	,,	space
100	,,	60 sett
20 = 8	,,	space
10	,,	60 sett
20 = 8	,,	space

and 5 shafts, striped:

100 = 40	ends	space
100	,,	150 sett
100 = 40	,,	space
20	,,	150 sett
10 = 4	,,	space
20	,,	150 sett

or the number of ends on each shaft may be specified at the rate per inch where they are to be knitted.

Some people prefer to lay off on a long strip of paper the exact pattern for the full width of the cloth. To do this a reed is taken and a strip of paper laid upon its face, then the number of reeds counted off for each portion of the pattern and marked upon the paper, thus giving an exact fac-simile of the whole of the pattern across the fabric.

This mode of treatment and combination of patterns necessarily raises the question of sleying the warp. I shall

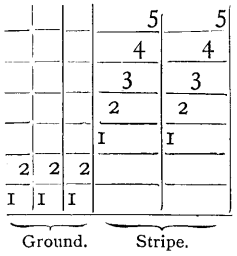


Fig. 26.

not attempt to lay down here any rules as to what should be the number of threads in a dent to suit any given pattern, as that is a matter which properly comes under the head of cloth structure, beyond saying that generally

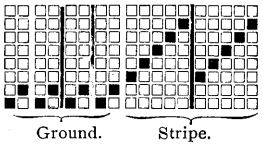


Fig. 27.

there should be some direct relation between the numbers of ends in a pattern and the number in a dent, though it is not imperative that it should be so. Consequently what I have to deal with is rather the mode of expressing or conveying to the operative how the threads should be drawn through the reed. There are really three forms of expression which may be used, the first in writing, thus:

ground, two ends in a dent; stripe, five ends in a dent. For simple patterns that is often all that is requisite, but for broken patterns that would not do, then the method illustrated at Fig. 26 might be resorted to, or on design paper as at Fig. 27. Either of these methods may be adopted, as the only object is to place on record the manner in which the threads are drawn through the reed.

One word more as to the sleying of the warp. I have already suggested that there should be some relation between the number of ends in a dent and the pattern. I will try to make that clear. Suppose a plain cloth is being woven, the threads would usually be sleyed two in a dent: to put three in a dent in a fine cloth would be to court trouble, for as the warp threads are separated there would be the two outside ends raised in one dent, and the centre thread in the next, and it would be difficult, in some cases almost impossible to prevent the weft curling, and so it would be with many other patterns. Loose twills may be sleyed in almost any order, but where there is firm texture, or combinations of patterns, regard must be paid to the relations of pattern and reed.

Again, if coloured or fancy threads are introduced they must be placed in such a position that they will not be liable to be buried at intervals by their companion threads. Let a worsted thread with silk twisted round it be working in a hop sack with two coloured threads, and put the three in one dent with the twist thread in the centre, and it will be buried at intervals by the others closing over it, and it will occasionally come to the top of the others, so giving a most irregular appearance to the fabric. I have simply mentioned this as a typical case, but there are scores of others which would be quite as much to the point.

A very useful little machine is shewn at Fig. 28, for the purpose of extracting water from bobbins of weft which have been wetted for weaving. It is a common practice in some industries, more especially the woollen, to weave the weft wet, and after the bobbins have been

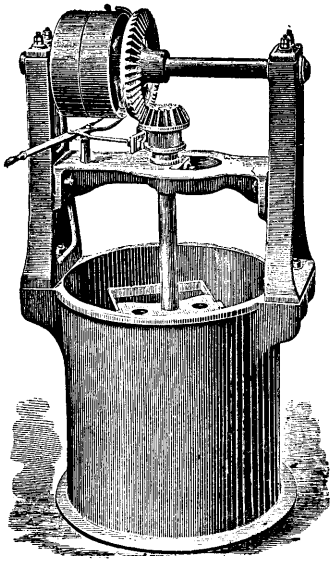


Fig. 28.

steeped it is necessary to remove the superfluous moisture; this was formerly done by swinging them round in a basket or perforated tin can, this little machine takes the place of that and does its work both more economically and better. This is one of Messrs. Hutchinson and Hollingworth's machines.

LECTURE 2.

PLAIN WEAVING.

In approaching the subject of practical weaving it will perhaps be as well to examine it from every possible point of view. We may ask ourselves first what is weaving? What are the operations involved in the process? How shall those operations be performed? And in asking ourselves those questions we have not only to consider what the operations are and their order of succession but the exact nature of each movement in succession. Dr. Cartwright was unquestionably correct in his surmise when he said "that he conceived that for the operation of weaving only three movements were necessary, viz.: the separation of the warp threads, the insertion of the weft threads and the beating up of the weft to the fabric." If we look at the illustrations of weaving as practised by the ancients, whether we take the Egyptians, the Hindoos or the Chinese, we find that they confined themselves strictly to these three operations. They have their warp threads stretched in a frame parallel to each other, and they either separate them by means of a rude flat rod, or form a heald of a simple character and then pass their weft through, either by means of a long hook or something approaching the form of the shuttle of to-day, and next beat it up to the cloth by means of either their "spatha" or their comb. In the hand loom of more modern times the healds for separating the warp threads became a necessity for insuring the repeated movements, or continuation of the work. The shuttle was formerly thrown through the warp threads by the weaver from hand to hand, and reeds separating the warp threads and determining their distances apart served also at the same time for beating the weft up to the fabric.

These three operations occurring intermittently might, in the simpler form of loom, be carried out without any special regard to the particular movement being given to any of the portions of the mechanism performing the several operations. For instance the "spatha" in beating up the weft might be made to give several blows, the shuttle in passing the weft through might be carried across as slowly as one may please, but in dealing with a machine which must perform those operations automatically the exact nature and movement of each part must be carefully considered, so that the several parts of the machine will fulfil their functions in the best possible manner.

Although the three movements mentioned are the only three absolutely necessary to the process of weaving, others must follow when the operation becomes a continuous one, as is the case in the modern power loom; such for example as the letting the warp off the warp beam and the taking up of the cloth on to the cloth beam. In what might be termed, comparatively speaking, the modern hand loom, these two latter operations were performed intermittently; the weaver for instance would let off a certain length of warp, say four or five inches, and he would go on weaving until he had not sufficient room for his shuttle to pass conveniently through between the reed and the fell of the cloth. He would then let off more warp and wind up the already made cloth on his beam, and this would go on continuously. It must be evident that in continuous weaving, where, as in a power loom, the reed must come up to a given point at every stroke, this intermittent taking up of the cloth could not possibly be practised, but that the cloth must be taken forward with perfect regularity, so as to ensure evenness of weaving. The hand loom weaver could bring his reed forward to any given point, and it was with him merely a matter of practice in beating up the weft to obtain evenness and regularity; but in the power loom, where the reed comes to a given point, this evenness

and regularity can only be determined by the cloth being carried away from the loom exactly and at the rate at which it is formed; so that those two apparently subsidiary motions become absolutely necessary in continuous or mechanical weaving. Then we may examine the nature of the movements, first as performed by the hand loom weaver, next as they must be performed by the power loom, and having taken a general survey of the whole field, the details of the loom may be closely examined and understood.

Taking then the modern power loom we have, for convenience, the warp threads stretched horizontally in the loom, so that for the purpose of separating those warp threads to allow of the weft being passed through them the healds must be made to work vertically, or to rise and fall; the shuttle must be passed along in the horizontal plane, and the reed beating up the weft to the fabric, must also move horizontally, or at least describe a small arc of a circle, and at right angles to the line traversed by the shuttle; so that we have to consider not only the nature of movements but the readiest means of conversion of motion in the best possible manner, and with the least loss of power. For convenience, power is usually transmitted from the engine, or motor, through the shafting either by means of belt or gearing direct to the machine; so that we may suppose we have received at our loom the continuous circular motion at the main or driving shaft; and that we have not only to communicate power to the several parts of the machine, but to convert them in such a manner as to ensure the work being perfectly done. Taking the ordinary plain loom as the starting point, the conversion of motion really is reversed from that of the hand loom, *i.e.*, the first conversion takes place from the driving shaft to the reed or beating-up motion, the second direct conversion being the picking motion, and the third the shedding or separation of the warp. Before going into the methods of conversion it would be as well to look at the nature of the movements

required; for instance the hand loom weaver in separating his warp threads can time the movement of his feet operating the healds, through the medium of his treadles or shedding machine exactly as he pleases, and generally speaking that will be to cause the first movement of his threads, as well as the last part of that movement, to be as easy as possible. He will avoid throwing any unnecessary strain upon his threads; he will carefully time the exact moment of opening or closing the shed to the nature of the material he is working with, and the character of the work to be done. Generally speaking he will avoid any unnecessary strain, especially when dealing with tender material. In weaving heavy goods he will assist the beating of the weft by the crossing of the warp threads exerting pressure upon the weft, and so assisting to press it up to the fabric. On the other hand in weaving light goods he will avoid putting unnecessary pressure or strain upon the warp threads. Generally speaking we may say that we have three distinct forms of shedding in common use: first, what is termed tappet, or open shedding; second, what is termed centre shedding; and third, what is commonly called bottom or jacquard shedding. The majority of hand loom weaver's work will come within the category of the centre shedding, *i.e.*, in the earlier forms of treadle weaving he would so operate the treadles with his feet. In weaving light goods he would cause the threads to meet at the moment when the weft is being beaten up to the fabric, but in heavier goods, or when he desired to distribute the warp threads evenly, he would cause his feet, and consequently the threads of the warp, to meet some time before the weft was beaten up so as to produce, what he would term, cross shedding or assist the beating up of the weft by the pressure of the crossed threads; and this humouring of the shed, along with the evenness of beating up, always constituted an important part of the hand loom weaver's work, and enabled one readily to distinguish a first-class from an inferior workman by his ability to adapt

himself to the weaving of the material in hand. Following from the ordinary shedding to what was termed the "witch," or what is now known as the dobby machine, the skill of the weaver was still called into play, and he would be required to time the movement of his foot much in the same way, though not in the same degree of perfection as in the treadle movement, and of course the same remark would apply to the jacquard. As developed in the modern power loom the three kinds of shedding referred to are capable of the finest possible adjustment in the hands of competent workmen. Take first what we term the tappet shedding, which is somewhat analagous to the shedding of the hand loom weaver with treadles, more especially when he was working what was known as "both feet down," *i.e.*, he would have certain healds remaining at the highest and lowest points respectively as long as required for formation of the pattern, and would cause others to change, first by one foot and then the other, as required. The second form of shedding, or what is termed the centre shedding consists in all the warp meeting in the centre after each passage of the shuttle, and then separating for the insertion of the next pick. The third form, or what is known variously as jacquard or bottom shedding consists in the warp, when the shed is at rest, remaining at what might be termed the lowest point, and the portion required for forming pattern being lifted to allow the shuttle to pass through; so that all the threads forming the upper half of the shed would be raised from the lowest to the highest point at each insertion of the weft.

It will be necessary at a later stage to examine very closely the advantages and disadvantages of each of the several methods of shedding, and also, it must be borne in mind, the direct connection of the letting of the warp off from the beam and the taking up of the cloth with the system of shedding. Now we may proceed to examine in detail the nature of the movements. First we may say that the warp

threads must be separated with the least possible strain being thrown upon them. Then with tappet shedding as the starting point it must be obvious that the threads forming the upper and lower half of the shed respectively must be at the highest tension when the shed is fully open, and consequently that tension should be relieved as easily as possible; and on approaching the other extremity the tension must be increased with equal care, otherwise breakage of the threads must of necessity follow; this then implies a distinctly eccentric movement of the healds from the highest to the lowest point and *vice versa*. This, of course, will have a direct influence upon the formation of the tappet used in forming the shed, as will have to be shown later. In the same way in dealing with centre shedding the strain must not be thrown upon the warp threads hastily or unequally. Every care must be taken to impart the best possible movement to the healds, and, as will be shown in dealing with some of the dobbies or shedding motions, this is a subject which may contribute very largely to the success, or interfere with the good working of the loom. What is said of dobby weaving may be made equally applicable to jacquard weaving.

We have said that the movements of the healds for separation of the warp threads must be of a distinctly eccentric character; the nature of the eccentricity will differ in the three modes of shedding referred to. Perhaps it will be as well at this moment to follow the warp line so as to ascertain what that line should be and its influence upon the work in each of the methods. First we must consider what is to be the nature of the shed; the object of course in separating the warp threads is to prepare a passage for the shuttle; that means that the shuttle must have a series of threads forming the lower half of the shed upon which it can run with the least possible obstruction. Then the threads forming that lower half must form as nearly as possible the same straight line, and, as far as consistent with good working, the upper

half of the shed shall have as nearly as possible the same formation. This implies that the healds furthest from the cloth must be raised higher and depressed lower that those nearest to the cloth. Take for example the illustration given in Fig. 29 where only eight healds are employed, and where the back healds are raised and depressed to such an extent that the shed above and below the shuttle forms a perfectly straight line. It must be obvious that there is greater strain upon the threads passing through the back healds than upon those passing through the front healds. Inequality of strain in almost any class of goods is a serious detriment, and, in

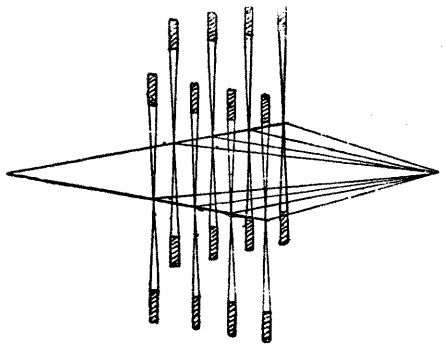


Fig. 29.

many, fatal; consequently this must be obviated as far as possible. The question arises, how can it be done? The only possible means of equalisation is the proper adjustment of the back rail and breast beam of the loom in relation to the position of the healds. Now take for example the illustration shown on Fig. 30 where the lower half of the shed is made even so that the shuttle can pass over it, but the same attention is not paid to the evenness of the shed in the upper half, but rather an attempt to obtain an equality of tension has been made. Make a careful measurement of the actual length of thread upon each of the several healds from the fell of the

cloth to the back rail, and it will be seen that the difference is comparatively small, more especially in that portion forming the upper half. Now let the weaver think for a moment what will be the effect of inequality of tension by always raising and depressing the back healds to form perfect sheds without regard being paid to the position of the back rail and breast beam. For an ordinary twilled cloth the difference between the tension of the threads on the back and front healds might be so great that positive stripes in the cloth would result, and this, of course, must be avoided. Generally this setting in position of the rails and of the sheds is a mere matter of

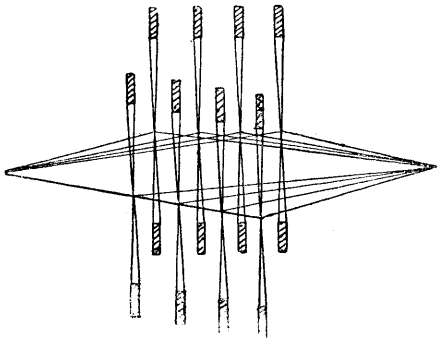


Fig. 30.

chance, or at the most dependent upon a general knowledge on the part of the overlooker, without ever considering the reasons why he raises or lowers either the back rail or breast beam. He has only to consider for a moment that the definition of a straight line is always sufficiently good, that it is the shortest distance between any two given points; then let him draw a straight line from the fell of the cloth, or the breast beam, or both, to the top of the back rail and so form his sheds that the threads through each heald will approach as nearly as possible equal distances from that straight line; by way of experiment to make this clear, let

him begin by placing the breast beam and back rail in exactly the same horizontal plane, then form his shed with any number of healds, first all raised or depressed exactly the same distance and he will find that he has an irregular and imperfect shed, both above and below his shuttle, and whatever may be the relative tension upon the several threads the working position is an impracticable one. Next let the shed be formed perfect both top and bottom by raising and depressing the back healds so that the threads form the straight line with those passing through the front; now measure carefully the length of yarn from the fell of the cloth to the back rail or lease rods on each heald separately, and it will be found that considerably greater length of yarn is required in passing through the back healds than through the front ones, consequently those threads must be at a much higher tension and this being maintained throughout will not only throw the work and strain upon them, but produce irregularities in the cloth. Now let the healds be so placed that the threads forming the lower half of the shed are as nearly as possible in the same straight line in front of the healds, but without regard to the straight line of the upper half of the shed. Let the position of the back rail be moved so that approximately the same length of yarn is required to pass through each heald, and it will be found, generally, that the position of the back rail is lower than that of the breast beam by a distance varying, of course, according to the number of healds employed. This variation will be dependent not only upon the number of healds but upon the distance apart of the healds, and in some measure on the depth of shed. The upper half of the shed being unequal necessarily involves a deeper shed upon the whole, because the healds forming the lowest line with its threads must be sufficiently high for the shuttle to pass through without friction; that means that the back heald must be raised high enough for the shuttle to pass under its threads and the front healds sufficiently

high to equalise the tension as far as possible. Here of course a difficulty arises, most machines, whether for tappet shedding or otherwise, are arranged on the general principle of raising and depressing the back healds more than the front ones. In tappet work of course this can be regulated more perfectly than in dobbies, although by a proper adjustment of the levers, as well as by the back rail and breast beam, this difficulty can in a great measure be overcome. This statement implies that so far as good work is concerned shedding with tappets is the most perfect; for the majority of work this is undoubtedly true. It is true in a double sense, that more perfect sheds can be formed by it than by any other means and with the least expenditure of power. It has its disadvantages, the chief one being in what is sometimes looked upon as its greatest advantage; what is termed the open shed. This open shedding implies that all the threads are kept at their highest or lowest position as long as necessary to form the pattern, which means that during the time the shed is being changed those threads remaining stationary have to bear all the weight and tension which should be equally distributed over the whole of the warp. This in working with tender material may prove a serious drawback unless every care is taken in the proper adjustment so as to ensure as near equality as can be obtained. Of course it must not be supposed that this absolute equality is always desirable, because it frequently happens that one portion, more especially the lower half of the shed, is required to be kept at a great tension whilst the upper half is comparatively slack, as, for instance, where the warp line is sunk; this is invariably the case where a perfect distribution of the warp threads is desired, such as in plain cloths. Reference has already been made to the hand loom weaver crossing his shed or causing the threads to pass each other before the weft is beaten up to the fabric. This crossing of the threads is more especially necessary when weaving

with the warp line sunk, because the great object is to have one half the warp threads tight and the other comparatively slack, so that the weft, as it is beaten up, will force the slack threads into the centre of the space between the tight ones. In plain cloths this is generally resorted to, though in twilled cloths it must be done with care, each succeeding shed being carefully adjusted so as to ensure the most perfect evenness, otherwise the stripiness referred to will become very apparent and produce imperfect goods; so that reduced to its ultimate position the whole question of shedding is dependent for good work upon the eccentric movement of the healds coupled with

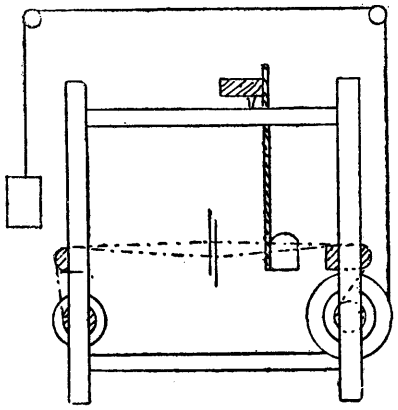


Fig. 31.

the perfect adjustment of the warp line or the relative position of breast beam, back rail and healds to ensure equality of tension. The details of the several different methods of shedding must be dealt with along with the machines made for the purpose.

The next movement or picking is one which will require to be examined very carefully in detail with the several methods in use. At the present moment it will be sufficient simply to ascertain what is the nature of the movement. We have simply to propel a shuttle from one side of the loom to the

other within a given time, and we have to consider in what manner this can best be done. If it were the mere propulsion of an object a given distance in a given time there would be little difficulty in the matter, but the shuttle carries with it the weft, which in many cases is somewhat tender and easily broken, and which in all cases should be delivered with as nearly as possible an even degree of tension. It may be said that perfect equality of tension can never be obtained, for instance the shuttle eye through which the thread is drawn is near one end of the shuttle, consequently the length of yarn delivered by the shuttle in passing from one side of the loom must be greater than that delivered in passing from the other side. It might seem that this would only affect the tension upon the selvedge, but in reality it affects the tension all across the fabric, indeed to such an extent is this sometimes apparent that the picking of the shuttle from the side where the least tension will occur must be made coincident with the shed of the warp where, if any difference exists, the greater tension will be upon the warp threads which are raised. Such, for example, as passing the shuttle through when the least tension is upon the weft at the time when the back heald is raised, which would give the greatest tension on the warp threads, and so allow one to neutralise the other, but apart from this consideration it must be obvious that the shuttle carrying the weft must not be thrown with any great amount of jerkiness, nor must there be great liability to rebound. To assist in this, the shuttle boxes are usually provided with a spring or pressure swell which helps to steady the shuttle on entering the box and keeping it firmly in position, this therefore implies that in sending the shuttle out of the box again the pressure must be relieved before the final blow is delivered for propelling the shuttle from one side to the other, so that the first movement of the shuttle must be very slow, gradually increasing until the final blow is delivered, therefore the whole movement is an accelerated one. Every method of

obtaining this must be carefully examined later. There is only one movement now to refer to of the three primaries, *i.e.* the beating up of the weft, or more correctly speaking, the movement of the sley or going part. The going part carries the shuttle as well as the sley, therefore its movement is to be so arranged as to give as much time as possible of comparative rest at the moment when the shuttle is being thrown across; of course it can never be brought to an absolute stand-still, it must always be moving backwards or forward, but the slower the movement at the time the shuttle is passing through, the less liability to throw the shuttle out of its course. At the other extremity of its movement, where the weft is beaten up to the fabric, exactly the reverse must take place; a smart quick blow must be delivered, a considerable amount of force exerted, this varying, of course, with the strength and character of the work. In very fast going looms the amount of eccentricity in the movement of the going part need not be so great, because the movement of the shuttle is so rapid that a very brief period is occupied in passing from side to side, but in slow heavy looms the eccentricity must be very great. In fact this difficulty has been found so great that various devices have been resorted to from time to time such as grooved cams, eccentric and even elliptic wheels, and in other cases an ingenious contrivance of cranks has been made to give a double beat, so as to give sufficient firmness to the texture and sufficient dwell to the going part for the shuttle to be readily passed through. Generally speaking however, a sufficient amount of eccentricity can be obtained merely by the movement of the crank itself. This I will illustrate fully at a later stage. Then at the present moment there are only the two movements of letting off the warp and taking up the cloth to be examined generally so that the nature of the apparatus employed will be better understood when examined in detail.

It will be necessary to take the two motions, the take-up and the let off together, because the nature of one must of necessity be dependent upon the other. If we were to go back to the primitive hand looms we should find, as already mentioned, that the weaver, after reaching a point in the process where he could scarcely get his shuttle through the warp, would let off a number of inches from the warp beam by hand and take up a corresponding amount of cloth so that the operation really was intermittent. One of the next forms of taking-up motion following upon that will lead us to understand a more recent form of operating, and one which is largely in use at the present time, generally spoken of as the negative taking up. This will be

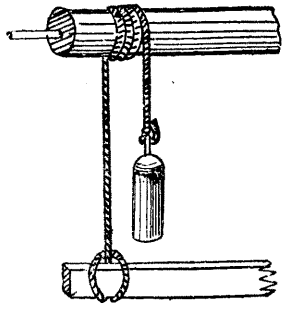


Fig. 32.

more readily understood by reference to Fig. 31, which shows a side elevation of the take-up motion and the loom and the manner in which it is operated. Here it must be understood that all the elements are present which must be present in the power loom; as will be understood the sley of the power loom being operated by a crank must be brought up always to a given point, and at that point always of course cloth must be formed, precisely the same takes place under the present arrangement. The going part of the loom is suspended from the top of the loom

frame, and the heavy beam is so balanced that it brings the lower portion of the going part always up to the breast beam, so that the weaver practically pushes back the sley and allows it to come forward with its own weight, aided by the heavy beam above, to beat the weft up to the cloth. On the head of the beam on which the cloth is wound are placed large moveable rollers, but which can be held in position by means of a rachet head and catch. A thin strong rope is coiled round this beam head, carried over a pulley attached to the ceiling immediately above the beam,

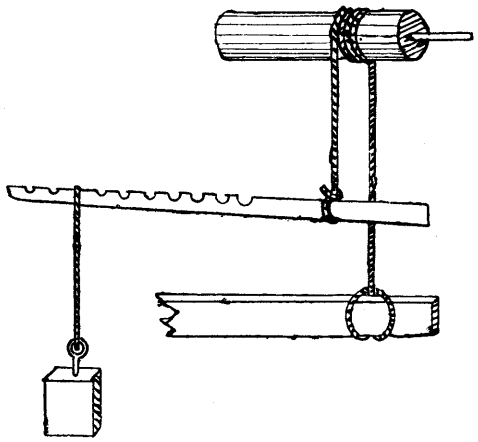


Fig. 33.

and also another near the back of the loom; at the other end of the cord a box would be suspended carrying weights. The arrangement is simply this, that after a pick of weft has been inserted the sley is brought forward up to the cloth, pressing the cloth forward at the same time, and just as much as the cloth is pressed forward the weighted box will pull the beam round and will wind the cloth pressed forward upon it. Then it must be clear that the heavier the box is weighted the more easily the cloth will be

carried forward and wound upon the beam, so that the smallest possible amount of compression will take place in the weft. On the other hand the lighter the weight in the box the more force will be requisite to carry the cloth forward and consequently the greater the compression in the weft and the firmer the fabric. This then is the foundation of the negative take-up motion and upon this principle all looms with the negative take-up motion have their mechanism arranged. In conjunction with this form of take-up motion, it must be clear the warp must be let off in a somewhat similar manner, or at least that the warp beam must give off as

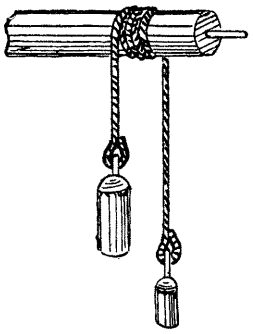


Fig. 34.

the cloth is taken up. The most convenient arrangement is simply to let off the warp, or in other words, to hold the beam by friction. This is most conveniently done by making one end of a rope fast to the loom frame, coiling it a number of times round the beam and attaching a weight to the other end, as shown in Fig. 32. Where sufficient weight could not be obtained by this simple means a lever would be employed as shown in Fig 33, so that the weight could be increased to an unlimited extent. Here again we have the system of letting off, which is largely in use in looms of every class. Even at the present day and

where special mechanism is employed, practically, this is the principle upon which they are built. It will be necessary to show that considerable elasticity in the movement of the warp beam must be provided for. As any one will understand at a glance when the warp threads are stretched straight from the breast beam to the back rail, or when the shed is closed, considerable less length of yarn is required than when the shed is fully opened; that being so, if the weft is beaten up to the cloth at the moment when the shed is closed, and which may be taken as a very convenient starting point, the warp would be slack always at the moment when the weft is beaten up unless some provision were made to prevent it. By the arrangement shown now every time the shed is open the warp beam will be drawn forward, and the weight instead of allowing the beam to revolve within the rope, will hold it firmly and slightly rise at the movement, and as the shed closes it will return, only allowing actual movement of the beam to correspond with the warp taken up by the take-up motion; so that this elasticity in the movement of the beam itself ensures something like equality in the tension of the warp, and, it must be borne in mind throughout, that whatever form of let-off motion be adopted this elasticity in the movement of the beam must exist, or some compensation be made for it. In weaving some classes of goods, more especially light ones, a sufficient degree of elasticity could not be obtained by the method shown of having one end of the rope fast to the loom frame. In that case a system which is known as balance weights would be resorted to as shown in Fig. 34. This is merely a small weight attached to the end of the rope in front of the beam, only sufficiently heavy to prevent the heavier weight at the other extremity from running down to the ground. Generally speaking this weight would be so arranged as to rise about an inch from the ground when the shed was closed, and the moment the shed

opened, the movement of the beam would bring it to the ground, and so give an ease to the rope which would allow a small quantity of warp to be given off. As the shed closed the beam would return, lifting the weight again and, by putting the full tension upon the rope, would hold it firmly, so that this system of working possesses the double element of giving the requisite amount of elasticity to the movements of the beam and firmness the moment the weft is being beaten up. These two arrangements may be taken as typical of the system of governing the warp beam by friction. There have been, of course, from time to time many inventions connected with the power loom for attaining the same object, and more especially for equalising the tension upon the warp from beginning to end. There must of necessity be a great difference between the amount of tension given to the warp when the beam is full and when it is empty; suppose, for instance, that a full beam has a diameter of 18in., and when empty say a diameter of 6in. The leverage of the full beam is to that of the empty one as three to one. Consequently a good deal of adjustment must be taking place from time to time as the beam is being reduced in bulk; this is not a serious matter for a weaver who thoroughly understands the work and can make the adjustment exactly as required, but any inattention or misapplication of a supposed knowledge of adjustment must cause great irregularities in the fabric, hence the attempts to make the loom do this automatically. It will be necessary to examine many of these attempts in the lecture devoted to this portion of the subject, the present object being to call attention to the matter generally. At the same time that reference is being made to the attempts to perfect these so called frictional let-off motions other attempts have been made to produce let-off motions of a positive character, or such as would give exactly the same rate of delivery as would correspond to the take-up. In all those cases it

must be obvious that some system of escapement which would liberate, or adjust, the tension in the event of the warp becoming too tight, or too slack, must be provided. Many of those methods or appliances possess some of the elements of success, but of very few can it be said that anything approaching perfection has been attained. That however we shall be able to determine at a later stage, at the present moment it must suffice to clearly understand the object and purpose of the motion under consideration. That being understood, we may now consider for a moment

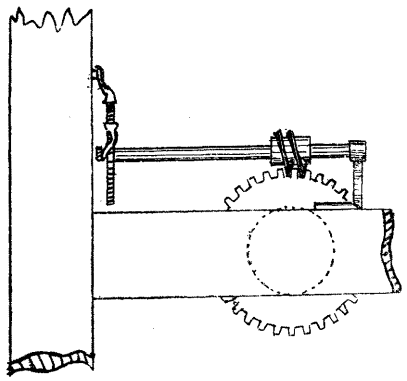


Fig. 35.

other forms of take-up motion. In the great majority of looms in use at the present time what is known as the positive take-up motion is employed. Perhaps in this as in the previous case it might be well to go back to the take-up motion of the hand loom, so as to understand by comparison the exact position of the two motions. One of the best forms of take-up motion in use upon the hand loom is shown in Fig. 35. Fig. 36 shows an end elevation. This consists of a shaft with the worm upon it, and a ratchet at the other extremity, the worm being

geared into the toothed wheel on the beam head. At the end of the shaft a lever actuated direct from the going part will cause the rachet head to revolve a given number of times at each stroke of the going part, causing the cloth to be carried forward a determinate length. In this case the cloth is wound direct upon the beam so that as the beam increases in bulk we shall have the rate of speed at which the cloth is taken down accelerated. Then the weaver must have some means of regulating the take-up motion to compensate for this. This he may do

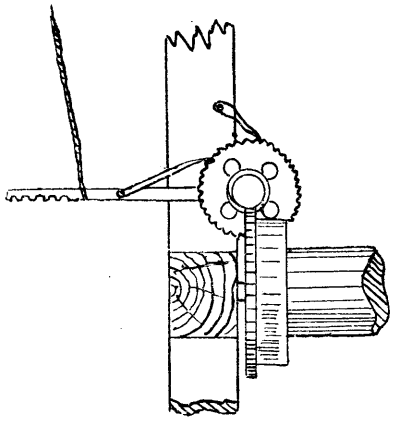


Fig. 36.

by moving the cord connecting the lever on the take-up motion with the actuating lever attached to the going part, so as to shorten the length of stroke and so reduce the rate of take-up in a degree corresponding with the diameter of his cloth beam. This of course will involve constant care and attention on the part of the weaver and in addition to this he will constantly find varying degrees of irregularity caused by irregularity in his movements of the going part. To meet these difficulties he provides

what is termed a regulator after the manner shown in Fig. 37, which consists of nothing more or less than a lever of the form of the letter F pivoted at its lower extremity, the lower arm of the F being connected to the catch of the take-up motion by a cord and the upper arm being acted upon by the going part; so that at every stroke of the going part it will just touch the regulator and lift the catch a short distance when the fell of the cloth is in proper position. But the moment that the cloth, from any

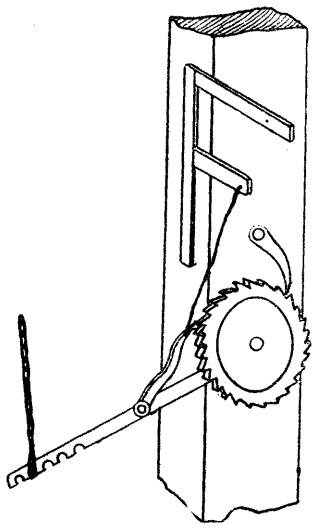


Fig. 37.

cause, has got too far forward then the regulator is acted upon by the going part, thus raising the catch and preventing the take-up motion going forward at the same rate of speed as before. On the other hand if the take-up has not been sufficiently rapid, the going part will cease to touch the regulator, so allowing it to take up the full extent of the leverage given to it. To make the regulator perfectly operative a little elasticity of movement must be given on

both sides, *i.e.* the catch must be operated upon slightly when the fell of the cloth is in proper position, otherwise, of course, the effect would be lost entirely in one direction; and a sufficient amount of leverage must be given to ensure a sufficient checking of the action in the event of the take-up being too great. Although this may be looked upon as, generally speaking, a positive motion yet it does not partake of that character in quite the same degree that the positive motion of the power loom does. In the power loom the reed cannot follow the cloth; it must come to one fixed point at each stroke, therefore any irregularity in the movement of the cloth must produce a corresponding irregularity in the cloth itself; so that if it is taken forward too quickly at one point a thin place in the fabric would result, or if not sufficiently quick a thick place would result. In other words the positive take-up motion of the power loom must carry the cloth forward at a determinate rate of speed and in this there must be no variation whatever. If it is set for 60 picks per inch to be introduced, the cloth must be carried forward $\frac{1}{60}$ part of an inch at every stroke of the going part, and neither more nor less whether the yarn be thick or thin. Whatever irregularities may exist in the yarn the same degree of irregularity must exist in the cloth because that number of picks per inch must be inserted, whereas in the negative motion the number of picks per inch will vary under the same weight or pressure exactly as the diameter of the thread varies, consequently each of the methods may have its own sphere of work, but neither of them should be misapplied. Now, it would seem as though the positive take-up motion should have a corresponding positive let-off motion; this has been the great aim of many inventors, how far it has been accomplished we shall be able to see later. For the moment it will be sufficient to say that the great majority of looms in use at the present time with the most perfect

positive take-up motion have let-off motions governed by friction, or where friction is not absolutely employed a combination of positive and frictional let-off is in use, or to say the least, the most perfect positive let-off motion is governed by some escapement regulated by the tension of the warp or by some frictional adjustment.

It will of course be impossible, in the lecture devoted to this branch of the subject, to give every form of take-up motion which has been invented, and for each of which perfection of working has been claimed, but at any rate, the leading features of some of the best in use may well be examined. When it is borne in mind that applications for patents for letting-off motions have been made for some years at the rate, I believe, of more than one a week, it will be easily understood that there is a vast variety of them in use. The object here must be not to attempt to deal with more than a few, which will cover the general principles involved, for after all, there is more value in understanding the principle of a required motion well, and knowing some of the best known methods of attaining the object, than in knowing a multiplicity of details of machines which have proved, more or less, useless.

LECTURE 3.

Beating up of Weft to the Fabric.

In going into details of the power loom I propose to deal with each portion in what might appear to be exactly the reverse order to that in which they would actually occur in the process of weaving. I shall do this for two reasons, in the first place, the conversion of motion from the main driving shaft first takes place at the going part for the purpose of beating up the weft, and what would appear to be the next direct conversion takes place at the picking, consequently the shedding comes last in the order of conversion. The second reason is that only one general principle underlies the motion of beating up; practically only one, although obtained by many and varied means in the picking, whereas in the shedding there are large varieties of machines, from the simplest tappet shedding motion up to the most elaborate jacquard machine for the purpose of producing pattern. Those shedding motions will require so much consideration that by far the greater portion of the work must be devoted to them.

Then coming down to the motion communicated to the driving shaft we have, as already said, a continuous circular motion. This must be converted into what is commonly spoken of as a reciprocating rectilinear motion, but as that is not of a perfectly regular character, it is necessary to consider the work to be done. The going part not only carries the reed but also the shuttle as pointed out previously. Then at the time the shuttle is passing across the loom as much rest must be given to the going part as possible, whilst in bringing it up to the cloth a smart blow must be delivered. Some of the first efforts

in this direction, notably the first of Dr. Cartwright, were by means of elliptical wheels which would give a sufficiently variable character to the movement, coming to almost a dead rest when the shuttle was being passed across and increasing in velocity as the reed is brought up to the cloth ; eccentric wheels have been employed quite recently for the same purpose, and in many cases grooved cams have also been made use of. In the use of grooved cams the great drawback has been the loss of power, and as a consequence they have never come into general use, but attention has been more generally turned to the use of the simple crank for the purpose. It would appear to the ordinary observer that the conversion of motion by means of a crank will give the same variation at each extremity of the stroke. A very little consideration will show that this cannot possibly be so, for instance, when the crank is at the back extremity of its movement the crank and crank-arm both form the same straight line, but the distance from the shaft itself to the point of connection of the crank with the going part is equal to the length of the crank-arm, minus the crank itself; whereas at the opposite extremity, when the crank and crank-arm again form the same straight line, the distance is equal to the length of the crank-arm plus the length of the crank, therefore the movement from the back extremity to the point midway between the two causes the crank and arm to form acute angles, the difference in the degree of acuteness will govern the rate of speed at which the going part travels. From this point midway to the front extremity a series of obtuse angles are being formed so that the crank being revolved at one rate of speed throughout, it must be obvious that from the point midway to the front extremity the velocity of the going part must be much greater than during the other half of its movement. This will be obvious by reference to diagram shown in Fig. 38. The circle is that described by the

crank itself, A to B represents the length of crank-arm, the point A being that connecting with the going part. A to B is a distance corresponding with the diameter of the circle described by the crank, A would be the position of the crank when the reed is in contact with the cloth, B would be the position of the point furthest from the cloth or when the crank is at the back extremity, C would be the position when the crank is midway. Then we should have the positions 2, 2′ occurring when the crank, as indicated by the dotted lines, is in the position corresponding with those numbers. A mere glance will suffice to shew that although the crank in each case from B to 2, 2 to C, C to 2′, and 2′ to B, has travelled exactly the same

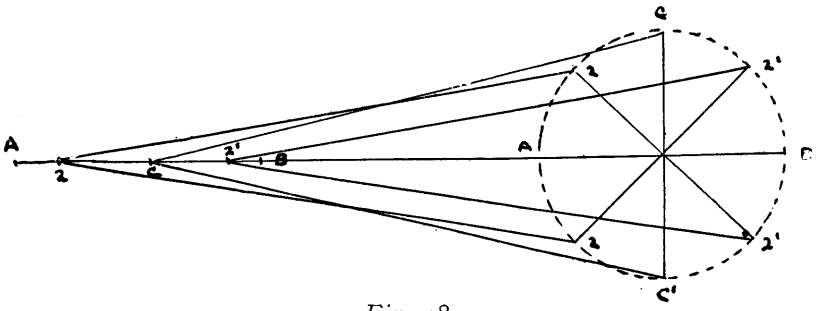


Fig. 38.

distance the going part itself has travelled a variable distance as indicated by the spaces marked from A to B. The distance from 2 to B being approximately half that from A to 2, showing that while the crank is describing one-fourth of a revolution at the back extremity, the distance travelled by the going part is only about equal to half that traversed whilst the crank is describing a quarter circle at the front extremity of its movement. Therefore it is perfectly clear that a considerable amount of eccentricity is obtainable in the mere conversion of motion by means of a crank. It is now necessary to examine how far this can be utilised and in the most perfect manner. There are

various reasons why this eccentricity should be varied but only one means of obtaining that variation, and that is, by an increased length or throw of the crank and a decreased length of the crank arm. This will be most readily demonstrated by Fig. 39, where one circle is made much larger than the other and the divisions of the circle exactly corresponding to each other show the variation in the movement of the going part from the front extremity to the back.

Now let us determine what is the exact position, and to enable us to do this we must assume some dimensions for the two circles given in Fig. 39, and also for the length

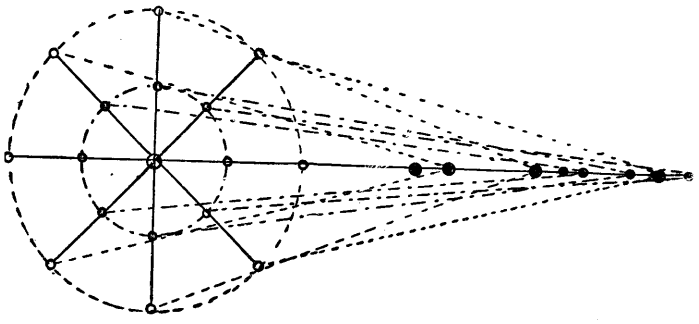


Fig. 39.

of the crank arm. The length of the crank in most fast running looms is from $2\frac{1}{2}$ to 3 inches, giving a stroke to the going part of from 5 to 6 inches. Now suppose we take a medium, and one which is commonly in use, viz.:— $2\frac{3}{4}$ inches, and see what is the exact position with a crank arm of, say 12 inches in length. Then take a second position with the throw of the crank $3\frac{1}{2}$ inches and length of crank arm reduced to 9 inches and a fair comparison can be made in every position of the two cranks. When the crank is at the back centre, as it is termed, the distance from the crank shaft will be $12-2\frac{3}{4}=9\frac{1}{4}$ inches, and when at the front centre it will be $12+2\frac{3}{4}=14\frac{3}{4}$ inches. Now we

must find its position from the crank shaft when the crank is at the top and bottom of the stroke respectively. Supposing for convenience that the centre of connecting pin and crank are in the same horizontal plane then a right angled triangle will be formed from the centre of the circle to C and C, the crank being one side, the distance from crank to connecting pin giving the second side, and the length of crank arm (C to C) the third side, so the crank arm forms the hypothenuse of the triangle; and the well-known rule that the hypothenuse is equal to the square root of the sum of the squares of the two sides will at once enable us to fix the exact position of the point C. The length of the hypothenuse is known, 12 inches, the altitude of the triangle C to the centre of the circle—which we will call D is known, thus if C is altitude, D the base, and 3 the hypothenuse, it will be $D^2+C^2=3^2$, therefore $3^2-C^2=D^2$ and $3=12$, $C=2\frac{3}{4}$ or 2·75, then $12^2-2\cdot75^2=\sqrt{144-7\cdot5625}=\sqrt{136\cdot4370}=11\cdot68$ inches, so that the point of connection of the crank with the going part has travelled a distance equal to the difference between $12-2\frac{3}{4}=9\frac{1}{4}$ and $11\frac{1}{3}$, which is $11\frac{1}{3}-9\frac{1}{4}=2\frac{1}{12}$ inches; for the going part must be at the distance mentioned from the crank of $9\frac{1}{4}$ inches when at the back position, and of $14\frac{3}{4}$ at the front position; thus the distance traversed by the going part from back towards the front $2\frac{1}{12}$ inches, or less than one half of the total traverse which must be $2\frac{3}{4}\times2=5\frac{1}{2}$ inches, or the difference is $2\frac{3}{4}-2\frac{2}{12}=\frac{2}{3}$rds of an inch, therefore the corresponding movement of the crank in passing the front centre will be $5\frac{1}{2}-2\frac{1}{12}=3\frac{5}{12}$, and as the crank is revolving at the same rate of speed all the time the difference in the rate of speed of the going part in the two portions of the stroke must be evident.

Then if there is this difference in the distance traversed by the going part during the period when the crank is passing from the back centre to the vertical position and

from that to the front centre, there must be an accelerated motion from the vertical position to the front, when the crank and crank-arm are in the same straight line. This degree of acceleration can be determined by the usual rules of trigonometry. It is only necessary to take a given number of points when the crank and crank arm form varying angles, as 90°, 60°, and 30°, or others if necessary, by taking the sine of the angle, which is the length of a line dropped from the circumference of the circle to the diameter, and the versed sine, which is the space between the circumference and the sine measured on the diameter, and following the general rule given for finding the relative lengths of the sides of a triangle to find the actual distance moved by the going part. To the ordinary student and workman this is more easily done by a graphic drawing than by figures, for by making an actual drawing to scale he can determine at once the relative distance travelled by the going part at any point of the stroke.

Then it must be understood that the force exerted is always as the square of the velocities, so that as the distance traversed by the going part at one point of the stroke squared is to the distance traversed at another part, for the same amount of movement of the crank, squared, so is the amount of force exerted at one part to that exerted at the other part. Then take the distance traversed from the point when the crank forms a right angle with the diameter line, and that when it brings the going part midway between that point and the straight line, or $\frac{3\frac{5}{12}}{2} = 1\frac{17}{24}$ inches from the cloth, then the relative velocity will be as $1\frac{17}{24}^2 : 3\frac{5}{12}^2$.

Then it follows that the eccentricity or the relative velocity can be determined for any loom. Suppose we are making light goods we require a very small amount of eccentricity, but in heavy goods we want a good deal. We say that the crank travelling from the back centre has

moved the going part $2\frac{1}{12}$ inches by the time it reached the angle of 90°, and $3\frac{7}{12}$ inches during the time it reaches the straight line, or a difference equal to $\frac{2}{3}$rds of an inch, then if we want to increase the eccentricity we must lengthen the crank and shorten the crank-arm exactly in the proportion desired, and the relative velocities will be found by the rule given.

The length of the stroke to be given to the going part must not be overlooked in this calculation, though it must always be conceded that a longer stroke must be given to the going part for heavy than for light work, both on account of the longer time generally required for the shuttle to pass across the loom, and for the required amount of force in beating up the weft to the cloth; so that, put on a broad basis, as the width of a loom and the weight of the work is increased the length of the crank must be increased and that of the crank-arm decreased.

Let the relative widths of the looms be 40 inches reed space and 72 inches, and in the first case the crank $2\frac{3}{4}$ inches and crank-arm 12 inches. In the latter the crank $3\frac{1}{2}$ inches and arm 10 inches and the weight of the going part in the first case 120lbs. Then assuming the force of impact to be the same, it would appear that the revolutions would be in inverse proportion to the width of the loom; but this could not be strictly true, for taking into account the amount of force applied to propel the shuttle across a space of 72 inches, as compared with that required to propel the same shuttle across a space of 40 inches, the former must be greater than the latter, and the time occupied could not be in the same ratio. Again in the wider loom the shuttle would be heavier, so that some retarding influence would be at work to neutralise the difference and bring it more nearly to a direct proportion.

As will be seen by the foregoing figures and details, the force of the blow delivered can be relatively determined with

the speed of the loom. Of course the question often arises up to what speed can a loom be run? It is almost impossible to give fixed data for this, but basing the calculations upon the data given, a simple calculation will assist the student in arriving, at least, at an approximation of what can be done.

The next question to enquire into is the position of the crank-shaft in relation to the point of connection with the sword of the going part. Generally speaking it might be supposed that the most convenient position would be that of having the crank and the connecting pin in the same horizontal plane; for light and fast running looms this is a very convenient position, but for heavier looms it is very often somewhat unsuitable. In the first place, by placing the crank in the same horizontal plane, there will be perhaps a better balance of the working parts than by varying that position. If heavier work is required and an increased eccentricity desirable, then from the mere fact that by placing the crank in a lower plane a slight increase in the eccentricity is obtained, and that the crank is more out of the way of the warp than it otherwise would be, there is some advantage gained. Let it be supposed for a moment that the connecting pin at the sword is as nearly as possible in the same horizontal plane as the warp line. Then the force is delivered direct to the cloth, there is practically no leverage, the point of contact of the reed with the cloth being in the same horizontal plane as the connecting pin compels the throw of the crank to be the greatest possible for the shuttle to pass through. Consequently the position of the crank must be placed below the warp line by something more than the radius of the circle described by the crank itself. Hence we are obtaining, quite apart form the relative positions of the crank and pin, all the eccentricity that can be obtained from a large throw of crank. In obtaining this eccentricity we also obtain, as demonstrated

by the figures given, an increased velocity of the reed when delivering its blow. Consequently we are gaining apparently all the advantages possible.

If we are gaining apparently everything by this direct action, the question may naturally arise whether, on lowering the crank shaft itself, and at the same time lowering the

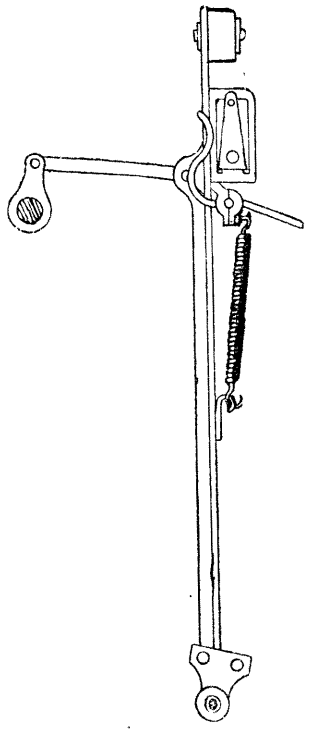


Fig. 40.

connecting pin, we should not gain in force by leverage more than we had lost by direct action. A reference to the end view of a loom as shown at Fig. 40, where the position of the crank and connecting pin can be clearly seen, will show us that by lowering the position of the pin we should obtain

an increased length of stroke of the reed. Now this must be looked at from every possible point of view. We have to determine what shall be the stroke of the reed, both as to the amount of force we can deliver in beating up the weft and as to the length of shed of the warp for the shuttle to pass through. Leaving the latter question aside for a moment we may suppose that we are dealing with a fast-going loom, where the length of stroke and the amount of eccentricity may both be reduced to the lowest possible point. Then we should place our connecting pin in the most convenient position in relation to the crank and it would be, comparatively speaking, immaterial whether this position be near the horizontal plane of the fabric or much below it, as the strength or force of blow required would be light. In the fast-going loom, admittedly a small throw of the crank may well be resorted to, and generally speaking the shorter the crank, consistent with reasonably good working the better; and the throw of the reed, or the distance it must traverse will be determined by the position of the connecting pin being placed so as to give the requisite amount of leverage. The question simply becomes one of leverage. We have the going part as shown in Fig. 40 working upon its axis at one extremity, the connecting pin being between this fulcrum and the point where the force is delivered, or in other words, between the rocking shaft and the reed. Now suppose the length of the sword from the rocking shaft to the reed is 28 inches, and from the rocking shaft to the connecting pin is 24 inches, then the throw of the crank is $2\frac{3}{4}$ inches, consequently as 24 inches is to 28 inches, so is $2\frac{3}{4}$ inches $\times$ 2 = $5\frac{1}{2}$ inches to $5\frac{22}{24}$, or practically 6 inches. Now it may be said we shall determine first what should be the throw of the crank, and second, what should be the stroke of the going part at the reed; then from this data we can find the position of the connecting pin. This, of course, can be readily done, as the whole question is simply one of

proportion to be dealt with as follows:—As $5\frac{2}{2}\frac{2}{4}$ is to $5\frac{1}{2}$, so is 28 inches, from the reed to the rocking shaft, to 24 inches the distance of the connecting pin from the rocking shaft. Then in a light-running loom we should make the throw of the crank as small as convenient; but it must be distinctly understood that although the requisite stroke of the going part and an increased force may be obtained by leverage, yet we could never apply this satisfactorily to heavy work. The lack of eccentricity in the movement of the going part would in the first place operate against it, the position of the connecting pin would be even a much more important factor in the matter. Taking this position of the connecting pin we should be applying the force between the fulcrum and the point where the blow is delivered. Everyone having the slightest knowledge of mechanics knows what this means, the power being applied between the fulcrum and the point where the blow is delivered, liability to breakage in the lever must of necessity exist, and this liability would be increased as the leverage is increased. Suppose, for example, that the connecting pin should be placed midway between the two points; at every stroke of the going part there is great liability to break the sword, and not only is this a theoretic proposition, but is one which actually occurs in practice. In the earlier days of the power loom broken swords were a matter of daily occurrence, and comparatively few of the men having charge of the looms could account for it, and those who did know the reason were practically powerless to remedy it. The looms were built in such a manner that they had no means of altering the position of either the crank shaft or the connecting pin; so that all they could do was to minimise in any way they could, either by varying the tension of the warp or careful adjustment of the sheds, the force of the blow requisite to be given by the reed to produce the weight of cloth required. Latterly, by proper attention to the questions referred to already, looms

are built and adapted to certain special classes of work, and although a light loom, or one built for the production of light fabrics, can never be made to do satisfactorily the work of heavier looms, without constant risks of derangement and breakage, the heavier loom may do the work of the light one, but at a corresponding loss of speed and production. One general rule might be deduced from this, that the amount of eccentricity is dependent directly upon the relative length of the crank and crank arm, and that the lightness of running may be practically determined in a similar manner; as the smaller the throw of the crank the less the amount of eccentricity obtained, and consequently the less hesitancy in the movement and the greater the ease of the motion. Now the next question arising will be as to the proper position of the fulcrum upon which the lever works, or as it is termed the rocking shaft. Of course for the moment the class of loom having the rocking shaft placed near the floor, or at the bottom, is the only one under consideration, the loom working from above must be dealt with presently. Considerable difference of opinion may exist as to what is the proper position of the going part at the moment when the weft is beaten up to the cloth; one safe position to assume as a starting point is, that the reed should be perfectly vertical when in contact with the cloth; this, of course, is based upon the assumption that the warp line from breast beam to the back rail is a perfectly horizontal line, and that the shed is closed, or that the warp threads all form the same line at the same moment. This is merely taken as the theoretic starting point upon which to base some data, but it must be understood that it is one very seldom occurring in actual practice. If this theoretic starting point is a good and sound one, then the position of the reed should be vertical when in contact with the cloth, for the two reasons, that first, the blow would be delivered finally with the reed at right angles to the warp, or the force

would be delivered exactly in the direction of the warp line. In the second place the lever of the going part will be working in what is commonly termed the quarter circle movement, *i.e.* it will never pass its fulcrum. Careful observation of levers working where they have to pass and repass their fulcrum will show that at every moment of passage some vibration must take place. This will vary, of course, and be determined by the amount of loose play of the spindle upon which the lever is working, and it may also be intensified by the amount of power applied; therefore anything that would produce vibration in the going part is likely to prove detrimental to the working. Suppose the fulcrum is placed midway between the front and back extremity of the stroke of the going part, and that a considerable amount of play is allowed in the spindle or rocking shaft; it is quite conceivable that at every passage of the going part backward and forward vibration would occur in passing this centre. Now another theoretic starting point must be assumed. We must suppose that the shuttle is leaving the box at the moment when the reed is midway in its passage from front to back, and is entering the opposite box at a corresponding point of the return stroke. Then if the fulcrum is placed midway between front and back any vibration resulting would occur exactly at the moment when the shuttle is leaving or entering the box; consequently there would be great danger of throwing it out of its course. This must obviously be avoided. As before said, in light running looms this may in some measure be ignored, because the very rapidity with which the shuttle is propelled would enable the picking to take place after this fulcrum had been passed; consequently vibration would be avoided, at least, in its detrimental effects upon the picking. Again the question of advantage would arise as to the balance of parts in working. A lever working equal distances on each side of its fulcrum must work more easily than one working in a quarter

circle movement, therefore for fast going looms the advantages are in favour of the fulcrum being placed in the centre of the stroke. But where heavy work is involved it is better as a rule to have the quarter circle movement in preference to the other. It will be necessary to turn to the question of the delivery of the blow to the weft. So far the assumption has been that the warp formed a perfect horizontal line, and the shed was closed at the moment of beating up the weft; but in the larger proportion of cases either the warp line would be sunk at the healds or the back rail would be depressed, so that an inclined plane would be formed by the cloth and the warp. Then if this blow must be delivered at right angles to the cloth the rocking shaft or fulcrum must be placed in front of the fell of the fabric, so that the sword of the going part would be inclined backwards. Again the question might arise whether it is desirable to strike the blow exactly at right angles to the fabric, or with the direction of the force in the warp line. Some will say that the weft should be pressed forward in such a manner as to cause it to rise somewhat up the sley with a view to bringing the weft more to the surface of the fabric. This is based upon the supposition that the weft will ride, more or less, upon the reeds or wires of the sley and so help to form the corrugations which are seen on the surface of a plain fabric, and in greater or less degree to be seen upon twilled ones. This notion, however, is entirely fallacious; the so-called formation of corrugations, or of distribution of threads more correctly speaking, is dependent not upon the action of the sley but on the arrangement of the tension of the warp, determined by the position of the warp line already referred to, and to be more fully demonstrated later on.

Then again it may be said that the conditions should be reversed so that the reed in delivering the blow, would neutralise the angle formed by the depression of the warp, and so assist in the distribution of the threads. This again

is a theory upon which no reliance can be placed. As a matter of fact whatever the class of the fabric no reliance must be placed upon the reed in distributing the warp threads, but rather we should look to its fulfilling its proper function of beating the weft up to the cloth; which means, generally speaking, that at the moment of contact the reed and the fabric should be at right angles to each other. This, of course, would involve some little adjustment of the rocking shaft of the loom so as to correspond with any alteration in the position of the warp line. It may seem that this involves an unnecessary interference with the working parts of the machine, but an intelligent overlooker will at once understand that not only is there very little work involved, but that once being adjusted the results must more than compensate for the small amount of labour. Some attention must now be devoted to a class of loom where the going part is worked from above, and although this class of loom is fast disappearing it does not follow that it has no good points; for heavy wide looms there is no doubt that the overhung loom possesses very great advantages for strength and the application of power. In fact for the steady solid work required in the weaving, more especially of woollen goods, there can be no doubt it is very superior to the fast going loom, though not equal to it in rapidity of production. In this case the rocking shaft being placed above, and the driving crank below the warp line the conditions are reversed; the leverage instead of being of what is termed the second order becomes that of the third order, the force is delivered between the fulcrum and the power; consequently greater throw of the crank is required. Suppose the lever from the fulcrum to connecting pin is in this case 28 inches, and the distance from fulcrum to cloth is 24 inches, and the stroke of the loom 6 inches, then the stroke of the crank must be as 24 : 28 :: 6 : 7 inches, then it must be clear a very long throw of the crank is

required. Then following the demonstration given in Fig. 38, a considerable amount of eccentricity must be obtained and also a considerable amount of force, or, what is equivalent, acceleration of speed when the blow is being delivered. In some of the looms built specially for heavy goods this has again been increased by having upon the back of the sword a large projection variously known as a "lug" or "horsehead," so as to shorten the length of the crank arm. This of course would give almost any amount of eccentricity required, indeed

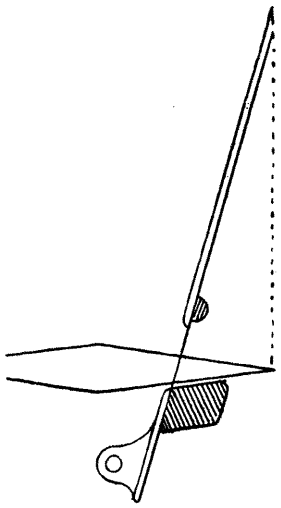


Fig. 41.

to such an extent has this been carried that in many cases a jerky movement has been produced, this, often being detrimental to good working. The amount of force in connection with leverage would be reversed as compared with the illustrations already given, and the force would be increased in the ratio of the increased leverage, so that what is gained in one direction in point of force and eccentricity must of necessity be lost in speed and production. Then the whole is reducible to the general proposition that

what is gained in power is lost in speed and *vice versa*. There is one important phase of this question which must not be overlooked. The position of the rocking shaft or fulcrum upon which the going part works will have a material influence upon the bevel of the shuttle race; two things must be considered in connection with the shuttle race, both of which must be always kept in view; first that the bevel shall be such as to coincide with the warp line when the shed is being formed in the most convenient

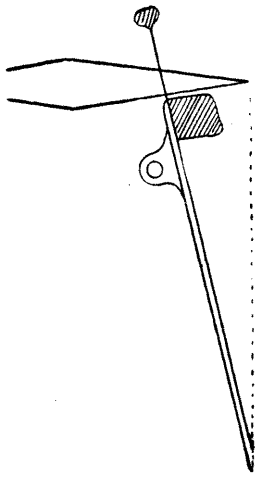


Fig. 42.

manner for the work to be done, and second so as to prevent, as far as possible, any liability to the shuttle flying out. Take two positions as demonstrated by Figs. 41 and 42, one is taken for the sole purpose of showing a deep bevel of the race to keep the shuttle in place in running regardless of the form of shed or position of the going part. Here the race and the reed form almost a V shape or at least a very acute angle; if the shuttle is shaped to this it will not be so readily thrown out of its course or made to

fly from the loom. But the question will be, will it be a convenient, or even possible working angle. Take for example the going part working with the reed in a vertical position when in contact with the cloth, the length of the sword is 28 inches. The stroke of the going part is 6 inches. Then at the furthest point from the cloth the position will be as shown in Fig. 42 and the angle of the shuttle race would be with the horizontal line one of 12 degrees. Now take the actual depth of shed required as being 5 inches at the healds, 12 inches from the cloth, and therefore 6 inches at the reed, the angle formed by the lower half of the shed will be 12 degrees with the horizontal line, consequently it will coincide with the line at right angles to reed of the loom. The figures are taken here quite at random, and might not exactly coincide with any loom, but should the actual dimensions on a loom produce any other angle of the shuttle race when the going part is at the back, not agreeing with the warp line, and which otherwise might be a convenient angle for the shuttle race, that line must be altered to coincide with the warp line with the result that it would form a different angle with the reed, and the shuttle must be formed to it so as to ensure perfect working. Then if this occurs on the assumption of the warp line being horizontal the angle must be increased as the warp line is sunk, and the greater the amount of sinkage the more acute the angles that would be formed. Then arises the difficulty; we should have to have a loom specially built, and with the angle of the shuttle race specially arranged, for every system of sinking or different method of shedding; this is obviously impossible, therefore some medium line must be taken which will give a convenient working position, sufficient to meet the requirements of the majority of cases as they may arise. Now suppose that the position of the going part is altered so as to have it working in the centre of the stroke; then this

angle may be varied from a right angle, and the more it varies from a right angle in the obtuse direction, the less protection for the shuttle and consequently greater liability to fly out; in fast going looms where light work only would be wanted this might be of trivial importance, but in heavy goods it would become a serious matter, so that on this ground alone the best working position would appear to be that which places the fulcrum at what might be termed the front extremity of the stroke. Some reference will have to be made to this later when speaking of boxed looms.

When the going part is working from above the conditions as to the bevel of shuttle race must be reversed, and one of the difficulties involved is to prevent the angle being too acute; the longer the sword arms of the going part and the less acute the angle will be of the shuttle race with the sley, when the former coincides with the lower part of the shed as formed by the warp. The shorter the swords and the more acute the angle. One feature here must not be lost sight of, the more acute the angle and the greater the tendency of the shuttle to become, as it were, jamm wedged between the shuttle race and the reed, an sequently the greater the amount of force required to propel it from side to side; whereas in the going parts working from below the nearer the angle of the shuttle race and reed is to a right angle the less the friction, and consequently the less the amount of power required to propel the shuttle; so that the suitability of this class of loom for light work and quick running becomes at once obvious, and has had no doubt considerable influence in the general adoption of this class of loom for light and medium work, and in some measure also for heavy work.

LECTURE 4.

PICKING.

Picking, on the face of it, is the simple act of propelling the shuttle from side to side of the loom, but there is nothing in the power loom requiring such close and careful attention to keep in order, even after the most perfect arrangements have been made for the work, and certainly nothing which can prove so disastrous to the good working of the loom in the event of the details not being perfectly worked out. Apart from the question of the good working of the loom the picking is generally responsible for accidents, not only to the material but very frequently to the operatives, consequently the subject cannot be too closely studied, and everything done that is possible to ensure its smooth and perfect working. In the earliest form of loom the shuttle was simply thrown from side to side by hand, then a system of mechanical propulsion was introduced, but in the hand loom of this form the method of propulsion would be unlikely to produce any serious accident. With the introduction of boxes for changing the shuttles the mechanism became more complicated and consequently accidents became more frequent. In the power loom, more especially in the fast running looms, and in weaving heavy goods, the liability to accident has always been great in consequence of the amount of force required to propel the shuttle in a given time across the loom, or to overcome the resistance offered to it in weaving heavy goods.

We cannot look at the shuttle as an ordinary missile projected through space. In the first place it carries the weft, which must be drawn from the bobbin, spool or tube,

and this weft must have a certain amount of drag, or tension upon it and for convenience the weft issues from the shuttle through an eye near one end. So that whatever tension, or drag, is put upon the weft must be within the shuttle itself, and as that must be near one end there must be a tendency to drag the shuttle out of its straight course, simply by the pulling of the thread upon it. Now suppose the shuttle eye is near the left hand extremity, and the shuttle is being propelled from the right of the loom, the whole of the drag of the weft will be upon that end which is foremost, and consequently will easily divert the shuttle from its course, as it will have a tendency to pull the shuttle outward from the reed, and this diversion may cause the shuttle to fly from the loom or produce the breakage of the warp threads. Then suppose the shuttle is going in the opposite direction the drag upon it will be reversed and the point of the shuttle will be directed towards the reed; this then suggests careful attention to the winding of the yarn upon the bobbins or cops, as any inequality in the winding will cause a sudden strain to be thrown upon the yarn, which in most cases is quite sufficient to divert the shuttle and throw it out. Or this tension on the yarn being maintained evenly throughout, the slightest obstruction in the warp will have the effect of diverting it for similar reasons, hence the question will naturally arise as to the weight of the shuttle to overcome obstructions. In dealing with light yarns, or yarns of a very smooth character, the amount of tension will not be very great, and a comparatively light shuttle may be used; but in heavy yarns, or yarns of a rough character, where there is liable to be catching or interference with the free passage, then the shuttle must have sufficient weight to enable it to overcome this resistance. It will then be obvious that for light goods a light shuttle may be employed, and for heavy goods the shuttle must be weighted proportionately.

The tension on the yarn is an important factor in the production of good cloths, apart from the consideration of throwing the shuttle out of its course, and it must always be borne in mind that the tension is increased as the bobbin becomes empty, as the thread has a resistance offered to it in dragging along the whole length of the bobbin. The question of the drag upon the shuttle by the weft involves the consideration of the direction of force to ensure direct propulsion. The first question that would strike one as having an influence upon this would be the exact movement of the picker, and the position of the spindle upon which it runs. Suppose the shuttle to be an evenly balanced body being propelled in a perfectly straight line without any interference, such as that already mentioned, or such interference as would be caused by the movement of the going part, then it would seem that the force must be exerted in a line exactly parallel with the sley. But it is often argued that some pressure must be applied which will keep the point of the shuttle always rather in the direction of the sley than otherwise; this is an extremely difficult matter to settle definitely, because the influences at work are so varied in the different classes of looms, and therefore the subject can only be treated in a general way. Take the direction of force as exerted by the picker as the most important factor, and we may start with the proposition that that force shall be directly parallel with the sley.

In the hand loom and in weaving light goods this would be practically true, because there would only be the resistance of the weft, practically speaking, offered to its passage; but in the power loom the pressure upon the shuttle in the box, for the purpose of keeping it firm and steady and preventing rebounds, as already mentioned, become very important factors in the process. Suppose for a moment this pressure is due only to the presence of a light spring in the back of the box;

this spring will be probably placed so as to press, as nearly as possible, upon the centre of the shuttle; consequently we may take it for granted that when the shuttle is at rest the whole of the front will be in contact with the front of the box, and that the back of the shuttle will be free from contact with the back of the box, but in contact with the spring in its centre. Now suppose the back and the front of the box to be parallel, which is the theoretic position of the two, then as the shuttle is brought forward by the picker the pressure of the spring upon the rear will tend to make the forward tip point towards the reed, and even if the direction of force is parallel with the sley there should be a slight tendency to throw the shuttle towards the reed; but it is often argued that this is not sufficient, and that it may be intensified by having the box front a little further from the back at the inside, or the point nearest the cloth, than at the other extremity. This it is claimed serves a double purpose: first, that it enables the shuttle to be thrown a little more in the direction of the reed than it otherwise would; and second, that it permits the shuttle to enter the box more readily than if the sides were parallel. There may be some reason in the latter proposition; as to the former it is perhaps open to question. Another arrangement is often advocated in respect to the position of the spindle. If the direction of the force is parallel with the sley, the spindle must be perfectly parallel with the sley, as it is the chief factor determining the direction; but many overlookers aver that the spindle should point outwards a little at the front of the box, or having the box forming this wedge shape the spindle should be parallel with the front rather than with the back, so as to assist in throwing the shuttle towards the reed. Advocates of this method of working always insist, when putting on a new picker, in cutting a small hole where it strikes the tip of the shuttle, so that the picker can "get hold" of

the shuttle and so ensure the direction of force being towards the sley. Another question of course follows upon this, that is, what should be the exact position of the shuttle tip? Should it be exactly in the centre of the shuttle end? Should it be above or below that centre? Or placed to the front or rear? It is often said it should be a little nearer the front than the back, and a little nearer the top than the bottom, as by so placing it the direction of force exerted, in the manner suggested, will be such as to keep the shuttle up to the reed, and exercise a little pressure upon the shuttle race, and so prevent, and counteract, any tendency to fly out. On the other hand it is sometimes said that the tip should be placed rather low down, mainly on the ground that in its passage across it often encounters threads that are more or less entangled, or "feltered"; hence it would pass under those threads readily, whereas if the tip were raised it might be liable to rise over them and so fly out of the loom altogether. Every consideration points rather in favour of the higher than the lower position for good working. But not only must this position of the shuttle tip be dealt with carefully, and its position moved in the slightest possible degree from the centre, but also that the direction of force must be maintained, if not absolutely parallel, it must remain very nearly so.

The influence of the movement of the going part upon the movement of the shuttle cannot be ignored. As demonstrated in Fig. 38, there is considerable variation in the rate of speed at which the going part moves, and taking the theoretic time of the starting of the shuttle from one box and its entering the opposite one as being when the going part is midway in its passage from front to back, or, as overlookers term it, when the crank is at the bottom, and at the corresponding point of the return stroke, or, when the crank is at the top, the shuttle will

be leaving and entering a box precisely at the moment when the going part is travelling at its highest rate of speed. So that it would seem as though the shuttle describes in its passage something approaching an arc of a circle; the highest velocity of the going part being when the shuttle is at each extremity of this arc, but the highest velocity of the shuttle is at the moment when it has received its impetus from the picker; then if the direction of force is such as to throw the shuttle towards the reed, of course, the direction will be in that of the reed itself; and as the going part is losing velocity from the moment the shuttle is thrown out of the box until it reaches its back extremity, and from there increasing in velocity on its return, it will follow that if the amount of force exerted in propelling the shuttle has been in the direction of the reed it will keep it well up to the reed until the back extremity is passed, when, as the velocity of the shuttle is gradually diminishing, the increased velocity of the going part towards the shuttle will practically serve the same purpose, so that *prima facie* this will appear to be the best, or at least, the most convenient solution of the problem.

An important question naturally arises at this point, viz.: when is the shuttle most likely to be thrown out? Or at what point of its passage will any obstruction placed in its way have the greatest influence in diverting it? This is a question which undoubtedly affects the use of the shuttle-guard, and, all other things being properly adjusted, it seems as though the positions are mainly when the shuttle is entering the warp, or when it is about to leave it. As it enters the warp it is travelling at the highest rate of speed, or with all the force imparted to it; therefore, even supposing the force to be well directed, any obstruction would be liable to throw it out with great velocity; on the other hand, it may be argued that this very force will enable it to overcome the obstruction. In a measure that is true; but if

the obstruction should be such as to throw it upwards, and outwards where there is the least line of resistance, then it must fly from the loom; but if the resistance should tend in the slightest degree in the opposite direction then the tendency must be to retard the shuttle. Should this occur when the going part is at, or about, the back extremity there is practically no interference with the movement of the shuttle by the movement of the going part, but on the return stroke any obstruction tending to throw the shuttle upwards must have a serious effect, both on account of the loss of momentum of the shuttle and the increased velocity of the going part in its forward movement, as both will tend to throw the shuttle outwards.

This may be demonstrated in the most practical manner in any loom by placing a little "thrum," or "beeting" in the warp at either one side or the other and note the effect upon the shuttle; this will be more noticeable if a greater amount of force is being exerted than necessary in propelling the shuttle. If the obstruction is placed near the side from which the shuttle is being propelled, the tendency will be to cause it to fly out with very great velocity, and at a low angle, so that it might travel a distance of even half way across a shed, to the imminent danger of any one in the course of its passage, before it loses its momentum; but if the obstruction is placed at the side where the force is being expended the tendency is to cause the shuttle to rise, and the greatest danger will be to the weaver at the next loom. In some cases it might rise clear of the loom and drop within a few feet. As a result it must be obvious that the most dangerous element in shuttle flying is where the obstructions occur when the shuttle has the greatest force behind it, or might equally arise, or be intensified, by a misdirection of that force.

Having now disposed of the question of direction of force two others necessarily follow upon it, first, as to

the nature and character of the force employed, and second, as to the amount of energy required. As to the nature of the force, whatever class of loom we deal with it partakes generally of the same character; there must be something in it of the nature of a blow, but this blow must not be delivered too abruptly but rather as a gradually accelerated force. For instance, we say that we must have in the shuttle box a spring, or lever, which will serve the purpose of steadying the shuttle and preventing rebounds; that means a considerable amount of pressure upon the shuttle, and when this pressure is utilized for the purpose of operating a stop motion, such as is known as the stop-rod, then it may be increased. The consideration of the details of this pressure, and the means of relieving it, must in some measure, at any rate, be dealt with along with the consideration of the several stop motions employed. At the present moment it is sufficient to consider generally the influence upon the pick and the character of the force employed.

A shuttle is driven into the box and held firmly by the pressure of the spring or lever; then in picking the first consideration must be the best means of relieving this pressure, next, the application of the force for propulsion. To relieve this pressure it is most convenient to begin to move the shuttle slowly, gradually increasing the velocity of movement until the pressure is virtually removed; then, what might be fairly termed the blow can be delivered for propelling the shuttle; so that from beginning to end the movement may be said to be one of gradually accelerated motion up to a given point when the force is suddenly augmented. It will remain to determine afterwards which of the various forms of picking motion in use will best accomplish this. For the moment let it suffice that we have what might be termed three factors; 1st, the amount of force required to relieve the shuttle from the pressure in the box; 2nd, the

amount of force required in propulsion, and to overcome the resistance; and 3rd, the amount of force required to overcome the resistance to the shuttle on entering the box. The consideration of those three factors will afterwards determine the form and character of the picking tappets employed, and also assist in determining which of the systems in use is most likely to be satisfactory in its working. Of course it must be understood that the speed of the loom is an important item as determining the nature and character of the pick.

We have assumed so far that the time occupied in passing the shuttle from side to side is equal to one half of a revolution of the crank or driving shaft. In a slow loom, and where considerable pause is given to the going part at the back extremity of its stroke, the whole of this time may be said to be fully occupied; and the slow movement of the shuttle will be assisted by the long, easy "dwell" of the going part, obtained by the long throw of the crank; so that the whole movement would be one of comparative ease, but in nearly every case this would be accompanied by a large heavy shuttle; and, all the facts taken into consideration, there would be little liability to throw the shuttle out; but in fast running looms the conditions would be very different. Instead of the time occupied in the passage of the shuttle being equal to half a revolution of the crank it might probably not exceed one-third, or even less than that; then the nature of the movement would be, of necessity, of the character of a blow sharply delivered; in fact a general comparison of the two movements necessary in the class of looms referred to would be, that one might be described as a long "slinging" stroke and the other as a sharp blow. Of course it will be easily seen that the relative speeds of the two looms referred to will tend to assist in the production of the character of stroke required. As to the amount of force or power required. Here

difficulties appear on every side. If the question was only one of propelling a body of a given weight through a given space in a fixed period of time, then the matter would be easy; but when we have to take into consideration all the items of resistance it becomes very intricate. First, the obstacles just referred to, of relieving the shuttle of pressure; of resistance of warp threads which will be variable, not merely in proportion to the varying thickness of the yarn, but in proportion also to the pattern; then the resistance offered to the shuttle entering the box. Assume a loom is running at 180 picks per minute, the shuttle weighs 12 ozs. and the space passed through is 6 feet, then we can easily determine the velocity per second—$\frac{180 \times 2 \times 6}{60 \times 1} = 36$ feet per second, assuming the time occupied to be equal to half a revolution of crank shaft. But this is only the average velocity, not the velocity at any point of passage. Then the energy required to perform this work is, on the usual formula, where W would be the weight of a projectile, V the velocity at which it travels, and G the influence of gravitation at 32·2, or as usual, $2 \times 32{\cdot}2$. $\frac{{\cdot}75 \text{ lbs.} \times 36^2}{64{\cdot}4} = 15{\cdot}09$, or in round numbers 15 foot lbs. per pick of the loom; or taking the power as generally stated at 33,000 lbs. lifted 1 foot in 1 minute as indicating 1 horse-power, then the energy developed would be equal to $\frac{18}{650}$ horse-power per pick. But this is altogether ignoring the resistance as mentioned. It is also ignoring the fact that what will hold good of the force required in a given width of loom, in weaving light goods, will not hold good of the same width of loom in weaving heavier goods.

There is a common expression current amongst overlookers, or those who have charge of looms, that as you change your work you must also change your pick; *i.e.*, as you vary your pattern, or weight of cloth, the force exerted in picking should be increased or decreased so as to

meet the requirements of the case. It may be said that the weight of the shuttle should be altered, that is quite true where the change is a very great one, but it would be a difficult matter to be constantly changing the shuttle for every weight of fabric, though there can be no reason why, say, two weights of shuttle should not be in use for the heavier and light classes of goods.

Broadly speaking there are two kinds of shuttle in use, those running upon wheels and those running without. There are many different classes of each species, if they may be so-called, all of which will have to be examined more carefully later on, but at present it will be sufficient to say that each one must be treated differently in the act of picking; the wheeled shuttle is generally used for heavy work and for comparatively slow going looms, and the nature of the movement in picking there is that which has been described as the "slinging" stroke; as anything in the nature of a sharp blow might tend to cause a rebound of the shuttle upon the wheels, and so, perhaps retard, instead of accelerating the motion. This of course would be materially influenced by the resistance offered by the warp; where the warp is heavy and bulky the retardation would be very great, but upon a light warp it might be comparatively small. The "sledge" shuttle as it is termed, or the one without wheels, may be described as thrown across the loom, so that the nature of the force imparted in propelling this must partake more of the character of a blow. Hence the difference in the nature of the picking apparatus in the several classes of loom.

Of the several forms of picking motion it will be simplest perhaps to deal with what is known as the lever pick, which is probably the best known form of under pick, a view of which is represented in detail at Fig. 43. Placed at the side of the loom and outside the frame, the picking arm is working upon a stud, and

attached to a frame carried by the rocking shaft of the loom, which is very near the floor; the object of so attaching it to the rocking shaft being that it shall oscillate to and fro with the going part; this being rendered absolutely necessary by the fact that the picking arm passes through the bottom of the shuttle-box so that it may act direct

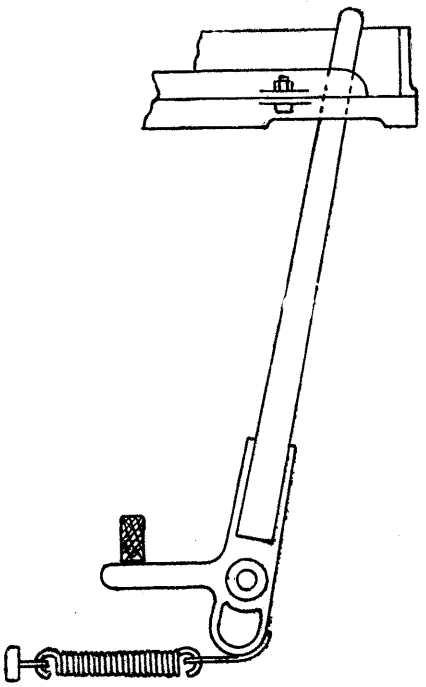


Fig. 43.

upon the shuttle. The mode of actuating it is by means of an arm or lever fastened to the lower, or tappet shaft, and revolving with it; or what is equivalent, bolted to a species of face plate upon the large toothed wheel of the lower shaft. Beneath this is placed a lever, generally of wood, having its fulcrum near the back of the loom and

passing forward to the front of the loom, where it is passed through a slot keeping it in position over an arm of the lever, at right angles to the picking stick itself. When the roller on the lever carried by the picking shaft strikes the wooden lever the latter is depressed, this in turn striking the arm connected with the picking stick, as seen in Fig. 43, depresses that also, thus causing the upper end of the picking stick to travel along the length of the box, and the picking stick having a leather picker running within the shuttle-box strikes the shuttle direct and propels it across the loom. Now suppose that the lever arm having its fulcrum at the back of the loom was a perfectly straight one, and the arm upon the tappet shaft striking it as it does, the movement would be, following that described in the revolution of the crank shaft, an accelerated one, the degree of acceleration being dependent upon the position of the lever in relation to the tappet shaft. If the lever was so placed that the arm upon the tappet shaft came in contact with it when in a horizontal position, and continued to depress it until it reached the vertical position, then the acceleration would be of that truly eccentric character which is approximate to what is known as harmonic motion; but in that case the length of stroke would be too great, as only a very short stroke is required to give the requisite movement to the picker; the relative length of the two arms of the lever, of which the picking stick is the longest, being such that the shorter arm must travel through only a small arc of a circle to give the necessary traverse to the picker. Again a considerable leverage is gained by the fact that the arm on the tappet shaft acts upon the horizontal lever at a point between the fulcrum and where the force is delivered; and so the position is necessarily one in which the revolving arm can be in contact with the lever for only a very brief period, hence the movement instead of being one corresponding with one of harmonic

nature will be in the nature of the direct blow. This must be modified as the character of such a movement could not be for a moment entertained in a good working loom. To meet this then what is termed a picking plate is placed upon the lever, and so formed that as the revolving arm strikes it, it will give the requisite character of movement, viz.: that described as an accelerated motion. In this form of picking arrangement there is one item which is not to be taken into account, viz.: the picking strap or leather. In any of the picking motions where the picking stick is connected to the picker by a long strap there must be a

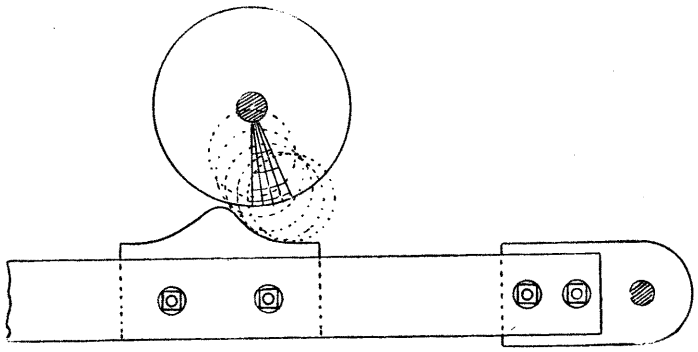


Fig. 44.

certain amount of slack, or extra length, given to the strap. In many cases, because of the picking strap having to bring the picker back to its normal position, it must have a very long traverse, so as to ensure not only the picker travelling the full length of the spindle, but also returning without any tension being thrown upon the spindle by the picking strap itself, as is the case in what is known more especially as the cone pick. In the lever pick the stick may be said to act direct upon the shuttle consequently only as much movement need be given to it as is requisite for propelling the shuttle. Then as to the question of the form of

picking plate and the amount of leverage to be given, suppose we take the lever as illustrated in Fig. 44, the fulcrum being at the back part of the loom; then we shall have the power applied from the tappet shaft. Now suppose the picking arm must traverse a distance of 15 inches, the full length of the shuttle-box, or at least sufficient of that length for effective work, because it must never be supposed that the force is applied to the whole of the traverse of the length of the shuttle-box. If it were so the picking stick would strike the end of the groove with such force that breakages would occur; but the application of force must cease a sufficient distance from that point to allow of the impetus expending itself so as not to cause too great a concussion. If the picking stick which is the long arm of the lever travels 15 inches the short arm travels, say 3 inches, and consequently the arm of the wooden lever must travel a corresponding distance at the point where it delivers the blow; then to determine the length of the arm upon the lower shaft of the loom we should simply say as the distance from the fulcrum to the point where power is applied, is to the distance from the lever end to the fulcrum, so is the distance travelled at one point to the distance travelled at the other; or in other words that would be the length of the stroke given by the arm on the shaft of the loom. This determines the depth of the picking plate from what might be termed the flat to the highest point of rise; the exact mode of drawing it is as follows:—Let the stroke to be given by the lever on the loom shaft be 3 inches, and the total length of the picking plate, say 6 inches. Then the time ccupied in the delivery of the pick must be determined. The usual period being about one-eighth, or a little more, of a revolution of the crank shaft. Then describe a circle equal to the distance from the centre of the shaft to the centre of the roller on the lever, and mark

off the period of time allotted for the pick. The path of the centre of the roller will be indicated by this circle.

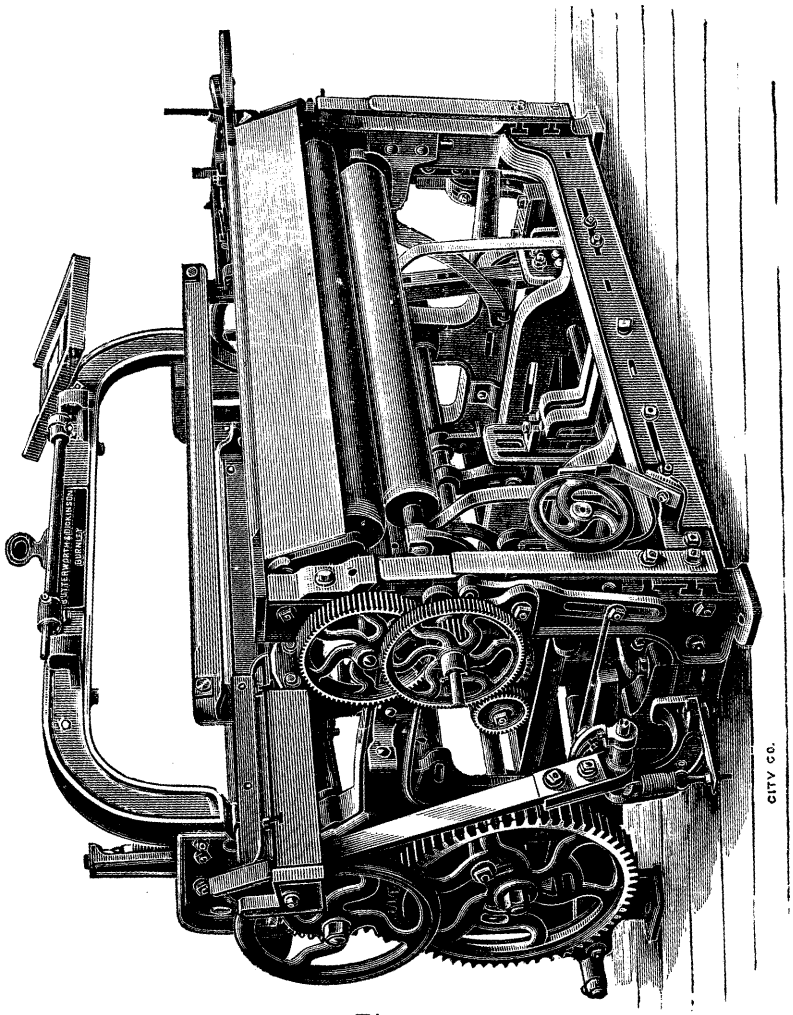


Fig. 45.

The roller must impart motion to the lever, and this motion must be an accelerated one, the degree of acceleration

being determined by the nature of the work to be done. Let it be taken that the increase is regular. Then divide the space marked off on the circle into any number of equal parts, say, for convenience 4, and lay off the distance the picking lever must travel, say one inch on the radius of the circle, and upon this segment of the circle a line must be drawn indicating the movement of the picking lever. Place the line from the centre in a vertical position and find the fulcrum of the lever, from there strike an arc of a circle from the vertical line which will indicate the course of the point of contact of the roller and lever inverted. Now divide the space already marked off upon the radial line into divisions corresponding with the degree of acceleration, say six, in the ratio of 1, 2, 3, &c., that is, the distances apart increasing in that ratio, and from the centre of the circle strike arcs of circles cutting the arc drawn from the fulcrum as a centre, and taking each point of intersection in succession describe arcs of circles, commencing where a line has first been drawn indicating the lower surface of the plate, and a line touching the peripheries of all the circles will indicate the true line of the picking plate surface, up to where the vertical line is dropped. From that point the plate may be drawn in any suitable form to allow the picking lever to return to its normal position, as no force is to be exerted. It is best to allow it to return easily and without jerking. Another form of the same class of motion is shown in the illustration Fig. 45, where the pick is virtually of the same order and carried out in the same manner but different in detail. In the illustration, which is that representing a heavy linen loom, it will be noticed that instead of the straight arm projecting from the bottom of the picking stick as in Fig. 43, there is what is termed a half-moon, and a strap connects this half-moon with a lever acted upon in precisely the same manner as in the other loom, but obtaining greater smoothness of action. In very heavy

work this is a most important feature, the details of the arrangement will be better understood by reference to Fig. 46 where the motion is separated from the rest of the loom. Another form of motion is shown at Fig. 47 applicable

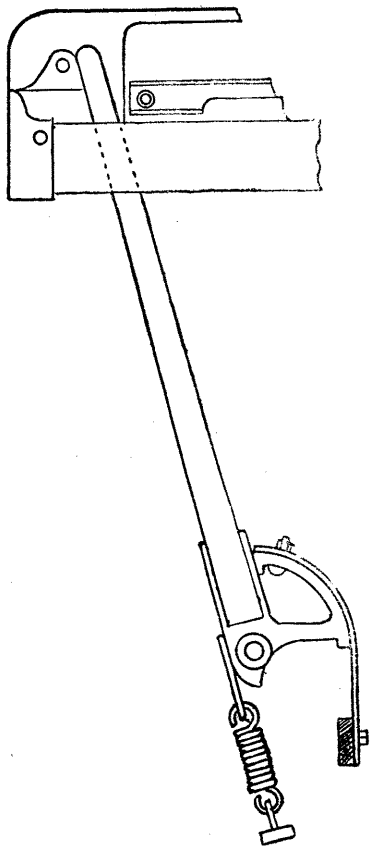


Fig. 46.

to heavy cotton or fustian looms, in this case the working mechanism, with the exception of the picking stick itself, is placed within the loom frame so as to be out of the way

of other apparatus required to be placed outside. The details of the mechanism are somewhat different but the principle is the same. This will be better understood by reference to details in Fig. 48.

There are several other arrangements of what are known as under-pick motions and although differing in detail from those just described are virtually the same in character and effect, notably two, one of which is driven direct from the

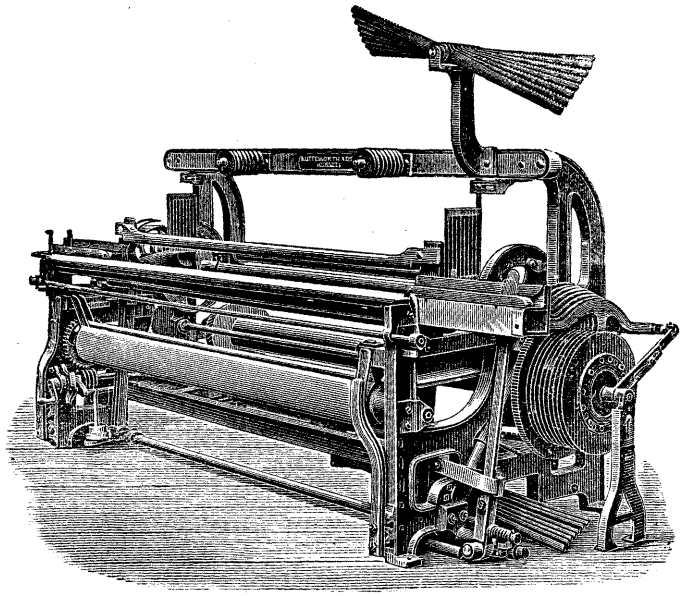


Fig. 47.

crank shaft and the other known as the scroll pick; these are made only for special looms and comparatively speaking little in use. Therefore it may be sufficient to describe the general principles involved with one or two detailed descriptions to make the matter clear and intelligible.

The object of driving from the crank shaft is to obtain greater force, by utilizing the speed of the crank shaft as is done in the high-topped or slow looms, all of which

pick from the top shaft; for the usual rate of speed of the two shafts—crank and tappet shaft—being as two to one, their relative powers with a lever describing a circle of the same

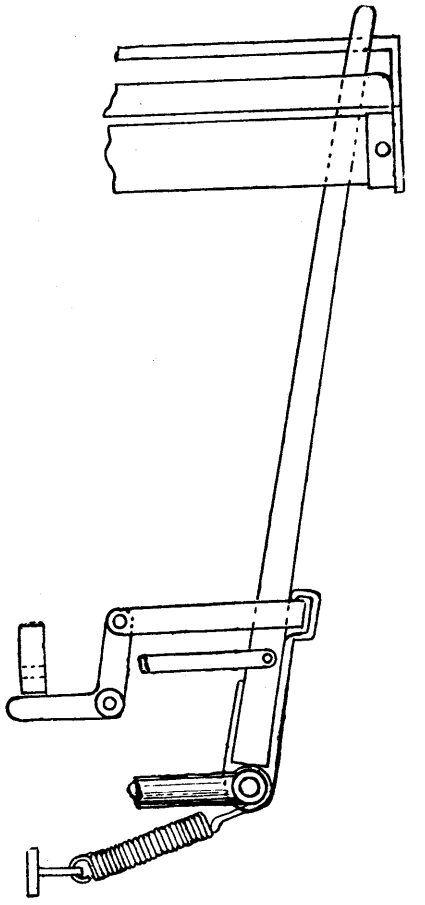


Fig. 48.

radius will be as one to four, as the power must be in the ratio of the square of the velocity; but one important fact is overlooked, viz., that the same effect may be obtained by

having a lever on the lower, or slower, shaft of the loom, which will make up for this difference. Again, there is the advantage in the longer lever of being able to arrange and adapt the shape to the exact requirements, whereas in the short lever of the crank shaft this is not so easy. In the slow running loom, picking from the crank shaft becomes almost a necessity, and, as will be shown, works well, but in fast running looms, in most forms, it is liable to be jerky in its action.

What is known as the "scroll" pick consists, as its name implies, in having a scroll formed on the surface of

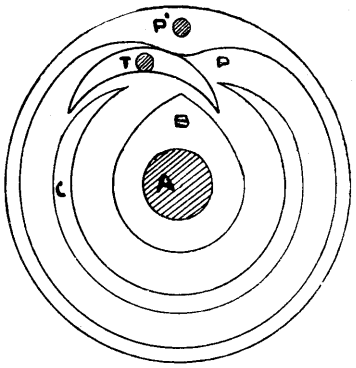


Fig. 49.

a disc, or it may be called a grooved cam, and in such a manner that two grooves run into each other. Suppose a surface plate to be arranged as shown at Fig. 49, where the shaft A forms the centre, and a pointed cam B is formed upon it, a scroll or bead C is cast upon the face of the disc, so that the grooves on the inside and outside merge into each other near the point of the cam at P. A movable plate P″ is so formed as to throw the crescent T from one groove into the other. The disc then travels first in the inner groove and then in the outer one as the disc revolves, and by means of a shaft placed diagonally

at the loom side, and which is really a fulcrum of an intermediate lever communicating the power received from the scroll to the picking stick, somewhat after the manner of the under-picks already described, propels the shuttle from side to side. (I am afraid the drawing is not strictly accurate in its proportions, the points of the governor or crescent T are a little too long. This has not been drawn to scale, but is only a rough indication.)

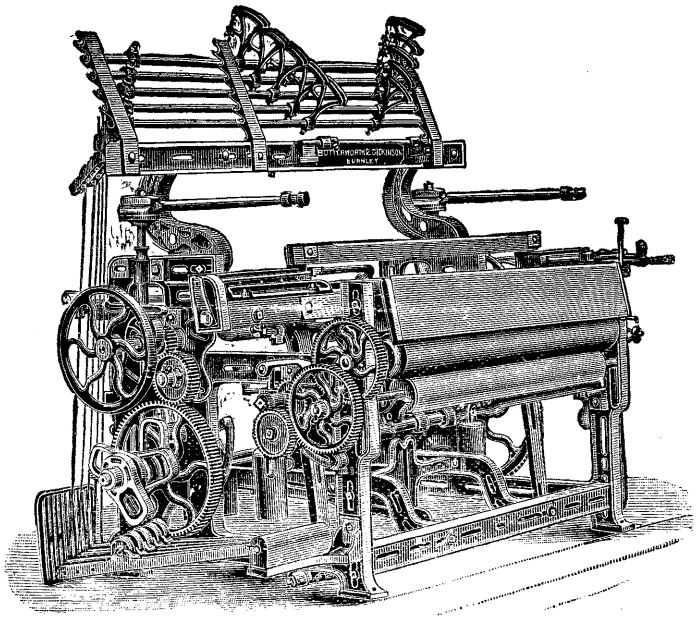


Fig. 50.

Now having dealt with the under-picks there are only two forms to refer to, both of which may be termed over-picks; the one most largely used in the worsted looms and light cotton looms, the other on what are known as high-topped looms, or more generally known as the Dobcross type. By far the largest number of looms in use have the over-pick motion of what is sometimes termed the Bradford

type. This consists, primarily, in a picking stick moving in a horizontal plane with the extremity over the top of the shuttle-box. This picking stick is placed on the top of a vertical shaft bolted to the outer loom frame, sometimes inside the loom frame and sometimes outside, as shown

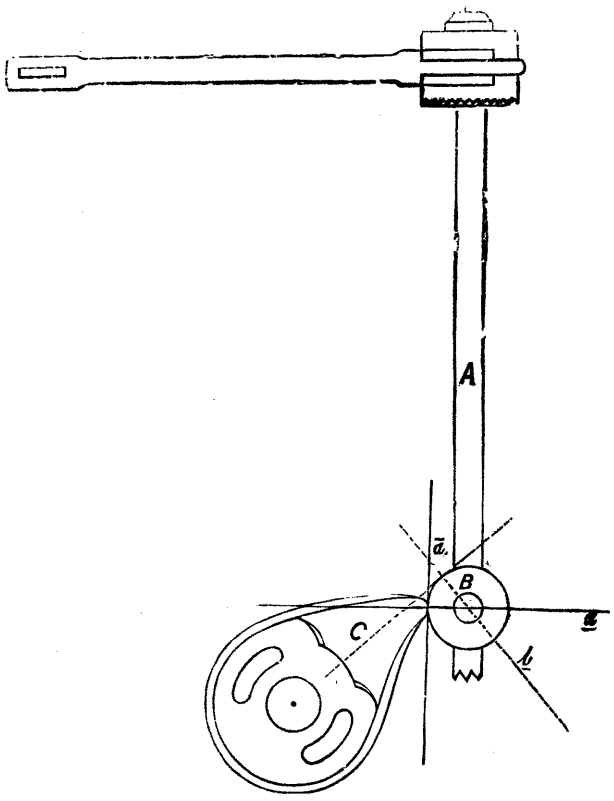


Fig. 51.

in Fig. 50. The general arrangement is shown detached from the loom in Fig. 51 where the upright shaft would be resting in a socket attached to the loom frame near the foot and supported by a bracket near the top.

Some little distance from the lower extremity a cone-shaped roller revolves upon studs attached to the upright shaft at right angles. This stud is really one arm of the lever and the picking stick is the other arm, in precisely the same manner as the lever is formed in Figs. 43 and 44, only that in this case the fulcrum instead of being a short horizontal stud is a long vertical shaft. This lower arm of the lever is acted upon directly from the lower shaft of the loom by what is termed the picking tappet as shown at Fig. 51. It must be perfectly clear that the picking tappet on the shaft, which corresponds to the lever arm on the shaft of the under-pick loom, cannot act directly upon the cone as in the other case it acts upon the long lever; the long lever in the under-pick motion serves as an intermediary, in this there is no intermediary, the revolving lever acts directly upon the lever communicating directly with the shuttle, consequently every care must be taken not only to impart precisely the character of motion required for the work to be done but with the least amount of friction, the least waste of power and harshness, and the least possible re-action in the several parts.

Then the first question to consider is the direction in which the force is to be exerted for, as in other forms of picking motion, the force must be utilised in the best possible manner, and from the nature of the arrangement in this case the difficulty of maintaining the direction of force is much greater than in any other form. We have first the tappet revolving with the tappet shaft, that shaft being placed in the horizontal plane, then we have the upright shaft revolving at right angles to it and forming the fulcrum of the lever through which the motion is communicated from the tappet to the shuttle, consequently we have the two levers, the tappet and the cone-shaped roller, moving when in contact through arcs of circles at right angles to each other. Consequently the surface of each must be so shaped

as to not only preserve the full surface contact but also to assist in maintaining the direction of force. Then we may ask the question, what is the direction in which the force should be exerted ?

As pointed out in my "Treatise on Weaving and Designing" the direction of force to be utilised to the fullest extent must be at right angles to the upright shaft, or the fulcrum upon which the lever is working, for it needs very little demonstration that if the force should be exerted either downwards or upwards it must either be pressing the shaft down into the socket or lifting it up out of it. The maintenance of the direction of force can be most readily shown by determining beforehand the position of the upright shaft in relation to the tappet shaft, as well as the distance of the tappet from the upright shaft. Here dimensions must be very carefully taken into account, for instance the picking cone must always be in contact with some part of the tappet, so that that implies that the diameter of the disc or shell of the tappet must be sufficiently large for the cone to rest upon it when not in contact with the tappet nose; or another form of expression may be used to make the matter more clear. Suppose that the disc of the tappet is a perfect circle and the cone of the picking lever is at rest upon it when the picking stick is in its normal position. So long as no movement is intended to be imparted to the picking stick the two would remain in that position and the surfaces would simply run upon each other; then it may be assumed as a starting point that when the two circles are so in contact that the centre of the cone is parallel to the tappet shaft, but it must be clearly understood that it is only supposed for the moment as a matter of convenience.

Leaving aside then the consideration of movement being imparted to the cone by adding a projection to the disc which will push the cone from this parallel position, there

would be no need for a conical shaped roller, or for any bevelling of the tappet disc, as the two centres being parallel to each other the surface of the roller and the disc might also remain parallel; and further supposing that this cone has only to move from this parallel position a given distance and then return to it, the shaping would have to be to suit the position and extent of movement; but the moment the shape of the cone is altered to suit the movement from this true parallel position then the shape of the disc must be altered to correspond with it on its return; so that reduced to simplicity the amount of bevelling or shaping must be divided between the two extreme positions, and in a great proportion of cases the object aimed at is to have the tappet nose as near a parallel as possible with the shaft upon which it revolves.

Now another question must arise which will determine the relative positions of the two shafts and that is the amount and the nature of the movement imparted to the cone. For instance we say that the cone must travel through a given number of inches. This will be determined by two considerations—the length of the shuttle-box and the amount of leverage given to the picking arm. Suppose for instance that the picker must travel through 15 inches, then the picking arm at its extremity must travel not only that distance but something more. There must be some amount of slack in the picking strap, *i.e.* the picking stick must travel outward some inches beyond the extremity of the shuttle-box, and of necessity a corresponding number of inches in the opposite direction beyond the spindle stud so that if the picker travels 15 inches and 3 inches is given at each extremity for slack leather, then the total distance travelled by the picking stick will be 21 inches. Now we have the length of the picking arm to take into account, and its position whether inside or outside the loom frame, as also

the angle it forms with the shuttle-box at each extremity of its movement.

Let it be supposed for convenience that at each extremity it forms an angle of 45 degrees with the shuttle-box then it would be at right angles exactly in the centre of its passage, which of course means that the arc of a circle formed by it in its traverse will be equal in distance at both extremities from the picker spindle; so that the direction of force as delivered by the picking stick will be the nearest possible approach to a line parallel with the spindle. The position so assumed is often very difficult to maintain more especially when the upright shaft is placed inside the loom frame. To have it placed in such a position as to have the angle indicated it would imply that the upright shaft should be opposite the centre of the shuttle-box which in many cases is a practical impossibility. Then the angle at each extremity must be varied, but following the assumption already adopted we can determine the length of picking arm from the position of the upright shaft or *vice versa*. Suppose the upright shaft is 18 inches from the picker spindle when the going part is in the centre of its stroke, that will immediately determine the length of the picking stick as being equal to that distance, *i.e.* with the point where the leather is fastened to the picking stick being directly over the picking spindle, so that the going part travels the same distance beyond it in each direction, or in other words the picking stick and spindle are at right angles to each other when the going part is in the centre of its stroke, and the picking leather is parallel with the spindle at the same moment. This then it will be seen is the most convenient starting point which could be adopted. As to its practical application we must see presently.

The amount of traverse given to the picking stick must always be an important factor in determining its

length, as if it be too short the arc of the circle formed in travelling will be such that the distance on each side of the parallel line spoken of will be too great, and it is obviously better to have this arc formed as large as possible for the purpose of avoiding strain upon the spindle and friction; then if the distance traversed is 21 inches, and allowing a distance of 3 inches on each side of the spindle, we should have a length of picking stick of 18 inches necessary. Then that will determine the position of the upright shaft, and we must now take the leverage into account for determining the length of the cone. If the picking stick is 18 inches long, and travels 21 inches, then the cone to be of convenient length should be certainly not less than about one-fifth of the picking stick, otherwise the arc of the circle which it describes will be too small for good working. Then those two important factors being determined we must consider whether the centre of the cone should be parallel to the tappet shaft in the centre of its stroke, or whether it shall be in that position at or near the extremity of the stroke. That of course will determine the diameter of the disc, and the length of the tappet nose will be determined by the amount of movement to be imparted to the cone; for instance, we have already determined that the picking stick must travel 21 inches at its extremity, and that the cone should be to the picking stick in length as one is to five, then the cone must travel $\frac{21}{5} = 4\frac{1}{5}$ inches at its point of contact with the tappet, so that the whole length of the tappet nose from the disc must be that number of inches. Now as to the movement of the cone. The quarter-circle movement has been considered by many to be the best, for the simple reason that in adopting that movement the arm of the lever never passes the centre of its fulcrum.

As any one will know who has ever observed the movement of a lever, especially when working upon a shaft

as in this case, there must be a certain amount of vibration occur at the moment when it crosses the centre; and as in picking this vibration would occur exactly when the force is being delivered, if the lever were allowed to travel the same distance on each side that would be the most critical period at which it could possibly occur, for the reason that it would then be imparting force to the shuttle at almost its highest rate of velocity, and also at the moment when the shuttle would be practically relieved of the pressure of the spring or swell in the shuttle box; any vibration occurring in the picking stick might be communicated to the shuttle and divert its course and throw it out of the loom. This of course need not necessarily be a fatal objection to the placing of the picking stick in this position, because proper care and attention to the working parts, so as to check undue wear and tear, would have the effect of reducing this vibration to a minimum, but there are other objections to this position even greater than that.

No doubt theoretically that is the best position, but practically it is one difficult to maintain. When the position of the upright shaft in relation to the tappet shaft is taken into account, along with the shortness of the cone in the lever arm, it will be seen that the angle formed would be so acute that the bevel on the surface of the cone, and of the tappet shell, or disc, becomes almost an impossibility, and the larger this disc and the more difficult this angle would be to deal with. Then a little must be given on the one side or the other. If we must run the risk of this vibration it is best to let it occur at a time when it will be least likely to be injurious. Suppose it is determined that the lever shall pass its centre at a point near the commencement of its stroke, say mid-way between the point where it commences and when the picking stick is at right angles to the shuttle box, that determines definitely the position of the upright shaft. Then we must see what

angle the centre of the cone will form with the picking shaft, and for the disc of the shell we should divide this angle equally between the disc of the shell and the cone itself, so that that portion of the question will be easily settled; the length of the tappet nose has already been determined by the leverage given to the picking stick. Knowing now what is the angle of the cone, and assuming that the extreme nose of the tappet is parallel with the tappet shaft, the angle formed by the cone upon the surface of the tappet should be determined at every point of the stroke. This will not be a difficult thing to do, as taking about 3 points between the highest and the lowest, the intermediate positions may be readily inferred. With the dimensions given, those three intermediate points would be as follows:—The tappet nose in contact, at its extreme point, with the cone, and the centre of the cone parallel with the tappet shaft, the angle of the cone surface with its axis may be supposed to be 5°. It may be anywhere from 5° to 10°, then the tappet nose must form a corresponding angle with its axis. Now let the picking stick move a distance of from $7\frac{1}{2}°$ to 10° in tightening the picking strap, say 10°, then the angle formed will be equal to 15°. If the time occupied in delivery of the force is about one-eighth of a revolution of the crank shaft, it will be equal to one-sixteenth of a revolution of the tappet shaft, or $\frac{180}{16} = 11\frac{1}{4}°$. So that the angle now becomes one of $15 \times 11\frac{1}{4} = 26\frac{1}{4}°$ on the surface of the cone, then the intermediate points will be $15 + \frac{11\frac{1}{4}}{4} = 17\frac{13}{16}°$. The next will be $17\frac{13}{16} + 2\frac{13}{16} = 20\frac{5}{8}$. Then $20\frac{5}{8} + 2\frac{13}{16} = 23\frac{7}{16}°$ respectively. Then from this the tappet can be drawn with perfect accuracy.

Now that the leverage, position and angle of the cone and tappet have been determined, the questions arising are as to the magnitude of force and the correct form of tappet required to produce the peculiarly eccentric motion referred

to. As to the magnitude of the force it has already been pointed out that it is practically impossible to determine it for all cases, simply because the amount of resistance offered is so varying in quantity that what will serve, and be perfectly correct, in one case would be utterly inadequate, or far too much, in another. Generally it may be stated as follows:— Let the loom be making 240 picks per minute, and the time occupied by the shuttle in passing across the loom be equal to a little more than one quarter of a revolution of the crank shaft, or for convenience say exactly a third of a revolution, then the time would be $240 \times 3 = \frac{1}{720}$th part of a minute. Now let the shuttle weigh three quarters of a pound, and the distance it is projected 6 feet, then the energy developed would be equal to $\frac{3}{4}$lb. projected 6 feet in $\frac{1}{720}$th part of a minute, or $\frac{180 \times 3 \times 6}{60 \times 1} = 54$ feet per second, and the energy would be—taking the work done on the usual basis of W = work done, V = velocity, and G at 32·2—$\frac{12 \times 54^2}{16 \times 2 \times 32{\cdot}2} = \frac{12 \times 54 \times 54}{16 \times 2 \times 32{\cdot}2} = 33{\cdot}96$ foot lb. per pick of the loom, or each projection of the shuttle; and as one horse power is indicated by 33,000 lbs. raised one foot in one minute, thus $\frac{33{\cdot}96 \times 60}{33{\cdot}000} = {\cdot}0617$ of a horse power expended each time the shuttle is propelled across the loom.

As to the form of tappet necessary to the production of the proper kind of movement, the simplest method of drawing it is as follows:—

Make a plan showing the exact position of the upright shaft: the picking cone in the two extreme positions, the picking, or lower shaft, and the tappet, as in the upper part of the drawing at Fig. 52. T is the tappet shaft, U the upright shaft, C is the cone, and D the disc or shell of the tappet.

The centre lines C^1 C^2 represent the exact distance traversed by the cone, which at the point of contact with the tappet is 3 inches. The diameter of the disc, or shell,

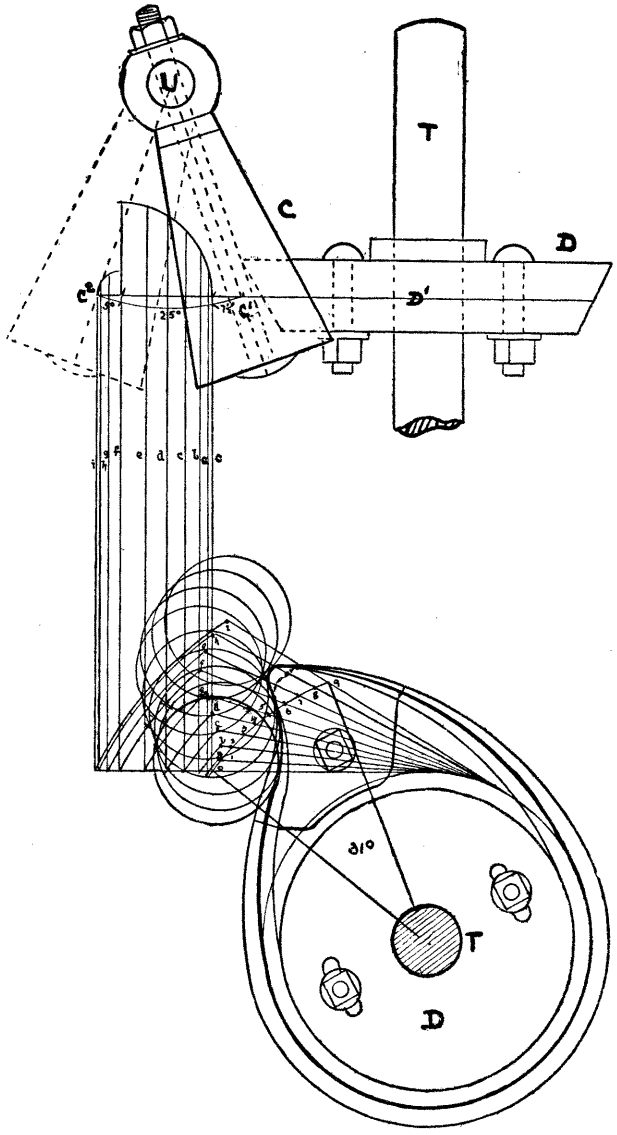


Fig. 52.

of the tappet is 8 inches at the centre line, or midway between the edges of the surface as shown by the line D^1 and the length of the tappet nose is 3 inches. The point of contact of the centre of the disc is $4\frac{1}{2}$ inches from the fulcrum, the length of the cone being 6 inches. Now take the angle enclosed by an arc drawn from C^1 to C^2 at the point of contact with D^1, and it will be found to be about $38\frac{1}{2}°$. This $38\frac{1}{2}°$ may now be divided up for the work to be done. Take $7\frac{1}{2}°$ for taking up the slack leather, 25° for the delivery of the accelerated force, and 6° for amelioration, or gradual

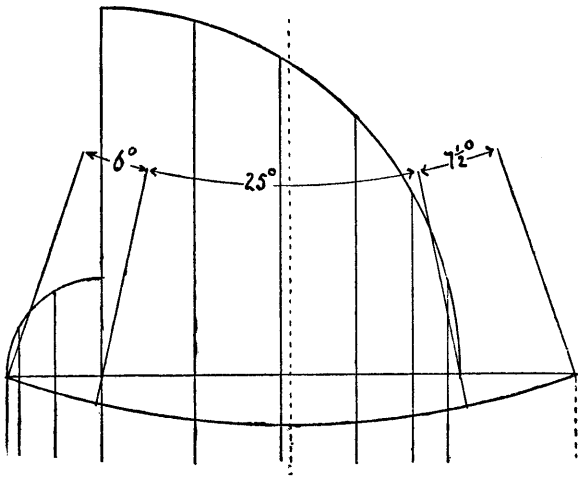


Fig. 53.

reduction of force, so as to bring the picker to rest without the violence of concussion with the spindle stud being too great, and lay off those angles as shown in the drawing. The next thing is to divide the several parts of the arc according to the movement to be given. The first $7\frac{1}{2}°$ requires but little attention, as it requires to be only a gently accelerated movement. The 25° should have accelerated motion in harmonic ratio, and the last six reduced in a similar ratio.

The determination of this ratio will be best understood by reference to Fig. 53, which represents an arc of a circle of $38\frac{1}{2}°$ and divided as mentioned. Take the 25° as laid off in the chord and erect a quadrant. Divide the quadrant into six, or any number, of equal parts, and drop perpendiculars, cutting the horizontal line, and the divisions thus produced will represent what is known as harmonic ratios.

Then the 25° having this accelerated movement, the next 6° must be reduced in the same ratio as shown.

Having proceeded thus far, next project the proportions by dropping perpendicular lines to the lower portion of the drawing, where the lettering again corresponds to the same parts. The line D^1 representing the centre line of the tappet surface, it is most convenient to draw to that. Then draw the horizontal line H tangent to the circle D^1, and let the vertical lines indicating the movement of the cone cut it at the points marked *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*. From the point where the line *i* cuts this horizontal line draw a line to the centre of the circle or tappet T, and lay off from that $38\frac{1}{2}° - 7\frac{1}{2}°$ as shown. Next divide this 31° into as many equal parts as the horizontal line H has been divided unequally, as at 1, 2, 3 to 9, on an arc struck from the point *i* on the line H. Then from the centre of T strike arcs of circles from *a* to *i* in succession, and through the points 1 to 9 draw lines tangent to the circle D^1 until they cut those arcs, and a line connecting all the points of intersection will represent the direction of force as required to be delivered by the tappet. From each of those intersections, and with the radius of the cone as at D^1, draw circles representing the exact position of the cone at each point in the movement, and a line tangent to all the arcs in succession will be the true line of the tappet on the surface, or continuation of D^1. The intervening space between the first arc and the true circle D^1 being filled up by a suitable curve to draw up the slack of picking strap, and coinciding with the $7\frac{1}{2}°$ allowed for that purpose.

Having now found the true line for the centre of the tappet surface, it only remains to fill up and make the angle of the surface correspond with the surface of the cone as already pointed out, and fill up the back of the tappet nose in such a manner as to allow the picker to return gently to its position at the back of the box.

There is but one other form of picking motion now to refer to, that is the picking motion attached to what are known as the high-topped looms, and this is so similar in character to the under-pick, and this class of loom is so

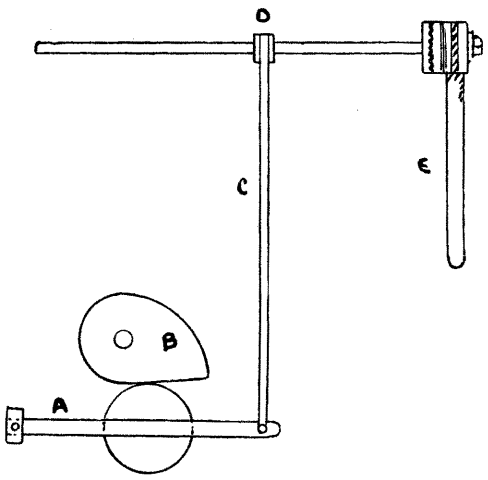


Fig. 54.

rapidly going out of use that little need be said upon the matter. The general arrangements are as shown in Fig. 54 and also at Fig. 55, one of which shows the side and the other the front view. A lever A has its fulcrum near the back of the loom and passes directly under the main driving shaft, upon the driving shaft is placed a cam B. The free end of the lever is connected by a rod C to a short lever arm D. The other arm of the lever E being

the picking stick. It will thus be seen that this is virtually the same as the under-pick motion described in Fig. 43 reversed, but with this exception that instead of an anti-friction bowl or roller being placed upon the lever arm revolving upon the shaft, and the picking plate upon the lever, a picking tappet is placed upon the shaft and the anti-friction roller upon the lever. The drawing of this tappet is comparatively simple as compared with the tappet for the cone picking; the surface of the tappet itself always being parallel with the shaft upon which it is placed.

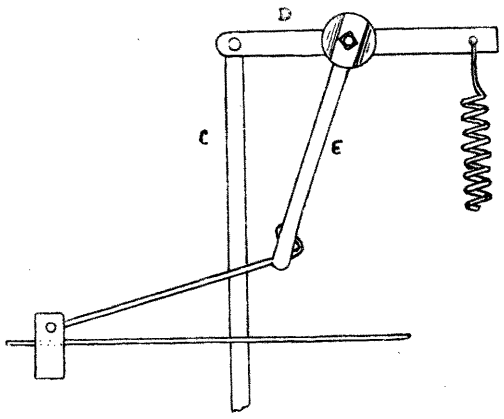


Fig. 55.

Of course the general form of the tappet will be determined by the same rules as to acceleration of speed as in the previous cases, but, generally speaking, a straight line drawn from the disc, at the point where the tappet nose begins to be formed, to the extreme end of the tappet gives a sufficiently accelerated movement for all practical purposes. This loom being invariably used for heavy goods and built for slow running there is not the same necessity for strict attention to the accuracy of form and the exact balancing of parts as in the fast running looms.

It might appear at first sight as though far too much attention had been devoted to this portion of the loom, but any one familiar with the working of looms of any description will at once recognise the necessity of paying the closest possible attention to every detail. From the very nature of the movement there is no part of the loom which is capable of giving so much trouble, or can be so productive of mischief as the picking mechanism. In the first place, the character of the force and the manner in which it is delivered, partaking as it does so much of the character of a blow, the force being withdrawn suddenly, and at the time when it has attained its greatest impetus, must cause a reaction; this reaction, of course, is always dangerous as affecting other parts of the loom, and unless well controlled may be productive of endless mischief; so that the easier the movement can be executed, and the better the parts are balanced, coupled of course, with proper timing in relation to the several working parts, the better for the work of the loom in general. Again, of course, the proper adjustment of everything having reference to the picking, so as to reduce the liability of throwing the shuttle out of the loom, must be considered of sufficient importance to warrant the closest attention to every minor detail.

Many means have been resorted to from time to time to relieve the pressure upon the shuttle in the box both at the moment of picking and also of entering the box, some of these are very ingenious and simple: for instance, taking what is known as the stop-rod motion, a simple connection of the upper arm of the lever at the back of the box with the crank arm by means of a short rod, as shown at Fig. 56, would effectually remove the pressure at the moment when the picking would take place. The picking usually commencing when the crank is descending, or approaching the lowest point in its revolution, and the action being completed about the corresponding point in the return stroke, this

method of connecting would ensure pressure being taken off both as the shuttle leaves and enters the box. Another method answering the same purpose, is an arm carried back from the stop-rod as a lever and made to travel over a bridge so placed as to give relief during exactly the same period as in the other case. Other aids are resorted to such as anti-friction rollers in place of the swell at the back of the box; all more or less effectual and tending to reduce the amount of work required.

There are several other matters connected with picking which must not be treated lightly, as having, not only an influence upon the good working of the loom, but also

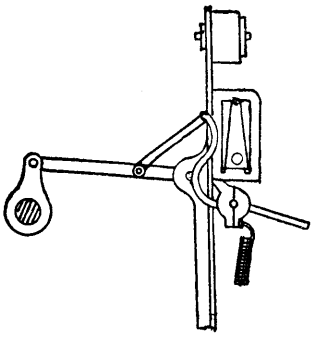


Fig. 56.

upon the amount of wear and tear. Manufacturers often look with dread at the annual bill of costs represented by the wear and tear in the picking arrangements of the looms. To begin with there is the wear and tear of the pickers, which will always be great unless the pickers are well made, properly seasoned and well used. When the nature of the work the picker has to accomplish is considered, the amount of wear and tear upon it must be evident, for not only has it to bear the strain of delivering the blow sufficient to propel the shuttle across

the loom, but it also has to act as a check upon the shuttle as it enters the box, and the shuttle tip in striking it must of course tend to wear it away; though the wear and tear in this part is not so great as might be anticipated, because, after a hole has been worn in to a moderate depth the force of the blow is not received from the extreme point of the tip alone, but practically from the whole surface. It will generally be found that pickers break most at the shoulders, more especially when they are not sufficiently pressed in making, or not sufficiently dried or seasoned.

In making pickers, the great bulk of which are made from buffalo hide, the skin must be softened so as to permit of its being readily moulded to shape, cut, punched and rivetted to the proper form and size; then subjected to great pressure so as to compress them and make them as solid a mass as possible. After this they must be thoroughly dried, and from the nature of the substance, this can only be accomplished by keeping them a long time so that the drying shall take place gradually. After that they are usually steeped in oil for a considerable period, this period should not be less than one month—but is much better if even for a longer period—after which they may be dried again; so that generally speaking a buffalo picker is not fit to put on the loom for at least six months after it is made, and if a longer time is taken the results are generally better.

The next point of interest and importance is the picking strap, and although considerable expense may be incurred through the wear and tear of the picker, much greater expense probably will be brought about by the picking strap. There are several considerations in this connection which must always receive close attention.

First the stopping of the picker without throwing too violent a strain upon the picking strap; this implies two

things, one of which has already been referred to, viz.: the exhaustion of the force some time before the picker comes up to the spindle stud, and the second is the use of a buffer to reduce the force of the concussion. Both these are items which may have an important influence upon the amount of leather consumed. In this direction, as in many others, repeated efforts have been made to minimise the difficulty, such as check straps upon the picking stick, springs and so forth, so that the picker would not be carried up to the stud with the full force of the picking stick. But practically the old fashioned buffer still holds its own. The general arrangement consists simply of a piece of leather picking strap with a number of holes punched in it and doubled backward and forward upon the spindle, so making a species of leather spring to receive the picker at each stroke. Of course what applies to pickers, as to seasoning of the material, applies equally to the picking straps, which are usually made of green, or oak-tanned leather, properly seasoned and steeped so as to give them all the strength and flexibility possible. Supposing now that every precaution has been taken as to the use of the buffers, &c., then the method of connecting the picking strap with the picker, and with the picking stick, are items to be borne in mind. The general method of attaching the picker to the strap is by passing the strap through a groove in the top of the picker and then threading it through a hole made in the end of the strap. A very cursory examination will show that as the picker is being drawn forward the strain will not be equally distributed over the whole width of the strap, but will be borne almost entirely by one side; as a consequence after the leather has stretched as far as it can fracture will occur at the tight side, and it will not be long before this goes across the strap. Then the fractured portion is cut away, a fresh hole made, and the strap re-attached, and this goes on until the strap is too short,

when the remaining portion is thrown aside to be afterwards converted into buffer leather. In attaching the leather to the picking stick the general method is to pass the leather through a slot in the end of the picking stick, coil it a number of times round the stick itself, and finally attach it to a pin. Now the question for consideration is, will such an attachment be likely to give distribution of strain over the width of the leather? In a great majority of cases it will not, but something like the same result will follow as that which arises from the method described of attaching

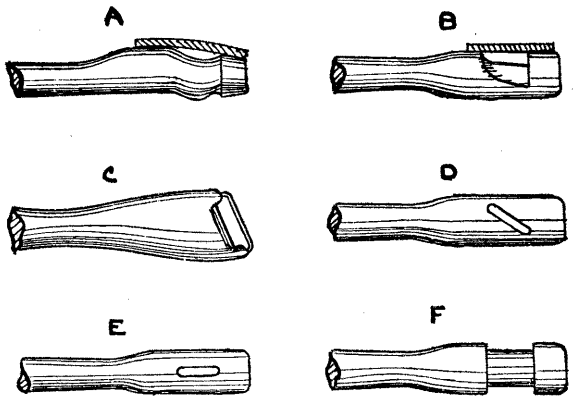


Fig. 57.

to the picker, though the wear and tear at the end of the picking stick is not, as a rule, nearly so great as at the picker. Then several methods of attachment are in use, both in connection with the picker and the picking stick, such as using a pin, or a rivet, or other means at the picker, and shaping the ends of the picking stick as shown in Fig. 57A, 57B or 57C, where the end of the stick is formed so as to obtain even distribution as nearly as possible over the width of the leather, and which if properly arranged will answer its purpose pretty completely.

57D shows simply a diagonal slot through which the leather is passed for the same purposes, whilst the most common form is shown at 57E, and another at 57F. The next item, and although of less importance as regards wear and tear than the other method referred to is the use of the check strap, yet it is still of sufficient importance in the work it has to do to call for attention. As its name implies the object of this check strap is to check the movement of the picker, and more especially the shuttle as the latter enters the box. Suppose the picker, after delivering its force, is brought back to the extreme end of the box, and the shuttle, on entering it again is allowed to come in contact with it without anything to modify the force, the result must be disastrous to the picker; a certain amount of check is given to the impetus of the shuttle by the presence of the spring or swell of the stop-rod in the back of the box, but this is not sufficient in itself, hence the necessity for the check-strap. This contrivance is simply a short strap carried over the end of the spindle and inside the box at each side of the loom, then a long strap is carried right across the front of the going part and buckled to each of the short ones; the length of this is so adjusted that as the picker goes to the back of the box at one side of the loom it draws the check strap some little distance from the end at the other side, so that each picker in turn going back to the end of the box draws the check strap from side to side, and this action, and the drag upon the picker, slight as it may appear, offers sufficient resistance to the shuttle, and modifies the force of the concussion of the picker with the box end sufficiently to prevent injury. Another important factor in the case is the tendency that would always be present of causing the yarn to fly off the bobbin or cop if the shuttle were stopped too suddenly, so that the check strap is of quite sufficient importance in the working of the loom to justify a considerable amount of

attention being devoted to its adjustment. Briefly put it may be said that neither too much nor too little play must be given to the check strap, otherwise its functions will be impaired.

With reference to the questions of the yarn flying off the bobbin, many contrivances have to be resorted to to meet this difficulty, some of which I shall refer to in dealing with shuttles, &c.; but it may be generally mentioned here that such arrangements as brushes in the sides of the shuttles, of such a kind as to press lightly upon the yarn on the bobbin are most resorted to. The strength of the brush will depend very much on the strength and smoothness of the yarn. For silk, for example, a piece of hare or rabbit skin is often used; for other yarns velvet or plush, and for the strongest, a series of hog's bristles, as in an ordinary brush. In dealing with smooth, slippery yarn, this matter often gives a considerable amount of trouble.

The most important item in connection with picking now to be dealt with, is the arrangement and working of changing boxes, which must form the subject for a separate lecture.

LECTURE 5.

CHANGING SHUTTLE BOXES.

In the lecture on picking arrangements all the details referring to the methods of propelling the shuttle have been dealt with. It now remains to deal with the various methods of changing from one shuttle to another when several yarns are employed. In the earliest form of hand loom weaving this was done by the weaver having, what he termed, a shuttle board at the side of the loom, upon which the shuttles containing the different colours of the weft were placed; these he would pick up with his hand, each in its proper order of succession; and after the introduction of the fly shuttle, by Kay, this practice still remained in vogue. Then came in a system of what is known as rising boxes, that is, a series of shelves attached to a vertical frame, each containing a shuttle, and which could be operated by the weaver by means of a simple contrivance of levers so as to bring any of the shuttles to the level of the shuttle race at will. This has remained in vogue, not only in hand looms, but is still admittedly the best system for power looms for weaving heavy goods at the present day. Another system came into vogue immediately after that, known as the Paisley sliding box. In this case the shuttle boxes were placed in a horizontal position and were actuated by the feet of the weaver instead of by the hands as in the previous case. In fast running looms, however, circular boxes have been found more advantageous.

In reality there are only two questions to consider in connection with this subject, the one is the exact moment when the change shall take place, so as to bring the shuttle required into position for being propelled by the picking stick;

the second is that of the exact method of changing from one box to another. The first question is easily disposed of, but the second involves careful consideration of a vast amount of detail; for not only must the method of changing be considered, whether the boxes be rising, sliding, or revolving, but all the mechanism connected with the system of changing, whether it should be in consecutive order, or skipping from one box to another, and also all the safe-guards to prevent accidents by false movements must be considered. Leaving the mechanical arrangements aside for the moment, the first general principle may be dealt with. It has been laid down generally that the shuttle should leave and re-enter the box at a point when the going part is mid-way between the front and back extremities of the stroke. That being so the time for changing the shuttle box is easily determined. A shuttle has entered the box as the going part comes forward to the cloth, and at the point indicated, and another shuttle, or the same, must be propelled from the box again at the corresponding point in the return. Therefore the time when the change must take place is definitely fixed as being that when the reed is actually in contact with the cloth, the movement commencing slightly before, and being completed slightly after passing that point. This determines the actual time within which the change must be made, but in many cases some little allowance must be made for the return of the picker. This may not be very much, still it must not be overlooked. Wherever direct acting picks are employed, as in some of the under-picks already mentioned, the return of the picker is very prompt, partaking as it does of almost a positive motion, but the over-pick loom is not so prompt in the return, as the slack of the picking leather must be taken up in full. This loss of time however is comparatively trifling, though it should always be reduced to a minimum, so as to give as much time as possible to the movement of

the box; whether we are working with circular or rising boxes, everything must be done that is possible to reduce the amount of jerkiness in the movement. In the earliest form of circular boxes this was extremely difficult to deal with. Perhaps this will be better understood by reference to Fig. 58, which gives a view of one of Hattersley's

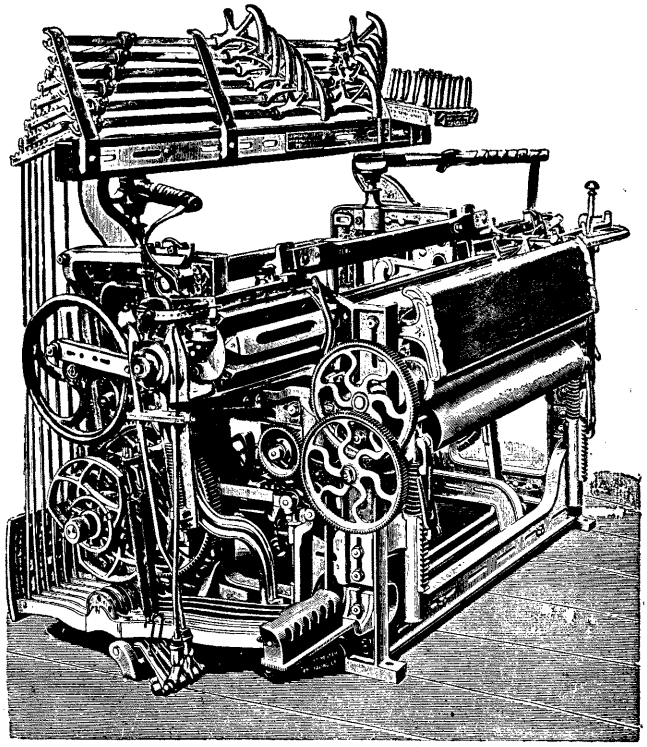


Fig. 58.

ordinary plain box looms. There are six holes in the box represented, and the box is so arranged, that it can be pulled over by means of the two catches, or pawls, as seen at the end, acting upon a toothed circular head. This will be more clearly seen in the detail drawing at Fig. 59, where the arrangement of the levers, and the teeth upon the circular

head, is such, that the box is pulled round a distance exactly corresponding with one hole in the box, and also showing the arrangement of the hammer, with a helical

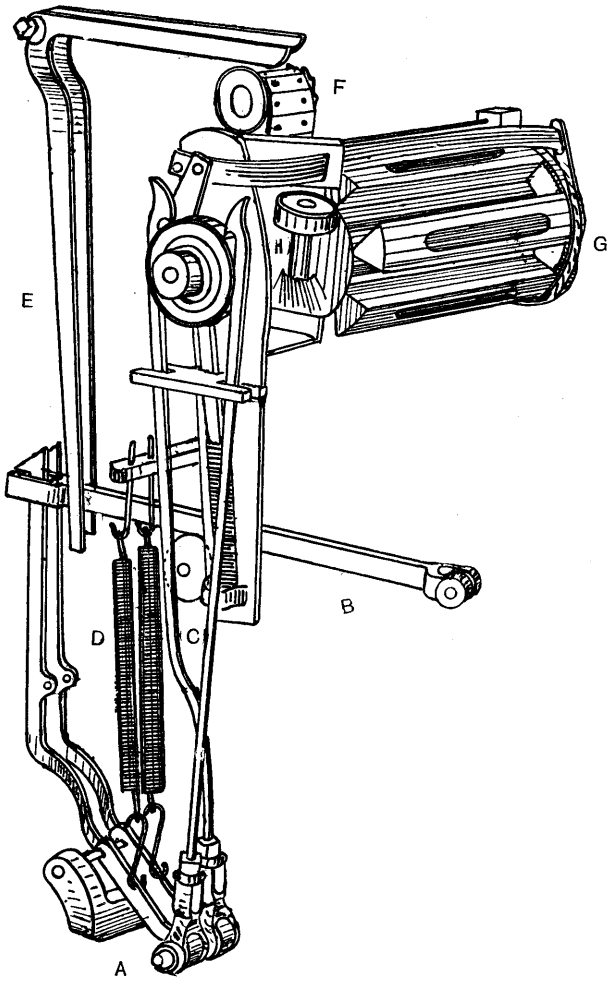


Fig. 59.

spring on its vertical spindle, keeping it in contact with the projections upon the head, in such a manner as to hold

the box firmly in position whenever one of the holes is brought opposite the shuttle race.

It would be well for the moment here to make a comparison between this method of working and some of the earlier forms of box looms. Here it will be seen that the box is pulled gently over, whereas in the earlier forms it was simply forced over by being brought into violent contact with a fixed lever on the loom end. Suppose for a moment that instead of the box head, as shown in the illustration, that two ratchet wheels were placed, one having the teeth pointing in one direction and the other in the opposite direction; then two catches or levers are placed upon fixed spindles at the loom end, so that they can be brought into play, one to come in contact with one of the ratchet heads and the other with the other ratchet head, at will. Then supposing the box is required to be turned, the upper or lower catch would be brought into contact with the ratchet head, just as it was desired to turn the box forward or backward, and as the going part comes forward towards the cloth the ratchet head comes in violent contact with the lever, so forcing the box over. This class of box loom is very appropriately termed the "tupper." The liability to breakage and the general interference with the working of the loom by this system of "tupping" will be easily understood, but it has the one quality of determining definitely the exact moment of turning, as it must be evident that the box must be turning exactly when the reed is in contact with the cloth. Therefore the operation is completed in a sufficient time to allow the box to be settled steadily to rest in its position by the time the shuttle is to be propelled from it. In the illustration shown here the movement is easier, but requiring quite as much attention and skill on the part of the overlooker in its proper adjustment. Now look for a moment at the details: the two long catches which serve to turn the box are

fulcrumed at their lower extremity to an end of levers A of a peculiar bent shape. The upper end of this bent lever has a catch upon it which is passed through a slot in the end of the lever B. This lever B is acted upon by a cam C upon the tappet shaft, and is raised at every pick of the loom; so that should one of the two levers A have the catch thrown over the end of the lever B it would pull the box over one hole forward or backward as required; then the lever A would be returned to its normal position by the spring D. The method of operating the levers A is by means of bell crank levers E. Each of those levers E having a pin at the upper extremity so arranged that it may drop into a hole on the card cylinder F. A set of cards are placed upon the cylinder perforated in such a manner as to cause the box to turn in the required direction. Suppose, for instance, that the box is required to be turned forward, then a hole left in the card under the lever acting upon the front catch will cause that catch to be pulled by the lever B. Or if it is required to be turned backwards the other catch will be operated in a similar manner, so that broadly speaking the arrangement of cards would be as follows:— Suppose the pattern to be made is a common check, in two colours, and say there are eight picks of each colour alternately, one shuttle would be placed in the box and seven blank cards would allow the box to remain stationary for that number of picks; on the 8th card a hole would be cut to cause the front lever to pull the box forward, when the second shuttle would be brought into play; again seven blank cards allow it to remain in that position, and at the 8th the back lever is pulled over, so returning the box to the position of the original shuttle. Consequently there are as many cards required as there are picks in the pattern. It should be said here that the reference is to a loom having a box at one side only, each card will act for two picks of the loom, or as it is commonly spoken of as one double pick. It is

necessary to make this explanation otherwise the reader might be under the impression it was a double box loom. There being a box at one side only it is obvious that the pattern must be in double picks. The method of giving instructions to the card-cutter will be as follows:— $\frac{8F}{8B}$ $\frac{}{16}$ indicating clearly to him that at the 8th card the box must move forward, and at the 8th again from that point it must move back. Of course in working with two shuttles the system is perfectly easy, but with a number of colours it becomes somewhat difficult as the designer of the pattern must so arrange his colours that he can move from one to the other with perfect ease. In many cases, although only three or four colours are employed, all the six holes in the box may require to be used, simply because they must rise in regular succession. There is no provision made for skipping from one shuttle to any other, consequently the box will have to be revolving continuously in one direction, or it may have to go a certain number of holes in one direction and then return; extra shuttles being introduced for the purpose of bringing the correct colour up when required. For instance, the two checks on the coloured plates will readily illustrate both these features, and the method of cutting the cards to produce the required pattern.

The first of these is the Tartan of Cameron of Erracht, and as will be seen, contains five colours. Yet it is necessary to use all the six boxes, because of the position in which they fall in relation to each other. The pattern would be as follows:—

Box.	Threads.	Colour.	Movement.
1	16	Black	F
2	2	Red	F
3	16	Purple	B
2	6	Red	F
3	6	Purple	F
4	4	Yellow	B

Continued.

Box.	Threads.	Colour.	Movement.
3	6	Purple	B
2	6	Red	F
3	16	Purple	B
2	2	Red	B
1	16	Black	B
6	16	Green	B
5	6	Red	F
6	4	Green	B
5	2	Red	F
6	8	Green	B
5	2	Red	F
6	4	Green	B
5	6	Red	F
6	16	Green	F
	164		

Then the black is placed in box No. 1, and each other in succession for the first portion of the pattern, but when the second portion comes on we cannot get from the green to the red shuttle without skipping, and as the box is not made to skip, but to move one hole at once in either direction another red shuttle must be put in, thus permitting the perfect working of the pattern.

In the next, which is the Tartan of the Clan of Munro, the method of working is even more notable. In this there are only four colours, red, yellow, purple and green, yet six shuttles are again necessary; there must be two red and two purple shuttles. Then it will be seen that the box makes practically a complete revolution in one direction and then one in the opposite, so as to bring all the shuttles into play in their proper order.

I have selected some of the most difficult to illustrate the point clearly. Generally there is little trouble, but it is well to know thoroughly the principles.

The following is the pattern and working:—

Box.	Threads.	Colour.	Movement.
1	48	Red	F
2	2	Yellow	F
3	4	Purple	F
4	8	Red	F
5	32	Green	B
4	8	Red	B
3	4	Purple	B
2	2	Yellow	B
1	8	Red	B
6	16	Purple	F
1	8	Red	F
2	2	Yellow	F
3	4	Purple	F
4	36	Red	F
5	4	Green	B
4	4	Red	F
5	4	Green	B
4	4	Red	F
5	4	Green	B
4	36	Red	B
3	4	Purple	B
2	2	Yellow	B
1	8	Red	B
6	16	Purple	F
1	8	Red	F
2	2	Yellow	F
3	4	Purple	F
4	8	Red	F
5	32	Green	B
4	8	Red	B
3	4	Purple	B
2	2	Yellow	B
	336		

Several features of this arrangement may now be examined in detail, some of them are of apparently trivial importance, yet they should all be thoroughly understood to enable one to arrive at a proper grasp, not only of this particular machine, but of other and more intricate ones which will have to follow.

Now first with regard to the levers E. They must be so constructed that the weight of the arm towards the card cylinder F is sufficient to bring the levers A, with their catches, over the end of B when required; and yet this weight must not be so great as to throw too much pressure upon the cards. Of course, from the very form of the levers, this is not difficult of attainment, but a little more difficulty may exist in regard to the levers A. In the first place they must be jointed to a faller as indicated, otherwise of course the levers E could have no power over them, and again, from the peculiar position, and the bent form it must assume to bring it from the loom side to the extremity of the box end, as will be seen in Fig. 58, renders it of the utmost importance that care should be taken both as to the proper adjustment of leverage and the position of the fulcrum. There are two considerations here which must not be overlooked, one in relation to the position of the fulcrum of the catches which turn the box, and the other with regard to the character of lever B and its work.

We will take the position of the two catches first. The question has often been asked why does the box turn more rapidly as the reed comes up to the cloth than it does when moving in the opposite direction? A careful examination of the position of the sword of the going part, the fulcrum of the long catches and the manner in which they work will readily explain this. Suppose the fulcrum of the catches is placed too far forward as the going part goes back, receding from the vertical line, the catch acting

upon the back of the box causes it to move more rapidly than the opposite catch would in the forward movement. This is self evident as it is practically equivalent to a shortening of the catch which has its fulcrum placed at some distance in front of the turning point. Now reverse the position and place the fulcrum of the levers behind that of the sword of the going part, and the box will revolve more rapidly in the forward movement than in the backward one, so that the whole question resolves itself into one of the proper placing of the fulcrum of the levers, a careful adjustment of the length of the levers or what is equivalent the length of the catches themselves; as from the position in which they are placed and the nature of work they have to do they become practically part of the lever arm. Now as to the second point it has been shewn already that when a blank card is placed upon the cylinder no movement of the box takes place, but when a hole is cut opposite one of the levers E the box is made to turn in one direction or the other. Now suppose the possibility of an accident arising; one common form of cards in use for boxes of this kind has both holes cut and a clasp of tin or other material is used to cover one of them, so that the same set of cards may be used over and over again. Suppose this tin clasp is either left off or falls off, then both levers will drop and both of the levers A will be brought into action, each trying to turn the box its own way; then breakage must occur unless provision is made to prevent it. This provision is made in the form of the lever B which is made in the form commonly known as a "broken backed" lever as shown in Fig. 60. Anywhere near the centre of the lever a hinge is formed and on one side of the hinge there is a projection, or lug; from this lug a strong spring is attached to any point on the other side of the joint, so that as the cam C revolves and raises the lever it will bend at the hinge, or joint, and

return by the strength of the spring, so that all risk of injury or damage is avoided.

One point here must not be omitted. It has been already said that the box may be caused to revolve continuously in one direction. A difficulty would arise with regard to the disposal of the weft threads if the box were carried upon a spindle which went entirely through it. This is not the case. A spindle certainly is inserted in the box and extended beyond the point where the catches act upon it, but it is not passed through the other end of the box, the end nearest the cloth is carried in a spring holder as shewn at G in Fig. 59. This holder is firmly fixed to the framework of the going part on the lower

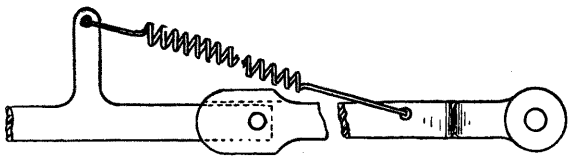


Fig. 60.

side, and to the back at the sword, but the front portion is left practically free. The form is such as to cause it to embrace a little more than one half of the periphery of the box itself, and a corresponding band encloses the box to ensure easy working. Then the upper extremity or the free end of the holder has a loop formed so as to permit of the passage of a check strap as shewn in the illustrations 58 and 59. Inside each hole in the box a small spring is placed for the purpose of steadying the shuttle as described in Lecture 2, and behind the box a couple of rollers are placed marked H, for the purpose of pressing the shuttle gently back as the box revolves, in the event of its having been driven too far in by the force of the pick. With reference to the spring at the back of the

box, something will have to be said in a subsequent lecture when dealing with the safety motions, such as stop rods and loose reeds. At the present moment of course it must be understood that the function of this spring is simply to steady the shuttle and keep it firmly in its place. Another feature of the arrangement will now strike the most ordinary observer. The bulk of the box and the mass of machinery attached to it, projecting as it does some distance from the sword of the going part, will suggest a difficulty in keeping it steady and well balanced. This is overcome by two provisions, the one is a bent arm extending from the rocking shaft to the extreme end of the box, and the other is a steadying crank from the fly wheel also to the end of the box, so that, between the two, the one extremity of the box is held as firmly in position as the other, so preventing vibration and enabling the loom to be run at a high rate of speed.

Another feature of the ordinary revolving box must be looked at next. In the one already dealt with the box changes only at one side of the loom, so that it could only weave patterns having an even number of picks of each colour; frequently it becomes necessary to have odd picks introduced more especially in making fancy goods. Then there must be changing shuttle boxes at each side of the loom. To accomplish this the two boxes at each side of the loom are sometimes connected by toothed gearing and a shaft running across the loom; this simply ensures the boxes working simultaneously, but accompanying it another provision also must be made. In using double box looms the picking arrangement must be so contrived that the shuttle can be sent from either side of the loom at will. This is generally done by having a contrivance connecting the box cards with the picking tappets. The most convenient arrangement and the one most generally adopted is to have a fixed disc to the lower shaft and a free sliding tappet;

the tappets at each side of the loom are connected together, so that the moment one is disengaged from one disc, the other is engaged with the opposite disc. The whole arrangement consists in having the two sliding tappets connected by a rod and a lever attached to them which can be actuated by the box cards in the same manner as the lever described in Fig. 58, and a notch in the rim of the disc which will take hold of the tappet, as soon as brought

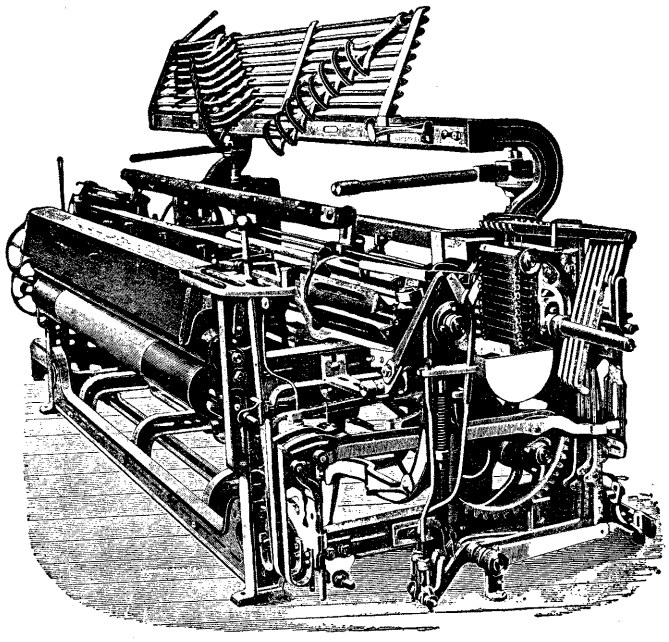


Fig. 61.

up to it by the lever, and so cause it to revolve and deliver a blow to the picking cone. There is little more to be said of this arrangement as it is simply an extension of the single six shuttle box. Of course as will be readily understood it gives an immense power of pattern producing from the mere fact that not only can six shuttles be employed but that any number of picks can be inserted

by each shuttle at will. Another arrangement for pick and pick looms is shown at Fig. 61, where there are six boxes at each side of the loom, each of which can be moved independently of the other. The movement of the boxes is controlled by a chain of pattern cards and the picking of the shuttle is also under the control of the same cards, so that the shuttle can be sent from either side of the loom in conformity with the movement of the box.

As will be seen there are six levers to be acted upon by the pattern cards, two for operating the tappets to control the picking so as to bring one or other into play at will; two for actuating the box at one side after the manner described in Fig. 58, and two for actuating the box at the other side in like manner.

By this contrivance any number of the shuttles may be made to follow each other from one side, or by a judicious arrangement of the movement of the boxes any number of shuttles up to eleven may be used, though great skill would be required in the arrangement of the pattern. Still these looms lack the skipping arrangement which will have to be described presently.

Before entering upon the details of the skipping box it will be as well to examine another feature in the arrangement of ordinary box looms. In weaving handkerchiefs or other articles having cross borders a pattern is formed at each end distinct from that of the middle of the handkerchief, and that would involve, in the ordinary box loom we are dealing with, the employment of two sets of pattern cards, which would have to be changed by hand each time the pattern was changed from border to ground; the object of this invention is to make the change automatic. There are two sets of pattern cards one corresponding with that shown in the illustration Fig. 58, which is cut for the pattern constituting the small check of the ground, and which may be repeated any number of times required for

the length of the handkerchief. Suppose, for instance, the ground contained, say 200 picks in the pattern, and twenty repetitions of this pattern would be required to form the ground of the handkerchief. Then the cards would be worked ten times forward and ten times backwards. Then the pattern cards for the border would be attached to those of

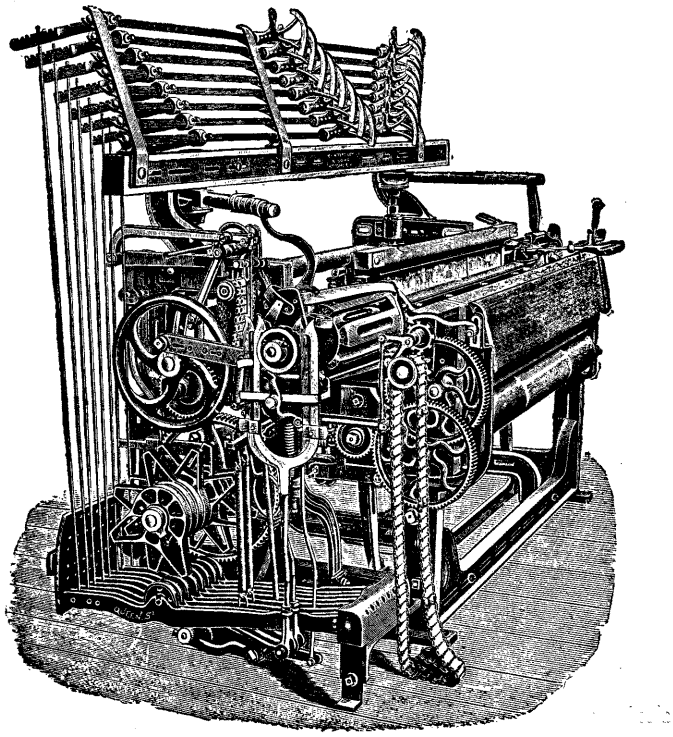


Fig. 62.

the ground and as soon as the ground pattern is completed the border cards are brought upon the card cylinder and they in the same manner would be repeated as often as necessary for the completion of the fabric. The contrivance is simply as follows:—The cards placed upon the usual card cylinder consist of the two sets, for the ground and border

respectively, and acting upon the box in precisely the same manner as in Fig. 58. But a second set of cards working from the cylinder at the front of the loom, as shown in the illustration Fig. 62, will cause the operating catches to be reversed. This will be understood by an examination of the details shown in Fig. 63. Each of the pulling catches is made double, so that it can pull the box backward or forward at will, and these are so coupled together that by means of the lever, actuated by the projections on the

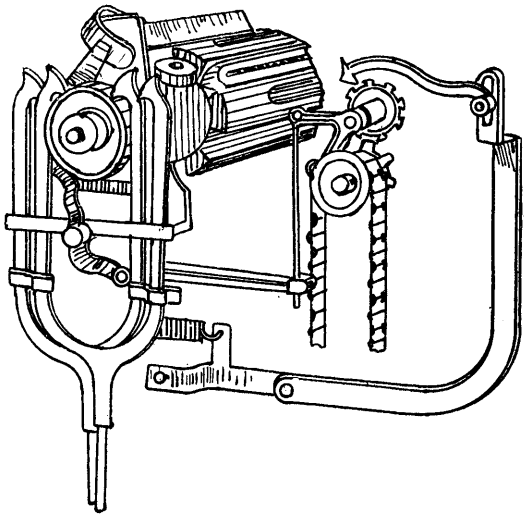


Fig. 63.

chain at the front part of the loom, their order of working is reversed. Suppose for a moment that the chain is working in the ordinary course as it would be in Fig. 58; each of the levers will operate the box in its ordinary manner, pulling it forward or backwards, and so long as the links in the front chain are of the ordinary kind this will continue, but the moment the links have a projection placed upon them then the conditions are reversed, and the box would

be caused to revolve in the opposite direction. The secondary chain is moved one card with each repetition of the pattern chain, so that by the simple insertion of a peg into the secondary chain the pattern chain can be reversed in its working, and thus any number of repetitions of the pattern can be made without any increase in the number of cards; hence both a large saving of cards and economy of space are secured.

SKIPPING BOXES.

When the principle of the ordinary circular boxes is understood little more is required to understand the action of the skipping boxes. As the name implies, this box is arranged to enable us to skip from any one shuttle to another in the series, but it must not be supposed that it is necessary to skip over the whole circle. For instance we have six holes in the box and we can move it either forward or backward, so that if we have the power of moving any number from 1 to 3 in each direction we have the power of reaching any shuttle at will. Let it be supposed, for instance, that we have No. 2 shuttle in work and we wish to skip to No. 4, then we should have to pass over one, or move two boxes; to go to No. 5 we should have move three boxes, and to go to No. 6 we should go two boxes in the opposite direction; so that it is quite clear that we have no trouble in reaching any one of the boxes required. Numbers of arrangements of mechanism have been attempted but none have attained the same degree of perfection as the one shown in the illustration Fig. 64, of Messrs. Hattersley, of Keighley. This machine is perfect, not only in the certainty with which the box is changed from any one shuttle to another, but also in the ease with which the change is accomplished. As will be seen here, there are three principal levers. The first P being for turning the box either backward or forward, the second L being for locking the box firmly in

position, and the third R for determining the direction, or reversing the movement of the box. Each of those levers is provided with a corresponding lever acted upon by the card cylinder C, exactly as in the ordinary box. Attached

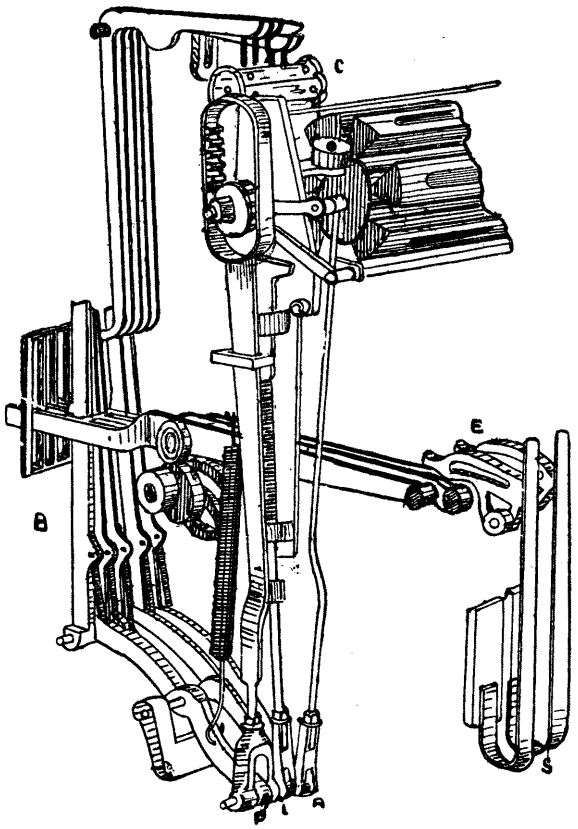


Fig. 64.

to the operating lever is a vertical bar with a toothed head, so arranged as to act upon a toothed wheel at the end of the box; this toothed head is so contrived that when in its normal position, and held by the strong spring, as seen, it

would pull the box forward, but if it is desired to reverse the motion then the reversing lever would engage the set of teeth on the opposite side at the lever head, disengaging those in the front, and so cause the box to be pulled backwards. It will be necessary to follow carefully the levers acted upon by the cards, and their connection with the pulling, locking, and reversing levers, as well as the arrangement of the lifters; the pulling and reversing levers are both connected, or passed through the end of one of the lifting levers so that the locking bar is removed at all times when the box is to be turned, and along with it the reversing lever may or may not be used; but the reversing lever can never be brought into play without the locking lever being operated at the same time. To the free end of the pulling lever there are three vertical catches, and the lifting levers connected with them are so arranged that it may be operated by any one of three cams. Suppose the box is to be turned one hole then a cam would lift the first of the levers just a sufficient distance to give the amount of movement required; if it must be turned two holes a larger cam moves it a greater distance, and if it must be turned three holes then a still larger cam is used. Then the method of selection is easily determined. First we have the card cylinder, and we have all the bell crank levers, with their pins corresponding to the holes so that we have only to cut the cards in such a manner as to first determine the direction of the box by acting upon the reversing lever, which will at the same time remove the locking bar, and then cut a hole corresponding to the lever which will pull the box over one, two or three holes so as to bring it to any shuttle we may desire. Now suppose we are weaving a tartan plaid, say for instance, the Victoria Stuart, or sometimes called the Dress Stuart, one of the most difficult tartans to weave, not merely because of the variety of colour, but the necessity of skipping from

one shuttle to another, then the arrangement for the card cutting will be as follows :—

The pattern is shown on the plate opposite, and consists of a white ground with blue and red lines, a green check edged with black, and yellow and white lines; this having in turn a red check with black and white lines. There are therefore, six colours, viz. :—white, blue, red, black, yellow, and green. Now let the number of threads of each be as follows :—

Threads.		Colour.
8	...	White
8	...	Blue
32	...	White
4	...	Red
32	...	White
8	...	Blue
8	...	White
8	...	Black
2	...	Yellow
4	...	Black
2	...	White
4	...	Black
12	...	Green
8	...	Red
2	...	Black
4	.	Red
2	...	White
4	...	Red
2	...	Black
8	...	Red
12	...	Green
4	...	Black
2	...	White
4	...	Black
2	...	Yellow
8	...	Black
196	threads in all.	

One good practice may be observed here: divide the pattern into its leading parts by marks on the left as shown, so that the eye can follow the pattern in writing as readily as it can in the actual colours. It must be borne in mind that in making patterns the designer or pattern weaver has not always the actually coloured pattern before him, and he must therefore have something to assist his imagination.

The pattern having been written down in this manner the next proceeding is to determine in which shuttle-box to place each of the successive colours. Some would say make the plan of your shuttles first and then proceed to determine the movements. Probably it is easier to do the two things at the same time, thus. Write down the pattern as already done, then begin with the ground weft in No. 1 box, thus:

Box.	Threads.	Colour.	Movement.
1	8	White	F1
2	8	Blue	B1
1	32	White	B1
6	4	Red	F1
1	32	White	F1
2	8	Blue	B1
1	8	White	F2
3	8	Black	F1
4	2	Yellow	B1
3	4	Black	B2
1	2	White	F2
3	4	Black	F2
5	12	Green	F1
6	8	Red	B3
3	2	Black	F3
6	4	Red	F1
1	2	White	B1
6	4	Red	B3
3	2	Black	F3
6	8	Red	B1
5	12	Green	B2

Continued.

Box.	Threads.	Colour.	Movement.
3	4	Black	B2
1	2	White	F2
3	4	Black	F1
4	2	Yellow	B1
3	8	Black	B2
	196		

White being the ground is the most convenient starting point, therefore we may call the box in which it is placed No. 1; this means nothing but that the first box in which a shuttle is placed is numbered 1. It may be any one of the six. Then blue is the next colour, therefore move the box forward one hole when the requisite number of picks of white have been put in. To indicate this to the card cutter place F1 to the right of the line, and the number of the box containing the colour to the left. When the blue is woven in the box must return to the white, therefore opposite blue write B1. Then red comes next, and as the red comes in the centre of the white, or it may be said the white is between blue and red, then put the red shuttle in No. 6 box, therefore the box must move back one from white to red, and so on till the white ground and its lines are woven. Then come the yellow and white lines upon black, so yellow must go into No. 4 box; after that the red check on green, so green must go into No. 5 box, so placing it within reach of all the other colours. Now the lettering and numbering to the right must be made so as to bring up the required shuttle at the proper time. From red to black three boxes must be moved, from green to black two boxes, and so on. Now go over the whole and the same number of movements will be found to have been made in each direction. It does not follow, however, that this is necessary, as in some patterns the box, as already pointed out, must make more or less continuous movement in one direction.

By this method of working, any check, however elaborate, may be arranged in a few minutes, and with very little risk of mistakes.

It will be seen then from this brief description, that although at first sight the mechanism is of a most intricate character, yet in reality it is simple and easily understood. One word should be said as to the safeguards, which are prominent in this as in other box looms, in the event of the pulling levers being brought into play accidentally without the locking bars having been removed. The lifting levers are fulcrumed near the front of the loom upon a peculiarly shaped joint, behind which are very strong steel springs, and should the levers, by any means, be put into action without the box being able to turn, this joint will give way, throw the spring back, and instantly the pressure of the cam is released the spring will force the lever back into its normal position. This is generally accompanied by a sufficiently loud noise to call the attention of the weaver to the fact that something is wrong. There are several forms of skipping boxes in use, but in nearly every case they are based upon the principles involved in this, and only differ from it in slight matters of detail.

Very frequently the boxes are operated from the Dobby or Jacquard, in fact it sometimes becomes a necessity. Suppose, for instance, a figured pattern is being made where various colours of yarn are used, and the boxes and figuring machine working independently, the slightest error on the part of the weaver, the turning by accident of the figuring or the box cards, even only one card, and the two cease to work in perfect unison; and in spite of every precaution this may happen at any moment, but if the boxes are worked direct from the Dobby or Jacquard there can be no risk of such accidents. The same cards which control the figuring control also the shuttles.

This is very easy of accomplishment. Hooks are set apart in the machine corresponding with the number of levers employed to act upon the boxes. A corresponding number of extra levers are placed in front of the Jacquard harness or healds. One end of these levers is connected with the hooks in the figuring machine, and the other end attached, or made to act upon the lever which would otherwise be actuated by the box cards; then holes are cut in the figuring cards to correspond with the hooks set apart for the box work, and the levers are actuated in precisely the same manner as they would be if an independent set of cards were used.

Harness or Dobby looms are generally fit up in duplicate so that the boxes can be worked either with their own cards or from the figuring machine.

RISING BOXES.

In dealing with rising boxes a difficulty arises from the multiplicity of systems used, but in principle they may be reduced to two, one of which we may describe as the negative motion and the other as a positive motion. Again each may be sub-divided in such a manner as to indicate the method of operating. For instance, in the negative motion we may have a lever fulcrumed at one end near the back of the loom, and attached to the box by a connecting rod at the other end, and a lever connected anywhere between those points which is attached to a third lever. This second lever may then be caused to rise and fall, either by means of tappet chains or plates; or it may be that the lever to which the box is attached is balanced by a weight at one extremity, nearly equivalent to the weight of the box itself, and the fulcrum placed anywhere near the centre; then motion may be communicated

All the circular boxes shown here are made by Messrs. Hattersley, of Keighley, and no greater compliment could be paid them than the fact that as soon as their patent in the skipping box expired, all the leading makers of circular box looms adopted their system in a greater or less degree.

to it either by means of a chain, or non-positive cams, which may be brought into action through the medium of card cylinders, somewhat similar to those in use in the circular boxes.

Boxes of a positive type may be acted upon by grooved cams, each cam determining whether the box should be raised one, two or more holes, or what is equivalent, by a series of eccentrics. Perhaps the principle of the positive boxes will be more readily understood if the non-positive is thoroughly dealt with first. One of the earliest forms of the non-positive motion, and upon which all others have been based, is known as Diggle's chain. This contrivance will best be understood by reference to Fig. 65, which shows an end elevation of the loom or at least that portion of it having direct reference to the box, and a full view is shown at Fig. 66, to work up to four shuttles. B is the box carried upon the rod from the end of the lever A. C is a rod connecting the lever A with the upper lever D. F is a star wheel driven by means of toothed wheels from the crank shaft, and in such a manner that at every revolution of the crank shaft the star wheel is carried forward one tooth, corresponding with the size of the link of the chain. The chains are so arranged that there are several heights, or projections, in the links and are made interchangeable, so that as each one comes under the lever D it determines the exact position of the box. Suppose, for instance, the box has four shelves, or made for four shuttles, then there would be four heights in the links each corresponding with the depth of the shelves of the shuttle-box, so that if we call the links 1, 2, 3, 4, and the boxes 1, 2, 3, 4, counting from the top box or shelf, No. 1 link will allow the box to remain at its lowest point; No. 2 link will raise it so as to bring the second shelf on a level with the shuttle race; No. 3 would raise it to the third shelf, and No. 4 to the fourth. So that

to bring any shuttle required it only means placing the links in the order required for the pattern. The different parts of the chain for actuating the box are shown at Fig. 67, consisting as they do of links of various heights and forms, and pins and connections for holding them

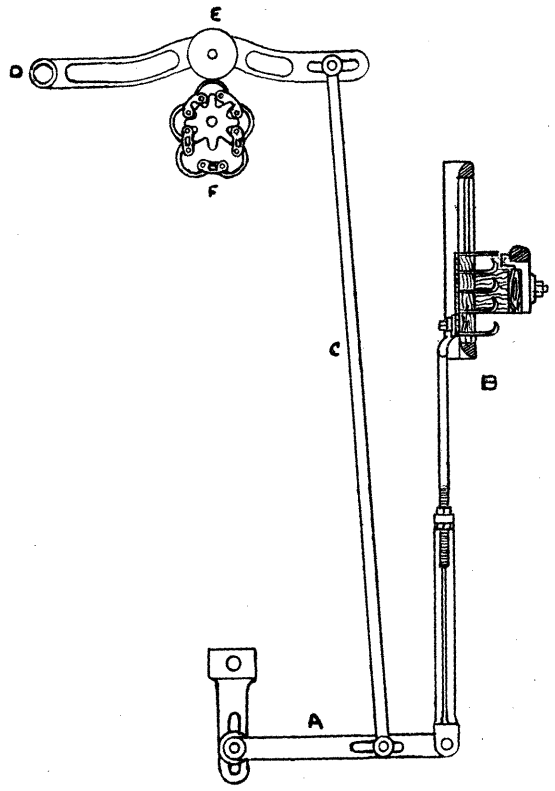


Fig. 65.

together. From these it will be seen that any variety of combination may be made and any one box kept in position as long as desired. The chain must of necessity have as many links as there are picks in the pattern. One feature

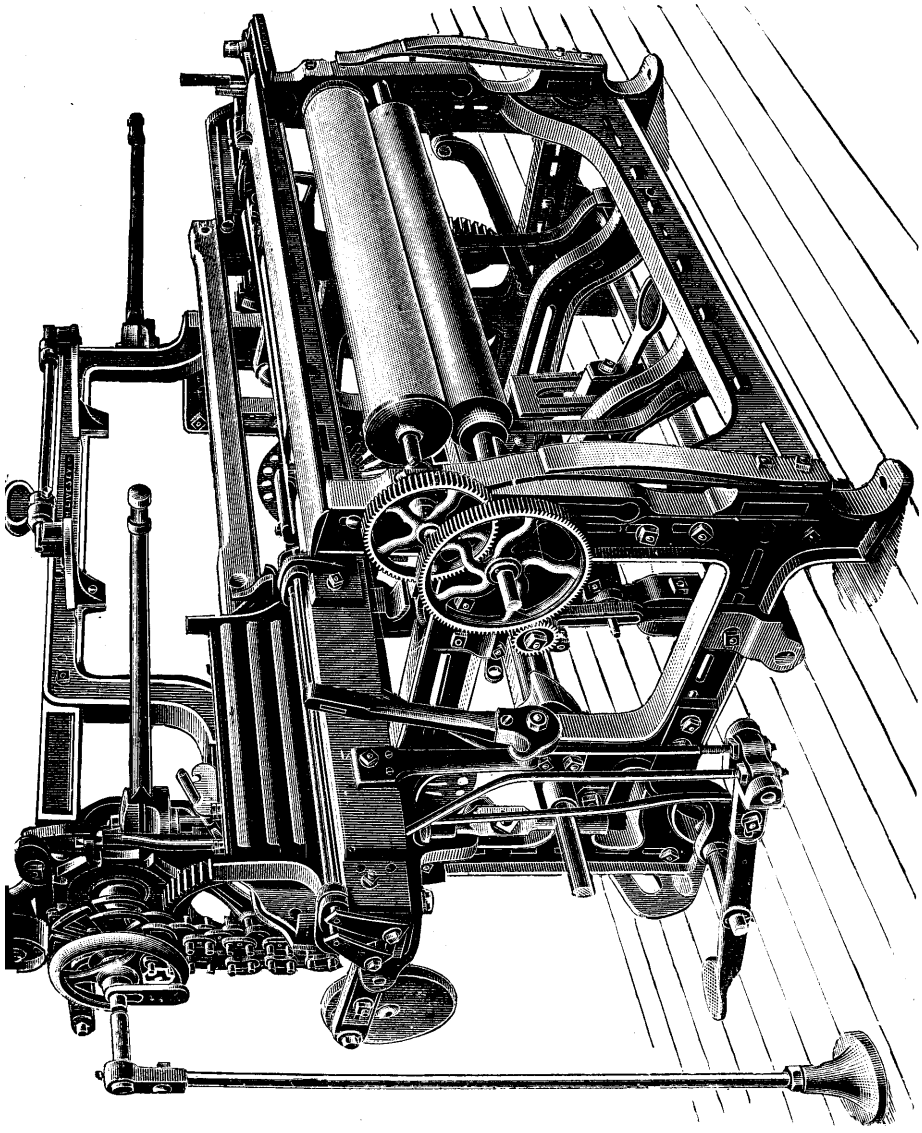


Fig. 66.

in this class of loom, and which is common to all negative motions, must not be overlooked or treated too lightly, the box is raised by the direct action of the chain, which is simply a non-positive cam, but it must fall by gravitation, and this fact alone renders it an unsafe arrangement. If the parts are so carefully balanced as to ensure easy working then there is considerable risk of hesitancy in the box dropping; on the other hand if this is sufficiently weighty to ensure its dropping, then power is required to raise it, and as a consequence wear and tear. The latter alternative is certainly the best as ensuring something like perfection of working.

The system possesses several disadvantages, one of which is, the difficulty in moving the box from any one position to another to change shuttles or when the weft has run out. Theoretically it can be done at once, but practically, as a glance at the details will show, it involves some labour and also some loss of time. Another disadvantage of this system, in making large patterns, is the enormous weight of the chain, as well as the time and labour involved in putting them together on a change of pattern taking place. But in spite of the disadvantages accompanying it the system has been in use now for about half-a-century, and still looms are being made where the principle is kept, although some of the details are varied.

KNOWLE'S CHAIN.

The next following chain motion is known as the Knowle's chain, and applied to the "Hollingworth and Knowle's" looms as made by Messrs. Hutchinson and Hollingworth, Limited, of Dobcross. The arrangement is in reality a combination of levers and chains; take the Fig. 68 and we have a chain there carried upon a cylinder A operating the lever at B, this again is made to act upon a rod, one end of which is carried by a toothed wheel C,

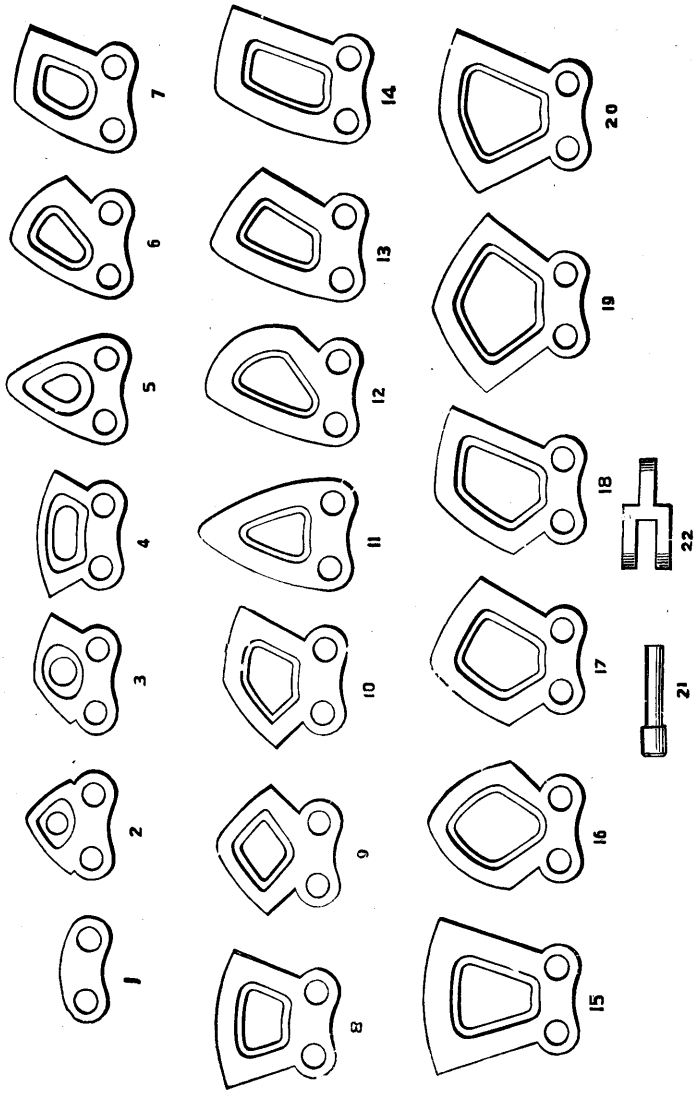


Fig. 67.

and from the end a long lever is carried downwards as shown at D, and to a point near the centre of this a chain E is attached, carried over the pulley F and the guide pulley G to the shuttle-box, or a lever connected with it. Then these connectors operate the two levers D and H—the roller F being attached to one end of the lever H. Then by altering the relative position of the two it is possible to bring any one of the four shuttle-boxes into

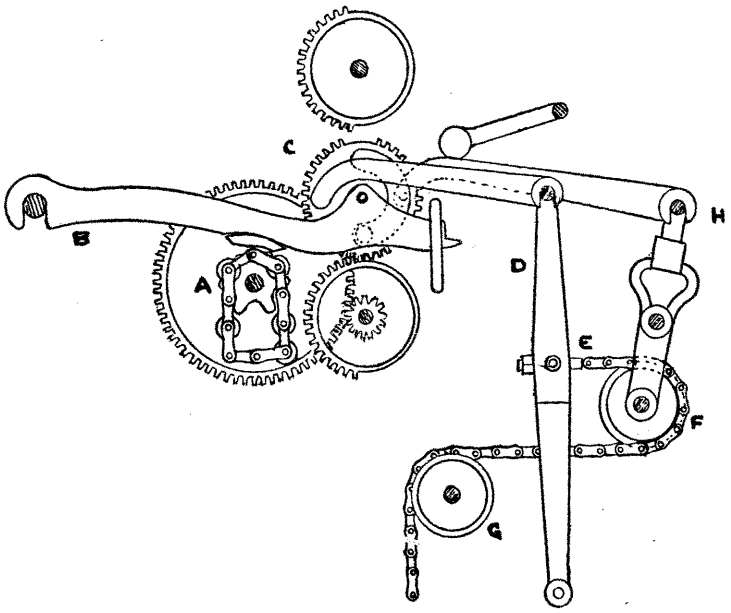


Fig. 68.

position for working. The details of the operation are as follows:—Above and below the wheel C are placed two wheels, each having teeth on half their periphery, and revolving in opposite directions—they form in reality part of the dobby motion, which will have to be described fully later. The wheels C are really a series of thin plates turning freely on a centre pin. The vibrator lever B

consists of two thin plates rivetted together and between which the wheel C is placed. The lever B will be raised or depressed by the chain A, a roller bringing the wheel C in contact with the toothed wheel above and a link with that below. In the wheel C a semi-circular slot is cut and a rivet in the plates forming the lever B will prevent it turning too far in either direction. A connecting bar is now hinged to the wheel C and the lever D, and in like manner the lever H is connected to a wheel plate. By raising the lever B the connecting arm of the lever D or H

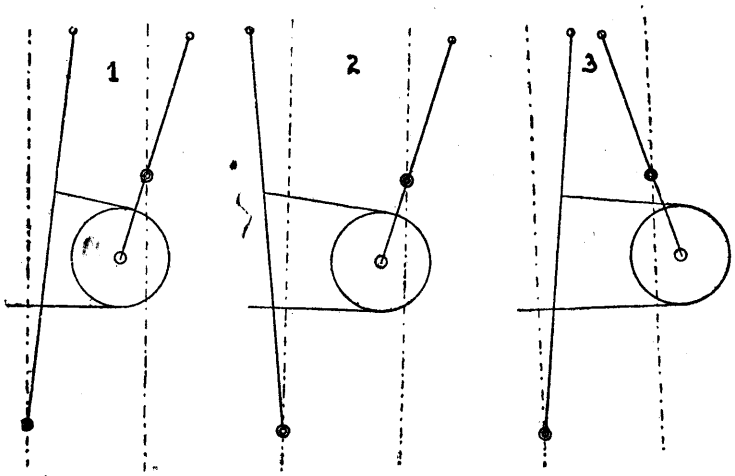


Fig. 69. *Fig.* 70. *Fig.* 71.

would be carried to one extremity or "dead centre," through the medium of the wheel above, and on being lowered it would be carried to the opposite extremity through the medium of the wheel below, so that either or both of the levers may be placed at the front or back extremity at will. It will be noticed that on the wheel C a tooth is omitted at one side of the wheel and several at the opposite side, so that when in gear, say, with the lower wheel, the upper one can revolve freely and *vice versa*.

Now let it be supposed that the box No. 1, that is, the upper box in the series, is in position when the pins connecting D and H are at the front extremity of the stroke as shown in Fig. 69. The second box when H is at the front and D at the back as in Fig. 70. The third box when H is at the back and D at the front as in Fig. 71. And the fourth box when both are at the back as in Fig. 68, or the reverse of Fig. 69.

The description given here applies to four boxes, but by the multiplication of levers, as shown at Fig. 72, which is for six boxes, any number of shuttles may be used.

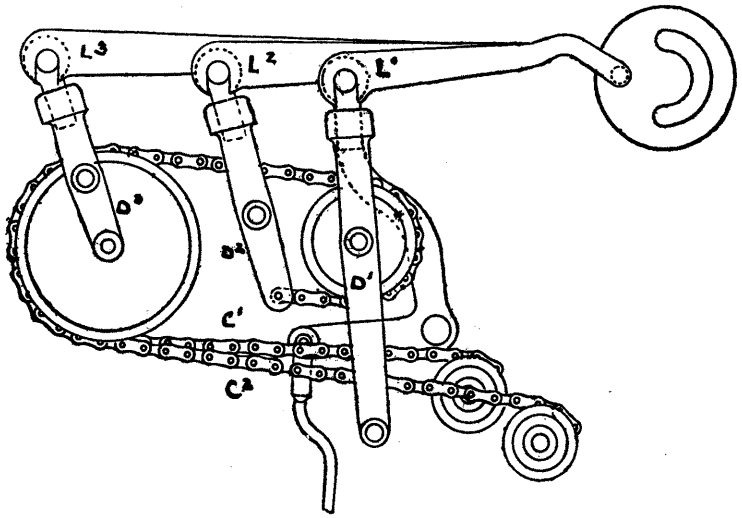


Fig. 72.

In this illustration all the wheels have been left out except that acting upon the vibrator and corresponding to C in Fig. 68. Here it will be seen there are three levers, D^1, D^2 and D^3, each with its corresponding vibrator, L^1, L^2 and L^3, and also with their corresponding chains, C^1 and C^2. The lever D^1 corresponds to D in Fig. 68, and D^3 to H, whilst D^2 is supplementary. The chain from D^2 is carried

over a guide roller on D^1, so that the movement of D^1 will affect it much in the same manner as would the movement of D^3. The movements will be best understood by reference

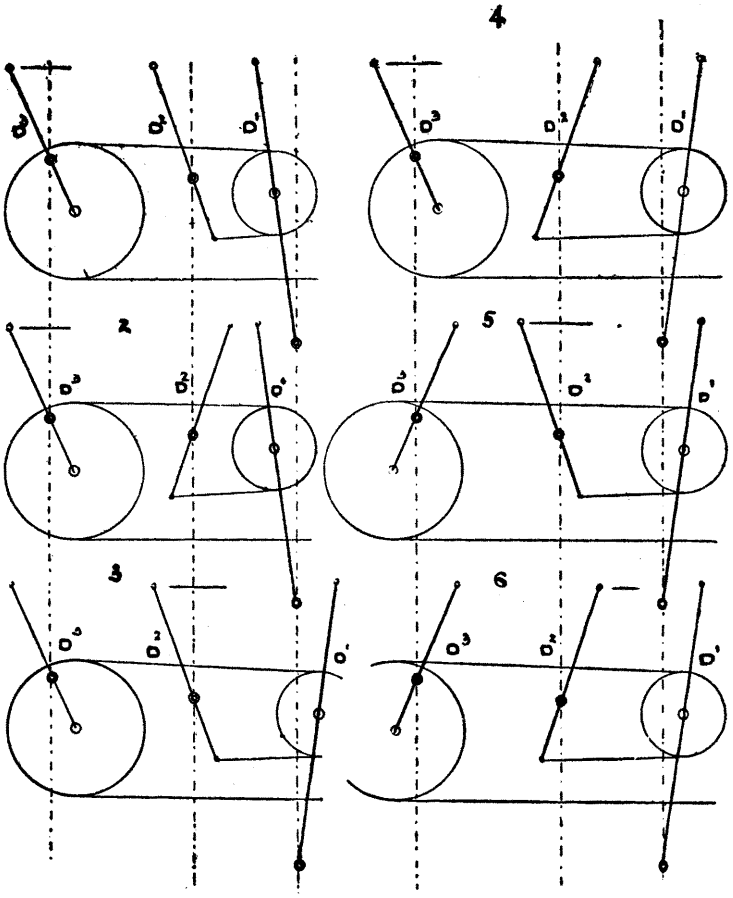


Fig. 73.

to the line drawings at Fig. 73, where the position of the levers for each box in succession is shown.

There is probably no more ingenious contrivance in the whole system of box looms than is displayed here. Whatever

opinion one may hold as to the relative merits of balanced as against positive box motions.

At first sight the mechanism seems very intricate, in reality it is very simple, we have in the wheels C what are virtually cranks, and through their medium the chain I passing round the roller at the end of the lever H and over guide roller G direct to the lever operating the box, thus giving a compound motion which enables us by working the two cranks in unison to give any degree of movement to the chain I and consequently to the box.

Some attempts have been made from time to time to make chain motions, as applied to boxes, partake of the character of the positive motion by the simple expedient of employing two chains to operate the same lever, one to raise and one to depress the box. A lever has its fulcrum placed between two chain cylinders, and connected by a rod to the lever which operates the box. Now suppose for a moment two shuttle-boxes only are employed, then two forms of link would be employed, one having a projection and the other being without; let a projecting link be placed upon one cylinder and a blank link upon the other—both being in contact with the lever at the same time—and the box must be depressed; then reverse the links, placing the projection in place of the blank link and *vice versa*, and the box will be raised, so that by the employment of two chains, one always the exact reverse of the other, a positive motion will be imparted, but of course having the accompanying disadvantage of not only having the double weight of chain to carry, but double the amount of labour in preparing it; at the same time it may be argued that ensuring the positive action is a sufficient compensation for the slightly increased amount of labour in preparing the chains and the additional weight the loom must carry. If this can be done then with two boxes it necessarily follows that with the links arranged

to the several heights corresponding to the number of boxes employed, or required to be moved, not only may any number of box be used but skipping may take place from any one to another.

There have been from time to time numerous modifications of the chain system but in effect many of them retain the same faults, the same liability to go wrong, but of course having the slight advantage of requiring a minimum of power to operate them as compared with some of the positive motions. The negative action in boxes differs from the negative action in some other machines, inasmuch as there must often be such a careful adjustment of levers so that the box, forming a weight at one end of the lever, is counter-balanced by what is equivalent to a weight at the other end.

POSITIVE BOX MOTIONS.

One of the most effective forms of positive box motions is that manufactured by Messrs. Hacking & Co., of Bury, and based upon what is known as Whitesmith's principle. The essential features of the motion consist in a combination of eccentrics—so connected with a lever which will actuate the box that the latter can be moved any distance required. Suppose for instance it is required to operate a shuttle-box having four holes, then two eccentrics will be sufficient for the purpose. The first, or inner one, for it must be remembered that one is outside the other, would be sufficiently large to move the box one hole, the outer one would be large enough to move it two holes; then by combination any distance can be moved from 1 to 3, so that allowing box 1 to be in the normal position three movements would bring up box 4.

This will be best understood by reference to Fig. 74, where the eccentrics are shown in four positions. In the position 1 the two are placed so as to both tend to bring

the connecting rod to the lowest position, and therefore the top box, which we will call No. 1, into the working position; in position 2 the inner eccentric is reversed in position, so moving the boxes a distance corresponding with one hole; in No. 3 the inner eccentric is returned to the normal position, and the outer one reversed thus moving the box two holes, and in No. 4 both are reversed, thus moving the box three holes, or from one to four, so that it will be seen at a glance that by moving the eccentrics in conjunction any one of the four shuttles can be brought up at will.

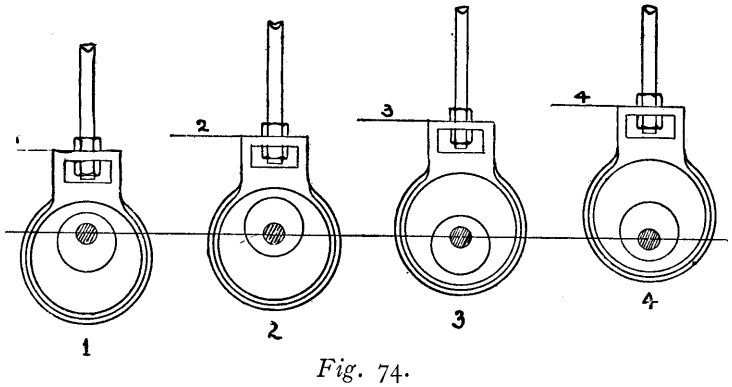


Fig. 74.

Now the mechanism connecting these eccentrics with the box may be examined. Fig. 75 shows the mechanism of the box separated from the other parts of the loom. The boxes themselves are shown at B^1 to B^4, supported on the vertical rod A attached to the lever L. This lever is connected by the rod R to the eccentrics E already described.

Leaving that portion for a moment it will be as well to follow the power from the driving shaft up to the eccentrics. On the driving or crank shaft of the loom a pinion P is placed communicating motion to a wheel W of double its own dimensions, and which has three teeth

projecting more prominently from its circumference than the rest. On one side a cam is formed, the whole being carried upon a tube which will not only revolve upon

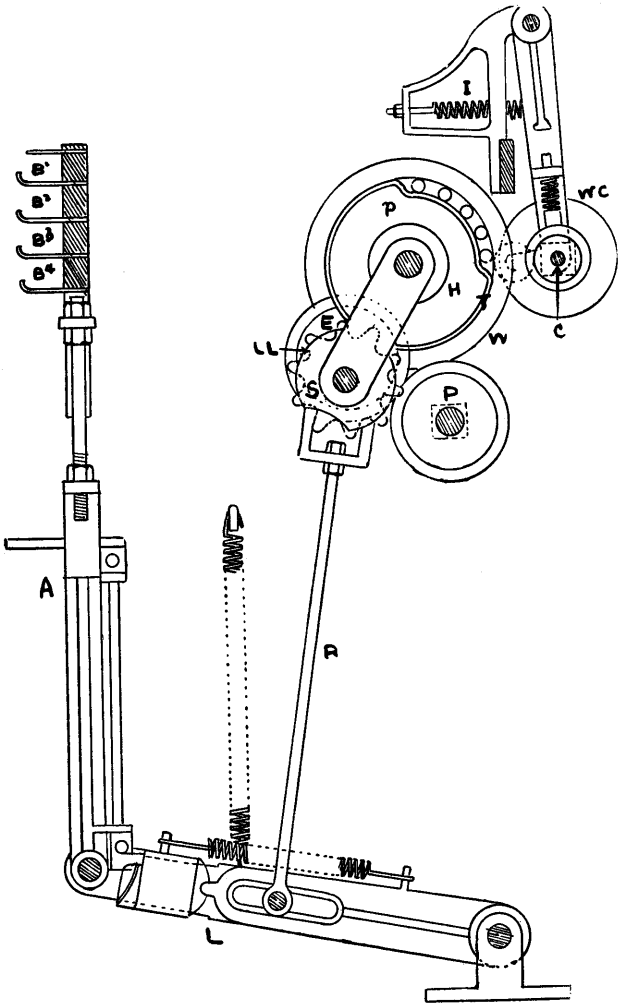


Fig. 75.

the stud or spindle, but also receive upon its surface two slotted hoops suggested at H. Two discs, or peg wheels

T are placed upon this tube and are made to rotate with the tube by the projections *p* upon it. These peg wheels are kept apart by a spiral spring (they are not seen in this elevation as one is behind the other), but are moved towards each other by needles and grooved cams. A card cylinder C is carried on a frame swinging from above, and has a bowl resting against the cam T on the face of the wheel W. As the cam revolves the card cylinder is pushed free of two horizontal needles, and at the same moment the three projecting teeth on W fall into teeth in a wheel WC and cause it to revolve so far as to bring the next pattern card in front of the needles. The card cylinder is returned to its position by a strong spring I.

Five teeth are cast upon the peg wheels, so that they may serve as teeth, and as the two are made to approach each other they may be made to actuate one or both of star wheels S, one of which actuates the smaller and the other the larger eccentric. The smaller of these is loose upon a spindle, the larger encloses it, and this is in turn embraced by a strap, or loop connected to the rod R. A locking plate L, L, with two pieces cut out at opposite sides coincide with the full curved surface of the tappet plate. The peg wheel then acting upon one of the star wheels the eccentric is moved from one position to the other, and the movement necessarily partakes of the nature of a crank, or slow at each extremity and quick in the centre of movement. The motion then is communicated through the rods R and A and the lever L direct to the box.

As will be seen the lever L is of the "broken backed" species, already mentioned, so that the result of any accident will be minimised, and assistance is given by a strong spring in balancing the several parts.

One of the difficulties connected with this motion lies in the preparation of the cards. The eccentrics moving in one direction only it is necessary to know exactly what

position the boxes occupy before preparing the card to make a change, but this difficulty, like others of a similar kind in shedding motions is easily got over by the exercise of a little patience and skill.

An improvement upon this is shown at Fig. 76. In this there is a separate needle acted upon by the pattern card for every box, each needle acting in turn upon levers C^1 to C^4, and so actuating the eccentrics as to cause the

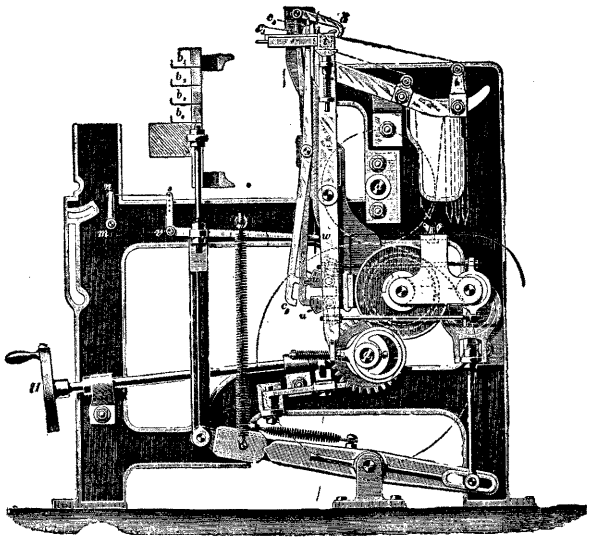


Fig. 76.

corresponding box to come into position, no matter what the position of the boxes previously; thus the needle C^1 will bring the box b^1 into positon, C^2 will bring the box b^2 into position, and so on for all the others. The pattern card barrel *t* is, as will be seen, placed within easy reach of the weaver when it is desired to turn the barrel in one direction or the other, and a simple contrivance of the levers *n*, *s*, *v*, acted upon by the weft fork arrangement raise the catch *d*, the moment the weft breaks, thus stopping the revolving

of the card barrel *t* and keeping the pattern cards in the proper position for the construction of the pattern when the shuttle has been replaced, and saving the weaver the trouble of turning the cards over to find the correct position in the pattern.

A convenient arrangement is also provided for moving the boxes into any position. By pulling the needles, or levers C, and turning the handle H, any one of the boxes can be brought into position at once. Any weaver will understand the value of a simple contrivance like this.

The construction of this loom permits it to be run at a high rate of speed, and the changes of the box, no matter how they are skipping, must, from the manner in which they are operated, be perfectly smooth and steady, and being positive the changes may be relied upon. It will be seen from the diagram that it is provided with the hinged, or "broken backed" lever as a safeguard in the event of anything preventing the boxes moving easily.

This loom is made by Messrs. Hacking, of Bury.

LIVESEY'S DROP-BOX.

Another arrangement of a positive drop-box motion is shown at Fig. 77, which is by Messrs. Livesey, of Blackburn, the principle of which will perhaps be more easily understood by reference to the detail drawing Fig. 78. The essential features of this motion are a forked rack A, a straight one B, and two wheels at C. The straight rack is attached to the lifting rod of the boxes. The rack A is suspended from the lever D, which is acted upon by cams or tappets at E. One of the wheels at C is in contact with the rack B, and the other is placed in the centre of the space between the arms of the fork A, so that unless moved to one side there would be no contact with either of the racks and the wheel, but when moved and brought into contact it would cause one of the wheels at C to

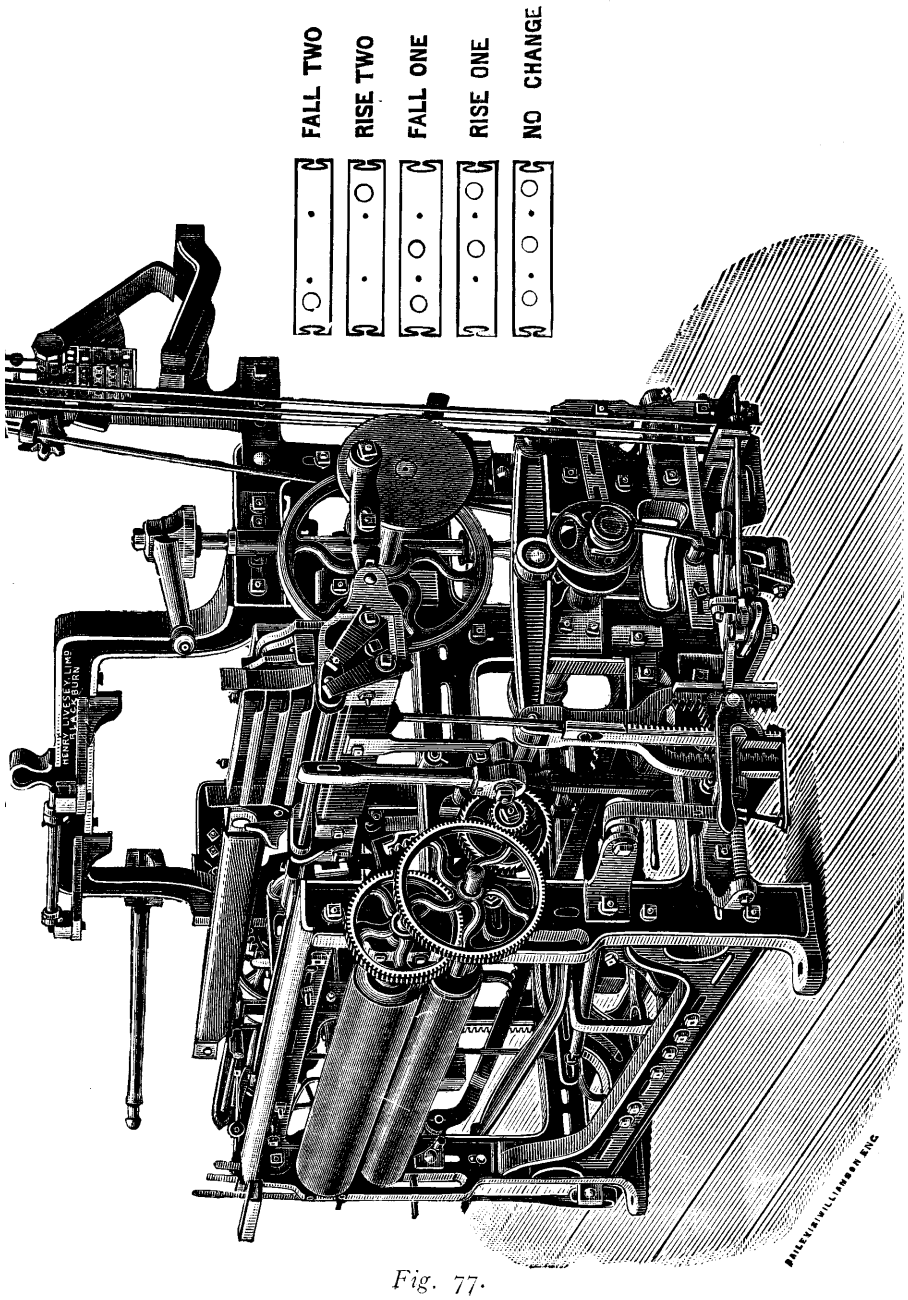


Fig. 77.

revolve, and that carrying with it the other wheel would move the rack B, and raise or lower the box. Then the cams at E are so arranged that one of them will cause the lever D, through A, C, and B, to raise or lower the box one or two holes; lower it by pressing A towards B and raise it by pressing A towards the back of the loom.

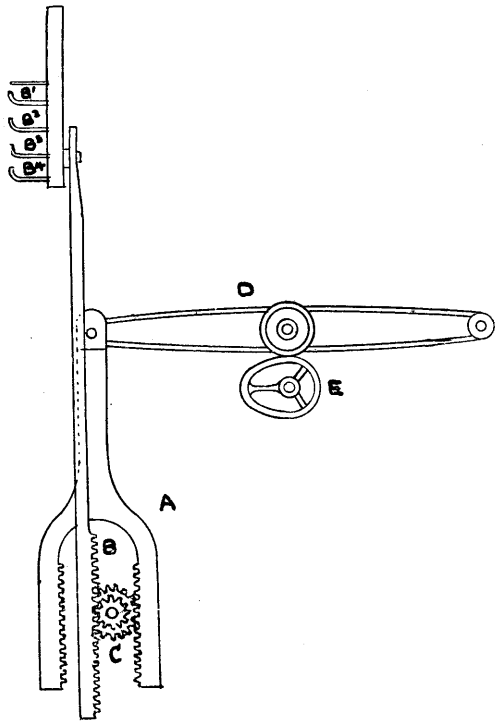


Fig. 78.

A pattern card arrangement is shown on the loom Fig. 77. At the back of the loom are three vertical rods acted upon by pattern cards carried over a cylinder or bar, and acting upon levers near the foot of the loom, two of which act upon the forked rack, and one upon a clutch which moves the cams at E, so as to bring either one

or the other under the lever D, as seen in the loom. The method of changing the boxes will be understood from the diagram of the cards at the side of the loom. No. 1 card would cause the boxes to "fall two" by pressing the rack A forward and being lifted by the larger cam will carry the wheel C round and pull down the rack B a distance equal to two teeth; No. 2 card will reverse the motion by reversing the rack A and consequently the movement of the rack B. No. 3 card will "fall one" by bringing the small cam at E under lever D, through the medium of the clutch, and No. 4 will reverse the motion by reversing A, as did No. 2. No. 5 will leave matters as they are by allowing the small cam to remain under D, and dropping A into the vertical position and free of the wheel at C, so that changes can be of either one or two boxes, rising or falling, as from 1 to 2, or 1 to 3, from 2 to 3, or 2 to 4, or *vice versa*, and of course with the same degree of precision in either direction.

THE ECCLES DROP-BOX MOTION.

In the arrangement of the details of this loom it may be said that there is something which partakes of the character of both the positive box of Messrs. Hacking & Co., and of the Knowles' arrangement already described. In the former as it is a positive motion, and in the latter in that the motion is communicated by cranks, the crank taking the place of the eccentric in one, and a direct lever with spring escapements taking the place of the balanced lever in the other. A back view of the loom showing the box motion is given at Fig. 79, and which must be followed carefully in conjunction with the end elevation at Fig. 80, so that the details can be thoroughly mastered; the lettering being upon Fig. 80 only, and some of the parts appearing in duplicate, though for separate purposes, in Fig. 79. The boxes B^1 to B^4 are carried on a vertical

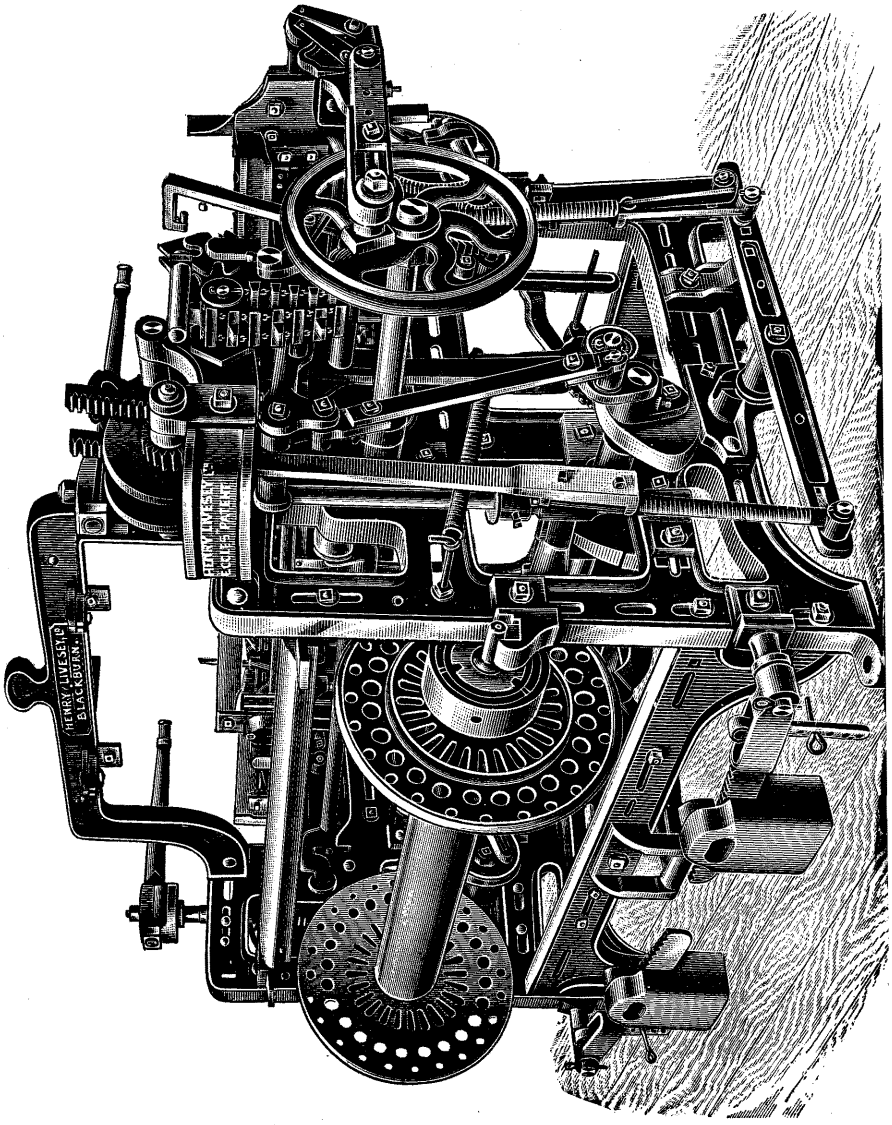


Fig. 79.

rod on the lever L, the other end of the lever being connected by a corresponding rod to a crank on the disc D. Although only one disc D is seen in the elevation, there are really two as seen in the view Fig. 79, each having

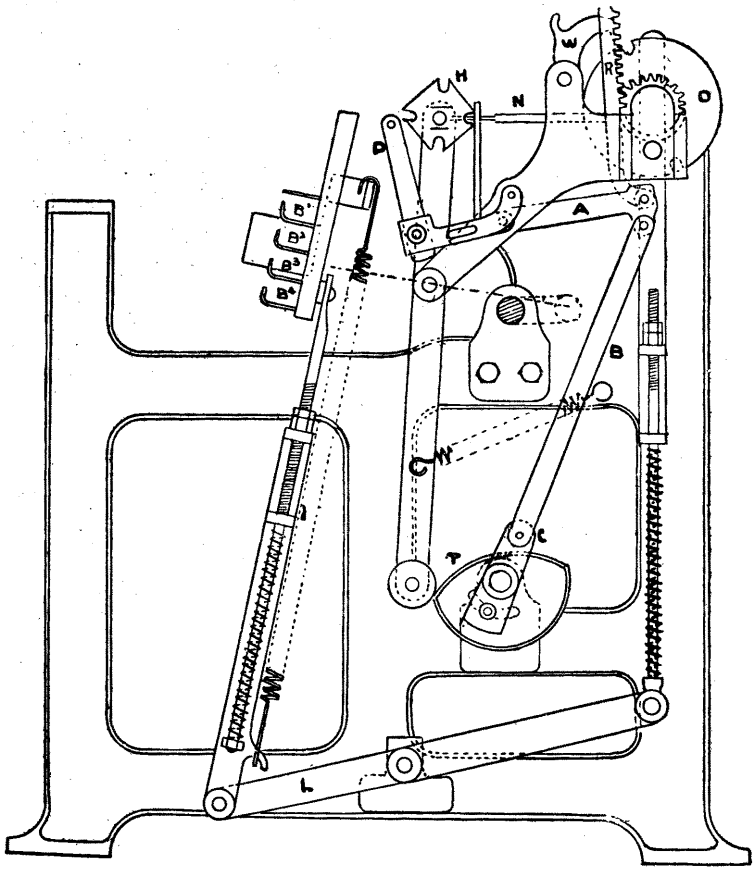


Fig. 80.

upon it a toothed wheel engaging the rack R in the one case and a corresponding one in the other. These racks having their fulcrums so placed below the disc D as to

fall backward by gravitation. A lever A is actuated through the rod B by means of the crank C, and constantly working the rack R upwards and downwards. A pattern card cylinder H is oscillated so as to act upon the needles N and engage either of the racks R with the toothed wheel upon the disc D at will, and as the rack is always moving upwards or downwards it will cause the disc to revolve whenever the teeth are engaged, and will always carry it a distance equal to half a revolution, so raising the crank to the top, or bringing it to the bottom. So far the principle of the disc is the same as that noticed in the

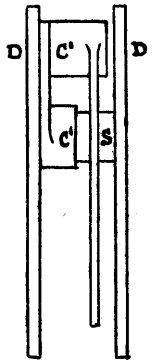


Fig. 81.

Knowles' chain, but actuated in a different manner. Now let us see how the boxes are moved. An elevation of the discs and wheels is shown at Fig. 81, apart from the other mechanism. The outer disc D carries a crank C^1 calculated to move the lever L a distance corresponding with one box. On the end of this crank another crank C^2 is fitted loosely, which will move the lever a distance equal to two boxes, the pin of which passes through a slot in the inner disc. Now let the crank on D and the second crank on the inner circle be both at their lowest points No. 1 box will be in position; bring them both to the top and the boxes

will be moved to No. 4. If the crank on the front disc is brought to the top and that on the back to the bottom No. 2 will be in position and when reversed No. 3 will be in position.

The rods connecting the discs and lever L, and L with the boxes are provided with spring escapements, so that in the event of the shuttle being caught by the box, they will give way and prevent breakages. The card cylinder is actuated by the tappet T on the bottom shaft of the loom in its movement to and from the needles, and the cylinder is turned by the lever arm P having a pin at its upper point, and moved backwards and forwards by the arm A connected to B. When brought into position the box is locked finally by the catch W being forced into a notch in the disc by means of a spring, so that no movement or vibration can take place until the catch W is removed by the action of the card cylinder and needles.

The reader may now easily reckon for himself the advantages and disadvantages of circular and rising boxes of positive and non-positive motions for the work which they are likely to be called upon to perform. For heavy work there can be little doubt of the advantage of the rising box loom as giving all the stability required by the use of a fast reed. When changes from one shuttle to another, which involves skipping are required the positive motion presents apparently all the advantages, though the Knowles' chain is a masterpiece of non-positive action, and for ease and facility of change the circular box presents features which cannot be ignored. It is difficult to give a positive verdict in favour of any one, each has its own sphere.

LECTURE 6

SHEDDING MOTION.

In the second lecture the general character of the movements involved in shedding, or separating the warp threads, was described, and it will be remembered that it was there placed under three headings. First what we speak of as the open shed, or that where the threads remain at their highest and lowest points respectively as long as required for the formation of pattern; second, where all the threads meet in the centre between each shed and separate again; and third, where one portion remains at the lowest point and the other portion is raised the entire distance representing the depth of the shed, or, as the latter two systems are known, centre and bottom shedding. Leaving aside the question of the advantages or disadvantages of each system, beyond what was laid down in the lecture referred to, attention may now be turned to the methods adopted for forming those sheds.

Of course every one will know that the separation of the warp threads, in addition to forming a passage for the shuttle, must also form that passage in such a manner that by the order of succession of the threads, in being raised and depressed, the pattern upon the fabric must be formed; so that we have not merely the consideration of the character of shed but also the production of pattern. Perhaps it would be best to take the simplest of the forms in use, or what is known as tappet shedding, first, and examine that thoroughly.

There are two distinct systems of arrangement of the mechanism connected with tappet weaving, but both have

for their objects the separation of the warp threads by means of what are commonly known as negative cams, or tappets. In the one case the treadles are placed under the loom, and the tappets acting upon them upon the lower shaft, and acting directly as shown in the plain loom at Fig. 82. The object then is to convert this negative motion of the cam into a positive one. In the

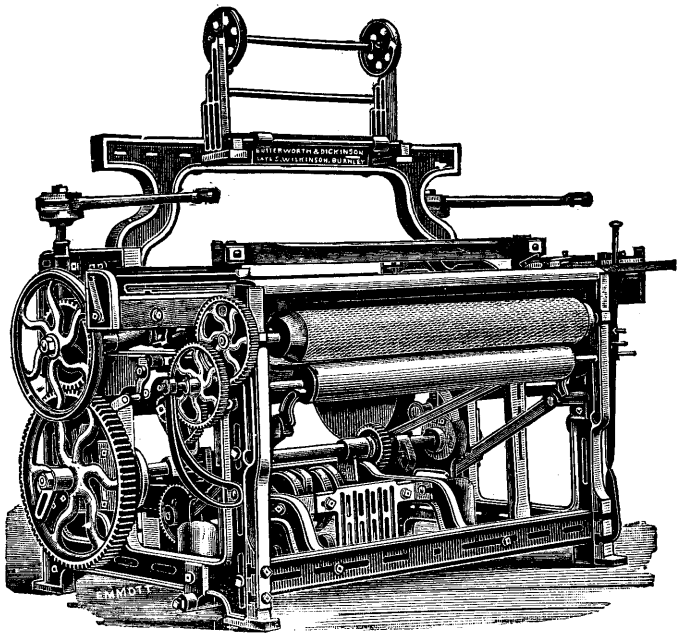


Fig. 82.

weaving of a plain cloth this is quite easy of accomplishment, the two treadles are connected as shown in the illustration, to the bottom of the two healds. The tops of the healds are attached to each other by means of cord or strap over a roller, or made fast to a shaft above the healds as shown in the figure, so that as one heald is depressed the other is raised through the medium of this cord or strap.

The weight of the treadles alone will serve to keep the healds at tension, but the tappets should be so constructed that as one is depressing its treadle the other is allowing the treadle upon which it acts to rise. Now to ensure good work those two tappets should be in contact with their respective treadles throughout the movement, otherwise at one moment considerable tension will be thrown upon the cords, and at another they would be comparatively slack, having only the weight of the treadle to keep them in position. This is one of the first points that must be attended to in weaving for the production of good work. The sheds should be perfectly even, not only as previously pointed out in the tension upon the warp threads, but also in the tension upon the healds. Two things will occur if this is not properly followed. First, the healds will, at one point of the movement, be very tight and have to bear considerable strain, whereas at another point they would be slack and liable to "knuckle."

In connection with tappet shedding there are three distinct questions to be considered; first, the formation of the tappet so as to keep the healds at a perfectly even tension; second, to give the exact depth of shed required so that we are neither overshedding, which will involve unnecessary strain upon the warp threads, and cause probable breakage; or undershedding, which would cause undue friction upon, and resistance to, the shuttle in its passage; and third, the exact amount of eccentricity required for the work. Again of course in tappet working we may have what is termed unequal shedding, which may mean either that the healds are not raised to their proper height in relation to each other, or depressed so that the threads passing through them will form the same straight line; or it may mean that one end of the heald is raised higher than the other and so cause inequality in the shed from side to side. Again we may have the mis-timing of

the movements of the healds in relation to each other, which really means that the tappets are not properly placed upon the shaft; and again we have the dwell or pause of the tappet, which may be a variable quantity according to the work to be done.

The question of evenness of tension has been already dealt with in the second lecture when speaking of the relative positions of the back rail and breast beam.

The depth of shed must be determined presently when the size of shuttle, stroke of the going parts and other details as to leverage of treadles, &c., are taken into account. The general character of the eccentricity has also been dealt with, but the exact method of obtaining that must now be dealt with along with the question of drawing the tappet. The timing of the tappets in relation to each other must also form part of the work of drawing, but the "dwell" must be governed by the character of the fabric to be woven. Then taking those questions in the order in which they occur we should have the tension, not only of the warp threads but of the healds, to deal with; the tension upon the warp threads passing through each of the several healds will be readily determined by the general rule laid down in the second lecture, but the tension upon the several healds will be governed entirely by the form of the tappets, their position in relation to each other, and the leverage of the treadles and any intermediate lever that may be employed; so that the question of drawing the tappets and of determining their position on the shaft in relation to each other must be reduced to a most exact science.

It is often said in practical working that no man can so adjust a loom that he will have even an approximation to evenness of tension in each of his healds at the several points of their passage in shedding, but on the other hand it has more than once been asserted that a man who cannot

construct his tappets, and adjust the leverage of the treadles and intermediate parts, so that a spring balance placed anywhere will show a difference of strain upon the cords of more than a few ounces, is not worthy to occupy a position of responsibility. Now we must see how this works out. Before coming to the actual construction of the tappet it will perhaps be as well to take each of the other points seriatim, so that we should have only actual dimensions to deal with when preparing the drawing. Then first as to the depth of shed. Take the elevation of the shedding motion as shown at Fig. 83, and we must suppose some dimensions, first we have the going part travelling a distance of 6 ins. from the cloth to its furthest extremity at the back, we have the healds placed at a distance of 12 ins. from the cloth, and we have a shuttle of 2 ins. wide and 1½ ins. deep, which must pass through the shed. Now we must determine the depth of the shed to allow the shuttle to pass through without too much friction upon the warp The lower half of the shed being laid flat upon the shuttle race the shuttle will run upon that, consequently the depth of shed must be determined by the depth required for the upper half of the warp to just clear the front upper corner of the shuttle, as shown in the illustration. Now we have the depth of the shuttle, its width and the stroke of the going part given, so that taking the position when the shuttle is midway in its passage, and where we may suppose that the shed is sufficiently open to give it absolute freedom of movement, we should have from the cloth to the shuttle front 4 ins., depth of the shuttle 1½ ins., then the depth of the shed at that point, and at that moment, must be at least equal to the depth of the shuttle; therefore the depth of the shed at the healds must be as 4 ins. from the cloth to the shuttle front is to 12 ins. from the cloth to the heald, so is the depth of the shuttle to the depth of the shed required at the healds; then of course we have

reliable data to work upon to guide us as to the stroke of the tappet acting upon the warp. The depth of shed at the healds being $4\frac{1}{2}$ ins. the displacement of the treadles

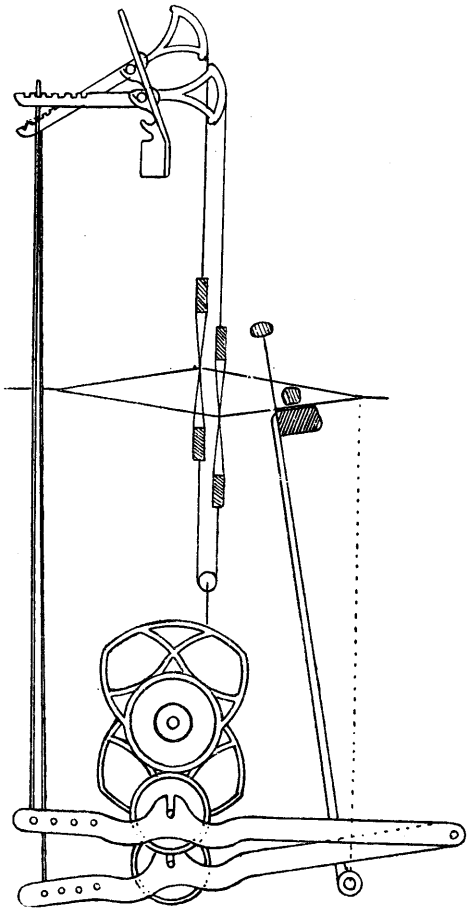


Fig. 83.

at the point of connection of the cords moving the healds must be equal to the exact displacement of the healds themselves, therefore to find the stroke of the tappets we

have only to take the leverage of the treadles into account; for instance we have the friction rollers placed at a point between the fulcrum and where power is applied to the heald, then as the distance from the fulcrum to the point where power is applied, is to the distance from the fulcrum to centre of friction roller, so is the stroke of the treadle at the point connected with the heald, to the stroke at the friction roller; so that if the displacement of the heald is $4\frac{1}{2}$ ins., the length of the treadle is 28 ins., the distance of friction roller from fulcrum is 16 ins., then as 28 ins. is to 16 ins. so is $4\frac{1}{2}$ ins. to $2\frac{4}{7}$ ins.

Before going further into the question of tappet formation another phase of the subject must be considered. Dealing only with what are known as negative tappets, that is, leaving aside all such contrivances as Woodcroft's section tappets, Nuttall's tappets, or Diggle's chains, we have two systems of working to deal with; the one just referred to where the treadles are placed in the centre of the loom under the healds; and where the treadles are placed at the side of the loom, or what are sometimes known as outside tappets. In the first case as already mentioned the treadles are connected direct to the healds, in the second case as shown in Fig. 58 and in Fig. 83, where the treadles are placed on the outside of the loom, they are connected to the healds by levers placed above, so that a second question of leverage will come in in determining the stroke of the tappet. Of course, that second question will be sufficiently simple, if looked at from the point of view of considering the displacement of the heald and treadles respectively. In the illustration given the displacement of heald and the treadle point must be equal because one is connected directly to the other; in the latter case it cannot be so, because the arm from which the heald is suspended is shorter than the arm connected to the treadle; therefore the displacement of one will be to that of the other as their relative lengths. Suppose the length of

the arm from which the heald is suspended is 6 ins., then the length of the other arm is 8 ins., then the displacement of the lever from which the heald is suspended will be to the other arm as 6 ins. is to 8 ins., so that the latter will represent the displacement of the treadle, and the rest of the working will be, of course, as before.

The depth of the shed and the question of leverage having now been determined it will be necessary to approach the question of eccentricity of movement of the healds, how this eccentricity may be obtained by the formation of the tappet, and how it may be affected by the relative positions of the several working parts.

Then taking the position of the treadles for the outside shedding as shown in Fig. 58 and Fig. 83, we may first consider the influence of the position of the tappet shaft in relation to the anti-friction roller, and the position of the treadle fulcrum in relation to the movement from top to bottom as affecting the amount of eccentricity of movement imparted. First suppose that the centre of the anti-friction roller, when the treadle is in a perfectly horizontal position, is in a vertical line with the centre of the tappet shaft, or in other words that a line drawn through the centre of the fulcrum and anti friction roller will be at right angles to one drawn through the centre of the anti-friction roller and the tappet shaft; and that the movement imparted to the treadle is equi-distant above and below that line, then a certain amount of eccentricity will be given to the heald from the fact that the point of the treadle is moving in an arc of a circle. Now it necessarily follows that in placing our tappet, and in forming it also, instead of interfering with this eccentricity, by reducing it at either extremity, we must increase it, hence the necessity for careful consideration of the position of treadle and tappet, as well as the actual formation of the tappet itself. Suppose, for instance, the centre of the anti-friction roller is moved to one side or

the other of the vertical line, then an increased amount of eccentricity would be given to that side from which it had been moved, and a decreased amount to the opposite side, so that if we say that, for convenience, the centre of the roller must be on one side or the other of the vertical line, then that fact must be taken into consideration in drawing the tappet, or the character of the movement is interfered with.

Having now determined the depth of shed, eccentricity of movement, and the influence of the position of the treadles upon the movement, there are three other questions which must be carefully considered, quite apart from that of formation of pattern, before we can proceed to the question of tappet drawing. Those considerations are, first, the size of the anti-friction roller, or, as it is commonly termed, the treadle bowl, the shape of the treadle and the leverage, so as to determine the stroke of the tappet for the depth of shed required. Then as to the anti-friction roller, as influencing the form of the tappet, the smaller it can be made the better. By what is commonly known as the method of cam drawing the point of contact of the cam with the lever upon which it acts is of necessity considered a point, and, if the action is direct upon a given point of a lever, the assumption will be quite true, and the method of working correct; but when instead of a point a large roller is introduced, and this roller of necessity moving to and fro in an arc of a circle, the point of contact of the tappet in relation to the centre of that friction roller, which after all is the conveying point of the power received, must be constantly changing; hence the necessity for adapting the shape of the tappet to the size of the friction roller. If we are working with the friction roller of, say, 1 inch diameter, we may treat it as a point, for all practical purposes, in the drawing of the tappet. If it assumes the dimensions of 3 to 4 inches diameter, as is the case in a large

proportion of the looms now in use, then the dimensions must be taken into account as an important factor in the formation of the tappet. The question is often asked, why have this large anti-fricton roller? And the general answer given is, that it reduces the friction and liability to jump in the treadle. But, as I shall have to show presently, whatever advantage may be gained in that direction may be more than counterbalanced by disadvantages in another direction. A roller acted upon by the surface of a cam or tappet, which is usually polished iron, cannot be looked upon as subject to the same treatment as a wheel passing over a rough road; as in the latter case the bigger the diameter of the wheel the more easily its circumference will bridge over roughs or irregularities in the road; but that could not apply in the case of a roller running on a smooth

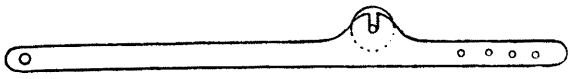


Fig. 84.

surface, so that the advantages in that direction are more fancied than real. Then there is only one other advantage which can possibly be gained, and that is in the actual form of the treadle. Suppose the treadle is made as a perfectly straight lever and a small roller is placed upon it to be acted upon by the tappet, this roller would never touch what is known as the inner circle or disc of the tappet, simply because the length of the wings, more especially in larger fancy patterns, would cause them to be in contact with the treadle at each side of the anti-friction roller before the roller could reach the inner circle; hence of course it would be impossible to work. This may be overcome in two ways, first, by raising, by means of a species of bracket, as shown in Fig. 84, the roller from the treadle sufficiently high to overcome this difficulty,

but another and a better form is shown in the bent lever Fig. 85, which accomplishes exactly the same purpose. In fact it may be said to do more, for the curves given to this lever at the several points will tend to give considerably increased strength; take for instance the point where the anti-friction roller is placed and a kind of bridge is built over an arch which must give considerably increased strength at that point, Again, towards the point of the treadle another arch may be formed, and this at the point where the power received by the roller from the tappet is communicated direct to the healds, so that all the strength possible is obtained whilst meeting the requirements of the shape of the tappet to keep in contact with the small roller. The

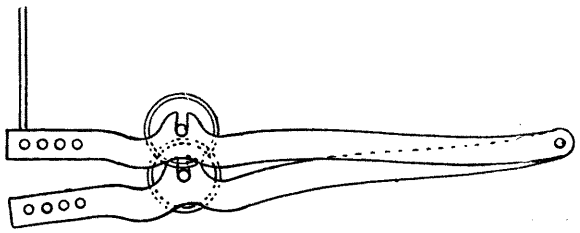


Fig. 85.

necessity, as well as advantage, of the small roller will be more fully demonstrated presently when dealing with other forms of shedding tappets or cams.

Before entering upon the question of the accurate drawing of the tappet, some consideration may be given to the dwell or pause of the healds at the highest and lowest points respectively. As already said, the theoretical time occupied by the shuttle in passing across the loom is equal to half a revolution of the crank shaft. In practice, really, somewhat less, more especially in light running looms, and in the heavier looms compensation is given by the length of the crank and the amount of eccentricity given to the movement

of the going part. In many cases the actual time occupied by the shuttle will not exceed one third of a revolution, and may be even less than that, but there are other considerations beyond the time occupied by the shuttle which may materially influence the dwell of the healds. It is often considered that the dwell should be as short as possible, and many look upon it that the period might be somewhat less than the time occupied by the shuttle in passing. If we were looking only to the question of friction upon, or resistance offered to, the shuttle, this view might be taken, but when we consider the influence of shedding upon the fabric then it must be obvious that, apart from the time of the shuttle passing across the warp, the regulation of tension in relation to the beating up of the weft must also be taken into account. Suppose for instance we are weaving a fabric where we wish to throw the least possible amount of strain upon the warp, and where the distribution of the warp threads, as affected by the shedding, is a matter of little moment; then we must give the least possible amount of dwell to the healds at the extremities of their movements, as by doing so the passage from the highest to the lowest point, or *vice versa*, occupies the greatest amount of time than can be given to it, and consequently reduces the strain upon the warp to a minimum. But in such case as weaving plain cloths, or cloths where the warp threads must be distributed, then a longer dwell must of necessity be given. Take for example the references to the warp line in the second lecture, where it is shown that the length of yarn between the back rail and the fell of the cloth is materially influenced by the position of the back rail, and also by the position of the healds. If the back rail and the breast beam are placed in the same horizontal plane, and the warp threads are sunk considerably below that plane when the shed is closed, then, on separation for the formation of the shed, one portion is carried below that point and the other an equal distance above it; that forming the upper half will be much

slacker than that forming the lower half, because it more nearly approaches a straight line, as demonstrated in my "Treatise on Weaving and Designing."

Then the general practice is, when the warp line is sunk in this manner, for the sheds to be crossed, or changed sometime before the reed beats the weft up to the cloth. The length of this period will vary according to the quality of the fabric and the ability of the yarn to bear strain. In some cases the change will take place when the reed is, say half an inch from the cloth, and will vary from that up to a distance of an inch and a half, or nearly equal to one-third the stroke of the going part. Then taking the extreme case it must be clear that the further the reed is from the cloth at the moment when the shed is changed the longer must be the time for the shed to be kept open, otherwise the shuttle could never be passed through the warp before the shed began to close upon it. One word of explanation is perhaps needed here; the reason for crossing the sheds so early is, that the warp threads forming the lower half shall be as tight as possible and the upper half correspondingly slack when the reed comes up to the cloth, thus forcing the slack threads into the space between the tight ones, and this occurring alternately with the two halves of the warp causes a most perfect distribution. In extreme cases the length of pause given to the healds, to assist in this distribution, will vary from three-fifths to two-thirds of a revolution of the crank; whilst at the other extreme, where attention to distribution is not so much regarded, more especially in fast running looms, the time may be one-third or two-fifths of a revolution.

Then the next question to be dealt with is the proper form of the tappet, and, as a consequence, the true method of drawing that tappet. In the second lecture it was pointed out very clearly that the movement of the healds must be decidedly eccentric, moving slowly at first with a gradually increased speed to the centre of the motion, and from that

gradually decreasing. Then we have to consider how the tappet must be formed to ensure this, and what is the correct method of drawing. To make the subject perfectly clear, I will suppose a pin to be so placed that it can be acted upon by a cam and moved only in a vertical direction, the cam revolving continuously upon a horizontal axis. Now suppose that, in the first place, a roller is placed in contact with this pin and the roller revolving upon this axis with its circumference in contact with the pin, there would be no movement. It would simply be one surface in contact with another without any motion imparted, but let the roller either have projections placed upon it, or indents cut into it, then movement will be imparted to the pin wherever this alteration in the circumference takes place. In looms, whatever form of arrangement we adopt, whether inside or outside tappets, whether positive or non-positive tappets, the same rule must hold good: the tappet must be so formed as to impart the exact motion required to the healds. Perhaps this will be better understood by a comparison: the pin already mentioned may be attached to a lever which can move in a vertical plane; a lever is placed in contact with it moving in the horizontal plane; this lever is moved backward and forward, but will impart no motion to the pin or the lever to which it is attached, but let a projection be placed upon the horizontal lever, and movement would be at once communicated: the character of the movement being determined by the exact form of the projection. Suppose, at first, the projection forms an angle of 15° with the horizontal plane, by degrees that is increased to an angle of 30°, then to 60°; as the lever is moved along, the motion communicated to the pin would be at first slow, gradually increasing until the top of the incline is reached; exactly the same thing will occur with the tappet; a circle revolving upon its axis is simply equivalent to a lever moving in the horizontal plane, and any projection upon the surface of the

circle is equivalent to a projection upon the horizontal lever. The angle formed with the circumference of the circle corresponds with the angle formed with the lever, so that a line drawn from the centre of the circle through its circumference, at any point, is exactly equivalent to a vertical line drawn to a horizontal lever.

Then what we have to consider is how to draw from this circle of the tappet a line which will communicate motion of the exact character required. Suppose a line is drawn from the centre through the circumference of the circle at any given point, and another line is drawn through another point exactly at right angles to it, or representing one quarter of the circle, as shewn in Fig. 86, at the points

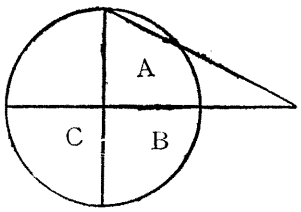


Fig. 86.

A B, now the angle formed by the two lines A B is one of 90°, then take the distance on the line B equal to the diameter of the circle from the centre C, or double the length of A; then a line connecting A B would form an angle of 60°, therefore it would be seen that that angle should be one of 60° with the circumference of the circle. In the aggregate that would be true, in detail it is not true; for at the point nearest to B a portion of the circle is cut off, and consequently the angle is more obtuse than 60°, but after cutting the circle it becomes more acute, in a proportionate degree, so that although the average may be equal to 60°, it will impart a variable movement to the tappet. Now suppose another illustration be taken. Divide

a square as in Fig. 87 into six equal parts, in both directions, and draw a line diagonally through the intersections, that line will be at an angle of 45° throughout, that is, the angle is precisely the same in each of the smaller squares as in the larger one; now take another square as in Fig. 88, and divide it vertically into six equal portions, but horizontally into six unequal portions; then draw a line diagonally through each of those divisions in succession, and it will be found that the first, second, and third, give very varying angles, and the fourth, fifth, and sixth in opposite directions; so that any body travelling along the incline formed by this line will have an accelerated speed from the commencement of the movement to the centre, and from that point a

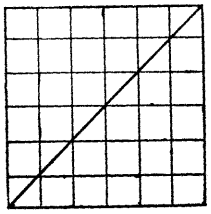


Fig. 87.

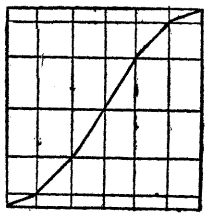


Fig. 88.

decreased speed. Now this is the kind of movement to be imparted by the tappet to the treadle, but the question then arises as to the degree of acceleration. Generally speaking it may be assumed that the best motion is that which is commonly known as harmonic, which consists of an accelerated ratio as follows: 1 is to 2 as 2 is to 3, &c.

This harmonic motion will be best understood by a reference to Fig. 89, where a line A B is drawn of any given length, and a semi-circle having A B as its diameter; now divide the semi-circle into any number of equal parts and from each of those divisions drop a line to the diameter. Now suppose a body to be revolving within the circle A B and connected by a crank to another body which it moves

in the horizontal plane, then the ratio of speed of the second body will be as indicated by the divisions from A. to B. and as represented by the figures given above. Now let it be supposed that the Fig. 88 is divided in the same ratio as indicated in Fig. 89, then the inclined plane would represent the varying velocities of a fallen body exactly corresponding to Fig. 89, and whether the space, as represented in Fig. 88, be a square or a parallelogram, the principle would not be affected in the slightest degree. Now take Fig. 90 for the purpose of explaining the practical application of the system of division of circles. Draw two circles, and from the centre two lines forming an angle of 90°, then the space between the inner and the outer circle and the lines A B will represent

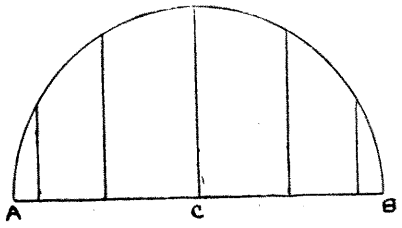


Fig. 89.

a parallelogram, and we desire to draw a diagonal line across that parallelogram as we have done in Fig. 88. It will be remembered that lines drawn from the centre through the circumference are vertical to the circumference of the circle, therefore arcs of circles struck from the same centre as the circles, must be parallel to the circles, and therefore are the same in relation to the vertical lines as are those in Fig. 88. Then make the divisions between the two circles in the same harmonic ratio, and a line drawn through the intersections of the arcs and radial lines as in Fig. 90 will exactly correspond with the diagonal in Fig. 88, so that the method of drawing the curved line of the tappets can be easily determined.

The next question is the division of the circle and the laying out of the tappets for the pattern. In weaving a plain cloth we have perhaps the best means of laying down a general principle. We all know that there are only two picks in the complete pattern of a plain fabric, so that the tappet must be so constructed as to raise and depress the treadle alternately for each succeeding pick, so that the circle representing the tappet would be divided into two equal portions. Then suppose a line to be drawn through the centre of the circle, cutting it at the points A B, Fig. 91, then A to B may be said to represent a period of time when the

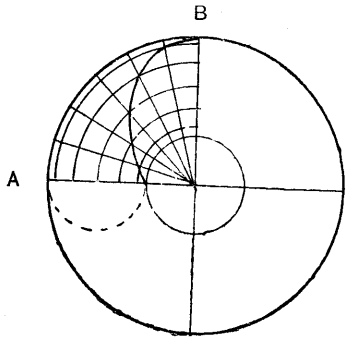


Fig. 90.

tappet is in contact with the treadle for one pick of the pattern, and B to A for the other pick. Now in this we must have a theoretic starting point, from which we may depart, in a greater or less degree, as occasion may require afterwards.

It has been suggested that at the moment when the reed is in contact with the cloth, the shuttle is in the box; the shed is closed; and practically all things are at rest. As the going part begins to move backwards, the shed should begin to open, and when the going part has travelled half-way from front to back, the shuttle should be leaving the box. Then at that moment the shed should be

fully opened, and if half a revolution of the crank is allowed for the shuttle to pass from side to side, the shed should be open during the whole of that period; then it should begin to close, and the healds meet in the centre of their passage when the reed is again in contact with the cloth. If that is so, the distance from A to B might be conveniently divided into four equal parts, as in Fig. 91, corresponding with the periods just referred to, and of course from B to A divided in a similar manner, each portion representing its own pick. Then it must be evident that from three on the inner circle to one on the outer circle will correspond to the period of time when the heald will be moving from the lowest to the highest

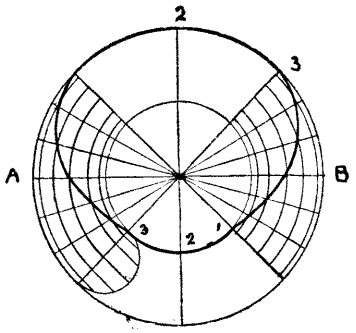


Fig. 91.

point, and from three on the outer to one on the inner circle the movement will be represented in the opposite direction. Therefore from three to one a curved line must be drawn in the same manner as from A to B in Fig. 90. This will represent the true movement of the treadle at the point where in contact with the tappet. From one to three will represent the dwell at one extremity, and three to one the other. This then, will represent one complete tappet, and for the purpose of a plain cloth, another of exactly the same size and form must be placed opposite to it, to act upon the second treadle

and heald. Now this tappet is theoretically true on two assumptions; first, that the division of time in the movement of the shuttle, going part and healds is exactly as suggested. Second, that the point of contact of the tappet with the treadle is a point without the intermediary anti-friction roller. It would be equally true if the anti-friction roller could be said to have no dimensions, and practically so if the dimensions were small, but when, as pointed out in the second lecture, the friction roller is made large, then its dimensions must be taken into account. This can be readily done by following

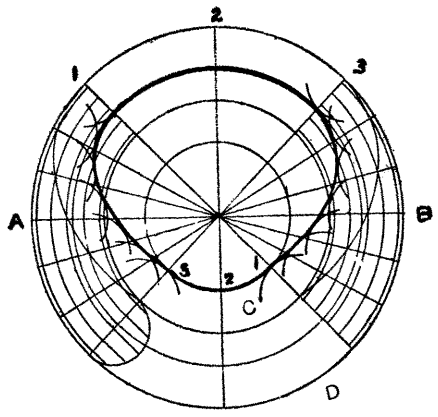


Fig. 92.

the proceeding indicated in Fig. 92. There, the two circles are drawn as in Fig. 91, but two other circles indicated by the circles C and D, each at a distance from the others equal to the radius of the friction roller, so that those lines would clearly represent the movement imparted by the tappet to the treadle. Then if the tappet were drawn from one of the lines C, D, to the other on the principle shewn in Fig. 91, and from that, arcs of circles be drawn cutting each other as shewn, and truly representing the position of the anti-friction roller at every point of its passage from one extremity

to the other, the circumference of the tappet would be indicated by a line drawn, which will be a true tangent to every one of the arcs of circles from the outer to the inner circles of the tappet. Then what is true of this plain tappet is equally true of all others, and it would only be a question of dividing the circle into as many parts as there are picks in the pattern, and of each part in succession in the manner indicated in Fig. 92, and proceeding to draw the curves for each pick, so as to raise and depress the heald according to

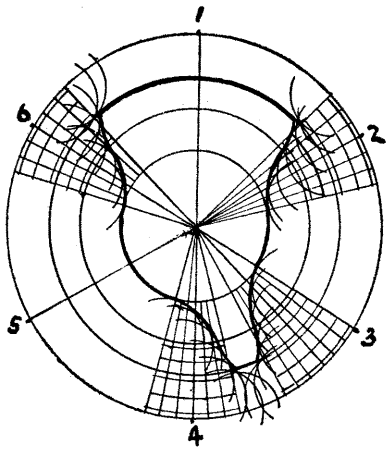


Fig. 93.

Fig. 93A.

the pattern. For example, Fig. 93 is a tappet for a six-end twill as shewn at Fig. 93A, and drawn strictly upon this principle. Then it must be obvious, if two patterns, varying so widely as the plain and twill here given can have a tappet drawn on this principle, that a tappet can be equally well drawn for any other pattern. There are several things to observe however. In the Fig. 93, one of the wings of the tappet is what is commonly known as a double one, that is, it holds up the healds for two picks, and one of the depressions is also a double one, leaving down the heald for

two picks. This, it will be remembered, has been pointed out as one of the features of tappet shedding. A heald is kept at its highest or lowest point, as long as required for formation of pattern, so that, what otherwise would be two wings for picks one and two, or two separate projections, is made as one projection or wing, thus avoiding the dropping of the heald half way down and bringing it back again ; and in the same way what is a double depression for picks five and six would otherwise have a small projection in the centre to raise the heald half way and drop it back again. Both these requirements are avoided by this form of tappet.

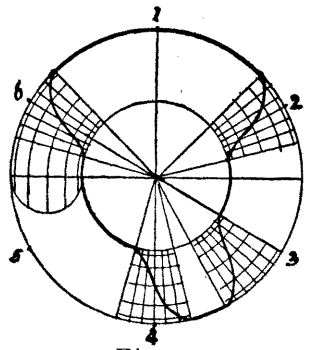


Fig. 94.

The next matter for consideration is the size of the tappet and the manner in which the size may be affected by the diameter of the anti-friction roller. Now take the Fig. 93 which is drawn for an anti-friction roller of 3½in. diameter, and Fig. 94 which treats the anti-friction roller as having no dimensions. And compare the space between the wings of the tappet and the incline formed by the surface of the tappets, and it will be found that in Fig. 93 not only is the space very small, although sufficient to give the requisite pause, but what is of more importance, the incline is very steep, consequently the movement runs the risk of being very seriously interfered with ; and although

theoretically a steep incline may act upon a large friction roller, in exactly the same manner, and obtain exactly the same movement as an easy incline upon a small friction roller, yet in practice, and more especially in a fast running loom, this is found not to be the case. In fact, the wing of the tappet, with the loom going even at a moderate speed, may run away from the friction roller and allow it to drop without ever touching the back of the wing. Consequently instead of that easy movement being imparted a sudden jerkiness would be the result, so that at one side of the stroke we should have tremendous pressure by the steep side of the tappet coming upon the friction roller, and, on the other side, the jerkiness referred to. This character of movement must be avoided for the two reasons, that it would cause too much reaction in the movement of the loom generally, and, that the jerkiness imparted to the healds would be seriously detrimental to the warp; nothing must occur which will affect in any degree the smoothness of motion already pointed out as being that which should be imparted to the healds. Then there are but two ways of obviating this difficulty, first, by increasing the size of the tappet; and, second, by decreasing the size of the anti-friction roller.

Let any one, for example, draw a tappet for a pattern of ten or twelve picks in the round, and with an anti-friction roller of say $3\frac{1}{2}$ inches diameter, and the necessary stroke of $2\frac{3}{4}$ to 3 inches, and it will be found that the space between the wings, when the diameter of the inner circle is anything reasonable, as say 6 or 8 inches, a dimension which may be considered as large as practicable in any ordinary looms, will be such as to reduce the dimension of the wings to an absurdity, even if they can be formed at all. Then if the diameter of the tappet is increased so as to permit the incline approaching a convenient one, the whole tappet must be so large as to be out of the

range of practical working. A very brief consideration of these points will give force to what has already been said of the desirability of working with small anti-friction rollers; and again another consideration will materially influence us, for with a large anti-friction roller the angle formed by the point of contact of the tappet with the circumference of the roller, and its centre, will be constantly changing; hence a considerable interference with the eccentricity which it is intended to impart to the healds from the tappet, so that however carefully a tappet may be drawn, unless this constantly changing angle is taken into account, along with the other items referred to, there is nothing to guarantee that the work will be satisfactorily done.

SPEED OF TAPPETS.

Apart from the questions of leverage, the depth of shed, and stroke of tappet, already dealt with, there is but one system of calculation required, and that is as to their speed; whether we are dealing with inside or outside tappets the regulation of the speed is an all important, though a very simple matter. The speed of the tappet in relation to the driving shaft must be governed by the number of picks in the pattern; it is a common error with people, who have not a thorough grasp of the subject, to suppose that the number of picks in the pattern, and therefore the speed of the tappet, must be governed by the number of healds. Very frequently there is some relation between the two, but it does not necessarily follow, either that they should be exactly the same or that one should be a measure of the other. This depends entirely upon the character of the design, but whatever the number of picks in the pattern the speed of the tappets must be governed by them. Suppose then, to begin with, there are four picks, then the tappet must revolve once for every four revolutions of the crank shaft; then to assure this the driving wheel upon the crank

shaft and the wheel carrying the tappets must be to each other as one to four. For convenience, and so as to prevent change in both wheels, an intermediate wheel is generally employed, which simply receives motion from the crank shaft wheel and communicates it direct to the tappet wheel. In that case the intermediate wheel has no influence upon the relative speeds, it simply receives and communicates power from one to the other; so that the change necessary to be made is only in the top, or crank shaft wheel. In a large number of looms the tappet wheel contains 120 teeth, simply because that is a convenient number; if there are four picks in the pattern then thirty teeth are required in the top wheel; if five picks a twenty-four wheel; if six picks a twenty wheel and so on. So that it is only necessary to have the intermediate wheel carried upon a bracket with a slot, so that it can be set in or out to accommodate the size of wheel required. But in cases where the number of picks in the pattern is not a measure of the teeth in the tappet wheel then double intermediate wheels may be required, and the calculation is a little more involved though not difficult. The simplest plan is that laid down in my book on "Weaving and Designing," of placing any convenient wheel on the top shaft and taking that multiplied by the number of picks in the pattern as a numerator, and the number of teeth in the tappet wheel as a denominator; then the two terms of the fraction will represent the two intermediate wheels. This will be perhaps better understood by reference to Fig. 95 which shows the train of wheels as they would occur in a loom. The upper wheel we may say, for convenience, contains twenty teeth and the tappet wheel 120, and there are nine picks in a pattern, then $\frac{20 + 9}{120} = \frac{180}{120} = \frac{18}{12}$ or as 3 is to 2, so that any two wheels bearing those proportions to each other may be employed as intermediate wheels, and so ensure the exact relative speed of the shaft and tappets.

There is only one consideration here, and I desire to mention this from a knowledge of mistakes into which I have known people fall, and that is as to the size of the wheels. Of course any two wheels bearing those proportions will give the requisite speed, but if, as sometimes may happen, they are too near each other in actual size, as for instance, should one be 60 and the other 54, there would be a danger, in the event of any obstruction, or of the shafts springing a little, of the tappet wheel slipping into gear with the wrong intermediate, and so causing gain or loss of a few teeth; this being repeated would cause a gradual gain of the shedding upon the picking, or *vice versa*,

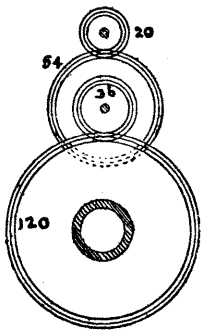


Fig. 95.

and would so disarrange the working that the whole loom would be out of gear. A very few minutes consideration would enable one to overcome this difficulty.

As the tappets so far dealt with act only in one direction, that of either raising or depressing a lever, some arrangement must be made for acting in the opposite direction. Where the tappets are placed inside the loom they usually act direct upon the healds and pull them down; then to ensure a return the healds are connected by straps over rollers at the top of the loom as shewn in Fig. 82. Where

the rollers are seen in front of the top rail, but this is only done for a very limited number of healds, as two or four; but where the tappets are outside the loom they are connected by means of levers so as to raise the healds; then some arrangement must be made inside the loom and underneath the healds to bring them back again. There are two methods of dealing with this, one by means of springs, or levers and springs combined, and the other by means of levers or rollers. In the first case each heald acts independently and may be raised in any order; in the second the healds are connected one to another, so that as one is raised it will pull another down. In the great majority of cases the latter mode is preferable, simply because there is no more work, or weight, thrown upon the loom than is absolutely necessary; whilst when springs are employed, in whatever form, a considerable amount of energy must be exerted in raising the healds and extending the springs. There is one disadvantage perhaps accompanying the use of levers, and that is, that the patterns must be perfectly regular, always the same number of healds raised for every pick in the pattern; this of course the great majority of patterns will comply with naturally, but there are always some exceptions, and whenever the exception arises, a general resort must be made to springs for every heald, or at least one heald must be provided with springs, even if coupled to others, so as to give the necessary degree of elasticity. One thing must be clearly understood in connecting healds together without the use of springs, and that is that the connection must be so made that, although one heald is coupled only directly to one other, yet the whole series must be connected indirectly. Take for example the illustration given at Fig. 96, which is really a representation of one of the earliest forms of pulley boxes, or pulley arrangements; in this it will be seen that every heald is connected indirectly with all the others, so that being once adjusted with, say one heald raised, then

any other may be raised in any order of succession and one will be depressed through the medium of the pulleys.

As will be seen by reference to the figure, the healds are coupled in pairs, each pair then is connected through the medium of a larger pulley to the next pair, so that the connection might be carried to an unlimited extent, and

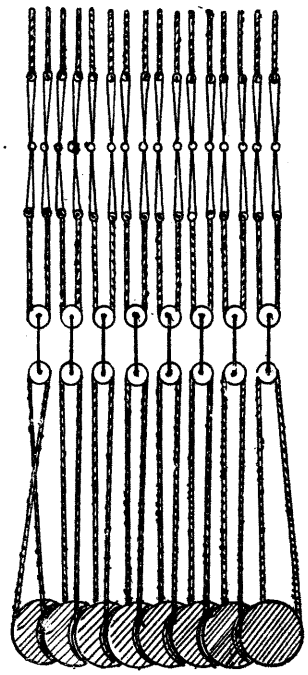


Fig. 96.

before the invention of the jacquard this system of connecting was very largely used in hand looms where, what was termed "witches," were used, as it enabled them to dispense with weights, which in heavy work is a great advantage. However it will be seen that the system would be too cumbrous for a modern power loom, and it is more

convenient to have some simpler arrangement which will serve for a fixed number of healds, and can be readily changed as the number of healds is changed. Fig. 97 will give a very clear conception of the arrangements adopted at present. Here we have a lever and pulley combined and so

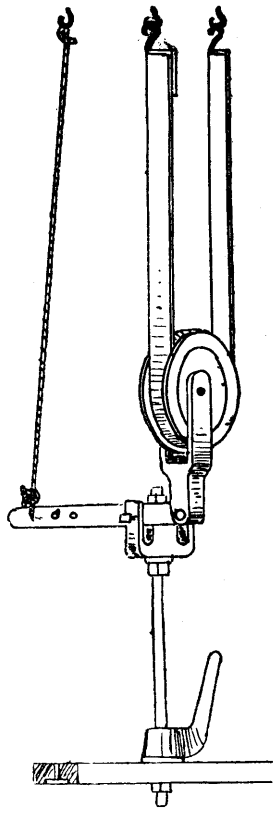


Fig. 97.

arranged as to actuate the healds; now the question of leverage as well as convenience of arrangement must be carefully taken into account. Suppose that the two healds, connected by means of the strap round the pulley, were

the only two in use, as one is raised the other must be depressed, and there is no difficulty as to leverage; but when the third heald is raised, and which may be acted upon by either of the others, then the question of leverage must occur. Here a lever is employed, perhaps as a matter of convenience, but a second pulley might equally well be employed, as will presently be shewn in connection with other contrivances. Now it must be obvious that if one heald is attached to one end of the lever and two healds to the other end, that if they are exactly to balance each other the length of the lever arms must be as two to one, just as we should place 2lbs. weight on the short arm of the lever to balance 1lb weight on the long arm. Then all that we have to do in this case is, to have the relative lengths of the lever arms properly adjusted, each heald connected after the tappets have been set, and then adjust the tension by means of the hand screw and nut on the rail below and have it ready for working.

A simple arrangement is shewn in Fig. 98, where provision is made for five healds, where pulleys and lever are again employed; but in this case the relative lengths of the arms of the lever must be as four to one. Instead of a lever, pulleys might well be substituted which answer exactly the same purpose as Fig. 97. Two pulleys of the relative diameters of two to one are made fast together, a small pulley is used precisely as in Fig. 97, but instead of that small pulley being attached to one arm of the lever, it is attached to one of the two smaller pulleys, and the strap of course connecting the third heald is attached to the larger pulley. Of course it must be borne in mind here that not only are the two pulleys made fast together, but that the straps, or cords, are also made fast to them, as the two serving the purpose of a lever it will not be possible for the straps to pass round them. Too much attention cannot be paid in arranging

these pulleys so that they can be adapted to other purposes for instance, the small pulley upon Fig. 97 should be so contrived that it can be also used for either plain weaving, or as part of a set for eight shafts ; and in like

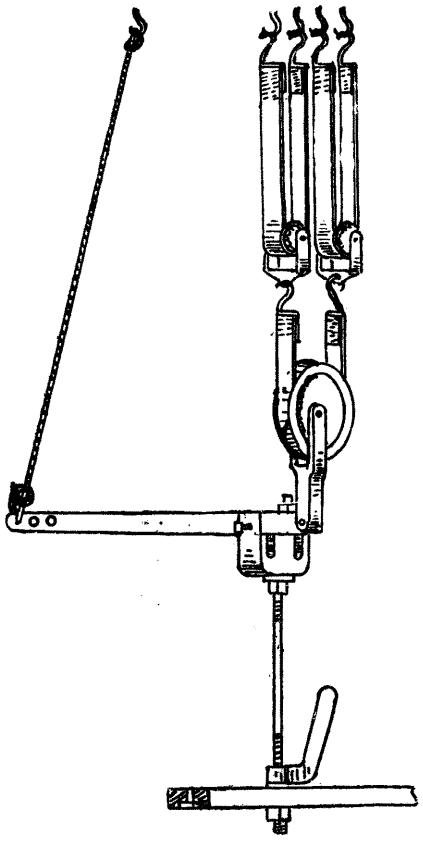


Fig. 98.

manner those upon Fig. 98 should be so that they can be used either for four, or half a set for eight, for it must be obvious that if the pulleys are detached from the lever that, of themselves, they form a complete set for four.

Another example is given in Fig. 99 where six healds are employed, and here it will be seen that not only is the question of leverage carefully considered, but the convenience of altering is also taken into account. If divided into several parts, the pulleys, with the exception of the intermediate pair, may be used as part of any other set, and it is only by this careful consideration of the use of any one article for different purposes that economy of production

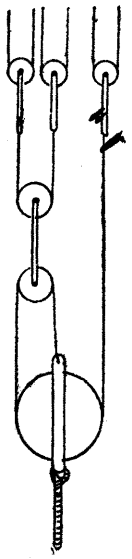


Fig. 99.

can be obtained. The question may be asked : What about seven healds ? Or nine ? The answer is obvious, that if you take the set of four from Fig. 98, and a set of three, as described, and you attach them to the two arms of a lever having the relative proportions of four to three, they must answer all the purposes. And so it may be said that with the few illustrations given here, and proper

manipulation of them, they can be adapted to any number of healds coming within the range of tappet work.

Only one more question in connection with this subject need now be considered, that is, the dimensions of the pulleys. Going back to the illustration, Fig 97, let it be supposed that the straps round the pulley are connected to the first and the third healds, and that the cord to the lever arm is attached to the second; this is a most convenient arrangement and enables the diameter of the pulley to be determined at once. Suppose, for instance, that the healds from centre to centre of shaft measure half inch. Then from the centre of the first to the centre of the third the distance will be one inch, so that determines the diameter of pulley at once. Now in Fig. 98, the most convenient arrangement would be to attach the lever arm, say to No. 1 heald, and the other four healds couple 2 and 4 together, and 3 and 5; then the diameter of the pulleys will be determined as one inch as in the first case, and the diameter of the larger pulley below is also immediately determined by the distance from the centre of one small pulley to the centre of the other, so that there need be no difficulty in ascertaining the dimensions required for any number of healds.

It will now be necessary to turn attention to what are known as positive tappets, which consist mainly in contrivances for forming a grooved cam with changeable plates, instead of having a groove cut in the cam itself. The plan most generally adopted is that known as Woodcroft's section tappet, which consists of a plate with a toothed rim and a series of perforations, so arranged that loose plates can be attached to it. In the first place a small plate called the centre plate, and which corresponds with the inner circle of the tappets previously described; then small sectional tappets are fitted upon this in such a manner as to form a running groove in which the anti-

friction roller of the treadle can revolve. There are two forms of these sectional plates, one to cause the roller to rise from the inner to the outer circle, and one to cause it to descend, each having a projecting rim which will carry the treadle the required distance. A view is given at Fig. 100 shewing the manner in which the tappets act upon the treadles, and which will be seen with their

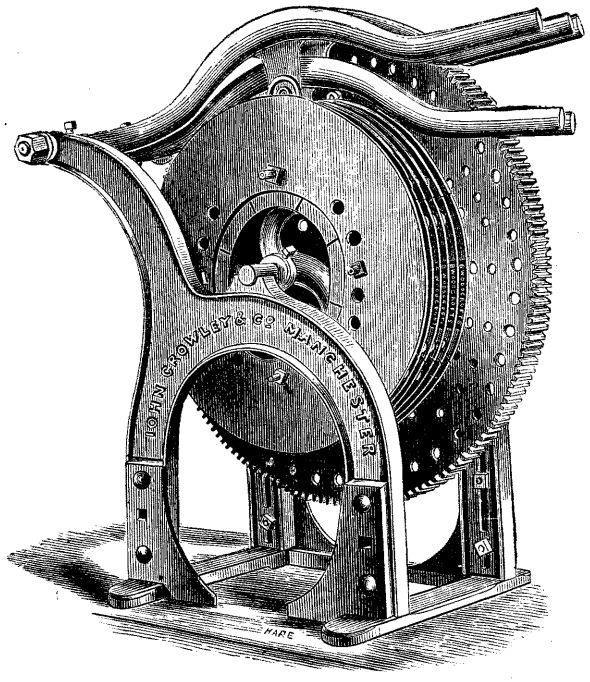


Fig. 100.

connections in the full view of the loom at Fig. 47, page 101, and the riser and faller plates at Figs. 101 and 102. It will be seen that the treadles consist of bent levers, having a roller attached, or carried by arms on the lower side, which may run in the groove formed by the tappet; at the free extremity of the levers, or treadles, cords

connect them with levers above and below, the opposite ends of these levers being connected to the healds as shewn in Fig. 47, so that a positive motion is imparted by means of a groove to the treadles and through them to the healds. This contrivance of loose plates certainly possesses many advantages for heavy work, first a positive motion is imparted to the healds, which is in itself a considerable advantage; in the second place it offers a ready means of changing the pattern, the plates having been placed in the position, as shewn, are held

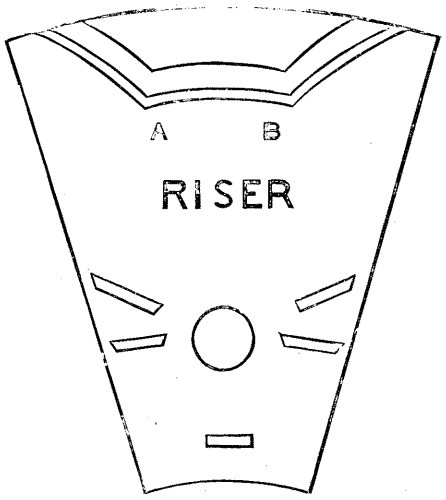


Fig. 101.

there by what is known as an outside plate, which is nothing more or less than a flat disc with bolt holes, so that it can be fastened down to hold the sectional plates in position. It must be understood that in building up a tappet plate, or a set of tappet plates, the same rule will hold good as in making ordinary tappets, viz.: that each treadle must have a separate tappet plate built up for itself, so that if we are working with twelve healds we must build up twelve sets of tappet plates. A decided

advantage in the use of this form of tappet, apart from the positive motion, is the fact that each heald being worked separately and distinctly from all the others there is no necessity for the pattern to be a regular one, but any degree of irregularity may exist. One reference made to the diameter of the anti-friction roller will be understood. As was pointed out in working with the non-positive tappets there has been a constant tendency to increase the diameter, and although the disadvantage has not been recognised there, in this case where a positive cam is

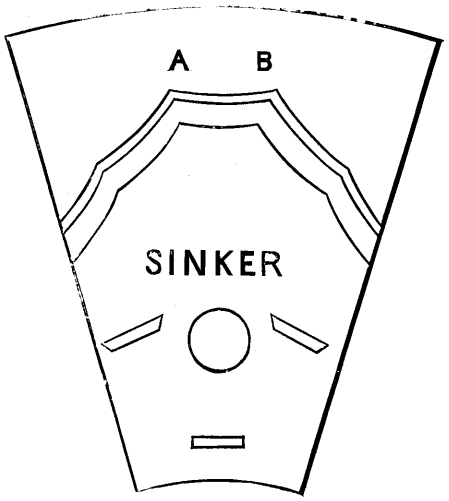


Fig. 102.

required it must be patent. In fact, the smaller the anti-friction roller, the more true the working.

Perhaps one word of warning may be given here, more especially to the student, as to the number of patterns capable of being woven with a section tappet. It has often been stated that the number will be determined by the law of permutation. Just to show the absurdity of this, suppose that our tappet plates are made for twelve healds and limited to twelve picks in a round, we should have

twelve changes upon each plate, which multiplied by 12 plates gives us 144 positions. Then by the law of permutation we multiply 1 by 2, the product by 3, then by 4, by 5, and so on until each successive product has been multipled by each number up to 144; this would give us a number represented by at least several scores of figures, of course, an utterly impossible one. This theory is based upon the possible re-arrangements, but this must be without regard to order. Now it is one of the first laws of pattern making, that we must have order and regularity; therefore reduced to this order and regularity instead of working according to the laws of permutation, we must work according to the laws of re-arrangement in definite order, and the doctrine of combinations. This, although giving us a sufficiently wide scope of pattern producing, and more than any one individual could possibly carry out in a life-time, is yet a very different thing from what we get from permutation.

There are several other forms of tappet to which some reference must be made, although they are not so much in use as those already referred to. One of them certainly deserves some consideration, not merely from the fact that it is still in use, but more especially that it has formed the basis of many forms of working rising shuttle-boxes, that is, what is commonly known as Nuttall's chain. This consists briefly in a lever having a chain at each side of its fulcrum, the chain consisting of alternately large and small anti-friction rollers, as shewn in Fig. 103. In this, a lever, which represents a treadle, has a small barrel at each side of its fulcrum, and round these barrels two chains are passed; one end of the lever or treadle is attached, in practically the same manner, to levers placed above and below, as in the Woodcroft's section tappet, and through these levers actuating the healds; so that to raise or depress the heald a large roller is placed upon the

chain at one side, and a small one on the corresponding link at the other, hence if the large roller is placed upon what is termed the heel of the treadle, the point will be depressed and the heald raised, but if the large roller is placed on the opposite side of the fulcrum, then the lever will be raised and the heald depressed. Without entering into the question of the exact nature of movement imparted to the heald by this method of working, one thing may certainly be said for it, that in addition to having a positive

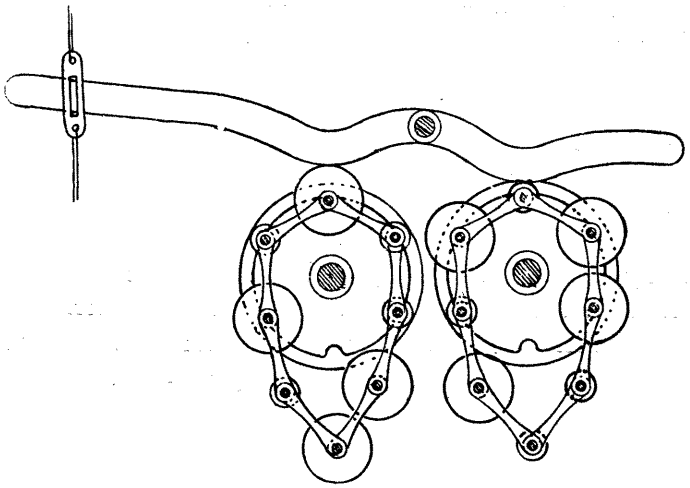


Fig. 103.

motion imparted to the healds we have the distinct advantage of being able to make a pattern of any length.

In all other forms of tappet working the number of picks in the pattern is limited, but in this it is practically unlimited, so that it presents the same features as the dobby in this respect. Of course if the chains get very long in the pattern they become heavy and cumbersome. In that one respect only, as well as the readiness of

changing the lags or cards, may the dobby be said to possess an advantage. Another form which is closely akin to this, is what is known as the oscillating tappet, or sometimes known as Clark's and Knowles' inventions. Practically the same principle is involved as in Nuttall's chain, but a slight difference occurs in the working detail.

Tappet working may now be easily summarised, whatever may be the particular form adopted, two priciples are involved, viz: negative or positive action on the healds, and, further, the open shed principle is almost universally adopted. For fast running looms all the advantages are in favour of tappets; for weaving a large proportion of fabrics, such as twills, and twills really represent the great bulk of woven goods, the tappet is most likely to ensure the production of well made cloth. Once being set, the healds work with a steadiness and precision which can scarcely be obtained by any other system of shedding; therefore the subject cannot be too closely studied, more especially the correct mode of forming the tappet, for upon the truth of the form and the equalisation of tension on the healds, almost everything depends in the production of good cloth.

LECTURE 7.

DOBBIES AND PATTERN SHEDDING MOTIONS.

The dobby, as known in the modern power loom, and the witch, as known in the hand loom, are machines coming intermediate between the treadle and jacquard loom in the one case, and the tappet, which is of course equivalent to the treadle, and the jacquard in the other. In fact the early witch of the hand loom was the forerunner of the jacquard, the principle being precisely the same in both, the difference being in the jacquard the substitution of the harness for the healds of the witch loom. The hand loom weaver in the early part of the present century, and in fact within the memory of some now living, would frequently have as many as 120 healds in the loom at one time. There were four standard numbers in regular use, viz., 52, 72, 96, and 120: of course comparatively few of the latter number as compared with the smaller ones. But by degrees the jacquard supplanted these, and for a long time there was a gradual decrease until it came to be looked upon as a machine which, in the power loom, should not carry more than from 16 to 24 healds, and in the hand loom from 16 to 32; but within recent years there has been a development in power loom dobbies, and patterns woven with them, which has brought the number up to 40, and even 48, though that number is very unwieldy and undesirable. There is but one reason that can ever be satisfactorily given for the use of such a large number of healds in the loom, and that is, that with healds and a well constructed dobby, a positive motion can be given, and consequently for many heavy fabrics a decided advantage gained over the harness where a negative

motion is necessary. The earliest forms of dobby were taken from the pattern of the hand loom which was simply a negative action machine, having in the majority of cases weights attached to the healds. This machine as seen in the illustration, Fig. 104, consisted in its essential working part of an upright hook having the healds suspended from the lower extremity; near or under the other extremity a lifting knife is placed. The machine shown has two lifting knives acting alternately to obtain speed in the power

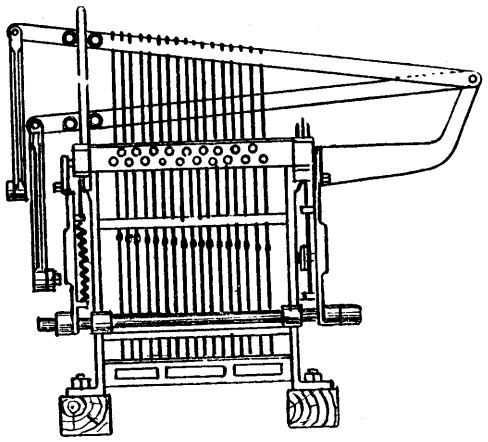


Fig. 104.

loom. This lifting knife having its fulcrum at one end and motion imparted to it by means of a connecting rod and treadle, so that as the lever was raised the hooks being placed intermediately between the fulcrum and the point where the power is applied, those furthest from the cloth would be gradually raised higher than those in front, this inclination being adjusted so as to form the upper half of the shed perfectly. Then to ensure the perfect formation of the lower half, the healds would be hung gradually sloping from front to back. This of course is, apparently,

a minor detail, but must be mentioned as leading up to an explanation of some of the points in more elaborate dobbies of the present day. So far as the internal mechanism of the machine is concerned, there is little in this case that requires elaborate explanation. The method of actuating or selecting the healds so as to form the desired pattern being the most important item. In this form of machine, a flat spring is placed in a vertical position in front of the hook, and from this spring a cross wire having a loop, through which the upright hook can pass, is carried to the back of the machine, so that whenever the spring is pressed back the hook would be pressed back also, so as to be free of the lifting knife. At the moment the pressure is released, the spring will return to its normal position, bringing the hook back over the lifting

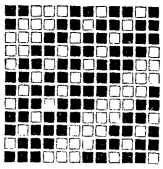


Fig. 105.

knife; so that what we shall have to consider first of all is, the method of selection to form the desired pattern.

Perhaps this point had better be made clear from the outset. Fig. 105 is a plan of a twilled cloth, that is exactly as we should see it on looking down at the surface of the fabric, the black dots indicating where the warp comes to the surface, and the blank spaces where the weft comes to the surface. Now reading this plan from left to the right, and taking each horizontal line as indicating one pick of the fabric, we should have three warp threads raised, three depressed, two raised, one depressed, two raised and one depressed again, so that the healds must be lifted exactly in the order indicated for the weft to

be passed through. On the front of the machine as shown in Fig. 106, we have a cylinder with a grooved surface at C. In each of those grooves is placed a perforated lag as shown at Fig. 107, the lags being connected together by iron links, at such a distance apart as exactly to correspond with those grooves, and having a shape something like a V, as shewn in Fig. 108, where the lag is represented in section, so that it may fall into and be

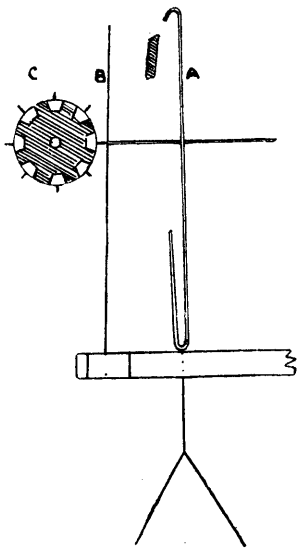


Fig. 106.

held firm in the groove. The perforations in the lag are exactly opposite the springs B, so that pegs may be inserted to strike back those springs and so throw the hooks back from the lifting knife. Then taking the 12 perforations, corresponding to the hooks to which the healds would be suspended, pegs are inserted exactly in the order of the first pick, as shown in Fig. 105, a second lag would be pegged in the order of the second pick and

so on, until the 12 lags corresponding with the 12 picks of the pattern have been pegged. Those 12 lags then laid out upon a table would be an exact representation of the plan in Fig. 105, the pegs corresponding with the

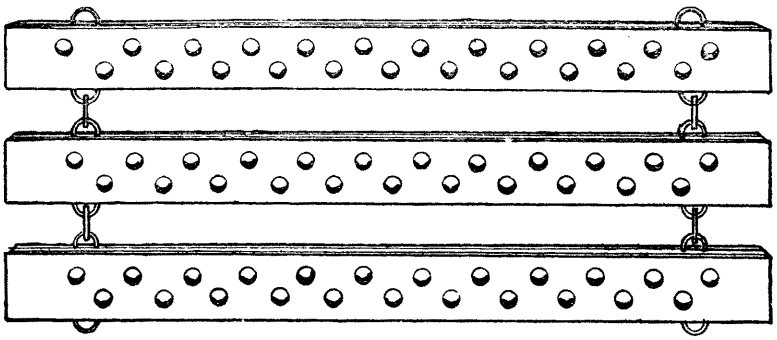


Fig. 107.

black dots, and the unpegged holes corresponding with the blank squares in the pattern. Although this is the simplest form of arrangement of patterns upon lags, it is the one which underlies the whole of the systems. Here it will be seen

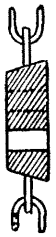


Fig. 108.

that the cylinder is provided with a head, having pegs corresponding to the grooves holding the lags. A pair of catches, or pawls, are affixed so as to pull the cylinder over at each succeeding pick, in order to bring the lags in their order of succession in front of the springs; the

object of the second catch being to reverse the movement should anything occur, such as the breaking of the weft, to cause the weaver to have to turn back to any particular lag. The cylinder having been turned into its position is held firmly there by means of a sort of hammer head upon a spindle which is kept closely pressed up to it by a spring, as shown in the illustration, Fig. 109, and the catches are shown at Fig. 110.

Now one point might be brought before the notice of the reader here, as, although apparently trivial in itself,

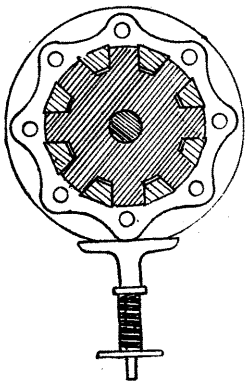


Fig. 109.

at this stage will render a clear understanding of the motive, and of the timing of the movements in the several parts of the machine, in the more elaborate dobbies to be dealt with at a later stage. The cylinder being in contact with the needles, and having by means of the pegs caused the change in the order in which the hooks should be lifted, must evidently be so timed in this movement as not to try to bring about that change when the hooks are actually resting upon the knife, with all the weight of the healds upon them. But the

cylinder must be moved round exactly at the moment when the lifting knife is clearing the hooks, and when no undue pressure would be exerted upon the springs, so as to facilitate the changing of positions and allow the lifting knife to pick up the new set of hooks with the least possible interference. This seems such a self-evident proposition that one feels almost called upon to apologise for calling attention to it, yet in the actual work of the mill, both in dobbies and with jacquards, a neglect of this arrangement of the timing of the parts is probably productive of more trouble and mischief than any other.

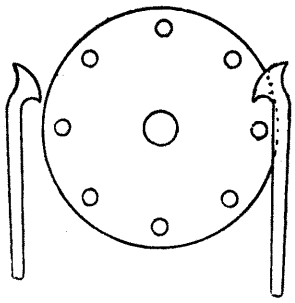


Fig. 110.

Then the next form following upon the lags of operating the needle is by means of perforated cards, and in that case an alteration of the system becomes necessary. Lags may be placed upon a perfect cylinder, and revolved in a stationary position, but when cards are employed this becomes impossible and, generally, a bar having a square section is substituted for the cylinder, although it is still known by the name of the cylinder, even in the most modern jacquards, so that anyone hearing the term cylinder applied to the rectangular bar carrying the cards upon a card machine will understand the origin of the term. This cylinder must be perforated at points corresponding to the

cross wires or needles, the arrangement now taking the form as shown in Fig. 111, where the cross wire projects through the needle board in front of the machine, and the vertical spring in front is replaced by a small helical spring at the back of the machine as shown. Then the cards here must be perforated in the same manner as the lag is pegged to correspond with the pattern, *i.e.*—going back to the pattern in Fig. 105,—wherever it is desired that the hooks should be raised, a hole must be cut in

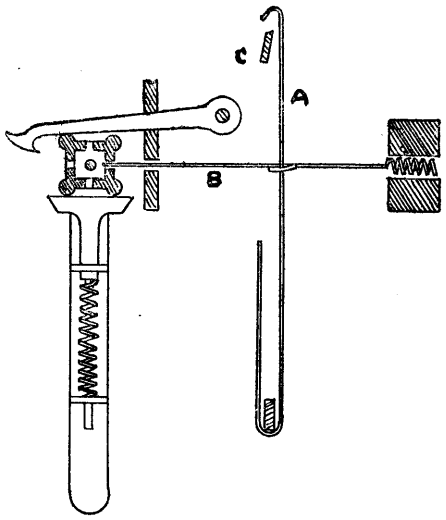


Fig. 111.

the card corresponding to the needle acting upon that hook; and again the cards when laced together as they are by means of string will present an exact facsimile of the plan, as would the pegged lags in the previous case.

The card cylinder must be actuated differently from the lag cylinder; every time the card comes in contact with the needle point, a number must pass through the perforations into the cylinder, generally to a depth of from

$\frac{3}{8}$ to $\frac{1}{2}$ an inch, so that even if the cylinder were a circular one, it could not be revolved with the card upon the needles; it is therefore placed upon an arm as shown in Fig. 111, and at every movement of the lifting knife, when it is engaged with the upright hooks, is thrown back a sufficient distance to enable the bar to revolve without coming in contact with the needle points. The revolution is caused by a catch, as shown, but in this case the catch is a stationary one attached to the side of the machine, so that as the card cylinder is thrown back, it will engage the corner of the cylinder head, and pull it over with the next face opposite the needle. The cylinder is again held in position by a hammer head and spring as in the previous case. Of course in this, as in the previous arrangement, the cylinder must be in contact with the needles when the lifting knife has disengaged itself from the hooks, so that the change takes place when there is no pressure upon the needle or the cards. This principle I desire to insist upon throughout, as it is one of vital moment in jacquard work.

Before going into the question of under motions, or other contrivances connected with non-positive dobbies, I think it will be better to call attention to the positive hand loom witch, so as to make the principle which must underlie all positive dobbies perfectly clear. Then it will leave the mechanical details of the several machines to be dealt with free from any question of principle, beyond an enquiry as to how far they comply with the best principles which can be laid down.

A section is given at Fig. 112, of a positive hand loom witch, where two hooks are employed in the place of one, one of which is attached to the upper half of the heald, and the other through levers to the lower half. The arrangement of the spring, crosswire, cylinder and lags, is precisely the same as in the ordinary witch, but

the second hook which is introduced, is placed with its back to the other one, and a second lifting knife is introduced so that as one hook is struck off the lifting knife, the other is struck on. Therefore as one rises the other will descend, and whichever of the two may be struck upon the hook, so as to either raise or depress the healds as the case may be, the character of the movement will be the same. To facilitate this, the bottom board of the

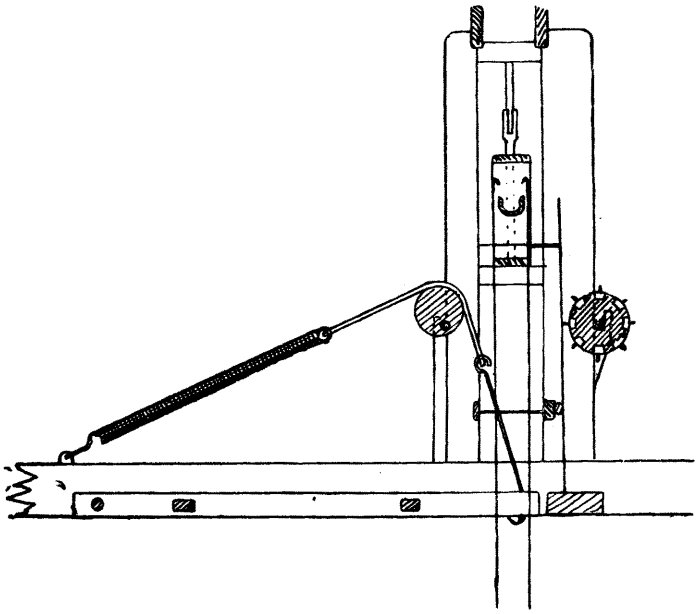


Fig. 112.

machine, upon which the hooks rest, when in the normal position, is made movable and descends exactly the same distance, and at the same rate of speed, as the lifting knives ascend. This bottom board is carried down by the pull of the cords through the healds of the rising hooks, and is brought back to its normal position by a lever and weight, or spring, so that not only do we get a positive

movement of the healds, although dependent for the return upon a lever, or spring, but we get, what is commonly termed, also a centre shedding motion, where the threads meet in the centre of the passage from the highest to the lowest point, instead of always descending at the lowest point, as in the previous case. This illustration will make the principle upon which all positive motion dobbies are based clear to some extent at least.

Of course in a power loom the application of the motive power can be varied to a much greater extent than in the hand loom, and therefore an absolute positive motion is more easily obtained. But one word now is necessary to this machine, it is shewn in Fig. 104 that the lifting knife was a lever which imparted considerably more movement to the healds at the back than at the front. In place of this lever, what has been known as a lifting block, or griffe, has been substituted, and this had its knives placed at an angle to obtain precisely the same effect. Where a large number of healds are employed this condition is absolutely necessary, in consequence of the great distance of the healds at the back of the set from the cloth in comparison with those in front. But when we come to the jacquard machine, where the space occupied by the harness is comparatively small, then this provision can be dispensed with.

POWER LOOM DOBBIES.

It will be as well to begin with the power loom dobby as with the hand loom, at the bottom shedding motion, or as it is sometimes termed, the single lift. In detail it is practically the same as that already described; the upright hooks, the needles, the lags and pegs and everything is practically the same, so that little need be said as to the general principle. Then the question for consideration in connection with this machine, apart from

what has already been said as to the advantages claimed for the different classes of shedding motion, is as to its ready and perfect application. For simplicity it is unquestionably the best. For weaving many classes of fabrics it has decided advantages, as also for the readiness with which the healds can be changed; but its one great disadvantage is in the employment of springs or weights. Very often this subject is looked upon from a very onesided point of view, but it should be faced fairly. Now taking the weight question first:—The common argument in favour of weights is, that in the average pattern the number descending will counterbalance those ascending, so that it is considered in the light of what has commonly been termed a counter-poise arrangement; but this is altogether overlooking the fact that at all times, whether moving or not, the whole weight is upon the machine though it may be said to be suspended as a dead weight. But in weaving irregular patterns, such for example as backed woollen or worsted goods, the variation in the weights of the sheds of the face and back cloths respectively is bound to have a serious effect upon the general working of the loom. Probably this is not so serious when weights are used as with a spring; for instance we take a spring and attach it to the bottom of a heald, when the heald is at rest there must be a certain amount of strain necessarily npon it for the purpose of keeping the heald tight, and in position, but the moment the shed begins to be open then the tension is gradually increased, so that supposing the tension upon the heald when at rest is equal to the 10 lbs. and the heald must traverse say not less than 4 inches, then as the strain is being gradually increased at every inch of movement, and in the ratio of 10 lbs. per inch, then the strain or tension at the extremity must be 10 lbs. by 4 inches, or equal to 40 inch lbs. in the aggregate.

Now look at the counterpoise in this case. Suppose we have sixteen healds and eight of them at their highest and eight at their lowest points respectively. Then 8 by 40 lbs. at the top as against 8 by 10 lbs. at the bottom represents the difference in the actual weight upon the two halves of the shed. Now here it must be observed that one portion is bearing the greatest strain at the moment when the other portion has the least, so that there cannot be said, by any stretch of imagination, to be any counterpoise here. Then as the strain is being released from the upper portion in its descent that from

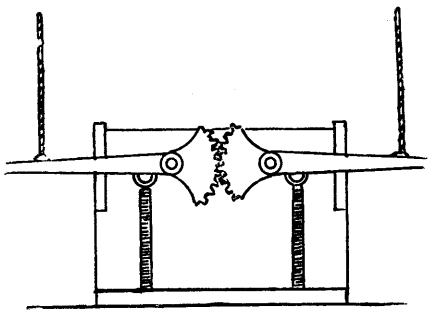


Fig. 113.

the lower portion is being correspondingly increased in the ascent, so that the exact balance of the two parts only occurs when they are passing each other in the centre. Even when the sheds are equally balanced this cannot be considered a satisfactory arrangement of the balance of weight, and with unequal sheds it must of necessity be less satisfactory. Now to meet, or mitigate this, various arrangements and contrivances have been resorted to, the simplest and possibly one of the oldest is shewn at Fig. 113 where two levers are placed beneath the loom having toothed gearing meeting each other in the centre, the fulcrum being very near the toothed gearing and the longer

arm on each side being attached to the bottom of the heald. A spring is attached to the lever between the fulcrum and the point of connection with the heald and, by preference, very near the fulcrum; the opposite end of the spring being made fast to the floor or a framework near the floor. The effect of this is that as the heald is being raised the point of connection of the spring with the lever is gradually approaching the fulcrum itself, consequently instead of the strain being a constantly increasing one, in the direct ratio of the length to which it is drawn out, it gradually decreases as it approaches the fulcrum. This is far from being satisfactory, even

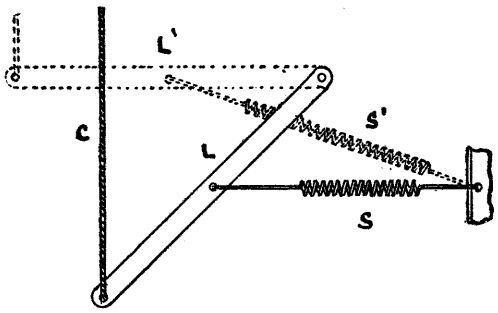


Fig. 114.

though it possesses advantages over the direct acting spring. Then we must look to other arrangements to overcome this in a greater degree. Another motion manufactured by Messrs. Hahlo & Liebreich is an improvement upon this, and another is what is now known as Kenyon's motion.

HAHLO'S UNDER MOTION.

In principle this under-motion is precisely the same as that of Kenyon, but instead of the lever as described in that motion an eccentric is used, this will be more readily understood by reference to Fig. 116, where the levers are seen attached to the eccentric at one side and the spring at the other. The spring is made fast to the

frame at one end, and from the other end a strap is carried to the eccentric and forward direct to the lever, being made fast to the eccentric by means of a small bolt at the point where the leverage is greatest, or at the furthest distance from the centre, so that as the lever is raised the eccentric is pulled round and a gradual decrease of pressure, or tension, upon the spring follows in precisely the same manner as in Kenyon's motion, shewn in Fig. 115. This has perhaps the advantage of compactness, as it will be seen that very little space is occupied by the apparatus itself and the methods of adjustment are quite as easy as in the previous case. It simply means the lengthening

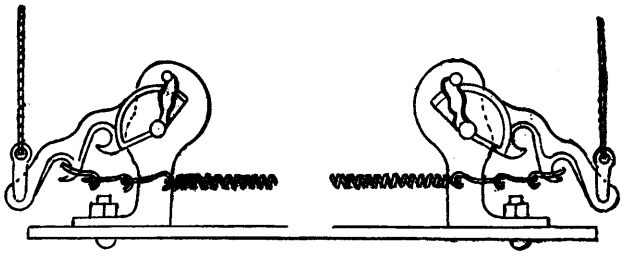


Fig. 115.

or shortening of the strap on one side or the other to ensure any amount of strain, great or little as required. It is claimed for this arrangenent that, with the eccentrics as shewn, the spring is distended only $\frac{3}{4}$ of an inch for a shed of 5 inches in depth. Then it must follow that the amount of weight upon the heald can be ascertained with absolute accuracy. Suppose one of Salter's springs being taken we know the strength of the first pull, and allowing for its being distended $\frac{3}{4}$ of an inch we can determine the exact ultimate weight upon the spring, and then we have only to ascertain the amount of leverage given by the eccentric and the weight upon the healds both at the highest and lowest point is determined

at once. One form is illustrated in Fig. 116 where two levers are shewn, one in the raised and one in the depressed condition. Another illustration of the same motion is given at Fig. 117. In this case two sets of levers are employed, one attached to each side of the heald so as

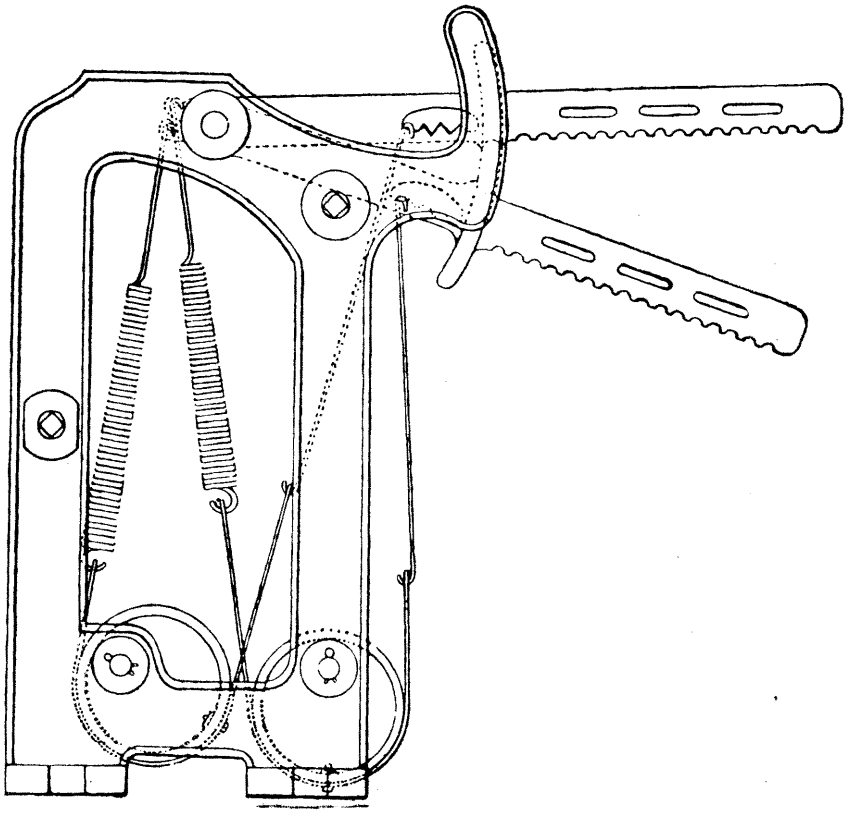


Fig. 116.

to dispense with bow bands. In this the two levers are hinged together at the centre in such a manner that one spring serves for both levers, this ensuring the action being precisely the same on both sides of the healds. This of course has the double advantage of not only

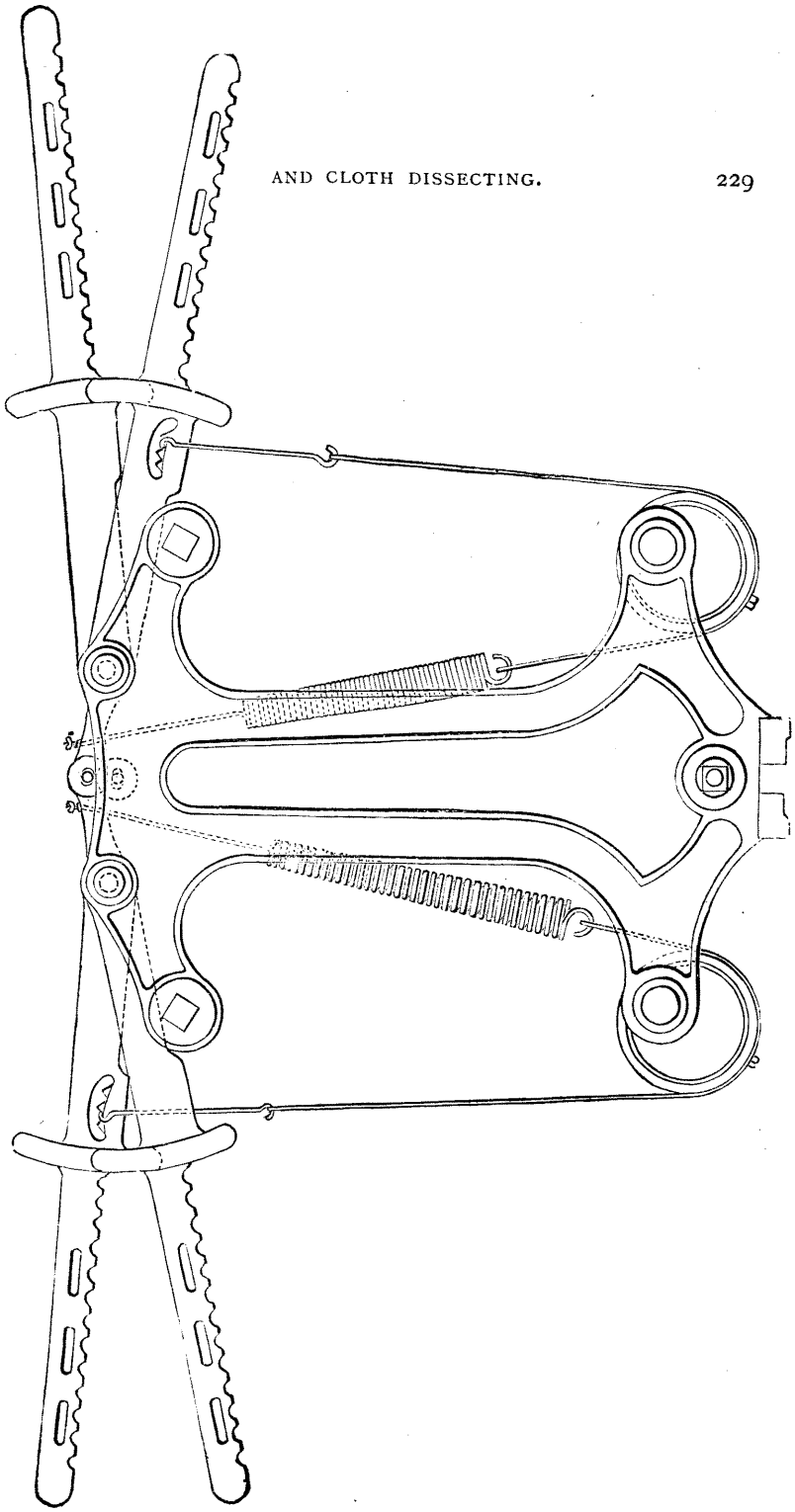


Fig. 117.

ensuring regularity of motion but of economising space. The amount of tension of each spring can be regulated first by means of a wing nut as shewn, and also by the provision of several notches in the levers so that all facilities for regulation are provided for. This is based upon an old and well-known principle. Suppose you take a lever L, Fig. 114, and place it at an angle of 45°, attach a cord to the free extremity and attach a spring S at any point between the fulcrum and where the cord is attached. You now apply force to the cord and raise the lever, the nearer you bring the lever to the horizontal line, as shown at L^1, the more you are diminishing the strength of the spring, or the resistance it will offer to the movement of the cord, simply because the line of direction of force as exerted by the spring and shown by S^1, is gradually approaching the horizontal, or is being exerted upon the fulcrum of the lever, so that when the lever reaches the perfectly horizontal position the tension upon the cord will be absolutely nothing, and if you pass that position the strength of the spring will be exerted in pulling the lever upwards and actually freeing the cord, as indicated by the dotted lines in the illustration. Now this principle has been applied over and over again in some of the earliest power looms, so that in its present form it is merely a revival of a well-known method which has always been more or less in use for this purpose.

Now one little point occurs here as influencing its practical application. The lever must be formed with a fairly broad base, so that the chain, or strap, connecting the spring with it may rest upon, and bend round the base to prevent, in the event of the lever being drawn beyond the horizontal position, the contingency which has been suggested, and to ensure that sufficient strain may be kept upon the healds. By a careful adjustment of the foot of the lever, that is by making it partake somewhat

of the character of a projection, the tension may be made to slightly increase after the lever has passed the horizontal. There is probably no absolute necessity for this, but often it may be somewhat desirable, so as to give sufficient impetus to the movement on the return. Now the question of leverage or power, or tension applied to the heald, may be very easily determined, the strength of the spring being known.

Let the pull upon the spring be 10 lbs. when at rest, and it is stretched 3 inches, the strength would be increased and three-fold added to the existing weight, thus 10 lb. × 3 = 30, add to that the 10 lbs. already existing and it would be 30 + 10 = 40 lbs. for a straight pull, but in the case of a lever such as this, the 10 lb. would be gradually decreasing, as shown.

One important modification has been introduced into this, as shown in the illustration, Fig. 115, and that is the ability to lengthen the chain connecting the spring with the lever, by introducing fresh links, or moving from one notch to the other on the lever, as shown in the illustration. A rather serious difficulty often arises in the use of under motions. In a large proportion of dobbies, what are commonly called bowbands must of necessity be used, *i.e.*, the two sides of the heald must be connected to the lever at one point above. Now suppose springs only are used, and one spring should be slightly stronger than the other, or there is the least variation in the tension upon the cord; at every effort to raise this heald, one side will constantly be rising above the level of the other, and it is only by the most careful adjustment that this tendency can be overcome, and even when everything appears to be perfectly correct in working there is no certainty that a little slipping, or stretching at the cords, will not cause a derangement at any moment. In the method shown at Fig. 113, this is overcome in

some degree by the gearing of the two levers into each other, and so equalising the strength of the springs, but that is not nearly so perfect as the method shown in Fig. 118, which is one of the improved modifications of Kenyon's, and ensures always the same freedom being given to both sides of the heald, and perfect equality in lifting, along with the advantage mentioned of a release of the spring as the heald is being raised. Of course in practical working, many modifications of the system as described may be found in use, but practically the principles are covered by what has been referred to.

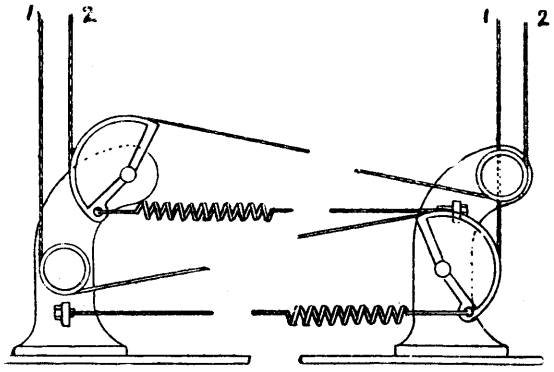


Fig 118.

Now to turn to the actual machine; there are several points in connection with this machine, which may well be thoroughly cleared up now, and it will serve as a basis for consideration of jacquard machines afterwards. In the first place, it has been pointed out that the lifting hook has a cord attached to it for the purpose of raising the heald, but no mention has been made of the constant tendency on the part of this hook to turn itself half round. This tendency exists not only in the single dobby, but in every machine, up to the most elaborate jacquard. There are several methods of obviating this, and those,

if pointed out at present, will considerably assist in the understanding of the details of the jacquard later on. A very simple contrivance is shown at Fig. 119, which shows the hook as being a double one. The second or shorter hook resting upon a bar or iron rod at the bottom, or in the middle of the machine, and the upper half having its hook placed over the lifting bar in the ordinary manner. The card cylinder acts upon it through the medium of

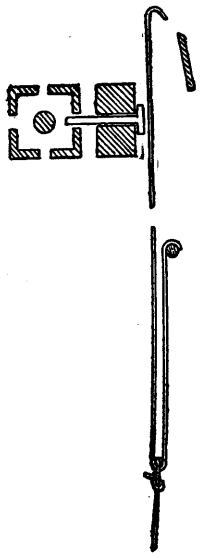


Fig. 119.

a small needle with a head, and the hook practically forms its own spring. One considerable advantage exists in this arrangement, and which is of much more importance in large jacquard machines, *i.e.*, that the lower half of the hook projects considerably below the bottom of the machine to permit of the ready replacing of a neck cord when necessary. A further arrangement is, where the bottom of the hook is simply turned up, and passed through a

second eye in the needle or cross wire, so of course effectually preventing its turning, but making a somewhat cumbersome arrangement.

There is but one other method we need dwell upon here, and that is, the method of actuating the card cylinder or bar. As already pointed out, the cylinder for lags may be revolved without its position being moved, but obviously a square bar cannot be so treated. It must be thrown back a sufficient distance from the needle points that its corners cannot come into contact with them. To accomplish this, two methods are adopted; one is to throw the cylinder back upon an arm, and the other to move it upon a bar having horizontal motion imparted to it. Both methods will be more fully described in connection with the jacquard. There are no special advantages attached to either of those methods, it is simply a question of mechanical arrangement. Only one thing must be considered in connection with either of them, and that is, the proper timing of the movement in relation to the lifting knives, as already indicated.

HATTERSLEY'S DOBBY.

After the single lift dobby came what is known as the Keighley dobby, or Hattersley's patent dobby. This machine is generally looked upon as an open shed dobby, strictly speaking it is not so, but one of those as already described where the upper half of the shed descends midway to the point where the change takes place, though the amount of descent is mitigated by the form and arrangement of the levers. This will be best understood by reference to the illustration at Fig. 120, which is a section of the machine as made by Messrs. Ward Bros. showing the whole of the working details. The leading features of the machine consist in a T lever having its fulcrum at A and connecting rod B attached to the long

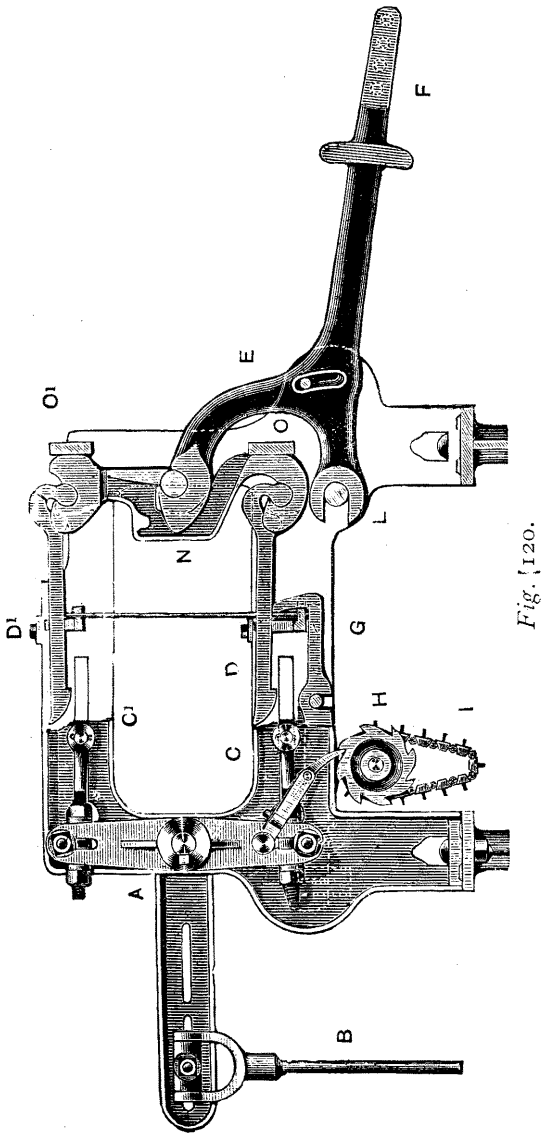


Fig. 1120.

arm of the lever. Each extremity of the head of the T acts upon a draw knife, C and C^1. Those draw knives in turn actuating the hooks D and D^1, each of which being connected with opposite arms of the lever E actuate the heald by means of the bow bands from F. So far this is sufficiently simple, the connecting or treading rod B is connected with a crank on the lower shaft of the loom, so that at each revolution of that crank the draw knives C and C^1 are both actuated, or one serves for one pick of the loom and the other for the next pick, the lower shaft revolving once for two picks. The manner in which the lever E is connected to the hooks D and D^1 and the readiness with which the hooks or levers can be removed will be best understood by a reference to the details of the illustration.

But the method of selection of the hooks to be actuated is at the present moment of much more importance to us as involving more important considerations. Immediately below the hooks are a series of levers G, and so contrived that a lever can act directly upon the hook D^1 by means of a vertical needle and one act also upon the hook D. Beneath this series of levers is placed the lag cylinder H with the lags I revolving upon it. This cylinder may be made to revolve by means of a pawl or catch which being connected to the lower arm of the T, lever A, will cause the cylinder to move one tooth at each stroke of that lever, so that each lag placed upon the cylinder must serve for two picks of the pattern. The method of pegging the lags will be described presently, let us consider at the present moment the exact action of the dobby.

Now refer to the lever E and note its peculiar form. It will be seen that at its lower extremity it has what might be termed a fulcrum at L, and a connection at M with another species of lever N. This lever N is the one connected with the hooks D and D^1, so that although E

at the point of connection at N is movable, the point L remains stationary. Now suppose the heald is at its lowest point. Both ends will be resting against the bars O and O^1, but should the heald be raised, say by the top hook, the bar N would be drawn away from O^1 a sufficient distance to raise the heald, or should it be acted upon by the lower hook it would be drawn away from the bar O in a similar manner. Now suppose the heald has been raised by the action of the hook D and the draw bar C, and held up for one pick, it is desired that it shall return to its lowest point after that pick, the hook D^1 would be raised by means of the peg in the lag and so prevent its acting upon the lever N, thus that lever would return to its normal position, resting against the bar O. But should the heald require to be held up for another pick then the hook D would be allowed to come in contact with the draw bar C, and so draw the lever N at its lower extremity away from the resting bar O, so that a double action would be taking place the draw-bar C would be pulling away at the lower end of the lever at the same moment that the draw-bar C^1 would be returning the upper end towards O^1, so that at the point where they meet for the change to take place from one draw knife to the other the heald would have been allowed to descend some distance from its highest point towards the centre of stroke, and then would be brought back to the highest point, so that although nominally an open shed dobby, strictly speaking it is not so, the lower half remains stationary but the upper half must always descend not less than one-fourth the entire depth of the shed as each change takes place. Strictly speaking there is no disadvantage in this, for the amount of work thrown upon the machine and the slight variation in the tension is of little moment compared with the advantage gained by the rapidity of change from one draw-knife to

the other, and consequently the increased speed at which the loom can be run. No better evidence of this could be adduced than the long and successful career of the machine itself, and the fact that it has been copied, modified and improvements patented by some of our best machine makers since the expiration of the original patent. There is one possible disadvantage connected with it, more especially for wide looms or slow running looms. The lever A being actuated from what is termed the tappet shaft of the loom and the manner in which the draw-knives act upon the healds through the levers L and E, comparatively small pause is given to the shed when fully open, consequently it is often found difficult to pass a shuttle across during the time when the shed is open. Attempts have been made to assist this by giving more pause to the going part, and in several modifications of the machine, both by the original inventors and others, the defect has in some measure been overcome.

The machine shewn at Fig. 120 is a modification, or improvement of the Keighley Dobby. This modification is simply in detail, there is no alteration whatever in the principle involved. As will be seen the working joints are made strong, the draw hooks are made solid instead of having looped eyes so that strength is obtained by increasing the width of the machine. Then not only are the needles reduced to half in quantity but the small collars have been dispensed with. The bottom draw hooks are brought into direct contact with the pegs so that the intermediate wire needles are dispensed with. Again the draw hooks are made to work in a grate so as to ensure a straight direct lift, and in fact the machine is put together in such a manner as not only to increase the efficiency, but so that every part of the machine can be removed without disturbing any of the other parts. This in itself is a considerable advantage

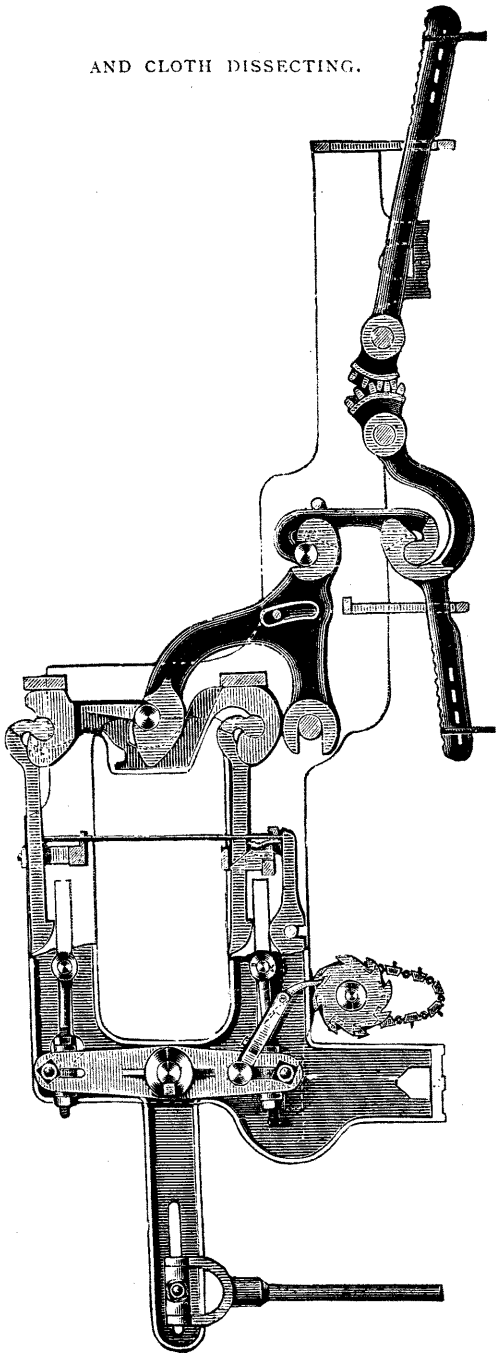


Fig. 121.

as saving time and preventing mishaps in making alterations or repairing damages.

Another modification and improvement of the same machine is shewn at Fig. 121, and a view of Hattersley's own make at Fig. 122, where double jacks are used dispensing with the bow bands above the healds, sufficient has been said already as to the use of bow bands and the disadvantages attending them that nothing more need be said as to the advantages of this class of machine.

A still further modification is shewn at Fig. 123, where instead of the double lever shewn in 121, extension levers

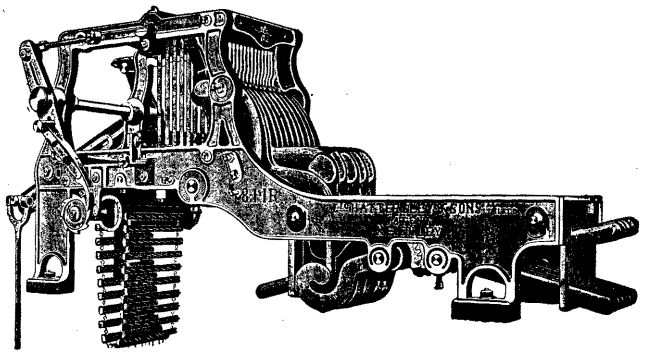


Fig. 122.

are employed, making it much more suitable for heavy strong goods and more especially for wide looms.

Another developement of the same machine and giving positive motion to the healds is shewn at Fig. 124, where by an ingenious connection of the levers the healds are either raised or depressed direct from the machine, thus dispensing with under-motions or springs. This loom is Messrs. Hattersley's make.

Now we come to another important improvement in this class of machine, namely, the use of what are known as cross border motions. Every one familiar with weaving is also familiar with the disadvantages attending the use of

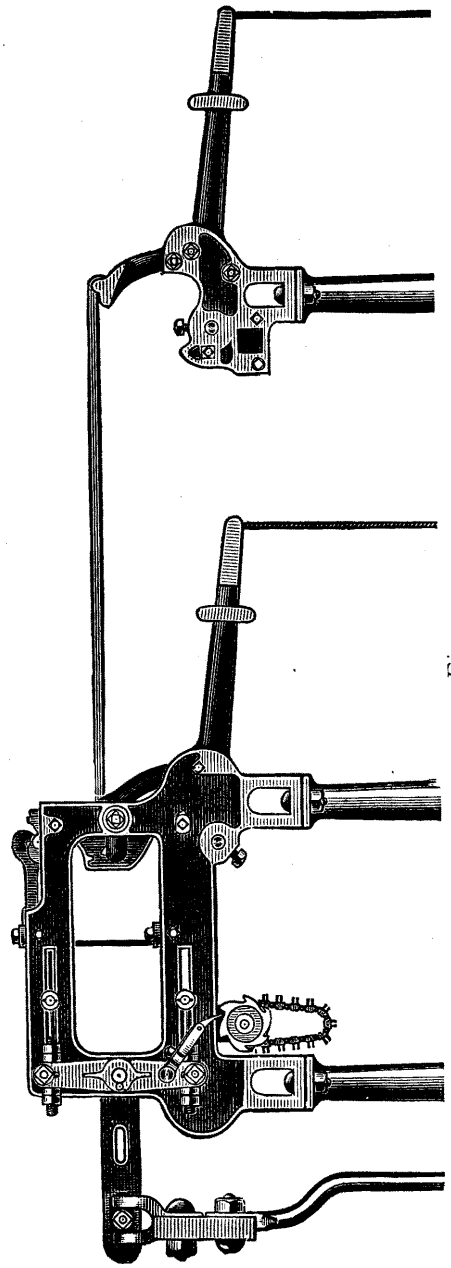


Fig. 123.

two sets of cards or lags; consequently the introduction of the machine which will enable the weaver to change from one to the other without actually taking the cards or lags off the barrel must of necessity be of great convenience to the weaver. A contrivance of this kind is shewn at Fig. 125

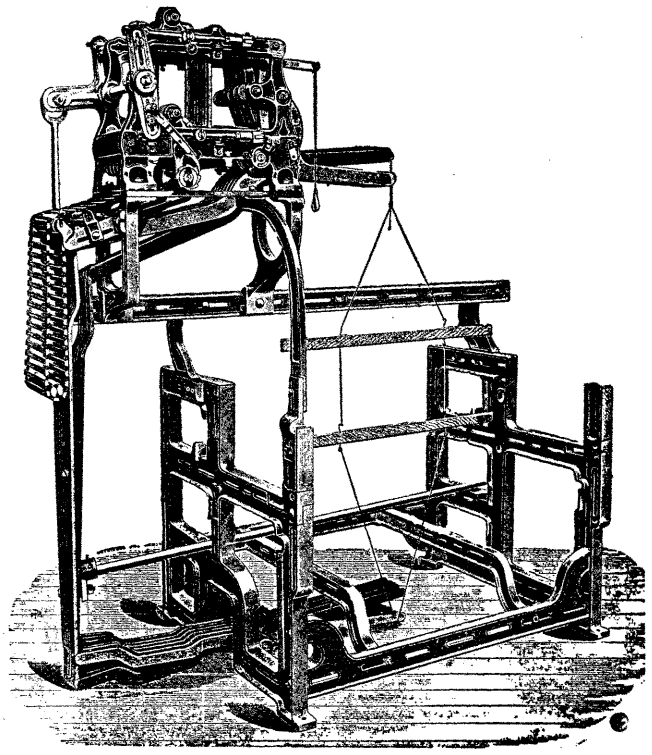


Fig. 124

in what is known as the L. and Y. Dobby of Messrs. Ward Bros. Here it will be seen that the apparatus is one of the double jack, or double lift motions, and is provided with two lag cylinders, one for working the cross border and the other for working the middle, or body of the towel or other articles being woven.

A glance at the machine will explain the simplicity of the arrangement; the two card cylinders are placed on opposite arms of the lever and so arranged that either one or the other can be brought into play at will by pulling the handle to the right the cylinder to the left is brought into action, and by pulling that to the left the opposite takes place. This will perhaps be better understood by reference to Fig. 126, which provides for an automatic arrangement to serve the same purpose. In this case there is nothing left to the weaver, but the machine

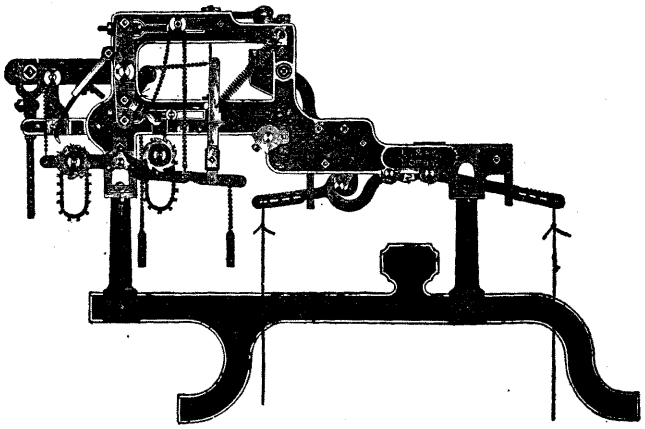


Fig. 125.

performs the change itself. The two lattice or lag barrels are carried on the lever CC, the inside barrel, or the one to the right, is shewn in working position, and upon it are carried the lags for weaving the cross border. A link E connected by a bracket and upright bar D on the rocking lever CC locks the inside barrel firmly in position when required. A series of jack levers marked A are employed exclusively for changing the barrel or bringing either of them into action at will. This lever A has no heald attached to it. When it is desired to bring the

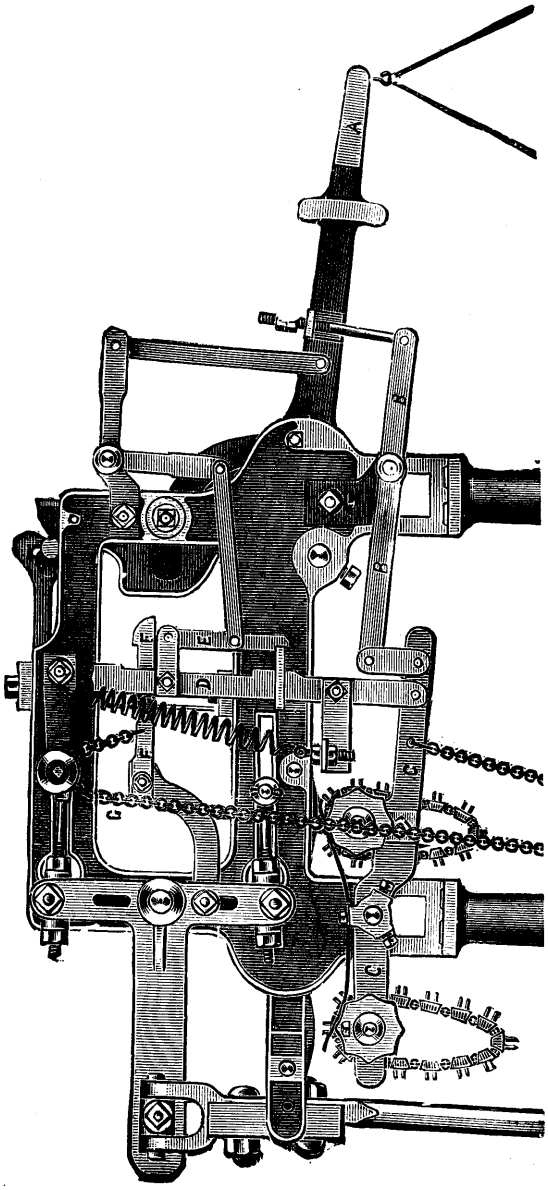


Fig. 126.

outer barrel, which carries the lags for weaving the ground portion of the fabric, into position, a peg is inserted on one of the lags on the inside barrel so as to operate the lever A, which in its movement first withdraws the locking link E, and then by means of the lever BB changes the position of the barrels by reversing the position of the lever CC. They are then locked in that position again by means of a ledging on the upright bar D. Now to return the barrels to their original position after the ground fabric has been woven, and with a view of weaving a second cross border, the catch F is caused to withdraw the bar D from its fastening by means of a chain GG, enabling the upright spiral spring, as shewn, to bring the whole of the mechanism back to its original position, and so the operations go on alternately, thus saving either the constant changing of cards or lags by the weaver, or the use of a sufficient number of cards to weave the whole length of the towel or handkerchief.

One other feature connected with this class of dobby must be noticed, and that is the use of a positive driving chain for the lattice barrel; the object of this is to drive the lattice barrel direct from the crank shaft, and is of most importance when the dobby is employed in connection with box looms. In weaving coloured checked goods, where there is a pattern formed by the healds in conjunction with the check, it is necessary that the two should be made to work in unison, so that should the loom be turned back the pattern chain and box chain will be reversed at the same moment. This is accomplished simply by placing a chain wheel B, Fig. 127, which can be driven by the chain from the crank shaft as shewn. On the opposite end of the shaft carrying B is mounted a recessed disc and pin C, each revolution of which will move the latticed barrel a distance equal to the width of one lattice or lag, thus by the simplest possible means continuity of

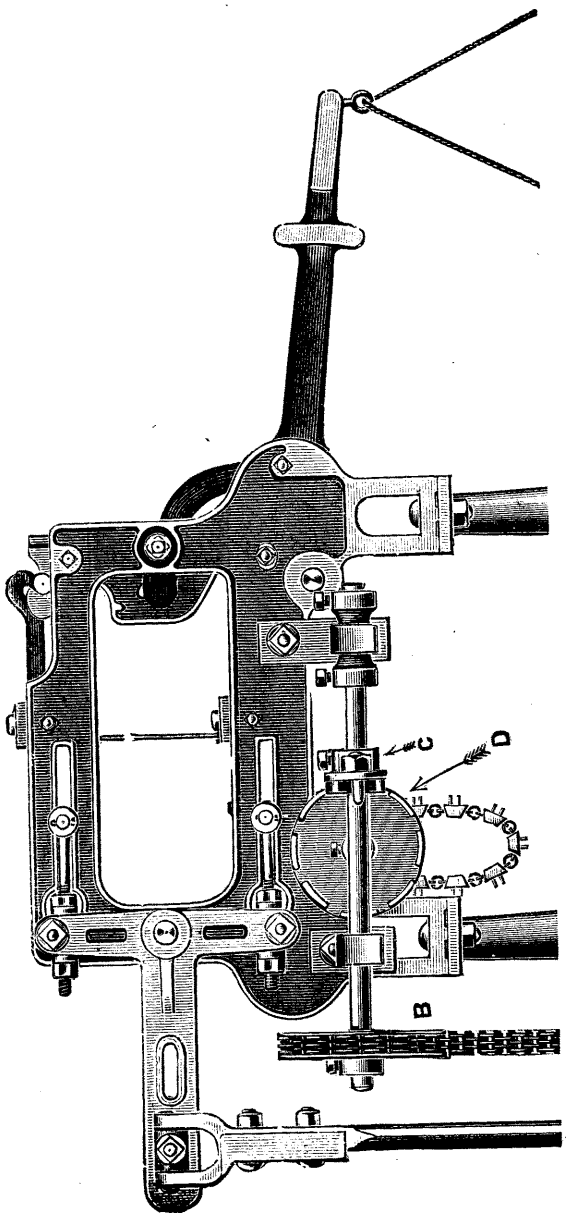


Fig. 127.

driving the lags of the dobby and the card motions is ensured.

HAHLO AND LIEBREICH'S DOUBLE-LIFT MOTIONS.

Now we have another machine somewhat different from the Keighley type but virtually built upon the same principle, a view of which is shewn in Fig. 128. This

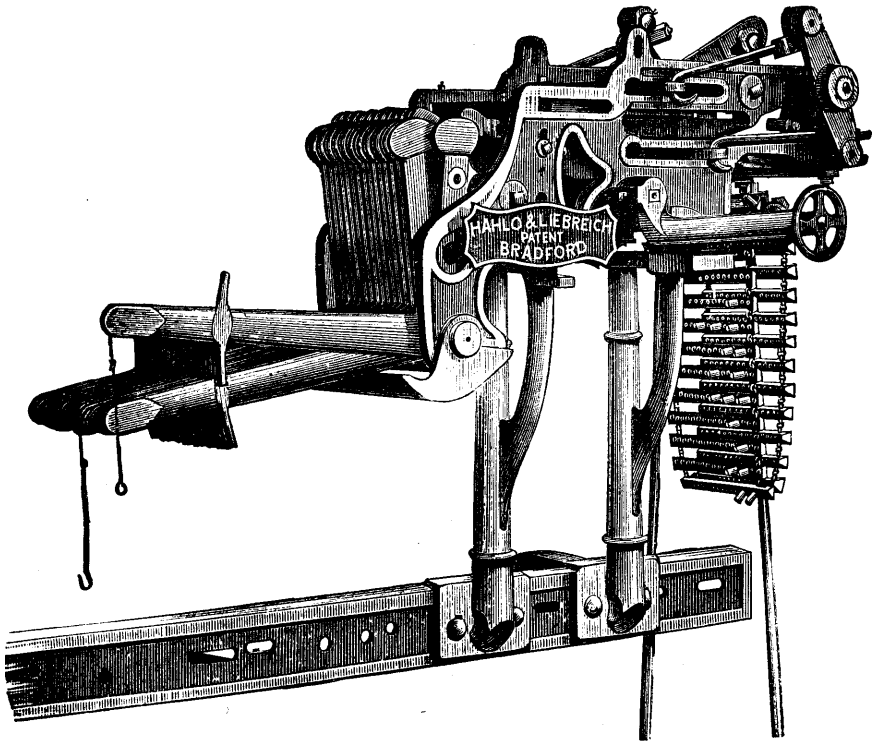


Fig. 128.

possesses the advantage of compactness, and perhaps a little more direct action than the original machine. It will be seen on reference to the drawing which represents the machine arranged to work on looms from 40 to 45 inches wide, where there are two draw bars of practically the

same type as the Keighley dobby, but the hooks or draw bars are placed much closer together and act practically as one. The general arrangement of levers, the action of the lags upon the knives in the selection of hooks, the jacks or levers and everything, although slightly differing in detail from the Keighley dobby are virtually the same in effect. Another modification of the same machine is shewn in Fig. 129, which is virtually the same machine but arranged to work with paper cards instead of lags, and with the addition of an automatic cross border motion. So far as the card motion is concerned, it differs from the lags and pegs only as already pointed out, viz:—the cards must be perforated and the card cylinder withdrawn and pressed up to the needles with each succeeding card instead of revolving in one fixed position, as is done in the lag motion. The cross border motion calls for special notice, inasmuch as it differs from the other ones entirely in principle. It will be remembered that in those already referred to two sets of lags or cards were employed, one for the ground and one for the border. In this machine the same set of cards is made to serve a double purpose, and not only may a cross border and ground pattern be woven, but any number of patterns, within reasonable compass, may be put upon the same cards. The arrangement generally is this, there is one row of needles to actuate the hooks, and the cards are so arranged that two, three, or more rows of holes may be cut upon them, and the card cylinder over which they pass is so arranged that any one of the several rows of holes may be brought under the needles at will. It will be seen from the illustration that a vertical motion is imparted to the card cylinder C. And whenever a blank in the card comes in contact with the lever, the draw bar H, drawing the catch P, moves the ratchet wheel R one tooth, thus moving the star wheel carrying the chain of links. Now these

links perform a very important function, as will be seen; actuating the end N of the lever O in such a manner that they can alter the position of this lever, raising or lowering it in any degree. This lever is so contrived that it brings one of the rows of holes in the cards opposite the needles which actuate the draw-hooks. Now suppose

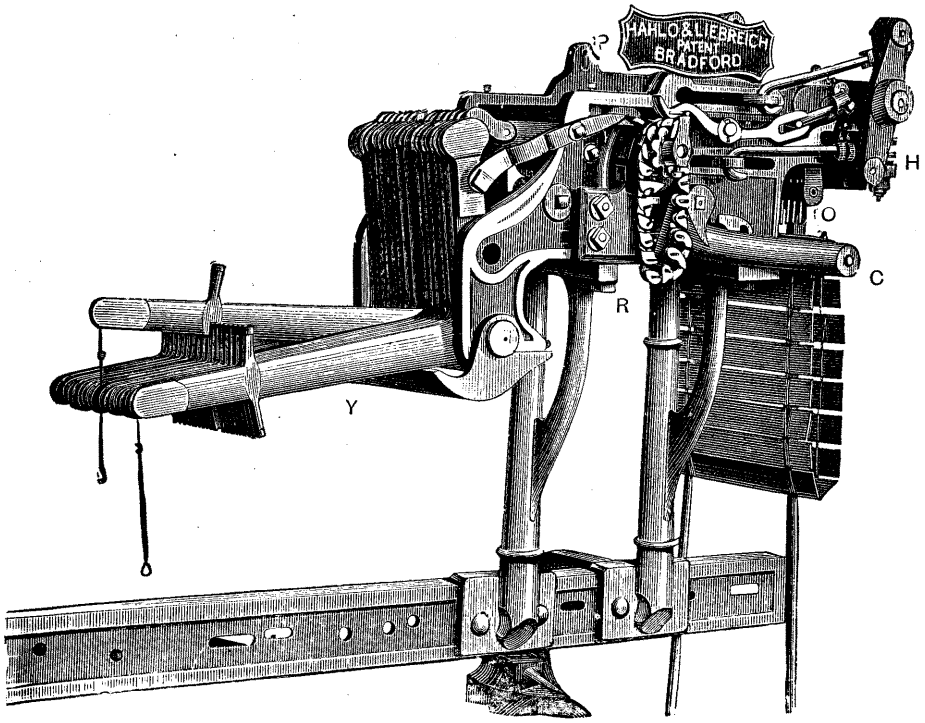


Fig 129.

there are two designs to be woven, one for the border and one for the ground. Then the border pattern would be cut upon the cards on one row of holes, and the ground pattern upon the other row of holes of the same cards, so that whichever row is brought in contact with the needles will determine the pattern to be woven. Then

it is obvious that a combination may be woven with any number of patterns and the links in the chain may bring any portion of the pattern in contact with the needles as desired. Then the knives being acted upon in this manner will actuate the healds through the lever Y in precisely the same manner as in the ordinary Keighley dobby.

One feature of this machine however must not be overlooked, there must be a direct connection between the number of picks in one portion of the pattern upon the cards and the number of links in the chain.

A most ingenious contrivance accompanies this arrangement. The chains need not be moved always with the cards, but by means of a separate lever acted upon by the cards, one link of the chain may be moved forward at any time, so that supposing there are twenty or forty cards, consecutively of one pattern, then by cutting a hole moving the chain one link the next pattern will be brought in contact with the needles. This will go on working until the second pattern is complete when another link in the chain will be brought forward, then a third link may be brought forward, and so on for any number; so that a combination of patterns may apparently be made extending to an indefinite number of picks in the whole, and of immense variety in the several parts. But the relation of the several parts of the pattern to each other must not be forgotten. The number of picks in one portion must always bear some direct ratio to that in the other portion. Let one contain for instance thirty picks in the complete pattern, the other must contain some multiple of 30, or the two must be arranged so that the changing will take place at a number corresponding with the least common multiple of the two. So that although there is virtually an indefinite range of pattern within the reach of the designer, yet there is a limitation governed by the figures referred to.

Another feature of this machine must not be lost sight of, and that is, a contrivance for levelling the healds when the loom is at rest; one can easily understand the advantages of a motion of this kind. We may examine it from two points of view, each of which will recommend it; first, a large number of healds may be employed, and a weaver on taking up a thread finds it difficult to have access to any one of the healds required, because of the great space they occupy. If one portion is raised to the highest and the other depressed to the lowest point, the

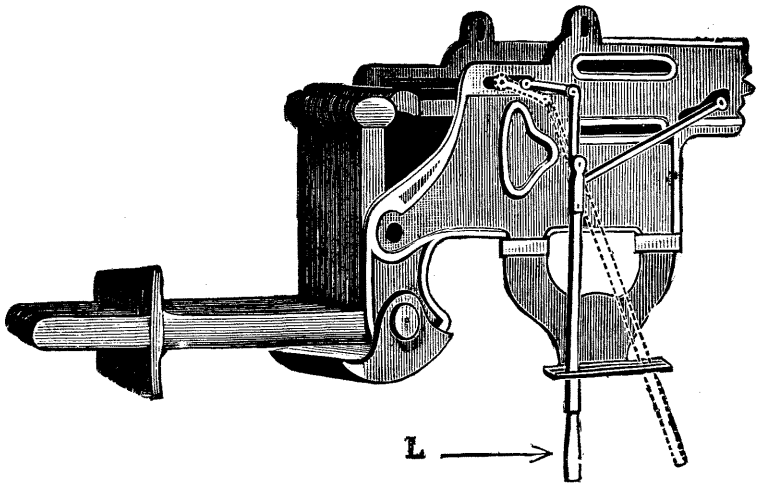


Fig. 130.

difficulty is of necessity much greater than when they are all at the same level. In working with very strong yarn this may not be of such serious moment, except as causing irritation to the weaver, but when working with tender yarn several threads may be broken in attempting to tie up one, thus not only causing irritation but increased work, and probable faults in the cloth. The arrangement of this portion of the mechanism will be understood by a reference to Fig. 130, where the lever L is shewn as

controlling it. From this lever are shewn two connecting rods, those connecting rods communicate motion to two bars, so contrived that they release the hooks from the draw knives on the lever L being drawn to the right, and bring the whole of the healds to a level, but on returning the lever to its normal position, as shewn in the drawing, the whole of the draw hooks are restored to the position indicated by the pattern card upon the needles, so that by the simplest possible movement on the part of the weaver any operation in taking up threads or correcting any fault is at once facilitated. For tender material too

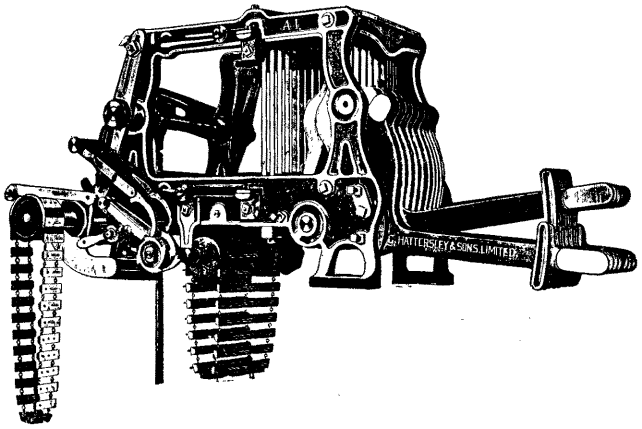


Fig. 131.

much value could not be attached to a contrivance of this kind.

Another automatic border motion is shewn at Fig. 131, which has something in common with that already described. In this arrangement each lag comprising the chain seen under the machine represents two picks, and are pegged alternate lags for ground and border. Two lags are moved forward at each movement of the cylinder by double pushers, either of which can be brought into operation at will. One lever in the machine is reserved to be acted

upon by a peg at each revolution of the chain of lags, and this lever turns a secondary chain of lags seen at the left, outside the machine. The lags upon this secondary cylinder are pegged or blank so as to determine which of the pushers shall act upon the primary or pattern card cylinder, and by those means bring the proper lag into position for the formation of border or centre. As will be seen this is one of Messrs. Hattersley's machines.

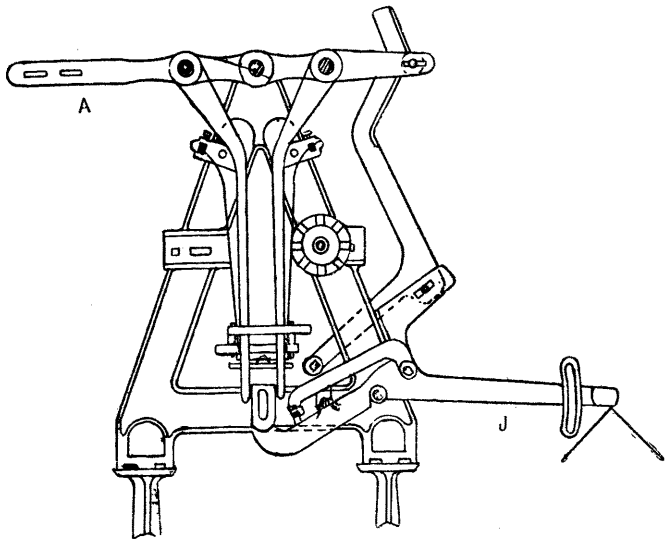


Fig. 132.

THE BURNLEY DOBBY.

The principle of this machine differs from those already described, in the manner in which motion is communicated to the levers, from which the heald is suspended. A long lever A has its fulcrum at what might be termed the apex of the triangle of the outside frame, the details of which will be seen at Fig. 132, and on each side of this fulcrum are hinged a series of bent levers, their lower ends forming a nearly vertical line. Below

these are placed the "Jack" levers J, from one end of which the healds are suspended, and the other end is operated upon by the vertical levers just mentioned. For every "Jack" lever there are two vertical levers, and in front of each of the vertical levers is placed a spring, which may be acted upon by the pegs in the lags. There are two sets of pattern lags, one at each side of the machine, and when a peg is inserted it will press the vertical lever into position over a kind of notch in the bent end of the jack lever, a mid-rib of the grate which keeps the vertical levers in position preventing it being pressed too far. As the top lever oscillates the vertical levers are pressed downwards and any that have been struck back by pegs will strike the notch on the jack lever thus depressing the bent end and raising the end to which the heald is attached. The spring in front of the vertical lever, and which is acted upon by the peg in the pattern lag is sufficiently flexible and strong to do its work and prevent any harshness or liability to injury.

As will be seen from the diagram every part of the machine is strong, the working is simplicity itself, and from the nature of the movement lends itself to a high rate of speed.

From this brief description it will be seen that the lower half of the shed remains stationary, and that the upper half must descend midway for the change to take place, so that it is a semi-open shed machine, practically as the Keighley Dobby is, but there is no compensation in the form and working of the levers. For general work this latter item may not be of very much importance, but for gauze weaving it is of some moment, as changes cannot take place in the crossing threads without the healds coming to the same level. Provision is made for this by placing in front of the machine a peculiar bent lever, the upper end of which may be acted upon by the extreme end

of the lever A, and the lower extremity carries a bar across the machine, this bar has a series of fingers placed immediately over the jack levers which carry the "standard" healds for the doups, so that at every move of the lever the standards are raised to the middle of the shed to meet the descending healds and facilitate the crossing of the threads.

The form of the lever at the top, when acted upon by the lever A is such as to give a slight pause, thus ensuring

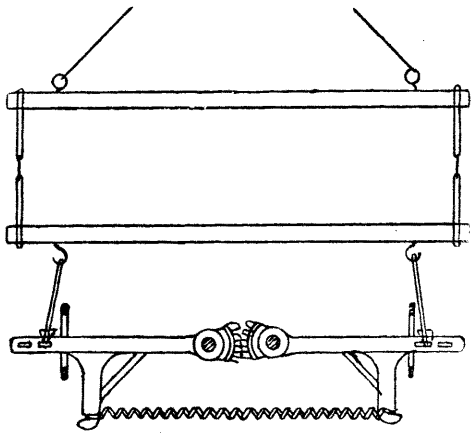


Fig. 133.

sufficient time for the threads to cross readily and prevent "knuckling" either in the doup or warp threads. This contrivance is one of the most ingenious for leno or gauze weaving in fast running dobbies. Provision is made to prevent the pattern lags from getting one in front of the other. An undermotion is attached to this dobby as shewn in Fig. 133, consisting of toothed levers and springs, upon the principles of those already dealt with.

BLACKBURN DOBBY.

The machine next calling for attention is what is known as the Blackburn dobby, an illustration of which is given in Fig. 134. In general principle this is practically the same as what is commonly known as a double lift Jacquard machine. In the machine there are two distinct sets of hooks and two sets of lags. The pegs of the lags acting directly upon the hooks without the intermediary

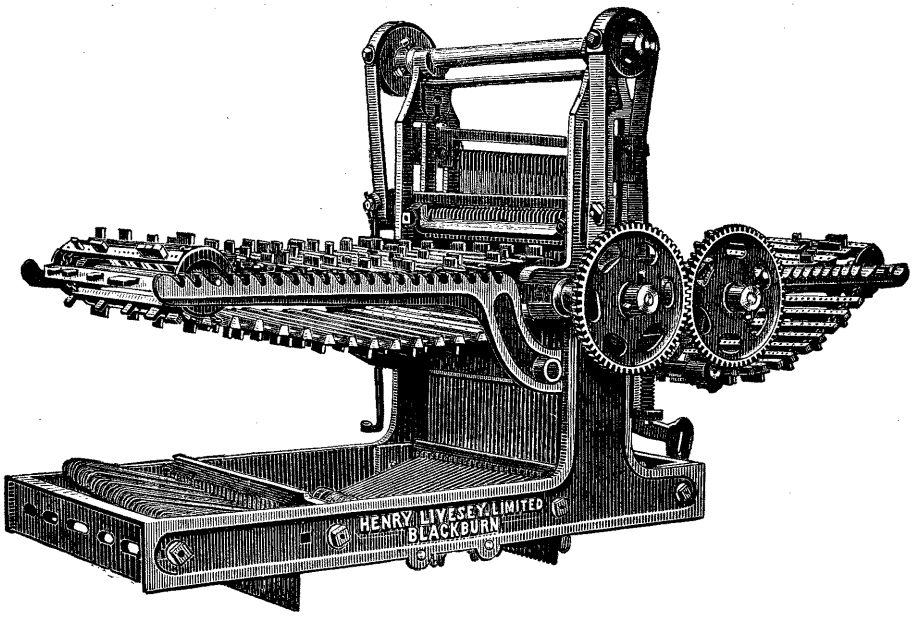


Fig. 134.

needles or cross wires of other machines. The position of the machine on the loom is somewhat similar to that of the Hattersley dobby and the motion is imparted to it by a crank upon the tappet shaft in the same manner as in the Hattersley dobby. A pair of tappets and treadles are also fixed under the loom and worked from the tappet shaft. There are two griffes connected by straps over a pulley

carried by a shaft parallel with the rows of hooks, so that as the treadles are actuated by their tappets under the loom pulling down their griffes alternately the connecting strap raises the opposite one. Each lag in the chain of course represents one pick as in the other dobbies, but there is this difference from the ordinary dobby that two sets of lags and two lag cylinders being employed, they act alternately. The odd picks of the pattern would be represented by one set of lags and the even picks by the other set. In this case the pegs by pressing back the hooks represent those which shall not be raised. Instead of the hooks acting directly upon the healds they are attached to them through levers or jacks, these being so joined together at the ends by teeth forming the segment of a circle that their concurrent action is assured. This will be understood by reference to previous figure, where the toothed levers are shewn in connection with each other. The barrels carrying the lags are coupled together by means of a third link and moving slide and bearings.

THE KNOWLES' DOBBY.

As a positive open shed dobby this machine has attracted considerable attention ever since it was introduced into this country, and, as pointed out in reference to the method of operating the box loom, it is quite unique in character. The principle of actuating the healds is practically the same as that of actuating the boxes, referred to at pages 154 to 161. With the exception that a positive motion is imparted instead of the use of the chain.

In the illustration at Fig. 135 a full view of the loom is given when both the box and dobby are seen, and a detailed drawing is given at Fig. 136.

The machine is driven direct from the crank shaft, and by means of a vertical shaft which communicates power to the two cylinders seen on the dobby, and which

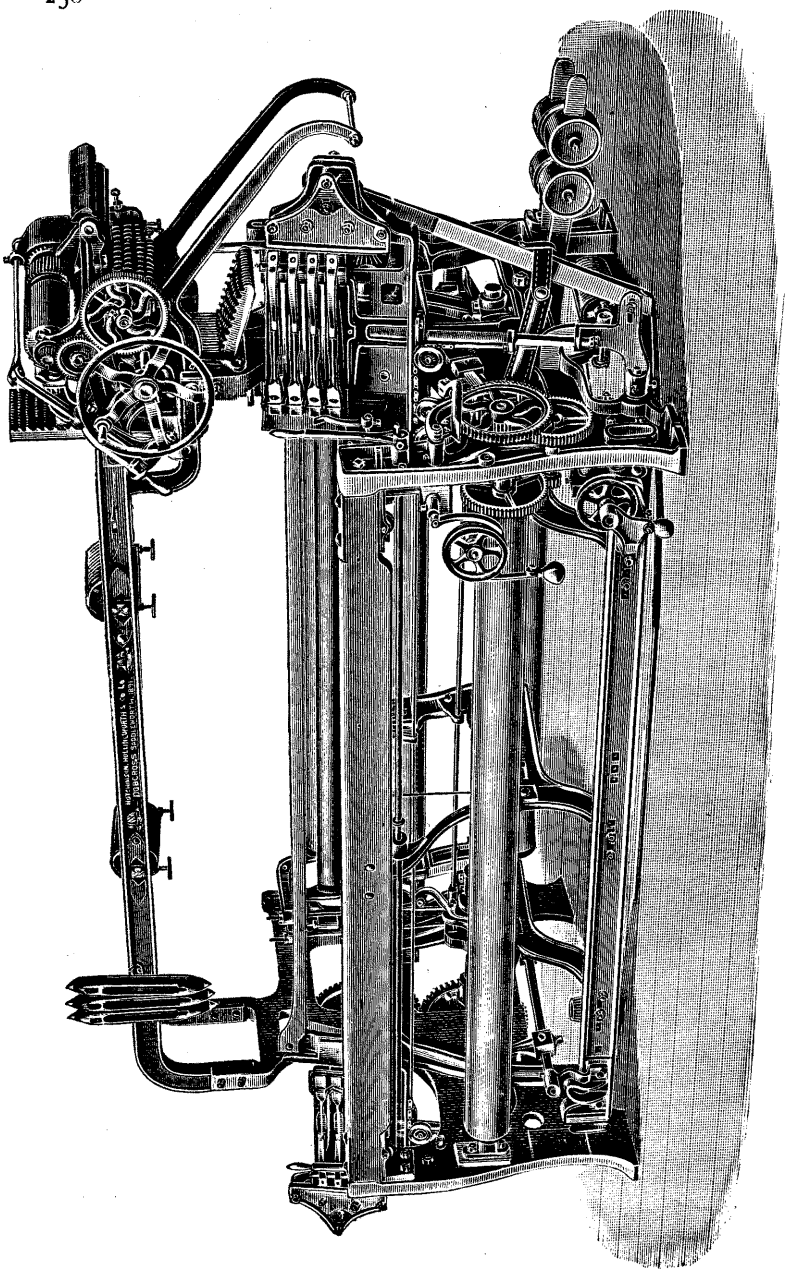


Fig. 135.

are represented in Fig. 136 at B and C. These cylinders have teeth on one-half their circumference, and revolve in opposite directions continuously. Between them is placed the disc wheel A as described in the box motion. To the left is the vibrator lever P (the lettering of the vibrator lever and connector have been crossed in drawing, but the description is corrected to suit it), which is acted upon

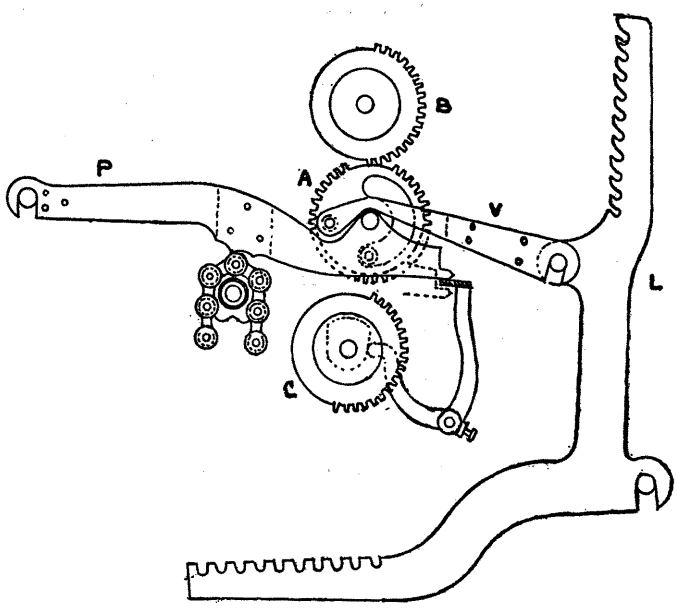


Fig. 136.

by the pattern chain placed below it, so that as the vibrator lever is raised or lowered by the pattern chain, that is by the introduction of a pulley or link, it will raise or lower the disc wheel A and bring it into gear with B or C, and be caused to make a half revolution upon its axis. The connector V then communicates motion to the L shaped lever, which is connected by cords passed over the pulleys, seen on the loom, to the healds, one arm to

the top and the other to the bottom, so that as the lever is pulled in one direction the heald will be raised, and when pushed in the opposite direction it will be depressed, and this is done in a positive manner without the aid of springs or weights. The crescent groove and stopping pin on A exactly correspond to, and serve the same purpose as described in Fig. 72, page 158, referring to the box motion.

Motion being communicated as it is by the connector being carried over a semi-circle by the wheel A, the most perfect harmonic motion is given to the healds, so that in this respect the machine is perfect.

One important item is the locking arrangement, which keeps the healds rigidly in position the moment the change

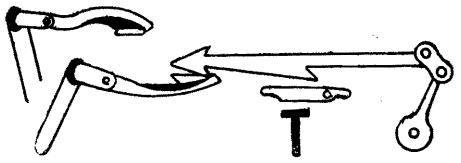


Fig. 137.

has been made until the time comes for changing again. Inside the cylinder C a cam is shown in dotted lines, and which acts upon the point of what is termed the "locking knife finger." This is really one arm of a lever the upper part of which is so contrived as to drop into a notch in the end of the vibrator lever P, so that as the cam revolves it will ultimately press the locking finger out of the notch and allow it to drop back again.

The object of the spaces between the teeth upon A has been already described in the box motion at page 157.

HODGSON'S OPEN SHED DOBBY.

Only a few words need be said of the open shed dobby of Hodgson. The leading features are shown at Figs. 137 and 138. To the left are two draw knives which travel

along inclined planes, or grooves, in the machine frame, approaching each other in the centre of the machine, so that they can catch the hook which is hinged upon a lever connected to the top of the healds. Beneath this hook is a short lever which may be raised by a short pin, which in turn is actuated by the pattern card. In Fig. 137 the hook is shown engaged with the lower draw knife, a hole in the card allowing it to drop, and the draw knife is letting it go back so as to drop the heald to the lowest point, and in Fig. 138 the little lever is raised by the pin and the hook engaged with the upper knife. When the heald is to remain up the little lever engages with the notch on the under side of the catch,

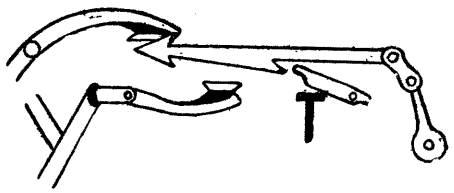


Fig. 138.

and if it is to remain down, the heald lever is allowed to be at rest.

In cutting the cards regard must always be had to the position of the hook and heald, and the little lever held up or dropped according to the nature of the change to be made.

The machine being of the negative kind, either springs or weights must be used to bring the healds down again.

CARD CUTTING AND LAG PEGGING.

This branch of the work is one which often gives considerable trouble to the beginner. In reality the process is simplicity itself. We take the plan as shewn at

Fig. 139, of any pattern, let it be as in this case a fancy twill, and we see there, an exact representation of the pattern as it will appear in the fabric. The dotted squares in the design indicate either that warp is passing over weft or that weft is passing over warp. It is quite immaterial which of the two, so long as there is a clear understanding. Generally speaking, the plans should be made so as to entail the least amount of work, though some have fixed methods; one will prefer to dot always for warp, another will prefer to dot always for weft; then again the machines may be contrived so that in the case of lag machines, pegs mean causing the healds to rise; in others, the reverse.

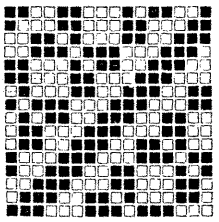


Fig. 139.

In card machines the same conditions prevail, so that before commencing to peg a set of lags, or cut a set of cards, we have to ask ourselves the questions: do the dots on the design indicate risers or fallers? and do the pegs in the lags, or the holes in the cards indicate risers or fallers? Now let us suppose for convenience, that the dots on our plan indicate risers, and that the pegs in our lags also indicate risers; then we should take from the plan, Fig. 139, the first horizontal row of squares, and that will exactly correspond with the row of holes in the lag. Let the two be supposed to be blank to begin with, then wherever we have filled up a square in the design, we fill up a corresponding hole in the lag. Each succeeding lag will be dealt with in the same manner, so that the

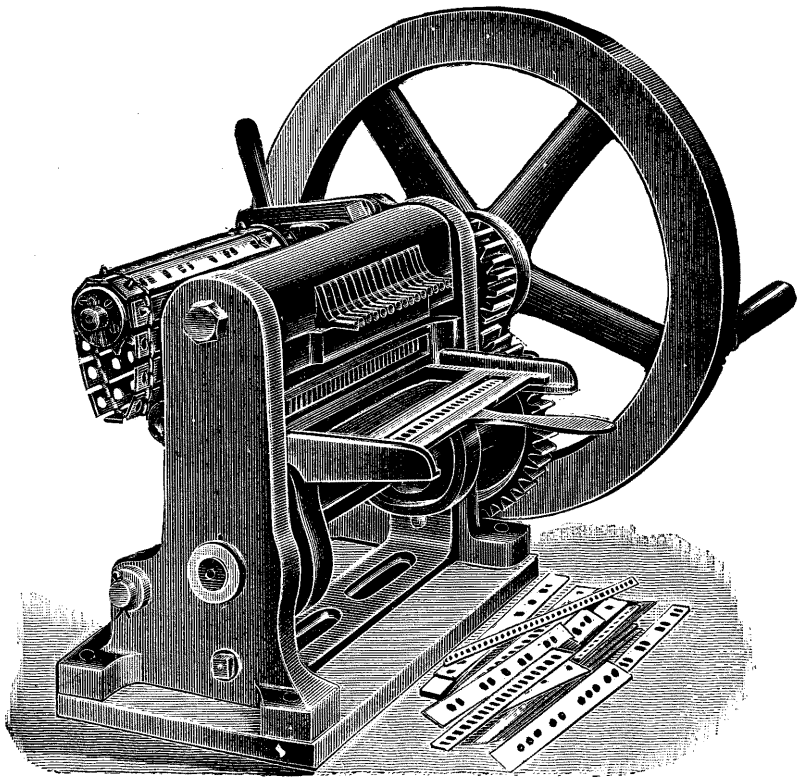
complete set of lags, when spread out, will be an exact facsimile of the plan of the cloth. I must here make one suggestion to students. Frequently a great deal of time is wasted in comparing a set of lags after being pegged with the design, lag by lag, and dot by dot, so as to ensure that when put upon the loom there should be no error; take the plan of the pattern upon paper and survey it as a whole, spread out the lags as though they represented also the same sheet of paper on a magnified scale, and any error or discrepency between the two, will be visible on the general surface, and even more readily detected than by a detailed examination on the plan generally adopted. What has been said of pegging lags, applies exactly to the cutting of cards, the process is the same, we cut a hole instead of inserting a peg. We have to ascertain first, whether the hole means rising or falling, and so it may be said that when we know how to peg lags, we know equally well how to cut cards.

In connection with some of the machines, the card cutting or lag pegging is somewhat peculiar, though the general principles must of necessity be the same. For instance, in the case of a dobby—and most dobbies working from the lower shaft of the loom—each lag is made to serve for two picks, then there are two rows of holes in the lag, one of which acts upon the lower set of draw knives, or hooks, and the other upon the upper set, so that care must be taken in determining which row belongs to each of the two sets of hooks. One cause of confusion often arises here, the holes in the two rows respectively are alternated, *i.e.*, the hole in one row is opposite the blank space in the other row; this often leads to confusion, as in many cases where one lag is made to serve for each pick, a similar arrangement is made for the purpose of economising space, and as a consequence, the beginner is often confused as to the meaning of this double row. This

however with practice is easily overcome. Much more difficulty arises in connection with what are commonly known as dwell-up machines, *i.e.*, where the heald remains positively at the highest or lowest point as long as required for the formation of the pattern. Then pegs or holes are cut only for the purpose of making a change; take for instance, Hodgson's open shed dobby, where by means of the small levers and the peculiar construction of the draw knives, the healds being once raised to the highest point or let down to the lowest, are kept there until a change is required, then a hole simply means the transference of the knife either from one draw bar to the other, or from the fixed position, whichever it may be, to the draw-bar. Consequently in cutting the cards, one must remember, or have some indication upon the design itself, what was the position of the draw knife corresponding to the healds which it is desired to change, prior to the moment when this change must take place. There is some similarity in the cutting of these cards to the cutting of cards for shuttle boxes; one, in making the plan, has to bear in mind what is the exact position of the box, and whether it should be moved backwards or forwards, therefore considerable practice and some skill in making of plans is requisite. In all dwell-up machines or open shed dobbies, this peculiarity exists in a greater or less degree.

As a rule dobby cards are cut by hand with a single punch on a hand plate. The process is slow and tedious, more especially when a number of looms have to be started on the same pattern. A machine is shown here, however, which mitigates this. As will be seen the machine is hand driven; a pinion on the fly wheel drives a wheel on the lower shaft, upon which are mounted two eccentrics against which rest the punching table or slide. This table is guided by vertical slide-ways and raised up to the punches by eccentrics. The

punches are placed loosely in a vertical position in the plate, and over them are placed a series of piano-keys. The card is placed upon the slide seen in front, and pushed under the punches. The piano-keys are pulled out according to the marks on the design indicating cutting, and the wheel revolved quickly. The table is



DOBBY CARD CUTTING MACHINE.

raised, and all the punches under the keys which have been moved are forced through the card, so that the operation is rapid and accurate.

The machine can also be converted into a repeater. The cards to be repeated are placed upon a cylinder at

the back, after being laced together. At each revolution of the driving wheel the card cylinder is brought up to the piano-keys, and a card having been placed in the slide, the operation of punching is just as if the pattern had been read from the design. When a number of cards are required of the same design, the catch operating the card cylinder is simply lifted until the requisite number has been punched. The machine is by Messrs. Hahlo & Liebreich, of Bradford.

Now as to the advantages or disadvantages of the several systems. It has already been pointed out generally what class of fabrics each system of open shed, centre shed or bottom shed is best suited, and what has been said generally will apply equally to dobbies intended for the production of varied patterns. But something more may be said of dobby shedding. Coming, as it does, between ordinary tappet work and jacquard work, it is capable of doing a great deal which can scarcely come within the range of either of the others; for instance, in open shed work it has had, until very recently, a great advantage over jacquards, inasmuch as until the introduction of the double lift jacquard any approach to the open shed was not practicable, and rapidity of working was even more difficult. Centre shedding in the jacquard is still only a partially solved problem, some attempts have been made such as Ainley's to get over the difficulty, but they have never been compatible with a high rate of speed. On the other hand in weaving gauzes tappet shedding could be readily adapted to the requirements of the case, and jacquard shedding naturally lent itself to it, but few dobbies, except those working strictly on the jacquard shed principle, or bottom shedding, could be said to be suitable for the purpose. A centre shed dobby would certainly come within a reasonable distance of the work, but was not considered so perfect as the bottom shed or single lift.

There is peculiarity in gauze weaving which makes it different from all others. At the moment of the crossing of the threads, either on being lifted by the doup or by the heald carrying the crossing thread, when the crossing thread must change from one side to the other of the standard thread, it is obvious that the crossing cannot take place easily until the crossing threads reach a point below the level of the standard thread, and any attempt to cause the crossing to take place until this point has been reached must result either in considerable strain being thrown upon both threads and healds, more especially the doup, and in all probability of breakage of the warp threads.

Another fault frequently arises when the doups are not adjusted in their movement exactly to the changing of the sheds, *i.e.* what is termed "knuckling." This means the doubling up of the doup slip, or loose half, in the shed, and entangling itself with the warp threads. Whenever this occurs there is not only considerable breakage in the warp threads but wear and tear in the doup itself. It not unfrequently happens that when a doup is not properly adjusted, so as to be brought to tension before any attempt at change is made, it will knuckle within the warp, and be cut to pieces before many yards of cloth are woven. But if it is properly adjusted so as to bring it down to the point below the standard thread, and in a state of easy tension, a doup, which would otherwise be worn out in weaving a few yards of cloth, may be made to last for several weeks. In all open shedding or semi-open shed dobbies, more especially such as those of the Keighley type, gauze weaving has been practically impossible until recently, from the fact that changes could not be made except with the shed partly opened. Various devices have been resorted to to overcome the difficulty; in some cases an extra tappet has been

added, so as to raise the standard thread midway between the highest and lowest points of the shed at the moment when the doup, or the heald carrying the crossing threads, has been descending, so as to cause the change to take place in the middle of the shed, whilst the remainder of the healds have been retaining their relative positions for the formation of pattern. This of course may be made to answer when only one doup is employed, but when more than one doup is in use the number of tappets required, and their being brought into action at the proper moment, has rendered the task a difficult and in most cases an impossible one. Several of these devices have been the subject of patents, but where an outside apparatus has to be employed, in addition to the dobby, although it would in most cases be controlled by the dobby itself, the success can only be in working one special class of pattern, and can scarcely be considered of general application. The one exception to this general rule is provided in the Burnley dobby already referred to, where in weaving lenos or gauzes a special provision is made for bringing all the healds, or such portions as carry the standard threads to a level at any given moment when a change in the doups or crossing threads is going to take place. The difficulty has been overcome frequently with the ordinary Keighley dobby by removing one of the draw knives and working the machine from the crank shaft of the loom as an ordinary single lift dobby; thus converting it from the semi-open shed to the common single lift dobby.

LECTURE 8.

TAKE-UP AND LETTING-OFF MOTIONS.

As pointed out in Lecture 2, there are two distinct classes of let-off motion, the positive and the negative, and from the general view given there of the leading features of each, as well as the leading features of let-off by simple friction, we may now be prepared to proceed to a much closer examination of the details of each.

Before taking up the actual forms and particulars of the mechanism in most general use at the present time, a further survey of the principles may assist us in determining what are the distinct advantages of any of the systems, or combinations of several. As the positive take-up motion is the one coming most generally into use for every class of goods, it necessarily will occupy the greatest amount of attention, and whatever may be the result of the enquiry as to the relations of the take-up and let-off motions, there is no doubt that thorough mastery of the relations of the positive take-up and non-positive, or positive, let-off motions commonly in use will be an advantage. In the very great majority of looms in use at the present time, in weaving all but the very heaviest classes of fabrics, the positive take-up and the non-positive let-off motions are in most general use.

As already mentioned the leading characteristic of the positive take-up motion is that the cloth shall be carried forward a given distance every time the reed comes up to the fell, and that this length carried forward is absolutely independent of the pressure of the reed upon the weft as it beats it up to the fabric. On the face of it then it will be seen that a positive let-off motion is the one which

should, apparently, naturally accompany the positive take-up motion, but here a difficulty arises, which when considered in all its bearings must help us very considerably in a study of every form of combination.

We begin by saying that the cloth is taken forward at a fixed rate of speed, therefore it follows that the warp must be given off at a rate exactly corresponding with it, plus the amount of take-up of warp caused by the bending of the warp round the weft in the process of weaving; this is one of the first difficulties, we may know that we are taking forward the cloth at the rate of 60 picks per inch, or, in other words, that the cloth is carried forward $\frac{1}{60}$th part of an inch every time the reed beats the weft up to the fabric; then we should have to let the warp off exactly at the same rate, with an additional allowance for the bending of warp round the weft; but it is this additional bending, or, take-up, as it is commonly termed, which causes us the trouble. To adjust a loom so that the amount of let-off, in relation to the take-up, shall be strictly accurate we should have to take into consideration first, the relative diameters of warp and weft, second, the intersections which occur in the pattern, and deduce from these the length of warp which must be used to produce a given length of cloth. This of course would not permit of any consideration of variation in the diameters of the threads, but would have to be carried out on the supposition that the threads are perfectly even in their diameters from end to end, whereas in the best forms of yarns there is a known variation in the diameter of a given thread of not less than 30%; so that it would be obviously impossible, even with the most careful experiment, to adjust the relative speeds with absolute accuracy. Added to this difficulty there is the additional trouble caused by broken picks, and by the weft running out and a number of other little accidents which render it necessary to let

the cloth back, so that the reed shall come up exactly to the fell and avoid inequalities in thickness. Unless the adjustments were absolutely accurate, which on the face of it, with two positive motions combined, becomes a practical impossibility, we must have on each of those occurrences a thick or thin place in the cloth; therefore if positive motions are used in combination safeguards must be provided; those safeguards hitherto, although many are of the most ingenious kind, have not been sufficient to bring the positive let-off motion in conjunction with the positive take-up motion into general use.

It may seem very absurd, but it is nevertheless a fact, that the best positive take-up motions are almost invariably accompanied by a negative let-off, and the best negative take-up motions are probably for the same reasons accompanied by a species of positive let-off. Although on the face of it this seems very contradictory, yet when carefully examined it will be found that there are substantial reasons. If there is a variation in the relations between the take-up and the let-off, brought about either by any inequalities in the yarn or pattern, there must of necessity be similar inequalities in the fabric, and, however trifling those may be apparently, they become painfully visible in the fabric, more especially if it be a light texture. Then this involves the introduction of some intermediary between the two motions which shall adjust their relations to each other.

Tension springs, balance levers, and other delicate adjustments have been tried from time to time, but, for anything approaching a light fabric, with only indifferent success. It is evident that this intermediary must be so delicately adjusted that the slightest alteration in the warp tension must affect it.

We must then suppose two cases to begin with. We are weaving an extremely light fabric, where we require only a sufficient amount of tension upon the warp to

ensure what is termed a clear shed; and where the reed in bringing the weft up to the fabric does not actually deliver a blow, but simply presses the thread gently into its position. Now let a pick be missed, for instance, either by the weft breaking or the shuttle running out, or in fact from any other cause, the cloth will be carried forward by the take-up motion a distance equal to that allotted to the single pick, the absence of the pick itself would cause a variation in tension, amounting exactly to the difference between the length of cloth represented by that one pick and the length of warp required to bend round it. So that supposing the cloth had 60 picks per inch, and the take-up in weaving equal to $2\frac{1}{2}$ per cent., then the length of warp would be 1/60th part of an inch, plus $2\frac{1}{2}$ per cent.

Is it conceivable that any attachment to an ordinary loom can be adjusted with such a degree of nicety as to take this fraction into account? Then, if not, a space is left equal to the length of warp required to take one pick, this, of course is not perceptible to the ordinary observer. But what follows? The succeeding pick is allowed to go into the cloth but does not leave a clear space equal to this 60th part of an inch; the threads are elastic and allow some encroachment upon the vacant space, so that instead of there being a clear line across the fabric this space will be gradually taken up by succeeding picks, until each one has taken up its normal position; this may extend over any amount of space from half-a-dozen picks upwards according to the character of the cloth. Trifling as the fault is it would be distinctly visible even to an ordinary observer. Here of course I am taking what may be considered an extreme position, yet it is one which is the foundation of much more serious troubles; the variation in tension alone, quite apart from the fact of the cloth being carried forward, even for a single pick,

is sufficient to produce inequalities which, especially in light fabrics, would render the goods unmarketable.

But there is another difficulty which has attracted the attention of inventors, of even much greater importance, and that is the variation in tension caused by the decreasing diameter of the warp beam as the warp is being drawn from it. This trouble is none the less real because of the apparently imperceptible effect upon the fabric. Suppose for a moment the following to be the case, we start to weave a cloth from a beam having a diameter of 12 inches, and we adjust the tension of the warp at the outset so as to make our cloth perfect; by the time we have finished the warp the diameter of the beam will have been reduced say to 6 inches, then it must be self-evident that if there has been no adjustment of the weight upon the beam, whether we are dealing with a friction let-off motion, or with any positive let-off motions, which usually gives so much of a fraction of the revolution of the beam at each pick, there must be a considerably increased tension when the end of the warp is reached. This has been gradually increasing. There has been no perceptible difference to the weaver; having the fabric under her eye from hour to hour she could never see that there was any difference in the fabric as it passed forward, and it might be argued by the non-practical reader that the amount of difference could have no material effect upon the fabric. Probably many weavers would say the same thing, but there are two aspects of the question to be dealt with, each of which may be materially affected by this point. Every weaver knows well that the best fabric is produced by having the warp threads stretched at the highest tension which the strength of the yarn will permit. There may be possible exceptions in such goods as soft woollen fabrics.

This is well illustrated by the common expression amongst hand loom weavers in the West Riding of

Yorkshire in former days, and which retains still some hold, that any person who is not of the brightest intellect would be commonly spoken of as "slack set up." Suppose two looms be set to work with the same material, warp and weft, woven with the same number of threads per inch, in fact every particular throughout being identical, except that in one case the warp is woven at the utmost tension, consistent with reasonable working, and the other is allowed to go in loosely, or slack; the difference in value of those two pieces on coming from the loom will be most marked. This remark does not apply merely to a section of fabrics, but may be taken as one which is practically universal. Another feature of the case may be taken into account; we cannot treat the warp threads of any textile fabric as we should treat a piece of brass, copper or iron wire; there is always a considerable degree of elasticity in the yarns, and this degree of elasticity will depend upon the quality of fibre and structure of the thread, and consequently it will have an important effect upon the fabric after it is woven.

Suppose we take a few extreme cases in cotton, let us have a single cotton warp of inferior quality heavily sized, no matter how much tension we put upon it in weaving there would be no "spring" or elasticity, the number of picks per inch put in in the loom would be practically the same after leaving the loom; now on the other hand take a fine two-fold cotton, made say from a good Sea Island cotton, and spun well, afterwards made into two-fold; then we have a thread which is extremely elastic—this degree of elasticity I shall have to illustrate in some measure in the lecture on "cloth dissecting"—weave this warp at the highest possible tension, consistent with good work, and after it comes from the loom a very considerable shrinkage will have taken place in the length of the thread, it will have returned to its

normal condition, and in doing so compressed the weft so that the number of picks per inch in the loom, and the number after leaving the loom may vary in any degree from 2½ to 20 per cent.

Again suppose we are dealing with wool. Let worsted yarns be spun from a good quality of English wool and others from a good quality of merino wools, and we shall have practically the same difference, and so it will follow with any material where there is a difference, either in the fibres of which the thread is composed, or in the amount of twist or structure of the thread itself. Pure woollen threads of the best kind as compared with the inferior ones are quite as susceptible to this variation. Again the pattern will influence it by the variations of intersections—as between a plain and a twilled cloth, the amount of take-up in the one being considerably greater than in the other; and the relations or the thickness of weft and warp to each other will have even a greater influence. All these considerations are quite apart from the amount of force exercised, or applied, in beating the weft up to the cloth. Of course the greater the degree of compression of the weft threads as they are beaten up to the fabric the less room there is for the elasticity of the warp threads to assert itself; and consequently in the heavier goods, or in goods woven with warps not so very susceptible to this influence, there is less need for this extreme delicacy of adjustment which is required in the lighter fabrics. At the same time even in the heaviest or the commonest goods the matter must not be ignored, otherwise faults will creep in.

POSITIVE TAKE-UP MOTION.

We may then proceed to make a careful examination of the positive take-up motion, first, in its simplest and common form and afterwards in the somewhat more elaborate forms, which are improvements upon the original one only in

so far as fineness of adjustment and accuracy are concerned. First of all, from the very name, we must assume that the cloth is carried forward and wound upon the beam at a given rate. This implies of course a system of driving the take-up motion which shall ensure absolute equality, and therefore must disregard the increase in the diameter of the cloth beam as the fabric is wound upon it. The arrangement will be best understood by a reference to Fig. 140, which shews a plan of a complete train of wheels. First we have the ratchet wheel A acted upon by the

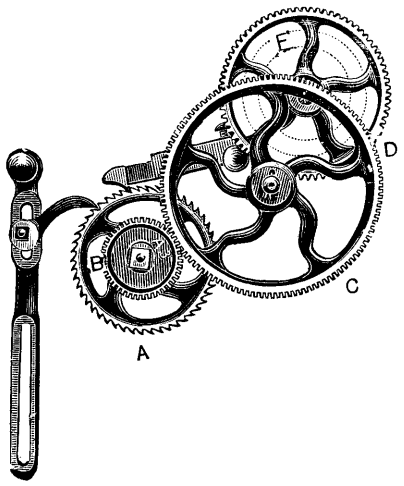


Fig. 140.

catch or pawl shewn to the left, upon this is fastened what is commonly called a change wheel B, which, as its name implies, may be changed so as to regulate the rate of speed at which the cloth shall be taken up; this drives an intermediate wheel, or what is commonly termed a carrier, C having a small pinion fastened upon it driving the beam wheel D. This beam wheel is made fast to the spindle of the driving, or carrying down beam, which causes the cloth to be coiled upon the actual cloth beam.

The general arrangement is to place the cloth beam beneath the carrying beam, and by means of weights and levers to keep the surface of the cloth beam in contact with the carrying down beam as shewn in the view of the loom at Fig. 45, page 98, and Fig. 50, page 104, so that really the cloth is carried forward by friction, the surface of the carrying beam being covered, either by a series of corrugations or teeth, or any other roughened surface which will prevent slipping. Then what we have to determine is the system of calculations which enables us to fix upon the exact number of picks per inch or the rate of speed at which the cloth shall be carried forward.

In principle this calculation is simple enough, but the one great difficulty with the student is often in determining which are the driven and which are the driving wheels of the train; suppose we take the lever to the left of the illustration and we connect that to the going part of the loom in such a manner that at every stroke of the going part the ratchet wheel A is carried forward one tooth, then the change wheel communicates the power received to the intermediate wheel C. The small pinion carried by C communicates the power to D the beam wheel, this in turn being made fast to the take-up beam causes the cloth to be carried forward; then it is evident that the ratchet wheel A receiving its power from the catch is a driven wheel, and the change wheel upon it, communicating that power to the large intermediate C becomes a driver; in like manner the small pinion upon C becomes a driver, and D is driven—thus the cloth beam becomes in turn a driver also, so that we can easily determine which are driven and which are driving wheels in the series. Then if we multiply all the driven wheels together and all the driving wheels together, and divide the greater by the less, we determine at once the relative values of the two series; but we must have a convenient method of calculating

which compels us to leave at least one of the wheels out, or to treat it as an unit, so that we may determine the value of the change which we must make in altering from one fabric to another. This unit is most conveniently the change wheel. Then suppose we have our lever adjusted to carry forward the ratchet wheel A one tooth at each pick of the loom, and we treat the circumference of the carrying down beam in inches as corresponding to teeth. Then we can easily arrive at what is commonly termed the standard dividend. Let the ratchet wheel contain 50 teeth, the large intermediate wheel C 120 teeth, and the beam wheel D 75 teeth; then we have all the driven wheels, which may be multiplied together; now assume the change wheel to contain one tooth or treat it as unity, the intermediate wheel on C to contain 15 teeth, and the circumference of the beam to be 15 ins., then we should have the formula as follows: $-\frac{50 \times 120 \times 75}{1 \times 15 \times 15''} = 2000$, that is then, if the change wheel be treated as unity the ratchet wheel A would move 2000 times for one inch, or one unit of the circumference of the beam, or in other words, there would be 2000 picks per inch. But of course a wheel of one tooth is a physical impossibility, therefore we must have one which is at least tangible; then to determine what that one shall be we must determine the number of picks per inch which the cloth must contain. Suppose, for example, that it must contain 50 picks per inch then divide the 2000 by 50 and we should have a change wheel containing 40 teeth required in place of the wheel of one tooth, as is shewn by the following formula:— $\frac{50 \times 120 \times 75}{50 \times 15 \times 15} = 40$. Then this 2000 is a standard number, or dividend, but frequently the number of picks are reckoned by the $\frac{1}{4}$ inch, so that in that case 500 would become the standard dividend, and whatever number of picks may be required per $\frac{1}{4}$ inch 500 divided by that number will give

the change wheel; or 500 divided by the number of teeth in the change wheel would give the picks per ¼ inch of the cloth.

Then comes a question which is often a source of trouble to overlookers. Generally speaking when loom makers send out their wheel lists with the looms they make an allowance of 1½% for shrinkage; but no notification occurs upon the list itself of this allowance having been made, and so confusion is caused in the mind of the overlooker. At any rate what should be done by the overlooker at all times is to determine the exact dividend so that he can vary the allowance for shrinkage as circumstances may require. It has already been shewn that this amount of shrinkage may be anything, and therefore it should never be fixed at one standard. What I should prefer at all times would be a standard number based upon the actual calculation, and the shrinkage allowance varied from time to time according to the quality of the work, and the nature of the material.

Before proceeding to any special arrangements of take-up motion, one or two features in the adjustment of the ordinary motion may be examined, for instance we have the lever carrying the pawl which drives the ratchet wheel A, which, with the long slot at its lower extremity, in which the pin from the sword of the going part works, and the slot in which the pawl itself is carried renders it easy of adjustment with the greatest degree of nicety. This is a necessary condition, as the wheel A must be moved always one tooth and no more. Above the rachet wheel there is usually a fixed pawl which drops into the teeth and prevents any rebound, or recoil; and then there is a second catch shewn in the illustration resting upon the wheel, and having its fulcrum in the front frame of the loom, which serves another purpose. When the loom is brought to a stand by means of the weft fork,

when the weft has run out, this fixed catch is lifted by its action so as let the ratchet wheel A run back; the catch seen in the illustration resting upon the wheel A is so contrived, by means of a slot, that it will let the wheel run back two teeth; the object of this is to allow the cloth to return a distance equal to two picks every time the weft runs out, or breaks, so as to prevent any thin place, or inequality, in the cloth. The reason for this arrangement is, that the weft fork being placed at one side of the loom, usually that side where the belt fork handle is placed, the weft must of necessity run out between the period when the shuttle leaves that side of the loom and returns to it, and therefore there must be generally two picks lost whenever the weft does run out; and the weft fork raising the fixed catch and leaving this one in contact with the wheel allows the cloth to run back this theoretic distance so as to avoid the fault mentioned. In ordinary practice this proves sufficiently true for the majority of fabrics, but of course is not absolutely infallible, as the distance over-run by the loom may be anywhere from one pick to three. If the brake gearing is not in good order it may run considerably further, but in any case there is always a margin of one pick on one side or the other, though the average of course must be practically the two picks allowed for.

It will be necessary now to examine one or two other forms of take-up motion, some of which possess a decided advantage, though there are many so-called improvements where the advantages are more imaginary than real. For instance, one difficulty arises in the take-up motion just referred to, in consequence of not being always able to find a wheel containing the exact number of teeth to give the picks required. Suppose, for instance, that 11 picks to the $\frac{1}{4}$ inch should be required, no wheel can be found to give that exactly, for 500 divided by 11 would give us

$45\frac{5}{11}$, and as it is obviously impossible to have a wheel with that number of teeth, then it is equally impossible, except by the allowance for shrinkage, to weave a cloth with exactly 11 picks to the $\frac{1}{4}$ inch. Here comes in the skill of the overlooker, what he cannot obtain by his wheel he can obtain by a careful adjustment of his warp tension; as already pointed out the tension upon the warp, accompanied by the elasticity of the material, may cause almost any degree of variation in the thickness of the cloth, then herein lies the overlooker's opportunity: if he cannot use a wheel giving the exact number of picks required, then he must adjust the tension of the warp to meet the difficulty; but some of the improvements are intended to obviate this, and by the use of double change wheels enable any exact number of picks to be put into the cloth at will.

To get rid of the difficulty referred to, of not being able to have a wheel which will give the exact number of picks per inch required, other arrangements of positive take-up motions have been devised. Probably the one in most general use is that known as the Pickles' motion, which consists of a train of wheels, two of them being changeable. One of the two is a driven wheel and the other a driving wheel. The arrangement will be best understood by reference to Fig. 141. Commence first at the ratchet wheel and follow the motion throughout. That wheel is moved forward one tooth at every revolution of the crank shaft, and it carries with it a change wheel, marked in the illustration 36. This drives another change wheel marked 60; change wheel 60 carries a pinion communicating motion to a large intermediate wheel which in turn carries a small pinion communicating motion to the beam wheel, and, of course, to the cloth beam at the same time. One peculiarity of this arrangement is that from its first introduction the number of teeth in each wheel

of the train has remained unaltered. Let us follow it all through and see exactly how it works out. The ratchet wheel contains 24 teeth, the large change wheel, which for the moment may be considered a fixture, contains 60 teeth; the pinion, or as it is sometimes termed the spring pinion wheel, carried upon the stud of the 60 change wheel contains 24 teeth. The large intermediate, or carrier wheel, contains 89 teeth, the small pinion, upon the same stud, 15 and the beam wheel 90 teeth. Then the circumference of the beam is 60·20 inches.

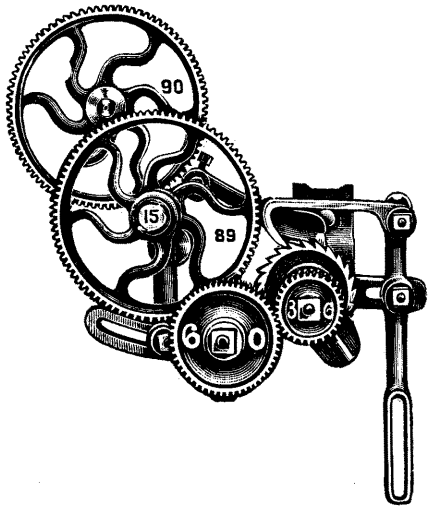


Fig. 141.

The result of all this arrangement is that the change wheel marked 36 in the illustration must run in 9's, or multiples of 9, and whatever number of 9's that wheel contains then the second change wheel must contain that multiple by the number of picks required per ¼ inch. For instance, the two wheels represented in the illustration are 36 and 60 respectively; 36 is equal to 9 multiplied 4 times. It is required to have 15 picks per ¼ inch or

60 picks per inch, then 15 × 4 will give 15 picks per ¼ inch, or 60 picks per inch, the picks per inch corresponding with the teeth of the wheel. Now suppose the change wheel marked 36 is changed for one containing 54 teeth, which will equal 6 × 9, then to weave a cloth with 15 picks per ¼ inch the second change wheel will require to be 6 × 15 = 90, so that we can be sure always at least of making our calculation within a ¼ of a pick per ¼ inch, or $\frac{1}{16}$th pick per inch. But the change can be made even more fractional than this. One wheel is a driver and the other a driven wheel, then as we increase the size of the driver we increase the rate of speed, and as we increase the size of the driven we decrease the rate of speed. 36 then is the driving wheel, suppose we reduce that by one-half, thus using 18 teeth instead of 36, then we double the power given to us by the change wheel, which is a driven one, and so enable us to reduce the fraction of a pick in a proportionate degree; or we may employ a wheel with 27 teeth and we find the point intermediate occurring between the two. If on the other hand we increase the size of this wheel then we obtain a power of varying the fraction to an infinite degree. Of course we cannot reduce it below a certain point because the number of teeth required would make the diameter of the wheel an impossible one; on the other hand there is a limit in the increased size because of space; but we have one option, which may or may not be resorted to, *i.e.* of increasing the size of the wheel and taking up two or more teeth at each stroke as required, so that our fractional division of picks per inch may be reduced to a point which will positively become absurdity. In many cases such a contrivance as this undoubtedly possesses a value, but any practical man will realise that, with all the nicety of adjustment of the take-up motion, a variation may be made in the cloth by a lack of judgment,

or improper adjustment, in the let-off motion. As already said this chain of wheels has remained unchanged, or practically so, from its first introduction, but there is no reason why a train having two change wheels, one a driving and one a driven, should not be arranged upon some other basis, such for instance as 10, which might be more convenient than 9. It may mean simply an alteration in the diameter of the beam, or in the relative number of teeth in the intermediate wheels, instead of 89 and 15, or the two combined; but whatever advantages may be gained by it would have to be set against the disadvantages of having a special train of wheels, any one of which could not be easily replaced in case of accident.

So far the positive motions described may be termed intermittent in their character, *i.e.* the wheel is driven forward at every stroke of the crank shaft, and whether the movement takes place as the reed comes up to the cloth, or on its return, the principle is virtually the same. The cloth is moved forward a distance equal to one pick at each stroke of the going part. But there is another class of motion which must be referred to and which may be described as a continuous motion. In this case the cloth beam, or more correctly speaking the carrying down beam, in the loom is driven directly from the crank shaft, sometimes by means of spur gearing, or by a combination of spur gearing or worm and wheel motion. One illustration of the latter arrangement is given at Fig. 142, where a pair of bevelled wheels A and B give motion to a worm C, which in turn communicates with the wheel D, and that through a train of wheels, somewhat similar in arrangement to those of the motions already referred to, communicates power to the beam E. After what has been said of positive take-up motions it will be self-evident that change wheels may be introduced anywhere between the worm C and the beam E. Suppose for a moment that the two wheels A and B bear

to each other the ratio of 2 to 1, then the wheel D would be carried forward one tooth for every half revolution of the driving shaft of the loom, and the train of wheels between that one and the beam would determine the rate of speed at which the cloth is carried round. Now let us decrease the size of the wheel F, and we increase the speed at which the cloth will be carried down by E, because F is a driven wheel; and in like manner if we increase the size of G we should get the same effect because G is a driving wheel. Then let it be supposed that both wheels are changeable,

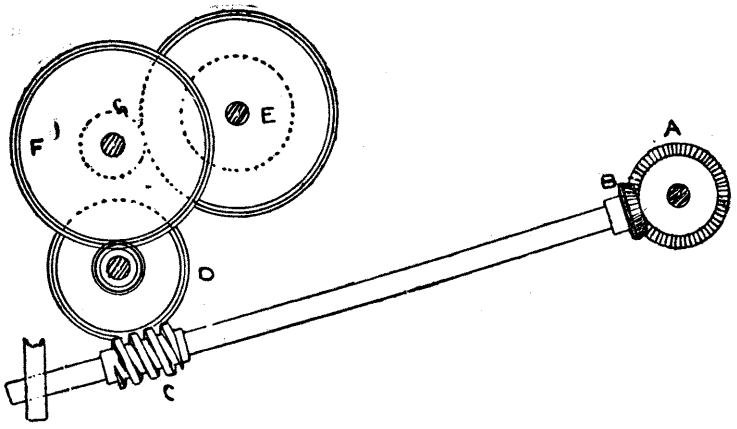


Fig. 142.

it is very evident that by increasing one or decreasing the other we get precisely the same effect, therefore if we change both at the same time we can make any degree of variation, to the most minute fraction of a pick per inch. Then take it for granted that this system of continuous driving from the shaft gives us the power of an infinite degree of variety or change, we must then look for its disadvantages.

As already pointed out in the positive take-up motions, of the ordinary kind, provision is made for an escapement

whenever the loom is brought to a stand through the weft having run out, or been broken, therefore in this case a similar contrivance should be provided and that must be applied somewhere between the worm wheel and the beam itself; or what is more to the point, on the loom being turned back the let-off motion is turned back at the same time, thus ensuring even more certainty than in the intermittent motions. One important claim is made for motions of this kind, viz.:—that not only are the changes available extremely ready, and affording a wide scope, down to the most minute fraction of a pick per inch, but more especially the take-up being constant and regular, both the fabric and the warp are maintained at an equable tension throughout, and consequently there can be no defective uneven cloth arising either from the undue straining or slackness of warp in the loom. Theoretically, this is perfectly true, practically other considerations must be dealt with; variation in the thickness of the threads of the weft, the possibility of missing a pick, even with the most perfect escapement that can be devised, and in most cases this escapement is rather a doubtful quantity, and other considerations which are so trifling that they may escape general observation will yet tend to neutralise, in some degree at least, all the efforts to make any positive take-up motion absolutely perfect. I might mention here one item which will have to be referred to later, and which every practical man is well aware of. In working with hemp ropes to the let-off motion any variation in the temperature will cause the ropes to stick a little, and, as a consequence, there will be variation in the tension of the warp, which must of necessity cause variation in the thickness of the cloth. It may be said that positive take-up motions will overcome this difficulty, but even they are subject to variation as already shewn; so that without disparaging for one moment the efforts that have been

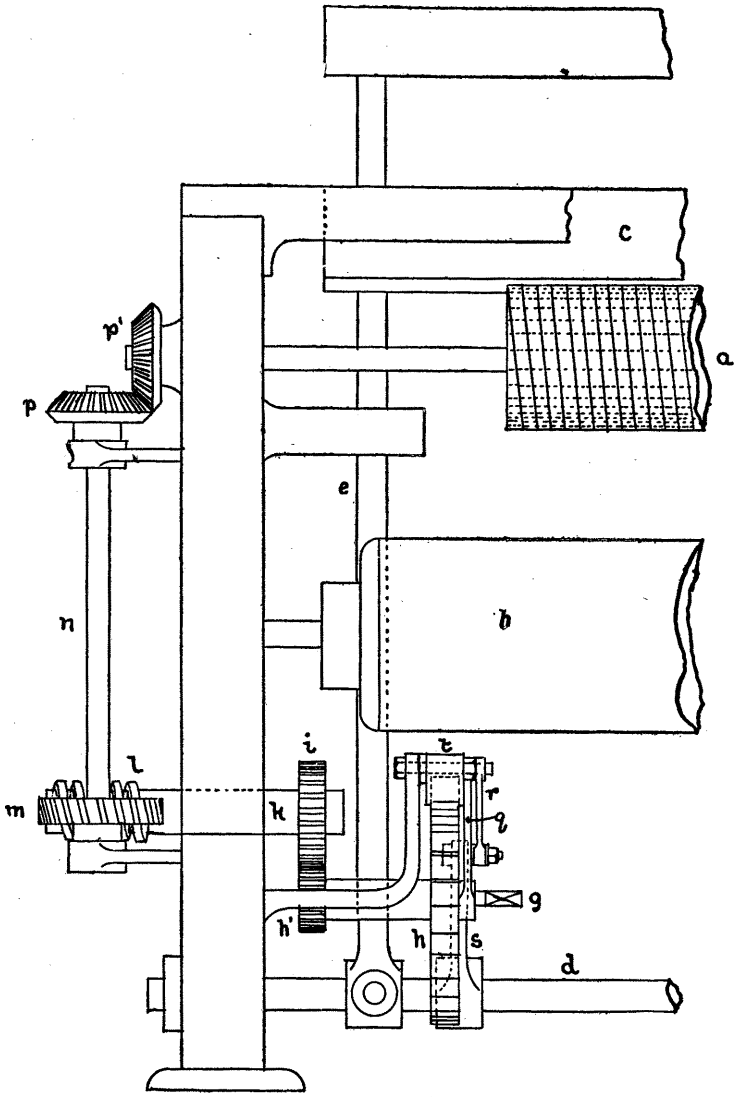


Fig. 143.

made it will not be wise to accept any motion as being perfectly accurate.

The degree of perfection after all is only a comparative one.

An ingenious contrivance of this kind is one patented by the Oldham Velvet Manufacturing Company, Limited, which is represented in Fig. 143, which shews the front elevation and Fig. 144 which shews an end elevation. In this we have the ordinary take-up roller *a*, and the cloth roller *b*. C represents the sley or going part of the loom, and *e* the swords of the going part. On the end frame of the loom a bracket is bolted carrying the shaft *g*, at one end of which is a ratchet *h*, and at the other a pinion wheel *h'* gearing into the spur wheel *i*. The wheel *i* is secured upon a shaft *j*, which in turned is mounted on a second bracket *k* fixed to the loom frame. Upon the other end of the shaft *j* a worm *l* gears into the worm wheel *m* fixed into the lower end of the vertical shaft *n*, so mounted as to revolve in bearings carried by the brackets fixed to the loom frame. The shaft *n* communicates power to the take-up roller *a*, by means of bevelled spur gearing, as shewn in both illustrations, then a pawl lever *q*, mounted loosely upon the shaft *g*, carrying a pawl *q'*, which engages with the teeth of the ratchet wheel moves it forward as desired. The free end of the lever *q* is connected by a link *r* to the end of the arm *s*, which is secured upon the sley shaft, or rocking shaft *d*. So that at each stroke of the going part the lever *q* is moved backwards and forwards, and the pawl is made to turn the ratchet wheel intermittently, in the direction indicated by the arrow upon the wheel, and may be turned one or more teeth at each beat of the going part, according to the number of picks per inch required.

Take now the continuous take-up motions. One of the most perfect and the most recent of the continuous

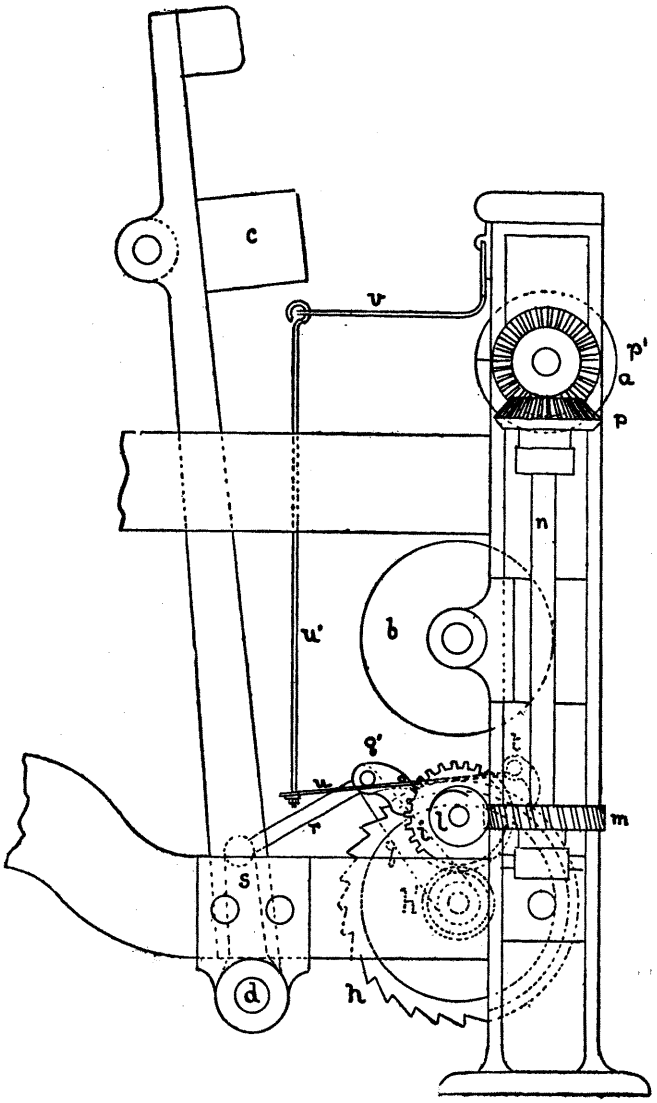


Fig. 144.

take-up motions is that of Messrs. Hutchinson & Hollingworth, as shewn on the loom at Fig. 145, an end elevation of the loom and take-up gearing at Fig. 146, and a front view at Fig. 147.

A and B are respectively the top and bottom chills of the well-known Hollingworth & Knowles' Patent Looms, revolving in opposite directions indicated. These are driven by means of bevel wheels C D on upright shaft E, which is driven from the crank shaft of loom in the ordinary way. The top harness chill A in place of being attached to the top centre shaft as aforetime is mounted on a barrel or sleeve, revolving in bearings in jacquard frame H. This sleeve extends through the bearing to receive the bevel wheel which is keyed on to it. Along side of the top harness chill (A) works the box section chill K, both of them being attached to the sleeve. Through the centre of the sleeve works a horizontal shaft fitted with a sliding catch box capable of being placed in gear with either of the bevel wheels by means of suitable connections from the front of loom, which wheels by reason of engaging with the upright shaft C are caused to revolve in opposite directions. On the opposite end of this horizontal shaft is a pinion N gearing with the intermediate O, which gears with the pattern cylinder wheel P on the end of cylinder which carries the pattern chain. On the bevel wheel end of this horizontal shaft is a rugged chain wheel Q, over which passes an endless chain extending down over rugged chain wheel R working with positive motion gears. Attached to the chain wheel R is a pinion S, into which pinion the change wheels S^1 can be placed by means of radial arms. Attached to the change wheel S^1 is a pinion gearing with the wheel keyed on the horizontal shaft W, on which is a worm X gearing with positive take-up beam wheel Y. On the end of horizontal shaft W is a spline knob Z, which can be drawn out so that the positive beam can be turned

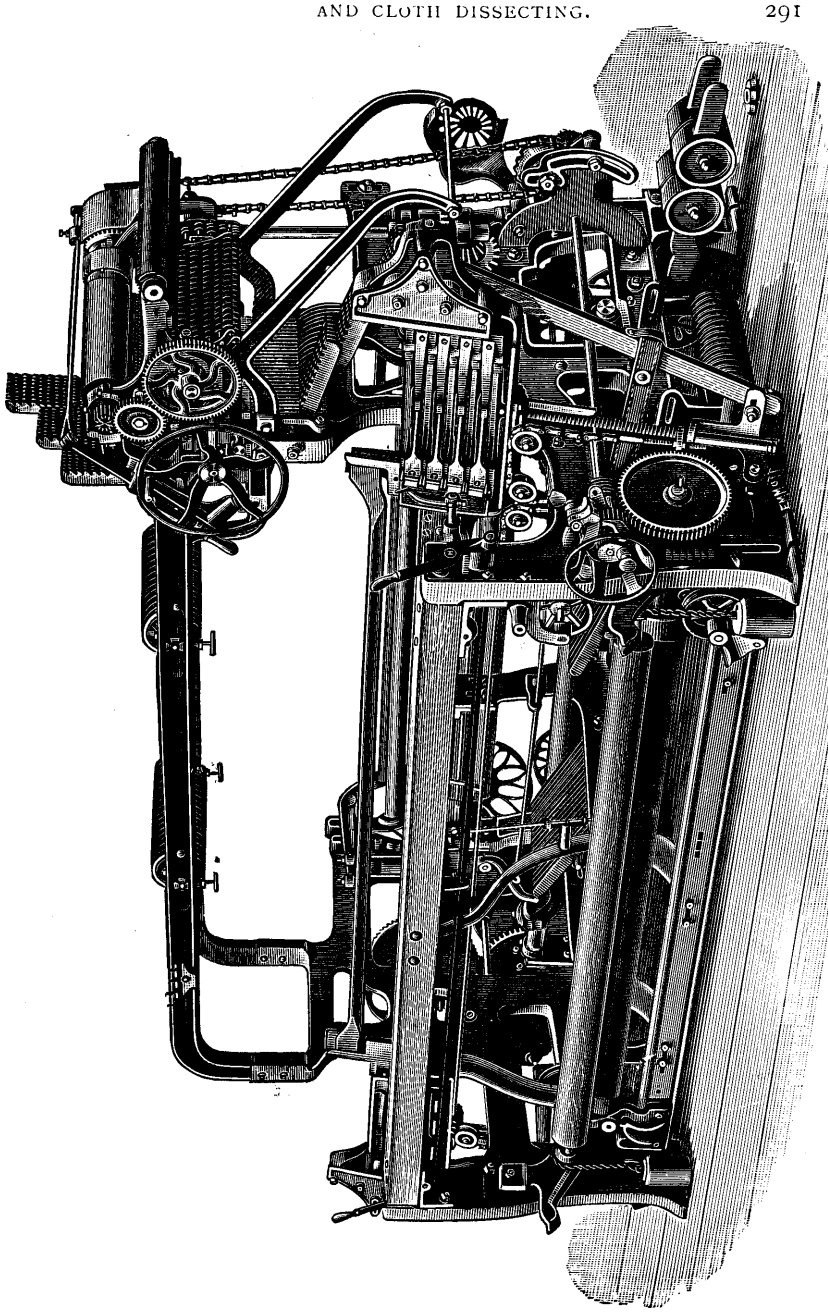


Fig. 145.

by means of hand-wheel for adjusting if required without the horizontal shaft having to move.

When the catch box is placed in gear with the inner bevel wheel the horizontal shaft is caused to revolve in the same direction as the chills A and K, consequently causing the pattern cylinder to revolve in the right direction for forward weaving, also by means of the endless chain and train of wheels, the worm and wheel X Y, the positive take-up beam moves in the right direction for taking up the cloth as it is woven.

When, however, the pattern chain is required to be reversed for finding broken or wrong weft, the catch box is placed in gear with the outer bevel wheel in which case the motion of the pattern cylinder, and likewise the direction of motion of the positive take-up beam, will be reversed turning back the distance equal to the amount of weft which has been taken out.

By the adoption of the motion when the loom is ready for starting again, the take-up beam and pattern cylinder will be at the correct position for the weaving being continued without shewing a faulty place in the cloth.

This motion is so arranged that it can be worked conditionally if required. Working loose on the boss of worm X is a lever carrying catches which fold over and engage with a catch wheel, which is keyed on to the boss of the worm X; this lever has a vertical rod attached to it at the end, which is capable of being lifted every time the lay moves back, by means of an arm attached to lay sword pin, grazing under the pulley on the vertical rod. This rod is also arranged to carry the weights required to give the necessary tension to the woven cloth. These weights can be increased or decreased according to the number of picks required. To effect the change from positive to conditional all that is necessary is to draw out the spline knob Z in which case the worm X and the horizontal shaft W are disconnected,

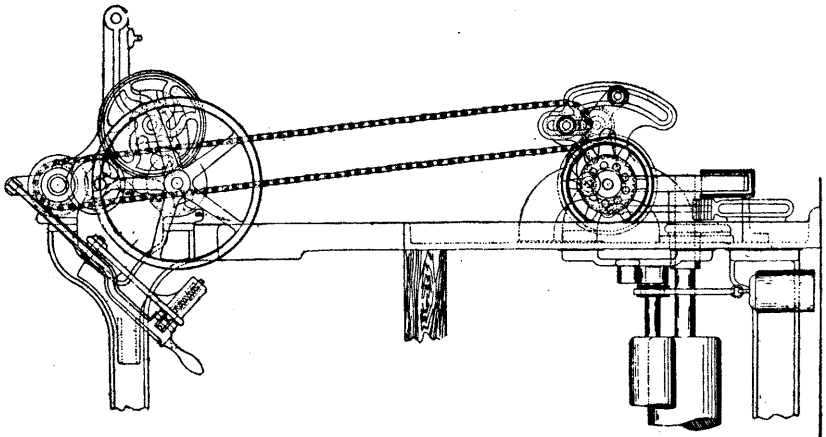


Fig. 147.

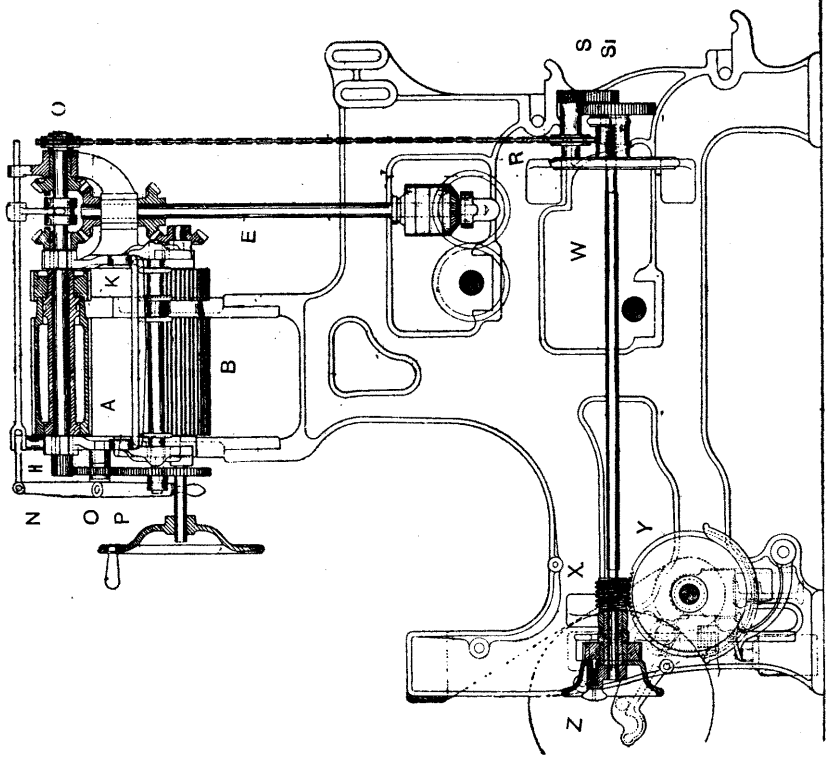


Fig. 146.

the one with the other. Catches are then placed on the teeth of catch wheel, and the necessary weight placed on the vertical rod to give the required number of picks.

As will be seen this is a continuous take-up motion of the most positive kind, and must of necessity be associated with a let-off motion of an equally positive kind, but with an escapement which will prevent the warp getting too

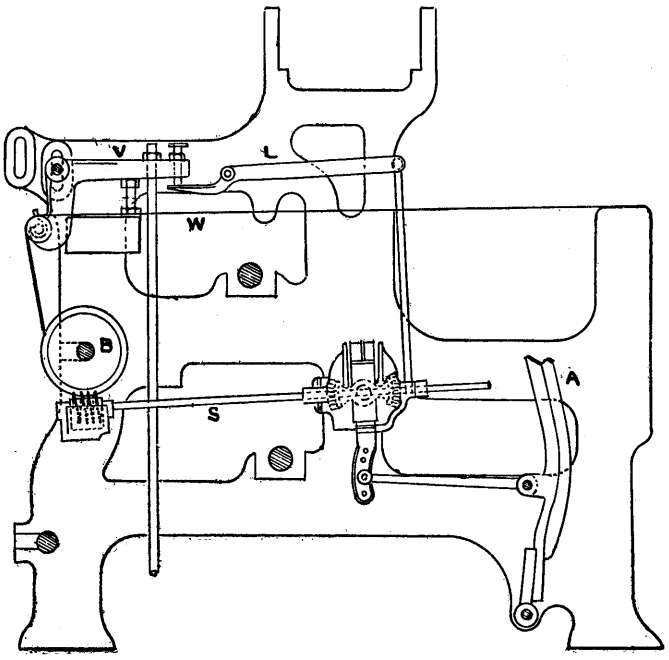


Fig. 148.

tight. This motion is communicated to the warp beam by means of the spurred gearing at the back of the loom, driven upon the shaft. Apart from the positive nature of the motion, and without further discussing the merits or demerits of continuous taking-up, this arrangement possesses the advantage of enabling the weaver to let back the cloth, in the event of broken picks or the weft running out, at

the same time that she turns back her cards to find the proper place in her pattern. In many looms the lack of this arrangement proves to be a very serious inconvenience, as the weaver will have to turn the loom over a number of times, and in most cases would carry the cloth forward in so doing, and a separate operation is necessary to restore the fell of the cloth to its proper position, and so run the risk of making cracks or thin places in the fabric.

Now with respect to the letting-off motions a view in outline of the details is given at Fig. 148. A is the lay-sword operating by means of a rod, a T lever under the loom, which operates a couple of pawls on a catch wheel, which will rotate the shaft S, having a worm at the end geared into teeth of the beam head B, and will let off the warp W. This would appear to be a positive and constant motion, and would be so but for the presence of an arrangement for letting off the warp according to the amount of tension. The warp is passed over a back rail which rests in one arm of the back swing lever V, the other end of which acts by means of an adjustable screw on the lever L, which in turn controls a shield on the shaft S, which determines at what rate the worm shall be revolved by the T lever, and consequently at what rate the warp shall be given off.

The details will be better understood by reference to Figs. 149 and 150. In these figures the T lever is marked D, and has two arms D^1 and D^2, each having a toothed segment on its upper surface, which gear with the pawl levers C and C^1, so that as the lever is oscillated by the sword of the going part, the pawls are acting alternately and giving motion to the ratchet wheel A. These pawls are then regulated in their movement by the vibrating roller over which the warp passes. The rod from the lever L in Fig. 148 operates the small lever F in Fig. 150, which is centred on the ratchet wheel shaft H, and

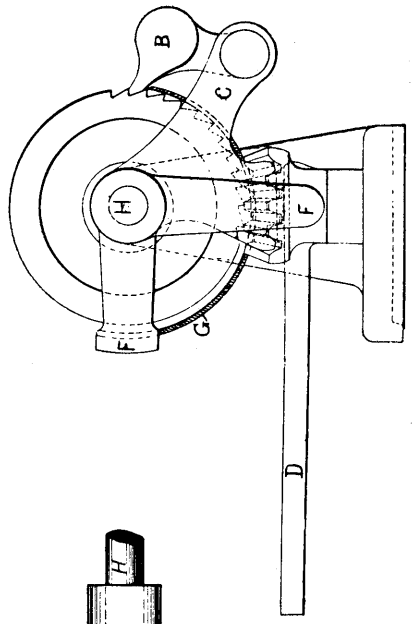


Fig. 150.

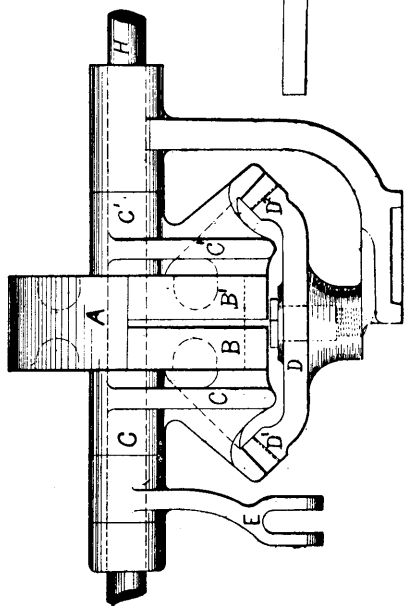


Fig. 149.

which has attached to it the curved shield G, which partly encircles the ratchet wheel, and the nose of which, when the lever to which it is attached is rocked, can pass under the pawls and prevent their engaging with the ratchet wheel. The weight is then so arranged on the vibrator levers that when the warp is at the normal tension the shield is withdrawn and the pawls are free to act, but when the tension becomes excessive, or the reverse, the

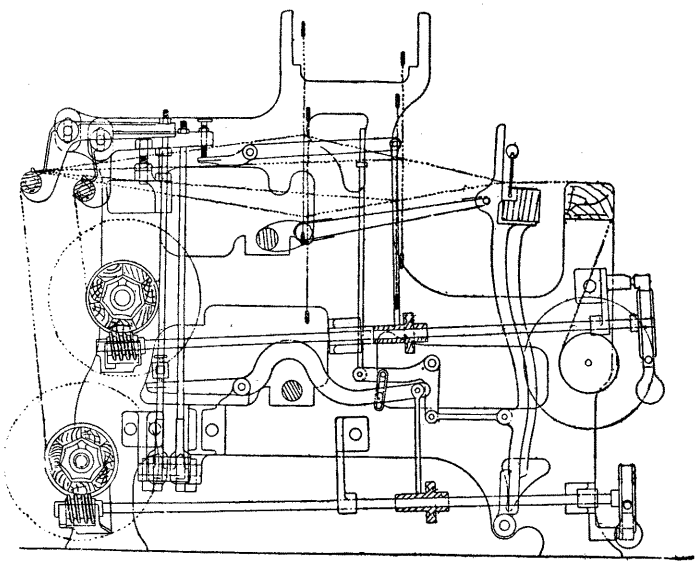


Fig. 151.

vibrating roller is depressed, it will act upon the lever, and so permit the shield to determine the length of stroke to be given by the pawls to the ratchet wheel, and thus regulate the rate at which the warp shall be let off.

A line drawing of the details is given at Fig. 151, where provision is made for two warp beams, and the arrangement of the weighting of the vibrating rollers is shown at Fig. 152. If the details of the Figs. 148, 149,

and 150, have been followed those of Figs. 151 and 152 will explain themselves.

The following points may be observed in starting the Hollingworth & Knowles' Open Shed Looms, so far as the let-off motion is concerned. When in other respects the loom is ready for weaving turn the crank so that the lay or going part falls to the back centre; the top let-off lever L, Fig. 148, should be so set as to be slightly

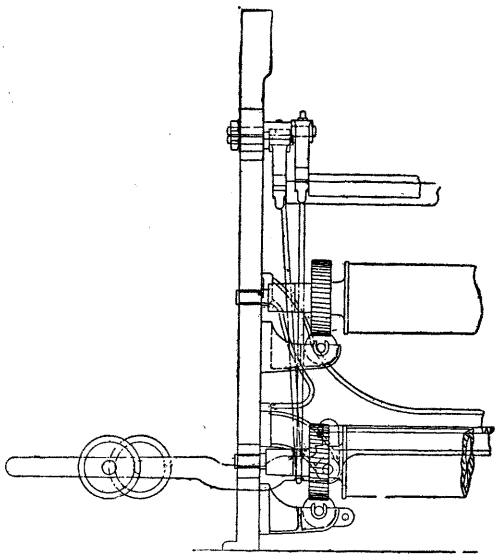


Fig. 152.

inclined by means of set hoop on the rod behind the going part, giving a distance between the opposite end of the lever and the regulating screw on V, of about $\frac{1}{4}$ inch for woollen goods and about $\frac{3}{8}$ of an inch for worsted. The weight lever should then be weighted according to the number of picks per inch.

A very brief glance now at the non-positive take-up motion will be sufficient. The most convenient arrangement

is shewn at Fig. 153, where a large ratchet wheel A is placed on the beam head and a lever carrying a pawl is actuated by the going part. A rod B is caused to lift the lever at each stroke of the going part and a weight or series of weights C are placed near the extremity of the lever. On the lower end of the rod B an adjustable nut is placed so that the lever may be lifted any height as desired, though it is not usual to lift it more than one tooth of the ratchet wheel. Then this rod B passes through

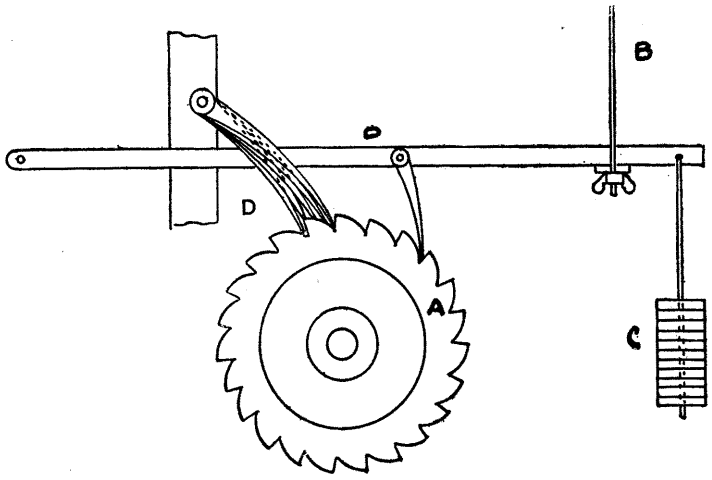


Fig. 153.

a slot on the lever in such a manner that although it always lifts a given height it does not necessarily force it down at each stroke to its lowest point. It will be remembered what was said of a box of weights in Lecture 2, the lever and the weights C take the place of the cord and box of weights in Fig. 31, page 51. As the lever is allowed to drop the weight C, pulling down the lever just at the moment when the reed is in contact with the cloth causes the beam to move forward and take up just so much of the cloth as the reed presses

forward. To ensure that this shall be as minute a fraction as possible the teeth on the ratchet wheel are very small, although shown here as being large, and a series of catches D all arranged on the same fulcrum rest upon the ratchet wheel, and are so arranged in their relative lengths that if the wheel is moved forward one fourth or one fifth of a tooth, according to the number of catches employed, one will drop into a tooth and hold it firmly in that position. To assist this a train of wheels is generally used instead of the ratchet wheel being on the beam head as suggested in the drawing.

Now here comes the disadvantage of this system of take-up motion. As the cloth is wound upon the beam the diameter necessarily becomes greater, and as it becomes greater the power of the lever and weight is proportionately diminished, so that at every coiling of the cloth upon the beam the number of picks per inch is gradually becoming more, and consequently a regular increase of the weight C becomes necessary. This is provided for by having a series of small weights which can easily be slipped upon the suspending rod as occasion requires, but it obviously requires the closest attention on the part of the weaver to keep the cloth anything near even in texture. What was pointed out before in reference to the influence of the warp tension upon the number of picks put in a cloth will now become apparent, for as the power of the weight C decreases in carrying the cloth forward the power of the weight upon the warp beam is increasing at the same time, and consequently tending to put more picks per inch in, so that unless provision is made in the mechanism of the loom for neutralising this the cloth will all the time be gradually increasing in bulk. In the loom to which we are referring ample provision is made to meet this contingency. The let-off motion consists of a worm and wheel driven by the going part by means of a rod which carries the

wheel forward one or more teeth at each stroke of the going part. In addition to that the back rail of the loom over which the warp passes is placed upon movable bearings so weighted and adjusted, that, as the tension on the warp increases it can act upon the worm wheel in such a manner, that when it has been moved forward a given distance it gives movement of an additional tooth to the worm and so releases the tension, practically as shewn in Fig. 148. This may occur any number of times, but of course it is part of the overlooker's business to so arrange that it shall not occur too frequently, the rate of delivery and take-up should be so adjusted in relation to each other that the escapement shall be brought into play in the most regular manner. Then it becomes the duty of the weaver and the overlooker together to keep a careful watch upon the cloth, first to see that the take-up motion is sufficiently weighted just to give the number of picks required, and that the let-off motion is so adjusted as to move an extra tooth as seldom as possible.

A general survey may now be taken of the several kinds of take-up motion and their influence upon the fabric as well as the faults which may be caused by improper adjustment. Something was said in the first lecture upon this matter and still something more will have to be said in a later lecture, but this is a proper place to make reference to those which are caused directly by the take-up motions. The positive take-up motions perhaps disclose their faults more readily than any others, and are the easiest of adjustment; for instance, the irregularity in the action of the ratchet wheel, caused mainly by an improper adjustment of the take-up catch, is one of the most frequent sources of trouble. The lever, actuated by the going part, and the catch which moves the ratchet wheel forward, should be so adjusted that the wheels move one tooth exactly at each stroke of the going part. Suppose it is

carried forward one tooth and a half. At the next stroke it would not necessarily be carried just one tooth and a half, because the pawl may just fail to drop into the third tooth, then of course a wide and narrow space will occur alternately, sometimes it will take too much and sometimes too little, and irregularity must follow. Suppose it takes one tooth and a quarter, the irregularity may then be even greater because the increased stroke would occur at more irregular intervals. A careless overlooker will say always let it take enough; but this is a most dangerous expedient, the enough should be one tooth and one tooth only, there must be no depending upon the tension of the cloth pulling the beam back to compensate for any increased length of stroke, because that would be a variable quantity at all times. Again the adjustment of the holding catches must be carefully attended to; they should be so contrived in the positive, as in the non-positive motion, that whatever is given forward must be held by them. There must be no liability to rebound or give back. Then the slip catch must be carefully adjusted so that every time the loom is brought to a stand by the weft fork or stop rod it gives back the orthodox two picks and no more.

Another matter must not be overlooked in the positive take-up motions, that is, the proper weighting of the cloth beam so as to keep it always in contact with the driving or taking-down wheel. The tension on both sides always being maintained at a perfect equality, otherwise of course one side will be pulling and bearing all the strain whilst the other side is becoming comparatively slack. So that reduced to the simplest form of expression the weights must be so adjusted that there is equal tension all across the piece, and no slipping can possibly occur; otherwise thick and thin places and faults, tending more or less in that direction will be constantly occurring.

Sufficient has already been said as to the relations of the letting-off and take-up motions, and it only remains to emphasize the necessity for having those two motions working in perfect unison to prevent faults constantly arising, in many cases utterly destroying the quality of the cloth.

Although the leading features of both letting-off and take-up motions, so far as principles are involved, have been dealt with pretty fully, it must not be supposed that every form has been explained. So far as take-up motions are concerned there would be comparatively few others to deal with, but as for let-off motions their name is "legion," when it is pointed out that an authority on the subject some time ago asserted that 800 patents had been applied for for letting off motions for looms in ten years, some idea will be formed of the amount of attention which has been given to the subject. Of this large number a very large proportion would never be put on the market, yet those which have reached that stage have been sufficient to bewilder manufacturers as to which would be the best to adopt. Of course, it must not be supposed that all these were supposed to be of universal application, some would be suited for heavy and others for light goods. Some would meet the requirements of one special set of conditions and some would be intended for others; but the mere fact that there is so much room for the exercise of ingenuity shows that the subject is well worth studying and mastering in all its details.

LECTURE 9.

JACQUARDS AND HARNESSES.

Without occupying time in going over the history of the jacquard machine, or tracing more than is necessary for a clear understanding of the development and changes that have taken place in the machine since it was first invented, I will proceed at once to an examination of the general principles involved. In reality the jacquard machine is an extension and development of the witch machine, and its great merit lies in the capability of having a practically unlimited power of pattern production within a very limited space in the loom. In referring to the different forms of dobby, attention has been called to the enormous amount of space taken up when a large number of healds are employed. The jacquard enables us, from the nature and arrangement of the harness, to work with an unlimited number of separate healds, or in other words an unlimited power of pattern production, without taking up too much space in the loom. If the principle of the witch machines used upon hand looms of former days be understood, the jacquard loom of to-day is easily understood. Put briefly, the jacquard machine itself is an extension of the witch machine, where the number of hooks employed for the purpose of raising the separate heald threads may be anything from 100 to 2,000; and in fact for large damask table covers and fabrics of that description several of the largest machines may be employed upon one loom. Not infrequently a fabric is made where every thread has its own separate lifting hook, and yet the harness comes within the compass which causes no inconvenience with the loom. Then taking the harness of the old draw

loom and coupling it with the enlarged witch, we have the real jacquard machine of to-day.

A general view of the machine itself is given at Fig. 154, which represents an ordinary single lift machine without the harness attached. In this general view a series of vertical wires are seen to fill the interior of the machine, and in front a perforated bar, or card cylinder, similar to those shewn in the dobbies, but having a much larger number of holes, is also seen. The details of the machine

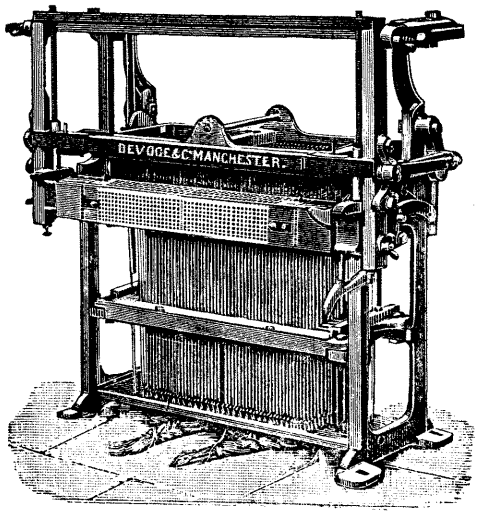


Fig. 154.

will be best understood by referring to the section Fig. 155. In this a series of upright hooks A are seen forming eight distinct rows. Each of those passing through a needle B, the needle is formed after the manner shewn in the figure where a loop is formed through which the upright hook can be passed and a longer loop is formed at the back through which a pin can be passed. This needle or cross-wire, as it is termed, is the medium of operating the harness and the warp threads through the upright hook

of the machine. The needle, as shewn at Fig. 155, passes through the needle board at the front exactly corresponding to the surface of the card cylinder seen in Figs. 154 and in section at Fig. 155. With this exception, the perforations in the needle board (see Fig. 155) are just sufficiently large only to permit the needles working freely backwards and forwards,

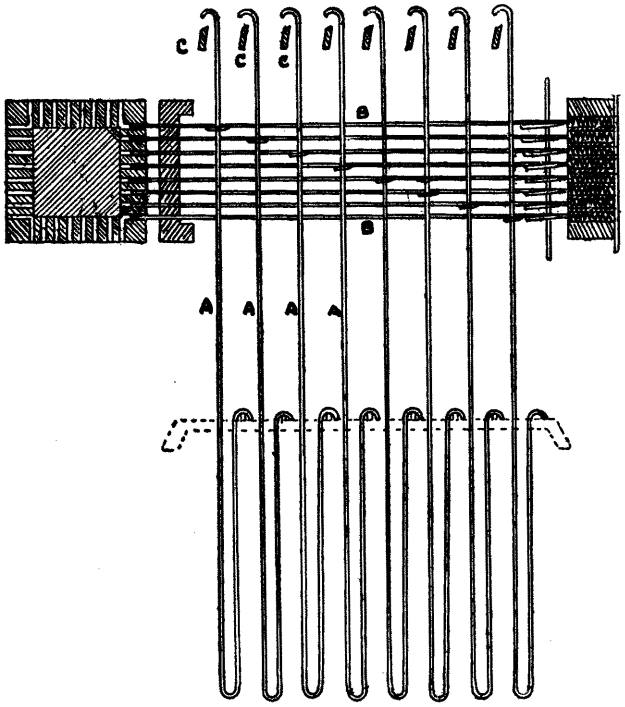


Fig. 155.

whereas the perforations in the card cylinder each have a diameter of about 1/8th of an inch, so as to permit of the needles entering them readily, even if the cylinder is not exactly accurate in its adjustment. The loop at the opposite end of the needle has a pin passed through it to keep it in position; and the spring is so arranged in a spring

box that the needle, when pressed back by any card placed upon the card cylinder, will compress it, but immediately on the card being removed it will cause the needle to return to its normal position. Now we must see what the normal position of this upright hook is. A series of lifting blades shewn in section C, C, &c., (Fig. 155) are placed under the upper extremities of the upright hooks, in exactly the same manner as illustrated in the witch machine, and the hooks are always supposed to be over the lifting knives, unless struck back by means of the blank in the card, ready for being raised at each movement of the griffe or lifting knives. Suppose the machine contains 400 of those vertical hooks, they will be arranged as shewn here in rows of eight, and there would be fifty of such rows in the whole machine Now we must follow the method of numbering or the order of succession; beginning at the left and top needle we should call that No. 1, and they would be numbered consecutively from top to bottom as shewn in the illustration. The next row commencing at nine and following up to sixteen, and so each row in succession until the last hook would be numbered 400. It is imperative that this order of succession should be thoroughly understood at this stage, for although a great deal will have to be said about the mechanism required for operating the card cylinder, and raising the hooks as required, the vital part of the machine rests in this order of arrangement. Now refer to the Fig. 154 and it will be seen that near each extremity of the card cylinder there is a row of holes; those are supplementary for the purpose of working selvedges or any extra apparatus which may be introduced. Then will be seen two movable pegs the purpose of which is to serve to keep the card in position upon the cylinder. Then follow a series of rows of holes with a space in the centre, which will be explained more fully later. Suppose the face of the card cylinder,

as seen in the illustration, to be really the needle board, of which it is a fac-simile, then the hole at the right-hand top will correspond with No. 1 needle, and so follow in succession downwards, the bottom will be No. 8, the next will begin at nine and end at sixteen; the next at seventeen and end at twenty-four, and so in succession until the bottom hole of the last row to the left will be No. 400: so that we have the order of succession of the needles clearly demonstrated. To prevent confusion arising here, come back to the cylinder itself. When the cards are placed upon the cylinder it is made to revolve so that the face of the card cylinder, which we see in Fig. 154, would carry its card to the top, and the next movement to the side facing the needles, so that that which is the bottom hole of the cylinder, as seen in the illustration, would become the top when the cards are brought opposite the needles or when the cylinder has made one-half of a revolution.

Before entering into the details of the mechanism of the machine it will perhaps be best to follow the methods of tying up the harness, because there are so many varieties of machine, each of which may be afterwards dealt with on its own merits, and without in any way interfering with the essential principles involved in the harness, and the method of producing patterns by its means. It will be remembered that in the witch or dobby machine each hook actuates a separate heald. For convenience we may suppose the harness really to represent a number of healds coinciding with the number of hooks in the machine, but instead of each heald having a pair of shafts the heald cords are carried direct to, what are termed, the neck cords of the machine, *i.e.* the cords which are attached to the hooks and passed through the bottom board of the machine, and seen lying upon the ground in the illustration, Fig. 154. To take the place of the heald shafts, what is known

as the cumber-board is employed. The cumber-board consists of a series of holes, formed in rows in precisely the same manner as the needle board of the machine itself, but at greater or less intervals. A plan of the cumber-board is shewn at Fig. 156, which is simply a piece of solid board usually 5 to 6 inches in width and about 1 inch in thickness, with the holes bored just a sufficient

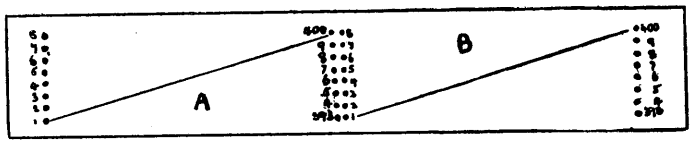


Fig. 156.

distance apart to determine the number of threads per inch. Suppose, for instance, it is desired that there should be 80 threads per inch then the 50 rows corresponding with the machine would occupy a space of exactly 5 inches or 10 rows per inch. If 100 threads per inch were desired, then the space occupied by the 50 rows would be 4 inches. It is necessary to bear this in mind as assisting us in

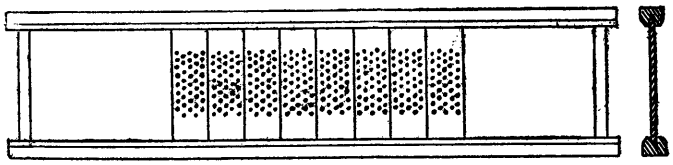


Fig. 157.

Fig. 158.

afterwards determining the question of what is termed casting out, or reducing the set or number of threads per inch.

One matter may be referred to here in reference to cumber-boards, namely, the frequency with which the cumber-boards are made in slips or loose divisions, so that they can be carried in a frame, as shewn at Fig. 157, and in sections at 158. One object of this is to enable

the slips to be set out, or the harness expanded, so as to reduce the number of threads per inch, as shewn in the illustration Fig. 159. But there is obviously a limit to this power of expanding, for if the harness be made much wider than it is originally intended to be, the cords towards the edges will become too short, and instead of the mails forming a perfectly horizontal line they would form a series of steps, corresponding with each division of the harness, and increasing in depth towards the sides of the warp. A recent improvement has however been introduced and patented by Messrs. Devoge & Co., Manchester, which permits of the expansion of the harness, say from 32 inches in width to 40 inches, *i.e.* 100 ends per inch for 32 inches

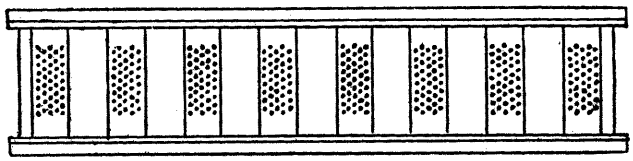


Fig. 159.

can be expanded to 80 ends per inch for 40 inches, or any intermediate stage and yet it is plain that the mails remain perfectly level. An illustration of this is given in Fig. 160, where two cumber-boards *a* and *b* are shewn, and the harness cords passing through both of them. The cumber-boards are about a foot apart, and taking the length of the harness into account the change in sett can be made without causing steps in the harness. The slips are set out, or made to occupy more space to reduce the sett, but the upper cumber-board should be carefully adjusted by setting out so as to neutralise the angle formed by the lower one; the length of the harness cord is suited to its position, and so as to enable the mails to be kept in a perfectly horizontal line. In any arrangement of this kind

the slips are carried in frames as shewn in section Fig. 158, so that they may slide about freely, and small wedges of wood are put in to keep them in position.

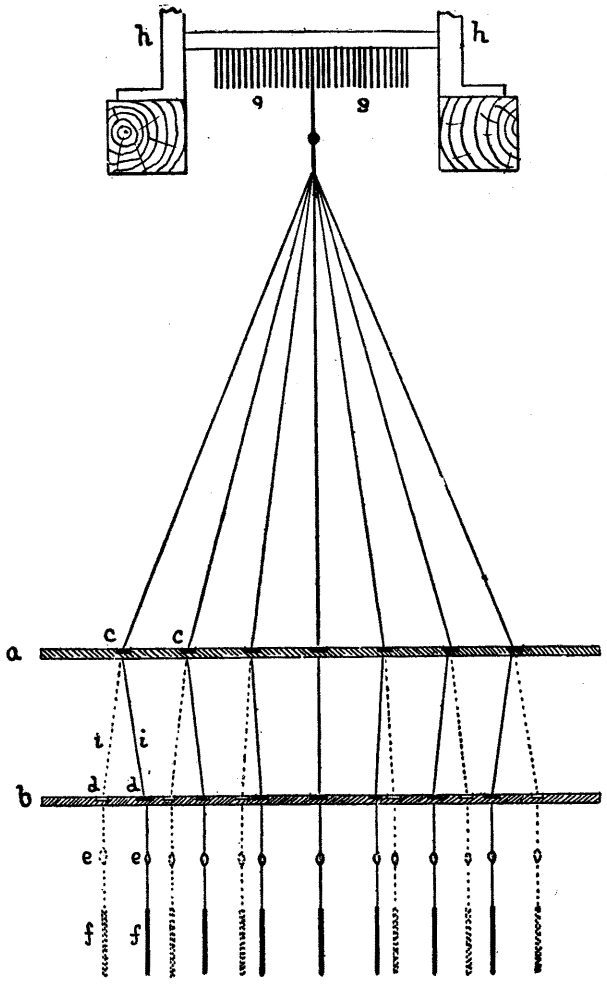


Fig. 160.

Now as to the plan of the harness, this perhaps will be best understood by making a plan of a cumber-board as

shewn in Fig. 156, where a series of holes are bored in rows of 8 and carried up to 400 and then repeated as suggested. No. 1 cord or that coming from the first hook in the machine would pass through the hole No. 1 in the cumber-board and each in succession up to 400. Then a repetition occurs and these 400 would be repeated as often as necessary for the formation of the pattern or the width of the cloth. This would perhaps be best understood by the projection of two rows of hooks in the machine and the cumber-board as shewn in Fig. 161, where the harness cords can be traced direct from the hooks, each in its order of succession, and again being repeated in the second division. This division really represents the full extent of the pattern capable of being produced. The method of tying-up being what is known as the straight through tie-up, implying that as a set of healds represents the working of a continuous series of patterns in the ordinary course, so a straight through tie-up harness will represent a series of successions of the same pattern across the fabric. Now follow the cords from the neck in Fig. 161. No. 1 hook of the machine is attached to No. 1 harness cord, No. 2 hook to No. 2 harness cord, and so in order of succession up to 400, when, of course, repetition will occur.

One reference must not be omitted at this point to two distinct methods of tying-up the harness. When the machine was first introduced into England it was found difficult to operate it in the hand looms in consequence of the position in which the machine was placed in relation to the cumber-board. The machine was placed as illustrated in Fig. 161, with the short rows of hooks parallel with the short rows across the cumber-board, so that the harness would come straight down from the hooks to the cumber-board without the unnecessary crossing, but it was conceived that this was very inconvenient, so

the working, and the position of the machine was altered; the rows of hooks in the machine being placed at right

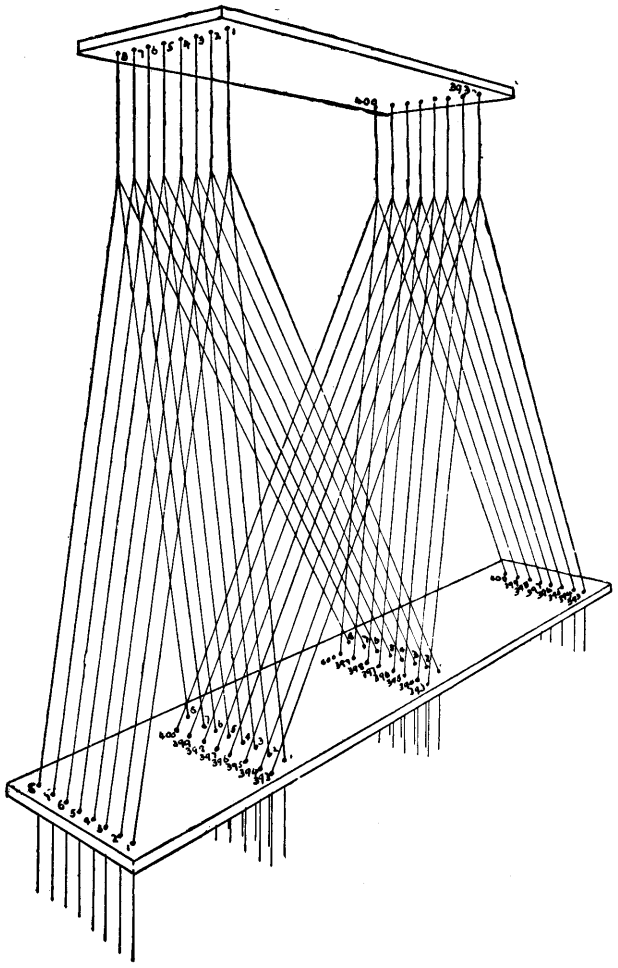


Fig. 161.

angles to those in the cumber-board, so as to permit the cards coming over the loom side and the treading lever

over the weaver's head. The two methods of tying-up are known as the Norwich and London tie-ups respectively, the Norwich tie is in use in Bradford and district at the present day, but the London tie has remained in vogue in some districts, more especially where hand looms are employed, and although it has a disadvantage of considerable crossing of harness threads, and a corresponding wear and tear, is still very frequently used. With this method of tying-up the extent of the pattern is at once determined. Any figure may be made with each thread working separately and independently of the rest, to the extent of the 400 or any other number of hooks which the

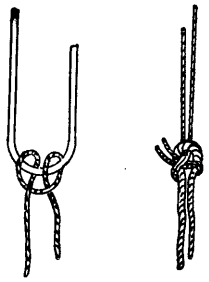


Fig. 162.

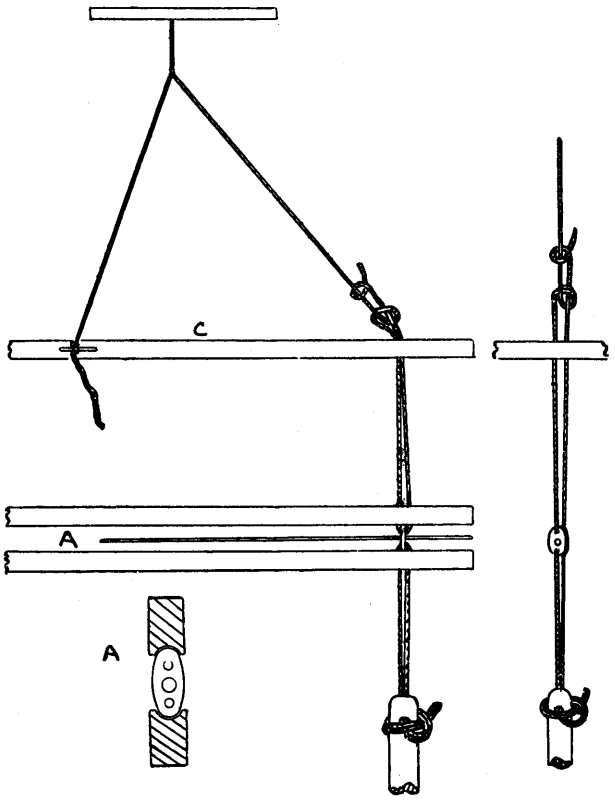
Fig. 163.

machine may contain, and would be repeated as often as necessary for the width of the fabric.

Before going further with the arrangement of the harness, something may be said upon the details of tying-up. I will endeavour to describe the method of tying as clearly as possible, because after all, a good deal hangs upon some of those trifling details. First, we have the neck cord passed over the lower part of the hook, and it should be done in such a manner as to ensure the least amount of wear and tear and the least liability to slip. The orthodox knot is shewn at Fig. 162. Then the neck cord is carried down to what is termed the neck

of the harness. Here again a special knot is tied as shewn at Fig. 163, the advantage of this form of knot being in the first place that there is no liability to slip, and in the second place when a new neck cord is being put in the tension can be adjusted with at least a reasonable degree of accuracy. Then the formation of the neck itself is a matter of some importance. In reality the neck is formed by all the cords of the harness being brought together and wrapped and tied round in such a manner that no slipping can take place; and should the wrapping or tying of the thread fail it would become necessary either to make a new neck, which would be a difficult operation, or to put in a complete fresh set of threads. Now the neck having been made, consisting of a sufficient number of cords, the actual tying up of the harness commences. The machine is placed upon a frame, or gauntry, as it is termed, at the requisite height, suitable to the loom upon which it is to be worked. The cumber-board is placed in the proper position, and beneath that a rod carrying the lingoes. Now one word as to the lingoe; this consists of the mail, a length of linen thread passed through the lower eye, and attached to the weight, as shewn in Fig. 164. Again comes in a special knot in this case, rapidity of tying and freedom from slipping being factors in the matter. The knot, as it will be seen, is precisely the same as that of the neck cord and neck. Then before proceeding to tie up the harness the number of lingoes required for one row of hooks are placed upon the shaft A, in Fig. 165, and distributed as evenly as possible over the space to be occupied. Then the neck is dropped down from the cord, one end to the left say, for convenience, is made fast under a wire staple or hook driven into the front of the cumber board; the one end which is to go down to the extreme right has a loose wide knot made upon it passed down through the

cumber-board, by the fingers, through the upper eye of the mail, and back through the cumber-board by means of a hook, and at the same time through the loose knot which has been formed in the harness cord. The free end is then drawn up until the whole cord is brought to the



Figs. 164, 165, 166.

requisite tension, and with the neck in a vertical position, and it is then tied with a knot, as shewn at Fig. 166, so that it will be seen that the portion of the harness cord passing through the cumber-board is double, whereas the upper portion is single; this process is repeated by each

cord in succession across the cumber-board until every hook in the machine has its neck attached to it, as also the necessary number of harness cords, so that supposing there are ten divisions in the harness, or ten repetitions of the pattern, there would be ten harness cords attached to each hook, or 4,000 in the aggregate.

Now let us suppose the harness is tied up in the ordinary manner, and to a given sett, and it is desired from any cause to alter this sett; an alteration may be made, as already shewn, by means of the expanding parts, or altering the spaces occupied by slips on the cumber-board. As a general rule the alteration must take place in the direction of a coarser fabric, or fewer threads per inch. If the alteration is made either by setting out the slips of the cumber-board, or, what is the same thing, the use of the expanding harness, the full number of hooks in the machine will be available for use; but if neither of those two methods can be resorted to, then the ordinary course, casting out, must be adopted. This means that a certain number of the hooks, and the harness cords attached to them, must be left idle; suppose as in this case the machine contains 400 hooks, and the harness is tied up with 80 threads per inch, it is desired to weave a fabric 72 threads per inch; then as 80 is to 72, so is 400 to 360; or as a formula:—$\frac{72 \times 400}{80} = 360$, or 360 out of 400 would be employed and the remaining 40 cast out, or left idle. Then it would be for the designer, or weaver, to distribute the cast-out as evenly as possible over the whole machine. It is not a good practise to have all the cast-out in one place. Suppose, for instance, the first 360 hooks of the machine are employed and the last 40 left idle, that would mean a gap of blank harness cords half an inch wide; this would throw the warp threads out of the straight line and cause friction; then the better plan

is to distribute the 40 idle hooks as evenly as possible over the entire length of the machine. This system of casting out, of course, may be carried to any length, but it is not desirable, at any time, to have too much of the harness idle; as, strange as it may seem, the wear and tear in the cast-out portion is much greater than in the working portion. The reason for this seems at first sight difficult to understand, but on a little consideration becomes quite obvious; the harness cords are passed through the cumber-board, which is supposed to be stationary, but as the working cords are constantly being drawn up and allowed to drop through the cumber-board considerable vibration must take place; in the working cords the friction is distributed over a length of cord equal to the depth of the shed, but in the idle portion it is confined to that over which the board vibrates; consequently the wear and tear in one case is distributed over a length anywhere from 3 to 5 inches, but in the other over a space limited to $\frac{1}{8}$th or perhaps $\frac{1}{4}$ of an inch; so that the reason for the rapid wear out of the cast-out portion is not far to seek.

The harness, tied up as described, refers to one where the machine is parallel to the cumber-board, and the cards would be working over the cloth, or over the weaver's head; but in some cases it is more convenient to have the cards passed over the warp. When tied up in this manner the order of succession appears to be reversed; in reality it is only reversed as regards each individual row of the machine, and a reversal either of the order of drawing the warp through the harness, or the position of the cards upon the cylinder will meet the difficulties. For instance, the machine is reversed in relation to the cumber-board, the order of succession is apparently still maintained, but in reality the first hook of the machine is attached to the cord going through the last row of the cumber-board, and the last hook of the machine to that

of the first row of the cumber-board; so that instead of drafting the warp threads through the harness in the order of succession from front to back, which would naturally follow when the cards are placed over the weaver's head, they must be drafted from back to front, or as it is sometimes expressed, instead of from left to right, it would be drawn from right to left.

A great deal of confusion often arises when the machine is placed at right angles to the cumber-board, or what is termed the London tie is adopted. Here every cord is crossed, and the whole of the cords forming one division appear to be half twisted round each other, as shewn in the illustration of compound harness at Fig. 194. In this case No. 1 hook, or that coming to the front of the cumber-board on the left is in the front row; number 8 to the right of the machine is in the back row, and they are all apparently crossing each other from front to back, and from left to right. This follows with each succeeding row of the hooks, and also at each succeeding repetition of the pattern, or the whole of the hooks employed; hence there appears to be endless confusion caused by this crossing and recrossing. In reality if the order of tie-up is properly understood, the cords are as easy to follow from the cumber-board to the neck in this system as in the other. The one thing the weaver should practise is to follow each cord direct from the cumber-board to its hook. It is absolutely necessary that the weaver should thoroughly master this, for several reasons; harness cords are frequently wearing out, and must be replaced: then the weaver must be sufficiently conversant with the order of succession of the cords to be able to tie-up any broken one in its proper place. It may be said it is easy to find, here you have a broken thread at the cumber-board and another broken thread somewhere near the neck; if the two loose portions can be found they are simply to tie

together again; but in tying together the new thread must be placed in exactly its own position, or it will be caused to wrap round a number of others, and will be constantly liable to be lifted by mere friction and thus produce a fault in the fabric. Again, occasionally, a needle or hook will go wrong in the machine; or a hole may be wrong in the cutting of the cards and a fault appears in the cloth as a consequence of this, but there is no means of tracing the fault to its source, except through the harness itself. Every thread of the warp should have its

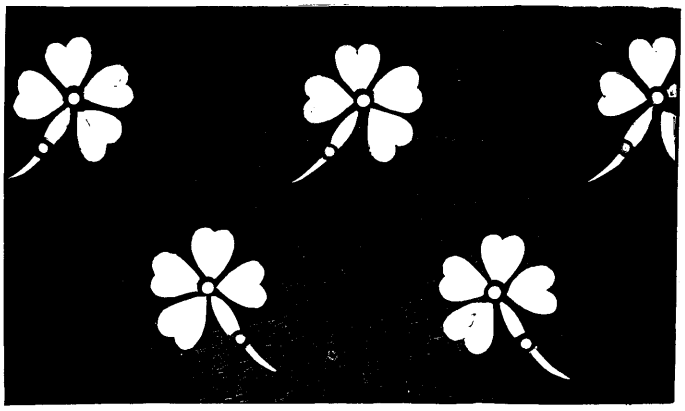


Fig. 167.

connection with the needle easily traceable, so that on the occurrence of the least fault it can be discovered. Of course it is obvious that by this method of tying-up the harness the wear and tear must be much greater than in the other methods, because of the friction of the harness cords upon each other. But it often becomes a necessity, where large numbers of cards are employed, because by bringing the cards over the loom side they can more easily be kept out of the weaver's way than when passed either over the warp or over the piece.

The use of this class of harness will be best understood by reference to Fig. 167, which shews a repeated design, the repetitions exactly coinciding with each division of the harness. Of course it must be understood that the design has been reduced to bring it within the space of a page; the pattern does not necessarily occupy the full division, or the total number of hooks contained in the machine, but it must always occupy a number which is a measure of that total. If the machine contains 400 hooks the pattern must occupy a number which will divide into that 400, otherwise some portion must be cast-out

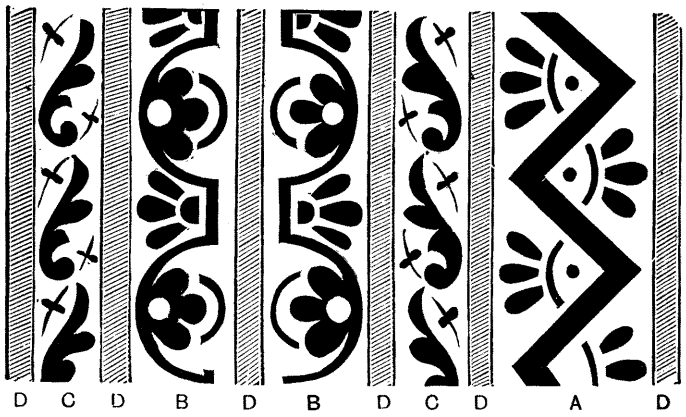


Fig. 168.

and a reduction in the number of threads per inch must follow.

The next subject for consideration is the tying-up of the harness to make what are termed repeating patterns, where three or four different effects can be combined in the same harness so as to get a wide range of pattern, apparently far beyond the range of a machine. In most cases such patterns assume a striped form, but at any rate that will be the most convenient form in which to deal with them at the outset.

The principle of this class of harness will be best understood by reference to design at Fig. 168, where we have a design or pattern, which may be broadly divided into four distinct sections. We have the section A which

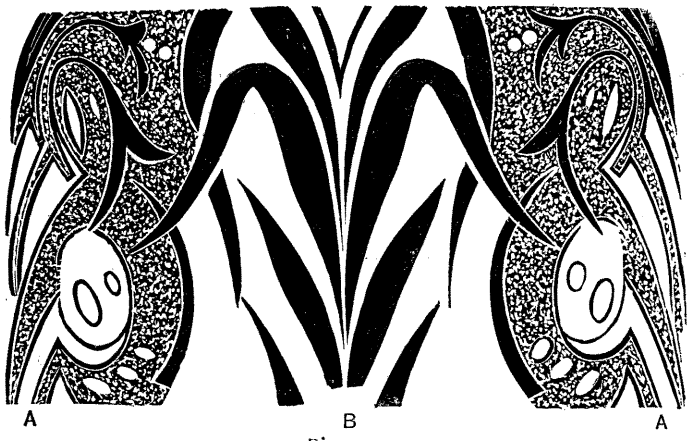


Fig. 170.

is the leading feature of the pattern; the two sections B which come next in prominence and importance; then the two sections C, and what may be termed the dividing stripes D. Perhaps it will make it more intelligible to follow the stripes D first. They are all exactly alike both in size and

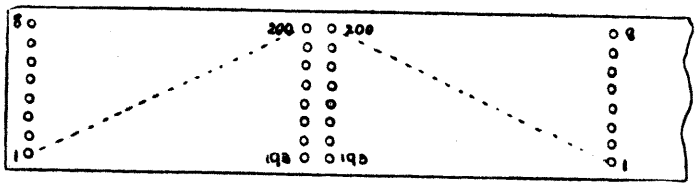


Fig. 171.

pattern and therefore, as we should say of heald work, capable of being woven with, or upon, the same healds; therefore we may say the same of jacquard work, that all the harness cords actuating the warp threads forming

the stripes may be operated by the same hooks. Again the two stripes C and C are alike and may be operated from the same hooks, and in the same manner B and B. Then taking the pattern as it stands, we will suppose

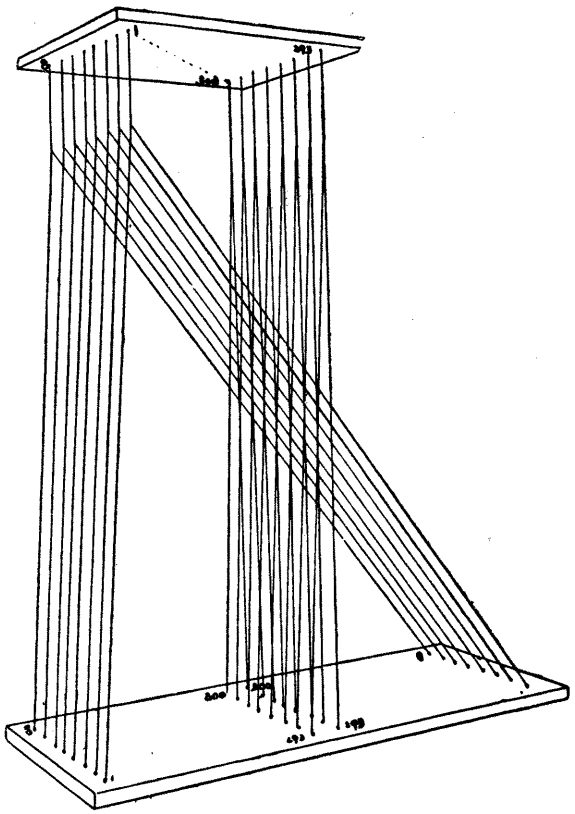


Fig. 172.

that the stripe A occupies 104 threads, one of the stripes B 32 threads, and one of C 48 threads, and one of D 16. So that we have, leaving aside repetitions, exactly 200 distinct threads, so far as their order of working goes in

the whole pattern. But including repetitions we have an aggregate of 328 threads. The harness would be tied-up

Fig. 173.

for it in sections, which will be easily understood after the description of border and centre harnesses have been dealt with.

CENTRE PATTERNS.

The next form of harness calling for attention is what is termed the centre tie-up, or, as they are sometimes termed, point patterns. This will be better understood by reference to a design Fig. 170, where the pattern is represented as run into a centre and back again, so that taking the figures from the point A to B and back from B to A,

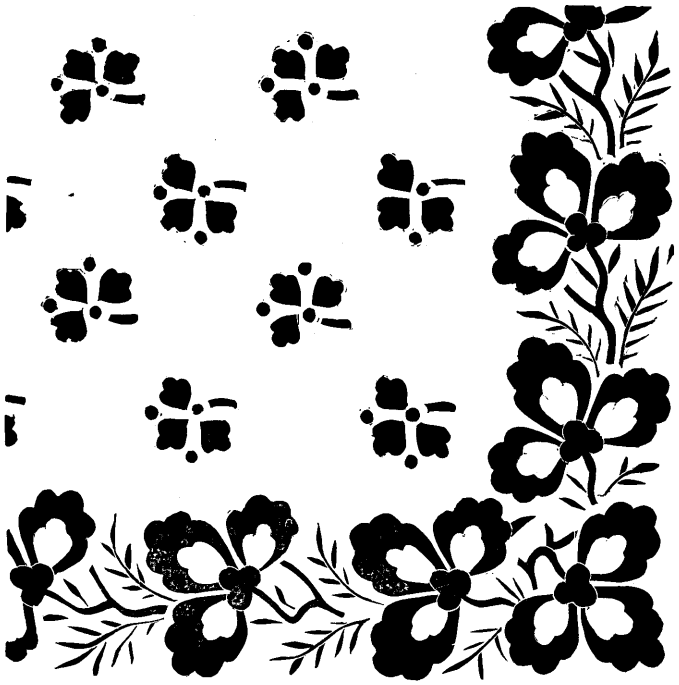


Fig. 174.

the threads on each side of B are exactly the same but in the reverse order. And again those on each side of A follow in the same manner. Now suppose this pattern to contain 400 ends, there would be 200 from A to B, and 200 back again from B to A, so that really only 200 separate hooks would be required in the aggregate.

Then for this the harness would have to be tied after the manner shewn in Fig. 171, which shews the plan of the cumber-board with the threads drawn through in their order of succession, 1 to 200 and 200 to 1, and Fig. 172 shows the actual harness corresponding with the cumber-board.

This method of tying the harness applies only to patterns of the character shewn in Fig. 170, where the figures form a centre and return again. A series of repetitions occur, each in precisely the same order across the fabric, and it necessarily follows that patterns of a continuous character could not be woven with it. The same system of tie-up is adopted for weaving rugs or other articles where a centre figure would be formed, but in such cases the harness would usually represent the full width of the article to be woven. For instance, let Fig. 173 represent the design for a rug; from the border to the centre every thread would be different, and from the centre to the opposite border there would be an exact repetition of the first half; so that the working design would be represented really by $\frac{1}{4}$ of the whole figure.

The next form of harness to be dealt with is what we commonly term border harness. This may assume several forms; first, we will suppose it to be tied up for a pattern such as shewn at Fig. 174, where the middle or body of the fabric forms figures of the continuous character, the same remark applying also to the border, but the border pattern being different from that of the middle; in this case we should divide the machine into two equal portions; say 200 hooks being allotted to the border and 200 to the middle; each of those portions would be tied up on the straight through principle, just as though they were being tied to two separate and distinct machines, and in making the design the first portion, or that for the cross border, would either have

the same pattern running upon the two divisions, or one pattern may be made to form the corner of the article being woven and another the cross border. Then the side border would have its design corresponding with the cross border, and the middle only have a separate and distinct

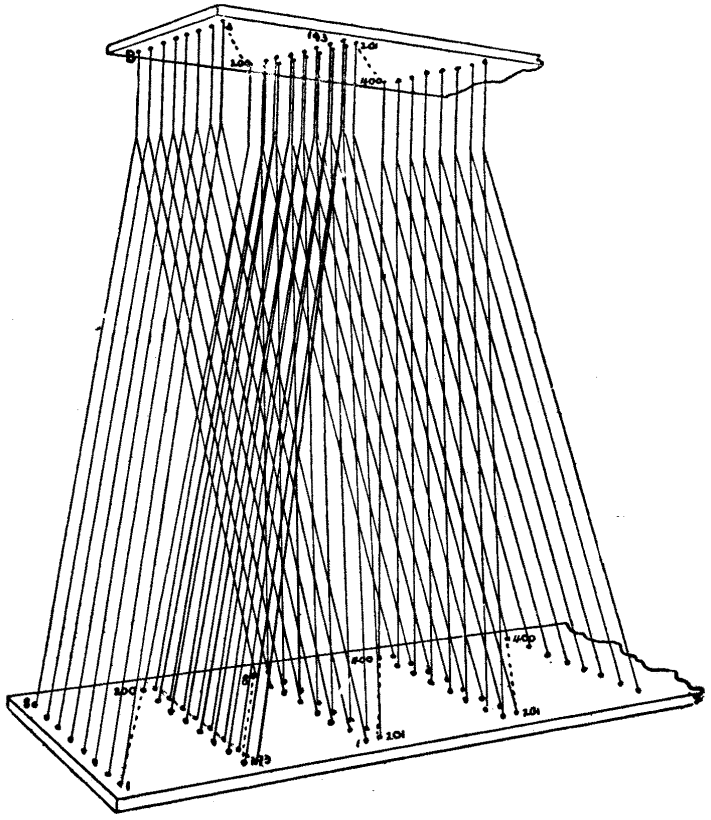


Fig. 175.

pattern as shewn in the illustration. It must however be borne in mind that if a separate figure is formed for the corner it must be so arranged that it will join and be common to both cross and side border. Fig. 175 shews method of tying the harness, the numbers indicating the order of succession of the harness cords in each division.

Sometimes ingenious contrivances are resorted to in weaving bordered articles; suppose, for example, a shawl is to be woven, and it is desired to have a border which may be figured, and that the border should be separated from the centre say by a solid line of colour, or a small figure, and again an outer border must be formed for the

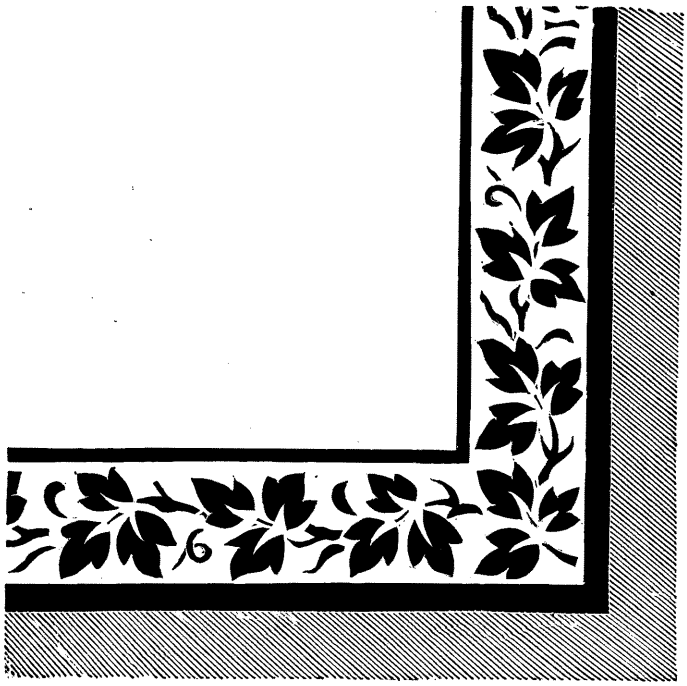


Fig. 176

purpose of giving a finished appearance to the whole; take, for example, the design shewn at Fig. 176, which may be supposed to be a representation of a figured double cloth where one figure is formed in the centre and a totally different one formed in the border, then we have a line A separating the border from the centre; another line C running outside the border; then after that, what might

be termed an outer border D. The great object must be to make those lines perfect, as surrounding the centre and border respectively, and yet without interfering with the actual border itself. One thing must be made perfectly clear, the number of hooks allotted to the side border for the formation of figure must exactly correspond with the number allotted to the centre, for the simple reason that the hooks forming the centre will also have to weave a pattern on the cross border, and if the pattern on the cross border, as usually is the case, must be identical with that of the side border, then the number of hooks allotted to each must be precisely the same, although a departure may be made by allowing the picks in the cross border to correspond with the ends in the side border and *vice versa.*

Suppose the machine contains 400 hooks, and we require say 16 to form the line A, and we may suppose that we require also 16 to form the lines C and D, then we should have to take from the 200, which would otherwise be allotted to the centre, 16 hooks; and we should have to take from the 200 which would otherwise be allotted to the border 16 others; in tying up the harness we should first tie the outer border D, and occupy the hooks Nos. 1 to 8, then for the line C we should occupy Nos. 9 to 16, each of those may be repeated as often as required to form the requisite width of stripe or border; we should now take the hooks from 17 to 200 for the border itself and repeat that any number of times; now we come to the stripe A, which would occupy the hooks from 201 to 216, but here there can be no repetition, simply because those 16 threads being taken off one division of the centre must be so arranged that they can work as part of that division, and any attempt at repetition would destroy that effect. Now the first division of the centre would occupy the hooks from 217 to 400 so as to make allowance for the 16 threads which have been taken for the stripe A. But the subsequent

divisions would occupy the hooks from 201 to 400. At the opposite side of the shawl, or other article being woven, we should either have to take 16 from the first division of the border or assign 16 distinct hooks which must be taken from the last division of the centre to enable us

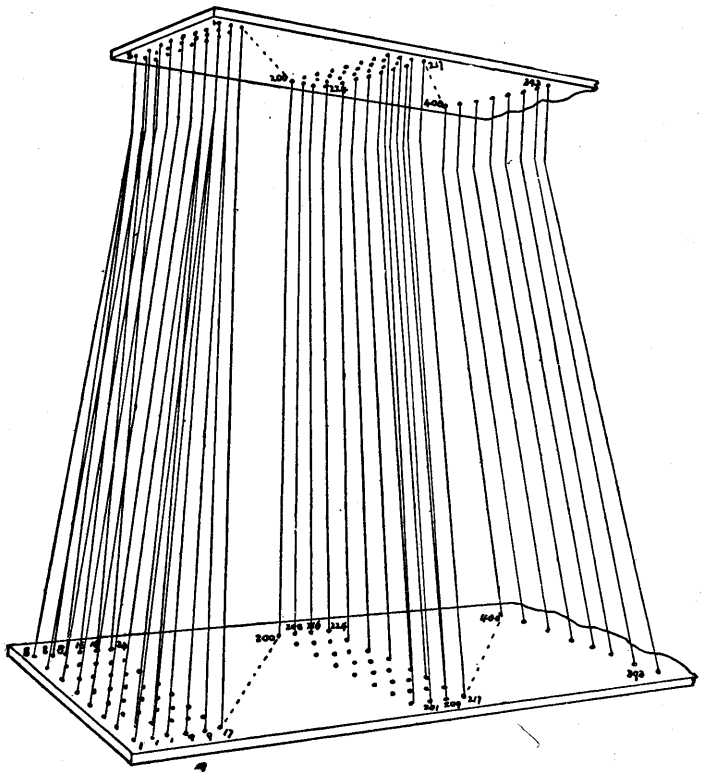


Fig. 177.

to make the pattern continuous, the latter being the proper arrangement. If the side and cross borders were always to be identical it would be more convenient to take the 16 in the one case from the centre division, and in the other from the border division, so as to leave the largest possible number of hooks available for figuring. But where the cross border and

side border are not necessarily the same pattern, then, the two stripes A must be taken from the hooks forming the centre, those on the one side taking the first portion as from 1 to 16, and those on the other side taking the last portion as from 185 to 200. In cutting the cards for the cross border pattern, it would then always be understood that the hooks assigned to stripe A would have to be cut exactly in the

Fig. 178.

same manner as the first 16 of the centre division ; in other words, in the cross border pattern, hooks 1 to 16 would be working as facsimiles of hooks 17 to 32, and of course it would be understood that in weaving the cross line A that 16 picks would be taken from the first division of the pattern in the cards, in the same manner as 16

hooks are taken from the first division of the pattern in the machine. So far as lines C and D are concerned, there would be little difficulty, they simply form a perfectly straight line or a plain border and do not in any way interfere with B. Fig. 177 illustrates the method of tying up the harness.

Now another form of border harness must be alluded to, such for instance as where the centre is a straight through tie up, and the border a point, or centre tie up. We may take it in two forms, first as illustrated in Fig. 178, where we have a border on each side of the fabric, both of them being exactly alike, but the inner cords identical with each other, so that if 400 hooks are employed, the border on the left would follow from 1 to 400, and that on the right from 400 to 1. Then the centre would occupy a corresponding number, but tied in straight order, so that the pattern would be continuous as shewn in Fig. 178. In this case the whole of the border threads having separate hooks assigned to them may have a corner pattern, so as to fill in the corner and give a complete finish to the whole, but so arranged as to join perfectly to both cross and side borders. Here again in all probability a limited number of hooks would have to be assigned to a separating line, as it is not usual to allow a border to merge into the middle; generally speaking, some dividing line is necessary.

In such a case a small number of hooks would be laid off exactly as described in the previous case, and which would be taken either from the border or the centre, or both, and working as duplicates during the formation of the cross border, but afterwards quite independently. Another form now may be looked at, where the border is tied up at the point and the centre straight through; in such case we increase the power of figuring with a limited number of hooks. For instance, with 400 border

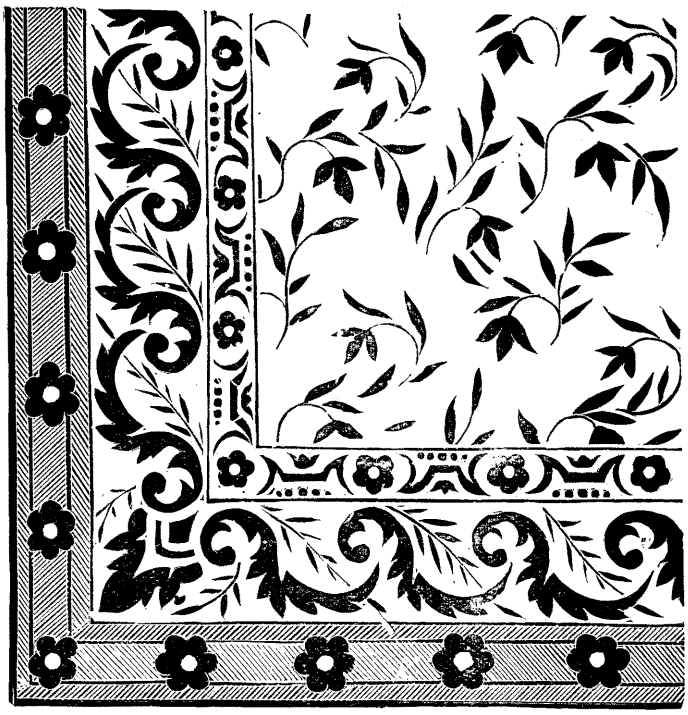
hooks we could make a pattern of 800 threads, or with 200 border hooks a pattern of 400 threads, so that we should divide our machine in such a case into three equal parts, one part assigned to the border, and tied up as a centre pattern, and the other two parts assigned to the centre and tied up as straight through; then in weaving the cross border we should cut one half the cards to

Fig. 179.

weave to the centre of the border and back again, but in the centre cards they would be continuous. A pattern is shewn at Fig. 179, and the harness will be understood from the previous explanation of centre ties.

It would be an easy matter to multiply indefinitely the various systems of tying-up for border work, but one more

illustration will be sufficient; take for example, the pattern at Fig. 180, where there are no less than three borders, one running inside the other, here we assign 60 hooks for the outer border, 110 for the centre or main border, and 30 hooks for the inner border, the remainder of the machine



Figs. 180 and 182.

being assigned to the centre. What was said in illustration of border lines in Fig. 176 will apply here in precisely the same manner, the only difference being, that in Fig. 176 the narrow lines were shewn of solid colour, whereas here all the portions are figured, each differently from the other.

One more illustration will serve perhaps to elucidate the whole matter. Where we have two centre tie-ups as

shewn in Fig. 181, one forming an outer and an inner border at the same time, a second forming the main border, both being centre tie-ups, and the third a straight through to form the centre or ground.

Now we may take a mixed tie of a different character, where we assign only a limited portion of the machine

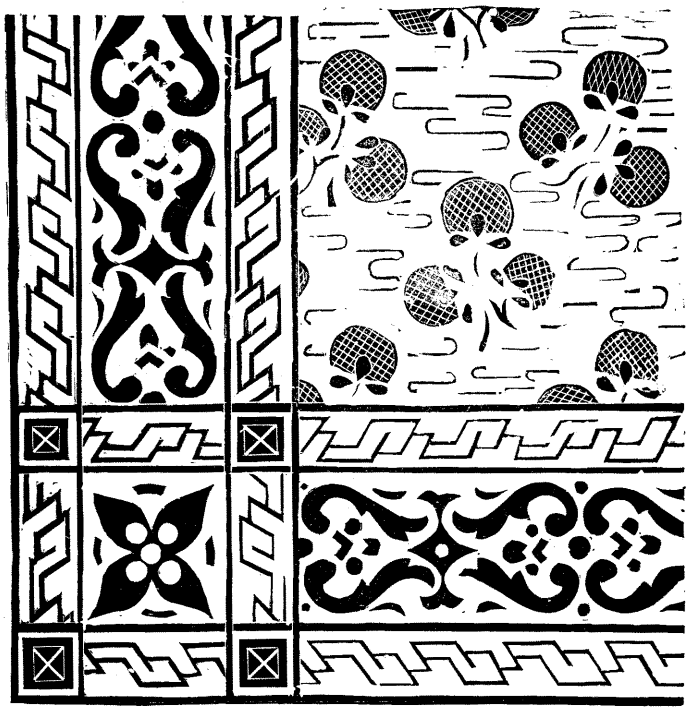


Fig. 181.

for the purpose of forming a centre figure; in this case we may divide our border into three or more sections, each section being either a continuous straight through, or a centre tie as required. For instance, we will suppose we have three divisions in the border, the outside is a straight through tie-up, the main body of the border a

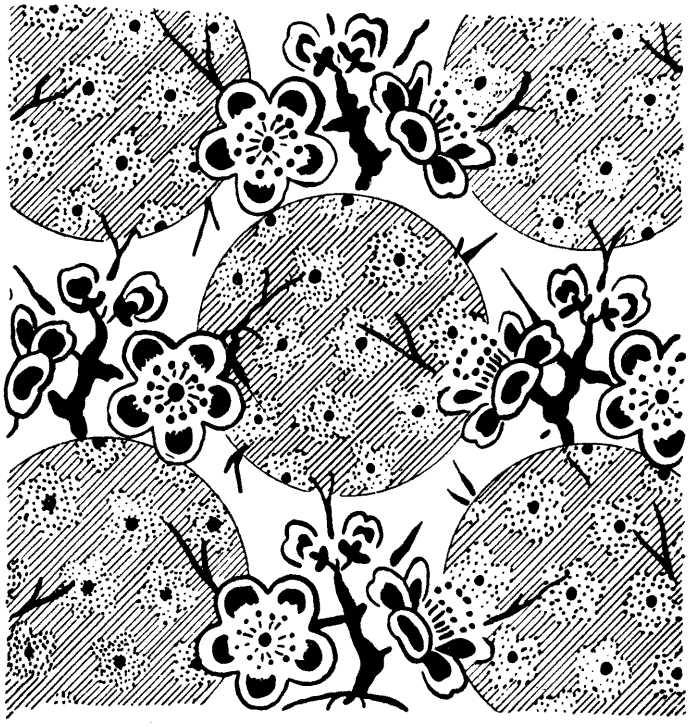
centre tie-up, the inside border a straight tie-up, then the main body of the middle also a straight tie-up, then a limited number of hooks to form a centre pattern and tied up as centre, the number allotted to each being as shewn in Fig. 182, which may be supposed to have a centre figure in addition to the ordinary ground figure as illustrated for the purpose of Fig. 180.

SECTIONAL HARNESS.

The class of harness to which we must now direct attention, and which I am terming sectional harness for convenience, is one in which one portion of the machine may be employed to weave the ground fabric, and another portion to weave a figure formed by extra warp. The sectional harnesses may be divided into three distinct classes, first, where the two portions, that forming the ground and that forming the figure, are equal to each other; second, where the one is not equal to the other, such for instance as where the ground may occupy, say one-third of the machine, and the figure, say two-thirds; or third, we may make a combination, and take one portion for the ground, a second portion for one extra material, and a third portion for another. And again, we may have the sectional harnesses arranged to work in stripe order, or divided and broken up in any manner we please.

The object of this system of arrangement is to lay aside that portion which forms the ground pattern, so that the design for the ground can be made in a straight forward manner, and the design for the extra figure in the material equally straight forward. Suppose, for example, that we are working upon an ordinary harness, a figure with extra warp, and we will say that we have 60 threads per inch in ground, and 60 threads per inch in the figure, making a total of 120, then we have 60 picks per inch of weft; it

would be necessary to have our design paper, supposing the machine to have 8 hooks in a row, ruled 8 × 4, or otherwise the figure would be distorted, the width being double that of the length, and in painting the design upon the paper we should not only have to paint the two portions of the figure formed by the ground and the extra



Figs. 183 and 186

material respectively, in two different colours, but the card-cutter would have to bear in mind, all the way through, that he must cut the ground pattern, say, upon odd numbers only, and the figure pattern upon even numbers only. In many cases to prevent mistakes by the card-cutter, this would involve dotting out upon every individual

thread of the whole pattern, the exact order of interweaving, involving an enormous amount of labour. If the pattern happened to be in three sections, as say, one ground and two figuring colours, the complication would be much greater, but it would be still greater should one of the figuring colours occur at intervals only. In that case one portion of the figure would necessarily be distorted upon the design paper, whilst another portion might be drawn in its natural proportions. I will endeavour to make this clear by an illustration presently.

Now to go back to the original two sectional harness, suppose we take the design at Fig. 183. We have there two distinct classes of figure visible, one being shewn in solid colour, and the extra material in shaded colour. This design is made to illustrate both two and three coloured sections, for two colours suppose the shaded circles to be without the dotted figures. The object of this system of pattern arrangement is to enable us to paint the design upon paper without any distortion whatever, and to enable the card-cutter to read from the design direct. Now the manner in which we accomplish this is to take one-half the machine, which we assign to the ground, and the other half to figuring material; for convenience I will take the harness as being tied up through two cumber-boards, one of which I mark "figure," and the other "ground" as in Fig. 184, where the harness is shewn as being tied up, the one-half of the machine to the one cumber-board, and the other half the machine to a second cumber-board, or two separate machines may be used. Then in carrying out our design upon the point or design paper, we should put the whole of the ground pattern, as represented in solid colours upon one-half the sheet, and the whole of the figure pattern, as represented in the shaded line upon the other half. In drawing the warp threads through the harness all the ground threads would be drawn through that portion in the cumber-board

marked "ground." The figuring portion in that marked "figure," a thread of each alternately, so that the cards being cut from the design laid out in the two divisions, as already suggested, would produce each portion of the figure on the fabric perfectly in its proper place. Of course it must be clearly understood that before each portion of the design is carried out in the manner suggested, that

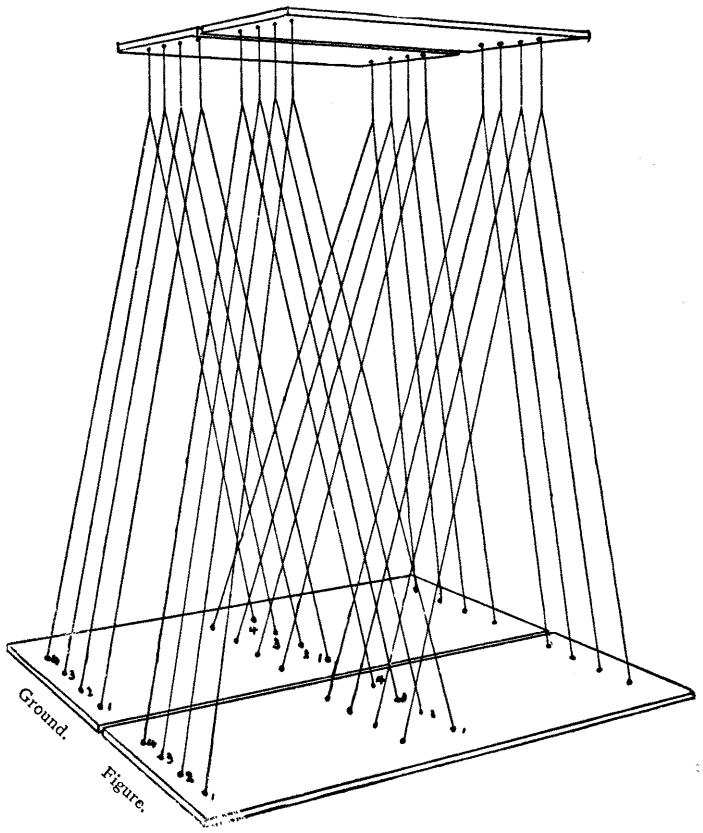


Fig. 184.

the pattern as a whole must be first drawn, and then each one re-worked out upon that portion of the machine to which it belongs. Then in this case, suppose the

machine contained 400 hooks, the extent of each pattern would be virtually 200, *i.e.*, the ground hooks would take, say from 1 to 200, and the figuring hooks from 201 to 400, but they would be intermixed with each other alternately; so that the whole would occupy virtually 200 of the ground threads, and these would be arranged in the cumber-board, the ground from Nos. 1 to 4 in the first row, the figure from 201 to 204 in the same row and so up to the 400th hook.

Then another arrangement may be considered, which is closely akin to this, where, for instance, we have three sections instead of two. It will be easily understood that the arrangement of the design, to be woven with an ordinary harness, must be infinitely more difficult when there are three threads of different material or colour, each working separately and independently, as has been suggested for the two threads. The distortion would be in the proportion of 3 to 1 instead of 2 to 1, and if the harness were tied up with 8 rows of hooks we should not be able to obtain any paper ruled to exactly correspond with it. Then the figure would of necessity be distorted in form, and the reading difficult. But suppose the machine to contain 312 hooks, then we should lay off, say 104 for ground, 104 for one figuring material, and the third 104 for the second figuring material, as shewn on Fig. 185, and for convenience we should use three separate cumber-boards, one behind the other; then we might produce a pattern such as illustrated in Fig. 186, where the three different colours are represented by the solid, shaded and dotted portions respectively. Before going further into this question I would suggest to the student the great possibilities of a three section harness such as this. The ground would be of one colour and each of the two figuring materials of different colours; suppose we call the three colours A, B, C. Then we may produce on the

ground of the fabric three distinct solid coloured figures; we may combine the ground weft with either of the two extra colours, and by combining with a variety of twill effects, letting either of the two colours take the place of the ground warp in interweaving with the weft, we may obtain any degree of shading we may require, or we may further alternate in any degree, or to any extent we please,

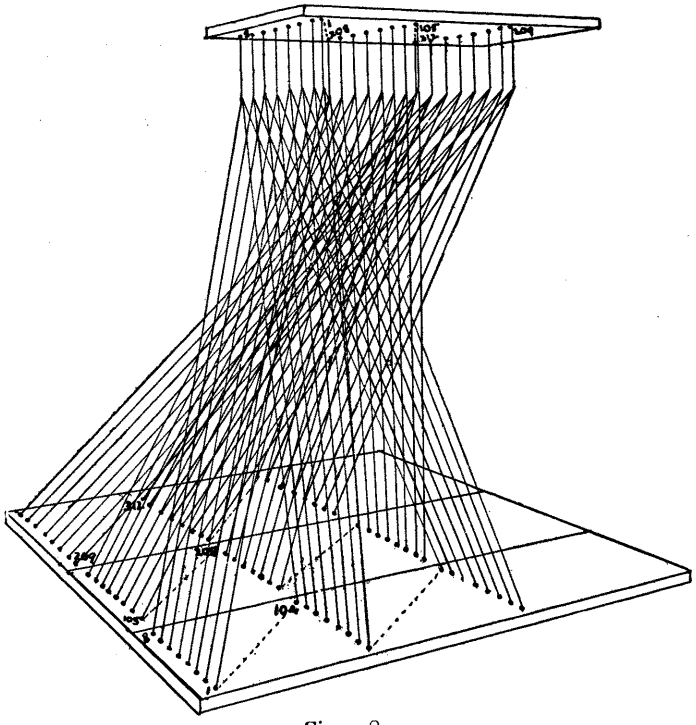


Fig. 185.

the several colours with each other and their order of interweaving with the ground weft, so that simply by the combination of the different coloured materials, and different orders of weaving, an infinite variety of colour and light and shade will be produced; one has only to look at some of the elaborate tapestries, and at some of the finest silk

fabrics produced to be able to understand this. Of course I need hardly say that, in the production of large figures, instead of dividing the one machine into several portions several machines may be employed, one machine say for the ground, and one for each of the figuring materials; this being nothing more than the enlargement of the one machine. For instance, we may put one machine containing 1,200 hooks upon a loom, or we may put three separate machines, each containing 400 hooks, and we may couple the three machines together, either by placing them all within one frame, with one common card cylinder, and actuated by one lever; or we may have three separate machines, each having its own set of cards, each having its own treading lever, but all actuated from the same source. It would be purely a question of convenience, space over the loom and economy; either of the expedients might be adopted according to the necessities of the case.

Now we may look at the arrangement from another point of view. Suppose we want to make a pattern where we desire to have a small figure distributed all over the ground and made from the ground material, and a larger figure formed by extra material over it. Suppose that we desire to lay aside only 60 threads for the ground patterns and 240 threads for the figuring material, then we should divide our machine into two sections, the first sixty being laid aside for the ground, and the 240 for figure, as shewn in Fig. 187. Then assume again that the ground threads and the figuring threads are alternate, we should either divide our cumber-board into two sections or employ two cumber-boards as before, but in one complete division of the pattern we should have the 60 ground threads four times repeated to one of the 240. So that on the assumption of the previous fabric with 60 ground threads per inch and 60 figuring threads the whole pattern will occupy four inches, whereas if the machine is divided

into equal portions, one-half for the ground and the other for the figuring, it would occupy one and a half inches, so it must be obvious there is an enormous advantage in tying up a harness on this principle, as giving so

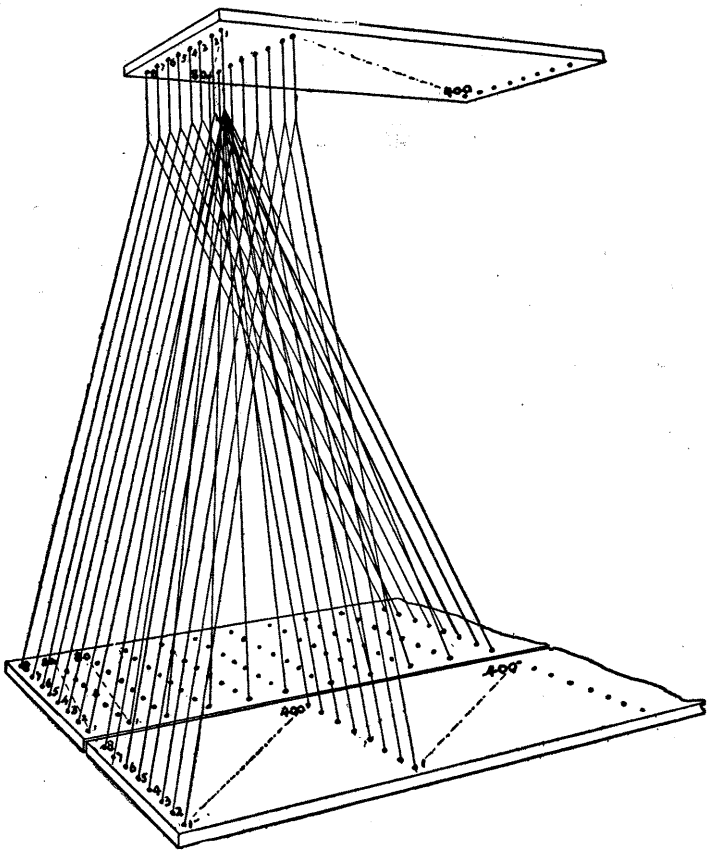


Fig. 187.

much more scope for the production of large figures. This will be understood by reference to Fig. 188, where the ground figure is shewn in comparatively small spots,

but the extra, or real figuring, material distributed freely over it in large figure.

Now I must turn to another and most important division of the subject, *i.e.*, where one portion of the harness is tied up to weave with extra figuring material, either in two or more sections in stripe form, and the other

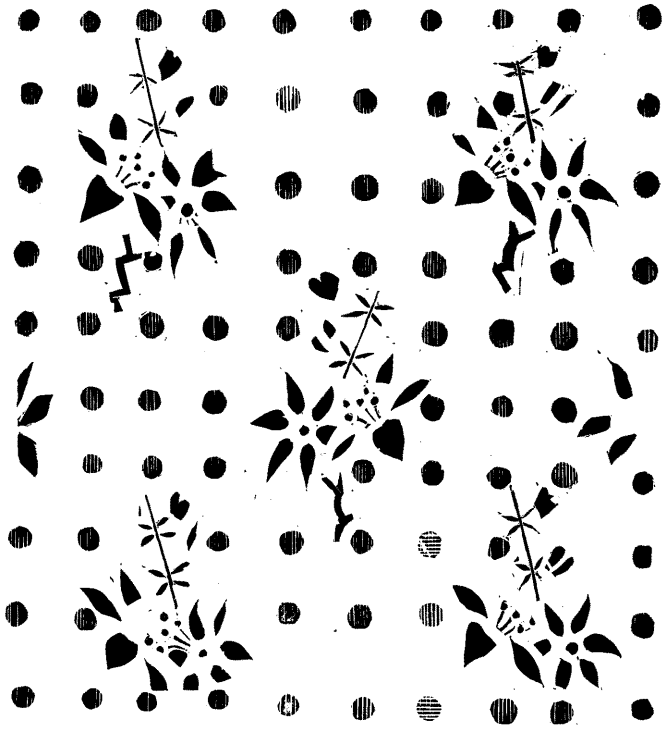


Fig. 188.

portion to work the ground. Suppose for instance that a stripe is to be formed of extra material upon an ordinary figured ground, such as illustrated in Fig. 189 where a ground pattern runs between the stripes and necessitating harness work, and a figure is formed upon the stripe itself by extra material. One of two courses may be adopted here; the first is to tie up a section of the harness

with one portion of the machine allotted to the ground fabric and the other portion allotted to the stripe. Suppose 240 of the hooks are laid off for the ground portion of the fabric alone, and 60 hooks are laid off for the striped figuring material, then that 60 would be distributed in precisely the same manner as in the arrangements already dealt with, but confined to a limited space. For instance we have 240 ground threads in the total and 60 stripe threads in the total; the 60 stripe threads must be

Fig 189.

alternated with 60 of the ground threads, leaving 180 to form the solid ground between the stripes as shewn in Fig. 189. Then the harness would be tied as shewn in Fig. 190, the cumber-board again being divided into two sections, the order of tying up being indicated by the numbers upon the cumber-board itself. By this system of tying, as illustrated in this particular case, the ground pattern may be made to run over the whole of

the fabric, and to combine, where desirable, with that of the stripe, but in the majority of cases this would not be desirable, the ground pattern usually being confined within the limits of the space between the stripes, and the stripe pattern to that of the stripe itself. The method

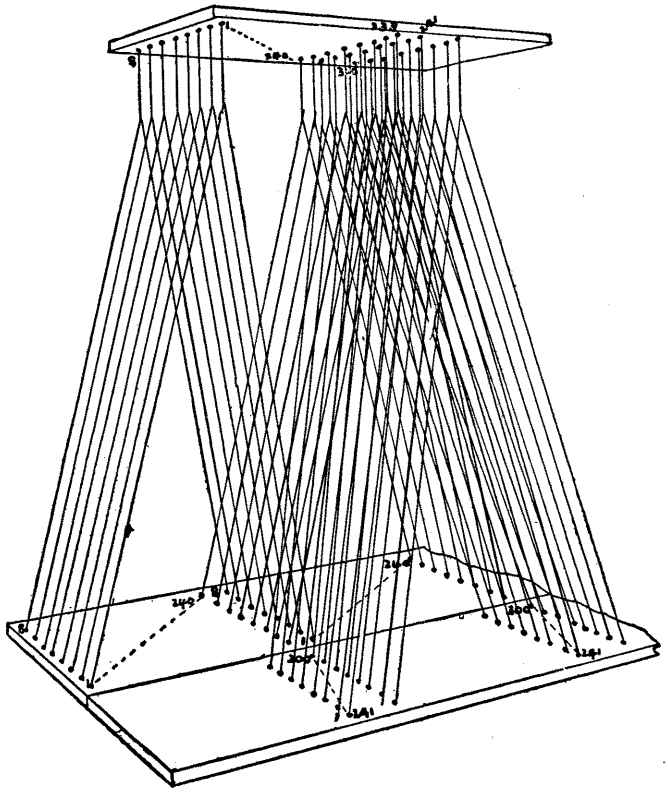


Fig. 190.

of tying the harness will be understood on reference to Fig. 190, where the divisions are laid out in precisely the same manner as in the previous illustrations. In the majority of cases the same effect which is aimed at here would be obtained by the use of what is commonly termed

compound harness, *i.e.*, by employing an ordinary harness which shall form a figure over the ground, in precisely the same manner as is done in this case, and where the stripe occurs the harness will work the figuring threads, but ordinary healds will be placed in front of the harness to form the ground fabric. Suppose we had in this case

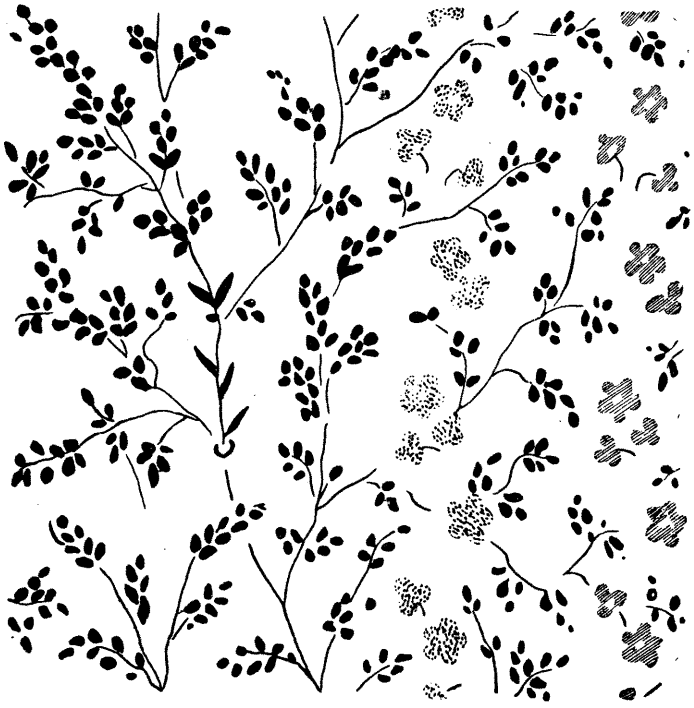


Fig. 191.

300 hooks in a machine, and 60 are required to form a figure, then we should have 240 left to form the ground instead of 180, as in the previous arrangement, and we should replace the 60 missing by passing them through a pair of healds, with their threads drawn alternately with the figuring threads of the stripe, so that the harness

would carry 300 threads and the extra healds 60, and consequently instead of having a capacity of 240 figuring threads only we should have a capacity of 300 threads from the machine, and the ground threads worked direct from healds to form the ground under the stripe. This method of working will require further explanation later on.

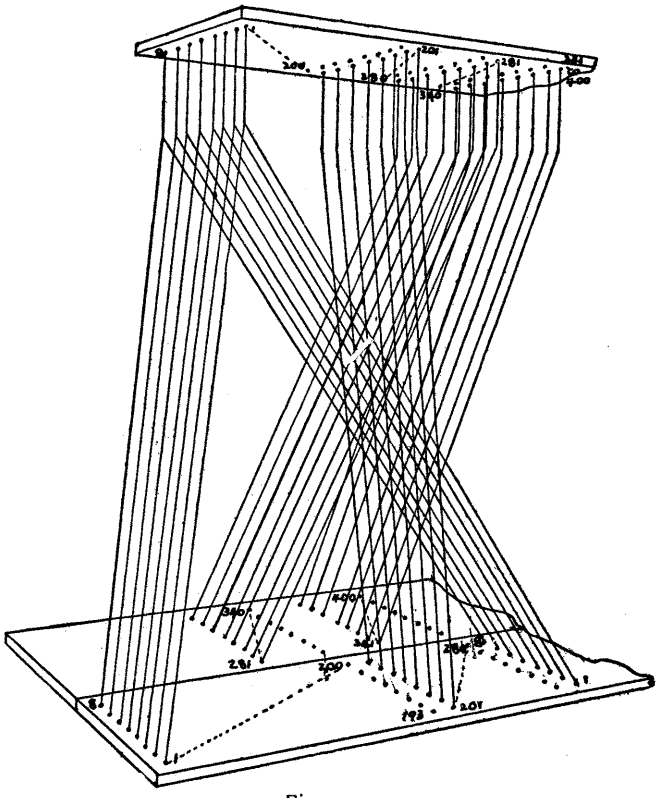


Fig. 192.

But to return to figuring where a stripe is not more than suggested, such for instance as the one illustrated in Fig. 191. We are still bound to work with the sectional harness, but our ground figure may be made to run over the fabric, and the extra figure occur only at occasional

intervals, as desired, producing a class of figure which is commonly produced by what is known as a swivel arrangement, but having the advantage over the swivel of rapidity of production, but also the disadvantage of waste of material. A further advantage of this system of tying-up in stripe form would be the use of what has already been termed point tie, *i.e.*, making a centre figure in the stripes, thus enabling us to make double the size of figure with the same number of hooks. The harness is shewn at Fig. 192.

Without going too much into detail and endeavouring to explain every class of harness it may be sufficient to say that extra figuring material may be tied up in the point, or reverse order, and the ground in continuous order. The stripe may be in the continuous and the ground in the point, or reverse order, or both may be in the point order, thus giving an enormous amount of figuring space with a very limited machine. It will, of course, be easily understood that when one machine does not give sufficient figuring capacity two or more machines may be employed, and coupled together as already suggested, each taking its own part in the work.

COMPOUND HARNESS.

The compound harness may be classified under two distinct heads, first, where the harness forms the figure and the healds associated with it form the ground under a portion of the figuring, as suggested in reference to Fig. 189, and the other where what we commonly speak of as pressure harness is employed. In both cases a number of healds, varying according to the ground pattern, are placed in front of, or in the case of common compound harness, behind the harness. Suppose, for instance, in Fig. 189, the ground formed under the figure of the stripe should be a plain cloth, then two healds would be employed, those two healds carrying only the ground threads and

the whole of the figure would be introduced from the machine. If it were a twill, or satin ground, then the number of healds would depend upon the twill or satin only; it is no uncommon thing in working fabrics, where it is desired to go to a much higher set than the harness is tied up for, to introduce healds in front or behind, which shall form either the whole or a portion of the ground fabric, and so devote the harness solely to the figuring portion,

S *Fig.* 193. S

and it is equally common to employ healds to form, say a close satin stripe, where the ground is figured by the harness. An illustration of the method is given at Fig. 193, where the solid stripes S shewn would be produced by healds alone, and with the threads very closely crowded, but the ground pattern would be produced by the harness alone. A general idea of the arrangement of compound harness may be obtained from Fig. 194, where the harness is shewn as one of the ordinary kind, and the healds

suspended in front of it. In this case the healds are usually actuated direct from the harness, so that their movements may be in unison with the harness itself; in such case some of the spare hooks of the machine,

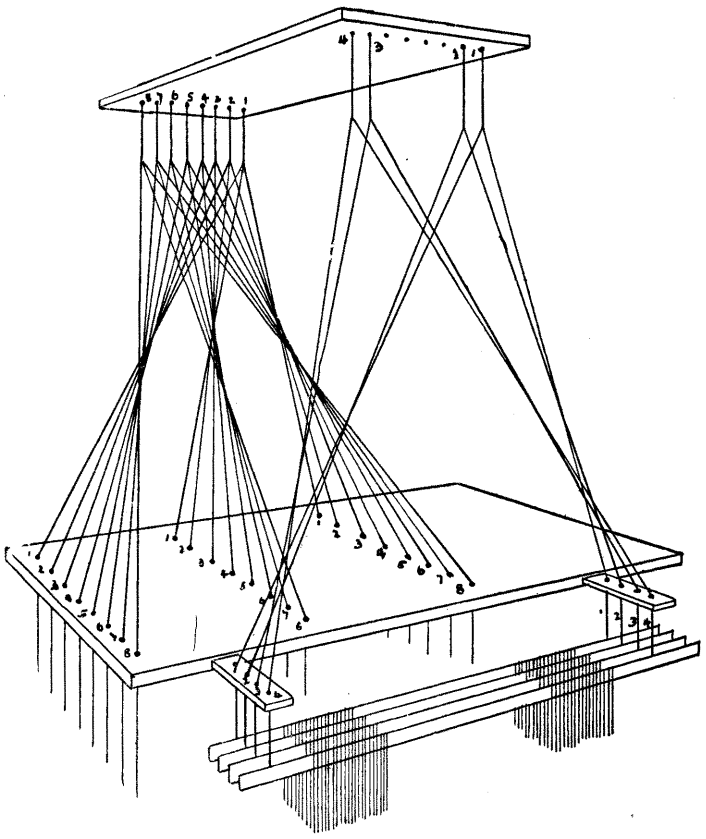


Fig. 194.

which are usually set apart for what are termed edgings, would be employed for the purpose, and the cards would be cut accordingly; but occasionally those extra healds

are worked direct from tappets and independent of the harness.

Now a very nice point arises here; when the heald is operated by tappets it is almost, if not absolutely impossible, to arrange those tappets to work perfectly in unison with the harness, consequently some little difficulty arises in the adjustment. This difficulty can be overcome by a little care, or skill, on the part of the overlooker, but sometimes a totally different question arises in this connection. I will take an extreme case; suppose the ground fabric to be perfectly plain, and one in which it is absolutely necessary to have a perfect distribution of the warp threads, evenness of texture being the essential feature of the cloth; every weaver knows that this cannot be obtained in any degree of perfection with what is termed harness shedding; but we must have this perfect ground along with an extra figure upon it; then the healds must be operated by tappets, and under the same conditions as if they were weaving an ordinary plain cloth. The difficulty will then arise, how can the open tappet shedding be reconciled and made to work with the harness shedding? It can be done, but only by the most careful adjustment of all the working parts. The timing of the tappets so that the shed is fully open exactly at the same time that the harness shed is open; the adjustment of the warp line so that the figure and the ground threads are perfectly even on the under side; the exact tension of the warp beam from which the threads are drawn, and the proper adjustment of the back rail, or what is better of two back rails; the placing of the lease rods, and the general relations of the two to each other may, in skilful hands, be made to work with that perfect degree of harmony which will produce the best possible results; but unless everything is adjusted in the most perfect manner it is utterly impossible to make those two systems of shedding work

together, but when they are adjusted not only is there the greatest amount of production, but the surest means of producing a good fabric.

I will deal now with a different class of compound harness, and which might be more correctly described as a compound sectional harness, and which is mostly employed in the manufacture of what are commonly known as quilt fabrics, or in the production of any fabric of a similar character. What is generally understood by a quilted fabric is one having a fine face, a coarse heavy back, with wadding inserted between the two; the face and the back cloths stitched together so as to form the fabric. In most cases the two fabrics would be perfectly plain in structure, and the pattern is formed solely by the stitching. Suppose we take Fig. 195 as a section of a quilted fabric, where

Fig. 195.

the upper surface is shewn as a perfectly plain fabric, and the lower fabric also plain, but the two cloths varying in the proportion of two threads to one; then a wadding is introduced represented by the thick dots marked W. Now we may weave the surface cloth with healds, and we may weave the back cloth with harness, or *vice versa*. Suppose we adopt the former plan, and we work the face threads through the healds 1, 2, 3, 4, in Fig. 196, and the back cloth in the harness through the cumber-boards A B, and we want to economise cards to the utmost extent. To bind the two cloths together, at the point where figure is to be formed, the warp of the back cloth must be raised at the time the face weft is being inserted, as indicated at the points 1 and 2 Fig. 195.

Now as to the method of actuating those healds and harness. Economy is the great object in this system of arrangement, first as regards the harness itself, and, second as to the number of cards employed. Then as to the manner in which this harness is tied; every thread of harness cord has a large knot immediately over the cumber-board sufficient to prevent it passing through the hole; then the cumber-boards A and B may be raised alternately, and the healds may be actuated at will, either from spare hooks in the jacquard or by independent

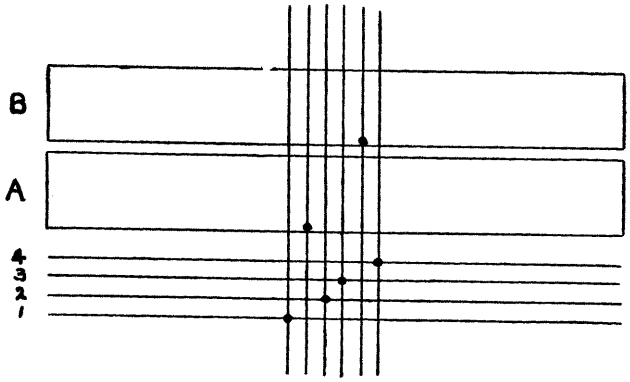


Fig. 196.

apparatus, therefore it is obvious that we can weave plain cloth by actuating the cumber-boards, raising them alternately, independently of any movement of the machine, and we can also weave plain cloth with the healds by raising 1 and 3 together for one pick and 2 and 4 together for the other; or by varying the draft we might couple 1 and 2 together and 3 and 4 together; in fact we should only employ four healds for the purpose of obtaining free distribution, as two would answer the purpose equally well otherwise. Then suppose we weave two picks of plain cloth by actuating the four healds only, then we

raise all the healds and insert two wadding picks, we next raise one of the cumber-boards as well as the healds and insert a backing pick. Then if the harness has been remaining stationary, excepting so far as the cumber-board has raised it, the two cloths will be separate, with the wadding lying loosely between them, but if during the period those five picks are being inserted any portion of the harness has been raised by the machine, back threads would be lifted and the face picks would pass under them, thus binding the two fabrics together at such points, in the manner indicated at points 1 and 2 in Fig. 195. Then from this it will be seen that one card on the machine really answers for five picks, *i. e.*, two for the face cloth, two wadding picks, and one backing pick.

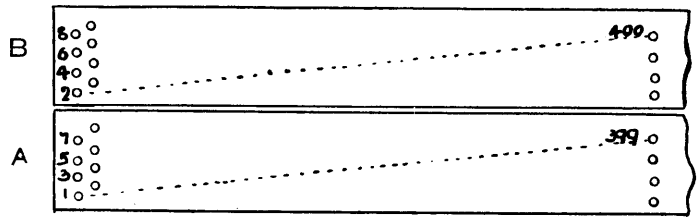


Fig. 197.

Then a change takes place, the contrary pair of healds are raised for the face picks, again the whole of the healds for the wadding picks and the whole of the healds and the reverse cumber-board B for the backing pick, so that this goes on continuously, the cards changing for every five picks only, thus it will be seen that the amount of saving in pattern cards alone will be enormous. The arrangement will be better understood so far as the harness is concerned, by reference to Fig. 197, which is a plan of cumber-board and shews the board A carrying all the threads from the rows of hooks 1, 3, 5, 7, and board B carrying those from rows 2, 4, 6, 8, and the warp threads

drawn through them in the order suggested. Fig. 198, is a reproduction by photography of a piece of quilted cloth made strictly on this principle.

Fig. 198.

COMPOUND HARNESS FOR EQUAL CLOTHS.

Another form of compound sectional harness must be dealt with, this is for weaving reversible figured cloths, where both are plain and equal to each other, and where

Fig. 199.

the figure is produced simply by the two fabrics exchanging places as shewn in Fig. 199, which represents a dark figure upon a light ground. The principle of this harness

will be best understood by a reference to Figs. 200 and 201, which are representative of four healds or harness cords arranged for the purpose of weaving double plain

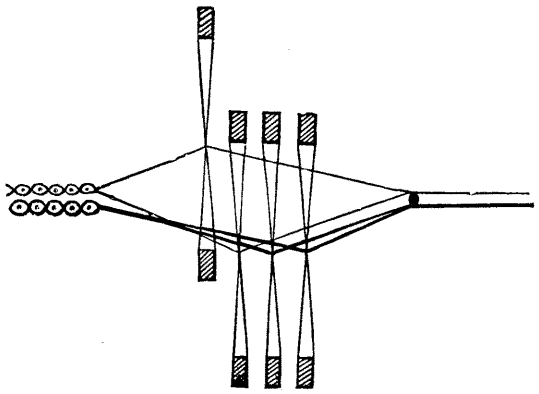


Fig. 200.

cloth ; two healds 1 and 3 carry the face warp threads and Nos. 2 and 4 carry the back warp threads, then in Fig. 200 one thread of the face warp is raised only to

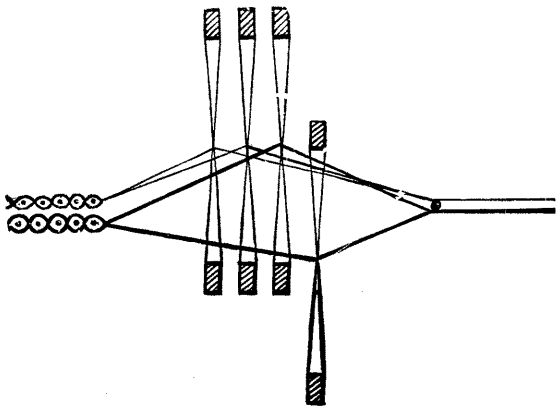


Fig. 201.

allow the pick of the weft to be passed through, and in Fig. 201 both the face warp healds and one of the back

healds are raised to allow a backing pick to be inserted; then for the next pick we should raise No. 3 heald only, and for the following backing pick leave down No. 4 heald only. Instead of employing healds we now divide our cumber-board into four sections, as shewn at Fig. 202, with the harness knotted above them, in exactly the same manner as suggested in the previous combination. Then supposing the jacquard machine to remain stationary we can weave two perfectly plain cloths by raising the cumber-boards in precisely the same manner as suggested

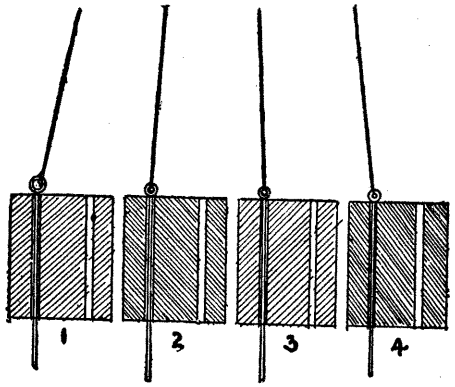


Fig. 202.

in Figs. 200 and 201. This will be understood, perhaps better, by reference to the plan of the cumber-board at Fig. 203, where we are supposed to be using a machine of 400 hooks, and where the first cumber-board carries the first and third cords of each row, the second cumber-board the second and fourth, the third cumber-board the fifth and seventh, and the fourth the sixth and the eighth, and the warp threads drawn through them, not in the order of the harness threads, but in the order of the cumber-boards, as shewn on the plan. Assuming that we can

weave the two cloths perfectly plain, and separate from each other, then by bringing the jacquard machine into operation we can cause the two fabrics to reverse their position, *i.e.*, the cumber-boards rise in their regular order for the purpose of forming the two plain fabrics, but the cords on the jacquard may cause the whole of the dark warp to be raised up at any point desired when the light weft is being inserted, and at the intermediate points the whole of the light warp can be raised whilst the dark weft is being inserted, thus producing figures,

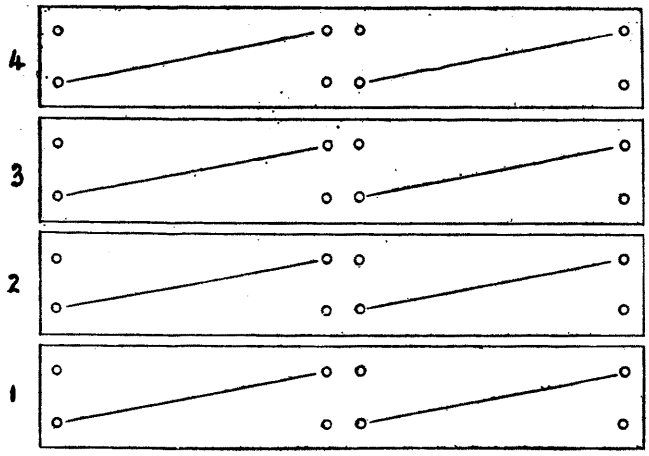


Fig. 203.

each perfectly solid in colour upon a ground equally solid; or by a judicious intermingling of the two, by bringing up a small number of threads at a place, producing any degree of shading which it may be desired to effect. Of course, by multiplying the number of cumber-boards two twilled cloths would be produced with equal facility, and a saving of cards will follow, the extent of saving being dependent upon the ground pattern and the frequency with which it is desired to change the two fabrics.

SPLIT HARNESS.

The split harness is in reality an extension of the ordinary single harness machine, and consists in tying up three or more harness cords to the same neck. Suppose for instance that we tie to each neck two or more adjacent harness cords, and we are to work in the ordinary manner, every time the harness cord lifted it would carry two threads with it. The object of this is to separate the threads, or in other words to make an extremely fine surface on the fabric by means of a coarse harness. Suppose we tie an ordinary harness up to a 400 machine, and we tie two threads to each hook, then we should have 800 separate threads in the whole pattern. Those 800 threads we split by placing a thin steel, or other rod, which becomes virtually a heald shaft, in a long loop of the harness between the warp and the cumber-board, as shewn in Fig. 204. Then suppose we have the splits in pairs the harness will work the figure, and the steel shafts taking the place of healds, will form the ground in precisely the same manner as the cumber-board in the previous case.

Suppose we are making a fabric sufficiently fine to justify us in splitting those threads into pairs, then we could weave a plain surface twice as fine as the harness was originally intended for, as represented by the number of hooks in the machine. All the way through by raising those shafts we should be making a perfectly plain surface on the body of the fabric, and by the manner in which the harness cords are raised we should be able to make a figure formed by warp threads on the surface, or by weft threads on the back. To vary the pattern we may employ any number of steel shafts which our cumber-board will permit, say 8, 12, or 16, according to the number of rows in the cumber-board. And by doing so we could vary the pattern of the ground to the same

extent; and as is the case of the compound harnesses, already referred to, we effect a saving not only of jacquard power, as represented by the number of hooks in the machine, but we also effect a saving of cards in the

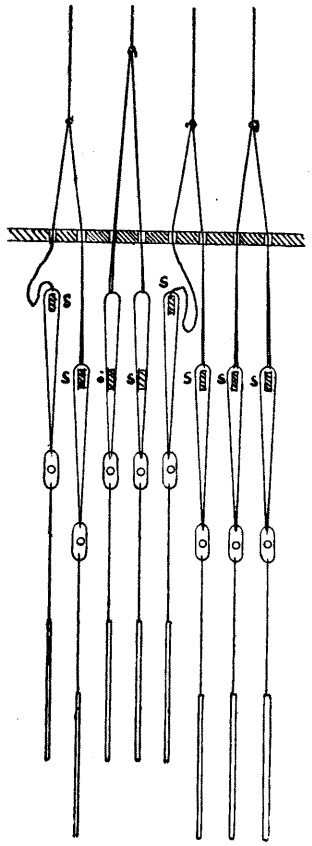


Fig. 204.

same degree. A harness tied up on this principle possesses several advantages; we cut upon the cards the pattern for the figure only, and we form the ground solely by

the lifting bars or steel rods, so that we can vary the ground pattern of the figure at will, subject of course to the lifting bars being actuated independently of the figuring cards themselves; but if they are actuated by ordinary spare hooks in the machine, then the figuring cards will have to perform the double function of forming the figure and governing the ground pattern. Two disadvantages as compared with the previously mentioned compound harnesses must of necessity accompany this form of machine. The first is the necessity of forming the figure with loose material, consisting of warp on the surface or weft on the back, and the second is the necessarily ragged outline of the figure in consequence of the steps being always over a number of threads, instead of following from thread to thread as in the majority of fabrics.

PRESSURE HARNESS.

The next step from this split harness is what is commonly known as the pressure harness, which is really a compound harness of the simplest possible type, having a set of healds different from the ordinary healds, in the length of the eyes, through which the warp threads pass, and also from the fact that the number of threads which pass through one mail of the harness are divided by the healds. Briefly expressed, a pressure harness may be explained as follows:—It is desired to weave a damask fabric, or a diaper of the true type, we should pass through each mail of the harness 4 threads if the ground fabric is to be twill, 5 threads if it is to be a simple satin, or more according to the ground pattern. Now suppose we have for convenience 4 threads in each mail, and the jacquard contains 400 hooks, we should then have 1,600 threads in one complete pattern, so far as the harness is concerned; those 1,600 threads represent only 400 thick ones, then it becomes the business of the pressure healds in front of the harness

to separate the threads which are carried by each individual heald and to form the twill or satin as required.

To understand perfectly clearly what is meant by damask, and in what manner the pressure harness can

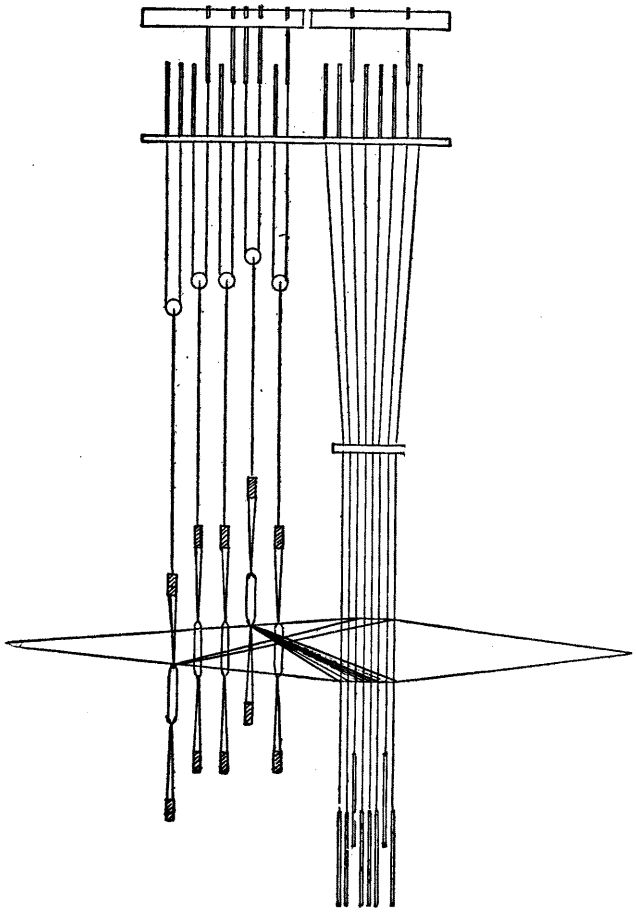


Fig. 205.

be suitably employed, it may be explained at once that the ground pattern consists, say of a warp surface of

twill or satin, and the figure having a ground surface of weft twill or satin, so that whichever material predominates in the ground the reverse must predominate in the figure. Then the healds in front of the harness, as represented in Fig. 205, have a long loop, which must not be less than the depth of the actual shed required, and the threads which are passed through each mail of the harness are separated and one passed through each of the long loops of the several healds, as shewn in the draft Fig. 206. The harness now simply determines the figure, the healds determine the ground; suppose, for example, that five threads, or four threads, as contained in one mail are required to be raised to form the warp surface, then the

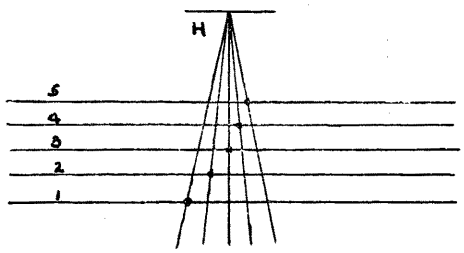


Fig. 206.

hook carrying those threads will be lifted, as indicated by the figuring cards, but one of them must be carried down for the purpose of binding the weft, otherwise no twill or satin could be formed; on the other hand supposing that five threads are required to form the weft surface then they would be left down by the harness, and the reverse of what occurred in the previous five must take place with this, *i. e.*, one of the five must be lifted for the weft to pass under so as to form the requisite ground pattern. Then this difficulty is met by raising and depressing at the same time one of the complete set of healds; for instance, if we were making a twill we may be depressing

No. 1 and raising No. 2 for one pick, for the next pick we should depress No. 2 and raise No 3 and so on. If a satin pattern they would be raised and depressed according to the order of the pattern, consequently one thread out of each group will always be at much greater tension than the rest, either by being raised or depressed, as indicated in Fig. 205, and consequently this might suggest to the mind irregularity in tension, but when it is borne in mind that this follows in regular succession through the whole series of threads no detrimental results can follow; then to ensure the raising or depressing of the pressure healds, exactly as required, each is suspended from a small pulley as shewn in Fig. 205. A cord is passed round a pulley and attached to two hooks which may be acted upon, either by the ordinary jacquard machine, or by a special machine erected for the purpose; when the healds are in what might be termed their normal position, one of the two hooks acting upon the pulley would be raised and the other depressed, or at least left at its lowest point. When the heald must be raised both the lifting hooks are carried up, when to be depressed or left at the lowest point both the hooks must be left down as shewn in Fig. 205. Consequently we have here the power of producing pattern to an unlimited extent, but subject, in some measure, to the fault which has been referred to in the split harness, of having the outline of the figure somewhat ragged. Practically the same principle is involved; if we were making a four-end twill ground we should spread the harness into four portions, so that at every pick the pattern must step in fours in the threads, or if it is five-thread satin it must spread in fives; this stepping is broken, or modified at least, not only by the fact that a change takes place in the twilling at each succeeding pick, but also that more especially in satin the warp and the weft surfaces would in some degree merge into each other, and consequently tend to soften

the irregularities in the line of the figure. This is the simple principle upon which all damask figures are made.

I shall have to refer presently to special machines which dispense with the pressure harness and reduce the number of pattern cards required, but necessarily at the cost of an increased fineness in the harness and an increased number of hooks in the machine itself, and so far as the contour of the pattern is concerned merely transferring the tendency to form steps from the warp threads to the weft threads. What are the advantages or disadvantages accompanying each of those methods will require to be carefully compared and analysed at a later stage.

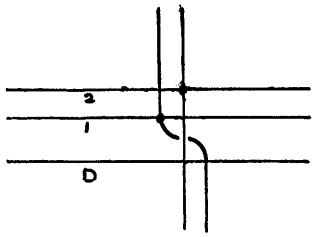


Fig. 207.

There is but one class of harness to be dealt with now, and that is for weaving gauze fabrics. In this the arrangement is different from all the others, insomuch as the threads are made to cross each other; perhaps a simple plan of a draft will explain this better than anything else. At Fig. 207 two lines 1 and 2 represent two ordinary healds, and the third line D represents a doup, then two threads, are drawn through the healds in the ordinary manner, No. 1 thread through the heald 1, and No. 2 through the heald 2; No. 1 thread is then passed under the thread 2 and through the loop of the doup, this doup loop will be best understood by reference

to Fig. 208, which in an ordinary heald is really an extra loose half passed through the eye and over the top of it, but in the harness it may be passed either through two eyes in the mail, or it may be a loose slip passed through one eye as shewn in Fig. 209. In the one case the loose slip will remain in position whether there is a thread in it or not, in the other case the moment the thread breaks it will fall out and disengage itself from the harness. The object of this arrangement

Fig. 208.

is to permit the thread No. 1 to be raised either on the right or the left of its companion thread, and so to cause crossing to occur at will. Without, at the present moment, discussing the manufacture of gauze fabric, beyond what has already been done in dealing with the dobby machine, the advantages of the doup harness may be readily pointed out. In the first place, by using jacquard hooks we have the power of causing the crossing to take place in any of the sets of threads, whether they comprise 2, 3, or more, and we may either provide each of the loose slips

with a separate weight, or what is more convenient, place all the loose slips corresponding to one row of the harness upon a common heald shaft; pass each one through its own mail, and let it be held in position by the warp thread, and the moment that thread breaks allow the loop to fall clear of the harness and so prevent trouble or confusion; so that reduced to simplicity the harness for weaving gauze fabrics will consist of an ordinary harness, properly speaking, divided into two sections, the one section being detached for the purpose of becoming the standard of the doup as shewn in Fig. 209, and the other portion fulfilling the functions of a doup.

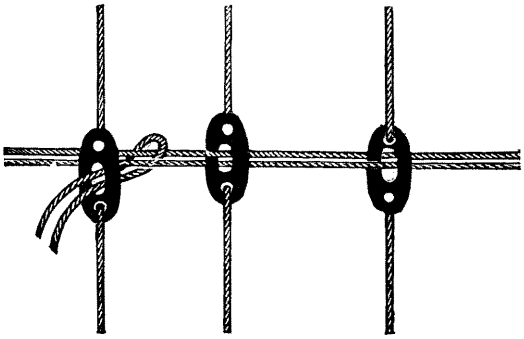


Fig. 209.

At this point attention must be called to what is a matter of necessity in gauze weaving, viz.: the slackening of the crossing threads at the moment of crossing; when working with healds, whether with tappets or dobby, the slackening is usually done by means of a lever and rod placed behind the loom, and, in the event of more than one crossing or doup heald being employed there must be a slackener for each of such doups, but in the harness there must be a slackener for each individual thread.

Without wasting time in describing the various devices which have been resorted to from time to time we may

at once approach the harness of the present day, and further, without waiting for a more elaborate description of the machine in detail it will be as well to presume for the moment that the general arrangement of the jacquard is understood. A general view of the machine

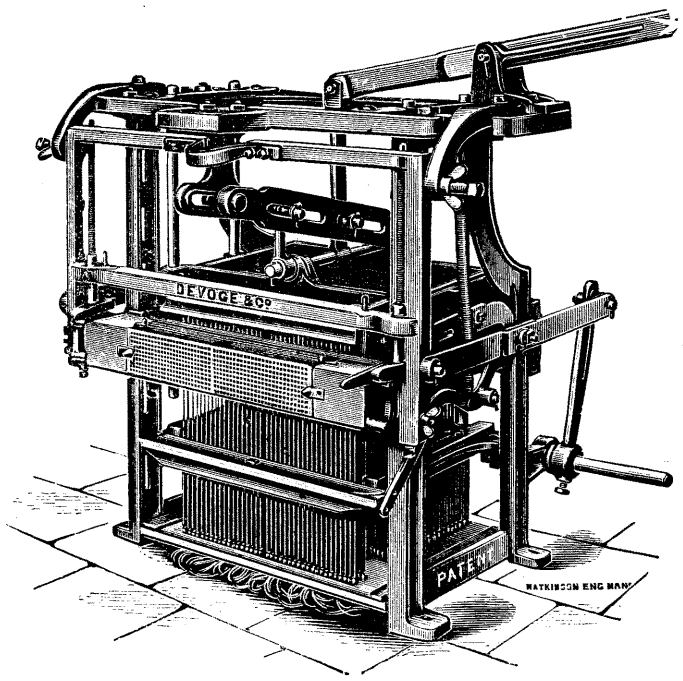


Fig. 210.

is given at Fig. 210. In this it will be seen that the two front rows of the machine are entirely detached from the rest, in reality the machine contains 600 hooks, 100 of these being detached for the doup harness, 400 for what is termed the figure harness, and 100 for the slackening harness; but although there are 600 hooks in the machine

only 500 needles are employed; the needle which acts upon the doup hook acts also upon the corresponding slackening hook, thus rendering it impossible in the first place to lift the doup harness cord without at the same time lifting the corresponding slackening cord.

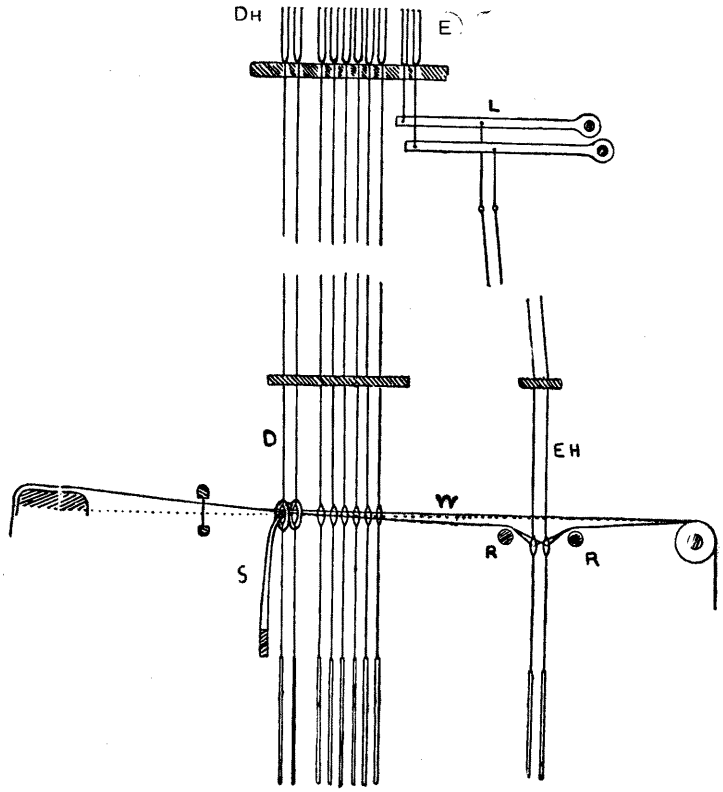


Fig. 211.

It will be necessary now to describe more fully the exact arrangement. Fig. 211 shews a section of the machine with the doup slackener and the common harness all attached, D is the doup, DH the doup hook, E the easer

or slackening hook, and EH the easing harness, and S the loose slip; W represents the warp thread passing through not only the loose slip of the doup, but the first harness cord of the figuring portion, then also through the slackening, or easing, harness and over two fixed rods RR behind the harness; now it must be perfectly clear, as already demonstrated, that when the doup itself rises carrying the crossing thread, in what is sometimes termed a false position, a sufficient length of yarn must be given off by the slackener to compensate for that taken up between the figuring harness and the doup in the act of crossing; then to meet this the slackening harness is tied up with the mail below the warp line and with the fixed rods RR sufficiently close to the harness itself to give off exactly the same amount of yarn as will be taken up by the doup when lifted in crossing. The whole arrangement so far is extremely simple, but the fact remains that considerable care must be exercised in the adjustment of the rod, the doup harness and the loose slip; in the first place so as to ensure exactly the length of yarn being given off by the slackener as will be taken up by the doup, and in the second place in the lifting of the loose slip just a sufficient distance to prevent any drag upon the yarn and at the same time to avoid what is commonly termed 'knuckling.' Intermediary between the hooks E and the harness EH are placed a series of levers L for the purpose of adjusting the amount of slack given off to the warp as the doup lifts. These levers are attached to each of the easing hooks, and each carry a set of easing harness cords, so that if there are 100 easing hooks there must be 100 levers. In the machine shewn at Fig. 210 those 100 levers are dispensed with, and instead of the hooks for the easing harness being lifted by the common griffe they are lifted by a separate griffe, the stroke of which can be regulated at will. The common lifting griffe is

shewn at G Fig. 212, and the supplementary one at G¹. A lever L is carried from the lifting rod R to a fulcrum at the back of the machine, and a second lifting rod R¹ is carried from this rod to the griffe G¹. Slots in the lever L permit all the adjustment necessary, so that this simple and ingenious contrivance avoids the use of the 100 levers as shewn in Fig. 211.

So far I have suggested only the arrangement of the doup for one thread crossing another, but it is equally

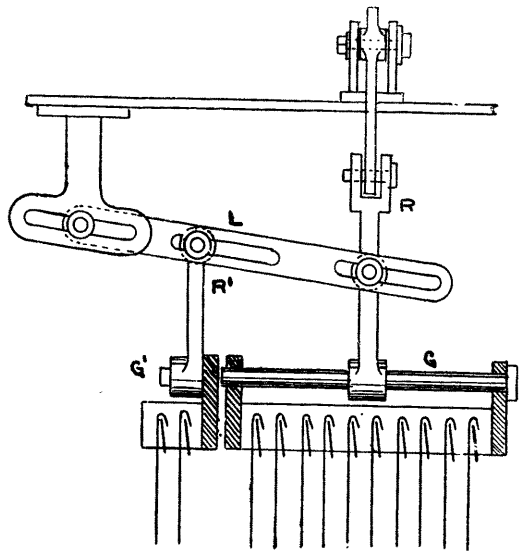


Fig. 212.

easy to make one thread cross two as shewn in Fig. 213, but what is still better and more generally practised is to have two crossing two as in Fig. 214. Without at the present moment entering too closely into the question of arrangement of design, or the practical application in weaving, both of which will be dealt with in their proper places, it will be desirable to point out generally the fact

that the more threads cross each other, each working independently when the crossing does not take place, the closer the texture of a ground fabric can be made, and, proportionately, the more open in the gauze portion. There really is no limit to this, harnesses may be built

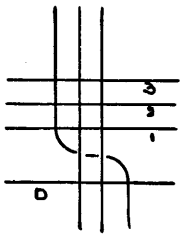


Fig. 213.

for two threads crossing two, or three, or more threads crossing each other, or in fact any combination, subject to the number of hooks in a machine being arranged and adapted to the purpose. But it must never be forgotten that the doup hooks must be detached from the ordinary

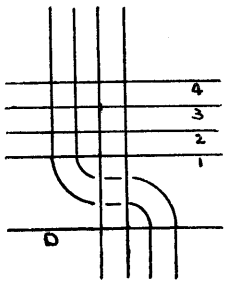


Fig. 214.

figuring hooks, and must be counted as duplicates so far as the figuring part is concerned, and must also at the same time be coupled with the slackening hooks which have no functions beyond that of giving off the amount of yarn taken up by the doup itself.

THE JACQUARD MACHINE.

A general outline of the arrangement of hooks and levers of the single-lift machine has been given in connection with Fig. 154, page 305. It now remains to give a description first of the internal arrangements of a few of the different machines, then of what might be termed the external apparatus such as the swing, or horizontal motion, for carrying the card cylinders, and of the card motions generally. I will adopt the course at first of dealing only with the interior, and of the connection of that interior with the harness, then what will have to be said afterwards of the external motions will have a general application and prevent in a great measure repetition which would otherwise of necessity occur. The general description given of the arrangement of the hooks in reference to Fig. 154, is perfectly true in its application to all single lift machines, it is only when we come to what are termed double lift machines that any considerable difference in detail arises; there may be differences in the form of hook, and the methods adopted for preventing turning, each of which will require a little notice later, but there is no difference in principle.

The double lift machines may be divided into two distinct classes, one where two cylinders are employed, one at each side of the machine, and two sets of hooks set back-to-back with each other. A full view of a two cylinder machine is given at Fig. 215, where as will be seen there are two card cylinders connected to each other by means of an arm on each side of the machine, those two cylinders carry each one half of the cards, one taking those corresponding with the odd picks as 1, 3, 5, 7, and so on, and the other carrying those corresponding with the even picks as 2, 4, 6, 8. A section of the interior of the machine is shewn at Fig. 216, where the hooks shewn must be both connected to the same neck cord. There are

necessarily two lifting griffes, each acting upon their own set of hooks and rising and falling alternately, so that as one cylinder comes in contact with the needles it will operate one set of hooks, the other cylinder operating the other set, and the two griffes acting in unison with them. This machine possesses peculiar advantages, and certainly is one of the earliest forms of double hook machines in use. First the griffes acting alternately enables the speed of the machine

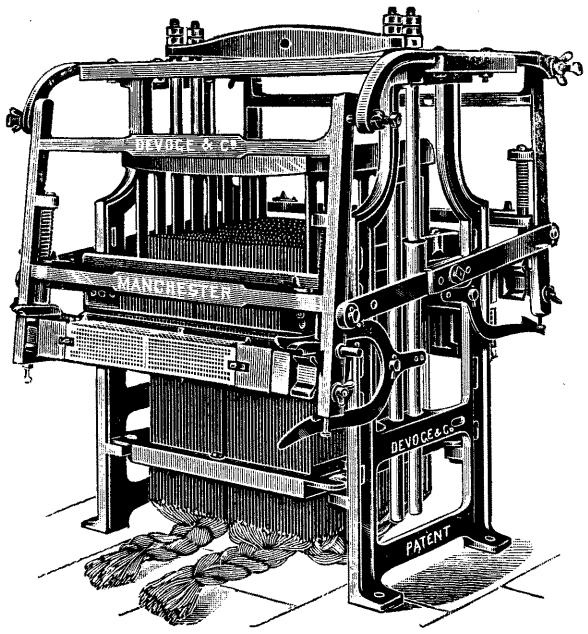


Fig. 215.

to be considerably increased; then comes in what is often termed the counterpoise principle, and suggesting what is termed the open shed; in reality there is no open shed, but exactly the same thing occurs as in the counterpoise dobby, or those already described of the type of the Keighley dobby, where it was shewn that one portion ascended and the other portion descended; a change takes place midway

between the two extreme points, so that although there is not actually an open shed, in the strict sense of the term, yet the shed is never actually closed, and in any case the descending portion serves to balance the ascending portion, so assisting to give ease in working. Then again in this machine by the form of the hook, when the double hook reversed is used, there is but one neck cord and it

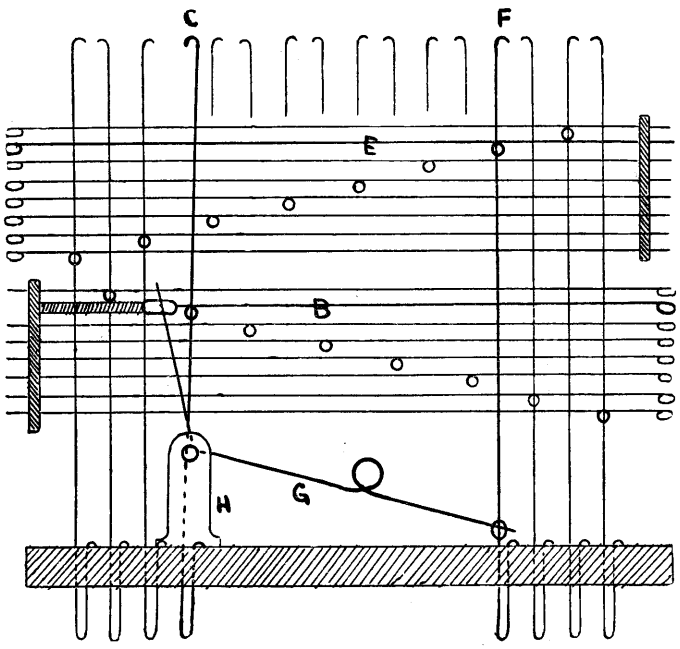


Fig. 216.

will have to be shewn in reference to other forms of machine that this is a decided advantage. Still further advantage is that each cylinder acting upon its own set of hooks there is practically the same freedom from strain upon the hooks and needle, and from pressure of the needles upon the cards, as in an ordinary single lift

machine, but a slight disadvantage occurs, sometimes said to be a serious one, in the employment of two card cylinders. It is quite possible in consequence of carelessness on the part of the weaver for one cylinder to turn over its cards and get in advance of the other, when, of course, the pattern will be broken off. A tendency to mishaps in this direction has made the double cylinder machine unpopular with a great many people.

The general practice however now is to use two sets of hooks in the double cylinder machine, as shewn in Fig. 215, each set of hooks having its own set of needles, and a most important improvement has been patented by Messrs. Devoge, of Manchester, in the shape of a stop-motion, which operates in the event of one cylinder getting in front of the other. The arrangement will be understood by reference to Fig. 216. There are two card cylinders, the odd-numbered cards passing over one, and the even numbers over the other. The second needle from the top in the series opposite the lower cylinder, and at the end of the machine, acts upon a stopper hook C, and the corresponding one in the series opposite the upper cylinder, on a corresponding stopper hook F through the needle E. The two are connected by a wire lever G, which passes through a loop in the lower part of the hook F, and another in the needle B, and fulcrumed on the bracket H on the side of the machine. The end of the needle B is cut off level with the needle board when the hook is at rest or off the griffe as shewn.

Whenever the hook F is raised it must press the needle B forward by means of the lever G, which would raise the hook C by the lower griffe acting upon the hooks operated by the upper card cylinder unless B is pressed back by the card on the lower cylinder, then it follows that if the hook F is raised and there is no corresponding hole in the cards on the lower cylinder that the hook C

would always be struck back and never lifted; but if a hole is cut in the cards on the lower cylinder to admit the passage of the needle B, immediately following one cut in a card for the needle E, then the hook C would be lifted.

The actual stop-motion is shewn at Fig. 217. J is the knocking-off handle of the loom, and K a small piece bolted to the back of it, L and M are species of brackets bolted to the loom frame, one on the outside and the

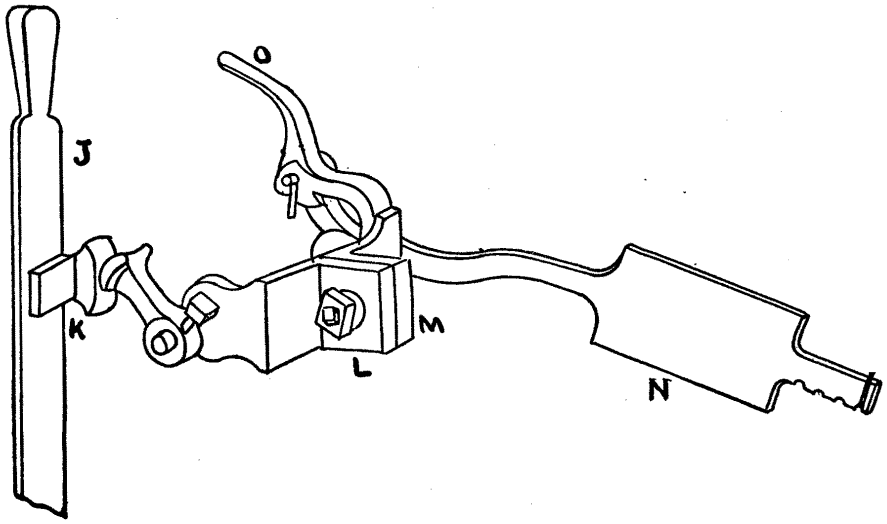


Fig. 217.

other on the inside. N is a lever connected by a string to the stopper hook C, and having upon its spindle the short lever arm P, so that whenever the stopper hook C is lifted the lever N is lifted and P depressed, at the same time pressing forward the belt fork handle J, and stopping the loom. It must then be obvious that the cards being cut for the proper order of succession prevent the contingency of a hole on the lower cylinder opposite the needle B, following one on the upper cylinder

opposite the needle E. Should either of the cylinders go wrong the loom must be stopped at once. Fig. 218 shews the order of succession which may be adopted, but it follows that any other arrangement as to numbers which will prevent the conjunction referred to will be equally effective.

The dots indicate where the holes would be cut in the two sets of cards (odd and even) respectively.

To overcome this difficulty, apart from stop-motions, what is known as the single cylinder machine has been introduced, a view of which is shewn at Fig. 219. In this case there are two sets of hooks, each acted upon by the same needle and the same cylinder, there are two

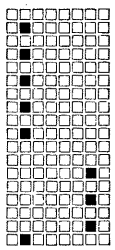


Fig. 218.

lifting griffes, just as in the previous case, each acting upon its own set of hooks; there is the same counterpoise principle, but instead of each hook being acted upon by its own card cylinder, both are being acted upon by one cylinder, therefore if the hook must be struck off the lifting griffes it must be done when one of them is carrying the whole weight of the harness attached to it, so that there must be considerable pressure of the needle upon the cards, as it is obliged to bend one of the hooks a distance corresponding with that which it presses the other hook back to strike it clear of the lifting griffe. That is one disadvantage, involving as it does great wear and tear upon the cards and upon the machine itself; accompanying

this is the disadvantage of there being two separate neck cords attached to each neck as shewn in Fig. 220, so that as one hook is being lifted and the other corresponding hook being left down there is always a slack neck cord. A considerable amount of wear and tear necessarily follows this. A good deal of this has been obviated by the arrangement of the lower part of the machine, where,

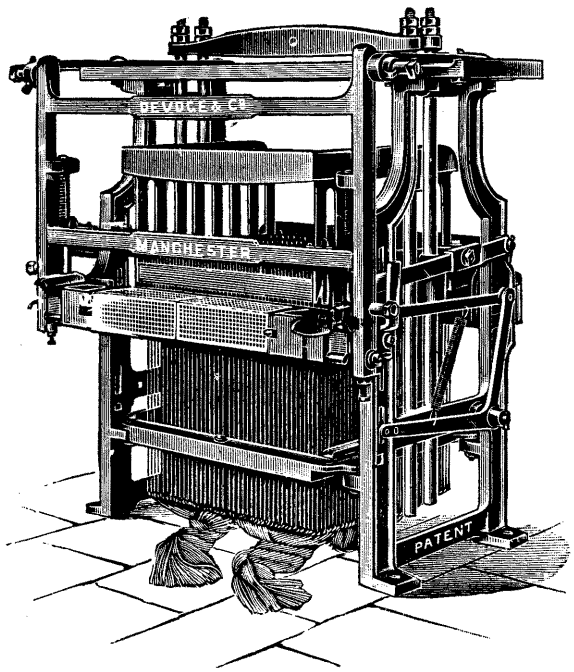


Fig. 219.

instead of the hooks resting upon the bottom board, as is the case in the ordinary single lift, they are bent over and hooked and made to rest upon cross bars, so that there is no friction upon the neck cord. Again this has been overcome recently by the introduction of a link, as shewn in Fig. 221, where the hooks are shewn both at

rest in one pair, and one raised in the other—as also is Fig. 220,—which couples the two hooks together, and in

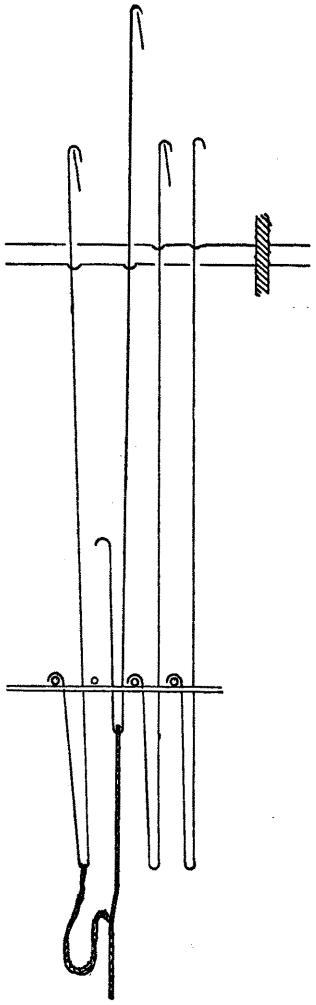


Fig. 220.

such a manner that when lifted by one hook it slides freely upon the other and one neck cord is then made

common to both hooks. The contrivance is simplicity itself as will be seen in the illustration.

As against the double cylinder machine we have the disadvantages pointed out of increased wear and tear, but

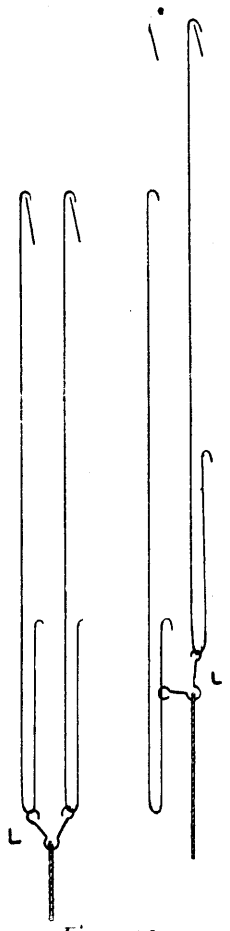


Fig. 221.

we have the advantages on the other hand of simplicity in the mechanism, one card cylinder only being required in the place of two, involving less trouble and watchfulness

on the part of the weaver, and also less wear and tear in the actual mechanical parts of the machine and less driving power. It is claimed for it also that it possesses the power of running at a higher rate of speed but this claim is open to some objection.

HORIZONTAL MOTIONS.

In the machines described so far the card cylinders are carried upon arms suspended from the top of the machine, but in many cases those arms, for various reasons, are somewhat inconvenient, when what is termed the

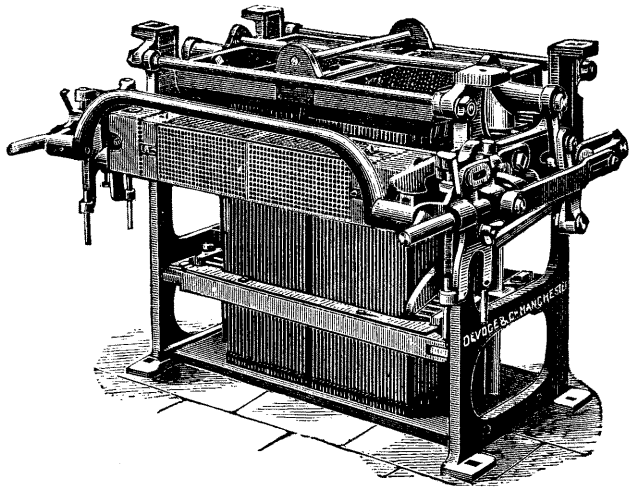


Fig. 222.

horizontal motion is resorted to. An ordinary single lift machine is illustrated at Fig. 222, which is virtually the same machine as the ordinary 400 single lift already described, but having the card cylinder carried upon horizontal bars. A similar motion is shewn at Fig. 223, and which would correspond with that at Fig. 215, the only difference in both cases being economy of space over the loom and consequently suitable for rooms, or sheds, where the roof is too low for the ordinary swing motion.

Now we must turn to another machine which is intended for what are commonly termed border patterns, *i. e.*, where two sets of cards may be dealt with separately, and each acting upon the same set of hooks. One form of machine, and which is really a compound machine, is shewn at Fig. 224, where there are two cylinders, and the two cylinders may be working alternately in the

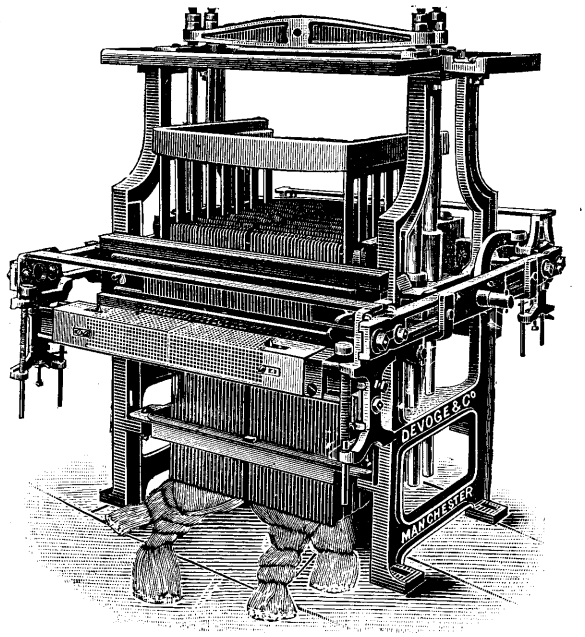


Fig. 223.

ordinary manner as in Fig. 215, or where the machine, which consists of what might be termed a double 400 machine, can be converted into an ordinary single lift 800 machine, but in that case the two cylinders must be working together instead of alternately as in Fig. 215; or again it may be converted into the cross border machine by allowing one cylinder to act with its own set of cards

for the cross border, and the other cylinder with its set of cards for the middle of the handkerchief, shawl or other article. By simply pulling a cord one cylinder is disengaged and the other brought into action at will. This of course it will be seen at once dispenses with the necessity of changing cards to form the borders.

There are several other contrivances of a similar kind, such for instance as Devonport and Crossley's, where two card

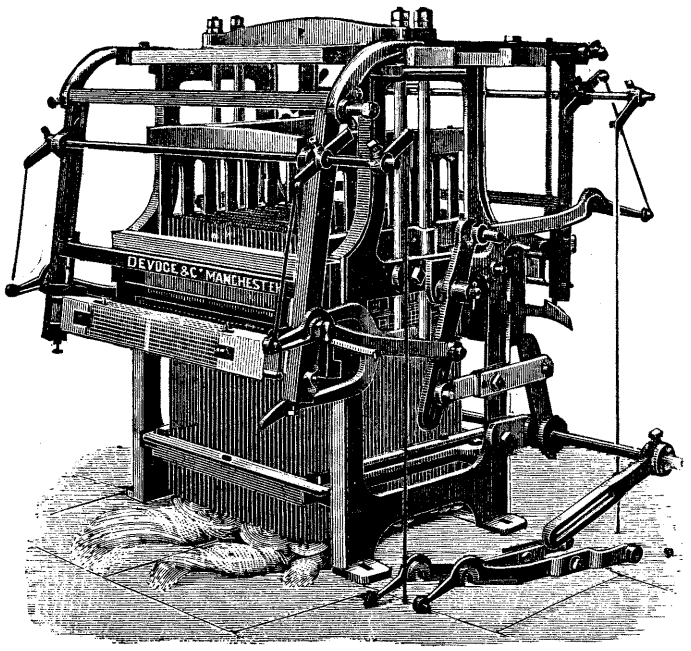


Fig. 224.

cylinders and two sets of needles are employed as shewn in Fig. 225, the lower set of needles are the ordinary needles of the machine, the upper set are supplementary, and intended to be brought into use by means of a supplementary set of cards. When the lower set of needles are in use the card cylinder operating the upper series remain stationary;

but the moment the cross border is come to, the lower cylinder is disengaged and the upper one brought into use in place of the lower one, and carrying the cross border

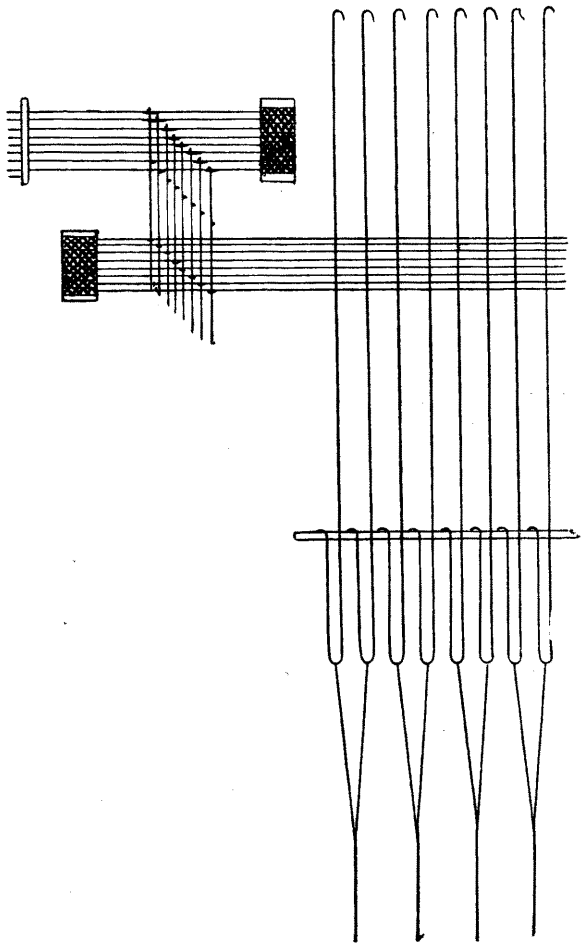


Fig. 225.

pattern. The action of the upper needles affects the lower ones by the series of vertical connecting levers as shewn in

the illustration. One of two methods may be brought into use, either the supplementary needles should be placed immediately above the other ones, or they may be placed on the opposite side of the machine, and so contrived to act and serve the same purpose, and then, of course, the two sets of cards will not interfere with each other.

Another form of arrangement for answering the same purpose is illustrated in Fig. 226, the invention of Messrs. Hahlo and Liebreich, where two patterns are cut upon the same set of cards. In this case what might be termed a double cylinder is employed, *i. e.*, if there are 8 rows of hooks in the machine, the cylinder will contain 16 rows, the border pattern is put upon 1, 3, 5, 7, and the ground pattern upon 2, 4, 6, 8 rows, then by a chain or link adjustment, the cylinder can be raised or lowered, so that in weaving the cross border the odd rows of the cylinder, with the necessary pattern, are brought opposite the points of the needles, and for the middle the even rows, with the pattern for that portion, are brought into operation simply by raising or lowering the cylinder as suggested. It may be a matter for consideration whether the labour involved, the weight of paper and the attendant trouble will be sufficiently compensated for in the saving of time of card changing.

The next style of machine calling for attention is what is termed the double shed or rising and falling jacquard, which really means a machine for working upon what has been described as the centre shed motion, or a perfect counterpoise. It will be readily understood that in very heavy goods, such as shawls, where the double cloth principle comes frequently into use; or in coatings which must be backed, or in carpets, where a very large shuttle must be used, or in fact in many very heavy goods the advantages of the counterpoise must be very great. In this arrangement the bottom board descends carrying with

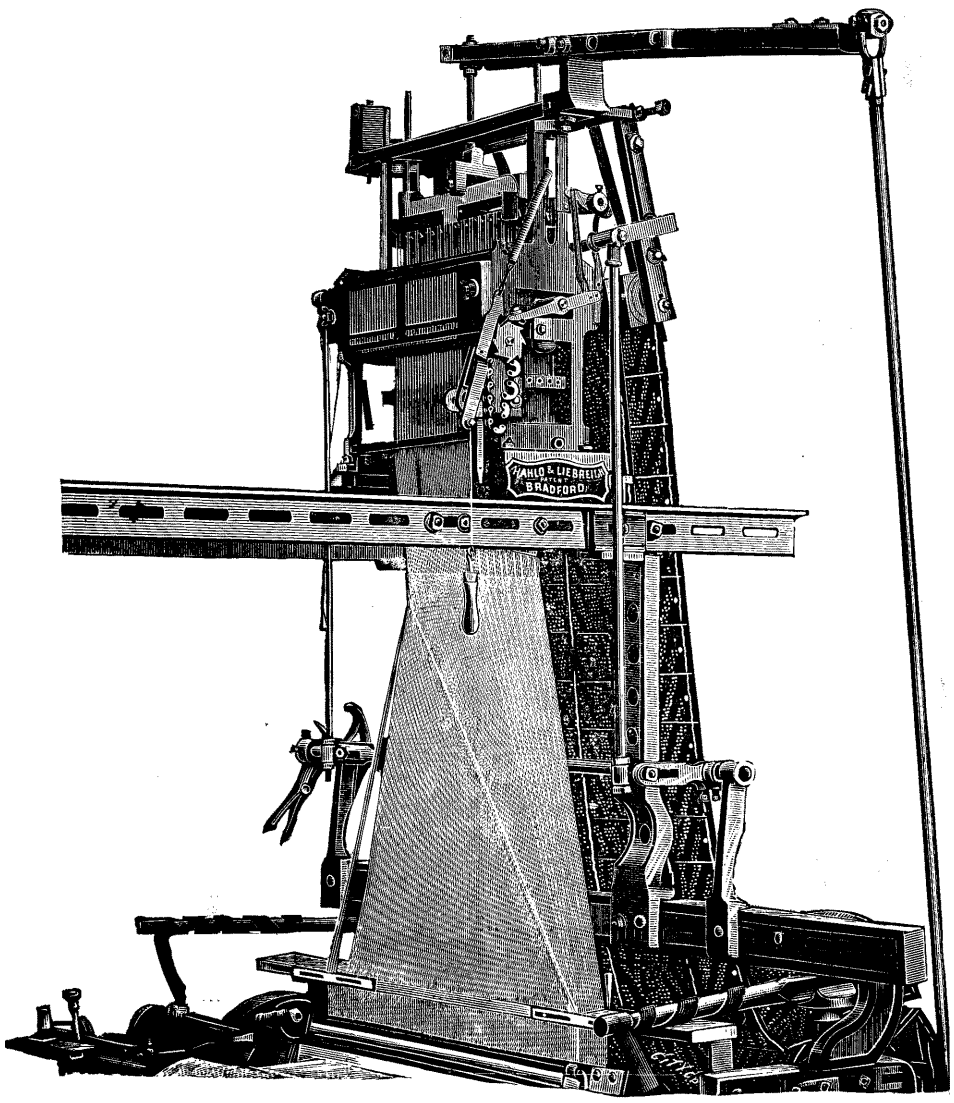


Fig. 226.

it the hooks that are not acted upon by the griffe, so that the shed is really formed always from the centre. As will be seen on reference to Fig. 227, there are four levers at the top, so arranged that they connect the griffe with the bottom board of the machine, and in such manner that as the griffe rises the bottom board descends. It is scarcely necessary to go very fully into the details of the mechanism because the whole arrangement is perfectly

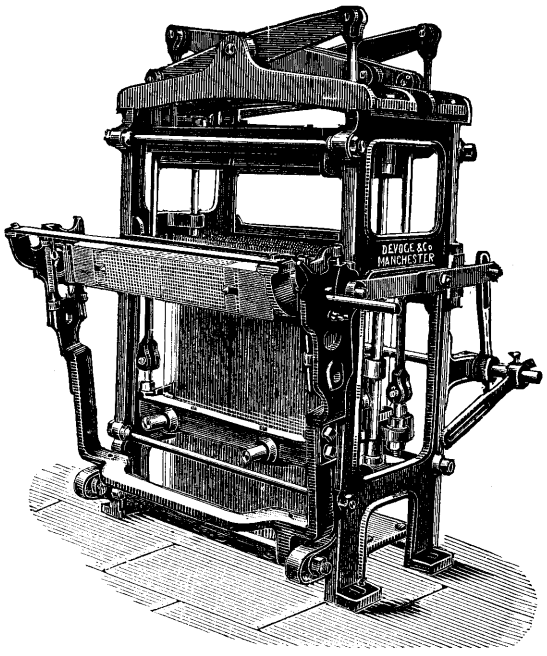


Fig. 227.

self-evident on the surface. From the very fact of the bottom board being connected to the griffe the centre shed is assured. The mechanism will however be even better understood by reference to Fig. 228, which shews a front elevation of the loom and jacquard stripped of all accessories. In this it will be seen that the lift is made, or more correctly, motion is communicated to the machine from

below, by means of a lever operated from the driving shaft of the loom. As I have already said everything is so self-evident from the drawings that it would be superfluous to enter into minute detail.

Numerous attempts have been made from time to time to accomplish this object, one of the earliest being that of Sowden's some thirty years ago or more, but the first really successful one for heavy work being that of Mr. Ainley's. One of the greatest difficulties of the case has been to make the mechanism sufficiently self-contained;

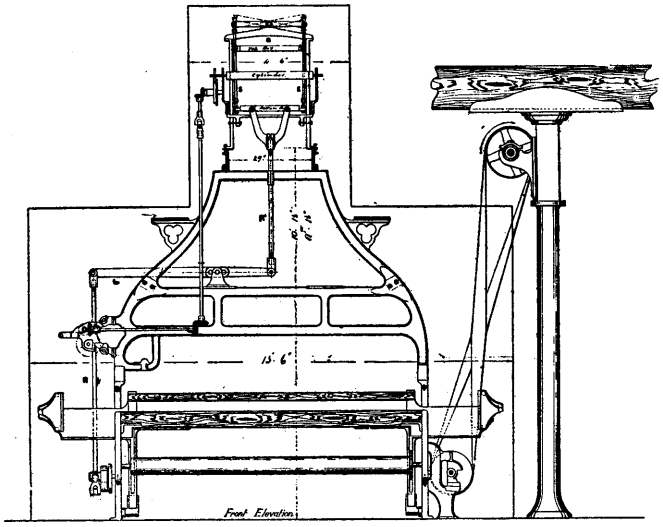


Fig. 228.

the levers being entirely outside the machine occupying a good deal of space and making the working somewhat cumbersome. But in the present instance, as will be seen, the whole of the mechanism is contained within small compass. The card cylinder arms instead of being suspended from above as in the case of the ordinary jacquard are worked from below; a lever at the back of the machine giving the necessary reciprocating motion as shewn. This

is probably one of the most compact and effective machines of this kind.

The illustration in question is that of the Hollingworth and Knowles' patent fast running loom, and one feature of the machine may be examined whilst the other details are under notice, namely, the communication of motion to the card cylinder. As will be seen the card cylinder is actuated by bevelled gearing placed to the left of the loom, so that the driving is positive and independent of the machine itself. Whatever advantages may be claimed for this particular mode of driving, or whatever disadvantages may accompany the use of gearing for this purpose, one thing at least must be abundantly clear, that in this, as in all other machines, the action of the card cylinder must, for easy and good working be independent of the machine itself. In a power-loom there are two reasons for this, one, and probably the one which led to the adoption of the system, is the necessity for turning the card cylinder over so as to find the proper card in a broken pattern, or when the weft has run out, without the necessity of turning the whole loom and the jacquard at the same time. The arrangement illustrated in this instance is one which offers the facilities requisite for this purpose, but a second and more important reason for having the card cylinders motion independent of the lifting griffe, so that the cards are not pressing upon the needles until the griffe has reached its lowest point, and the lifting hooks are free of the blades of the griffe, will be better understood by reference to Fig. 229. which shews the earliest form of machine in use for hand looms, where the card cylinder was thrown out by means of a curved bar attached to what is called a swing frame, and a pulley attached to the griffe and working inside this curved bar; from the shape of the curve, as the griffe is made to rise, the cylinder arms are thrown outwards and

as the griffe descends the cylinder is brought towards the point of the needles, but for the purpose of ensuring perfect working, and the proper indication of the pattern by the cards upon the needles, they were usually made to strike the needle points somewhat before the griffe had reached its lowest point. Of course there were opportunities

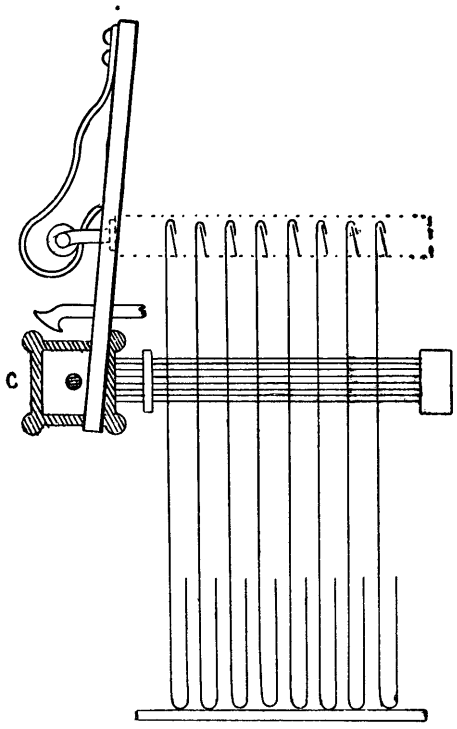


Fig. 229.

of adjustment which would enable the weaver to bring the cards in contact with the needle point exactly at the moment of releasing the hooks from the griffe, and also of keeping the card in contact with the needle until the return of the griffe had made sure of the necessary hooks being caught, and so preventing any risk of mistake in the

pattern. This would involve not only careful adjustment of the bent lever arm, but also a proper adjustment of the curve itself. This however is not an extremely difficult

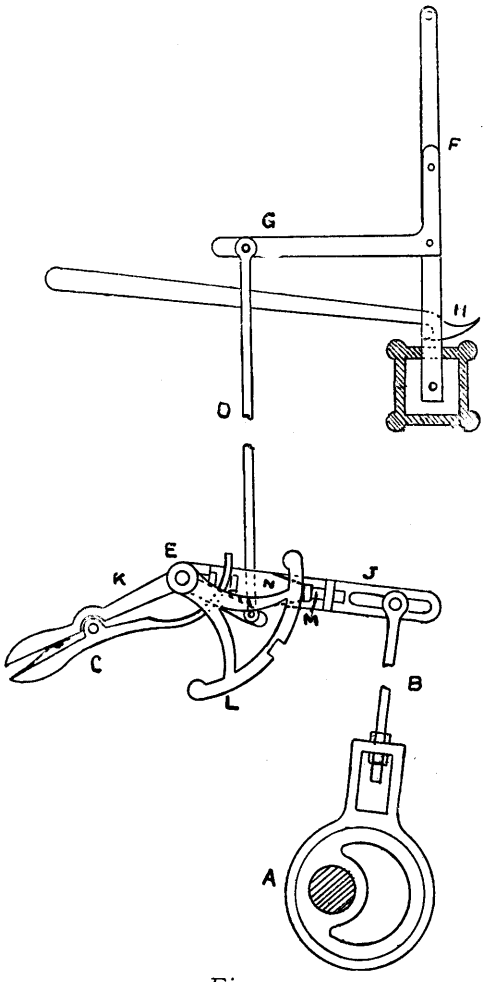


Fig. 230.

matter, but up to the introduction of a separate motion for actuating the card cylinder independently of the griffe

itself there was no means of moving the card cylinder without moving the whole body of the machine.

The card motion in almost universal use will be best understood by reference to Fig. 230. An eccentric A is placed upon the driving shaft of the loom and connected by a rod to the lever B. This in turn acts upon a lever J which is made fast to a horizontal shaft E, from which another lever L K communicates motion to the swing arm F of the machine through the arm G and rod D. The lever J has adjustable slots so that the throw of the cylinder arm, or batten, as it is sometimes called, may be regulated at will; but an intermediate arrangement comes in, which really is the valuable feature of this contrivance; for instance, the eccentric would communicate motion to the card cylinder every time the loom was turned over just as the crank would communicate motion to the griffe, so that although the two motions are in a sense independent of each other they would always be acting in unison. The object of the intermediary arrangement is to enable the card cylinder motion to be detached and operated independently of the other parts of the machine and by hand. On one arm of the lever L K is an arc of circle formed at its extremity. The lever J is loose upon the shaft E, but that portion carrying the arc of a circle is made fast; a notch is formed in this arc of a circle into which a catch M sliding upon the lever J may fall; the opposite arm of the lever K is formed in such a manner as to give name to the arrangement, viz.: the "duck bill," as seen at C. One side of this duck bill is a fixture on the lever, but the other is hinged to it with a curved arm at the opposite extremity, this curved arm being so contrived that on pressing the two portions of the duck bill together it pushes the catch M, by means of the slide N, out of the notch in the arc of a circle at the opposite extremity of the lever arm, thus liberating

the lever and permitting movement to be communicated to the swing arm of the card cylinder without any other portion of the loom being moved. In all probability the introduction of this arrangement has done more to popularize and render the jacquard machine a practical one as applied to power looms than any other.

BESSBROOK JACQUARD.

The Bessbrook machine is really a development of the twilling machine of Mr. Shield's, of Perth, both of which are described in my "Treatise on Weaving and Designing," and is in reality a machine for dispensing with the pressure healds already described. It has many good points to recommend it, but is only of service for weaving large damask figures, such as table cloths, &c., where great jacquard power is required, and cards can be saved by twilling arrangements in the machine.

OPEN SHED MACHINES.

A few words must be said at this point on what have been termed open shed jacquards, and although up to the present time nothing of a very positive character can be said of their success, yet of the principle and its advantages there can be no doubt. For instance, it has been pointed out in reference to centre shedding machines that the counterpoise principle is of considerable advantage, but if this can be carried out in its entirety, and produce a shedding which is practically equivalent to that obtained by tappets, an enormous advantage would arise in weaving many classes of fabrics; apart from the advantages of working with the open shed, which, of course, in some fabrics may be a doubtful quantity, there would always be the advantage of economy of power if one portion of the hooks carrying the harness threads, and the warp, could be held at the highest point as long as requisite for the formation of pattern, and another portion kept

at the lowest point. Then the two portions changing from the highest to the lowest, and in the opposite direction, would tend to balance each other and so economise power. Without attempting to go into the details of each one the general principles of one or two may be referred to briefly.

We may take first that of Cheetham and Sutcliffe's, which at one time promised to fulfil all the expectations held out, but the intricacy of the mechanism and the tendency to fail at the critical moment, did much to damage its reputation.

The chief object in the machine is to keep up the lifting hook, and consequently the harness, for any length of time required for the formation of pattern, as described in the open shed dobbies. The machine is on the double lift principle, with a double hook acted upon by the same needle; that is, one piece of wire is bent round to form two hooks and receive one neck cord at the bottom, and there are two loops in the needle, and there are two lifting griffes. A series of pushing off bars are employed above the knives of the griffe, and a resting hook is formed upon the back wire of the double hook below the needles, and a resting bar placed so that this lower hook may rest upon it when required. When the hooks have been lifted and deposited upon the stationary griffe they will remain until struck off by a card, and the vibrating levers above will prevent the ascending griffe from carrying them up again until required for the pattern.

Another machine has been since introduced by Mr. Wm. Hardaker, of Great Horton, on the "dwell-up" principle, the resting griffe and double hook being employed. The hook is of a special form and held in position by the bottom board, which forms a kind of grate.

So far as can be seen this machine seems to do its work satisfactorily, and certainly it has the merit of simplicity.

An attempt has also been made upon a different principle by Wilkinson. He depended upon the use of a species of pulley block between the hook of the machine and the neck cord, *i.e.*, he took a couple of pulleys, made one end of a cord fast to one of the hooks of a double lift machine, passed it round the upper of the two pulleys, made the other end fast to the second hook, the centre of the lower pulley he made fast to the centre of the upper one. He then passed the neck cord over the lower pulley and made the other end fast to a bar, practically on the same principle as the healds are actuated as described in the pressure harness, so that when both hooks were raised the harness would be lifted, and the hooks meeting in centre of their movement they may be transferred from one griffe to the other. In other works the principle is the same as that underlying the Hattersley dobby.

Efforts in the same direction have been made by numbers of people, and, as already said, for some purposes a machine of this character is much needed, but whoever succeeds in meeting the demand, he must do it with the simplest possible mechanism. There is sufficient machinery in the ordinary Jacquard, and anything which tends to complicate it will meet with strenuous opposition both from weavers and overlookers. Once, however, the end is attained, a liberal recompense will follow to the successful inventor.

LECTURE 10.

JACQUARD, CARD-CUTTING AND PATTERN ARRANGEMENT.

Having dealt with the bulk of the systems of jacquards and harness tying-up, it is necessary for completing this portion of the work to go through the methods of arranging patterns on paper to suit all the different systems of jacquards and harnesses, the cutting of the cards and all the necessary work in connection with it. One thing however, I must make clearly understood, I have no intention of entering into all the details of pattern making, or of the system of applying twilling to jacquard figures, except in so far as it may involve a knowledge of the use of compound harnesses. The principles of designing and pattern arrangement, so far as a knowledge of the application of design to the structure of cloth is concerned, is a matter altogether outside the province of the present work. First I will take the arrangement of patterns on paper for the ordinary single jacquard. This being the simplest form of machine in use, if the subject is dealt with thoroughly, it will make it very easy to understand the preparation of designs for the more complicated harnesses. It will be remembered that in dealing with the construction of the harness for a regular tie-up as illustrated in Fig. 167, page 320, two things were pointed out, first, that the space occupied by one division of the harness, or that which represents one complete set of hooks in the machine, will be dependent upon the number of threads per inch; suppose, for instance, the machine contains 400 hooks, and the fabric contains 80 threads per inch, one complete pattern then will occupy a space of 5 inches, and this would be repeated as often as requisite for the

width of the fabric. Then practically our pattern must be complete within the 5 inches, and it is repeated six times across the width of the piece, supposing that the fabric be 30 inches wide. Now take the Fig. 167, page 320, for example. There we have a small figure which we may suppose to represent either the whole division of 5 inches and repeated a given number of times across, or it may represent a fraction of the 5 inches; a complete pattern is shewn repeated, and this pattern, of course, will be continuously repeated both across the piece and lengthwise. Then we should have to arrange the pattern upon our design paper, supposing the whole of the machine to be used, so that it will occupy exactly 400 squares across, but the number lengthwise will depend upon the length of the pattern. It is not necessary that the pattern should occupy an exactly square space. The number of picks occupied in most figured designs need not necessarily bear any relation to the number of ends occupied. It is only where patterns such as diagonal or similar figures are taken into account, the angle at which they run across the fabric, or where there is some direct relation between the ends and pick in the pattern, that any attention need be paid to the relations, or to the number of picks employed. Suppose then that the pattern does not occupy the whole 400 hooks, then it must be made to occupy a number which is an exact measure of 400, or some of the hooks in the machine must remain idle; this will involve a reduction in the fineness of the cloth.

Perhaps it will be as well at this point to deal with the whole question of casting out, as, whatever applies to a plain harness will equally apply to all other harnesses. Now we will take it for granted that our jacquard contains 400 hooks, and suppose our pattern must occupy only 48 hooks, this is, of course, supposing a small pattern, but one commonly occurring; then if we divide 400 by 48

we shall find that we have 16 hooks which cannot be employed, and therefore only 384 in actual use; those 16 hooks must have no warp drawn through their mails, hence we should have 384 mails forming the pattern, which must of necessity occupy precisely the same space as the 400 did, so that we should have to reduce the number of threads per inch in the same ratio; then the calculation would stand as 400 : 384 : : 80 = $76\frac{4}{5}$, or a reduction of three ends and one-fifth per inch. This of course is very trifling in itself, and in regular practice would probably be ignored entirely, as the number of harness cords cast out in the whole width, of say 30 inches would only be equal to 80 threads, or exactly one inch in the width of the harness greater than that in the sley. This would scarcely have any detrimental effect in the working; but suppose the difference should rise to 2 or 3 inches, as is often the case, then it must be taken into account and the set in the reed reduced proportionately. Then this casting out, as it is termed, must of necessity occur where the pattern will not agree with the machine in the number of threads, but it is often resorted to for the purpose of reducing the set of the harness so as to weave cloths in a set lower than that for which the harness is tied up. Suppose the harness be tied up to weave 80 threads per inch, and it is desired to weave only 70, then the difference must be cast out, which in such a case would mean 50 hooks of a machine standing idle, or $\frac{5}{8}$ of an inch in each division. Such a number as that must be taken into consideration, as the difference between the width of the harness and the sley would, even in a narrow cloth, be so great as to preclude the possibility of good work. Then to put it as a general formula we should say as the number of harness threads per inch in the harness, is to the number required in the reduced set, so is the total number of hooks in the

machine to the number that must be employed. Or as 80 is to 70 so is 400 to 350.

The difficulty attending this is in a great measure overcome by the expanding harness which has already been described. This contrivance enables us to get over all the difficulties, change of set can be made within certain prescribed limits, and which are usually sufficient for all practical purposes, and although provision is not made, ostensibly, to meet the casting out of hooks to suit the pattern, yet it must be obvious that it can be made to serve both purposes in a sufficient degree. Then to turn to the pattern shewn at Fig. 168, page 321, here we have what is termed a repeated design and with the slightest knowledge of the arrangement of patterns for small effects a designer will readily understand that there is no necessity for putting down repetitions upon his design paper. For instance, we have the pattern A repeating itself, and we have the pattern B repeating itself, but seeing that each repetition is worked from the same hooks one section of the pattern on the design paper is sufficient to represent the whole of the repetitions, so that we should simply take the sections A, B, C, put them down upon the design paper in a position corresponding to the hooks which actuate them and the whole work is complete. Precisely the same rule will apply, although the method of working appears different, in the case of the centre harness and pattern in Figs. 170 and 171, but in this we have not only one half the pattern saved, so far as the warp threads are concerned, but we have also the power of saving one half the picks, if the pattern should be worked out to form a square or parallellogram. Suppose we divide the design Fig. 170 down the centre and take the left-hand portion as representing the pattern which must be placed upon the design paper, and the right-hand half could be repeated by the harness, then if the pattern be

designed for a table cover, or any fabric in which the two ends, as well as the two sides, should be alike, we should simply make a design for one quarter of the whole fabric, and having woven the cards over from the border, or from one end, to the centre we should reverse the order and weave them back again, so making the complete pattern, and effecting not only economy in the harness, but in the cards as well. Now take the centre repeated pattern as suggested, and all that has been said of the repeated design at Fig. 168, and of the centre design Fig. 170, will hold good here, excepting so far as the saving of cards is concerned, and even in some cases that might follow, but in stripes it is very seldom that the system of repetition in the weft is resorted to, as the majority of patterns would preclude this being done from the nature of the figure. With regard to the border harness the explanation would be comparatively simple, we have one set of hooks detached and tied up specially for the border and another set for the middle. Now suppose the side and the cross borders to be the same pattern; in weaving the cross border the cards would be cut for both portions of the machine alike; but in the side borders they would be different, so that two sets of cards would always be involved, and then it would simply be a question of whether these cards should be changed by hand, when required, or whether the cross border machines already described should be resorted to. In the sectional cross border harnesses, everything turns, practically, upon what has been said of the common harness, and those tied up for repeated patterns; a set of hooks is set apart for each division or section, and when weaving the cross border the several sections go to make up one complete division and the pattern forming a complete division must have its several portions repeated on its sectional hooks, but the moment the cross border is completed, then each

section of hooks takes up its own duty in the formation of side border, so that in the cross borders they form really units of the whole, but in the side border each is practically independent of the other.

In making designs for the harness pattern represented in Figs. 175 and 176, we should have to treat the border pattern in precisely the same manner as the pattern Fig. 170, that is, the harness being a centre tie only one half the figure would have to occur on the design paper, and the middle being tied up in straight order would be treated in precisely the same manner as in Fig. 167 and 170, so that the harness may be compound tie, centre and common repeat patterns, and the design would be a compound one in the same sense. In all other respects the treatment would be precisely as for the common border represented in Fig. 174 Then coming to the triple border as represented in Fig. 180, the arrangement would be simply an extension of the treatment in Fig. 174, that is, in working the cross border all three sections of the harness would partake in the formation of the same figure so as to make it continuous; in the second or middle cross border the outer section would be detached and begin to form the side border; then in the third cross border both the outer ones would be detached, and when we reach the middle of the fabric each of the border sections would be forming its pattern independently of the others. Then the next arrangement is that represented in Fig. 182, where the outside border and the inside border are both straight ties, but the middle border is a centre tie, as well as the middle of the fabric itself; then for the first cross border in this case the pattern would have to be so arranged that the presence of the centre tie is not made visible, *i.e.*, the borders must be of such a character that although there are two centre ties the pattern appears to be a continuous running one. For

instance, refer to Fig. 181, and it will be seen that is the case, that although the middle of the three borders is a centre tie there is nothing in the cross border to suggest it, or should there be anything of that kind; the pattern must be so contrived as to make the cross and side borders join in such a manner as to produce the effect which will hide the suggestion of a repeat from the centre. In some cases this is difficult to accomplish without making the pattern appear too much in squares and too stiff in form. In other respects, of course, it will be understood the working is a combination of Figs. 176 and 178.

Now we must look to the sectional harnesses where one portion is intended, we will suppose, to weave the ground pattern and the second portion to weave the figure which may be formed by extra material. Then if we refer to Fig. 183, where the two patterns, ground and figure, as they are termed, respectively, are shewn differently, we see at once which portion must be worked by each section of the harness. It will perhaps make the value of this principle of harness tying more clear if it be compared with the ordinary harness as shewn at Fig. 167. If a pattern such as this had to be woven on a harness such as Fig. 167 each alternate hook of the machine would take the ground and figuring threads respectively, then the figure would either have to be distorted, supposing the ground picks to be equal to the ground threads in number, to double the width, because of the figuring threads intervening; or paper having twice as many squares in one direction as the other would have to be employed; not only that, but supposing the pattern to be painted upon the paper in two colours the card-cutter would always have to bear in mind that one colour represented the ground threads and the other the figuring threads, so that he would have to cut odd numbers for one and even numbers for the other.

In the event of any elaborate variety of twilling being necessary, as is often the case, in the production of such patterns, the operation is rendered very difficult, and in most cases will involve carrying out the twills by the designer over the entire surface of the paper, which of course involves an enormous amount of time, and even then the card-cutter's work will be difficult; but with the sectional harness one pattern would simply be put upon the hooks assigned to it and the other upon the opposite set, so that in reality the two sections of the machine are treated as though they were two separate machines, and the card-cutter would practically treat them as though they were designs for two separate fabrics. The same conditions apply exactly to Fig. 186, where there are three sections; each section carries its own pattern or figuring material, and the design for each is made separately and to all intents and purposes, so far as the card-cutter is concerned, independent of each other. Of course it will be understood that the designers business is to so arrange the patterns upon the paper, that when they come into the cloth they fall into the proper relations with each other, as it would be absurd were the figures to begin to overlap or fall into any accidental position. And it follows equally that the designer would be compelled to consider the nature of the twilling given to each section for the production of special effects, and more especially when working any two or more of the sections together for the purpose of producing, either variety of colour or light and shade. Of course the same rules will hold good with regard to the Figs. 188 and 189, where the two sections are not of the same size. It simply means in that case that the pattern upon the smaller section of the ground may be much less than that on the larger section. But one thing must always be perfectly clear, viz.:—that the two patterns must be complete at the same time. Little need be said now of

the stripe section shewn in Fig. 189 or of those in Figs. 190 and 191, because the principle of application of patterns to sections, whether of the character described in reference to Fig. 183 or the more elaborate ones remain the same and it must only be a matter of application. In Fig. 191 perhaps there might appear to be some difference as compared with the others, but in reality we are taking the healds placed in front of the harness as representing one section of the harness, as represented in Fig. 183.

The compound harness with which we have next to deal differs from the others inasmuch as the jacquard machine itself takes no part in the formation of the ground pattern, but only in the production of figure by causing the two fabrics, of which the whole is composed, either to combine together or exchange places as shewn in section at Fig. 196. The cumber-boards are arranged in such a manner as to form the ground pattern, each pair of boards for its own fabric; then as the several picks of the face weft are inserted the harness lifts in such a manner as to cause the two cloths to exchange places and intersect each other as required by the pattern, so that really the general principle upon which the patterns are laid upon the design paper is simply laying on a wash of colour to represent the form of the figure, and then the cards are cut so as to lift the fabrics separate from each other.

In the use of the split harness practically the same thing may be said. The machine forms the figure and the shafts which lift the harness cords form the ground pattern, therefore the method of laying the design on paper is simply that of laying a wash, or washes, of colour to represent the pattern, and operating the shafts to form the ground. With reference to the pressure harness, the principle of twilling with the healds has already been

fully explained in reference to Fig. 191, consequently again here there is little to say as to the arrangement of pattern, if the whole fabric consists simply of a warp and weft satin, or warp and weft twill, then the design is simply laid on with a wash of colour; the cards are cut as though it were a solid figure, and all the twilling is done by the pressure healds, and it is only where special twilling would be introduced in combination with the ground twill that any variation need be made in the pattern upon paper; but when there is any variation it must be laid on very carefully, and in such a manner as not to interfere with the working of the ground healds, and the card cutter must carry out his instructions in their entirety.

Only few words now need be said with reference to the gauze harness. The arrangement of the design differs in this machine from all others; here we have a certain section of the machine set apart for actuating the doup; we have a certain section set apart for actuating the slackening portion; each of these is supplementary and cannot be treated as the sections in the previous harness. For instance, one thread passes through the slackening harness, then through one of the common harnesses, and then through the doup; the arrangement of the pattern upon paper must, so far as the extent of the hooks in the machine is concerned, apply to those only which form the actual plain harness; again the hooks forming the doup and slackening portions have their needles placed in rows as in the plain harness. Consequently, although the design paper may represent only eight rows of hooks there may be in reality twelve rows in the machine; usually, however, the same needles which actuate the doup actuate the slackening harness, simply by having two loops or eyes, so that that would make ten rows of needles for the ten rows of hooks, and twelve rows of holes in the cards. The pattern would be painted on in the usual manner,

and where no gauze is being formed the harness would be treated in every respect as an ordinary plain harness, but the moment gauze is formed, then the gauze hooks must have holes cut for them, and consequently some representation must appear upon the design paper to indicate the order of cutting. This will be best understood by reference to Fig. 231, which shews a design of a portion of a small figure. The figure itself is laid on in the usual manner as for plain harness, and the gauze portion is represented by working in a different colour upon the first, or first and second threads of each row

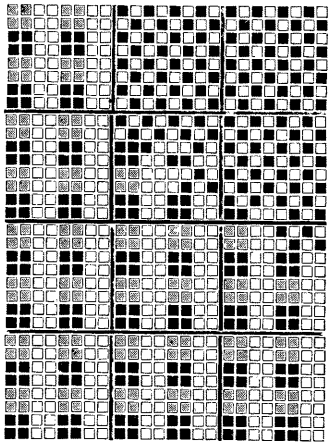


Fig. 231.

thus indicating that the extra hooks which operate the doups must have holes cut for them in the place of the ordinary hooks of the figuring harness. A comparison of this design with the harness Fig. 212 or 213 will make this quite intelligible.

CARD CUTTING.

It will be necessary now to explain the exact process of card cutting. Suppose we take the card cylinder as represented on the machine at Fig. 154, and place it before us on the table with the cylinder head to the left

we have then on the outsides, or towards the extreme ends, to make provision for the lacing or linking together of the cards, for that purpose two holes are usually cut as shewn in the laced cards at Fig. 232. Then a larger hole is cut for the peg upon the cylinder to pass through, and hold the card in position. Then come four hooks, two on each side of the peg hole, for working selvedges or any extra apparatus which may be attached; then the first hole nearest to us represents the first hook of the machine, and going across the first row of eight hooks on the cylinder they would follow each other in order of

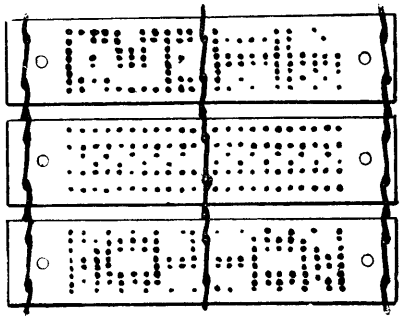


Fig. 232.

succession from 1 to 8, the second row would follow from 9 to 16, exactly as indicated on the cumber-board at Fig. 156, page 309, then referring to the small piece of design paper Fig. 233, we may compare it with the cylinder. The first row of little squares across the paper represents one pick of weft, and each card represents also one pick of weft, so that if we place a dot upon the design paper to indicate that the warp thread must be lifted to permit of the weft thread being passed under we must cut a hole in the card exactly corresponding to that thread. Suppose we are cutting cards, for instance, for a plain cloth and we wish to lift, for the first pick, the 1st, 3rd,

5th, 7th, and so on throughout, we should make a plan upon our design paper corresponding to that, and we should commence cutting the cards from the left by making holes in each row exactly corresponding to the dots upon the design paper. Then for the next card we should cut the 2nd, 4th, 6th, and 8th holes in each row, and by bringing such cards upon the cylinder, and pressing them upon the needles alternately, we should weave a perfectly plain cloth, and so with any other pattern. If we are cutting cards with the ordinary plate machine, and inserting the punches in the plate with our

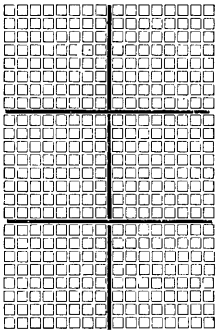


Fig. 233.

fingers, we should place the plate in front of us, in precisely the same manner as we have placed the card cylinder, and so by inserting punches in each of the holes corresponding with the dots upon our paper, taking each square of paper in succession, and the row of holes in the plate corresponding to the squares, until we have read all across the design; then the plate would be placed upon the carriage of the stamping machine, the punches pressed through the card and the operation repeated, card by card, until the whole design is gone over.

It will be necessary now to describe the various types of card stamping machines in use. I have spoken

of reading direct from the design to the stamping plate; this plate then is usually placed upon the carriage of what is known as a railway press as illustrated in Fig. 234. The press is pushed forward and the roller revolved, and as the press passes under the roller the punches are pressed down and perforate the card which has already been placed between the plates in the carriage. There

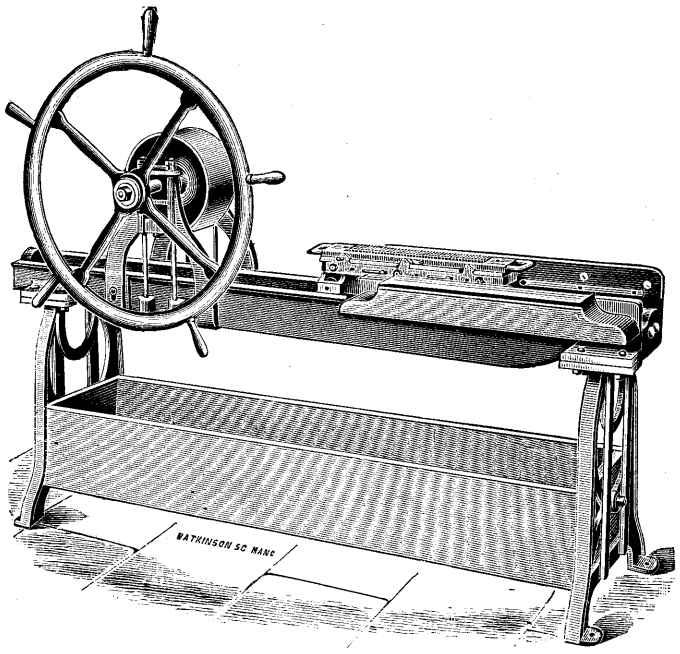


Fig. 234.

are two forms of machine, broadly speaking, of the railway press type used; one where the roller is covered with buffalo hide, so that the pressure upon the rollers may not be too hard, and the other where the roller is a smooth iron surface and a sheet of buffalo hide is placed upon hinges over the plate on the carriage, something like the lid of a box, so that it can be lifted free

of the plate and laid down upon it at will. Again there is a difference in the construction of the carriage. In some machines the loose plate must be lifted off and the upper of the box plates raised for the purpose of changing the cards; in others the two box plates are fixtures with a contrivance for sliding the card in between them, so that

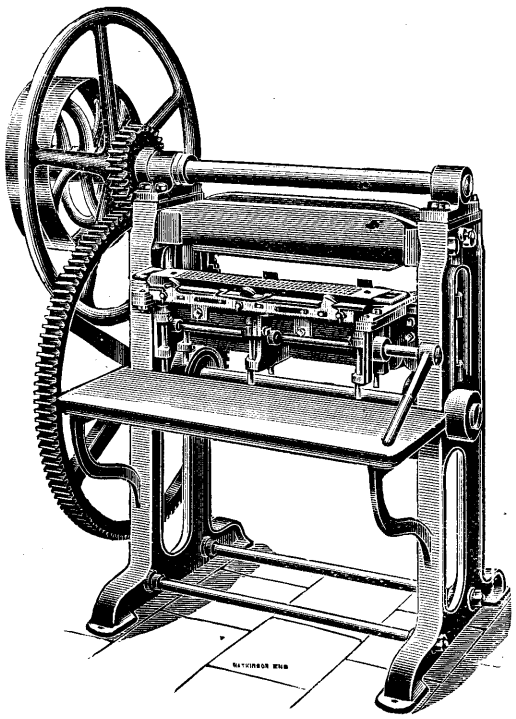


Fig. 235.

the change can be made without the removal of the punch plate. For rapid work, where a number of cards have to be cut from the same plate, as for instance in the old system of repeating, the latter machine has considerable advantages, as far less time is consumed in changing the card and less exertion required on the part

of the operator. These machines are usually made to be driven by power or by hand at will. Another form of machine is illustrated in Fig. 235, but instead of working on rails as the previous one, the press moves vertically. The punch plate is placed upon box plates in precisely the same manner as in the previous case, but instead of the box plate moving upon a carriage, and passing under a roller, it is moved into the press by a slight movement horizontally, and then vertically, thus causing the punches to pierce the cards in the same manner as in the railway press. It is not necessary to enter into the details of either of these two machines beyond general description. For instance, in the railway press the moment the carriage has passed under the roller it strikes a lever, which, moving the axis of a species of roller, upon which the rails along which the carriage slides rest, causes it to move about one-eighth of a revolution. A flat has been filed or formed upon the surface of the discs, so that the carriage is allowed to drop somewhat and is relieved from the pressure of the roller, so that it can be withdrawn without the movement of the roller being arrested. Then as the carriage is drawn back by hand it strikes a corresponding lever, bringing the eccentrics, or discs back to their normal position. At the same time a lever underneath the carriage itself and connected with a series of vertical pins passing through the box plates is made to slide under a bar at the back of the machine, causing the pins to rise, at the same moment pushing up the punch plate and releasing the punches from the card they have just perforated. So that the plate may be easily removed or the card may be removed and replaced by a fresh one. Where a number of sets of cards have to be cut this system is very convenient, but in many cases must be worked in conjunction with the repeater, which will have to be described presently.

Before dealing with the repeating of cards, a glance may be permitted of other kinds of machines for reading in as it is termed. One of the most generally used machines is that one known as the piano, and which is represented in Fig. 236. In this machine, as will be seen by the illustration, the design is placed upon a reading

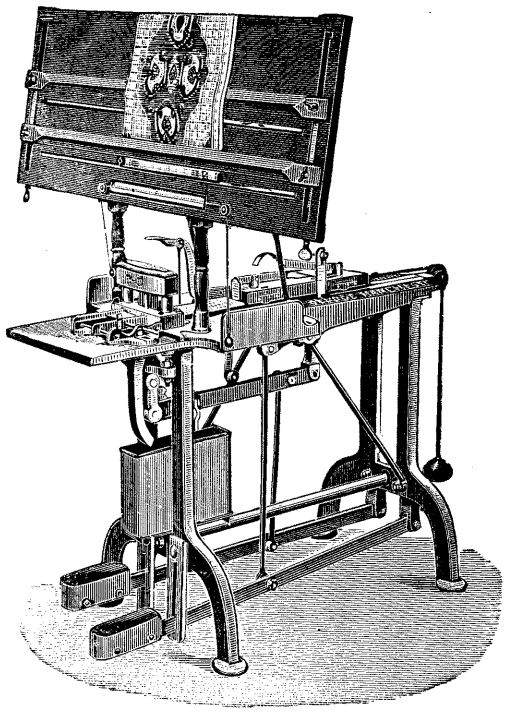


Fig. 236

board over the machine, the operator sits upon a stool in front of the reading board, the card is inserted in a species of slide in the front of the machine, and under a series of vertical punches, under the keyboard as it might be termed. A carriage is placed upon a slide behind those punches with a gripping jaw in front which

takes hold of the fore end of the card. This carriage has a cord attached to it passing over a pulley at the back of the machine and to which a weight is attached. On the left is a rack, and immediately to one side of the slide on which the carriage moves is placed a sort of rack head, or catch, having a movable portion; beneath this a treadle is placed and so connected with the rack head as to lift it on the treadle being depressed. Every time the rack head is raised the fixed catch is freed from the rack upon the carriage and the movable catch,

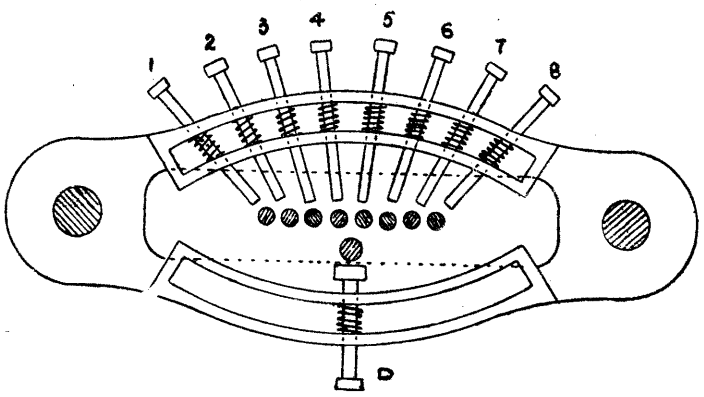


Fig. 237.

which is always one tooth in advance of it, takes its place and allows the carriage to recede a distance equal to one tooth. A second treadle is employed which brings down the keyboard—this keyboard, which is shewn in section at Fig. 237—has in front of it, usually, one key for acting upon the large punch for cutting the peg hole, frequently also two keys for acting upon the punches cutting the the lace holes, and on the back of it are eight keys corresponding to eight punches for cutting the ordinary figuring holes in the card. For 600 machine four extra

punches would be on the front to make up a row of twelve. In reading from the design the operator presses the keys corresponding to the dots on his paper, and which really represent the punches which he would insert in the plate already described; as the keys are pressed when they come over the heads of the vertical punches, and on the right foot of the operator being depressed, the punches are forced through the card. The moment that is done the left foot is depressed and the two being connected by the levers, seen under the machine, the right treadle is raised, the carriage allowed to move one notch, carrying with it the cards and bringing it into position for the next row of holes to be cut. This is repeated continuously from end to end of the card, so that a rapid operator, and who can read quickly from the design, can on this machine cut a card in an incredibly short space of time.

I must briefly describe another machine illustrated in Figs. 238 and 239—one showing the front elevation and the other a cross section of the machine—although it has virtually gone out of existence, but it is one which did, in its day, good service; my object here being not so much to give a sort of historic sketch as to shew the application of old principles to new machines. This machine was purely and simply a reading-in machine. A series of cords *a* are carried round the machine, and on the one side being leased through a pair of rods *f f*, and those answering to each row of hooks being passed over separate rollers *b* at the head of the machine. The whole mass previous to passing through these rods *f* which are seen in front, and under the design, were divided in 8's or 12's, according to the size of the machine, by a comb *g*, and then the whole mass passed under a roller, or rather a pair of rollers, b^1 and b^2 at the foot of the machine. Then up through a set of needles *i*, corresponding with

the needles of a jacquard machine, over another roller at the head, down through rings attached to lingoes *d*, which pass through the cumber-board *c*, exactly the same as the

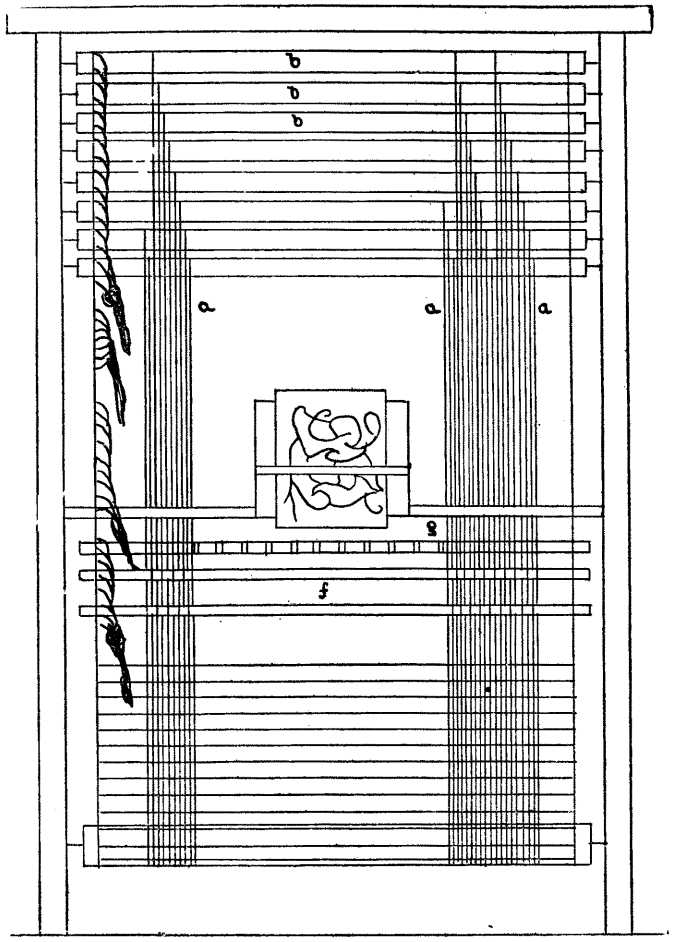


Fig. 238.

harness of the jacquard, and forward to the dividing rollers already described. So that each lingoe in the cumber-board had a species of harness cord attached to

it which consisted of an endless band passing round the machine. The card reader would then insert cords which correspond really with the picks of weft in the fabric, or in other words he would weave into those endless bands

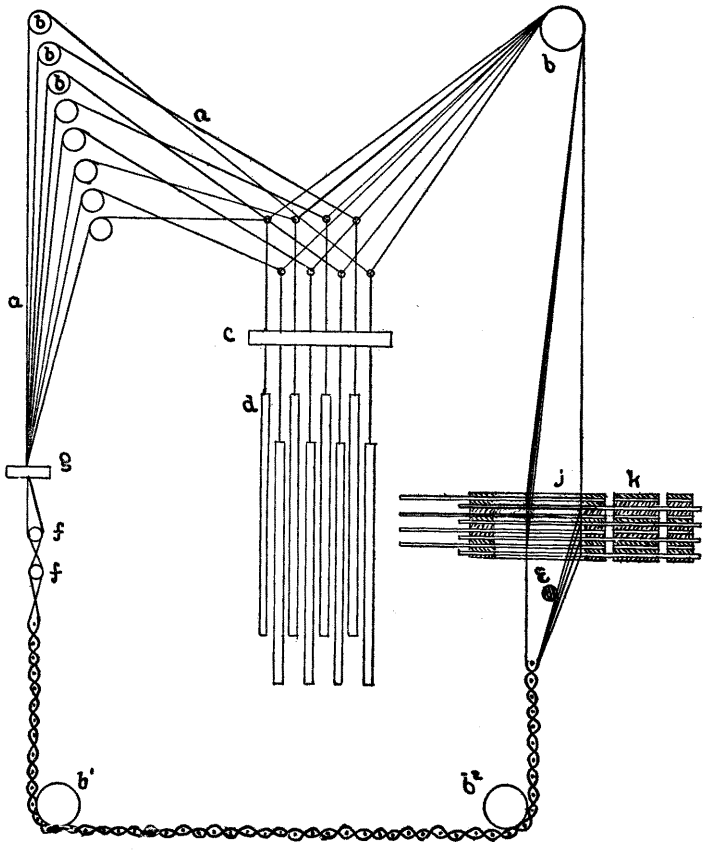


Fig. 239.

as warp threads a series of weft threads, producing precisely the same pattern as was intended to be produced in the cloth, as seen in both the section and elevation.

Those who have any recollection of the old draw loom or who have read the description of it in my "Treatise on Weaving and Designing," will recognise at once that the endless cords correspond with the tail cords of the draw loom, and that what I have here described as the picks of weft correspond with the draw cords. As a matter of fact this machine is based upon the draw loom; the pattern having been read in the cords are drawn round to the opposite side and immediately under the needles *i*. In front of this series of needles, each of which are passed through a needle board exactly corresponding to the needle board of a jacquard machine, is placed a punch plate *k*, containing a punch corresponding with every needle in the machine. In front of that a second punch plate may be placed for the purpose of receiving such punches as are drawn from what might be termed the magazine plate. Then a roller *e* is inserted in the place of the first cord which has been woven in to form the pattern and placed upon the arms of the sliding carriage which may be operated by a lever. The carriage is drawn forward causing the cords to exert pressure and move the needles in the direction of the punches, thus forcing out of the magazine plate punches corresponding to the needles acted upon, and pressing them into the punch plate which has been placed in front of it. This punch plate was then removed to the carriage of the railway machine, passed under the roller and the card is punched. I need not dwell upon the advantages of this machine for rapidity of execution in several classes of work, as it has, practically, become obsolete and many of the special qualifications it possessed have been replaced by the method of harness tying, which I have already described, more especially for the production of double cloth figured goods; but we shall see presently when the machine for self-acting repeating is described the principle still has some existence.

CARD REPEATERS.

I may turn attention now to what are termed repeating machines. One of the simplest forms is illustrated in Fig. 240, here a set of cards is seen passed over a cylinder corresponding in form with the cylinder of the machine. It is then brought down between the magazine plate containing

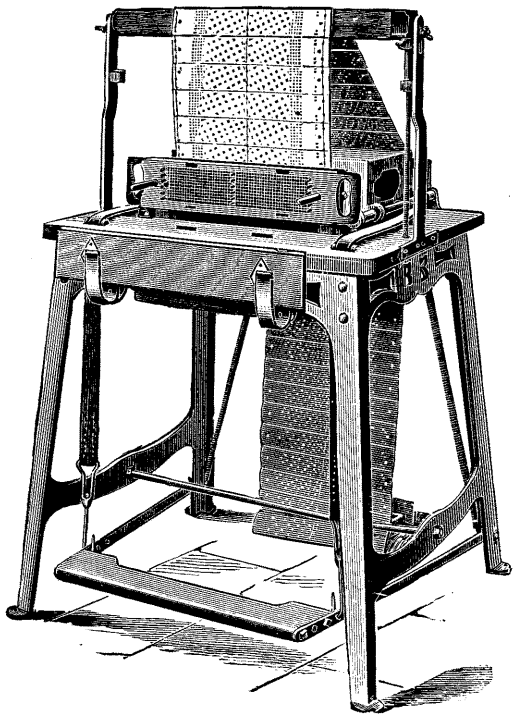


Fig. 240.

the punches, and similar to that described in the reading-in machines, and a series of needles carried in a box and corresponding to the needles of the jacquard. Each of those needles has upon it a helical spring, some eight or ten inches in length, in reality the needle box is a species of carriage; in front of the magazine plate is placed the

stamping plate as seen in the illustration; a treadle connected by straps causes the needle box to move forward upon the slides. Wherever there is a hole in the card, the needles pass through it, force the punches out of the magazine plate into the stamping plate; the stamping plate is then taken and placed upon the railway press and the card punched. The plate is then returned to its position upon the repeater, and a comb which is seen resting on the hooks in front, is put upon the slides and the punches forced back out of the stamping plate into the magazine plate. And so the operation is repeated continuously. Here it will be seen that three movements have to be executed; first the drawing of the punches into the plate; second, the stamping which really takes place upon a second machine—and third, the return of the punches into the magazine plate. In machines of more recent construction although it may be noted that this particular machine is in regular use at the present time, the first and last operations are performed simultaneously, or at least by one movement of the treadle, thus economising in some measure the time occupied.

A self-acting repeater is illustrated in Fig. 241, which will be seen to embody the principles involved in the reading-in machine which I have just described. The cards to be repeated or copied, are passed over a cylinder at one side of the machine and act upon the draw cords, in a manner very similar to that of the roller in the reading-in machine, and actuate needles at the other side which in turn cause punches to be pressed through the card. The advantages of this machine over the ordinary repeater must be obvious, the machine itself being self-acting and capable of cutting, as alleged, from sixty to seventy cards per minute, although the makers, Messrs. Devoge and Co., Manchester, say that forty per minute is recommended for good work.

Another machine for answering the same purpose is shewn at Fig. 242, made by Messrs. Wm. Ayrton & Co., of Manchester. Here the pattern cards to be copied are put upon one side of the machine and over a card cylinder, just as it would go into the jacquard, as seen on the left; the card cylinder revolving and bringing the cards against a series of needles in precisely the same manner as the

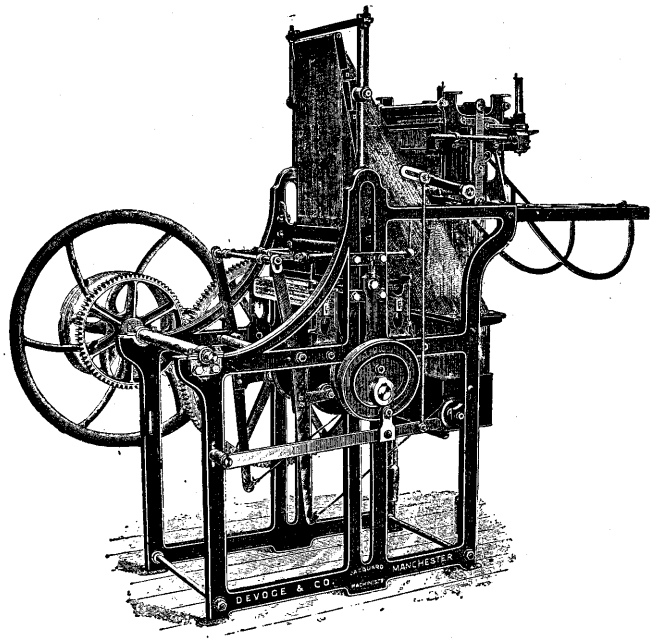


Fig. 241.

ordinary jacquard. When there is a hole in the card, the needle of course passes through it and remains stationary. The needle is connected to a rod, which will act upon the punch by means of an abutment bar, so that if the needle remains stationary, a hole will be cut in the new card corresponding to that being copied, but if the needle is pressed back by the pattern card, the vertical rod is moved off the bar, and the punch, having nothing to hold it in

position, simply rises with the blank card which is placed in position to be punched, and consequently is not perforated. The cards to be cut are laced in a long chain and stacked under the machine as seen in the illustration. They are

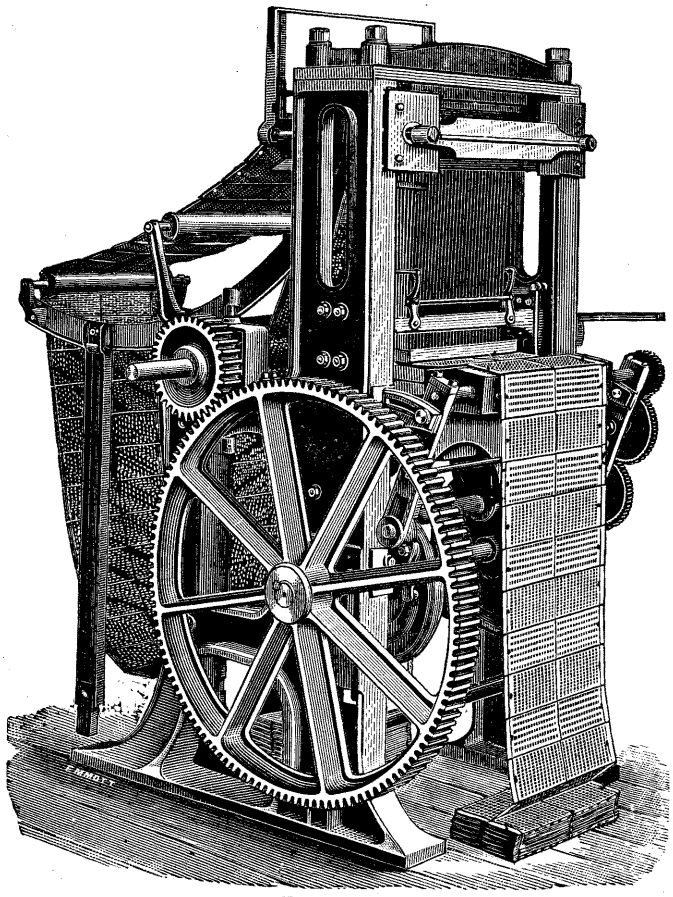


Fig. 242.

brought over an ordinary jacquard cylinder as seen on the right for the purpose of being moved forward at a rate corresponding with the movement of the pattern cards being copied. The cards pass between two die plates

which rise simultaneously, the upper plate really being the magazine plate, having a punch in every hole, and each punch being placed vertically in the magazine plate has a vertical pin placed above, and subject to the action of the selecting needle as already described, so that when the machine is set in operation the cards being copied are brought in contact with the needles, the selection of

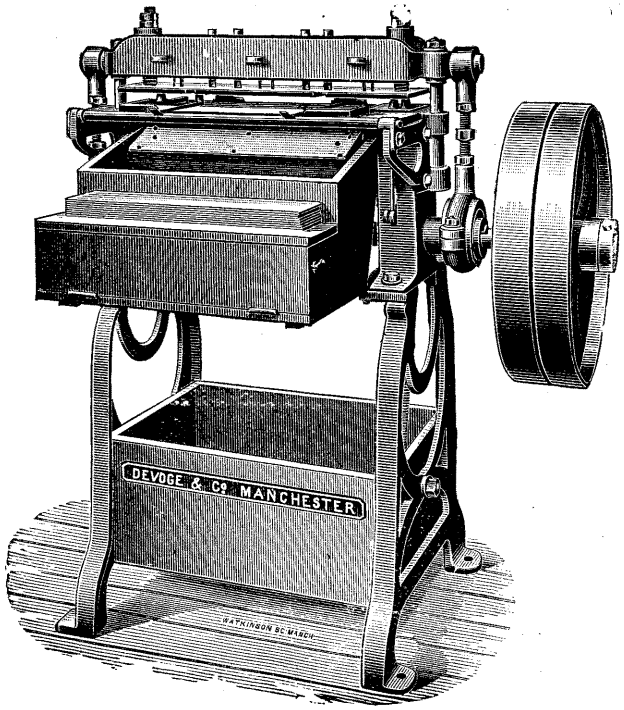


Fig. 243.

punches being made simultaneously with this movement, the die plates are raised and the plain cards perforated; so that the work can be carried on almost at any rate of speed desired. It will be seen that the cards to be cut must be laced together before being placed upon the machine, instead of placed in separately as in the ordinary

machine. Then two machines are required to prepare the cards for this, the one being a machine for cutting, what are termed, the peg and lace holes, and the other a lacing machine itself. In the ordinary way the cards are laced by hand, but for the rapid preparation of a large number of sets of cards this operation is too slow. One of the machines is shewn in the illustration Fig. 243. Here a bar, carrying the necessary pegs is caused to rise and fall by eccentrics on the driving shaft, the cards are fed in by a boy or a girl and drawn automatically between the plates and punched and dropped into a box, the details of the machine are so simple that further explanation is unnecessary.

Another machine of a similar kind is illustrated in Fig. 244. Here again the cards are placed by the attendant between adjustable guide plates and carried under the punches by two double oscillating levers mounted on a short counter shaft under the machine, each being connected at their upper extremities by curved plates, which form a kind of support for the cards to rest upon temporarily, projections being formed at equal distances apart, and sufficient to allow of the cards to rest between them. A combination of levers actuated by cams on the driving shaft are so arranged that immediately the cards are carried under the punches there is a dwell sufficiently long to permit of the punching operation. This is effected by means of a centre plate lifted by two eccentrics and bringing the cards immediately under the punches with sufficient force to perforate them; while the punching operation is being performed the oscillation of the curved plate continues and returns to its original position for receiving another card. After punching the first card the centre plates recede from the punches, still allowing the card to rest upon the curved plates, but move beyond the first stops and ready for delivery, the operation is carried on continuously in this manner.

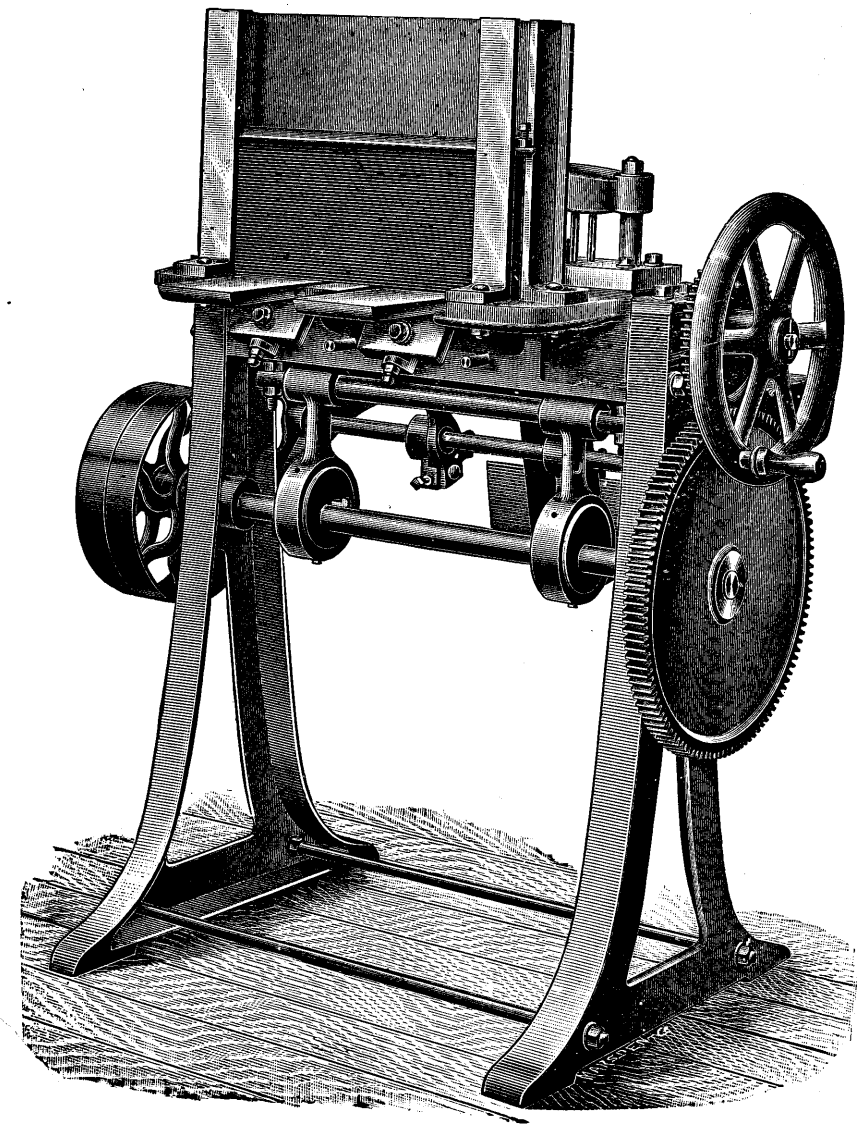


Fig. 244.

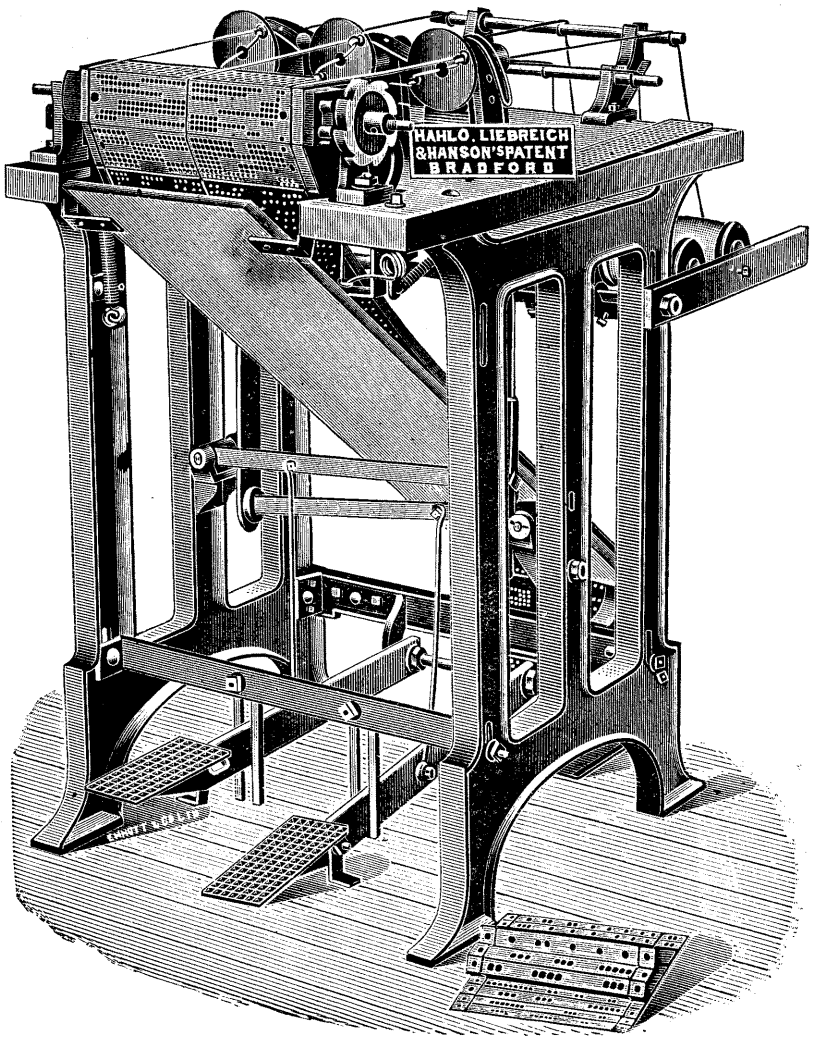


Fig. 245.

LACING.

The next operation is the lacing of the cards and for this various devices have been invented. As seen in the illustration already referred to, the usual practice is to thread cords through the holes at each end and in the centre of the cards, and to cross them between the cards themselves so as not only to form a continuous chain, but also the space between each one to permit of its passing round the corner of the card cylinder. Sewing machines have been introduced to perform this work, and other machines where the cord or lacing band, as it is commonly termed, instead of passing through holes in the card simply fall into notches, of the form of semi-circles, cut in each side, and twisted round each other between the cards so as to hold them in position.

The machine illustrated in Fig. 245, of Messrs. Hahlo and Liebreich, of Bradford, is one of the most ingenious for this purpose. As will be seen at the back of the machine are spindles carrying bobbins or balls of the lacing band, and the band is made to revolve with a face plate, the end being brought through holes in the face plate to the front of the machine, a boy sitting in front of the machine places a card upon the resting plate and between the two sets of cord, and by a simple movement of a wheel, or treadle, the face plates are made to revolve, giving a twist to the cord which presses up to the card. Another card is inserted between the cords, placed upon the pegs of the receiving plate, or bar, the previous one having been moved forward, and the operation is complete, and so this goes on until a long chain is made. The speed is only determined by the rate at which the operator can feed the cards to the machine.

LECTURE 11.

ADJUNCTS TO THE LOOM.

In the previous lectures the principal movements involved in the operation of weaving have been fully dealt with. It now remains to deal with the various additions to the looms for the purpose of ensuring not only continuous working, but all the freedom from accident, either to the machinery or material, which can be introduced. The most important are those for protecting the warp, or bringing the loom to a stand in the event of a shuttle not having reached its destination, because accidents arising from this are most disastrous to the material, and cause greater loss of time than from any other cause. Following that then we must have the apparatus which have been introduced for bringing the loom to a stand when the weft breaks or the shuttle becomes empty. In this case, of course, there is no serious injury to the material; it is only really a contrivance for assisting the weaver to prevent irregularities in the cloth which would occur if the loom was allowed to run without any weft. Then I will take those motions in their order of merit.

In the ordinary plain loom what is known as the stop-rod motion is most generally in use. This consists of a lever and a swell, which have been already referred to in Lectures 4 and 5, placed in the back of the box, but the details will be more readily understood by reference to Fig. 246, which shews an end elevation of that portion of the loom with which we are immediately concerned. This swell is hinged at one end and really becomes a lever to be pressed back by the shuttle as it enters the box. Behind the

box is a bent finger of the lever A. The opposite arm of the lever L being nearly at right angles to it, the fulcrum being on the stop-rod at the point R. This rod is carried across the loom so that the levers placed at each box will be actuated at the same time. On the loom frame and in front of the lever arm L is placed what is termed a frog F, and in such a position that when the shuttle is in the box the point of the lever arm L will be lifted sufficiently high just to pass over it, but if the

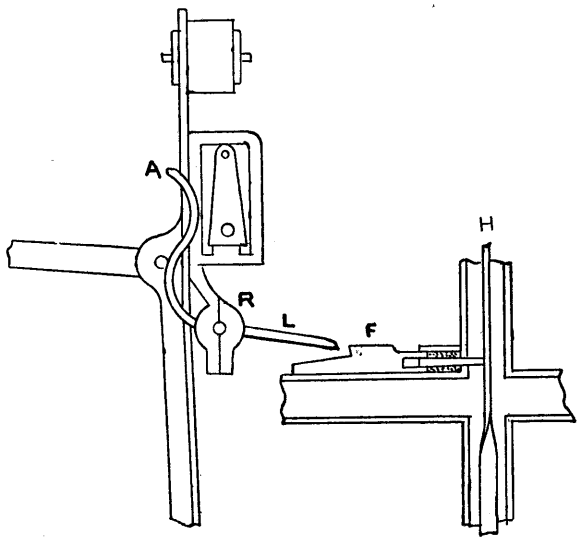


Fig. 246.

shuttle is not in the box then the lever L will strike it and arrest the forward movement of the going part. In the earliest form of loom, the loom was stopped practically by the force of the concussion, but now several contrivances tend to minimise this, and, in fact, to bring the loom to a stand as gently as possible. The frog F for instance is made to slide upon the loom frame and a pin projecting from it strikes the belt fork handle H and

throws the belt from the fast to the loose pulley. At the same moment a brake, which is also attached to it, and seen in the illustration Fig. 247, is allowed to drop and so soften the force of the impact. Consequently the loom is brought to a stop with comparatively little risk of breakage. The arrangement of the mechanism is simplicity itself and really the only questions for careful consideration are the placing of the fulcrum R and the balance of the several parts.

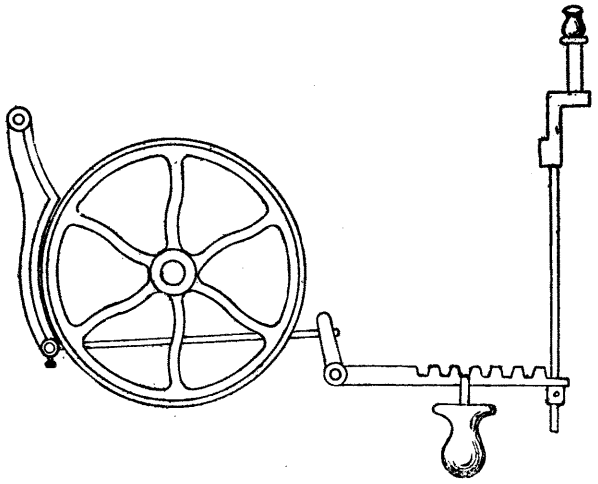


Fig. 247.

Perhaps we had better examine the question first by considering the amount of work we should have to give the shuttle to do. The point of the lever L must be raised clear of the frog, so that the heavier it is, or the greater the distance we have to raise it, the more work we throw upon the shuttle; and consequently the greater amount of work required to send it into the box, and also the greater amount required to send it out of the box. Again the position in which we have placed

the fulcrum R will have a material effect upon the liability to injury as the lever strikes the frog. Suppose the lever L forms a very obtuse angle with the sword of the going part, then it is liable to be bent every time it strikes the frog, and the slightest bend in it has the effect of preventing the shuttle raising it sufficiently to clear the frog, and consequently the liability to touch the frog in passing and to stop the loom, even although it does not actually come into full contact, becomes a source of constant irritation. Then, of course, it will be understood also, that the lower this lever points from the horizontal line the greater the weight, or more correctly speaking, the power required to raise it by means of the finger A. So that for a perfect balance, as well as for certainty in working, the nearer L approaches the horizontal line and the better; so that the frog upon the loom frame must be placed sufficiently high to admit of this horizontal line being maintained as nearly as possible.

Now another thing arises in connection with the position of the fulcrum R, that is the tendency to break the sword of the going part. The nearer this fulcrum can be placed on a line with the connection of the sword with the crank arm the better. Suppose it to be placed considerably below that point of connection, then the liability to breakage, in consequence of the amount of leverage given to the sword arm is very great; so that taking the matter generally we may say that the loom frame which has the frog sliding upon it should be so built as to bring the frog, not only in the position for striking the belt fork lever, and also of throwing the brake into action at the moment of striking, but also for maintaining the best position for the delivery of the blow by the stop-rod finger whenever it should come into use. Every good overlooker will, of course, recognise that the less the stop-rod comes into use and the better; generally

speaking, it may be said that with a good working loom, with the picking arrangements properly adjusted, and the shedding properly timed, the stop-rods should never come into use except through some accident, such as the "feltering" of broken threads, or broken healds in the warp, which would either retard the shuttle in its progress or throw it out of the loom altogether. Such a thing as "knocking off" by the stop-rod ought never to occur in a well managed room. As a matter of fact this, along with the other stop-motions, is a contrivance which only should, as it is intended, come into use in the event of unforeseen accidents occurring and should not be relied upon to cover bad workmanship on the part of the overlooker.

LOOSE REEDS.

The stop rod of the loom is invariably connected not only with fast going looms, but looms built for heavy work; and it is either associated with the ordinary plain looms or the rising box. In the circular box loom it is impossible to make use of the stop rod, at least in its ordinary form, for the simple reason that we cannot have a swell in the box which can act upon the stop rod finger; in a plain loom or rising box this is quite easy. Then in the circular box we have to resort to what is known as the loose reed, that is, the upper part of the reed is held in the hand rail of the loom in the usual manner, but the lower part instead of being placed in a groove, is held in position by a lath as shewn in Fig. 248. In one sense this lath, and the lever to which it is attached, may be compared in its movement to the stop rod, but that is only as to the nature of the movement imparted to it, its functions are entirely different. The stop rod brings the loom to a dead stop in the event of the shuttle not having reached the box, but in this case the lath gives way and allows the reed to fly out so as to prevent injury to the warp. This

in itself is extremely simple, but it must be obvious that one of two conditions must attend the working of this arrangement. In the first place a spring A must hold the reed in position, and that spring, although it may be strong enough to hold the reed in position during the time the shuttle is passing, would not be strong enough to hold it for the beating of the weft up to the fabric,

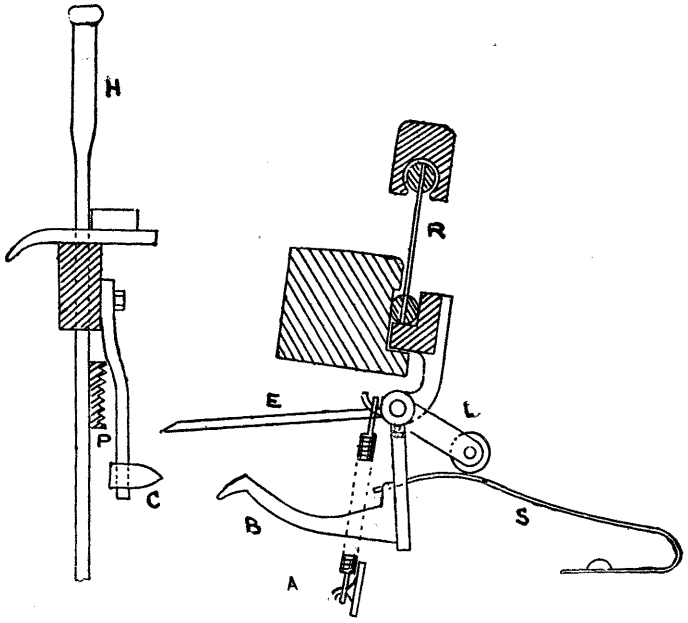


Fig. 248.

otherwise it could be no safeguard against breakage of the warp threads. Then as seen in the illustration Fig. 248, other provisions are made; as the reed comes up to the cloth a finger B somewhat similar to the stop-rod finger in character, but different in shape, is allowed to pass under a V shaped frog C attached to the loom frame. So that at the moment the reed comes into contact with the cloth

it is held almost as firmly as an ordinary fast reed. On the other hand there is a lever D projecting in the opposite direction and having a roller at its end, and under this roller is a peculiarly bent spring S, and so placed that as the shuttle is passing across the loom it presses the reed close up and holds it in position, but as it goes forward the pressure is released until the frog takes hold of the opposite finger; so that the spring A which nominally holds the reed in place need not be a very strong one. The object of this is to prevent damage in the event of the shuttle being caught; for instance the shuttle could never be caught when the reed is at the back extremity of its stroke, nor could it occur at the extreme front, but it must be at a point about midway during the passage of the reed when the shuttle would begin to press upon it. That is, the moment when there is the least pressure on the reed neither the frog at the front nor the strong spring at the back have any hold upon it, consequently there is little danger of damage even to the most tender warp. In addition to the arms B and D another arm E is attached to the same fulcrum, and so that it will be raised or depressed with B. On the front of the belt fork handle H is a projection P, having a sort of toothed surface. When the reed R is held properly in position, that is, when the shuttle is not in the shed the finger E passes clear of P, and everything goes forward, but should the shuttle have remained in the shed the reed will be struck back as shewn in Fig. 248a, the finger B will be thrown on the top of the frog C, E will be brought in contact with P, the belt fork handle will be struck back, the belt thrown on the loose pulley at the same time, the brake will be brought into use as in the stop-rod loom and the loom brought to a stand. This contrivance works very well for light goods but it has always been one of the drawbacks of circular box looms, that, in spite

of the apparent perfection of the frog and lever for giving firmness to the reed in delivering its blow, it has never been sufficiently rigid to enable a blow to be given suitable for heavy work. Numbers of contrivances have been invented for the purpose of overcoming this difficulty, but without attempting to detail them the general principle may be illustrated in what is known by the paradoxical name of a fast loose reed. This contrivance consists in a

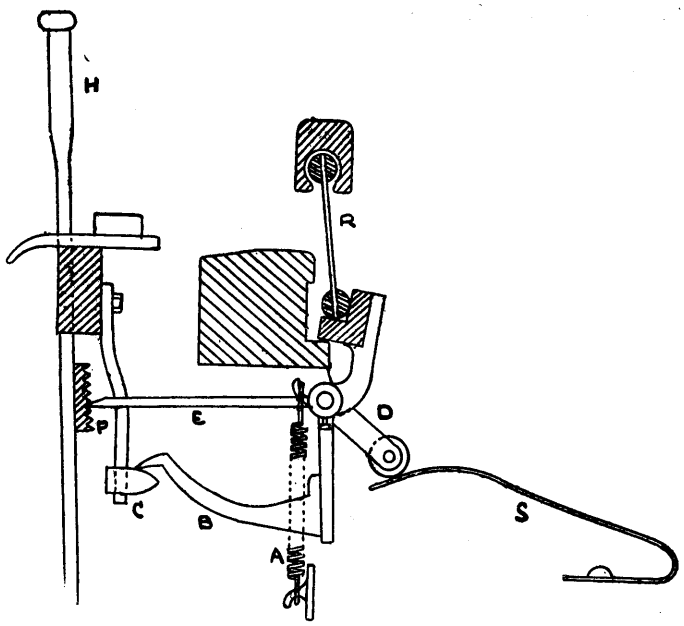


Fig. 248A.

series of levers which lock the reed in a perfectly rigid position the moment it has passed the centre of its stroke towards the cloth, and holds it there until it has returned to the corresponding point, when the locking arrangement is released and from that moment it becomes a loose reed. So that from the moment the shuttle is in danger of being trapped until the reed has delivered its blow it may

be described as a fast reed loom, but after the blow is delivered it becomes an ordinary loose reed loom. The advantage of the system will be evident at a glance and of course can be applied to any ordinary existing loose reed loom. The attachment of the additional levers being all that is requisite to effect the transformation.

SHUTTLES.

As explained in the second lecture the function of the shuttle is to carry the weft across the loom, but as explained there it must do this in a particular manner. It not only must carry the bobbin, or cop of weft, but it must carry it so as to prevent any interference with, or damage to the warp; and also in such a manner that the weft leaves the cop or bobbin exactly at the rate of speed desired, and as the shuttle delivers it to the cloth there must be as nearly as possible an even tension upon the thread. Then at least two things are implied here, first, a ready means of placing the bobbin in the shuttle and holding it firmly in position when so placed, and, secondly, a ready means of regulating the tension upon the thread. In the great majority of shuttles the weft issues, as already described, through an eye near one end, and various methods are adopted for regulating the tension. If only one shuttle eye is used then a series of brushes, rollers, or tension pins are contrived inside the shuttle to keep the yarn from running off too quickly, or failing that two or three eyes are used through which the thread is passed to give the increased tension. The various means resorted to will depend in a great measure upon the nature and strength of the yarn. Silk threads for example may be treated with a series of delicate springs, or springs and rollers combined; or in some cases as already suggested, brushes in the shuttle, not only to keep the thread at a steady even tension, but also in keeping the

yarn from flying off the bobbin or cop. In cotton yarns practically the same means are resorted to. In woollen or worsted the brushes, or tension pins, may be stronger, but in all these contrivances there is a tendency to increase the tension as the bobbin becomes empty; and although in a great proportion of goods this variation in tension may not have a seriously detrimental effect in light goods it is always liable to produce unevenness. It may seem singular that the same effect is produced in extreme cases, for instance, very heavy goods are liable to be affected by irregularity in the tension in precisely the same manner as light goods, whilst medium weighted fabrics may absolutely escape. This may be due to the fact that in the very lightest goods it is necessary to have the least possible amount of tension upon the thread, consistently with keeping it straight, as it passes into the cloth, whereas in heavy goods it is necessary to have a great amount of tension upon the thread for the purpose of compelling it to lie straight, so that the variation of tension upon the delicately weighted fine thread has practically the same effect as the variation in the heavily weighted strong thread. A recent contrivance goes a long way to fulfil the necessary conditions in weaving heavy goods. For instance, in jute or linen yarns the cop is placed in the shuttle without being put upon the peg or tongue and the thread is drawn from the inside. In this arrangement the drag is obtained by means of a spring, the pressure of which is adjusted by means of a set screw 4 in the illustration Fig. 249. This spring is in contact with the small hinged drag lever 1, over the upper end of which the yarn passes, being bent round it as it leaves the cloth, and from there it is passed forward through the shuttle eye in the usual manner; so that there is very little of mechanism, the whole of the details being visible in the two figures, one of which shews a section of the

shuttle with the thread as it comes from the cop, and the other the elevation or plan. The arrangement is so open and free that there is no danger of locking by waste or fly from the yarn, and once the tension is adjusted it cannot be altered by the weaver. It is claimed also for this arrangement that it is suitable either for heavy or light jute or linen yarns. The inventor and maker is Mr. Ireland, of Dundee.

Apart from the question of tension on the weft thread as it is drawn from the shuttle the next in importance is the shuttle tongue. In the hand loom, where the shuttle was thrown at a comparatively slow rate of speed,

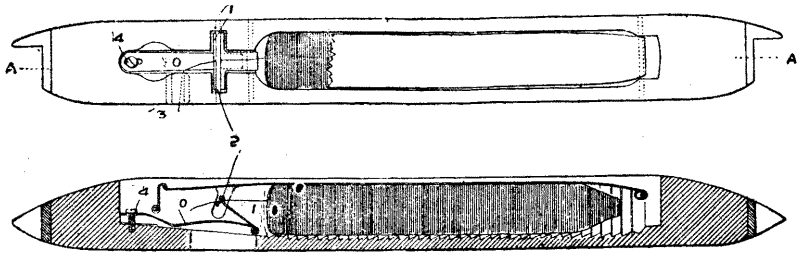


Fig. 249.

this was not a matter of such vital importance; any simple contrivance that would hold the bobbin in place would be sufficient for the purpose, but in fast running looms, or looms weaving heavy goods, accompanied by the various forms of bobbin or cop upon which the yarn is spun, and the liability not only to throw the yarn from the bobbin, but to breakages in both bobbin and shuttle renders this part of the mechanism most important. Without attempting to go through the various forms of shuttle, or to point out all their various advantages and disadvantages, it will be sufficient to call attention to the leading features of those in most general use. Fig. 250 shews a series of shuttle tongues of different form, and Fig. 251 shews a section of a shuttle with the tongue and tongue rest.

Now first refer to the tongue No. 6 in Fig. 250. In this we have simply a straight spindle passing through a holder which could be hinged within the shuttle. A spring on the upper side of the peg is designed to keep the bobbin, or cop, in position; in the ordinary shuttle the whole arrangement is held rigid when the bobbin is placed upon the peg and returned to the inside of the shuttle, and consequently there is liability, in the event of the spring on the peg becoming weakened, for the shuttle or cop to fly off, and on the other hand there

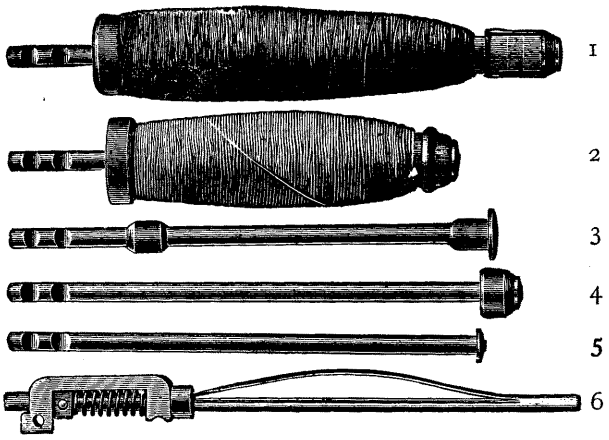


Fig. 250.

is liability if the bobbin is held too rigid when the loom is picking very harshly for the weft to fly from the bobbin. It will be obvious at a glance that the bobbin, or cop, only being held on by the strength of the spring that the arrangement could only be suitable for light running looms, where the pick is of the smoothest possible, and the speed not excessive; but in the arrangement shewn here, where a spring is placed on the tongue, and inside the head, the vibration will occur in the tongue in consequence of any severe shock and will prevent, in a

great measure at least, the shock being communicated to the bobbin, thus reducing the tendency of the weft to fly from it to the lowest point. A tongue of a different form is shewn in Fig. 251, where a spring is placed on the under side for holding the bobbin, and a notch is formed at the extreme end to prevent any possibility of the bobbin coming off in the process of weaving. This tongue it will be seen is hinged at the back, and beneath it is placed a strong steel spring to keep it in position; the whole arrangement having, first, for its object the holding of the tongue and bobbin in the proper position during the weaving, and permitting of the tongue being raised to enable the weaver to change the bobbins.

Now it would be as well to examine from every point of view possibilities of damage, either to the bobbins, to the shuttle, or to the warp; as also the probable interference with the regular tension of the weft. In the first place a glance at this tongue will shew that in putting the bobbins on and taking them off what is termed the bobbin nose is always liable to injury, and any crack or injury to the bobbin is liable to catch the weft as it is drawn from it, to break it and bring the loom to a stop. This, if of frequent occurrence, is not only irritating to the weaver and causes a loss of time, but it is practically impossible to weave the fabric without imperfection either in the form of broken picks or thin places.

Then again the shuttle tongue must be held in a perfectly horizontal position, so that the weft can come straight from the bobbin to the shuttle eye. Should it point either upwards or downwards there must be considerable drag upon the weft, and that would be increased as the bobbin becomes empty. Again should there be any vibration in the bobbin, either by the spring at the back not holding it sufficiently rigid, or the peg passing through

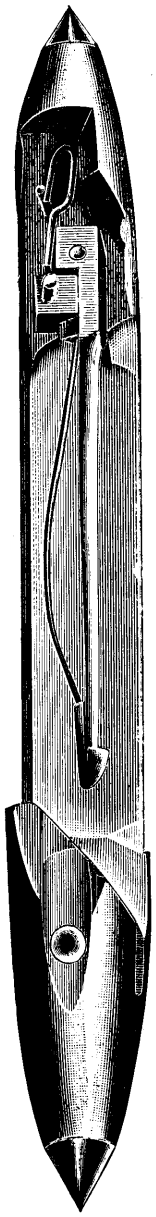


Fig. 251.

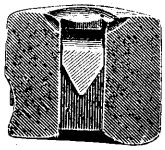


Fig. 252.

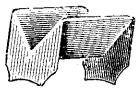


Fig. 253.

Fig. 255.

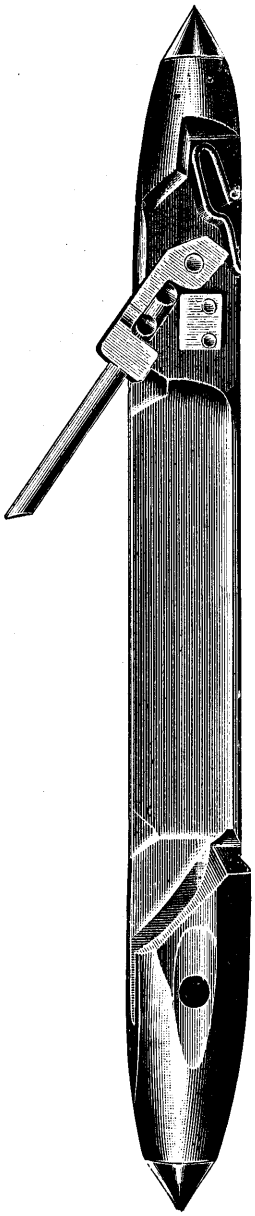


Fig. 254.

the tongue head becoming loose and permitting it to vibrate sideways the same fault will occur, but in an irregular manner. Sometimes too, the tongue will permit the nose of the bobbin to rise above the level of the shuttle when it will be liable to catch the warp.

Another fault is of more frequent occurrence even than that. In the usual form of shuttle the tongue rests upon a pin which is put through from side to side, or it may rest upon ledges of wood, left for the purpose; where it rests upon the pin there is a constant tendency to split the shuttle, and everyone knows that this is the most vulnerable point, because at the point where the pin is put through the sides of the shuttle have been weakened by being cut away, partly to permit the ready insertion of the tongue, and partly to facilitate the raising of it for changing bobbins. To dispense with the pin through the shuttle, and prevent splitting, various devices have been resorted to; one where a small peg is passed through the shoulder of the tongue and rests upon solid wood at each side. Theoretically this seems perfect, but in practice it is not quite so, for, with the constant raising and depressing of the tongue in changing bobbins and from other causes, apparently of a trivial character, the wood at the side gradually gets worn and allows the bobbin nose to point downwards until it reaches a point where weaving becomes practically impossible. The only way to meet this difficulty, it is said sometimes, is to build the shuttle so that the tongue, when new, shall point slightly upwards and so allow for a certain amount of wear and tear. This then reduces it to the proposition that the shuttles shall be in perfect working order when half worn, because there must be some irregular tension upon the weft when the shuttle is new by reason of the tongue pointing slightly upwards, and a corresponding tension when the shuttle is getting worn out, by reason of the tongue pointing downwards. There is no remedy

for this but constant packing at the sides as wearing takes place. This is not only difficult, involving time and labour, but is a very unsafe mode of procedure. Metal bearings certainly offer the most ready solution and the illustration given here is one which apparently will meet the requirements. Instead of the tongue resting upon wood, or upon a pin passed through wood, it is made to rest in a V shaped metal groove which is inserted under the tongue, the tongue itself being formed to correspond with it. Fig. 252 represents a cross section of the shuttle with the tongue in position, and Fig. 253 represents a metal packing which may be inserted in the tongue rest in the event of the tongue getting too low. The change is easily accomplished and all being of exactly the same form they assure the fitting and cause no trouble. This contrivance is patented by Mr. James Waddington, of Bradford.

Now attention may be directed to one or two other forms of tongue designed specially for the protection of the bobbin and preventing the yarn slipping off, as well as ensuring even tension. In No. 1 of the Fig. 250 an arrangement is shewn where the end of the tongue is provided with combined cushion spring and cover, against which the end of the bobbin is pressed in weaving. Here a difficulty presents itself, apparently, in the use of an arrangement of this kind, in consequence of the tongue having to be removed from the shuttle every time a bobbin is changed. This is got over by a very simple arrangement in this case, and there are numbers of others of a somewhat similar character, by having a couple of notches cut in the end of the tongue; the tongue is inserted in the shoulder or head after the manner shewn in Fig. 254, and as the tongue is dropped into its place with the bobbin the two notches engage with two pins passed through the tongue rest as shewn at Fig. 255, which indicates

the rest. Thus it will be obvious that when the tongue is raised for the purpose of changing a bobbin it is perfectly free and can be drawn out readily, but the moment it is dropped back into the shuttle it is securely locked into position. Then to come back to the shuttle peg No. 1, shewn at Fig. 250. The end of the bobbin pressing against the flexible spring not only prevents the yarn being thrown off by force of concussion, but it acts as a shield, and anti-vibrator as well. Other forms of the same contrivance are shewn in Nos. 2 and 4 of the same figure. Nos. 3 and 5 are simply plain tongues for different sized bobbins, all of them being interchangeable so that they may be used for the same shuttle and readily adapted for different kinds of bobbin or cop.

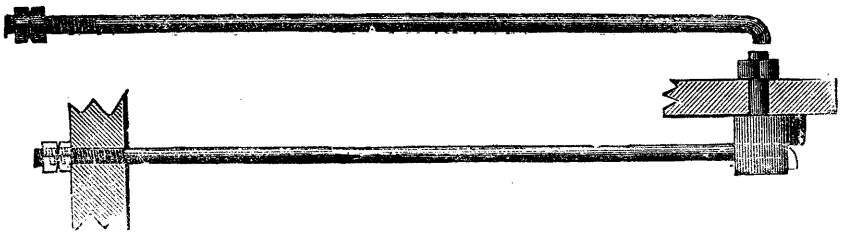


Fig 256.

Whilst dealing with shuttles perhaps one word may be said in reference to the picker spindles. The general arrangement has been already referred to in dealing with shuttle boxes, but a contrivance has recently been patented by Messrs. Bentley and Ramsden, of Bradford, which is said to be an improvement upon the existing system. An illustration is given at Fig. 256, where the spindle itself is shewn and also placed in position. One end of the spindle is slightly bent, the other is provided with lock nuts, so that when placed in position and the nuts screwed up tight it is held perfectly rigid. Two things in special are claimed for it, the first of importance is,

that the shortening of the picking strap by the weaver would not have the usual dangerous effects in consequence of the rigidity of the spindle itself; and a second is, that in the event of the spindle breaking no portion of it could fly, as sometimes happens, and consequently no liability of injury to the weaver. Of course it is also claimed that from the rigidity of the spindle the liability of the shuttle flying out is also reduced.

SHUTTLE GUARDS.

There is probably no subject connected with looms which, during the last few years has attracted so much attention as that of shuttle guards. In fast running looms, more especially in weaving heavy work, or with rough fibrous material, the tendency to fly out is very great and also the consequent risk to the weaver. The various causes have been already dealt with, so that it is only necessary at the present moment to refer to means of prevention. Broadly speaking, it may be said that the best shuttle guard is a competent overlooker, a man who will look to his loom always being in good working condition; the great majority of shuttle accidents undoubtedly arise either from incompetence or carelessness. To arrive at a conclusion as to what is the best form of guard, leaving aside all questions of automatic arrangement, we have only to consider what are the probable causes of a shuttle leaving the loom. If it is from any fault in the picking arrangement we can determine almost immediately at what point it would leave the loom, and the probable direction it would take; on the other hand if the shuttle is thrown out merely by an obstruction in the warp we could only determine the direction it would take by a knowledge of the position of the obstruction. Suppose, for example, that the loom is picking in the best possible manner and the shuttle is being propelled from side to side with just sufficient pressure upon the reed to ensure

good running; we are weaving a heavy yarn and one which requires great force in picking; then an obstruction occurs, either by the warp threads having broken or become entangled, or from any one of the numerous causes so well known to the weavers, and a bar is offered to the passage of the shuttle. If the shuttle point is thrown upwards it will in all probability be thrown outwards at the same time; if the upper half of the shed is a very light one the shuttle will then leave the loom in an oblique direction and probably in the direction of the weaver's head at the next loom; then serious danger exists, but should the upper half of the shed be heavy the shuttle, in forcing its way through the threads, will not only be retarded, but also somewhat diverted, and it would in many cases drop quietly on the floor a yard or two from the point where it leaves the warp, and there is, comparatively speaking, little risk of injury either to the weaver at the loom from which the shuttle flies or the one at the neighbouring loom. The greatest danger always arises from the shuttle flying nearest the side from which it has been picked, as it would then, not only rise higher, but travel considerably further, in consequence of only a small amount of the force of propulsion having been exhausted before it leaves the warp; but if we add to the causes of shuttle flying the more probable ones of having a bad picking arrangement, misdirection of force, or the reed and the back of the box not forming a perfectly straight line, any bulging of the reed, or any of those apparently trivial causes, then the danger is increased considerably.

Now the question arises, assuming any or all of these conditions to prevail, as to the best methods of prevention. To attempt to enumerate all the shuttle guards that have been invented during the past eight or ten years would be not merely an act of folly but perfectly useless. The first and simplest shuttle guard ever applied contains, so

far as protection, all the requisite elements; this simply consists of a couple of small brackets attached to the handrail of the loom and extending forward over the shuttle race; these brackets carried one or more light iron or wire rods across the width of the fabric; but two objections were raised to their use, the first and the most vital one was the interference with the weaver, not only in taking up the threads, but also in interfering with the seeing of the fabric as it was being made. The latter objection is not of so much importance as the former as the rods might be made so light as to offer practically no interference with the vision, but the interference with access to the reed is certainly an important one. The next objection is as to the insecurity, as the shuttle could often fly out between the shuttle box and the guard itself; a system of flying which is not only in itself most dangerous, but in all probability it would strike the guard and have its course averted, to the imminent danger of any one in the immediate neighbourhood, for if it did strike anyone it would certainly strike high. This could be met by extending the shuttle guard closer to the box, but in doing so security is gained at the cost of the weaver not being able to take out the shuttle to change it as the weft is run out, without considerable difficulty and loss of time. Then recognising these objections the next movement was to form a species of grate which could be turned up and out of the weaver's way to permit of ready access to the reed.

Here again objection arises on the part of the weaver; this grate must be thrown back by the hand, and however simply contrived it usually involves two movements; when the guard is in position it must be held down firmly, so that the bracket on the handrail to which the guard is hinged, is usually provided with a sort of incline and a

notch, and a spring upon the spindle of the guard itself presses a small catch into this notch, so that to raise it the guard must be moved to one side and lifted upwards. Then the most acceptable arrangement is after that for the guard to fall down simply from the vibration of the going part on the loom being started. To this there would seem to be little objection, and absolute security may be obtained by having a guard sufficiently long, and projecting sufficiently far forward; yet the weaver's object to the time occupied, and the trouble involved.

Numbers of so-called automatic shuttle guards have been invented, and it will be absolutely impossible to deal with them in detail. One of the earliest and most effective ones consists of a rail running across the front of the going part, and actuated by means of a lever direct from the belt fork handle, so that the moment the loom is started the rail is thrown out from the hand-rail into position, as suggested by the preceding remarks, and there it remains so long as the loom is running; but the moment the loom stops, from any cause, it is thrown back under the handrail out of the way of the weaver. The mechanism is so simple that it needs no explanation, the method of connecting to the belt fork handle being the only matter of moment. Many others have been made having practically the same principles involved, in some cases the rail being formed of wood and moving either vertically or diagonally, sometimes falling back under the handrail, sometimes in front and sometimes on the top of it; but seeing there is no real principle involved it would be unnecessary to go into the details of any number. Many objections have been made to these so-called automatic ones, sometimes on the ground of the mechanism involved, and sometimes on the ground of the trouble caused by having to detach them whenever the sley has to be taken off, and at other times on

account of the liability to failure to act at the proper moment, and as a consequence attention is directed by many inventors to the production of a shuttle guard which would fulfil all the conditions of safety with the least possible amount of mechanism and the least liability to go wrong. It will only be necessary here to mention one or two for the purpose of shewing the direction in which inventors have been working. One of those is the invention of Messrs. Raper, Pitts and Noble, and is illustrated in Figs. 257, 258 and 259. It consists simply in a series of

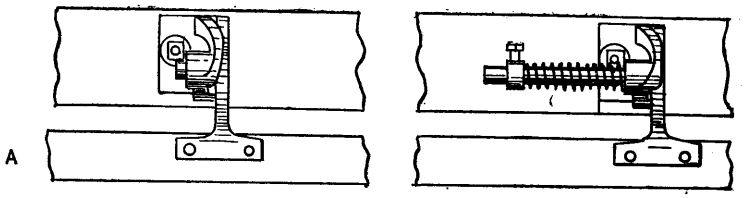


Fig. 257.

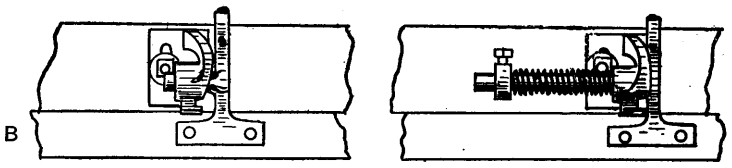


Fig. 258.

brackets attached to a handrail, one at least of which is formed after the nature of a cam; these brackets are made to carry lever arms, to the lower end of which either a wood rod or a series of wires are attached, and they are so arranged that when the loom is in motion they are held in such a position over the warp and shuttle race as to effectually prevent the shutttle from flying out as shewn at A. Whenever the weaver desires to remove the shuttle guard it is only necessary to turn it inwards or upwards and the rod will lay close under the handrail

as shewn at B. To facilitate this, and to keep the guard in either of the desired positions, the cam-shaped bracket has a swell upon it in the direction of the sley, and the arm carrying the rods is produced beyond the fulcrum so as to slide upon the surface of the bracket as shewn in Figs. 258 and 259. Then upon the spindle carrying the lever arms a helical spring is placed and held in position by a screw-collar so as to always keep the lever arm in contact with the cam-shaped bracket. By this arrangement when the loom is at rest a slight pressure of the finger will bring the guard up to the handrail and out of the way of the weaver, but the moment the loom is started the vibration of the going part is sufficient to throw the guard

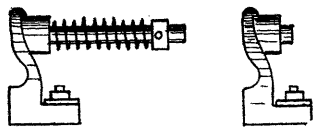


Fig. 259.

out into the position for protecting the shuttle; so that the apparatus is automatic in one sense, that the moment the loom is started it falls into its proper position and only requires the pressure of the finger of the weaver to remove it when desired.

Another apparatus of a similar character is the invention of Messrs. Redman and Sons, of Haworth. In this case there are brackets employed somewhat after the same manner as in the previous one, but the movable arm assumes a cam shape instead of the bracket itself, and instead of the spring being placed upon the spindle, so as to keep the arm and bracket in contact, it is placed within the bracket, or in other words the conditions are simply reversed with some slight modifications in detail,

that which exists in the bracket in the one case exists in the lever arm in the other; the effect is precisely the same, and the efficiency of the two are about equal, so that as between the two inventions it is simply a matter of economy of production.

The three illustrated here may be taken as sufficiently typical of all the inventions and amongst the most efficient. It remains then only to describe one of the fixed arrangements, which not only differs from those previously described, but possesses special merits as a fixed guard. This is the invention of Mr. Jonas Hey, of Bradford. In this case a bracket is fixed to a handrail projecting in the usual manner towards the cloth, but made from flat steel, and in such a manner as to partake of the nature of a spring, and to these brackets bars are fixed in position parallel to the sley or handrail, these also are made of flat steel, or charcoal wire, so as to be very elastic, and they are placed at such a distance from each other as to make an absolute cover for the shuttle race, at the same time in their very lightness and elasticity they offer no interference to the weaver, and also not only prevent the shuttle flying out, but should it rise from the warp they readily force it back again. As a fixed guard this certainly possesses more merit than any other from the very elasticity of the material and the small amount of interference with the weaver's work.

TEMPLES.

There is probably no accessory to the loom which is of such importance in the production of good fabric as a good temple, and although at the present time there are scores of forms in use they may all be reducible to three practical forms. The object of the temple is simply to keep the cloth distended in front of the reed in such a manner as to keep the fabric the full width occupied by the

warp threads in the reed, so that as the weft is being beaten up there can be no interference either from the pressure of the threads upon the reed itself or by friction of the reed upon the threads. To make this clear it will be perhaps necessary to explain what actually takes place in the process of weaving. As cloth is formed and carried away from the reed a considerable contraction usually takes place in the width, the amount of this contraction being dependent upon two things; first, the amount of warp or the bulk of the threads forming the fabric; second, upon the nature and elasticity of the weft, and those two conditions may also be influenced by the character of the pattern. Suppose, for instance, that the warp is very thick or very closely set in the reed, then very little contraction will take place, simply because the weft can exercise very little influence over it; if on the other hand the warp threads are fine, or very openly set, then contraction will take place in consequence of the weft bending round the warp threads after being beaten up by the reed and they are left at liberty to assume corrugations, which in many cases are leading characteristics of the fabric. If the weft is very strong, or made from very stiff fibres, or twisted threads, then their flexibility is lost and very little bending takes place; consequently the contraction is limited, whilst, on the other hand, should the weft be of a very soft and flexible character the contraction will be great. The influence of pattern follows practically upon the same lines. The frequency with which the weft and warp intersect each other may give opportunities for increased bending which will generally imply a tendency to contraction. This, of course, will also be dependent upon the relative bulk and quality of the two materials.

One thing may seem difficult of explanation, after what has been said of the manner in which the weft is thrown

across, and the length of yarn actually employed in forming one pick. It will be remembered that in dealing with the tension upon the weft the thread forms a diagonal line across a parallelogram represented by the width of the sley on one side and the length of the shed, from the fell of the cloth to the front of the shuttle, on the other; so that the length of the yarn thrown across the piece, and beaten up to the fabric by the reed, must of necessity be somewhat

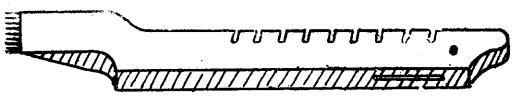


Fig. 260.

greater than the actual width of the threads in the reed itself, consequently it would seem that this increased length would be sufficient to allow for the corrugations formed by the weft threads after leaving the reed. But as a matter of fact, in very fine material, the contraction in width, due to the causes already mentioned, may be anything from 1 to 15%, and as this contraction increases

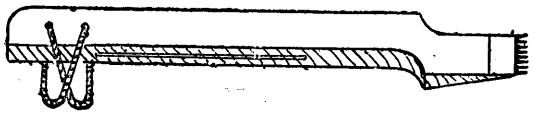


Fig. 260A.

the difficulty of weaving a good fabric becomes intensified. In the first place the friction upon the outer threads will become so great as to be absolutely cutting; in addition to that the resistance offered to the reed in its progress towards the cloth will prevent the requisite number of picks per inch being beaten in, and there is also a tendency to cause what is termed curling in the weft at the same time. In fact the defects in the cloth

are such as in most cases, especially fine fabrics, to render them absolutely unsaleable.

The earliest forms of temple in use for hand looms consisted simply of bars of wood with pin points projecting from the extremeties, and coupled together in such a manner as to form a sort of hinge in the centre, so that on the insertion of the pins in the two selvedges and the downward pressure upon the two levers the cloth would

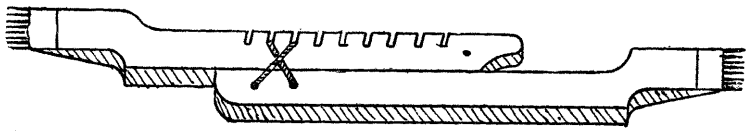


Fig. 261.

be distended. Figs. 260 and 260A shew the two separate parts of an ordinary temple, Fig. 261 shews them joined together as in use. The weaver had simply to place the teeth through the selvedge within a very short distance of the fell of the cloth, press them down, and make a notch in one of the arms to drop into a groove in the other one, which combined with the pressure on the pin points would cause it to be held firmly in position.

Fig. 262.

Another form is shewn at Fig. 262, where instead of the parts being joined together by a piece of string they are joined by a pin passed through them and when pressed down are held in position by a small button. The form shewn at Fig. 261 was, however, preferred by most weavers on account of the exact nicety of adjustment which could be obtained by the use of the string. Where the two parts were hinged together with a pin

the width at which they could be set could only be varied as the distances apart of the holes through which the pins passed, but with the string it could be set to the exact width of the warp in the reed with the utmost nicety. This form of temple, however, possesses two serious disadvantages, especially for power loom work. In the first place some time is occupied in moving the temples up to the fell of the cloth periodically; and in the second place, the tendency to irregularity in the fabric if the temples are not moved with sufficient frequency. It was a recognised maxim with hand loom weavers that the temples should never be woven more than an inch, or inch and a half, from the fell before being moved, but a careless weaver might allow them to run 3 or 4 inches, or even more, with the result that, in fine goods at any rate, a marked unevenness in the cloth was visible. In the power loom, of course, this is an impossible position especially in fast running looms, for not only would it take up too much of the weaver's time to keep moving the temples forward, but it would be necessary to stop the loom every time to permit the operation, so that a continuous temple becomes an absolute necessity.

I shall not attempt to deal with every form of temple in use or to say much as to their relative merits as it would not only occupy too much time, but involve entering into a vast amount of unnecessary detail. There are two principles directly involved and all the various forms of temples belong either to one or the other, or are in some measure a combination of the two.

In Fig. 263 we have what is commonly known as the star temple. This is simply a roller placed horizontally with teeth upon its rim and surrounded by a shield plate, with grooves cut so as not only to permit the cloth to embrace a section of the circumference, but also to hold it in position there. This temple is placed under the

cloth with its circumference in a line with the warp as it leaves the reed. The selvedge of the cloth is pressed under the shield plate and engaged with the teeth of the roller, and as near the fell of the cloth as possible, without being in the way of the shuttle race. Once being properly adjusted, and the cloth placed upon the teeth so as to engage a sufficient depth into the fabric to have a good hold, the cloth will always remain held by them and distended equally in front of the reed to the requisite width. For a large proportion of fabrics this temple is all that could be desired, but there are cases where it scarcely fulfils the conditions; for instance in fine fabrics, and especially those made from very shrinkable material, the tendency to contraction after passing the temple is so

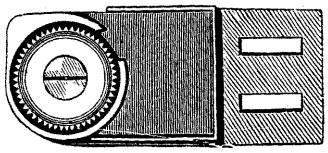


Fig. 263.

great as to cause injury to the selvedge; to mitigate this sometimes the double star is used, one being placed behind the other, and the position of the second star relieves, in some measure, the strain upon the first. In other cases however it has been found necessary to get a much greater hold upon the cloth than could be had by merely taking hold of the selvedge; then what is known as the segment temple is brought into use. Since its first introduction the segment temple has not only undergone a vast variety of changes and been used in various forms, but it is also used in combination with the star. The Fig. 264 represents one of the most improved forms of segment temple; this consists of a series of rings revolving upon

a horizontal spindle. In the earliest form of segment temple the rings were placed in a sort of diagonal position, but exactly parallel with each other, so that they would all take hold of the cloth to the extent of say 3 to 6 inches, according to the strength or width of the fabric, and as the cloth is carried forward they would gradually stretch it out. To ensure the work being done satisfactorily the rollers are covered with a shield plate which compels the cloth to embrace about one-third of the periphery, so that sufficient hold will be had to ensure its being kept extended. In some cases, especially where the fabrics are of a light character, all the rollers dragging with the same amount of tension will be liable to cause a little damage by displacing the threads in the cloth. This was sought to be overcome by placing the rings in the position shewn in the illustration Fig. 264, where the angle is gradually varied so that the greatest amount of pull is on the extreme edge of the fabric, and gradually decreasing towards the centre; that is the rings A^1 are nearly at right angles to the axis, and have very little pull upon the cloth, whilst from A^2 to A^4 and forward, the angle is constantly increasing. Of course those rings would vary not only in size, but in the strength and number of the teeth on their circumference according to the weight of the cloth.

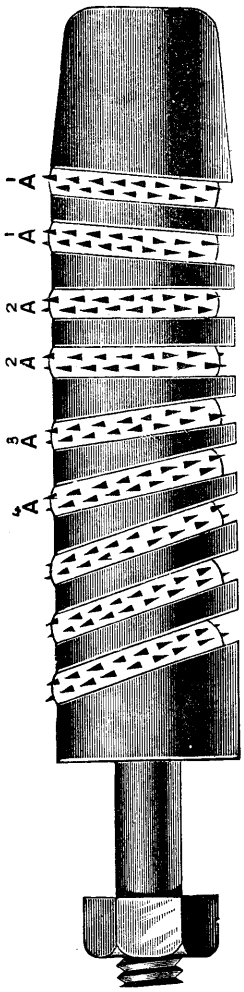


Fig. 264.

In addition to segment temples there are many in use commonly known as roller temples, which consist simply of a roller with teeth on its surface taking the place of the segment rings; these of course are cheaper and for many purposes sufficiently good but not suitable for the finest woollen or worsted fabrics. Then a compound of the two principles comes in, and numbers are employed in fine worsted goods, such as cashmeres or merinos, where one roller, or a double roller, somewhat after the segment is used, but being rather more rounded off so as to get full hold of the whole of the selvedge, without going too deeply into the body of the fabric; or again one of these rollers may be used in conjunction with the star. But whatever may be the form of temple adopted two things only must be looked to, the first is that involved primarily in the use of the temple to keep the cloth distended so that the reed can be brought up to the fell without undue pressure upon the threads at, or near, the selvedge; and to do this without any risk of injury to the fabric by displacing the threads. In some cases instead of these temples being held rigidly springs are placed behind them so as to give some elasticity of movement and allow them to travel forward with the cloth a little as the reed is striking the weft up, and then to return on the pressure on the reed being released, but those are details which must always be considered in connection with the class of work to which they are applied.

THE WEFT FORK.

One of the most important additions to the power loom is that for stopping the loom in the case of the weft breaking or the shuttle becoming empty. The contrivance is simplicity itself and only requires a very brief explanation. Fig. 265 gives a representation of the weft fork detached from the other parts of the loom. F is the fork in the

form of an L lever, having three prongs at one extremity and a hook at the other, and as seen in perspective in the illustration. In the going part, and alongside the sley, is placed a small grate through which the prongs of the fork can pass as the reed is brought up to the fabric; under the hooked end of the fork is placed a lever L, with what is termed a hammer head, that is, a flat cross head with a notch upon it and hinged near its centre,

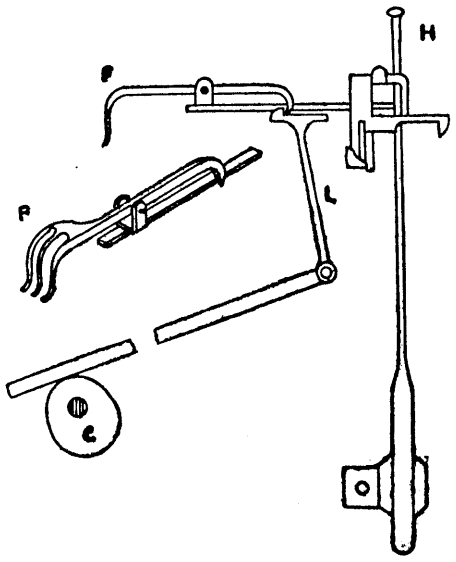


Fig. 265.

the lower end resting upon the tappet of the loom; upon the tappet shaft is placed a cam C, which will lift the lever L at each revolution; as the lever is lifted the hammer head will be thrown back and in the event of the hook of the fork resting upon it will pull it backwards towards the belt fork handle H. The spindle upon which the fork is hinged is carried to a lever resting upon the

breast beam, and in such a manner that on being pulled back by the lever H it would strike the handle and throw it out of the notch in which it usually rests when the belt is on the driving pulley, and so throw the belt on to the loose pulley and stop the loom. Very little need be said of this contrivance, everything depends simply upon the careful balancing and adjustment of the parts; the fork must be placed exactly opposite the grate at the end of the reed so that it will pass readily through it; it must be carefully balanced so that as the weft strikes the lower part of the prongs it can raise the hook clear of the hammer head, and this being done the timing of the movement need only be adjusted, so that the hammer head begins to recede exactly as the reed comes up to the fell of the cloth, which requires only a moment's consideration to see that in the event of the weft being in its usual place the prongs of the fork will be pressed back and the hook raised to the highest point just when the reed is in contact with the cloth, and that before the hook is allowed to descend the hammer head must have moved sufficiently far to prevent the hook dropping into the notch for it, and so permitting the loom to run; but if the weft is absent the prongs of the fork pass clear through the grate allowing the hook to remain immediately over the hammer head, when it will be caught and the belt thrown off, so that very little is required on the part of the weaver or overlooker to ensure good working on the part of the weft fork.

CENTRE WEFT FORK.

The weft fork just described is only really useful at one side of the loom. For plain looms, or for box looms, where the boxes are at one side only, and consequently where the pattern can only be in "double picks" it is, both for simplicity and efficiency, no doubt the best; but

where there are boxes at both sides of the loom, or for "pick and pick" looms, it is quite useless, as there might be weft at both sides of the loom at the same time. For a long time there was a difficulty in dealing with looms with boxes at each side until the centre weft fork was introduced. The centre weft fork consists of two essential parts, one attached to the shuttle race, whose chief function is to feel for the weft, and the other attached to the inside of the breast beam, and which will be acted upon by the feeler in the case of the weft being absent, and bring the loom to a stand by acting upon the belt fork.

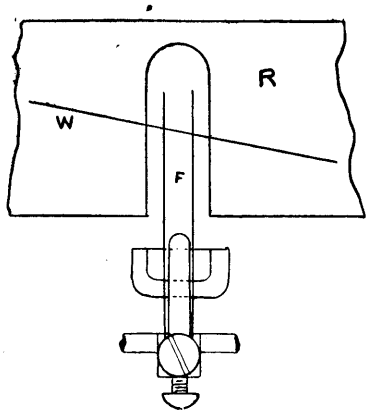


Fig. 266.

In the shuttle race R of the going part (Fig. 266, which shews a plan of that part attached to the going part) a groove is cut, and the fork F having two or more prongs is made to rise and fall, being hinged to a vibrating pin the prongs of this fork are made to feel for the weft. A front elevation of the whole apparatus is shewn at Fig. 267.

The fork F is hinged upon a pin as shewn at the extreme front of the drawing Fig. 266, and carried in brackets on the front of the sley board, or under the

shuttle race, and marked B in Fig. 267. A rod T passes through in the flanges of a forked guide, which swings freely upon its holder or bracket arm H, which in turn is fixed upon the bar V which runs across the loom; immediately above the flange the rod T is provided with

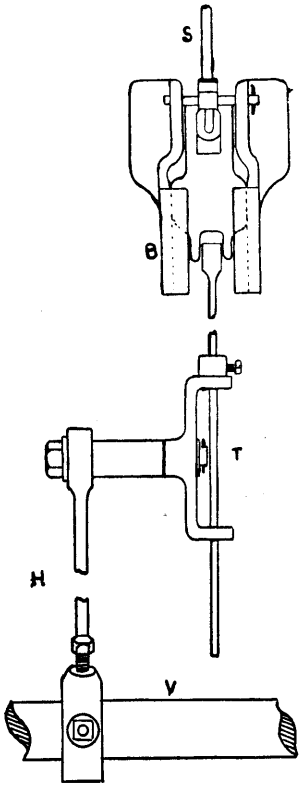


Fig. 267.

an adjustable collar and set screw, which practically rests upon the flange, and so adjusted that when the going part is thrown back the fork F is raised. From the position of the guide below the Fork F and its shifter, which is

carried upon the rod T, the fork is acted upon as the sley moves forward in such a manner that the space between the top flange, through which T passes, and the fork F is increased, therefore all these parts, upon, or connected with the spindle T will fall by gravitation. The fork comes in contact with the weft W lying across the groove in the shuttle race and arrests the downward progress, and the fork is held in position until the movement of the going part has carried it forward until

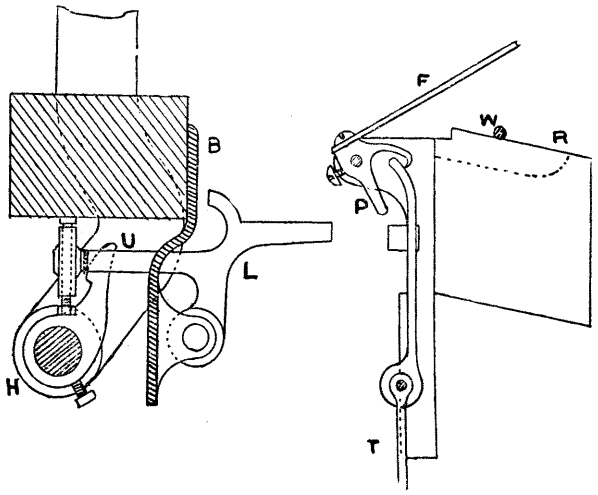


Fig. 268.

the prongs are clear of the weft, when it drops into the bottom of the groove. In the meantime that part hinged to the upper end of the rod T, with its slot, has dropped too low for the peculiarly shaped hook, seen at the lower end of the fork F in Fig. 268, to take hold of it. Should, however, the weft be absent, this hinged arm on T would be caught in the hook, and the downward progress would be at once arrested; then the projection on the front of this hinged arm would be held opposite

the lever L under the inside of the breast beam. This lever or finger turns upon a centre placed below as shewn in Fig. 268, and held in position by a bracket attached to the breast beam. Another lever U is attached to a rod under the breast beam at H, and to which is also an arm pressed against by the opposite arm of the lever L, so that should the projection in front of the upper part of T strike the lever P the lever arm U would be pressed back and striking the belt fork handle would throw the belt from the fast to the loose pulley and stop the loom.

Careful adjustment and balancing of parts are absolutely necessary for the successful working of this, as well as the ordinary weft work.

THE BRAKE.

An important adjunct to the stop motions and one which, in fast running looms, is an absolute necessity is the brake, this is illustrated in Fig. 247, page 431. The actual brake itself is simply a piece of iron, shaped so as to embrace a considerable portion of the circumference of the brake wheel, the wheel being placed upon the driving shaft of the loom; from the brake a connecting rod is carried to an L lever; the opposite end of this lever is connected by a second rod to the lever already spoken of in connection with the weft fork resting upon the breast beam of the loom; a weight is placed between the hinge of this lever and the end nearest the belt fork handle. In box looms where there is no stop rod the brake is actuated only by the weft fork and the moment that comes into operation, or when the belt is thrown off by the weaver in the usual course, the brake lever is dropped and assists in bringing the loom to a stop; but where the weft fork is used a pin projecting from the frog, as already described, has practically the same effect. The mechanism of this contrivance is simplicity itself and requires little explanation.

It is only necessary to say that it should be kept always in good working order as it may often save trouble which arises from the loom overrunning when the weft breaks, which as already explained, may cause irregularity in the fabric.

SELVEDGE MOTIONS.

The term selvedge motion may have two distinct meanings, first, where a special arrangement of apparatus is employed for weaving a selvedge of a totally different pattern from the body of the cloth, and second, where it is used for making what is termed centre selvedge, *i.e.*, for binding the sets of threads firmly together at the middle of a wide fabric, so as to permit the fabric being cut at the centre and making two pieces without any risk of the selvedge fraying. In the first category will come such cases as weaving a satin or twill fabric and it is required to have a plain selvedge, or it may be any other pattern. When worked from a dobby or jacquard this is easily accomplished and special selvedge healds or harness cords will be employed, and actuated by their own hooks will permit of any pattern being made at will. In many cases of twilled fabrics a plain, or approximately plain, cloth may be formed on the selvedge by a mere drafting, or arrangement of the threads through the healds, but such a thing could only occur when the number of picks in the ground pattern should be an even one, and the order of succession in raising and depressing the healds such that, by a selection of threads, could be made to alternate with each other. Sometimes one extra heald is introduced, and some of the threads drawn over the tops of some of the mails and threaded through others may serve the purpose, but all these devices are dependent upon the ingenuity of the overlooker or designer. The one thing to avoid is the use of extra tappets for actuating the selvedge motions, and if possible to avoid the use of any special appliances.

To name the different devices that may be resorted to, such as suspending the selvedge healds from two different jack rods, or other devices of that kind would not only be tedious, but it would be impossible to give illustrations which would meet every case. On the other hand to describe all the various apparatus which have been employed from time to time would be equally tedious, one example must suffice for the purpose. This consists of placing upon the lower shaft of the loom a scroll tappet, or cam, as shewn in the illustration Fig. 269. This tappet acts upon one

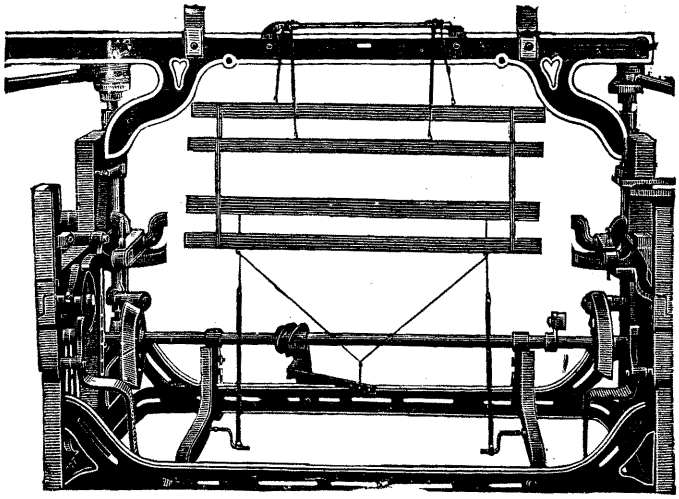


Fig. 269.

arm of the lever which is connected at the opposite extremity to the bottom of the heald; two healds are employed for the selvedge only and are connected by cords passed over a roller, or pulley, in precisely the same manner as described in the plain loom with the under shedding tappets, so that as one is pulled down the other is raised, and so going on alternately; as a consequence with this simple contrivance, which can be applied to any loom at a very trifling cost, a plain selvedge may be woven, no matter

what the pattern of the ground. The simplicity and effectiveness of the apparatus is so obvious that it would be idle to waste time in describing it. This is the invention of Messrs. Bracewell Bros., of Shipley.

CENTRE SELVEDGE MOTIONS.

Of all selvedge motions the one which attracts most attention generally is that which is commonly spoken of as the centre selvedge. This is simply an arrangement which is used when two fabrics are woven side by side and cut up so as to form separate pieces. In the ordinary course there would be, on the cut up side, what is termed a raw edge, and one which would be very liable to fray, and the object is to prevent not only the fraying but to make the edge as firm as possible, and present all the appearance of a proper selvedge; strength, neatness, and firmness being important factors. From time to time methods have been resorted to, varying from the commonest attempt at gauze weaving to a system whereby the weft threads were cut immediately they were beaten up, and the next insertion doubled them up and inserted them into the selvedge, so as to give all the appearance of a perfect selvedge. Between the two extremes however, there must be some medium which is not only sufficiently useful but also sufficiently simple for all practical purposes. To again revert to the two extremes let it first be imagined that two pieces be woven side by side and then split up the centre, and have the two inside selvedges woven as firmly as possible; no matter how firm the texture of the selvedge is, a small fringe of weft must be left after cutting, and in all probability some tendency for the warp threads to fray out will exist.

A difficulty in weaving will naturally accompany the extreme firmness of the centre selvedge and also a tendency to curl or cockle. Then to take the opposite extreme,

the one just suggested, and which has recently been the subject of a patent, of doubling the cut thread into the centre selvedge, must, although producing an apparently perfect selvedge, have exactly the same effect, in consequence of the crowded condition of the weft threads. After all, in spite of the enormous number of devices that have been attempted from time to time, the best remedies, or the best methods of making a firm centre selvedge is dependent upon one of two means, either the working of a small number of threads at the extreme edge up to the cutting, in gauze fashion, or causing them to twist round each other after the manner of a lock-stitch sewing machine. For the first of these any weaver having sufficiently wide aquaintance with practical weaving will find numerous devices which will answer his purposes. He may rig up an ordinary doup and actuate it either direct from his tappets or treadles, or by means of what may be termed jury jacks; or he may resort to the use of a common bead through which a couple of loose heald threads are passed and attached to ordinary heald shafts of the loom; the warp threads also being passed through the eye of the bead, and as the heald shafts are raised and depressed alternately the bead will cause the thread to cross from side to side of two or more of the selvedge threads, and so bind them so firmly into the fabric that fraying cannot possibly occur; it is then only necessary that the crossing threads should be drawn from a bobbin so as to give the requisite length, for crossing and wrapping round the others. Sometimes the same thing is accomplished by using an apparatus consisting of a fixed needle placed above and pointing down between the warp threads, and a movable needle pointing upwards and passing this one, either by means of a small cam on the lower shaft of the loom, or any other arrangement which will cause it to rise and fall for alternate picks, and at each upward movement pass first on

one side and then on the other of the fixed upper needle, so causing a crossing which is identical with that of common gauze. It would be no exaggeration to say that there are scores of devices of this kind in use varying simply in the details of their mechanism, but all having precisely the same movement imparted and producing the same common gauze. Then there are numbers of others also which partake of what has been described as the lock-stitch sewing machine, these also are so nearly akin to each other that I shall only attempt to describe one which is illustrated in Fig. 270, and is the production of Messrs. Boyd, of Glasgow. In this a thread A is caused to be continually wrapped or twisted round another thread B in the course of the weaving. The thread A is wound on a bobbin contained in a shuttle, and which is held loosely, sewing machine fashion, in one of the spaces of the casing C, by a slightly raised rim or socket on the centre sliding piece F. The tension of the thread A is regulated by a small spring and holder on the friction plate of each shuttle, the thread B is wound on a bobbin E and drawn, as represented, round the back of the warp beam and over the slab stop, or back rail, and through one of the eyes in the metal strap D, and through one of the shuttle spaces of the casing. Then along with its respective shuttle thread A it is taken between the healds, and through a space in the reed, at a point where the selvedge is required to be formed. In the working of the mechanism the sliding piece F in the back strap D is made to reciprocate in concert with the healds F, sliding in the casing C, so as to cause the threads A and B to be alternately brought to the top and bottom by means of the two parts D and F, which are connected above and below respectively by the straps passed round two small pulleys, and worked from beneath by a cam, lever and spring, as seen in the illustration. Then as the thread

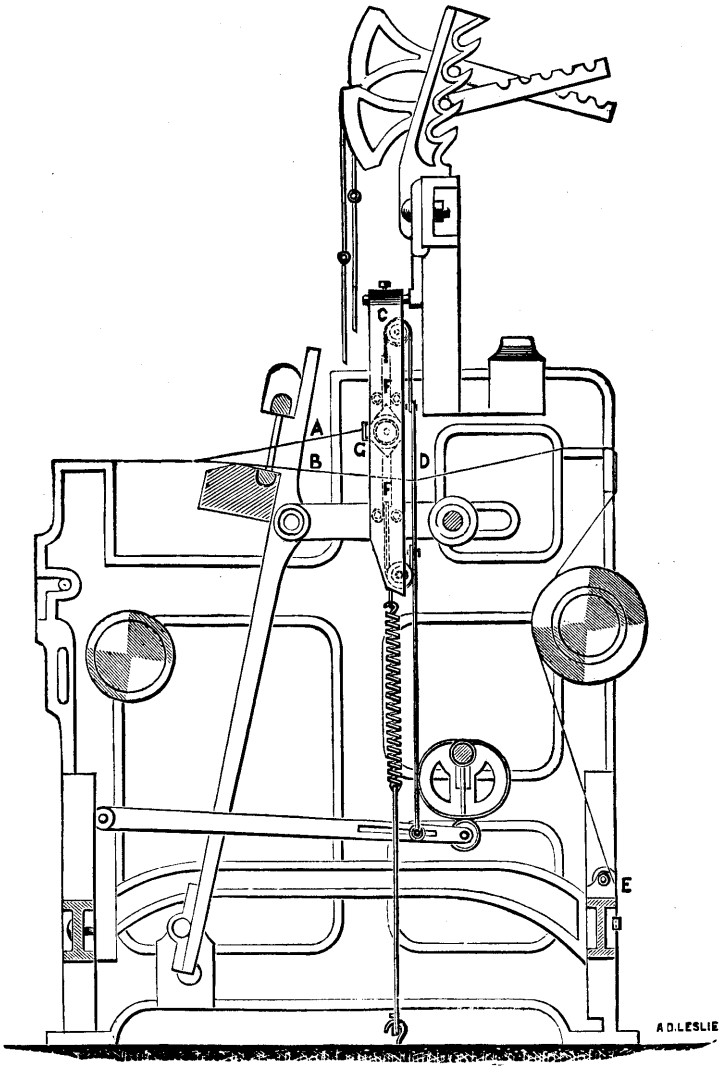


Fig. 270.

B is drawn through the casing in travelling from top to bottom of the shed it passes down one side and returns up the other side of the shuttle G, thus causing the twisting continuously round A, as already described, and binding the threads firmly together and preventing any possibility of fraying, the firmness being dependent upon the amount of tension put upon the two crossing threads. Each selvedge motion has a right and left shuttle answering to the two selvedges to be formed, and, of course, it is necessary to have them in their proper places, the rule

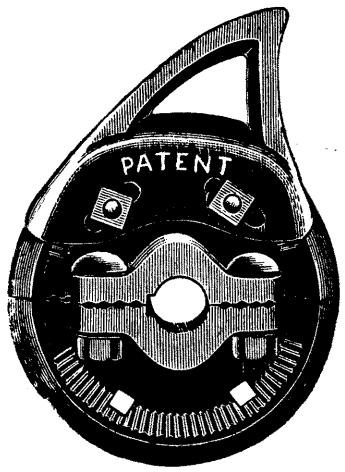


Fig. 271.

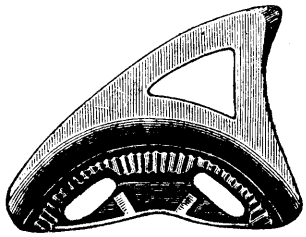
being to place the shuttles so that the tension springs are turned outwards and upwards as represented in the illustration.

PICKING MOTIONS.

I must now give a few supplementary details in reference to picking motions. Strictly speaking these should have been included in Lecture 4, but have been overlooked. It will be remembered that in that lecture some attention was given to the arrangement and form of picking tappet for

what is known as the cone picking motion. A recent improvement in this connection is illustrated at Figs. 271 and 272. This consists in a form of disc and tappet nose which are readily adjustable, and are said to meet all the requirements of the ordinary picking tappet. The tappet in its complete state is shewn at Fig. 271, and consists of the disc and two parts, bolted together upon the shaft after the manner of a clamp; the tappet nose is bolted to it in somewhat similar manner to the

Fig. 273.



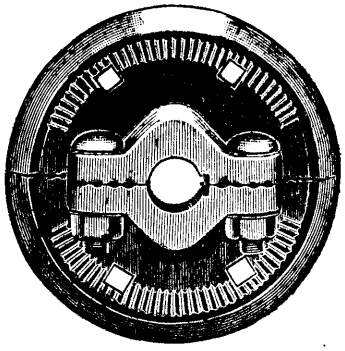


Fig. 272.

ordinary tappet nose, but presenting this difference; a series of teeth are formed in the rim of the disc as shewn in Fig. 272, and a corresponding set inside the rim of the nose at Fig. 273; the tappet nose has two slots corresponding to the bolt holes in the discs, so that it can be adjusted to any position; and it differs also from the ordinary tappet, inasmuch as the disc remains a perfectly true

circle, and the whole of the rise for picking purposes is contained within the tappet nose ; and it is also contrived so that it is interchangeable and may be placed upon either one side or the other of the disc. It need hardly be said that the shell, or boss, or disc instead of having the bevel formed as suggested in Lecture 4 for tappet drawing is a more rounded surface than a truly bevelled one, and consequently evades, at least in some measure, the principles there laid down. Whether this evasion and the form of the adjustable tappet nose is really advantageous, there are several advantages at least claimed, the one being the readily adjustable character of the tappet nose, the other the fact that the noses are interchangeable, and finally their ready adjustment and easy application either by skilled or unskilled workmen. So far as the advantages of being able to change without having to remove the driving wheels, which always involves the risk of breakage, and the ready facility for adjustment, there can be no doubt, but as to the true form of tappet only the question of application in practice can determine whether the advantages are all that are claimed for it.

Another form of picking arrangement which should have been dealt with in Lecture 4 is dealt with in Fig. 274, and which refers to the Knowles' loom, which has been so often referred to. It will be remembered that something was said as to the use of sliding tappets for what are known as pick and pick looms ; this is one of the contrivances based upon the use of the vibrator lever and revolving discs so fully described, both in reference to the box motion and the shedding motion of the Knowles' loom ; the vibrator lever V is acted upon in precisely the same manner as the vibrator in the box arrangement, the rod R communicating motion to the lever L, which in turn causes the picking arm P to slide upon the picking shaft and come in contact with a short lever arm which acts

upon the picking stick in precisely the same manner as the under pick motions described in Lecture 4. The connecting rod C connects the two tappets so that as

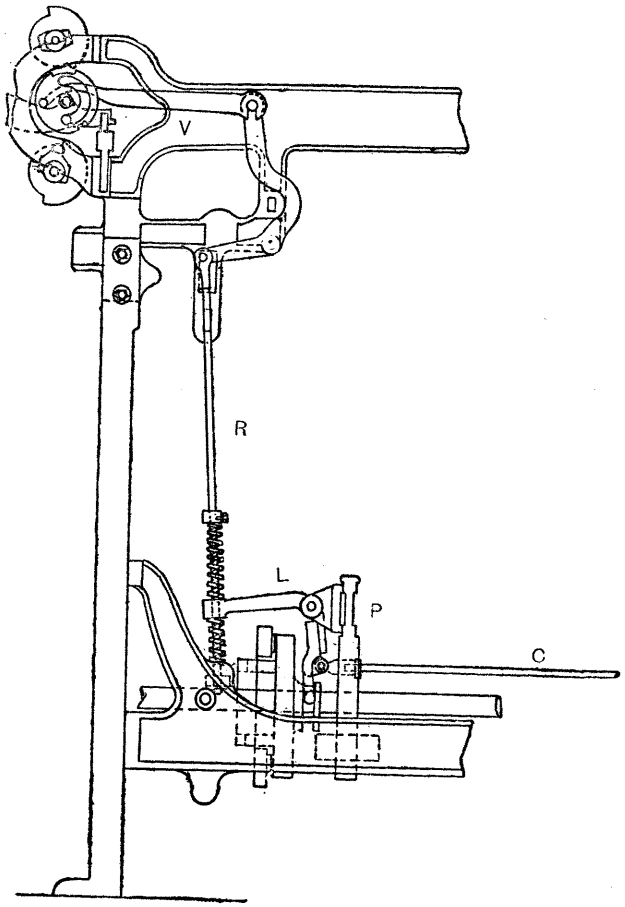


Fig. 274.

one is engaged with the picking lever the other is disengaged, and consequently there can be no liability to mishap by both being brought into action at the same

time. To ensure sufficient ease and elasticity of movement the lever L is placed between two springs upon the rod R, each held in position by collars and set screws so that there is sufficient room to give way and prevent any harshness or liability to mishap.

MEASURING MOTIONS ON LOOMS.

I must make some passing allusion to a contrivance which, although not usually necessary may be for some special reasons desirable, that is, the measuring of fabrics as they are being woven. I need not attempt to define all the conditions under which this may become either necessary or desirable, nor shall I attempt to describe all the methods which have been resorted to for attaining the object. One is shewn at Fig. 275, as made by Messrs. Ward Bros., of Blackburn. The apparatus is simple and needs only very brief description; a chain wheel K is mounted upon the taking up beam L, and by means of a chain M motion is communicated to the chain wheel K^1, and on this is mounted a change wheel which gears into another change wheel mounted on the disc N. On this disc are moveable pins N^1 which in rotating come in contact with the upper extremity of the catch J, a slight movement of which will depress the end of the lever L, to which it is attached, sufficiently to lift the catch of the dobby by means of the connecting chain G, and make a change in the lattice barrel of the dobby machine. This, it will be understood, in weaving towels or dhooties, or any bordered article, is of considerable importance as ensuring the exact length of fabric being woven, and in fact takes the place of the border dobby as already described. By means of the chain I which is connected with the swing lever of the dobby the catch J is released from the pin N^1 immediately the change in the lattice barrel has taken place, and is thus brought

into position for being operated upon by the next pin; so that the operation goes on continuously, weaving borders and middles alternately, and ensuring accuracy of measuring.

BELT FASTENINGS.

Amongst the trifles which go to make up the sum of the troubles of the power loom overlooker, the methods

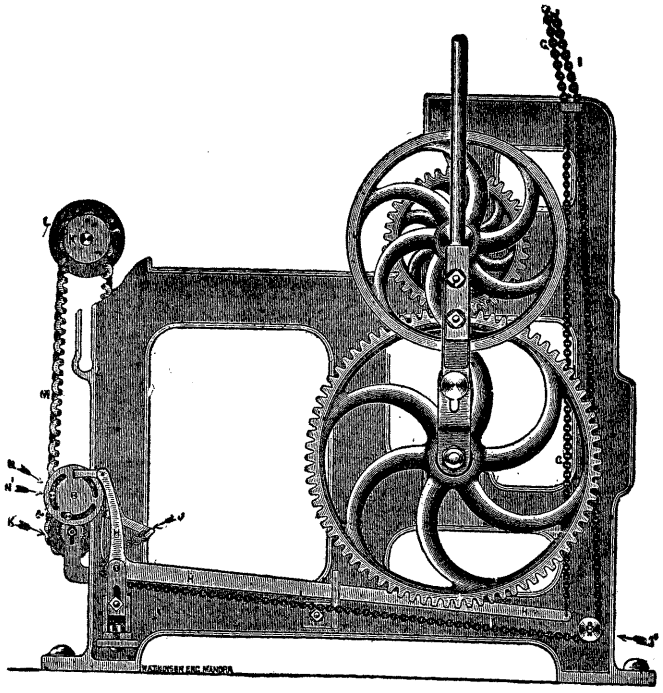


Fig. 275.

of "sewing" or fastening the ends of belts are not to be overlooked or too lightly treated. In heavy looms "sewing" with a proper "lace" was at one time the regular practice; in light looms "sewing" with a bit of wire was considered good enough, and is still practised; but belt fasteners of one kind or another have of late

become more general, both on account of the facility with which the ends of the belts could be joined together and the increased security obtained. To enumerate all the various systems would be too much of a task, but one may be referred to. This consists of a species of staple

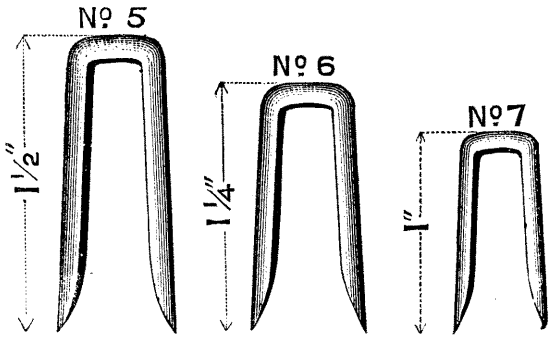


Fig. 276.

having the points slightly diverging and tapered on the inside, as shewn in the illustration Fig. 276, and made, as shewn, in different lengths to suit the thickness of the belt. For the purpose of "sewing" the staple is placed in a holder, as shewn at Fig. 277, and driven by a hammer through the belt, whilst the latter is resting

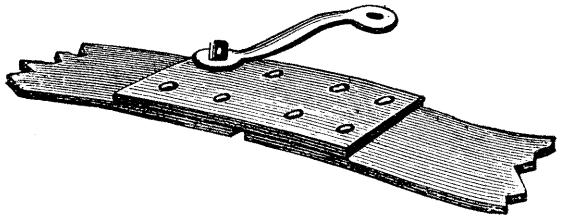


Fig. 277.

on a smooth surface, the result is that as the points of the staple emerge from the leather and come in contact with the metal they immediately begin to turn outwards and upwards and clinch themselves in the leather, as shewn at Fig. 278, thus making a most secure joint. Whenever it is

necessary to extract the fasteners for the purpose of shortening the belt, or any other reason, a ready means is provided in the "extractor" hook shewn at Fig. 279. The whole contrivance is the production of Messrs. Davidson and Co.. of Belfast.

Fig. 278.

REED AND HEALD MAKING.

I shall now refer, but briefly, to machines which scarcely come within the province of a lecture on weaving and yet have a direct connection with the subject. That is the manufacture of reeds and healds. It is a far cry from the time when reeds, as their name implies, were

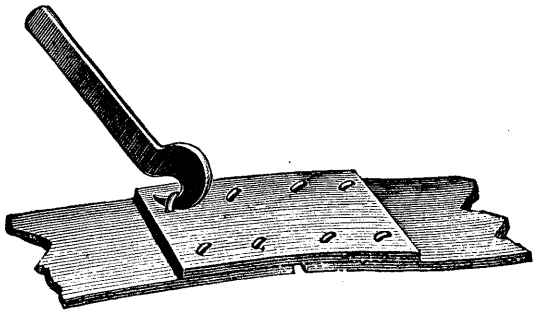


Fig. 279.

made from the split reeds or canes, and placed by the fingers between the ribs which held them together, to the time of fine iron or steel wire placed in position in the ribs by machinery at perfectly even distances apart, and to any degree of fineness. In one sense reeds may be said to be woven. The ribs are placed in holders upon the bed of the machine, as shewn at Fig. 280, and which

bears some resemblance in appearance to the mechanic's lathe, and passed through what might be termed the head-stock; the wire, which has already been rolled, flattened and polished, is fed from a reel and inserted between the ribs by a species of automatic pliers in front of the head-stock, and instantly cut off to the proper length. At the same moment a pair of fine steel beaters, which fulfil the same functions as the reed itself does in weaving, press the wire into its position, and simultaneously a bobbin placed upon a species of face plate is made to revolve round each rib and coil a thread round to hold the wire in position. The number of wires inserted per

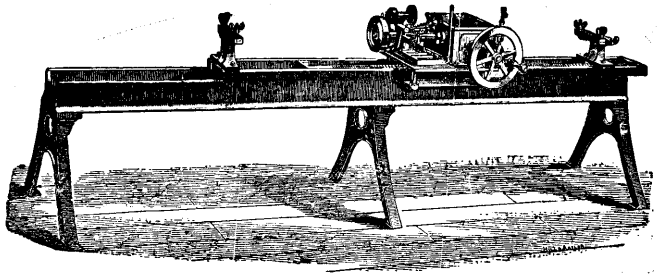


Fig. 280.

inch is determined by a train of wheels, one of which is changeable, somewhat after the style of the taking-up motion of the loom. To ensure the wires being held in position by the cord which is wrapped round the rib the cord is saturated with pitch as it is wound upon the bobbin, and is kept soft during the working by a small gas stove placed immediately under the bobbins as they revolve. Altogether the machine is most ingenious in construction. It must not be supposed, however, that the reed is absolutely perfect when it comes from the machine, some of the wires may not have been inserted quite straight, or may have partly turned; then the work of the "setter" comes in with a pair of fine pliers, every

wire which is out of place must be put perfectly straight before the pitch upon the rib has had time to set, otherwise faults would occur in the cloth from the irregularities.

In reed making, just as in cloth making, strict attention must be paid to the size of the wire, and the thickness of the cord wrapped round the ribs, otherwise the wires would be held too rigidly or too loosely, and all good weavers know the value of a proper degree of flexibility in the reed.

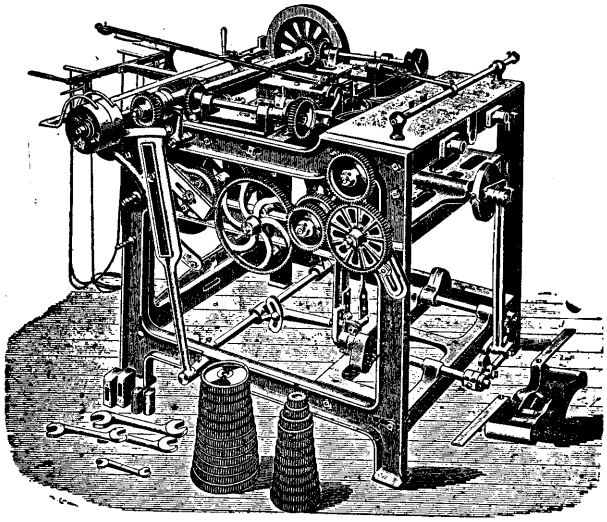


Fig. 281.

HEALD KNITTING.

The term heald knitting is a survival of the days when they were all made by hand, and when the knot fastening the heald thread to the "rig band" was made by the thread itself. In machine-made healds this is different. True in one form of heald, where the eye for the warp thread to pass through is formed by a loop knotted on the heald thread, a species of knitting is resorted to for fastening

to the rig band, and the manner in which this is performed by the machine is both ingenious and interesting. A general view of the machine is given at Fig. 281, and without attempting to describe all the working parts it must suffice to say that the knots for the loop or eye are formed by the bobbins being carried round upon a species of spindles and face plates, which with the assistance of sundry hooks in throwing the loops over, perform the work in a most astonishingly short time.

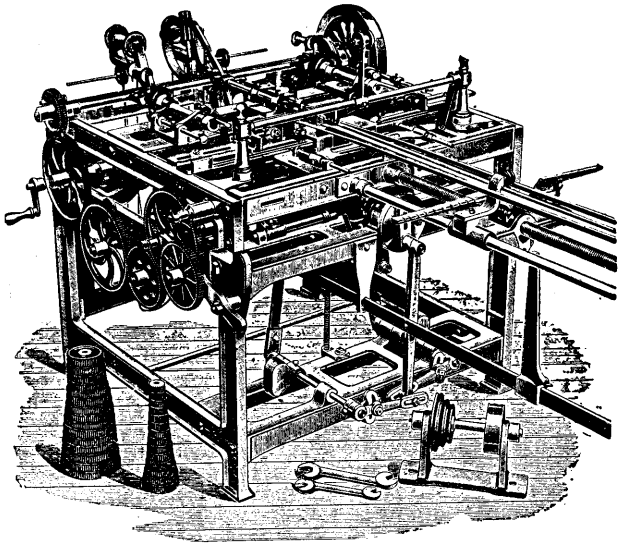


Fig. 282.

Another machine is shewn at Fig. 282, for making healds with mails or metal eyes. In this case the heald yarn is threaded through a large quantity of mails and passed forward to the machine. A species of feeler passes the mails forward one at a time, whilst the thread is at the same moment brought up to the rig bands, the moment this is done a bobbin carrying a fine strong thread

revolving upon a face plate through which the rig band is passed coils its thread several times round and thus secures the heald thread; this is repeated continuously.

Again as in the loom, each machine is provided with a train of wheels which determine the fineness of the healds. These machines are made by Messrs J. Kitson & Sons, Bradford.

A few words might be said here which might well have been said in a previous lecture, as to the proper depth of healds for different classes of work. It is matter of common knowledge to weavers that if the healds are too "shallow" it is very difficult to weave some classes of goods, and that it is therefore better to err on the side of having the healds a little too deep—if such a term may be used. The deeper the heald, and, naturally the more elastic it is, and the reverse; and we know that elasticity in the healds will prevent friction on the warp threads, therefore let all the elasticity possible be obtained. I do not mean to suggest that it should be carried to an exaggerated or ridiculous length, but that any tendency to error should be on the safe side. True, the cost of the healds will be greater, but probably it will be more economical in the end.

LECTURE 12.

LOOMS FOR SPECIAL PURPOSES.

In speaking of looms for special purposes, the first difficulty which arises is the selection of those worthy of a description without creating unnecessary repetitions; we may say, for instance, that a loom must be built for any special purpose from the finest silk fabric through the whole range of cotton, woollen, linen or worsted down to that required for weaving the heaviest cocoa fibre matting; but although looms may be built specially for all fabrics within that wide range it need not necessarily follow that any special or new principle of construction will be involved; it might resolve itself simply into a question of weight or power to produce light or heavy fabrics, and consequently what has been said in a general way of loom construction might be equally applicable to any or the whole of the series. It will be necessary then in this lecture to confine attention to looms constructed for the production of special fabrics and pay attention to the methods of ornamenting or constructing fabrics for special purposes. Perhaps the first loom calling for attention under this heading is that generally known as the swivel loom. This loom may be built to serve two distinct purposes, the one being the production of narrow fabrics, such as ribbons or tapes, and the other the production of a figure confined within a limited space on the surface of any ordinary fabric. It will be best to begin by first dealing with ribbon or tape looms, as the principle involved there will cover the whole field of swivel work. The great object is to be able to weave upon one loom a large number of narrow fabrics, each complete in itself, each

having a perfect selvedge and made as though they were made upon separate looms; or in other words, a large loom must be made to weave a number of narrow fabrics side by side. In all the looms described up to now a shuttle has been propelled from side to side, but in the swivel loom the shuttle must be driven positively; carried, not thrown across, and for weaving a large number of fabrics at once, we must have a separate shuttle for each fabric, otherwise each cannot have its own selvedges, but we should be compelled to resort to the split-up, or centre selvedge, as described in the last lecture. A general idea of the arrangement of a swivel loom may be gathered

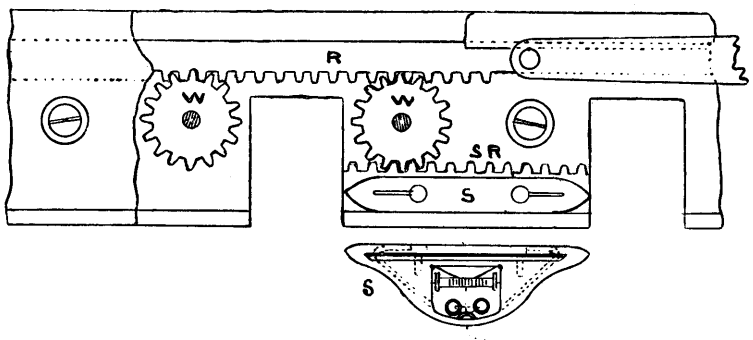


Fig. 283.

from the illustration at Fig. 283. To what is generally termed the handrail of the loom a long rack R is attached, this acts upon a toothed wheel W, which in turn operates the swivel rack SR, which carries the shuttle S. The rack R is actuated from the side of the loom either by means of a cam, or any convenient arrangement, and so carries the shuttle across the intervening space between the wheels W and W, within which the fabric must be formed. The form of the shuttle is illustrated beneath the figure, at S, which is really the plan of the shuttle

itself. The yarn is wound upon a small bobbin placed within the shuttle and brought through an eye in the extreme front, and at the back of the shuttle a groove is formed to permit of its being placed in the carrier, or rack at R.

Now suppose we are weaving a large number of tapes we should have a separate shuttle for each one; then occurs the question how many could we put upon one loom, or what are the conditions which will govern the width of the tape and the size of the shuttle. A reference to Fig. 283 will readily enable us to get rid of one or two of the questions. The width of the space between the shuttles must determine the width of the fabric; but it might be said we may make those anything; so we may, within certain limits, say from one inch to four, but whatever the width of the space wherein the fabric is to be formed it must be obvious that the length of the shuttle, and the space between the fabrics, should not be less than double the width of the fabric itself. Suppose, for instance, we are weaving a tape or ribbon, one inch in width, then we should have a space between each of such ribbons of not less than two inches; the wheel W must carry the shuttle by positive motion across the space, and it must carry it forward so far that the next wheel can take hold of it, so that making a moderate allowance between one wheel and the other, from the centre of the wheel itself to the margin of the fabric cannot be less than half the width of the fabric, so that the distance from the centre of one wheel to the centre of the other must be equal to double the width, therefore the length of the shuttle and shuttle rack should correspond approximately to this. Beyond this there are practically no limitations; we may work not only with one shuttle for each fabric but with any number; the usual practice is to work with rising boxes and each having its own rack

driven from one common rack behind, so that whichever shuttle is brought to the level of the fabric may be acted upon; for ease and steadiness of working there is probably no loom which works so easily and smoothly as the swivel loom. To those accustomed to ordinary looms, more especially of the fast running type, where the shuttle is thrown from side to side, as it were by a spasmodic effort, it is almost painful at first to watch the slow easy going motion of the swivel; it seems to the unaccustomed eye as though the shuttle will not get clear of the shed in time to avoid being crushed as the reed comes up to the cloth, and this feeling is intensified by the appearance of a huge projection in front of the shuttle which seems to be sweeping the very fell of the cloth as it goes across. The question may naturally be asked, why have this huge projection in front? The answer is obvious and simple. The shuttle is driven slowly and by positive action, no more drag is put upon the thread than is absolutely necessary, and the nearer the shuttle can lay the thread to the fell of the cloth the more certainly it will accomplish its work and make a perfect selvedge at each side; so that the apparent inconsistencies in this class of loom, when compared with the ordinary loom, almost explain themselves when carefully examined.

In many cases, for the purpose of economising space, what is commonly known as the circle, or as it is sometimes called, the circular, or Swiss swivel loom has been adopted. This is shewn in the illustration at Fig. 284, and really consists in placing the shuttle within a species of wheel which carries it through an arc of a circle instead of horizontally, as in the common swivel loom; thus it will be obvious from the angle formed by the shuttle at each side of the fabric, that at least one half the space is economised. And it is also claimed for it that there is a corresponding economy of power. Whatever may be the fact as to the

economy of power there is no doubt the economy of space is one of the most important factors. Generally speaking, however, this class of loom is only used for weaving very narrow ribbons or tapes, such, for instance, as those ranging from ½ inch to 1 inch in width. Of course one thing must be obvious in the circle loom that it does not present the facilities for weaving with a number of colours or shuttles as in the ordinary swivel loom, the circles being attached to the handrail precludes, practically, the use of more than one colour; special contrivances may be adopted, but generally speaking, circles are worked with one colour only.

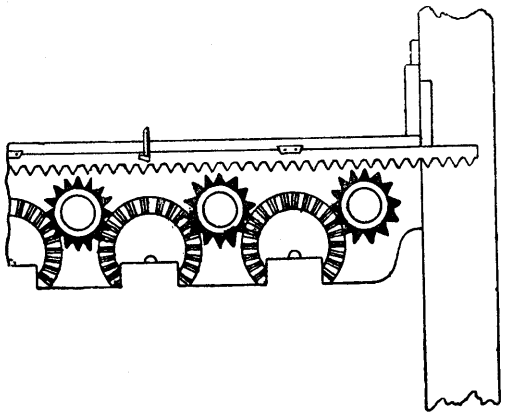


Fig. 284.

The use of the swivel loom for figuring upon solid fabric must receive some attention, and it is only necessary to consider it from two points of view, first where the swivel shuttle is made to act in introducing the extra weft or figuring material during an interval between the passages of the ordinary shuttle, and second where attempts have been made to cause the two to pass across the loom simultaneously. Whichever of the two systems may be adopted, the general arrangement of the swivel shuttle

will be practically the same. In the one case a separate shed will be formed for the swivel shuttle in the same manner as the ordinary shed is formed; where the ground and the swivel shuttle are operated simultaneously, two distinct sheds must be formed, one for each. This will be better understood by a reference to a bordered dhooty loom which will have to be described presently. Apart from what has been said of the method of operating the shuttle, there is but one thing requiring special attention in the management of this class of loom, that is, the determination of the space to be occupied by the figures and the distances apart of the figures. As seen in Fig. 283, the size of the figure must be limited to the open space between the several shuttles, and the rack carrying the shuttles must remain stationary until the complete figure is formed; then as one figure is completed, another may be commenced at a different part of the fabric, and for this purpose a rack and frame, made moveable, so that the figure can be formed in any position, so long as it is confined to the amount of space allotted to it, and the distances apart represented by the length of shuttle is used for carrying the shuttle boxes. Of course it must be understood that the mechanism of the swivel apparatus must be made to work in perfect unison with the other parts of the loom and that when the swivel shuttles are being passed across, the ordinary picking gear is altogether disengaged.

LOOMS FOR BORDERED DHOOTIES.

This is a swivel loom of the most improved type, made by Messrs. Platt Bros., Limited, Oldham, of which a full view is shewn at Fig. 285. Fig. 286 shews a section of the loom with the sheds open for the passage both of the ordinary and the swivel shuttle. 1 to 6 represent the healds both for borders and ground work, 1 and 3

carry the border warp, 2 and 4 the ground warp, and 5 and 6 actuate what are termed catch threads. It will be seen that there are two sheds formed at the same time, one for the ground shuttle and one for the swivel shuttle. The ground warp threads W and X pass over the back rail F from the warp beam in the ordinary manner; the border warp threads are brought from the beam H mounted above the loom and are then passed under the rollers G and G and direct to the healds; then catch-threads Y and Z are

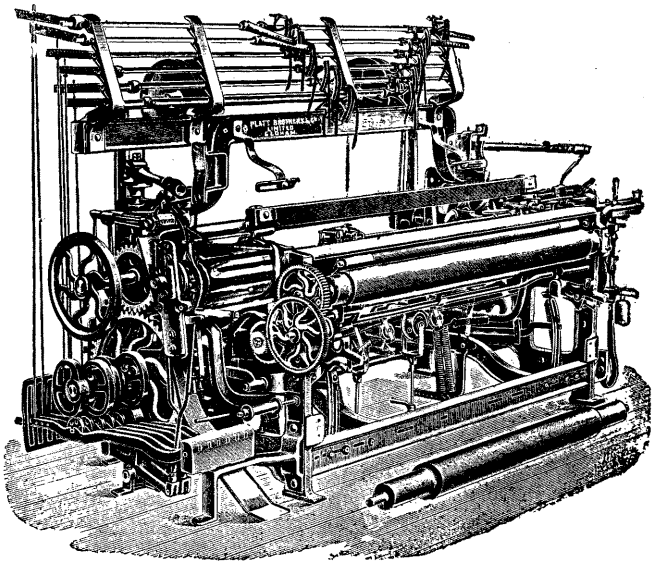


Fig 285.

carried, along with the ground warp, over the back rail F, so that it will be seen that each warp is placed exactly in the proper position for carrying on its work. The picking rods D D for actuating the border shuttles in one direction, in Fig. 287, which is an elevation of the working parts of the loom, are connected together by the rods I I entending from one picking rod operating the shuttle from one border to the next picking rod operating the shuttle

for the other border. The picking rods are fulcrumed on a fixed bar or bearer J J at E^1, and one of them is provided with a leg E^2 to which is attached a strap or band K passed over the pulleys L and L^1. The other end of the strap or band is attached to the lever O which is fulcrumed to a bracket on the back rail and actuated by a picking tappet, or cam, fixed on the tappet shaft of the loom in

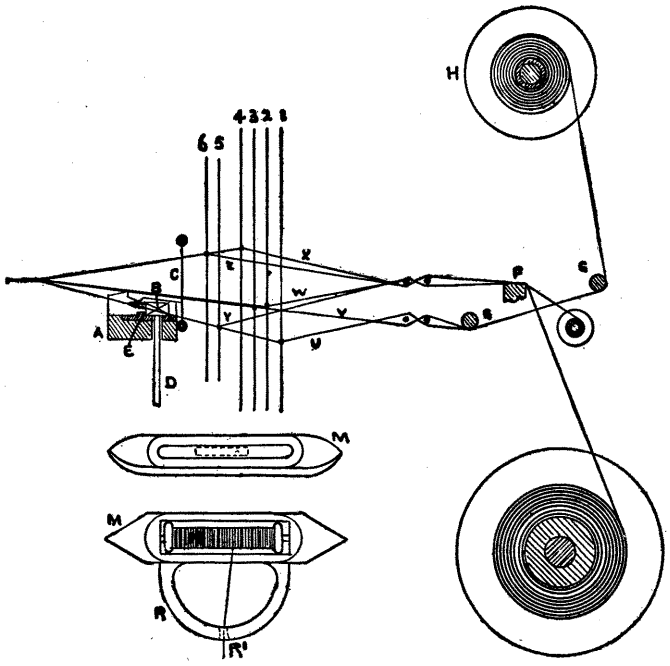


Fig. 286.

the ordinary way. The small shuttle boxes B B, formed for the border shuttles, are fitted into the lathe, or going part, which is recessed for their reception, and stops are formed in the front as shewn at B^1 through which the arc or bow of the shuttle protrudes. E and E represent the small pickers for actuating the border shuttles. A

plan and front view respectively of the shuttle are shewn at M and M in Fig. 286, the arc or bow R, having a

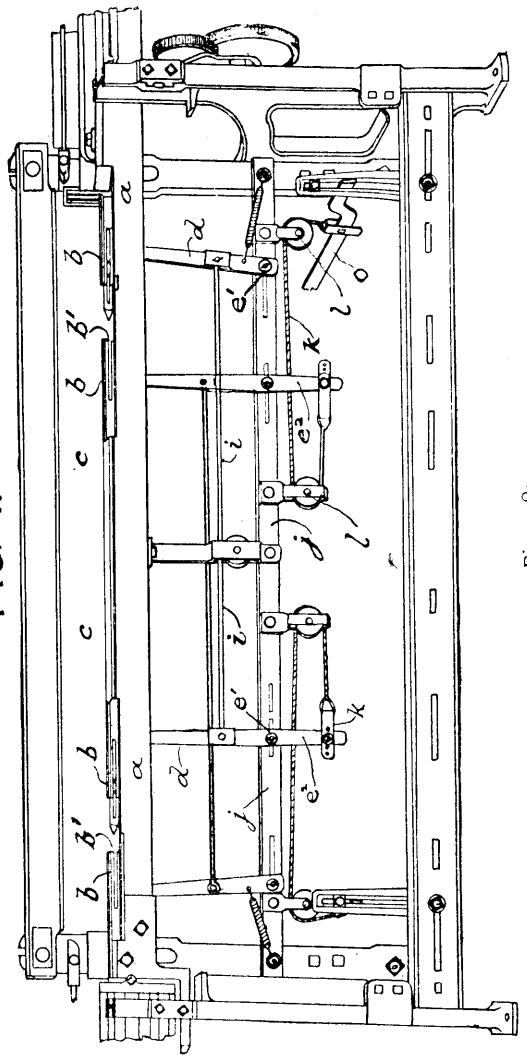


FIG. 4.

Fig. 287.

small opening at R', through which the weft passes; the size and form of the bow being, as already described, for

the purpose of laying the weft evenly in the shed. The shuttle boxes are provided with springs or box swells for keeping the shuttle firmly in position immediately on its arrival. As will be seen the shuttle boxes for the border shuttles are recessed below the level for the ordinary warp, and the two are so arranged that the lower half of the shed of the ground warp, or the central part of the dhooty, forms the same straight line with the upper half of the border warp; in other words the central warp forms the shed in the normal position, whilst the border warp is placed below it. By this arrangement the shuttle carrying the weft for the centre is always thrown clear over of the warps V and W, as shewn in Fig. 286. So that really the border and the centres are woven as it were independently and side by side but at two different levels. An extra weft fork is provided for each of the border shuttles and to enable them to be operated for stopping the loom when any one of the three weft threads break, or give out, the border shuttles are set to pick always in the opposite direction to that of the main or ground shuttle forming the body or centre of the fabric, and the hammers of the border weft forks operate at the contrary pick to that of the hammer operating the main weft fork, so that only one weft thread will pass in front of any weft fork at the time when motion is communicated to the hammer. Then the binding of the borders to the centre will be understood on reference to Fig. 288.

The catch threads which are marked Y Z in Fig. 286 are here bracketted together at B, and it will be seen that the weft threads A and C of the border and centre respectively are common to all the catch threads; the reason for this will be apparent on following the threads Y and Z in Fig. 286, where they are shewn as forming a shed equal in depth to both the others, so that both shuttles must pass through at the same time. In fact the two wefts

forming the border and centre respectively are common to all the catch threads. During the time the loom is weaving the centre part of the dhooty, and until it is required to produce the heading, or cross border, the motion for actuating the shuttle-box pattern cards is kept out of action, and only one shuttle is used for putting in the grey weft; but when the requisite amount of plain cloth has been woven an automatic arrangement worked from the taking-up

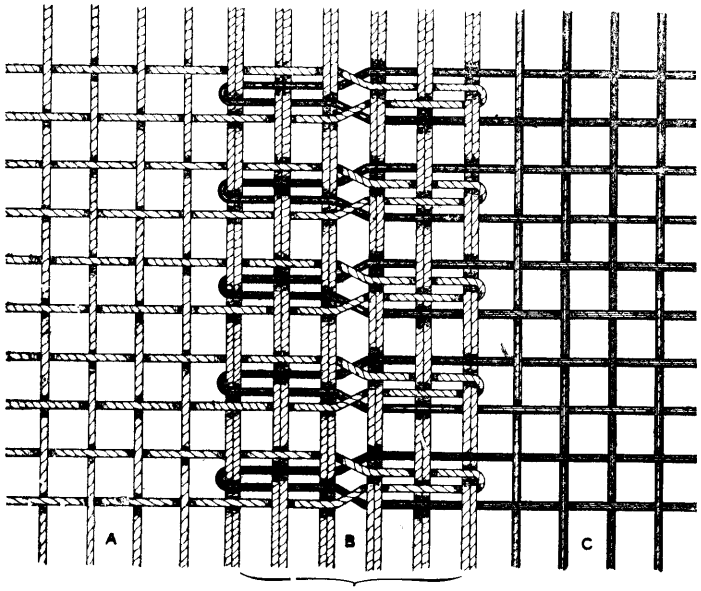


Fig. 288.

or measuring motion allows the catch which actuates the pattern card barrel to engage with the ratchet wheel, and so move the cards forward to select the shuttle forming the cross border. When this is completed the loom is stopped again, automatically, so that the weaver can wind the cloth forward a sufficient distance to form the fringe for two dhooties, then the loom is again restarted, a heading woven for the next dhooty, at the end of which

the grey shuttle is again brought into position, and so the operation goes on continuously. This description will probable assist us in understanding the use of the swivel for ordinary figuring purposes.

The principle of all swivel weaving is the same, when used for forming figures on a solid fabric, they differ from those described by being fixed upon a rack attached to the hand-rail, and so that they can be raised or lowered, so as to be out of the way of the ground shuttle as it is thrown across and dropped to the warp level when the swivel shuttles are in use. The rack may be moved from side to side, so that the figures may be formed on any part of the fabric.

LAPPET WEAVING.

The object of lappet figuring is to produce patterns by the introduction of extra material which in some respects is similar in appearance to swivel figures, and by a judicious arrangement and combination of figures may be made to approach very nearly the same appearance. Swivel figures as already shewn consist in the introduction of extra material figuring over a limited space and recurring at intervals across the fabric. So far the general explanation will apply also to lappet figures, but where the figure formed by a swivel consists essentially of weft threads that formed by a lappet consists of warp threads, but carried across the fabric by a series of needles, and stitched into it so as to present all the appearance of pattern being formed by weft. To abbreviate the explanation and make it clear, we may refer to the plan shewn at Fig. 289. In this illustration suppose the vertical and the horizontal line to represent warp and weft threads respectively, and interweaving so as to form a perfectly plain texture. Then a figure is formed by the introduction of an extra thread which is shewn as being carried backwards and forward over the surface of the fabric and stitched into it at

every point of turning. A fair comparison might be made between lappet weaving and other modes of figuring, by supposing that a perfectly plain fabric was taken, and with a thread in a needle stitched back and forward

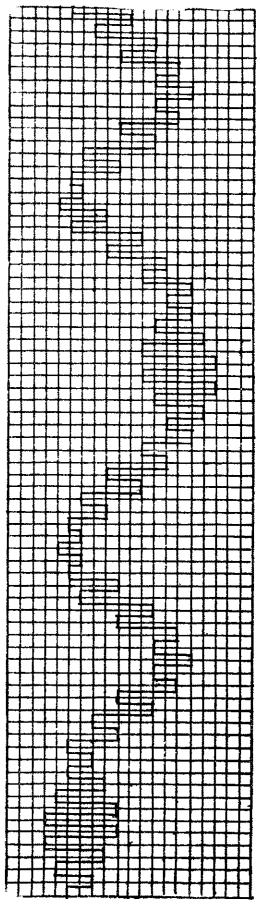


Fig. 289.

exactly in the manner suggested in the illustration. But instead of one figure being stitched in, a series of figures would be worked during the process of weaving, the

distances apart only being determined by the distance apart of the needles carrying the figuring threads. I will endeavour to make the process as clear as possible by reference to two illustrations Figs. 290 and 291. 290 shews a front elevation of the loom, and 291 a section shewing all the essential parts of the lappet arrangement. In both illustrations a series of needles N are shewn, those being carried in a

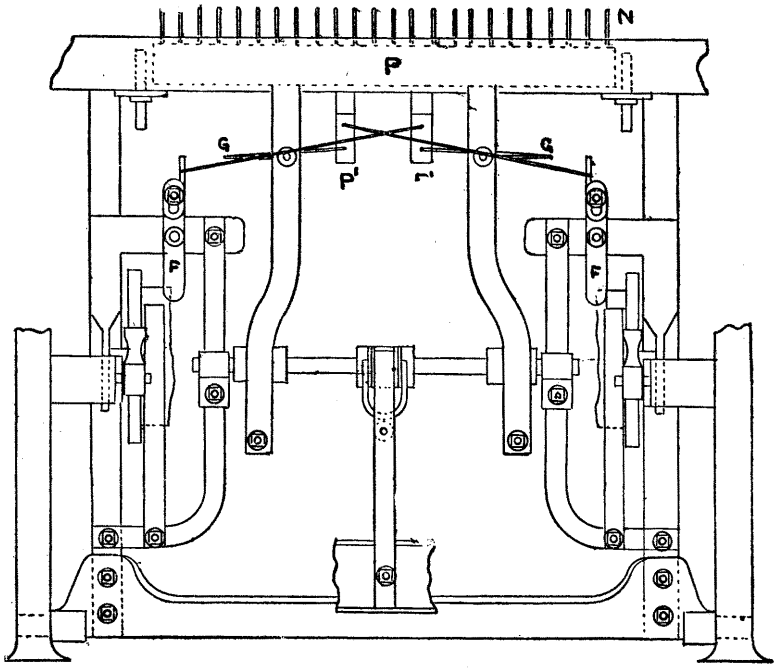


Fig. 290.

moveable frame seen at P in Fig. 290, and in section between the shuttle race and the reed at Fig. 291. Those needles carry the figuring threads which are brought under the sley board from the figuring warp beam over a small roller and through a tension arrangement as shewn at S in Fig. 291. At this point a clear explanation must be given of the arrangement of the whole apparatus; at N

in Fig. 291 there are apparently three needles between the shuttle race and the reed R, the front needle of the three is really one of a series for the shuttle to run against; the other two represent two distinct lappet frames, each of which may be forming a figure of its own.

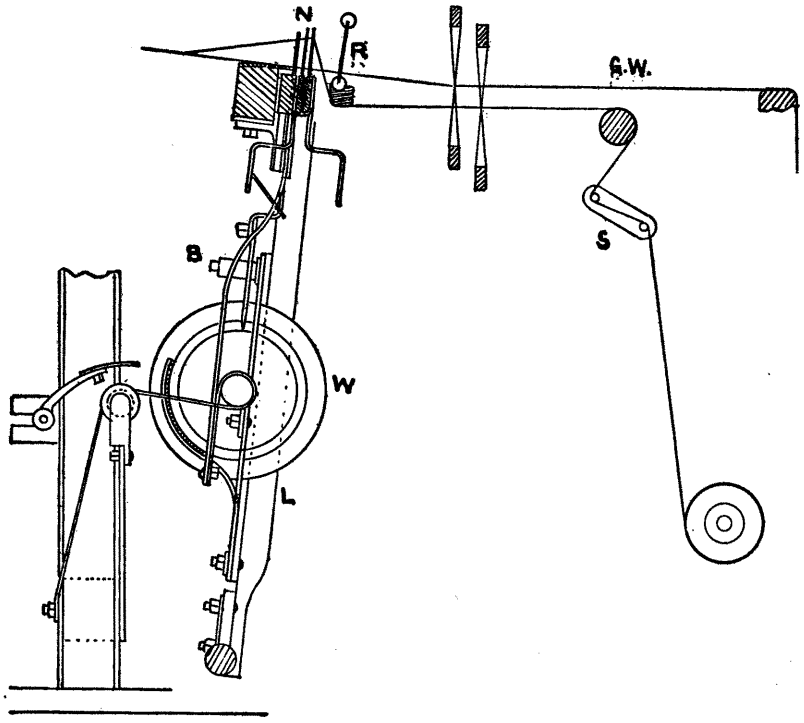


Fig. 291.

To those familiar only with the ordinary loom the introduction of needles between the reed and the shuttle may seem very singular, but a moment's consideration will at once shew that if the warp threads must form a figure by crossing and recrossing of the threads, as shewn in Fig. 289, the figuring must be done in front of the reed.

That being so, the figuring needles must of necessity rise in the fabric between the shuttle and the reed, consequently one series of needles must rise at every pick for the shuttle to run against, and the figuring needles must rise, carrying their figuring threads with them at any point desired for the formation of pattern, between what might be termed the standard needles and the reed. Although I am using the term standard needles here it must be understood that they are standard only in one sense, that they always rise and fall in exactly the same position, and that their sole function is to form a rest for the shuttle to run against, for the moment the shuttle is passed across the loom they must be lowered clear of the warp so as to permit the figuring needles to be moved as required for the formation of pattern, and also to permit of the reed beating the weft up to the fabric.

Now for a moment we might refer to Fig. 290, the needles N are carried in a needle frame P, to which are attached two vertical arms P^1. From each of those vertical arms, cords or straps G are carried to lever arms F, which may be acted upon by rods, governed by the lappet wheel with the pattern cut upon it. Of course it will be understood that P is attached to and carried by the going part and upon the swords L, as seen in both Figs. 290 and 291. I need scarcely stop to describe the whole of the details of the levers or brackets as seen in Fig. 290, as they are simply carriers for so many of the working parts.

Suffice it for the moment to say that the levers F are actuated, and the extent of their movement determined by a pattern groove cut in the wheel W at Fig. 291, and which will have to be more fully described presently. This lever F is hinged upon a bracket in front of the sword of the going part and the true position of which will be better understood by the spindle at B in Fig. 291.

The lower arm of this lever is seen to correspond at its extremity with a groove in the wheel, this groove being the determining agent in the formation of the pattern and which will cause it to move sideways by means of a feeler, and so cause the needle frame P to oscillate from side to side any distance corresponding to the groove cut in the lappet wheel. A cord will be seen passing round a small pulley in the centre of the wheel W, over another pulley attached to the front frame of the loom, and made fast to the loom frame. The function of this cord is simply to raise the needle frame every time the going part moves backward and to allow it to drop as the going part moves forward. In reality there are two systems in use for working the needle frames, the one briefly described here and the other known as the Scotch lappet. In the Scotch lappet loom the frames are raised by means of a series of cams, or by a sort of fixed levers under the loom, upon which vertical rods press as the going part moves, and the horizontal motion is communicated to the figuring frames by means of weighted levers which are operated also by cams. But although there is a difference in the manner in which motion is communicated there is no difference in the principles involved. Then only two things need be insisted upon here as necessary to a clear understanding of the manner in which the work is done. The first is that the needle frame carrying the needles against which the shuttle runs must rise and fall at every pick, that the needles carrying the figuring threads must be moved from side to side at every pick, and exactly the distance required for the formation of the pattern. Those two points being clear, the details of the mechanism for operating them may be varied to any extent, as it is obvious that the time when the needles rise and fall and the time when the figuring needles are made to traverse from side to side will be governed by

precisely the same considerations as those which determine the shuttle-box, that is, that the change must be accomplished when the shuttle is in the box, otherwise, of course, disaster must follow. Then before entering into the question of cutting the figuring groove on the lappet wheel I need only refer briefly to the arrangement of the threads as they pass through the needle from the warp beam. In Fig. 291 the ground warp is shewn passing over the back rail, through the healds and the reed in the usual manner. (By the way a mistake in the drawing might easily mislead a casual observer; two healds are employed, one of them shews the ground warp passing through it, the other one from its position, will suggest that the figuring thread passes through it; this is not so, the figuring thread does not pass through a heald at all, but simply through the tension rods S over the roller under the reed and direct to the needles.)

So far as the ground warp is concerned nothing need be said, as the arrangement is almost precisely the same as on any ordinary plain or plain gauze fabric, but so far as the figuring threads are concerned, a few words of explanation are necessary. The figuring threads are carried from the roller through the tension rods, as shewn in the illustration, but the object of those tension rods, as the name implies, is simply to keep the threads at a sufficiently high tension without being too great. To make this matter clear, begin by supposing that the warp is drawn from the roller direct to the needles in the usual manner of drawing the warp from the beam, then it must be considered that the figuring threads at each insertion of the weft pick may have to traverse half an inch, or any other distance according to the pattern, and be stitched into the cloth; there is no system of weighting a warp beam or roller which would give a sufficient amount of elasticity to the rollers to permit of such

varying quantities, as, say, from one-thirtieth part of an inch up to half an inch being drawn from it and yet have the threads held at approximately the same tension, hence the necessity for the tension rods. The arrangement of those tension rods is truly characteristic of the early hand loom weavers, there is no elaborate arrangement of springs, we simply have a flat piece of wood of the form shewn at S in Fig. 291 placed, say, within a foot of each side of the loom, the tension rods consist simply of two moderately stout wires; from each end of this piece of wood a piece of strong loom cord is carried either to the loom frame or to a strong spring attached to it, the wood frame is carried round and round until a twist is given to the loom cords and a tendency to the whole framework to spin round; then the warp threads are passed through in the manner shewn in Fig. 291, the result is that a kind of natural spring is formed with the loom cord itself, and whatever distance is taken up by the needles in their crossing and recrossing, the tension rods give it off readily and as rigidly take it off from the warp beam after the weft is beaten up to the fabric; so that there is not that tendency to pull the warp threads of the ground fabric at each point of intersection of the figuring thread that there would be if sufficient elasticity were not given to them. Then it only remains now to explain how the wheel is cut so that the feelers running in the groove may operate the needle frame and produce the pattern.

The cutting of the wheel is the most important item in the production of the lappet figure. The arrangement of the plan is in itself comparatively easy, suppose for instance we refer to the pattern represented in Fig. 289, we should make the design for it upon point paper as shewn at Fig. 292, and of course in this case it must be understood that the dots upon point paper indicate

crossing and re-crossing of the figuring thread. Whichever form of lappet loom we are working with the principle remains the same. So that the feelers must pass from side to side of the groove upon the wheel and the length of the traverse of the feeler will determine the distance over which the figuring thread is carried. Then we take a wheel formed of wood, and turned to perfect truth, and allowing a certain space in the centre for the holder or boss, and a corresponding space on the outer

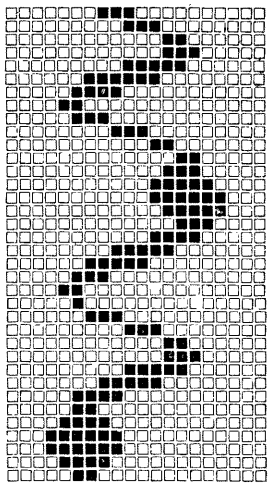


Fig. 292.

ring for formation of the teeth, the intervening spaces are divided by concentric rings exactly corresponding in distance apart with the fineness of the reed. Suppose, for instance, that we had 40 reeds per inch, then the concentric rings must have exactly the same number, because they have to determine by the distance the feeler travels from one side to the other the exact distance the needle frame will travel. Fig. 293 will shew how those rings are dealt with. First we have to take into consideration the thickness of the wire of which the feeler

is made, it may correspond with 3, 4, or any number of the divisions, then a space must be assigned to it corresponding with its bulk. That having been done we must take the pattern and lay off the number of the concentric rings corresponding with the number of reeds in the pattern. We must then divide the circle into a

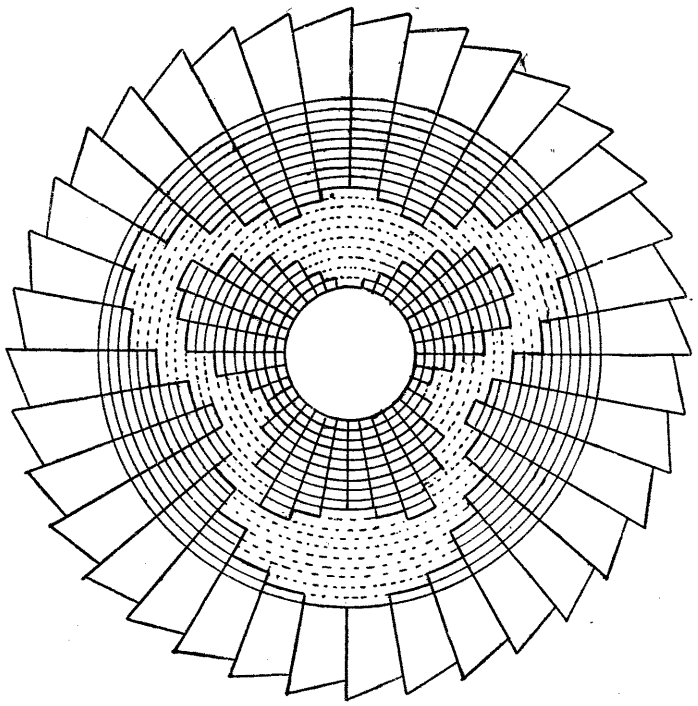


Fig. 293

number corresponding with the picks in the pattern. For instance the pattern we have to deal with here occupies twenty threads and thirty-six picks, so that we lay off twenty divisions with the concentric rings and four added for the size of the feeler wires. The circle is divided

into thirty-six parts corresponding with the picks. Commencing then with No. 1 pick of the pattern we find that the thread must cross over the sixth and seventh reeds or ends, and we lay off a space exactly corresponding to that. It must then cross back to the fourth, then in the opposite direction to the seventh, and so on in succession over each pick; all the points over which the feeler must pass are marked in succession, then a deep groove is cut in the wood, such as that indicated on the wheel at Fig. 239, where the dotted lines shew what has been cut away. Then at each pick the feeler can travel from one side to the other of the groove, always being arrested at the exact point where the pattern must be determined.

Although the machine seems an extremely complicated one from the number of parts, yet it will be seen that the principle is clear, and it possesses the one great advantage in looms figuring with extra material of rapidity of production. No extra shuttle is required as in swivel weaving, and consequently no loss of time in passing from side to side. The one important point to consider is, as already pointed out, the exact time when the movement of the needles must take place, and of course it must be obvious, as already shewn, that that must occur exactly as in changing shuttle boxes, when the shuttle is at rest, or in other words, practically when the reed is in contact with the cloth, and that the needles like the ordinary healds must be at their highest point at the moment when the shuttle leaves the box, and remain there until the shuttle has re-entered the box. So that practically everything that has been said of shedding and box motions will apply to the movements of the needle frames. There is one matter in connection with this which may perhaps trouble the beginner, *i.e.*, the determination of the quantity of figuring material required in the production of a piece of fabric. Suppose, again, we refer to Fig. 289, there

are thirty-six picks in the pattern, and we should have to determine exactly the number of reeds over which the figuring thread crosses; for instance at the first crossing it goes over two reeds, at the second over three, at the next over four, and so on; then we know the number of reeds per inch, so that adding up the total crossings in the pattern, plus the number of picks or the length of cloth formed, we should have the entire length of yarn required for the formation of one pattern. That multiplied by the number of patterns, or needles, and by the number of patterns per yard would give us the total length of yarn consumed in one yard of fabric. Then from that, following the usual mode of calculation for warps, we should determine immediately the weight or quantity of material used for figuring purposes; so that there is no difficulty in dealing with that beyond what occurs in ordinary figured fabrics.

WEBBING OR BELTING LOOM.

Having already described in detail the swivel loom, what has to be said of the webbing or belting loom is really very little. It is, in fact, the same as the loom for weaving tapes or ribbons, but of a much stronger construction. An illustration of one of the best looms is shewn at Fig. 294. On the front of the loom are seen the taking-up motions for each web separately, and driven positively by a train of wheels, after the manner already described in reference to other looms. Then again the shuttles are seen in front of the sley board and are carried positively after the type of swivel looms, but of course are made large and strong. In the loom which is illustrated here the shuttle is propelled in a slightly different manner from that described by the rack and pinions in the ordinary swivel loom; the interior face of the sley board front is formed with a groove from end to end;

immediately under each warp the groove is lower than that portion between the warps, the two straight portions being connected by inclined grooves; the rod for propelling the shuttles has pegs or bowls fixed upon it which engage with the slot in the sley board. This rod is actuated by a chain which is moved longitudinally, and as it is so moved rises and falls with the grooves; the picking arrangement consists of a double tappet fixed on the ordinary tappet shaft of the loom and operating a pair of levers or treadles which are fulcrumed at the rear of

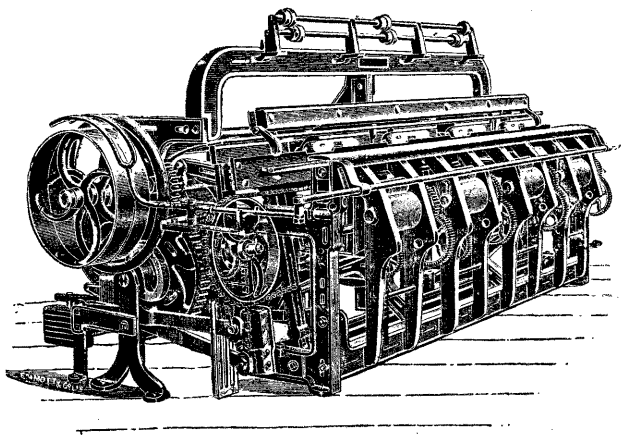


Fig. 294.

the loom in the usual manner. The free ends of the treadles move vertically in the slots of a guide plate at the front and are attached to the ends of a strong flat link chain; the loop of which is passed over and secured to the middle of a small pulley; this latter is fixed to the boss of a larger pulley round which a similar chain is passed and secured, both pulleys are free to rotate on a stud fixed to a bracket on the lathe sword; a similar bracket is also fixed to the lathe sword at the other end

of the loom which carries a stud mounted on a carrier pulley, round which another chain is passed; the ends of the two chains are coupled together by the pair of light rods already referred to. The upper rod is connected to the shuttle carrier and enclosed in the sley or race board case, so that the whole mechanism moves forward with the sley as the weft is beaten up. In the top edge of the rod several pairs of pegs are fixed, one pair to each shuttle, and each of these engaged in a corresponding hole in the face of the lower shuttle: the pegs are fixed at such a distance apart, and the space between two warps is of such a length, that the shuttles are engaged by one peg at a time, pushed partly through the shed and then engaged by the other pegs of the series and their traverse, or pick, is completed. The backward stroke is made in precisely the same manner by the operation of the second treadle, so that a considerable saving of time is effected as compared with the use of the rack and pinions. The healds are actuated in practically the same manner as in the ordinary looms. The take-up motion, as already said, is a positive one and the let-off motion of the usual kind, each beam being provided with a grooved flange, round which a heavy chain is passed and attached to a weighted lever, so that the tension upon each separate fabric can be regulated at will. This loom is the production of Messrs. Wilson & Longbottom, Limited, of Barnsley, who claim for it that they can obtain an increased production over the old looms of fully 90 per cent.

Although this is called a webbing loom it may be equally used for weaving belting or heavy girthing bands for conveying mineral or grain and goods of a similar class. It may also, of course, be made applicable to the weaving of hose pipes. It would simply mean that the shedding motions would have to be enlarged so as to

form double cloth, allowing the shuttle to pass through the upper and lower cloth alternately, so that it would be continuously forming a circle with the weft, the result of the product being of course a tube.

CIRCULAR BAND WEAVING.

What is really meant by circular band weaving is the formation of a fabric longer at one side than at the other, as for example, that shewn at Fig. 295. It may seem at first sight an extremely difficult matter to weave a fabric which is not perfectly straight; we all know,

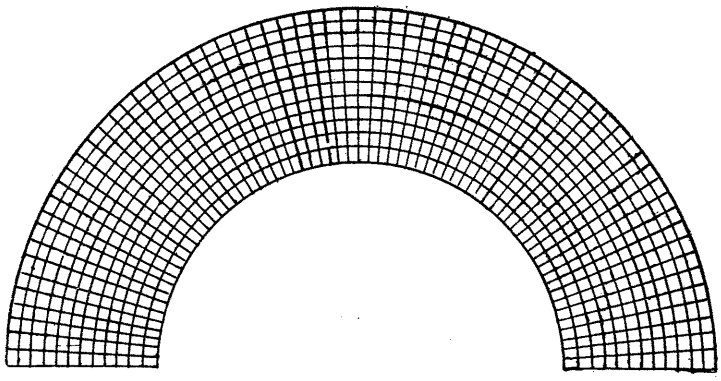


Fig. 295.

for instance, that the reed always comes up to the cloth in exactly the same position, and parallel with what is termed the breast beam, therefore it would seem that at all times the weft threads would be laid exactly parallel to each other in the fabric, but let any one familiar with the looms imagine the weight being off one end of the taking-up beam and he will at once discover that a fabric was being formed something approaching a circular fashion, *i.e.*, the threads on one side would be much tighter than those on the other and

consequently the two sides of the fabric would not be equal in length. This of course could not go on very long in an ordinary loom without the results being more or less disastrous, simply because, although the taking-up rollers would be carrying the cloth forward at different rates of speed at the two selvedges the warp beam would be giving off uniform length throughout the width of the fabric. But now suppose that we deliberately not only

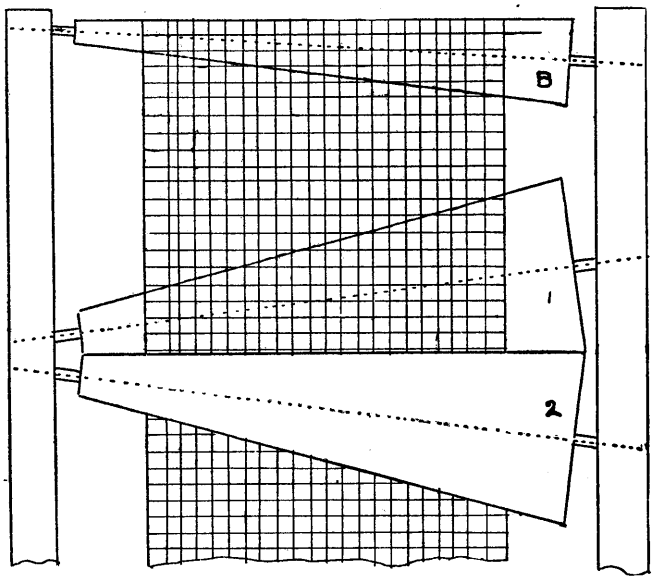


Fig. 296.

take the cloth at one side at a more rapid rate than at the other, but that we also arrange for the warp to be given off at a corresponding rate. This, although it seems at first sight extremely difficult, is in reality very easy. For instance, we will take the arrangement shewn at Fig. 296, where the cloth passes over a conical roller B, which represents the breastbeam in an ordinary loom. It is then passed between two conical rollers 1 and 2, which answers

the ordinary purposes of take-up rollers and are driven in precisely the same manner. Those rollers being much larger in diameter at one side than the other must of necessity carry the cloth forward at rates of speed, from one selvedge to the other, varying in the exact ratio of the variation of diameters; consequently instead of the weft threads being placed exactly parallel to each other they would be woven into the cloth radially, as shewn in Fig. 295, and the fabric must therefore assume a circular form with one selvedge much longer than the other; the diameter of the circle so formed will of necessity depend upon the conical form of the rollers. Those fabrics are, or may be, made to serve a variety of purposes, such for instance as skirt bands, or collars, or

Fig. 297.

for any similar purpose where a circular fabric could be made to serve better than an ordinary straight one; and the structure of the fabric would be suited to the purpose to which it was to be applied.

For instance, we will take the case of the ordinary skirt band, and we should have a section as shewn in Fig. 297; we commence first by forming two distinct fabrics, simply on the ordinary double cloth principle, as already described, and those two fabrics we bind together at one selvedge and at another point a short distance from it. It is desired, for instance, to form a kind of tube at A, through which a cord or tape might be passed, and then it is desired to form two separate fabrics below that between which the body of the skirt might be

stitched. Then all we have to do is to make our plan for actuating the healds so as to form two separate fabrics and bind them together at the points indicated; weave this on a loom with conical rollers as shewn in Fig. 296, and we have a band, or binder, for which it is claimed that it will fulfil all the conditions for the purpose to which it is to be applied. In a loom of this kind we have really but two leading considerations; the first is the exact shape of the conical rollers so as to give us the diameter of the circle formed by the fabric; and of course there must be a distinct and definite relation between the cone representing the breast beam and the take-up rollers. Then a second consideration is the delivery of the warp to exactly correspond with the take-up. This implies that one of two methods must be adopted, either that the warp must be drawn from bobbins and delivered through rollers corresponding to the take-up rollers, or it must be drawn direct from bobbins and through tension bars or rods, so that every thread will be kept as nearly as possible at the same tension, no matter at what rate of speed it is taken forward. With a little care and proper arrangement of the rollers this system of weaving may be made useful in producing fabrics of almost any shape. For instance, a system, not exactly like this, is in vogue in weaving ladies' corsets. In the weaving of those articles, of course, there cannot be exactly the same circular form, so that conical rollers would be of no use. What are known as a series of "gussets" are formed both on the upper and lower side of the article, and not only from the varying sizes and varying number of those gussets in one article, but from the varying rate of take-up required by the introduction of cordage or ribs, or for the formation of tubes in which steel ribs may be inserted, it would be impossible to construct a loom which would take-up continuously. To

meet this difficulty the article, as it is being woven, is simply held by a clamp which serves the double purpose of a temple and a general holder. For instance, in forming a "gusset" the weaver will begin by throwing his shuttle through a section of the warp which we will suppose to represent a space of 6 inches, and will weave a few picks, then by an arrangement of his dobby machine he will drop one section of the healds and allow the weft to go through, say a space of 5 inches of warp; then he will reduce that to say 4 inches and so on, until he gets down to almost nothing; then he has been weaving all this time a V shaped fabric on one side of the article; he then uncloses the clamp liberating the fabric, presses the fabric forward with his reed until all the sections he has just been weaving are brought into the same horizontal line with which he started; the clamp is closed down upon the fabric, holding it firmly in position, and the process of weaving is continued, either to form a straight piece across the fabric or to form tubes by means of double cloth for the insertion of springs or whalebones, and other "gussets" are formed at will, either on the upper or lower side of the article in precisely the same manner, so that seeing that the "gussets" can be formed of any length, of any width, or of any degree of angularity it necessarily follows that fabric of any shape can be woven by having the healds properly and suitably dealt with, and the use of clamps or suitable shaped rollers so as to make the take-up exactly what is required for the shape of the fabric. It might be interesting to describe many other productions of the loom on the principles suggested here, for instance, almost any article of clothing might be woven in one complete piece, but as to whether it could be done successfully as a commercial undertaking would be another matter.

CARPET WEAVING.

I shall not attempt to deal with all the different classes of looms used in carpet weaving, were I to do so I should have to explain the loom frame of the Turkey and the Indian carpet weavers, which simply consists of a vertical frame with the warp threads stretched and the pile being knotted in with the fingers of the operative, and the weft thrown across and beaten up by hand, and I should have also to deal with the common Kidderminster or Scotch carpets, which simply means the production of a double fabric, the principle of which has already been explained. I shall not attempt either to deal with the so-called Axminster or imitation Turkey, which is nothing more or less than a Chenille carpet made upon the principle which I have already described in my "Treatise on Weaving and Designing"; but I may venture to call attention, although in a very general way only, to the weaving of tapestry or Brussels carpet. The Brussels carpet really consists of a body fabric in which any number of threads from 3 to 6 are embedded, and out of which any one of the series may be made to issue for the purpose of forming pile, and they are brought up in succession according to the order of the pattern. In reality the Brussels carpet loom forms an ordinary pile fabric having its warp threads selected according to colour and brought to the surface over wires to form the pattern.

With the exception of the system of selecting the coloured threads the method of weaving is exactly the same as in ordinary pile fabric, although the structure of the cloth is somewhat different, and therefore the chief item of interest, so far as the power loom is concerned, is the method of inserting and withdrawing the wires.

Tapestry carpet weaving is practically the same as Brussels carpet weaving, so far as the formation of the body of the cloth is concerned, and the formation of the

loop pile, but with this one exception, that whereas for Brussels carpets all the differently coloured warp threads are drawn from different bobbins and brought to the surface as required for the formation of pattern, in tapestry the warp threads are printed with the exact pattern which must appear upon the body of the fabric, only very much elongated so as to give sufficient length for the formation of loops, and without the distortion of the figure. A general view of the loom for weaving Tapestry cloth is given at Fig. 298. The ground warp,

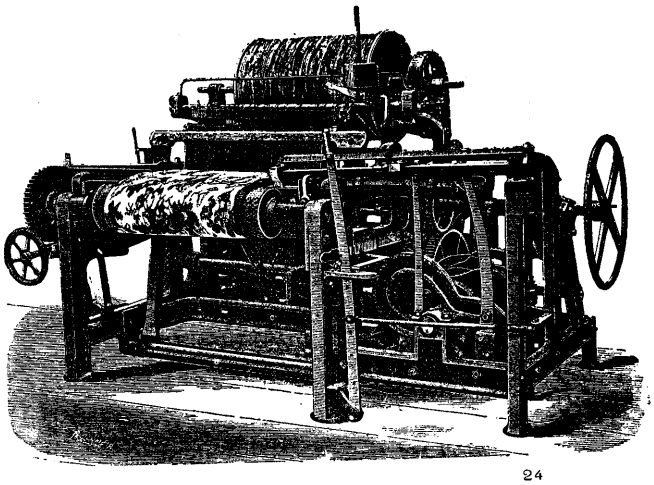


Fig. 298.

or that forming the body of the cloth, is brought through the healds in the usual manner, the pile warp is elevated, as seen at the back of the loom, and weighted in such a manner that on the insertion of the wires the warp threads can be drawn readily away from the beam, and yet the beam be held sufficient rigid when the ground picks are being inserted. The pile warp is printed, as seen in the illustration, and as it is drawn forward forms the proper pattern upon the fabric.

The insertion and withdrawal of the wires is the really interesting feature of this class of looms. To the right of the loom is seen a long kind of holder, and beneath it are two arms hinged to the lower framing of the loom and actuated by a peculiarly shaped cam which is distinctly visible, this cam is so arranged that it throws the two arms in such a manner that they push a wire, held by a species of plier or jaw at their upper extremity, and carried by a guide, through the warp between the reed and the fabric. This is done in this particular loom simultaneously with the throwing of the shuttle across, although in the usual tapestry or Brussels carpet loom the picking is suspended during the time the wire is being inserted; the moment the wire has been inserted the jaws are made to open, and being pressed slightly aside in a slot and frame they are brought immediately in front of a wire end which has already been inserted, and which it is now intended to be withdrawn. For instance, supposing we are weaving with four wires this lever would be moved forward a distance corresponding to the space occupied by four wires in the fabric, and the jaws of the holder being held open up to that point would now be liberated and immediately close upon the wire to be withdrawn. This having taken place the lever is returned by the cam to its normal position, carrying the wire with it, and ready for insertion immediately the requisite number of ground picks has been put in; this process is repeated continuously; if the fabric is an ordinary loop pile of the Brussels or tapestry type the wire is simply pulled out leaving the loops intact, but if it is required to be a cut pile the wire is provided with a species of flanged knife at the end which severs the warp thread as it is withdrawn, and so leaves a velvet surface instead of a looped one. The same principle applies to the production of every class of velvet or pile

fabric. There may be numbers of different looms in use, which, except those forming double surface piles, which I shall have to deal with presently, differ from this, but the principle of the mechanism is practically the same in all of them, and therefore need not be dealt with at length. This loom is made by Messrs. Sowden & Sons, Shipley.

LASTING LOOM

I must not omit a passing word for a loom of a special type, which, although, possessing many of the leading

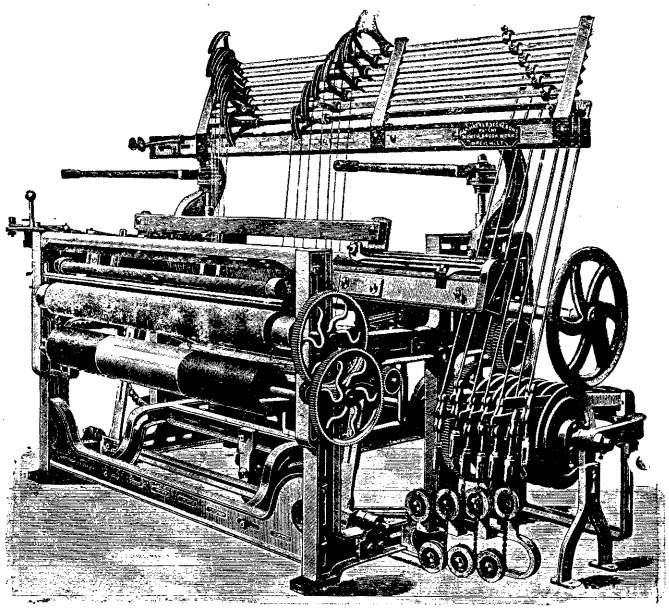


Fig. 299.

characteristics of the ordinary Bradford loom, is built and used for a special work, and for one class of fabrics only, viz.: lastings, or the cloths used for tops of boots or shoes. The lasting is built on the basis of a seven thread satin and from very strong worsted, and must be well put together and firm in structure, therefore a good strong

loom is necessary for weaving it. An illustration of a loom for the purpose is given at Fig. 299. So far as one can see from the illustration, the loom differs from the ordinary loom of the Bradford type in having positive tappet plates, and the motion communicated to the healds above by means of the usual jack rods, and below by pulleys and cords. Everything is, however, made strong and rigid. The loom frame is strong in all the parts, and a longer throw is given to the going part than in the ordinary loom. Of course there is no new principle. The loom differs from others in strength suitable to the work it is intended for and the positive action of the healds.

DOUBLE PLUSH LOOMS.

I must now direct attention to a class of loom, which, although not so largely used as some of the special looms which have been referred to, has played an important part in the history of textile manufactures during recent years, that is, the loom for weaving velvets or plush two pieces at a time, face to face, and cutting them asunder.

Serious attention seems to have been directed to this matter, first about the year 1848, and for several years following improvements were made, but in most of those efforts the plush had to be cut after leaving the loom, and considerable difficulty was experienced in keeping the plush even, partly from the imperfection of the mechanism of the cutting machine, and partly from the uneven tension on the pile warp threads, which would cause the distance between the two fabrics to vary; these difficulties have since been overcome, mainly by the exertions of Messrs. Lister & Co., of Manningham Mills, and others who have been from time to time associated with them.

I shall not attempt to go into the details of the structure of the fabric, beyond saying that in all respects it is the ordinary velvet or plush, and that two fabrics

are woven face to face and cut asunder, leaving pile on both. A full view of the loom is given at Fig. 300 and a section at Fig. 301. As will be seen the healds are actuated by positive tappets, and levers above and below, and behind the healds are a series of vibrating tension

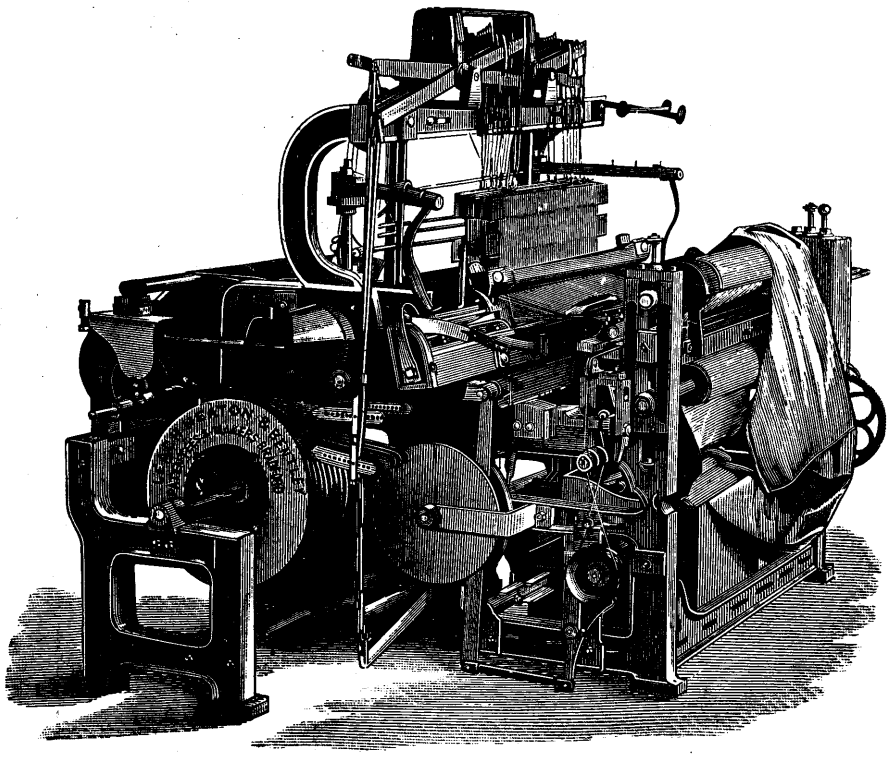


Fig. 300.

rods for the pile warp to pass over. The details will be better understood by reference to Fig. 301. The ground warp is taken from the ground warp beam A, over the back rail of the loom, and through the ground healds in the usual manner; the pile warp is drawn from the two

beams B and C, passed under and over guide rollers to the delivery rollers TT, which are driven positively by

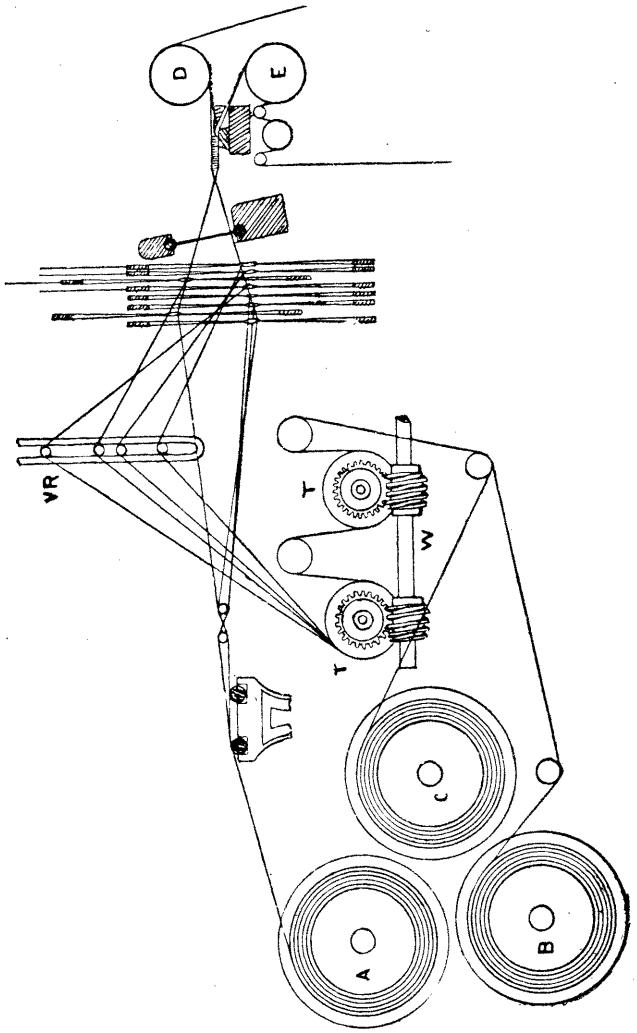


Fig. 301.

worm and wheel, and covered with plush so as to have a sufficient hold on the warp threads. The rate of speed

at which these rollers deliver the warp will determine the length and evenness of the plush, and that is controlled by a train of wheels, one of which is changeable. On leaving the tension rollers T, the warp passes over the vibrating tension rods VR, which are placed in slots considerably above the level of the ground warp, and the object of which is to keep the pile warp thread at an even tension. These rods are connected by levers above to the levers actuating the pile warp threads, and as the latter are raised they are depressed, but between those levers and the rods themselves there is a spring which will give to the tension on the warp, and so avoid too great a degree of rigidity.

The warp threads are passed through the healds and the reed in the usual manner, but every care is taken to ensure perfect accuracy of movement of the healds; instead of ordinary cords the healds are suspended, in the best looms, by steel bands, and this coupled with the positive action of the tappets and levers ensures them rising and falling with perfect evenness; the levers are notched so as to permit of variation in the depth of the shed corresponding with the varying length of the pile, and every precaution is taken to obtain regularity. As the cloth is formed it passes forward to the breast beam, and is severed by a knife. Numbers of cutting arrangements have been invented for the cutting, ranging from a V shaped knife, and a circular knife to an endless band, differences of opinion existing perhaps at the present moment as to the relative merits of each. On leaving the cutting knife the two cloths are carried away by the rollers E and D, the lower one E being supplemented by another small roller, and the upper one being covered by a shield which carries the cloth round a great part of its circumference, and then to pass it over the front and drop it into a box in front of the loom.

With the best constructed double plush looms there is always liability to trouble in producing perfect fabrics; it is notorious that there is no class of fabric so liable to disclose faults as velvet or plush, and those arising frequently from absolutely unforeseen causes. There is a tendency to bars across the piece, to mitigate this the pitch of the take-up wheels is made finer than formerly, the result is satisfactory in one sense, but when one fault has been removed another is created; in place of the bars a sort of "watered" effect is produced; this again must be overcome. In the desire to get a good firm edge there is a tendency to produce a peculiar effect due to unevenness of cutting in consequence of the edges of the two cloths being kept too firmly together, which causes the plush threads to buckle and cut unevenly. The general method of obviating this is to keep the top rail well up so as to avoid this cramping, in fact the strictest attention must be paid to every detail of the loom or there is liability to serious faults, and in costly goods this must be avoided.

The take-up motion of this class of loom necessarily forms an important item.

THE DOBCROSS LOOM.

I shall make no apology for introducing the Dobcross Loom here. In the strict sense it is not a loom built for special purposes, except that it is intended, primarily, for weaving heavy woollen goods. I do not think it necessary either to describe it in detail: the principles upon which it is built have been dealt with already under the several heads corresponding with the parts of the loom. The dobby is a centre shed and positive in action; the going part is suspended from above, and the picking sticks work in the vertical plane. The let-off motion

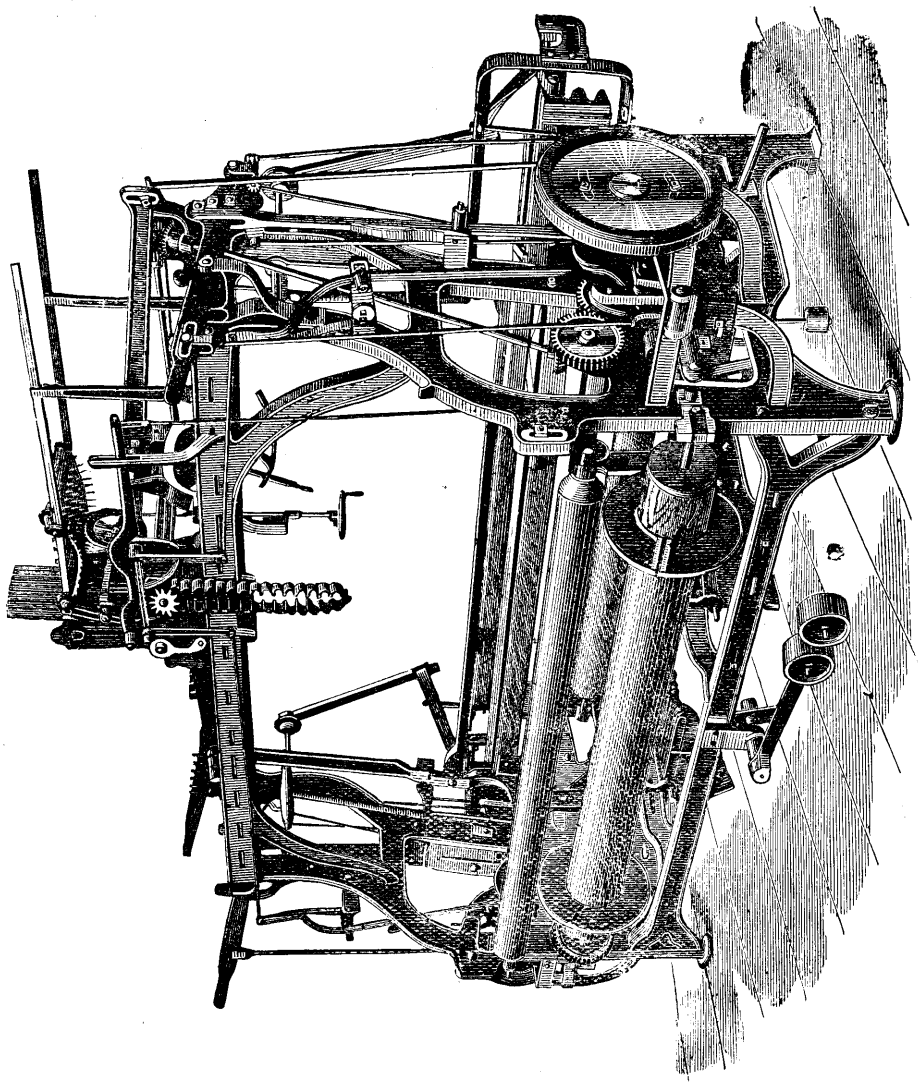


Fig. 302.

is of what is often called the positive kind, governed by a vibrator lever, and the take-up motion is a negative one: the boxes are rising boxes, so that by reference to the several parts dealt with in the previous lectures, the whole of the mechanism will be easily understood. Fig. 302 shows a back view of the loom, disclosing, practically, all the working parts.

LECTURE 13.

GENERAL SUMMARY OF ALL THE VARIOUS LOOMS.

In the previous Lectures I have endeavoured to deal at length with every class of loom, and for weaving all classes of fabric, so that I find myself now with very little to say in analysing and comparing the various looms and their working parts, and I shall not occupy much space in making this general comparison; but I will deal with each leading feature of the several classes of looms in the briefest possible way. Perhaps it would be as well to refer generally to each of the principal working parts, such as the shedding and picking, box motions, and the several adjuncts in succession, as it will not only bring the work into the most compact form but will render comparisons more pointed and easily understood. Commencing, for instance, with the shedding, we might compare the several systems of tappet working. We have first the under tappets, or those placed under the loom and inside the loom frame; second, the outside tappets, and third, the positive tappets, either of what are known as the Woodcroft section or any other positive shedding motion. The under tappets by their direct action are undoubtedly well suited for heavy work, or for goods where the loom may be run at a high rate of speed, but the necessarily restricted space which they occupy, with difficulty of access to them either for changing tappets or making any alterations, render them, though especially suitable for heavy work, most undesirable arrangements in consequence of the difficulty of access for any of the operations of adjustment. The outside tappets on the other hand are always readily accessible, not only permitting of easy adjustment of the sheds by means of the jack rods and

side rods, but also admitting the use of any reasonable number of treadles and healds; for instance it is no uncommon thing to work up to ten treadles and ten healds with the outside arrangement, but with the treadles under the loom this would be a practical impossibility; again with the treadles working outside the loom, motion is communicated to the top of the healds instead of underneath, thus rendering it easy to use either what has been described as the under motions, or springs or stocks and bowls. Those additions to the loom could not possibly be worked with any reasonable probability of success if they had to be placed over the healds.

It is quite true that in the earlier days of hand loom work, the pulley boxes, as they were termed, were frequently placed over the loom, but in that case, the hand loom weaver was not only compelled to have his treadles under the loom, and within the loom frame, so that he could operate them with his feet, but he had absolute freedom as to space. He was not encumbered with driving shafts, tappet shafts, or picking arrangements under the loom, and consequently his arrangement permitted much greater freedom of choice of action than can be permitted in the power loom, so that for purposes of comparison the hand loom of former days and the modern power loom do not present, in this respect at any rate, any parallel. Now as to the good working of the various forms of tappet, the under tappet and the outside tappet both being non-positive, present identically the same characteristics; it is only a question of what has been already fully dealt with, the proper construction of the tappet itself; the proper placing of the friction, or anti-friction, roller on the treadle; the relative dimensions of the two, and their direct or indirect action. In all respects except in the matter of convenience of space, the two systems are practically identical, but when we come to the positive kind, either of the Woodcroft or other type, then

we have a somewhat different class before us. The non-positive cam may be rendered positive in its action by the use of stocks and bowls, which have been described, but the Woodcroft or similar tappets are positive in themselves, and therefore must be connected by means of levers both to the top and the bottom of the healds, each treadle to its own heald. It must be obvious then that one risk of difficulty is avoided, namely, that of variation in the tension of the cords which may be brought about by the varying action of the non-positive tappets, which would arise in the majority of cases, from faulty construction, and which may be increased by the improper setting of the tappets in relation to each other, or in relation to the friction rollers on the treadles. In the great majority of positive tappets too little attention is paid to the proper form. In many cases the term "jigger" is unfortunately applied with only too much truth, for instead of a smooth easy motion being imparted to the heald it is often a very jerky one. When weaving strong material such as well spun cotton or linen, this may not be a matter of very serious importance, but with soft threads the case would be very different; there is no reason why positive tappets should not be made to work with almost the same ease as the non-positive ones, but unfortunately the same attention does not appear to be paid to their construction, hence they will often have a bad character given to them when a little more care and attention in their preparation and arrangement would render them quite as valuable as the best of the non-positive motions. These remarks would apply of course only to such as sectional tappets, they could hardly apply to chains which consist simply of links and bowls; here there is no possibility of varying the nature of the movement for the roller, or bowl, being once inserted is incapable of any variation either of form or character, and can only impart one motion. This, of course, applies only when they are

made to act directly upon the treadle; in dobbies of any form no matter what may be the character of the internal arrangement, they would not apply in any sense. I must now examine generally the leading features of the several dobbies.

As I have already pointed out in the lecture on dobbies, they may be classified under three distinct heads, open shed, centre shed, and bottom or jacquard shed, as they are severally known. I need scarcely add much to what I have already said as to the relative merits of each for the several classes of work for which they are intended. One remark which may be taken as of a general character would be that in selecting the dobbies there are three things I should look for, first, simplicity of mechanism; second, strength of the working parts, and freedom from liability to get out of order; and thirdly, a ready method of applying the design to the card or lag so that they could not only be cut, or pegged, with facility, but they could be easily read for the purpose of ascertaining or correcting errors. Of course, accompanying those qualifications a necessary condition is that perfect easy motion be communicated to the healds, which prevents either a too sudden strain being thrown upon the warp threads, or too great variation of tension at the different points of the passage of the threads. Again accompanying those conditions we must have the necessary one of being able to form a perfect shed, which means a perfect line of warp thread for the shuttle to run over, and capability of adjustment, the healds forming the upper half of the shed so as to have as nearly as possible the same tension upon the warp threads which pass through the front and back healds respectively.

This is difficult of accomplishment in some forms of machine, but it is a feature which must never be lost sight of. Then again we may discuss the relative merits

of positive and non-positive machines. Generally speaking, I should give an unqualified preference to the positive machine, provided that the movement imparted to the healds is sufficiently easy and all other conditions are equally well fulfilled. It must be obvious that unless there is some special reason, either dependent upon mechanical contrivances within the machine itself, or interference with the strength of the working parts, that the use of springs or under motions of any kind must necessarily require a greater amount of power than the motions communicated positively, and when we have increased power required to drive a machine it is necessarily accompanied by increased difficulty, and in many cases by increased wear and tear, all of which it is desirable to avoid.

JACQUARDS.

It seems difficult at first to make analysis, and more especially comparison, of the different systems of jacquards and harnesses. Were we to speak of the machine alone as between the single lift and the double lift, or of the open shed machine in comparison with either, the relative merits might be easily determined. For regular work or for gauze weaving, or for any fabric where speed is not the essential requisite there would be no difficulty as to the merits of the common single lift jacquard, but when we come to the question of speed, under what I have already spoken of as a system of counterpoise harness, then the double lift machine undoubtedly possesses advantages, and in respect of very heavy goods, such as shawls, coatings, or mantle cloths, or other heavy goods, then there can be no question as to the merits of the centre shed machine, or what might be more correctly termed the true counterpoise. When we have done with the actual machine the question of the different systems of harness tying is in itself sufficiently clear that we are bound to

admit of the advantages of tying up every harness specially for the work it has to do. Straight harnesses for straight figures, centre or repeat harnesses for their several purposes, pressure, compound or split harnesses for the weaving of goods where the extent of figuring must be accompanied by limited jacquard power; harnesses tied specially with doups for gauze weaving, and all harnesses where special work of any kind compels us, on the ground of economy, to make all our arrangements so that we have not only the harnesss best suited for the special purpose to which it is to be applied, but which will also be most economical in the working. In this aspect of the question we have to include the economy of tying in making the designs; the economy of cards and the labour in cutting them, and, as pointed out, where this can in many cases be reduced to one fourth or even less than would be involved in the use of a jacquard or harness not specially adapted to the purpose to which it is to be applied, the item is too serious to be treated lightly. It will be no exaggeration to say that in some large business concerns the economy of time in the preparation of designs, the labour of cutting cards and the actual saving of cards themselves would, with specially adapted jacquards, or harnesses, amount to a substantial profit to the business. It follows also, from what has been pointed out in reference to harnesses such as the expanding harness, that considerable saving will be effected in cost when changing from one degree of fineness in the fabric to another; and also a proper knowledge of, and adaptation of design paper, which will exactly correspond with the relative degrees of fineness of warp and weft, some influence upon the good working of the business must be at least existing if not predominant. Generally speaking, in fact, a thorough mastery of the whole system of tying harnesses and the different systems of jacquards suitable for the several uses

must tend not only to economy in production but to general efficiency.

Then with respect to the several forms of take-up and letting-off motions. Those have been dealt with in Lecture 8, so exhaustively, that it is scarcely necessary to say anything with respect to them. We have the positive and non-positive take-up motions, and we have the so-called positive and friction let-off motions. With respect to the take-up motions it may be said to be a matter of opinion as to the relative advantages of what may be termed the intermittent and continuous positive motions respectively. For instance, the intermittent motion must carry the cloth forward at each stroke of the reed, and it must carry it forward a distance corresponding with the space intended to be occupied by one pick of the weft; the continuous motion does the same thing, but instead of bringing the cloth forward the requisite distance at one movement it is gradually taking it forward in what might be termed a creeping fashion. Really they both come to the same thing in the end; the cloth is moved forward the requisite distance between, or concurrent with each stroke of the going part; but it is claimed for one that by the creeping method the equal tension of the fabric is maintained throughout. Whatever alleged advantage may accrue, in any event there can be very little difference; if the cloth is moved say $\frac{1}{60}$th part of an inch between each stroke of the reed, or during the time the reed is delivering its stroke, it can surely make very little difference whether the motion is a continuous one or intermittent, and more especially when we take into consideration what has been said of the elasticity of movement of the warp beam which must compensate for the variation in tension upon the warp threads by the opening and closing of the shed. If we were simply dealing with the carrying forward of the cloth without

the attendant circumstances of the variation in tension by the opening and closing of the shed, and the elasticity of movement of the warp beam, or of the effects of the weft being beaten up to the cloth, then we might at once say, that the continuous take-up motion might possess considerable advantages in consequence of its apparent freedom from variation as compared with the intermittent motion; but when all the facts of the case are taken into consideration it seems extremely difficult to draw a line between the merits of the two systems. As to the negative, or what might perhaps be termed the non-positive motions, something of a more definite character might be said. Here we are dealing with a motion that carries the cloth forward exactly as it is given; the weft may vary in bulk to any extent, but the cloth will be carried forward only just as much as the pressure of the reed upon the weft gives to it. Here an extremely difficult situation might be created or imagined. For instance, let it be supposed that we are dealing with a fabric where there is great variation in the order of interweaving, such for example, as combination of plain cloth and a very loose twill, then the negative take-up motion might give us a result which would be very undesirable. I will suppose a case. We are making a checked pattern in which we have a perfectly plain ground formed, say, with wool or worsted warp; we have a stripe in the warp formed of silk and weaving in twill or satin order. We must have the stripe much finer in the set than the ground, but this degree of fineness is determined as a fixed quantity, say twice or three times as fine. Then we want to cross the fabric with a stripe corresponding to the warp, this also must be in a fixed relation to the ground; in the positive take-up motion we should arrange our change wheel so as to take up the exact rate of speed required for the ground fabric, and when we come to the crossing

we should alter that rate of speed by a system of lifting, or operating upon the take-up catch, so that it moves the train of wheels forward one tooth at every second or third pick as required to correspond with the warp stripe. Then in this positive motion we have the power of controlling the relative degree of fineness of the ground and stripe to any extent, but in the negative motion we could not by any means so control it. We should be dependent entirely upon the relative bulk of the two materials forming the fabric, coupled with the relation of the orders of interweaving, which of course, even with the most careful system of calculation, could never be brought to that absolute degree of truth which would ensure the production of a fabric even approximating to perfection. Consequently we may say with the utmost confidence, that the negative take-up motion may be a most desirable one where evenness of bulk in the texture of a fabric produced from uneven yarns is aimed at, but in the production of absolutely even texture where variation of pattern occurs, or where we have a combination either of different orders of interweaving or of different yarns, or both, then unquestionably the positive take-up motion has the advantage. As to the faults caused by irregularity in working, sufficient has already been said to call attention to their general character, and I shall have something more to say in the lecture on cloth dissecting, so that I need not occupy time in speaking further of it at present.

With respect to the stop motions on looms their importance and value cannot be overestimated. In fact the success of the modern power loom may be said to be in a great measure due to the efficiency of those safe-guards which have been applied, for they not only ensure the work being carried on continuously, but also ensure, as far as possible, the freedom from accidents to, and faults in, the fabric. For instance, in weaving with

an ordinary fast reed loom, if the shuttle should by any accident remain in the shed as the reed comes up to the cloth, every thread on one side of the shuttle, and for the full length of the shuttle, must be broken by the pressure of the reed upon it if the stop rod is not in existence, or from any accident be non-operative. This means not only a serious fault in the cloth, but in most cases hours of labour in taking up the threads and putting everything into working order again; but with the stop rod in proper working order nothing more serious can happen than the sudden stoppage of the loom with a more or less violent concussion and accompanying noise: so that one cannot insist too strongly upon the necessity of this stop rod being kept in good working condition, and more especially of not neglecting the brake arrangements being in perfect working order. The same remarks will apply also to the loose reed loom, where the arrangement shewn in Lecture 11 for allowing the reed to fly out of the loom when the shuttle is caught; where circular boxes are employed or where from any reason the stop rod cannot be applied; every attention must be paid to the working parts being in such good condition that as the shuttle is being thrown across the reed is held sufficiently firm to resist the pressure upon it, and the moment when pressure would be placed upon the shuttle in the event of this being caught the reed should be as free as possible, and then as the reed comes up to the cloth it should be held as fast, or as firm in its position as it can be by the use of the finger and frog, but should the shuttle be caught it must be at liberty to fly out and with as much ease as can be, and avoid risk of injury to even the most tender warp. The knocking off arrangement and the use of the brake must have the same attention of course as in the stop rod loom.

With respect to the shuttles, little more need be said than has already been said in Lecture 11, beyond impressing the

necessity for keeping the shuttles in good condition, for instance a few of the points may be enumerated which are liable to cause trouble. The point of the bobbin must neither be too high nor too low, otherwise constant breakage of the weft will be occurring as the bobbins become empty, which means loss of time, faulty cloths and broken picks, and general irritation. The shuttle peg must not be too loose or the point of the bobbin may rise above the shuttle and tear down the warp threads. It is no extraordinary thing in weaving light fabrics, if the point of the bobbin should rise, to see threads torn down by it for almost the entire width of the fabric; again attention must be paid to the strength of the shuttle, so that the pegs shall not split the wood and render them useless. The grain of the wood and the proper seasoning of it are matters of no small importance, for if a shuttle should split in weaving, the results to the warp are disastrous. The tension of the yarn accompanied with proper regard to the power exercised in picking, will have no small influence upon the production of a good fabric and more especially good selvedges, and it is a recognised fact both in the factory and the warehouse, that a good selvedge adds considerably to the value of a piece of fabric. The use of this expression might be misleading, as it carries with it the suggestion that a good selvedge simply lends smartness to the appearance of a piece by the fact of its being straight and even; but there is much more involved, for it implies at once that if the tension of the threads had been sufficiently even to make a good selvedge, that it must have ensured a corresponding evenness in the fabric itself; consequently the question must be treated as a whole, and regard paid to the selvedges with a view to ensuring the fabric being good and even throughout. The temples form no inconsiderable item in the production of a good selvedge and consequently in the production of a good even cloth,

Wherever the tendency of the fabric is to contract, eitner in consequence of the open texture, the character of the pattern, or the natural elasticity of the weft threads, temples must be employed, and the more perfectly these are adjusted, so as to keep the cloth at an even tension and perfectly straight in front of the reed, the better this work will be done : and even where the tendency to contraction is very slight the temples may be of considerable value.

Then with respect to the weft fork little need be said beyond what has been already said, as every one must recognise, that for efficiency of working, the chief items for consideration are proper timing of the several parts, and more especially the perfect balancing of the fork so as to avoid any risk of breakage of the weft, and to ensure sufficient sensitiveness for the fork to act and avoid stopping the loom unnecessarily. With regard to selvedge motions they are in themselves important as enabling us to make a firm selvedge, which in many cases may really be a necessity for the protection of the body of the cloth. Simplicity of arrangement must always be aimed at; the loom is sufficiently complicated without adding to it unnecessarily, but efficiency must never be cast aside for the mere sake of simplicity, though as a rule the two accompany each other. I have dealt pretty fully with the principle of shuttle guards although I have not attempted to describe more than a few of those which have come into use, and although they may be desirable, or may be necessary in weaving some classes of goods, such for instance as very heavy fabrics, or fabrics made from strong fibrous yarns and where great force is exerted in picking, yet I would again repeat that the most efficient shuttle guard is a thoroughly competent overlooker.

With respect to looms for special purposes, it is scarcely necessary to take up time in what would be simply the reiteration of what I have said in reference to

them. Every manufacturer and every loom maker must take special pains to adapt his loom to the work it has to do, to avoid unnecessary complication in the machinery; to have his looms sufficiently well balanced in parts that there is no unnecessary power required to drive them, and to have them sufficiently strong and well built to withstand the strain and bear the force of the concussion in the process of weaving.

As to the special advantages which each loom may possess, that would be at once determined by an examination of the strength and weight; for instance the light looms shewn in the early part of the lectures on plain weaving when compared with the lasting loom described in Lecture 12, will at once shew that the light loom would not be suited for weaving heavy lasting goods nor the lasting looms for weaving light goods. Again the heavy Dobcross loom although eminently suited for woollen goods is too pondrous for weaving many other classes.

Coming to the looms for very special work such as the swivel and the lappet loom, their functions are for producing in the one case either very narrow fabrics, or fabrics ornamented with extra material at intervals, or they are devoted solely to the production of fancy fabrics, each having a characteristic of its own. So that we may sum the whole thing up by saying that the manufacturer must first possess a general knowledge of the principles of weaving, of the different systems of ornamentation and a special knowledge of the requirements of the looms for special purposes.

LECTURE 14.

CLOTH DISSECTING.

Under the head of cloth dissecting I propose to treat the whole subject of analysis and testing, so that we may not only be able to copy a pattern from one fabric and reproduce it in another, or similar fabric, but also to be able to analyse a cloth thoroughly and completely, and determine everything which may lead to a thorough understanding, not only of how the cloth is made, but what it is made from. For instance, we may have to dissect or analyse cloths for various purposes; the most common use of analysis is for the purpose of reproduction, either of the same or the making of a similar fabric. It may be for the purpose of discovering a fault or cause of imperfection existing. In any case the term analysis or dissection should embrace every known test and every known method of examination which will enable us to discover either, what is vaguely termed quality of threads of which a cloth is composed, or the quality of the material, or the quality of the fabric itself. It involves the calculation or determination of the weights or counts of yarn, the tensile strength of both yarns and fabrics; the twist of yarns and elasticity, evenness and general characteristics. The question may be asked, how can we carry out tests which will enable us to determine all those qualities? The leading characteristics can, as I shall be able to shew, be well defined and determined, but there are certain qualities which must of necessity be matters for judgment. What I might term the determinable qualities, or characteristics of quality, I will endeavour

to take in order and shew how each one may be treated as follows:—

A. for counts. B. for evenness. C. for strength. D. for elasticity, and E. for twist. I will then endeavour to illustrate how each one of those elements of quality or quantity may have an influence upon the structure of a fabric, and tend to produce either good or bad results. Before entering into the details however, I must make it clear that for a proper analysis of the cloth the analyst must be able to determine with absolute accuracy any or all of the characteristics which have been referred to. Guessing, estimation, or approximation may sometimes serve useful purposes, and an expert may arrive at almost absolute truth from a knowledge gained by long experience, but even the most experienced should never place too much reliance upon either a rough comparison or an estimation, or what is sometimes termed a judgment, of cloths or yarns for any important matter at stake. Undoubtedly a sound judgment based upon a long experience and careful observation may go a long way, and may not only support the most careful analysis, but will unquestionably in the face of difficulty suggest the direction in which experiments or tests should be made. I will endeavour to shew as I go along in dealing with each of the several tests what influence any one of the qualities which have been referred to may have upon the fabric, as a knowledge of the influence will be of value to the analyst in two directions, first in the determination of the structure of a cloth which is intended to fulfil any given condition, and second in the discovery of any mixing of yarns, or the use of yarns in the production of fabric differing, either from the original pattern after which it may have been made, or from the original intention of the designer. It is no uncommon thing after a designer has made out his particulars of a fabric,

specified the exact counts, quality and character of the yarn to be employed, for the fabric to come up altogether different to that which he anticipated. The differences may be apparently so trifling as not only to be undiscoverable to the ordinary observer, or even the expert, which properly examined, and with a proper knowledge of the influence will at once render an explanation of what otherwise appears to be a mystery.

TESTING FOR COUNTS.

In going over the system of yarn testing for the purpose of ascertaining the counts I will take first the one in common use in the mill, and where large quantities are available, because by doing so I shall be able to make the whole system more intelligible and point out the necessity for absolute accuracy, both in the apparatus employed and in the methods adopted for the purpose of securing the best results. There are two considerations which must in the first place be thoroughly looked into, the one is the method of indicating the counts in the yarn we are dealing with, and the other the condition of the yarn itself. If we are dealing with worsted yarns the determination of counts is based upon the number of hanks of 560 yards each contained in one lb., but in cotton the number of hanks of 840 yards each, and in woollen and other materials varying according to practice of the district. The general principle however being once laid down will be equally applicable to all of them. It will be only a question of varying the formula to correspond with the relative lengths of the various systems. As to condition, we may test a yarn, for example as it comes "red hot" from the spindle; we may test it after it has been kept in a cellar for a sufficient length of time to be conditioned, and then we may test it after it has been made into a cloth and subjected to the

processes of dyeing and finishing ; but we should have in each case to consider if any, and what allowances should be made for the state of the yarn in which we find it. For instance for some purposes the testing of the yarn as it comes from the spindle would be utterly misleading ; the fibres would be absolutely dry, at least so far as moisture is concerned, although they may have some oil upon them ; they would in many cases be charged with electricity, the fibres would be projecting from them in every possible direction : any test made of the strength or elasticity would be unreliable ; an examination for evenness would not necessarily give the best possible results. The yarn must be placed in the cellar or other damp place for the purpose of discharging the electricity ; it will then acquire a certain amount of moisture and the question of proper condition is dependent upon this amout of moisture. The regulations of the conditioning houses say that this amount of moisture, is for worsted 1 oz. $4\frac{1}{4}$ drs. per lb., or a regain from absolute dryness of $18\frac{1}{4}$ per cent. ; for cotton a regain of 1 oz. $4\frac{1}{4}$ drs. per lb., or a regain of $8\frac{1}{2}$ per cent., and silk 1 oz. $9\frac{1}{4}$ drs., or a regain of 11 per cent. ; so that for a proper estimation of the counts of yarn it should be brought to one standard condition which may, of course, be either absolute dryness or with a regulation amount of moisture. Then again in estimating yarns taken from a cloth there is another element ; after a thread has been woven into a cloth, and subjected to dyeing and finishing, there is a greater or less amount of curvature, or perhaps they might be termed corrugations in the thread ; so that the thread taken from a cloth which represents one inch in length may be anything from $2\frac{1}{2}$ to 20% greater than one inch : then the question should be, how should we measure this individual thread ? The natural answer is by pulling it straight, but in doing that we are liable to make an error even greater than the one

we are correcting ; pulling straight may mean a great deal of stretching, especially if the yarn is of a very elastic nature. To attach any fixed weight for the purpose of stretching the thread to its normal condition would again be misleading, as the same weight could not possibly serve for yarns differing in strength, in weight and in the nature of the fibres of which they are made; consequently judgment must be exercised, and, as I shall have to point out later, it is better in most cases to take the length of the yarn as being equal to that of the cloth from which it is extracted and make an allowance

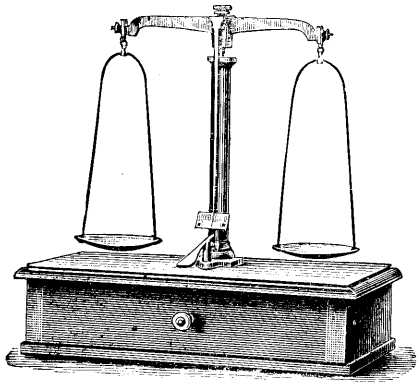


Fig. 303.

for loss or shrinkage on the one hand, and the length due to the corrugations on the other. Then suppose all those general conditions to be settled, we may proceed to the actual discovery of the counts of a given yarn. In dealing with the yarn in the bulk there are several rough and ready methods adopted. For instance a hank may be weighed, or any fractional part of a hank, with a recognised standard weight, and the weighing may be done either upon an ordinary balance or by what is commonly known as the quadrant. A simple balance

sufficiently good for weighing either a hank, or say anywhere from forty yards upwards, is shewn at Fig. 303, but it would not be sufficiently fine to weigh any small

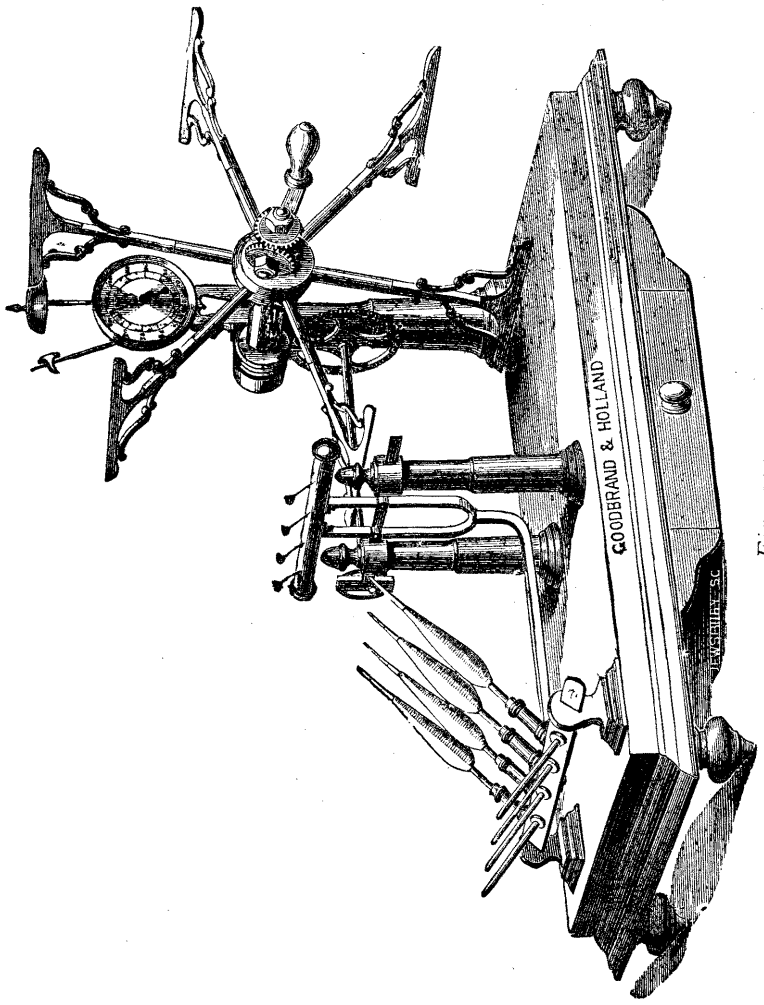


Fig. 304.

quantities; then the mode of procedure is to reel from the cop, or the hank, a given number of yards on an apparatus illustrated at Fig. 304. Here a wrap reel, as

it is termed, is shewn, with which we can draw the yarn either from cop, bobbin or hank. The circumference of the reel itself is usually one or one and a half yards, and a dial driven by a worm wheel indicates the number of yards put upon the reel, and if we are reeling a full wrap of say 80 or 120 yards, an indicator bell placed over the dial gives warning the moment that length is put upon the reel. Suppose, for instance, we are reeling from four cops, as shewn in the illustration, we might make any length from each cop, and then weigh them either separately or collectively. An important matter in connection with reeling is the proper distribution of the yarn upon the reel. For the purpose of ensuring this being done in the best possible manner the guide eyes through which the threads are passed are placed upon a rail which is made to move from side to side by means of a worm and wheel and a short counter shaft, as seen in the illustration, so as to spread the thread evenly over the surface of the reel, the object being to prevent any overlapping, as it must be obvious that when overlapping does occur some of the threads must be longer than others; this must interfere with the absolute accuracy of the measurement, although no allowance is made for it in the trade, the overlap being recognised as part of the actual length. Then of course the tension upon the thread will also have an influence, and this tension will vary when the yarn is drawn from a cop, a bobbin, or a hank, and the velocity at which the reel is revolved will also influence it. The recognised velocity in the conditioning houses being at the rate of 560 yards per 120 seconds. Then after the requisite number of yards have been reeled the question of weighing comes in, the usual practice is to reel, as I have already said, a fixed number of yards and weigh by standard weights, sometimes the standard weights being made and numbered

to represent the actual counts. Suppose for instance, our standard weight is made for one hank, then that indicating the counts of 30's yarn would be equal to $\frac{1}{30}$th part of a lb., that indicating 20's yarn would be $\frac{1}{20}$th part of a lb., and so on. If on the other hand we reel a fraction of a hank, as say 40 yards, which would be $\frac{1}{14}$th part of a worsted hank, then this weight would be divided by 14, or in other words we should have it represented in grains; that for indicating counts of 30's yarn would be equal to $\frac{7000}{30 \times 14} = 16\frac{2}{3}$ grains, and the same formula would answer also for any other count. Another system is to reel a number of yards corresponding with the alleged counts of the yarn. Suppose, for instance, that the yarn is said to be 30's, then 30 yards of yarn would be reeled off and weighed, if worsted against a weight of $12\frac{1}{2}$ grains, simply because there are 7000 grains in 1lb. and 560 yards in one hank, therefore if one hank weighed 1lb. one yard would weigh $12\frac{1}{2}$ grains, hence it follows that whatever number of yards weigh $12\frac{1}{2}$ grains the same number of hanks must weigh 1lb. In the same manner we should divide 7000 by 840 for cotton and obtain a standard weight of $8\frac{2}{3}$ grains, and so on for any other material. Then by this process it follows that if a surmise as to the counts of yarn is not correct that more must be added, or some taken away, as the case may be, this being usually done in $\frac{1}{2}$ yards or $\frac{1}{4}$ yards, so that although when dealing with bulk this system of determining the counts of yarns may be sufficiently near accuracy, for practical purposes, it must be evident that for purposes of analysis it is not accurate.

Before entering into finer analysis it will be necessary to deal with another method of ascertaining the counts, that is by the use of what is known as the yarn quadrant. One form is shewn at Fig. 305, it is commonly known as

the hank quadrant, and is graduated for the purpose of weighing one hank at once. As will be seen it consists of a pillar with an adjustable foot, and fixed firmly to this pillar is the quadrant, from which it takes its name; hinged to the centre of the quadrant is, what might be properly termed, a balanced lever, having a hook at one

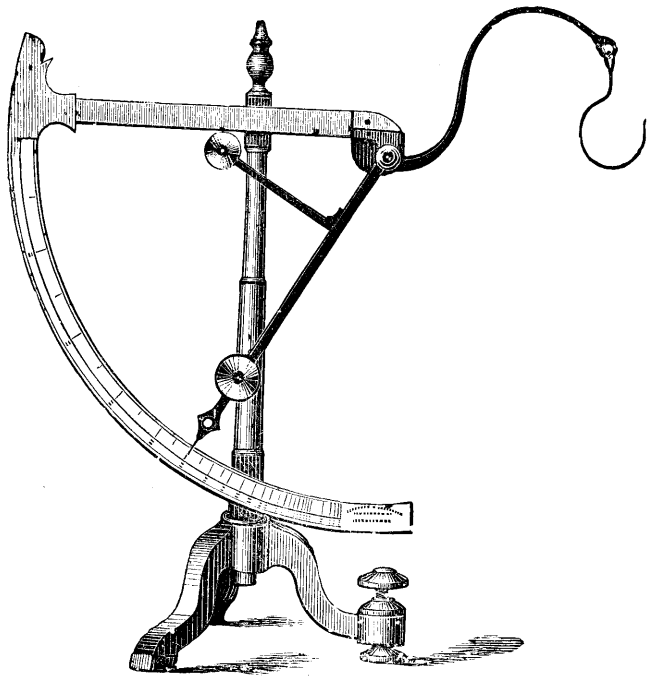


Fig. 305.

end upon which the hank may be placed for the purpose of weighing, and an indicator at the opposite extremity which shall point to the exact counts of the yarn upon the graduated dial of the quadrant. This lever is so balanced, and the indicator so graduated, that the moment a hank is placed upon the hook the counts of yarn will be at once determined.

Another and a more delicately balanced one is shewn at Fig. 306, and which is made for weighing a much smaller quantity of yarn than that shewn at Fig. 305. On the face of it it seems as though very little need be said as to those two pieces of apparatus, for the simple reason that the dial is graduated, and the lever balanced, so that the counts of yarn, or the weight of cloth will be indicated at once, and therefore apparently the analyst need not trouble himself any further. But to the student

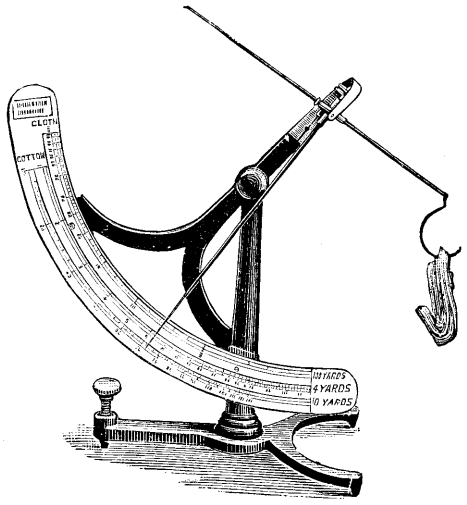


Fig. 306.

there are two questions of importance, first, how, and upon what principle is the dial graduated? And the second, what would be the influence of temperature upon the accuracy of the balance? I will deal briefly first with the principle of graduation. I have made a line diagram at Fig. 307, which will enable me to explain briefly the principle. One arm of the lever with the hook attached to it as shewn at H and the corresponding arm pointing to the dial would, with the hook in its present position, be

opposite the point 7 on the large quadrant, the two thus being at right angles to each other. We have to consider first that the arm H and the arm I, are so balanced in relation to each other that when the arm I is placed in a horizontal position, it would require a weight of say 10lbs. upon H to keep it there. And on the other hand, if the arm I is brought into the vertical position and H to the horizontal position they would exactly balance each other. We then know their exact relations to each other in respect

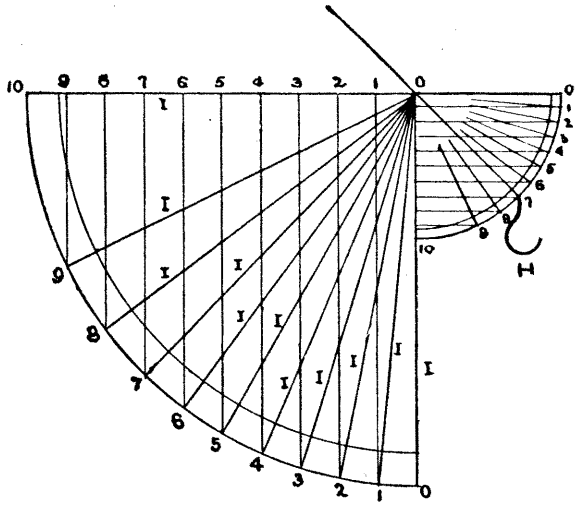


Fig. 307.

to weight, and of course leverage. Now then, assuming that the two lever arms are placed at zero or at the point O, then if they are balanced in the manner suggested, a weight of 1lb. placed upon the hook H will bring the lever I to point 1 on its quadrant, the weight of 2lbs. would bring it to the point 2, and so on in succession up to 10; the long lever approaching horizontal and the short lever approaching the vertical line in precisely the same ratio. The reason of the graduation then becomes obvious; when

the arm I is in a vertical position, and the arm H in the horizontal, the length of I may be said to be nothing, but if it is moved a distance corresponding to one tenth of the radius of the quadrant, then it ranks as a lever of 1 inch length, assuming the radius of the quadrant to be 10 inches, for it must be obvious that the length of the lever is represented not merely by the distance it travels through the arc of the circle, but by the distance which would be represented by a vertical line dropped from the horizontal radius; consequently for the purpose of graduating the quadrant we should first divide the horizontal radius into the number of equal parts corresponding to the weights intended to be represented—I have taken in this case 10 as a matter of convenience—then drop a vertical line from each division to the circumference and it must be obvious that as the lever arm I travels from one point to the other in succession that the length of lever arm it represents will correspond to the number on the dial and consequently assuming, as I have done, that the divisions represent lbs. it would indicate lbs. weight required to bring it to each point in succession. The weight of the corresponding lever arm H must of course be taken into account and I have graduated the arc through which it travels for the purpose of shewing that the two would necessarily coincide; then what appears to be a third element in the matter is the third lever arm shewn as being at right angles to the arm I. This is simply a balancing arm, and it may be so arranged, either in its position or as to its weight, as to be an exact counterbalance to the hook arm H: or it may be used as a means for varying, or of producing what might be an equalisation of the graduation on the dial. The first suggestion is probably the one most generally acted upon, but in either case of course its position, the arc through which it travels, and its influence upon the relation of the two arms at every point of

movement must be carefully estimated, otherwise graduation could not be perfect.

So far the principle of graduation is easily understood; we have then only to look at it from another point of view. In Fig. 306, there are three indicatory dials on the quadrant, one graduated for weighing 10 yards, one for 4 yards and one for cloth. The two yarn dials will be seen to be graduated in precisely the same manner as the rough diagram I have shewn at Fig. 307, but the cloth dial is graduated in the opposite direction; a little reflection will explain the reasons for this. The heavier the yarn the lower the counts, and consequently as the weight increases then the number decreases, so that although there is no actual difference in the method of graduation, there is a difference in the order of numbering, so that the counts are indicated with the highest numbers at the bottom, but the weight of cloth is indicated by the highest number at the top. Of course the difference in the scales in relation to each other will be explained and understood by the difference in the weight. In dealing with cloths or yarns where a fair quantity is available, and where absolute accuracy is not necessary, but a sufficient degree of accuracy for general commercial purposes, the quadrant is a very convenient instrument, but where the quantity available is variable, or where absolute accuracy must be obtained, then of course its disadvantages appear. Each scale must be graduated for a fixed length and only that length can be weighed with certainty upon it. Then there is another element of inaccuracy of such a nature that the Board of Trade will not sanction it as a trustworthy indicator of counts in any official department; the well known influence of temperature upon the metals causing expansion and contraction which must of necessity interfere with the absolute truth, but yet it may be sufficiently accurate for the general mill purpose.

KNOWLES' PATENT YARN BALANCE.

This is a yarn balance which although differing in structure from the quadrant is intended to serve the same purpose and to ensure a greater degree of accuracy. As will be seen at Fig. 308, the general arrangement is after

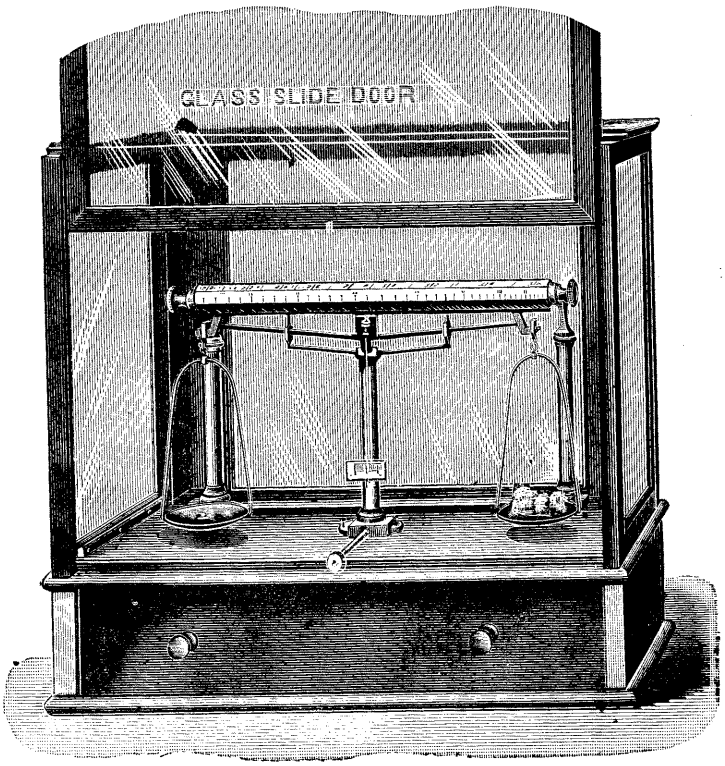


Fig. 308.

the character of an ordinary chemical balance; there are two pans, the one to the left on which a weight of a given denomination must be placed, and the one to the right upon which the yarn must be placed. The balance during the operation of placing the weight and the yarn

in the pans is at rest in precisely the same manner as a fine chemical balance; behind the beam a graduated bar is placed, having a number of flat surfaces, each surface being graduated to correspond with the varying counts of yarn; suppose, for instance, the surface A is graduated to represent from 20's to 40's, and B might be graduated from 40's to 60's, C from 60's to 80's and so on; then a weight corresponding and marked with each of the several graduations would be placed in the pan, just as one or the other scale is brought to the front: an indicator sliding along the beam points to the number of the yarn being weighed. Then for the operation of weighing, the moment the weights and the yarns are placed in their respective pans, the lever in front of the pillar is pressed down and the indicator is moved along the beam to balance the scales, and when they come to rest will point to the exact counts of yarn. The machine is finished in a very fine and delicate manner, so as to ensure accuracy, and is enclosed in a glass case to prevent dust getting into the joints. Possibly some objection may be raised to this as to other forms of automatic balance in consequence of the variation caused by temperature, but it must be obvious that it cannot be affected in the same degree as the ordinary quadrant.

It will now be necessary to enter fully into the use of balances and weights for testing the smallest possible amount of yarn. The first, and most important, apparatus is a first class balance, such as the one shewn in Fig. 309 enclosed in a glass case so that it will not only be kept free from dust but from draughts when in use; with adjustable screw feet so that it can always be set perfectly level, and the firmer the table on which it is placed and the better; in fact in careful weighing, if there is the least vibration the accuracy cannot be depended upon. As will be seen, the balance is provided with rests, and also with

a steadier for the pans, so that when the material or the weights are being placed in the pans they are not swinging but are held perfectly steady. In addition to those provisions there are a pair of rods, as seen projecting from each side, each carrying a small hook for the purpose of placing riders on the beams when it is desired to work to a degree of accuracy beyond the limit of the usual weights. The first thing to do is to take care as to the

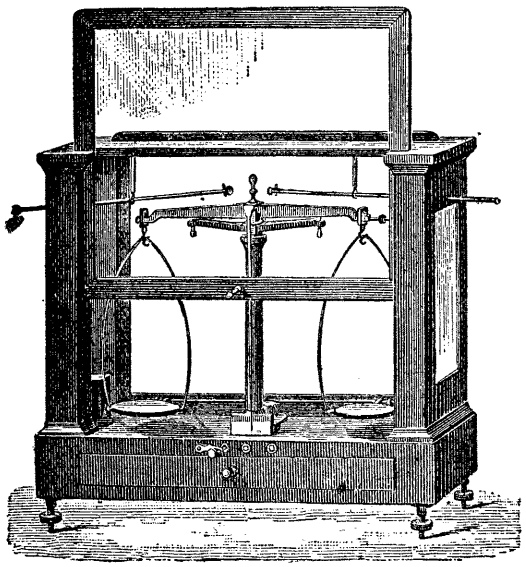


Fig. 309.

accurate adjustment of the balance; place it on a firm stand or table, level it by means of the screw feet, then close down the front of the glass case and test it with a view to adjustment. A small adjustable screw at the end of the beam to the right permits of this operation being carried out perfectly; but the balance must not be considered as adjusted until it will stand with the pointer

exactly opposite the centre of the ivory indicator at the base of the pillar; this having been done it is ready for use. The next thing is to secure a set of good weights, those may vary in extent from anything representing say 1000 grains, or from 100 grains down to one-hundreth part of a grain. The grain weight is to be preferred for ordinary determination of counts, as it can be readily worked into the English systems, but if the work should be for the simple purpose of determining percentages, such as for loss in treatment, or the relation of one material to the other in a fabric, then the gramme weight is most convenient, being based on the decimal system. Then taking the grain weight, what we should have would be a set ranging from 100 grains down to 1/100th. As following:

100 grains	6 grains	·6 grains	·06 grains
60 ,,	3 ,,	·3 ,,	·03 ,,
30 ,,	2 ,,	·2 ,,	·02 ,,
20 ,,	1 ,,	·1 ,,	·01 ,,
10 ,,			

and with such a series as this the test can be carried out to almost any degree of nicety. A box is shewn at Fig. 310. For the present I shall speak only of ascertaining the counts of yarn, the questions of shrinkage, gaining by stretching and other matters must be left until a later stage. Then assuming that we have only a very small length of yarn available, say, for example, a few inches; we must weigh it and ascertain the exact number of grains it will weigh; suppose, for example we have 6 inches and it weighs ·25 grains, then 1 yard would weigh 1·5 grains, and as there are 7000 grains in one lb. there would be $4666\frac{2}{3}$ yards or $8\frac{1}{3}$ hanks per lb. Suppose we put it another way we might find the counts by a direct formula, for instance there are 7000 grains in a lb., and, as already pointed out, if we divide 7000 by 560

we have a standard weight of $12\frac{1}{2}$ grains, which corresponding with the yards in one hank will give the counts, so that, let L represent the length of yarn weighed, W the weight in grains, we should have the formula: $\frac{L \times 12{\cdot}5}{W} =$ counts, or in this case $\frac{1 \text{ yard} \times 12{\cdot}5}{1{\cdot}5} = 8{\cdot}33$, or if 6 inches be taken it would be $\frac{6'' \times 12{\cdot}5}{36 \times {\cdot}25} = 8{\cdot}33$.

In the weighing of these small quantities too much care cannot be exercised, as the most minute fraction in the weight will make a difference in the counts of fine yarns

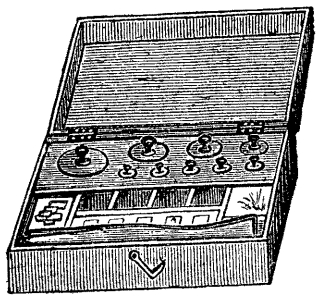


Fig. 310.

of several numbers. In many cases perhaps only a few inches may be available, whilst in others a yard or two may be obtained. The analyst should always get as much as he can so as to reduce the error to the lowest point.

In addition to the weights mentioned there are riders or small weights of fine platinum wire to place on the beam, the beam is graduated as a scale so as to indicate the value of the rider from the position in which it is placed, so that the same balance may indicate the weight to the 1oooth part of a grain.

For those who can afford it is best to buy a good balance, which may cost anything from 7 to 20 guineas,

but good, and fairly reliable ones may be had for from 2 to 3 guineas.

TESTS FOR EVENNESS.

So far the tests have been applied only to the determination of the counts in yarns, but we have now to come to tests which cannot be measured with the same degree of scientific accuracy, but which are in themselves quite as important in the production of good fabrics. We cannot look at the production of threads in the same manner as we might look at the production of say a brick; absolutely evenness and straightness may, in many cases, be the chief thing aimed at, but there are instances where this is not the final consideration, although no doubt in the great majority of fabrics it is one to which the closest possible attention must be paid. In any case we must have some means of ascertaining, or judging as it is termed, of the degree of evenness in any yarn. Sometimes this is done in a rough and ready manner by drawing a thread from a bobbin and casting the eye along it. The practised eye can form a very good opinion but it is sometimes difficult by this means to obtain a sufficiently reliable one; again sometimes the sense of touch is cultivated by running the thread through the fingers, and here a considerable degree of proficiency may be acquired, but something of a more tangible character is required of the kind shewn in Fig. 311, where a blackboard with a perfectly even surface is placed in a frame, the yarn being distributed by guide eyes, and driven by a screw from the main shaft of the apparatus in such a manner as to distribute the threads with perfect evenness upon the board, so that the bulk of one thread can be compared with that of another. Of course it will be understood that in making comparisons of this kind a number of threads will be seen side by side, so that all the variations in bulk may come within

the range of vision at once. The question of evenness of yarn carries with it a good deal more than might appear at first sight, not from the mere fact that any unevenness in the yarn would cause unevenness in the fabric, but also because of the inequality in strength, and our methods of estimating must be reduced to that which would give us the most reliable results. But the

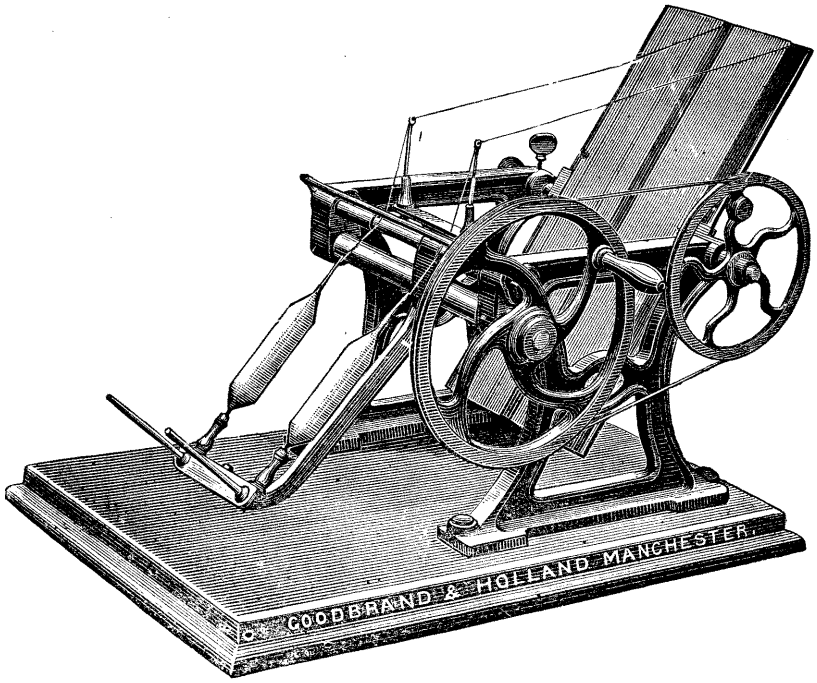


Fig. 311.

question naturally arises, what degree of inequality may exist in yarns, for instance a spinner may give a guarantee that his yarns will not vary more than from 1 to 2 per cent., and when tested hank by hank he may keep well within the guarantee, but in the average yarns of commerce the difference in the bulk as would be determined by

micrometrical measurement would give vastly different variations. In a large number of experiments which I have made from time to time I have found in very good yarns indeed, variations in the thread drawn from the same bobbin to amount to not less than 30 per cent., although the average variation as tested by the usual tests for counts would not exceed in all probability 2 per cent.

STRENGTH TESTS.

In testing for strength of yarns there are many reasons why very strict attention should be paid, not only to the absolute strength, but to the degree of elasticity in the thread, and although I am proposing to deal first with the strength and elasticity of the yarn in the hank I shall have a good deal to say presently of the value of testing single threads for the purpose of discovering defects in fabrics, or of ascertaining the suitability of yarns for special purposes. The operation, whether taken in the hank or single thread, is both an important and delicate one, and although the apparatus appear, especially the hank testers, to be capable of a considerable amount of rough treatment, yet carelessness in their handling must have a most prejudicial and misleading effect upon the results. First, we may be asked what should create the necessity for a knowledge of this strength, or more especially elasticity. There may be many important operations or results dependent upon a thorough knowledge either of what a yard would stretch, or what may be its breaking strain, so that we may be able to determine either the absolute strength of the cloth; what may be the result of a certain process of treatment, either in the weaving or finishing, and what may be the ultimate result to the fabric as it will affect the application for which it is intended. Even in the simple process of weaving there are considerations which render it necessary that we should at

times be able to determine the degree of elasticity and the strain the threads will bear. For instance, in many cases, if the yarn is lacking in elasticity, although it may have ample strength, we shall have some difficulty in dealing with it in weaving into some classes of fabrics.

In the hank tests there are several machines in use, driven either by hand or power, and having either a dead weight or a spring. The simplest of these is shewn at Fig. 312, which is driven by hand, and having a dead weight for determining the breaking strain. As will be seen the hank is placed upon two hooks, one immediately under the dial and the other near the base of the apparatus; a handle driving a worm which causes the lower hook to recede, pulling at the same time the upper hook, which acts upon a lever with a heavy weight attached will cause the weight to rise; at the same time the pointer on the dial is made to travel and indicate the strain upon the face of the dial; to the right is placed a rod which is made to travel with the hook and indicate the stretching of the hank before breaking, so that the moment the hank breaks the indicator on the dial is arrested, and so is the elasticity rŏd at the side, and the results can be read off at leisure. So far the apparatus will appear to be perfect, but the results obtained from it may vary considerably. In the first place it must be obvious that the yarn must be very evenly reeled, otherwise the test for elasticity would be of no value, as a considerable allowance must be made for the slack threads to come to the same degree of tension as the tight ones, and it is only after that that the real test of elasticity commences. Then again the rate at which the wheel is driven, whether it be perfectly regular or irregular, will have an important influence upon the test. Suppose, for instance, the moment the hank is brought to tension, the wheel be allowed to revolve very rapidly, then it would be brought to the

breaking strain before a real test of elasticity could be obtained; on the other hand, if it is revolved slowly the yarn may be made to stretch in a degree beyond its

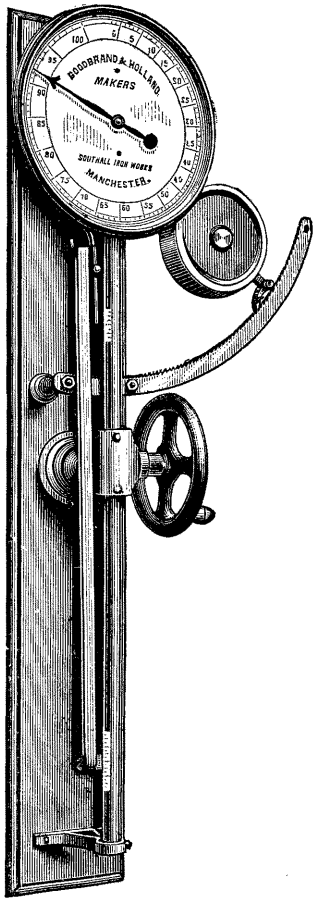


Fig. 312.

natural tendency, simply by subjecting it by a series of easy stages to a strain which is neither sufficient to break it nor to test its strain bearing qualities in the ordinary

way, or its elasticity in a proper degree; in fact it would be a point where the endurance of the yarn may be more correctly said to be on trial. Inequality in driving will have a somewhat similar effect, for it may cause undue stretching at one point, and by too abrupt movement, a sudden fracture at another before the true breaking point is reached. What I wish to convey by this comparison is that tests applied to yarns in any irregular or spasmodic manner can have no practical value, as they neither indicate the real strain bearing qualities of the thread or its proper degree of elasticity; and the same yarn subjected to a number of tests under different conditions would give a variety of results, whereas good yarns tested under the same conditions for any number of times would give practically the same results. It is on this account that the power driven testing apparatus illnstrated at Fig. 313 is always preferred, the speed is uniform and is fixed to be driven at what might be termed a medium rate; the operator cannot play any tricks with it, as it must be obvious that in the hands of either an incompetent or unscrupulous operator the hand machine may be made to prove almost anything which he desired it to. In conditioning houses, a standard rate of speed of 5 inches in 15 seconds between hook and hook is imposed, so that the tests should be of one uniform character.

For the purpose of testing, the hank is placed upon the upper and lower hooks in the same manner as in Fig. 312, and the belt is thrown from the loose to the fast pully communicating motion to the bevelled gearing at the side of the machine, causing the lever and weight to travel up the rack, at the same time indicating in the same manner as in the previously described instrument the strain, by the pointer and figures on the dial. When the hank breaks, the catches seen at the end of the lever hold firmly in the rack, thereby causing the pointer to stop and

indicate the number of lbs. at which it broke. The top hook descends a little as the lower one descends, and an

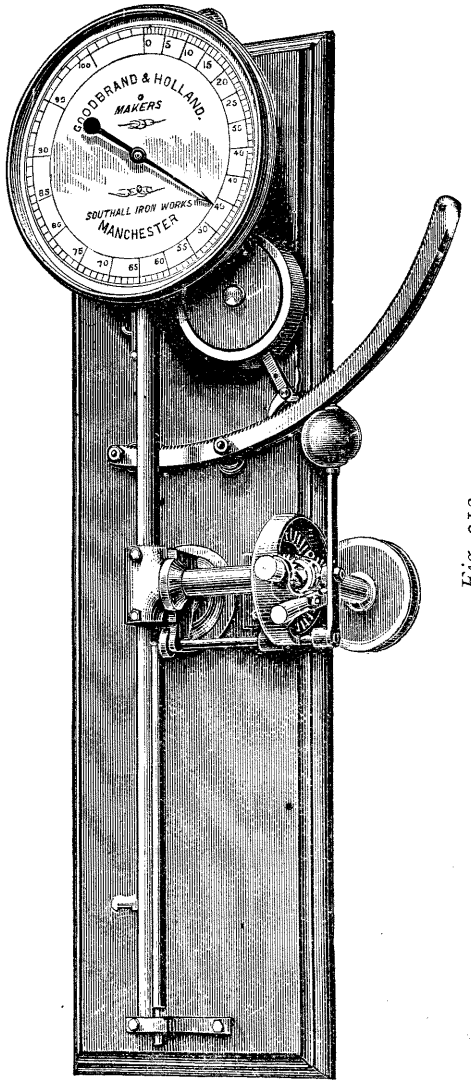


Fig. 313.

indicator is attached to it, which measures the exact amount of the descent on a scale on the upper tube which is

divided into inches, and a corresponding indication is made on the lower tube ; then to ascertain the amount of elasticity, the figure denoted on the indicator of the upper tube is deducted from that upon the lower one, the difference being the exact number of inches the yarn is stretched. The self-acting stop motion is very simple ; when the yarn or hank breaks, a catch acting upon the levers pushes the strap from the fast pulley to a third pulley, causing the machine to run back to the starting point, *i. e.*, it takes the upper hook back to the top after which the strap may be brought to the middle or loose pulley again, where it remains until it is required to be put in operation. For hank testing this is unquestionably a good machine.

Another important machine is that for testing the strength and elasticity of single threads. I should like here to lay very great stress upon the necessity of paying strict attention to tests of single threads, and at the same time to give one word of warning as to the unreliability of tests made in a careless manner. A single test of a single thread either for strength or elasticity can possess no practical value ; every thread varies not only in its diameter as I have already said, anything up to 30%, but it varies also in the amount of twist, and as is well known, and as I shall have to demonstrate at a later stage, the thinner the thread and the greater amount of twist will run into it. Then in the thick parts the fibres may have a tendency to slip from each other, and instead of the thread breaking, it would be simply drawn asunder, or it might break at any thin or weak part ; in the one case there would be a clear fracture of the fibres, but in the other the bulk of the fibres would remain intact. In neither of those two cases could the breaking strain or the elasticity be taken as a fair record, and accidents of this kind are always liable to happen in ordinary threads. Of course in hard spun threads the tendency to variation will not be so great, still it would

have some existence: but without looking at the extreme cases there must always be a variation, consequently it is never safe to rely upon one test, but a number of tests should be made and the average taken of the results. Ten to twelve tests is not unreasonable and I should not like to place any reliance upon any experiments of less than that number. These remarks will apply not only to strength, but elasticity as well.

Now I would wish to point out the necessity of applying single thread tests for the purpose of discovering any inequalities in yarns, more especially when taken from cloths. I will give one or two illustrations for the purpose of impressing this. Supposing the warp for a cloth to be made from yarns spun from the same counts, having the same number of turns per inch, and to all appearances in every respect the same; one possesses a great deal more elasticity than the other, or a greater tendency to shrinkage; then in the process of finishing they will behave differently, and as a consequence, the fabric will present the appearance of stripiness, and the stripes may be of the most irregular character, the irregularity being dependent of course upon the manner in which the threads have been mixed. Then how is the fault to be traced to its source? Threads are taken out of a cloth and tested for counts and proved to be exactly the same; they are tested for twist and are proved to have the same number of turns per inch; they are examined for quality, but the question of quality is a matter of opinion or judgment; there is nothing to prove it, and as a matter of fact two yarns may be of precisely the same quality and yet possess a different degree of elasticity; the difference either being due to their treatment after spinning, or to one having been spun a long time and become set, and the other, as I have already explained, come fresh from the spinning frame. A proper test of the elasticity, or of elasticity and

strength combined, would disclose at once that there is a difference in the yarns. If the difference is in elasticity only then probably the fault will lie in the treatment

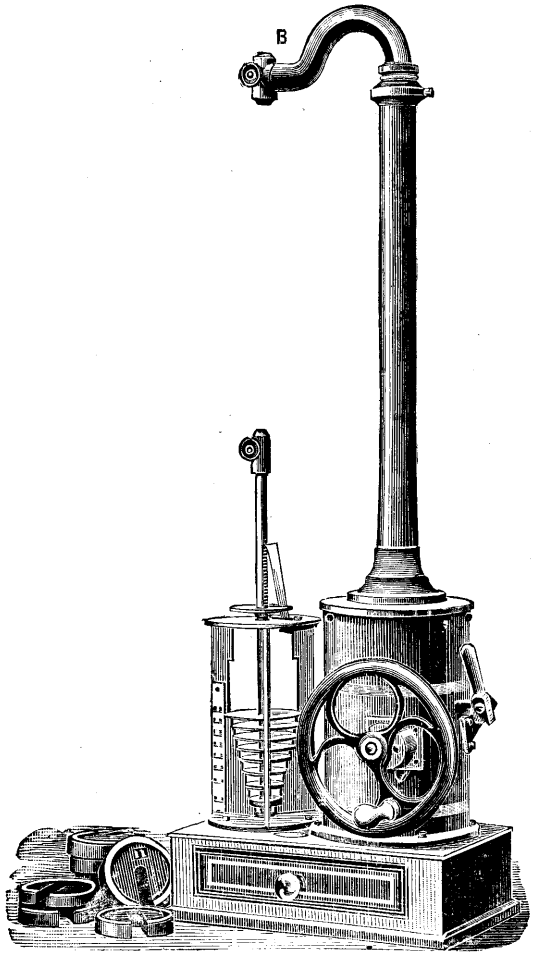


Fig. 314.

after spinning, but if in both elasticity and strength it would probably indicate a difference in quality. I have had many cases come under my observation where a

single thread test for elasticity alone has led to the ascertaining the cause of the fault, consequently I feel disposed to lay considerable stress upon it.

One machine for testing strength with elasticity of single threads is shewn at Fig. 314. The apparatus is extremely simple. A vertical pillar carries a small clamp at the end of a bent arm at its upper extremity; immediately beneath this a vertical spindle is placed with a corresponding clamp; this spindle passes down into a sort of holder for weights, and upon one side of it is a rack which may be engaged with a catch as it rises. Then the thread to be tested is screwed firmly into the two clamps, and a handle at the base of the pillar operates a toothed wheel, which, being engaged in a rack raises a spindle with the upper arm; this gradually lifts the small spindle and weights suspended by the thread; as this spindle rises it lifts one weight after another until the breaking point is reached, when the breaking strain will be indicated on the dial placed alongside the weights, and the degree of elasticity indicated upon the spindle held, as it is, rigidly by the catch engaged in the rack. To all appearances this machine would be perfect, but there is one fault which must not be overlooked, that is the variation of tension at which the threads are screwed into the clamps, if the thread is left slack, of course, the degree of elasticity would appear to be very great, whereas if it is pulled tight it appears slight in comparison. Only practice and judgment can determine what shall be the proper tension before proceeding with the test.

Another machine for testing single threads is shewn at Fig. 315, and for reliability I should prefer this, where the question of elasticity only is concerned, to the one already described. In this case the threads are screwed into a clamp on the horizontal tube to the right and

passed through another clamp at the top of a pillar to the left, then over a horizontal bar and fastened to a small weighted lever; the object of this latter part of the apparatus being to ensure that each thread tested shall be held at exactly the same tension, for it is not made fast in the clamp on the pillar until the weight behind has brought it to its proper degree of tension. This weight is, of course, capable of variation to suit the different counts of yarn. Then all being in readiness, a little wheel is revolved and acting upon a rack upon the tube, gently carries it along until the thread breaks; a most ingenious stop arrangement comes into action; on one side of the tube a long wire is hinged, having a small pulley at its free extremity, the pulley resting upon the

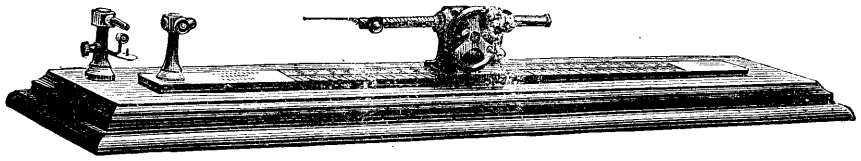


Fig. 315.

thread being tested, but having no appreciable weight; the moment the thread breaks this wire drops, and engaging a catch falls into a notch on a ratchet wheel and arrests the further progress of the tube. This stand carrying the tube is moveable upon a species of bed plate marked in inches. The tube itself is also marked in a corresponding manner, so that we can see at once the length of the yarn being tested, as also the length it is stretched before breaking, and can easily ascertain the degree of elasticity. Suppose, for instance, we set the apparatus to test 10 inches, and it stretches one before breaking, we know at once, and can express in figures the degree of elasticity as being 10 per cent., that is, it will stretch 10 per cent. of its length before it breaks; but in testing single threads,

as I have already pointed out, we must take a number of tests and then take an average. Again we must make a careful examination before recording a test, first, to ascertain whether a fracture, properly speaking, exists, or whether the fibres have been drawn asunder, and we must look whether the fracture has occurred close to the jaws, because if so, it is not a proper fracture, but is a cut by the jaws being screwed too tightly upon it. Then if at each test the fracture is what may be termed a proper one, the average of the tests being taken would give a fairly reliable result. There is one feature of the case here which may perhaps have some interest as bearing upon the question of the relations of elasticity and strength; threads spun to the same counts, and from fibres of the same quality, will, presumably bear the same weight and strain, but may differ considerably in the degree of elasticity. There will be presumably the same average number of fibres in the thread throughout its length, but if the thread is very softly twisted there would be a tendency in the test to draw out, and therefore the elasticity would appear to be greater than it really is; but assuming that they are sufficiently firmly twisted to fracture all at the same time, then a difference in breaking strain, or a difference in the degree of elasticity would suggest a difference in quality. But the thread which is hard twisted must of necessity stretch more and break at a higher point than the soft twisted thread, properly speaking, because of the firmness with which the fibres are held together and the necessity of drawing them to nearly a straight line before a fracture actually occurs.

In respect to the question of quality it is often assumed that the yarn which possesses the greatest degree of elasticity has the most "quality;" that may be true or not, if both are twisted in the same degree it is probably true, but the twist must be taken carefully into account.

As regards quality there is another factor, namely, the fineness of the fibre of which the thread is composed; fineness of fibre and quality would be in most cases synonomous terms, but the term quality implies even more; the fibre must be in good condition, evenly grown, and possessing all the qualities of loftiness, and with those conditions present there would be no difficulty in determining the quality.

THE TWIST OF YARNS.

In dealing with the question of twisted yarns we must approach the subject from a point of view beyond that merely involved in methods of testing. The first question one is naturally inclined to ask is, what number of turns should there be in the yarn? The answer would depend naturally upon the purpose to which the yarn is to be applied. In the first place, it would be generally the relations between the warp and weft. There may be general rules which are sufficient for the guidance of spinners when no special conditions are laid down or required; any departure from those general rules, or what we might term standard twists, would produce hard or soft twist yarns, just as the departure had been made in one direction or the other. For instance, in cotton spinning, there is a general empirical rule for determining twists of any count of yarn, viz.:—to multiply the square root of the count by $3\frac{3}{4}$ for warp and by $3\frac{1}{4}$ for weft, the product being the number of turns per inch required. This comes out very well in general practice but it is not exactly true, although sufficiently near to serve all the purposes, especially in yarns of lower counts. The twist must be varied according to the square of the counts on the well-known principle that the areas of circles vary, not in the ratio of the diameters, but as the squares of the diameters. Consequently if we treat the threads as representative cylinders, the variation in the counts will

determine the variation of the number of turns in the ratio of their square roots, in consequence of the counts going higher as the thread becomes finer, or in other words of the counts and the diameters being in inverse ratios. This may be demonstrated immediately by drawing two lines parallel to each other at a distance of say one inch apart, and drawing lines diagonally at any angle to represent the twist; suppose for convenience of illustration lines be drawn at an angle of 45°, that would illustrate one turn per inch in a thread of one inch in diameter; now draw another thread of $\frac{1}{2}$ inch in diameter and draw diagonal lines at 45° also to represent the twist; then there will be two of those diagonal lines in one inch of the thread; but although the threads have diameters of 2 to 1 relatively, their weights will be as 4 to 1, simply because of their weights being in the ratio of the squares of the diameters. Then we say that the twist varies as the square roots of the counts, and if we call the one inch yarn in this case 1's counts and the $\frac{1}{2}$ inch yarn 4's we have the exact ratio of the weights. Then the square root of 1 is 1, and the square root of 4 is 2, therefore we have one turn per inch in the 1's and two turns per inch in the 4's yarn; then this rule must of necessity hold good in any number. But to return to the empirical rule before referred to, Dr. Ure makes reference to it in his "Cotton Manufacture," and gives the correct method for working it out. But here as in everything else we must have a starting point, and this starting point he takes what he alleges to be the standard used in some of the Scotch mills, where he says they make "25 turns per inch for 50's warp yarn and the same number for 60's weft." Then if we have this as the starting point we can readily determine the number of turns for any count; it would simply resolve itself into the formula, as $\sqrt{50} : \sqrt{36} :: 25 : x$ or as $50 : 36 :: 25^2 : x^2$, assuming

the yarns to be 36's; then the same rule will hold good for any other yarn. Of course from this base, or from any other base adopted, we may make the yarn hard or soft and we should only have to consider its influence upon the fabric and the influence of take-up in doubling or twisting, and afterwards the methods of testing.

THE TAKE-UP OR CONTRACTION IN YARN TWISTING.

When yarns are being twisted together what is known as the "take-up" or contraction will have a material influence in determining both the length or counts of the folded yarn, and also the character of the thread, and in analysing cloths the determination of the character of the thread is important. The importance may have bearings in two directions, first, the influence of the character of the thread upon the fabric, and second, the influence of the twist, or the method of twisting upon the counts. Suppose we are twisting two threads together of equal counts and quality in any material, as for example 60's cotton, we should be said to be making a two-fold 60's yarn. Really we should be doing so, but the yarn would not be of the value usually expressed by the term 2/60, and which would be equivalent to single 30's, but it would be heavier than that, there has been some "take-up" in the twisting. Now let us see if we can discover the value of this take-up.

Assuming the two threads to be equal in every respect, and held at the same tension during twisting, each will form a diagonal across the other, and each will be bent out of the straight line a distance equal to the diameter of the thread, as shewn in the illustration at Fig. 316, so that there would be two diagonal lines for each turn or twist, and each of those diagonal lines must represent a distance equal to half the diameter of the two threads combined, as shewn from A to B and from B to C,

With this data, coupled with a knowledge of the diameter of the thread the take-up or contraction should be readily discoverable. For instance, the cross section of the thread, and a line drawn equal to the length of the half twist, may be treated as two sides of a right angled triangle, and the line of the twist as the hypothenuse, as shewn from A to C. Then as pointed out in my "Treatise on Textile Calculations," the diameter of the thread may be found either by reference to the tables given there or by extracting the square root of the yards per lb. of the yarn, which is really a deduction from these tables. For instance, suppose the yarn to be 20's cotton, thus $20 \times 840 = 16800$ yards per lb., and the square root of 16800 is 130 nearly, or the diameter of the thread is

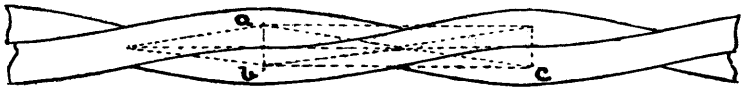


Fig. 316.

$\frac{1}{130}$th part of an inch; but for the diameter of the doubled thread we must not add the two diameters together, but treat them as a folded yarn, on the assumption that the two together would make one of exactly double the weight, but not of double the diameter. That has already been explained. Then the diameter of the compound yarn would be equal to $\sqrt{10 \times 840} = 92$ nearly or $\frac{1}{92}$nd part of an inch. Now suppose we have eight turns per inch in the yarn we have to ascertain what will be the length of yarn required to make one-eighth of an inch of the twisted yarn, or in other words, what will be the amount of the take-up. It will resolve itself practically into the question of the length of the hypothenuse representing the length of yarn required to make the length of folded yarn equal to the altitude of the triangle. Then the formula for working is, hypothenuse H is equal to base B^2 + altitude A^2,

therefore there being two hypothenuse for each twist in the thread it will be $\sqrt{\frac{1}{9^2} + (\frac{1}{8} \div 2)^2} = \frac{1}{84^4} + \frac{1}{256} = \frac{87}{216678^4} = \frac{1}{247}$ and $\sqrt{\frac{1}{247}} = \frac{1}{15\cdot64}$ and $\frac{1}{15\cdot64} \times 16 = \frac{16}{15\cdot64} =$ 1·0294 or nearly 3% take-up. There would then be a little more gain in getting the jaw into condition.

When the threads are not of the same bulk, the bending would take place in a greater degree in the thin than in the thick thread, and the allowance of length would have to be varied proportionately, but in what are known as the corkscrew yarns one thread is held perfectly straight to form a core, and the other twists round it, as shown in Fig. 317. Then taking the two threads as A and B, the length of yarn of A will not be varied, as there is no take-up, but the length of B will be

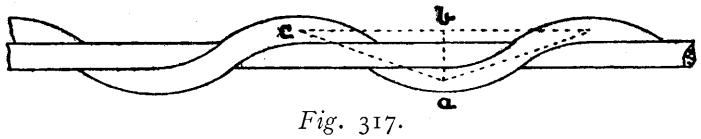


Fig. 317.

varied as the length of the hypothenuse C, and to find this we should have to add the diameters A B to find the base, and proceed as before thus, taking the counts as 10's worsted for both threads, we should have $\sqrt{560 \times 10} = 74$ nearly as the square root or $\frac{1}{74}$ as the diameter, then say with 6 turns per inch, and to find the length of yarn for one inch we should have $\sqrt{(\frac{1}{74} + \frac{1}{74})^2 + (\frac{1}{6} \div 2)^2} = \frac{1}{37}^2 + \frac{1}{12}^2 = \frac{1}{1369} + \frac{1}{144} = \frac{1513}{197116} = \frac{1}{130\cdot3}$ and $\sqrt{\frac{1}{130\cdot3}} = 11\cdot4$ and $\frac{1}{11\cdot4} \times 12 = \frac{12}{11\cdot4} =$ 1·052, or an increased length of the bending thread of 5·2%.

This formula is not absolutely correct, for it treats the threads practically as though they were flat bodies instead of cylinders, so that to the length of the hypothenuse should be added the difference between the diameter and half the periphery, as representing the length of yarn

taken up in bending round the core thread, and which would be equal to the diameter multiplied by $\frac{3\cdot1416}{2}$. Then to reduce the fractions to decimals for ease of working, $\frac{1}{7\cdot4} = \cdot135$ the diameter, and $\cdot135 \times \frac{3\cdot1416}{2} = \cdot212$ and $\cdot212 - \cdot135 = \cdot077$ as the length taken up in bending: then the length of the hypothenuse is $\frac{1}{11\cdot4}$ or $\cdot88$, and $\cdot88 + \cdot077 = \cdot957$, and $\cdot957 \times 12 = 11\cdot1484$, or a gain of nearly 15 per cent.

In the actual process of twisting there would be some compression of the threads and consequently this would be reduced considerably in most cases. As pointed out in my "Textile Calculations," the influence of bending is in the direct ratio of the cubes of their diameters if the threads are held at the same tension, but this tension is varied by spinners in accordance with the character of yarn it is desired to produce, so that the take-up would be between the two extremes I have demonstrated.

Then as to the methods of testing twisted yarns; there are many methods in use, some of a reliable character and others very unreliable; of course it must be understood that in testing single yarns there is always considerable difficulty because of the almost impossible task of following the number of turns through the individual fibres, and even in the best twist testing apparatus the length to be tested must be carefully considered in relation to the length of the fibre, otherwise if too great a length is attempted, the moment the whole of the twist is taken out the thread will fall apart. One method sometimes resorted to is to place a magnifying glass and count the number of turns per inch, this is a most unreliable one, not simply on account of the difficulty of counting the number of turns per inch, but also on account of the difficulties attending an equalisation, or supposed equalisation of the threads, and the fact that only a very short length can be measured by any magnifying glass of reasonable power;

consequently one test may be made upon a very thin part of the thread, and the next upon a very thick one, so that to obtain any reliable result a large number of tests must be made, and an average taken. It is best, wherever possible, to test as great a length as is available, say 10 or 12 inches, and even then a number of tests should be made to find an average. A very good instrument is shewn at Fig. 318; this consists of a base board with a brass plate upon it marked off in inches; to the extreme left of the plate is a little upright pillar with a pair of jaws or clamps at its upper extremity; sliding along the plate is a pedestal carrying a short shaft with a worm

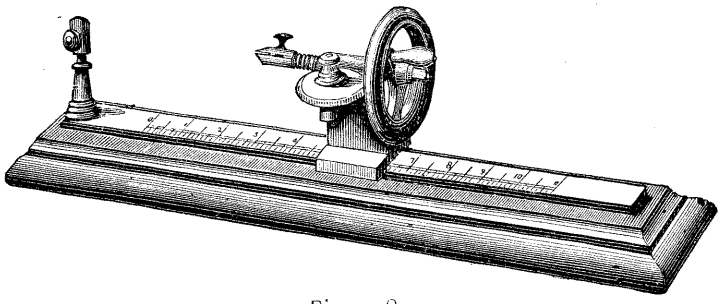


Fig. 318.

upon it made to revolve a disc placed horizontally. To the left of the shaft is a clamp, or pair of jaws, holding one end of the thread, and at the opposite extremity a small wheel to be revolved by hand. The horizontal disc or plate is simply a dial divided round the circumference so as to indicate the revolutions of the horizontal shaft and worm; in fact there are two dials, one inside the other, one indicating the number of turns when the wheel is revolving in one direction, and the other when revolving in the opposite direction, so as to ensure accuracy of counting. Then the pedestal is moved along the plate to a position corresponding with the length of yarn to be tested; one end of the thread made fast in the jaws on

the horizontal spindle, and the other made fast in the jaws of the small pillar.

At this point perhaps attention should be called to what was said in relation to the question of elasticity. If a thread is drawn to tension after being fixed in one jaw by means of the fingers, it is liable to great variation, and no test could be considered absolutely reliable, therefore it is better to have a weighted lever, as shewn in the elasticity test at Fig. 315, for the purpose of ensuring all the threads of one series being held at one tension. This having been done, and the thread secured in the clamps, the wheel is made to revolve, until the twist is entirely taken out of the thread; the surest method of determining when the twist is entirely removed is to insert a dissecting needle between the two threads close to the pillar at the extreme left, and gradually slide it along as the threads are untwisted from each other until it comes to the jaws on the horizontal spindle, when of course the threads must be absolutely free from twist. Then the number indicated on the dial will be the number of turns for the whole length of thread, and that divided by the number of inches tested will represent the number of turns per inch. Suppose, for instance, we are testing 5 inches, the dial indicates 45 revolutions of the spindles, then 45 divided by 5 will give us 9 turns per inch. That of course is an average for 5 inches only, but it must be obvious that an average of 5 inches can scarcely be taken as a true average for a large quantity of yarn; in fact I should scarcely consider a series of tests reliable unless I have taken averages representing at least from 60 to 100 inches, varying of course with the bulk and quality of the yarns under examination.

There are several forms of twist testers, but the principle is the same, the difference being mainly in the mechanical arrangements for facilitating the work; such

for example as making the jaws revolve at each extremity of the thread in opposite directions, or by the use of gear, making the spindle revolve twice for each revolution of the handle wheel. But in any case there is no difference in the principle, it is only a difference in the mechanism.

A few words may be said with reference to the necessity for testing yarns to ascertain the number of turns per inch. To enumerate all the irregularities in cloth which have been brought about by uneven yarn and the difficulties of detecting it would be an almost impossible task; for instance, for some purposes it is necessary that the yarn should be very hard twisted, and it is equally essential that each succeeding lot must be absolutely up to the standard of twist, then just as it is necessary to test the counts to ensure the yarns being equal in weight it is equally necessary that we should be able to test for twist so as to have the quality of the fabric even throughout. Of course the question may naturally be asked, why all these precautions? There may be many reasons. For instance, the spinner may have instructions given to him specifying that his yarns must have so many turns per inch, but to increase his production, or to save labour, he may easily alter the wheels of his spinning or twisting frames so as to produce a little less number of turns but an increased quantity in bulk. So that the manufacturer may be at the mercy of a dishonest spinner or the honest spinner at the mercy of a dishonest workman; again, of course, variation in twist may be the result of accident, and faults in cloth arise. I have seen numbers of cases where in consequence of a slack band on the spinning or twisting frame, or from one of a multitude of causes, either one bobbin has been spun, or doubled, with less twist than the rest, or variation in the thread upon the same bobbin which has proved most disastrous

to the fabric; consequently, although the matter appears to be trivial, yet it is one of the most important points to be watched in the preparatory stages.

HOW TO DISSECT CLOTHS.

The actual dissection of fabric with which we have now to deal means, first, the determination of the weight of any cloth actually submitted; second, the ascertaining of the pattern of such cloth; third, the nature of the materials from which the cloth is made, and the actual proportions of each material in the case of its being a compound fabric; and fourth, the determination of the existence of foreign matter, such as size, &c., and the exact quantity. Then first as to the determination of weight, counts, &c., I will endeavour to describe the best modes of procedure. The simplest method is first to weigh a given quantity of the cloth, such as one square inch, and after having ascertained the weight of that, in grains, to work out the weight, either of one square yard, or of one lineal yard, by the width of the fabric usually made. Suppose, for example, we are dealing with woollen goods, or heavy worsted goods, we have a constant expression used, that the cloth weighs so many ounces per yard; a yard means usually 54 inches wide by 37 inches long, the odd inch being an allowance by the manufacturer to the merchant, and by the merchant to the retailer, for leakage in measuring; sometimes by special arrangement the yard is 38 inches, and again in others there are extra allowances beyond this for leakage; sometimes for the purposes of declaration in shipment to foreign countries, for the purposes of duty assessment the weight must be declared per square yard. No matter which of the systems it is necessary to act upon the principle involved is the same, and I am merely calling attention at the present moment to the variety, so that what I shall have to say

presently as to the use of plates or dies will be better understood. I will suppose first that we are working strictly to the square inch. We must have some method of cutting out this inch of cloth with absolute accuracy. Really there are but two methods of doing this, one by the use of a steel die, which encloses exactly one square inch, the outer edges being bevelled for the purpose of grinding or keeping sharp so as not to interfere with the actual area enclosed: this steel die is placed upon a cloth, struck with a wooden mallet so as to cut the piece of fabric out. There are objections to the use of the die; the use of the mallet unless in very skilful hands is not certain to make a clean cut all round, and any little irregularity will interfere with the weighing when it is desired to obtain absolute accuracy. I have generally found it better to place the die upon the fabric, hold it down firmly with the left hand and with a very sharp knife cut round it; but what is much better than this, as permitting one to see exactly what they are doing, is to have a piece of plate glass cut exactly to one square inch, and it can be laid upon the cloth and the operator can see that the edges are parallel with the warp and weft threads respectively, and can also see when a clean cut is made, so that there need not, at any time, be any mishap or failure to make a clean cut, everything being distinctly visible. For the purpose of cutting either a specially made V shaped knife, something like the common erasers used by bookkeepers, or what is even better, an old razor blade fixed firmly in a handle will serve all the purposes.

Another advantage of the use of glass plates is that a number could be made at a comparatively small cost which will serve the purpose of determining the weights per yard of any given cloth. For instance, I have had occasion to recommend to manufacturers and merchants the use of glass plates which enable them to determine at once the

weight per yard of any given fabric for a fixed width without a second weighing or calculation. We are dealing with cloths 54 by 36 inches, and it is desired to have a plate which will enable us to determine the weight of cloth in ounces at once. 54 by 36 will give us 1944 square inches; there are 7000 grains in one pound; therefore if we divide 7000 by 1944 we should have 3·6 inches as a quotient. Now suppose we have a glass plate made which covers 3·6 square inches, whether it be 3·6 inches in length by 1 inch in width, or in any other proportion we can cut out a piece of cloth which we may weigh, and the number of grains this bit weighs will exactly correspond with the number of ounces per yard. This at once saves not only the use of any reference tables, or the system of calculation necessary to be followed for determining the weight, but also ensures readiness, and perfect accuracy of results. With the balance such as has been described, and with glass plates, ground as they might be to perfect accuracy, and readily obtainable from any good glass cutter or scientific instrument maker, there is no further trouble; but assuming these not to be immediately available, then the most convenient method is to weigh 1 square inch, and having ascertained the weight of 1 inch we can easily ascertain the weight per yard. Suppose, for example, that the square inch weighs 4 grains, and we want to find the weight of the square yard. Then the calculation would simply be $\frac{36 \times 36 \times 4}{7000} = \frac{648}{875}$ or very nearly three-fourths of 1 lb. Of course the calculations should be worked out to perfect accuracy in ounces and fractions of an ounce. Then for complete analysis a number of weft threads must be taken out, not necessarily out of the square inch, but preferably out of a larger piece of cloth, weighed and the counts of yarn ascertained in the manner already described. The counts of warp must

also be determined in the same manner ; then the number of threads per inch in both weft and warp must be discovered. In some cases this is a somewhat difficult matter, and in others perfectly easy. For instance in closely milled fabrics it is difficult to pull the threads asunder, and in consequence of the fibrous character of the threads, it is equally difficult to count the number per inch; with a comparatively open fabric, and smooth threads, the usual practice is to use what is termed a piece glass; these are well known in form, having a stand or base with a hole cut in it, sometimes $\frac{1}{2}$ inch by $\frac{1}{4}$ inch, sometimes 1 inch by $\frac{1}{2}$ inch, and sometimes 1 inch square. When working with $\frac{1}{4}$ or $\frac{1}{2}$ inch, great care must be taken to count the threads accurately, as it must be obvious that the error of a fraction of a thread per inch would prevent the agreement of the calculation from the counts of the yarn to the total weight of the fabric. It may be said that when the counts have been discovered and the number of threads per inch in both warp and weft ascertained that the whole process is complete; practically that is true, but it is always better to work out the calculation to the weight of a yard from the counts of the yarn and the threads per inch, so that it can be verified by the actual weighing of the cloth.

A very good method of counting the threads per inch is to make an inch gauge, which can be done by any one simply by inserting two needle points in a small piece of wood at exactly one inch apart. Place the cloth down upon the table and insert the needle points, then with a sharp knife or scissors cut away the warp threads from each side leaving only those enclosed within the inch guage; then with the weft threads pulled away from them say to the extent of $\frac{1}{4}$ of an inch, as shewn in Fig. 319, the threads per inch can be counted with perfect accuracy, either with the naked eye or with a magnifying glass,

If the fabric is a very fine one I generally find it more convenient to use what is known as a watchmaker's glass than the naked eye, *i.e.*, a glass which I can place and hold in my eye, and taking the fabric in my left hand lay off the threads from the left with a dissecting needle point and hold them between the finger and the thumb as they are counted off. By this method it is very seldom that a mistake could be made as the eye is not compelled to follow each thread and keep it in view as it is with

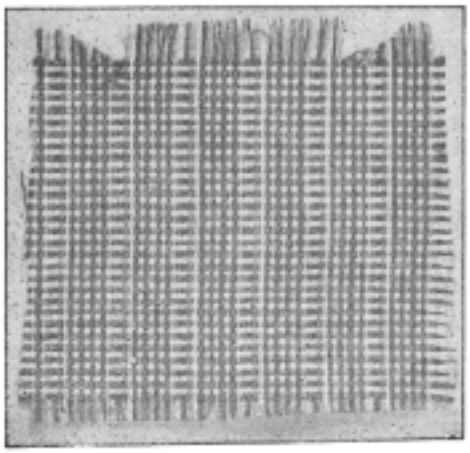


Fig. 319.

an ordinary piece glass in counting across a whole inch of cloth. If the fabric is a twilled one and the twill is visible, then it is perhaps easier, after ascertaining the number of threads in each pattern, to count the number of patterns per inch; or what is better still for ensuring accuracy to count the number of twills over several inches and from that reduce it to the threads per inch. I need hardly say that too much care cannot be exercised in counting the threads, because just as in the ascertaining

of counts a fraction of error in counting the threads may make a very great difference in the calculation of the actual weight of cloth.

We now come to a question which is perhaps the most difficult to deal with of any one connected with the analysis of cloths. That is, what allowances should be made for shrinkage, what amount of loss or gain will occur in the process of finishing *a*, of the fibre lost in treatment, *b*, of loss by the removal of foreign matter, such as grease or dirt, and *c* the gain in bulk caused by the shrinkage of the fibres, or perhaps more correctly speaking, the shrinkage in the cloth by the fibres becoming more closely incorporated. First as to the fibres lost in treatment. Before this can be estimated we must know the character of the fibre itself; we must know the character of the thread, and the treatment it is subjected to in finishing. Suppose, for instance, we are dealing with very long wool, there is no loss in the process of weaving by what is known in some branches of the trade as "fly," that is, there are practically no loose fibres detaching themselves from the fabric, and consequently we may say that the whole of the calculation weight of the yarn goes into the cloth. Then in the process of finishing unless the cloth is subject to severe raising, or cropping, or cutting, again there is comparatively little loss; if the surface must be a clear one, as we find in bright lustre goods, then the whole loss of fibre would be due to the cutting and singeing of the stray ends projecting from the piece, which would be very trifling indeed, and the loss by the removal of foreign matter would also be very slight. On the other hand the amount of shrinkage in the threads would be slight, as the strong bright wools shrink very little. If we then come to the other extreme and deal with wools made from very short fibres, and more especially if we have

a good deal of what the French very aptly term "*laine régénérée*," or what we vulgarly term "shoddy," then we may expect a considerable loss from fly, *i.e.*, loose fibres dropping from the yarn in the process of manufacture. We may also expect a good deal of loss in finishing, no matter what be the character of treatment to which it is subjected, and there may also be a fair amount of shrinkage in the width and length. If we are using good wool of a fine quality, whether spun into woollen or worsted yarns, the loss from fly would be comparatively small, the loss from foreign matter would be less than in shoddy, but greater than in yarn from lustre wools, and the shrinkage would be greater than either; then we should have to consider carefully what would be the relative counts of the yarn as it comes from the finished and the grey cloths respectively.

One general rule will hold good, although it must never be taken as being absolutely true, viz.: that the counts of yarn discovered in a finished cloth will be equal to the counts in the grey cloth; the loss occasioned in scouring by the removal of foreign matter, and in finishing by the raising and cropping will, in the majority of cases, approximately balance the gain in shrinkage. So that put very broadly, the grey counts and the finished counts will be practically the same; the loss on the one side and the gain on the other neutralising each other in the average.

METHOD OF COPYING PATTERNS.

I must now turn for a short time to the method of copying the design from a piece of cloth. This in itself is, with most people, the most difficult system of cloth dissecting; in reality there should be no difficulty at all about it. The common practice is to take out the threads from the fabric one by one and make a record by laying

it down on design paper. This is laborious, and quite as uncertain as it is laborious. Generally speaking, the extraction of two or three threads, either of warp or weft, is quite sufficient to give a clue to the whole pattern; suppose, for instance, we have a common twill cloth, such as that illustrated in Fig. 320. We first proceed to remove a few threads of both warp and weft so as to leave a fringe; we then draw one thread away from the fabric as seen in the illustration, and ascertain how many threads the warp and weft passes under and over respectively;

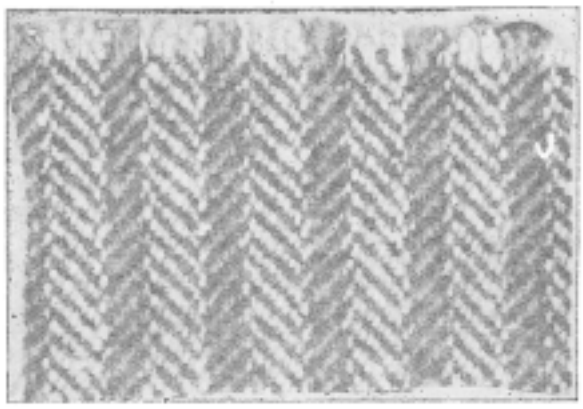


Fig. 320.

then having sufficient knowledge of the making of twills, and seeing from the succeeding pick that the order of the pattern follows consecutively, we can put the design down on paper without the removal of another thread.

Before going further I might say one word as to the method of ascertaining the order of interweaving; the simplest plan is to remove the threads of weft or of warp so as to make a fringe, then by means of a dissecting needle bring one thread from the body of the fabric as

shewn in Fig. 320, and if the eyesight is sufficiently good, holding the cloth in the left hand with the threads pointing outwards, examine them with the point of the dissecting needle to ascertain how the weft and the warp interweave, or in other words, how many weft threads the warp passes under and over in each repeat of the pattern; if the cloth is so prepared that there is a fringe at one side, and at the top of the small sample being examined, then count continuously from the left, or from the right, as the case may be, and the moment the first thread has been put down on paper remove it from the cloth so as to prevent any liability to confusion; bring out the next thread with the dissecting needle in the same manner and copy it, and so on until a sufficient number has been copied to indicate the exact order of the pattern. Now I must assume that the analyst has some knowledge of pattern making to begin with, if so, in dealing with twilled cloths he will discover first whether the twill follows consecutively in the order of interweaving, or whether it is a combination of two or more twills. If it is a combination, then of course he will have to take out several threads, find the order of interweaving of each in succession, and from that determine the order of succession. Suppose, for example, the pattern should prove to be a combination of two simple twills, such as shewn at Fig. 321, he would first discover the order of interweaving of what we will term pick No. 1, then he will discover the order of pick No. 2, then he would take pick No. 3, and finding that No. 3 is like No. 1, and advancing only one thread in the order of succession, and that No. 4 is like No. 2, advancing also one thread in the order of succession, he will at once determine the nature of the combination, and it is not necessary to examine another thread in the pattern to ascertain what the whole is. Again, supposing we take a pattern as illustrated in Fig. 322, which is a combination of the same two bases, but taking alternate picks of each

of the two component parts instead of taking them in consecutive order, the same rule will hold good, and the same mode of procedure would be followed. He finds each of the two parts of the pattern advancing two threads instead of one, therefore it is at once obvious that it is a combination of two patterns, taking alternate instead of consecutive picks. In arriving at a definite conclusion as to the nature of the combination or composition of the pattern he would be assisted by the general appearance of the pattern, for the angle at which the twill runs will indicate, generally, the character of the combination. Of course there are patterns which cannot be determined so

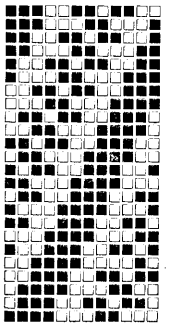


Fig. 321.

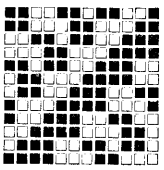


Fig. 322.

readily as either simple twills or combinations of simple twills, but most of those are based on twills and their order of succession may be determined almost as easily. For instance, there are such as what are termed crapes, which is a general term for a pattern which appears to have no regular order of succession ; in reality it is generally a twill re-arranged or transposed, either in satin or some other equally regular order ; then it is only necessary to take out two or three threads to see whether the order of interweaving of each in succession is the same, and the distance apart from each of the starting points, then

the order of the arrangement will be determined and the remainder of the pattern can be carried out at once. The basis of these orders of arrangement I have already sufficiently laid down in my "Treatise on Weaving and Designing," and in "Design in Textile Fabrics" to render it unnecessary to deal with it here.

In dealing with striped or checked patterns the same system of treatment may be observed, but it will generally be simply a question of determining the number of threads occupied by the twill running in one direction and then in the opposite direction, or in the case of a re-arrangement or combination, ascertain the extent of each; the actual analysis and the following of the individual threads in the orders

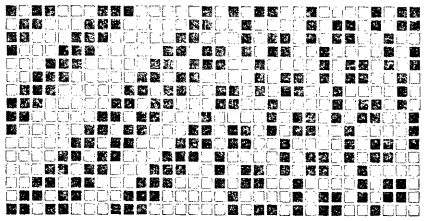


Fig. 323.

of interweaving need not, in most cases, go beyond that already illustrated, but a general survey of the surface of the fabric will enable one to complete the pattern without any further examination. For instance the pattern in Fig. 323 will give a general indication of what I mean by this, consisting, as it does, of a combination of two orders of interweaving, each being sufficiently visible on the surface and the order of succession readily followed; as a matter of fact it only requires in the analysis of a pattern of this kind a good general knowledge of the arrangement of designs and the exercise of that faculty of observation, which is usually termed common sense.

One difficulty often arises with the analyst as to the determination of which is warp and which is weft. The experienced analyst is not often troubled with this difficulty; he determines as it were by instinct; at the same time it is well to suggest to a student some general guiding indications even if they cannot be termed rules. First of all if the piece of fabric submitted has a portion of the selvedge attached to it there is sufficient indication as to which is warp and which is weft. Failing that he should examine the characteristics of the two sets of threads; it is well known that the warp is usually much harder twisted than the weft, so as to facilitate the process of weaving. Any Lancashire weaver will determine this at once, for their practice is not to speak of weft and warp yarns respectively, but to speak of twist and weft yarns; the term twist yarn is invariably associated with warp threads. Then again, the difference in the degree of thickness, if any should exist, will almost infallibly indicate which is warp, as the weft threads are generally, even in what is termed a square cloth, slightly thicker than the warp threads, and even if not actually heavier in counts the difference in the degree of twist will indicate at once the weft and warp respectively. In some fabrics, such as Cheviots for example, or worsted serges, the difference is so slight that it may be difficult to discover by a casual observation, for the pattern is usually such that the order of interweaving in both warp and weft is the same. On the other hand if it is a finished, or faced cloth, as we term it, the warp threads may be ascertained by the lay of the nap; then again, if we are dealing with a union fabric, such as cotton warp and woollen, or worsted, weft we may take it for granted that the warp is cotton; or supposing we have one all cotton to deal with, and one of the two materials is sized, both being single yarn, then the sizing will indicate the warp threads, the size

having been applied for the purpose of facilitating the weaving; again we may have the evidence of reed marks where the threads have not been absolutely evenly distributed in weaving; and we may often be guided also by the character of the pattern, more especially if the fabric is closely set and there is a well defined twill which will run in the direction of the warp, and many other little evidences which perhaps would only be visible or noticeable to a close observer, but above all we must depend upon the faculty of observation, and we might almost say instinct, on the part of any one engaged in the industry coupled with a proper use of common sense.

In dissecting double cloths the work is more difficult than with an ordinary single fabric, because of the tendency to confuse the threads forming the back with those forming the face fabric. Two methods may be adopted, the one to examine each of the two cloths separately, or in some cases it would have to be the examination of the two surfaces separately; for instance, the so-called double cloth may be merely a double faced one, *i.e.*, there may be two wefts and one warp, or two warps and one weft, as the case may be; then in taking off the face pattern always remove the back thread, so as to leave the face perfectly clear, and in the same manner in copying the back pattern remove the face thread, and having got the pattern of the face and the back respectively gently draw a thread of each from the body of the fabric into the fringe, so as to discover the exact relations of the two patterns at the point of binding, and whatever the relations may be of the first two picks they must necessary follow throughout. In most cases without even taking the trouble to count the threads the relations of the two patterns, face and back respectively, may be determined because the rules governing the combination of two materials forming the surfaces are so definite that they can hardly

be mistaken. The points of intersection must always be so arranged that the covering on both sides is perfect and the order of succession of the two patterns must be so as to retain this perfect position throughout. Consequently, whether the relations between the two are discovered by careful analysis, or whether they are surmised, the order must be maintained throughout; and it will be easy to determine almost at a glance, for the two patterns must always bear a definite relation to each other. For instance, a four end twill must either have a 4, 8, or 12 end backing, a five end twill must usually have a 5 or 10 end backing, and if the picks are alternate face and back, then both the patterns must either be twill or satin arranged upon the same base; but if there are two or more picks of face to one of back, then the relations of the two are determined whether the backing shall be a satin or any other order, and what shall be the basis of the satin. If the two cloths are separate, that is, one distinct cloth for the face and one for the back, then the pattern of each should be taken separately, following the same principle as before, and placed together in such a manner as to ensure good positions for binding. In many cases it is convenient to cut the two cloths absolutely asunder and after examining each for the pattern, then to follow the threads to discover the exact point of binding. Of course it must be understood that a successful analyst must have a sound knowledge of the principles upon which patterns are made and he must bring this knowledge to bear in the copying of the pattern from the fabric. Any attempt at slavish copying trhead by thread is liable to lead to mistakes, besides occupying an enormous amount of time, but possessing a sound knowledge of the principles to begin with any tendency to error would be discovered as the work proceeds, and consequently would be corrected on the spot.

When the materials of the face and back cloths respectively differ from each other, the analysis is very much easier, simply because the threads, face and back respectively, can be more readily identified; but in any case the two sets may be kept from each other sufficiently to prevent any confusion by the exercise of a little care. Occasionally for some special purpose a white thread may be drawn through between the coloured threads representing each fabric so as to hold them asunder, either for the purpose of ascertaining the order of interweaving or for determining the number of threads per inch. It is not often necessary to resort to this expedient, but it is a very useful one in cases of difficulty.

Probably the greatest source of trouble to analysts is the dealing with woollen cloths or cloths which have been heavily milled, or made from very fibrous threads. It is almost impossible either to pull the threads asunder or to distinguish them from each other, consequently the determination of both pattern and the number per inch is extremely difficult. Again, if they are in very dark colours, such as blacks, blues or browns, the difficulty is increased. There are two methods of dealing with this, the one is the application of an acid to remove the colour, and the other is the removal of the fibre by burning. In treating with acids very great care must be exercised, more especially if there is any cotton present, or the cloth will be utterly destroyed if the acid is too strong. Some people keep by them standard solutions of sulphuric, nitric or hydro-chloric acid according to their own particular fancy; in the use of any one of them there is an element of danger. Admittedly, if the colour is removed the fabric is better to see, but by far the best plan is to have the acid very dilute and make repeated applications, as in that case there is less liabilty to injure the fibre; exactly the same may be said of the

method of burning or singeing. Some make use of a red hot poker, with the result that it will probably burn half through the fabric. The best and surest method is to use a small Bunsen burner which can be had anywhere for about 1/-. Get a small flame, but let it be a pure Bunsen flame, so that there shall be no smoke—anyone can discover whether this is sufficiently good without much previous training, the intense blueness of the flame will shew whether it is sufficiently good,—then pass the cloth gently over it and with a brush remove the singed fibres. Repeat this operation a few times until the threads are made quite bare. With care and a little skilful treatment even very closely milled fabrics may be analysed with considerable ease, for the simple reason that the Bunsen flame not merely removes the loose fibre from the surface, but will penetrate the cloth and burn away the fibres even in the smallest interstices betwen the thread, consequently leaving them free for examination. Of course this operation, like any other operation in analysis of any kind must be conducted with care. There must be no hurry over it, and at each singeing and brushing, or shaking, the cloth should be examined carefully to see whether sufficient has been removed; and with the exercise of care and skill even the most refractory fabric may be analysed. In some cases cloths are very bulky, such for example, as some of the thick roller covers made from wool; those it is impossible to penetrate either with flame or acid without destroying the outer surfaces; very frequently the pattern may be discovered by what I might term sectional analysis, that is, take a very sharp knife, such as I have already described for cutting fabrics for weighing, make a clean sharp cut down the side of the fabric, then another cross section, and in the majority of cases the order of interweaving will be distinctly visible. But by this method of analysis there must be no attempt to disturb the

threads otherwise the counting will probably be misleading. But to ensure arriving at accurate results several sections may be made in succession, and comparison will at once shew whether the work has been correctly done.

COPYING FIGURED PATTERNS.

The copying of figured designs from the fabric is probably the easiest part of the Analysts' work. In the great majority of figured single cloths the threads are of what might be termed the easily distinguishable character, *i.e.*, the fibres are laid as straight as possible, the threads are made as smooth and even as possible and everything is done, both in the manufacture and finish, to give a clear definition to the pattern, consequently by the aid of an ordinary magnifying glass the order of interweaving of each successive thread can be followed with ease, as seen in Fig. 324. Consequently the analyst is not under the necessity of taking the threads out one by one as in the previous case, but simply placing his piece glass upon the fabric and first copying the outline upon his design paper, then he can easily follow each individual twill in each part of the pattern instantly, so that the reproduction of a design of this kind can scarcely be spoken of as analysis, but would be more correctly described as a copying of figures or patterns from one cloth to another; there is no very great skill required, it is simply a matter of patient plodding on the part of the copyist. If he is dealing with very large patterns, or in very fine material where it is difficult to follow the individual threads or in fabrics formed on the principle of double cloth, such as quilts and similar articles, then his best plan is to make a sketch of the design upon his paper and to follow it in the usual manner as though he were making an original design; in this case of course it can only be termed copying in the ordinary sense; there really is no

analysis except in so far as may be required to ascertain the exact character of the twill in each of the several parts, or whether the fabric is double, single or extra figuring material may have been introduced. In many cases to assist in the drawing, or where it is desired to enlarge or reduce the figure, the designer adopts a method which will ensure a reasonable degree of accuracy; his design paper, as already pointed out, must be ruled to

Fig. 324.

correspond with the number of hooks in the row of his jacquard. Therefore he has only to line his cloth in squares corresponding with the ruling of his paper, or increasing or decreasing it in size as he may wish, and then he takes a literal copy from the smaller to the larger, and thus ensures accuracy of form at least. This mode of procedure is so simple and self-evident that anyone may carry it out without any previous special instruction.

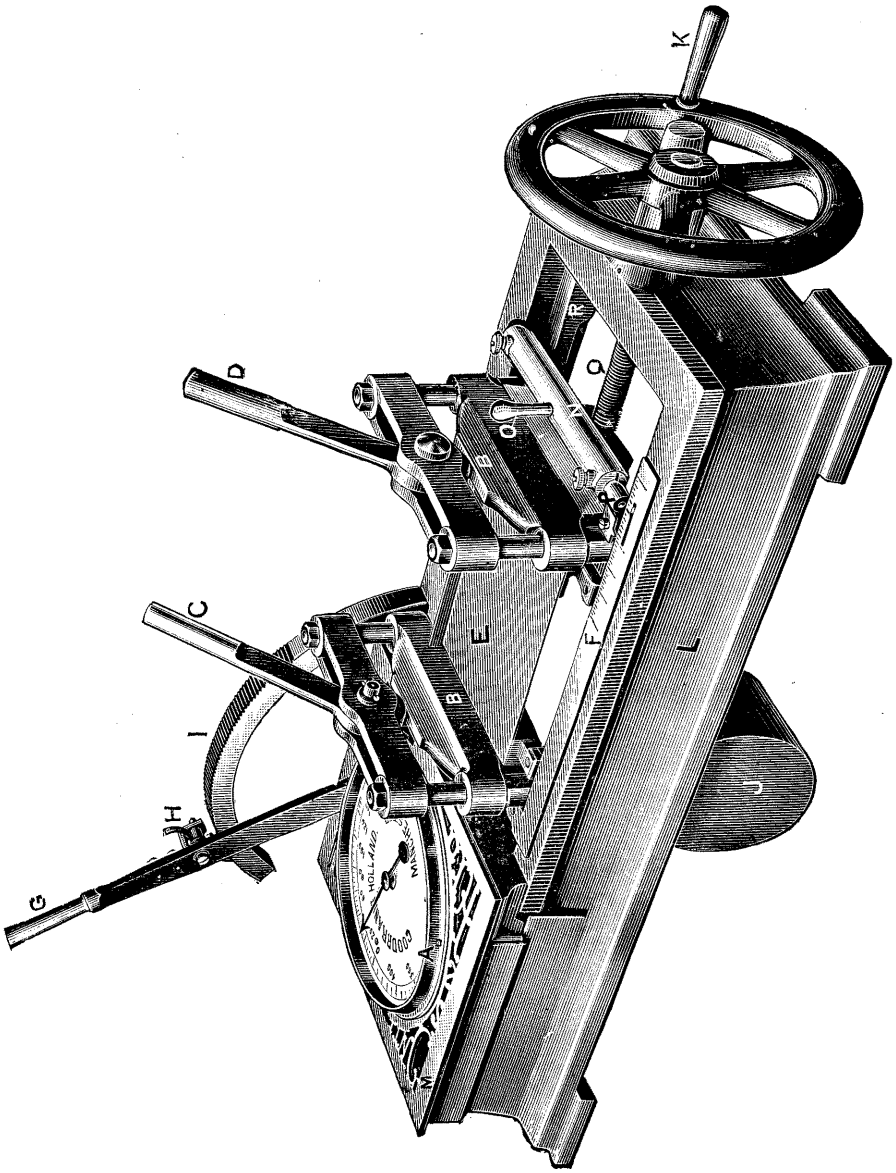
TESTING FABRICS.

In the manufacture of a large variety of fabrics it becomes a matter of imperative necessity to be able to test for strength and elasticity. For instance all the fabric supplied for military clothing must be tested to ascertain that they are equal to the quality specified; strength and elasticity tests usually being specified in the contracts. Cloths intended for special purposes, such as sail cloths, linings, tapes, sheetings, beltings and webbings, should all be subjected to a test to ascertain not only what is their breaking strain but what degree of elasticity they will possess. Of course those tests may be varied so as to ascertain the nature of the fabric for the purpose to which it is to be applied. For instance, in testing woollen goods our great object is to ascertain its actual strength, and whatever degree of elasticity it may possess will in some measure indicate the quality of the material of which it is made, the structure of the threads or the treatment to which it has been subjected in finishing. We may, for some purposes, require the cloth to possess very little elasticity although made from very good material; for other purposes we may require it to be very elastic, and the degree of strength, of course will depend upon the amount of strain to which it is liable to be subjected. If we are testing sail cloths, bindings, or sheetings, we want not only the breaking strain, but what we might term a test for endurance, that is, the cloth brought to a great degree of tension somewhere near the breaking strain and see how long it will bear that, and what effect it will have on the elasticity. To make a comparison, we will suppose a cloth to break at a given weight, under what might be termed a normal test, and we bring it gradually to a point very near the breaking strain and allow it to remain there. How long would it bear it without fracture; or, what degree of elasticity would it

display? If it shews some degree of elasticity then the period before breaking would be prolonged. To shew what I mean I will suppose three cases, first, we test the cloth by a rapid motion of the jaws of the machine, and we bring the cloth to the breaking point before it has had any opportunities of stretching properly, and consequently it will present, apparently a very high tensile strength, but with comparative little elasticity. We then test it at a moderate rate of speed and we find that it displays greater elasticity but less tensile strength. This is the natural outcome, for the threads will have been drawn into a straight line by a very gradual process; any tendency to slip in the fibres will have had every opportunity possible, and any excessively tight fibres or threads will have been gradually fractured, consequently we might look upon the test as being a test of strength which would occur under ordinary conditions, whereas the rapid movement might be looked upon as a test under extraordinary conditions. Now to take the other extreme, the cloth may be stretched to a given length and allowed to remain at rest; then a little more and allowed to remain at rest again, and so on by degrees until the breaking strain is actually reached. The tensile strength in this case must of necessity appear to be very much less than in either of the previous cases, properly speaking, it would be a test of endurance. For instance, let any one compare, say a sail cloth, subjected to the variety of treatment it is liable to; it will bear a great strain under ordinary conditions, but a sudden gust of wind, or any sudden strain put upon it may cause the sail to split in the most unexpected manner; that may in many cases be due to a cause which would not come in under any properly conducted test; the sudden strain may have been thrown upon some part instead of upon the whole at once, and of course, that does not give the fabric a

proper chance of settling into what might be termed a normal position. I will endeavour to illustrate this presently by reference to the testing machine. At Fig. 325 we have an illustration of the recognised tester, an enamelled dial at A is divided in such a manner that the pointer will indicate the actual breaking strain in the same manner as in the previously described machines. A pair of jaws marked BB are so arranged as to clip the fabric firmly between them. Now in the preparation and fixing of the fabric in those jaws depends entirely the success of the experiment.

Suppose we are testing for the strength of cloth in the direction of the warp, we must have the cloth cut perfectly straight and parallel with the warp threads, all loose threads being removed from each side; and the cloth must be placed in the jaw B in a line perfectly parallel with the weft, then made fast there; then the fabric is drawn through the second jaw B, and pulled to an easy tension when it is again made fast. In the illustration given here the jaws are operated by a cam and lever C and D on each jaw respectively, so that the fabric E once placed in position is instantly gripped and held firmly. But even now, supposing the cloth has been carefully cut to the regulation size, the government test being 9 inches by 7 inches, and is placed in the first jaw under lever C in the most perfect manner, it is not so easy to place it in the jaws under D, as the operator, either from carelessness or intent, may render the test utterly useless. Suppose he has it tight at one edge, it will commence to tear then and follow across the fabric; but an expert would at once repudiate this as an improper test, as it is evident the fabric is not to be torn but to be broken; a tear from the edge is easily followed, but a complete fracture takes place almost instantaneously. Something however may be taken from the value of the test without



Fig, 325.

being readily detected; instead of having the tight at the edge let it be a little tighter in the middle than at the edges, and it will break there first and with all the appearance of producing a fracture across all the fabric at the same time. There is a guide bar against which the material is placed to assist in setting it evenly. The cloth being secured the handle K is turned, and by means of the screw Q the jaw B nearest the wheel is gradually drawn away from the other, and at the same time the dead weight on the lever G is raised, the pointer on the dial travelling at the same time to indicate the strain. A brass plate is engraved from 1 to 7 inches for showing the stretch or elasticity before breaking. When the fabric

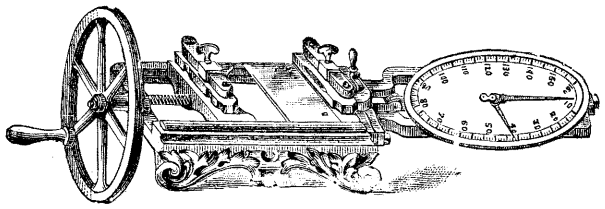


Fig. 326.

breaks the pointer remains stationery as in the yarn testers, and to release it and return to zero the catches, or pawls H, are lifted, and the handle G, and the weight returned to their original positions. The regulation rate of speed adopted by the conditioning and testing houses both in England and on the Continent is 5 inches in 20 seconds from jaw to jaw. The machine illustrated here is by Messrs. Goodbrand and Holland.

Another is shown at Fig. 326 by Mr. J. Nesbitt, of Market Street, Manchester. The principle is the same, but the strength is tested by springs instead of dead weight, and the jaws are worked with a screw instead of a lever and cam. Some prefer this system as giving better opportunities for accurate setting of the cloth;

by means of the lever the cloth is gripped instantly, but with the screw it can be made just fast and examined for evenness of tension, and if not correct, it can be adjusted.

TESTS FOR WOOL, COTTON, &c.

Perhaps some of the best tests for discovering the characters of fibres are the simplest, certainly the two most reliable ones are the microscopic tests and the simple tests by burning. If we try the microscopic test we must know beforehand the appearance of the fibre, and that is easily discoverable by any one. Put broadly, wool has a characteristic peculiar to itself, consisting, as it does, of a hollow fibre or tube, and covered with scales, which in some measure resembles the scales of a fish, but forming rings, and not quite so clearly defined as the fish scales; the rings will vary in number and definition as well as in the sharp points on the rings themselves. A knowledge of this will be best acquired by collecting a series of samples ranging from the finest merino to the strongest English wools; then to these may be added a few samples of mohair and alpaca. The finer the wool the more frequent the markings until we get down to the very coarsest wools, when the markings are only just perceptible, and not very frequent, whilst in some mohairs and alpacas of extremely bright surface they are only just visible. A simple method of examination is, instead of mounting them in the usual elaborate manner, simply to place them upon an ordinary micro-plate, and place a thin cover over it, or if it is to be kept for permanent use mount it in a dry cell, but with a very thin rim between the plate and the cover glass, otherwise only a very small portion can be brought into focus at once. If they are mounted in Canada Balsam it seems to fill up the pores, and consequently instead of appearing with their characteristic structure visible they present almost

the appearance of glass rods. To bring the scales into greater prominence the wools may be washed so as to relieve them of foreign matter, or even boiled in clear water for a short time and then thoroughly dried. They are often treated with re-agents for the purpose of both removing foreign matter and causing a slight expansion in the scales at the same time, but there is a danger in doing this of allowing the treatment to go too far. For instance, if the fibre is treated with dilute caustic potash it will spread its scales out considerably more then if simply washed; it is quite interesting to place a few fibres upon a slide and drop a few drops of caustic potash on the plate, place it instantly under the microscope and watch the action of the re-agent, and if a specially good fibre is wished for preservation for future reference, it should be watched very carefully, and as soon as the development has gone far enough, dropped into clean water and washed off; then allow it to dry and be prepared for mounting. In the same way cotton fibres may be examined; they present simply the appearance of collapsed tubes and more or less twisted, due to their collapsing; flax or jute present microscopically something of the appearance of long grasses or reeds, the flax having a knotted character, very similar to the knots upon the bamboo cane, and jute, a straight fibre in layers, something like a reed. Silk, on the other hand, presents the appearance of a continuous filament without any structure, just as you would expect to see a glass rod, so that the characteristics of each of the leading fibres may be very readily discovered. If a microscope is not available, then what is termed the burning process is fairly reliable. Let a few fibres be burnt, say of cotton, there is only a very light fine ash left at the end, but if wool is burnt it forms a little hard cinder, which, if pressed between the fingers will be reduced to a fine powder.

Accompanying those characteristics the smell is a most reliable guide; wool, for instance, has the smell of a burnt horn, being itself a horny substance, whereas cotton has scarcely a perceptible smell. Silk, so far as burning is concerned, presents the same characteristics as wool, although it is little more inflamable in consequence of its lightness, and, of course, it will be easy to discover, once the horny smell is present, the difference between woollens and silks from the brightness alone. Linen and jute both burn readily, but not so readily as cotton, and they leave an ash also somewhat similar to cotton, but not of so light a character either in weight or appearance. Of course one would scarcely take cotton for jute or linen in consequence of the difference of the strength of the fibres apart from the microscopic appearance, but it will not be so easy to discriminate between linen and jute. In those two one must be guided in a very great measure by the general appearance and length of the fibre unless the microscope is resorted to. Burning or chemical tests will give almost the same results.

Then for the chemical tests. There are two distinct modes of procedure, although I am not going to attempt to deal exhaustively with this subject, only the tests in ordinary use and which can be applied by any one who is not a chemist. Vegetable fibres will be readily dissolved in sulphuric acid, but if this is used too strong it will also attack and dissolve the wool, consequently it should be applied in a dilute state, and a sufficient length of time given for the vegetable matter to be carbonised and then washed off. On the other hand wool is readily dissolved in caustic soda, more especially if it is boiled. A common test is to boil the fabric in a 5% solution of caustic soda, if it is intended to dissolve wool and leave cotton intact, in the case of a union cloth, for thirty minutes, when the wool will be entirely dissolved

and the cottton left practically untouched. If a rapid test is required, and it is not desired to ascertain the exact quantities, it may be boiled for three minutes in a strong solution of caustic soda, but if the analysis must be a quantitative one care must be taken in every test. For instance, a piece of cloth may be taken and weighed, either in its ordinary state or in a state of absolute dryness, boiled in caustic soda, say 5% solution, for thirty minutes, then washed clean, or boiled for a short time in distilled water, thrown upon a filter paper and carefully filtered, the filter paper having been previously weighed. Place the filter paper in a drying oven at a moderate heat and allow it to remain until absolutely dry. If it has been weighed at absolute dryness in the first instance the residue should be weighed in the same condition, and the difference will represent the quantity of wool which has been dissolved out of the fabric, but if the cloth is weighed in its normal condition then the residue should be left exposed to the air at a normal temperature for 24 hours, when it will have regained the amount of moisture natural to it; and the exact percentage of loss, or in other words, the amount of cotton and wool respectively will be determined. Now I will suppose another case where we have a compound fabric and cotton heavily sized, wnich means the addition of a considerable amount of foreign matter. In all probability in a case of this kind the two sets of threads could be easily separated from each other, then it is best to separate them and weigh each one in the condition in which it comes from the fabric. That being done take the cotton first and wash it in clean water, then it may be boiled, say for thirty minutes in a 2% solution of caustic soda, or some prefer to boil it an hour in a 1 per cent. solution. Wash it off again and boil it for thirty minutes in a 2% solution of hydro-chloric acid, wash again and

boil in distilled water for thirty minutes, after which it is again washed, submitted to a moderate heat in a drying oven for an hour and left loose in the air for 24 hours to regain its normal condition as to moisture. Then the wool may be simply boiled for thirty minutes in distilled water, as the size will probably be confined to the cotton, then washed off, dried, and completed as before. The weighing of the two sets of fibres will now disclose the exact weight of pure cotton and wool respectively in the original sample, and the missing quantity will represent the exact amount of sizing, or foreign matter, removed from the fabric.

FAULTS IN FABRICS.

In dealing with this branch of the subject I shall confine myself to faults of two distinct classes, first, those which occur in the actual process of weaving, and second, those which are the result either of improper preparation of the yarns prior to weaving or in the mixing of yarns. In the one case we shall have to look to the details of the loom for the purpose of discovering the causes of imperfections, and in the other we shall have to test the yarns after the manner which I have already described. Suppose we first turn to those which are most liable to occur in the bad working of the loom. We have the common term uneven cloth, this must be due either to imperfect letting-off or imperfect taking-up, and either of the two will produce approximately the same results. Suppose for instance, we are working with the ordinary friction rope; we find it sticking from any cause such as damp; the beam would allow the warp to go off, as it were, in a spasmodic manner, at one moment held very tight and then a sudden slip of the beam gives off a considerable amount of slack; no matter how perfectly the take-up motion may be working, the irregularity in the tension will produce uneven fabric. In the same

manner if the let-off motion is of a positive type any imperfection in its working, such as the vibrator levers or the escapement motions, whatever form they may assume, failing in their action will produce the same result. In the take-up motion irregularity in the action of the catches; improper weighting of the cloth beam; slipping or sticking of the teeth of the take-up motions, or anything which will either push the take-up motion forward at one point or retard it at another will produce unevenness of practically the same kind, although perhaps it may sometimes appear of a more definite character, as that produced by a let-off motion. Then again the weft fork not working properly will cause the same kind of fault, and we have first what is generally called a broken pick; broken picks may be due simply to the carelessness of the weaver, *i.e.*, the yarn is broken or the bobbin run empty and the loom stops; if she simply puts in a fresh bobbin and starts the loom, either without taking the precaution of finding the proper place for the pick, of letting back the cloth a distance corresponding to that taken up without any weft, then a thin place will result. Again, if the weft fork has failed to act and the loom has run over two or more picks before the weaver has noticed it there will be a thin place, unless exceptional care is exercised, simply because the weaver is unconcious of the fact that the weft fork has not been acting properly and takes the ordinary precautions only, instead of taking the extraordinary precautions which are necessary in such a case.

Then another class of fault may be produced by imperfect shedding, that is, the healds are not forming a sufficiently straight line for the shuttle to pass over, or the upper half of the shed is so badly formed that the shuttle passes over some which should be passed under. Again we have what is commonly known as

stitching; stitching of course may arise from other causes than this; from the sheds not opening at the proper time; from excessively loose fibre between the reed and the healds, causing, occasionally, threads to hold together and the shuttle pass over or under wrong ones. Or it may be caused by an occasional broken thread, but in that case it produces a fault which is commonly known as "feltering" as distinguished from stitching. It is hardly necessary to speak of the faults caused by ends being allowed to run down, as that is not only a preventible fault but one due to gross carelessness; there are sometimes other imperfections produced, not so readily traceable, such for example, as when a weaver crosses a thread from one part of the warp to another without taking care that the tension shall be properly equalised with the rest, or where an extra thread is introduced and run from a bobbin, when the same fault will arise. In each case it would simply shew a perfectly straight line all through the piece and there is no known test which could discover it except an examination of the loom in work, so that should the fault not be discovered until the warp has been finished there are no posible means of tracing it. Again a similar result will be produced by having heald threads which have been broken down improperly tied up; they are tied too tight, with the mail too high or too low, causing the shuttle to be constantly rubbing upon the thread in a greater degree than the rest, and, in fact, making that one thread shed differently from the rest; the effect will be apparent in the fabric; sometimes perhaps in the grey or unfinished state but almost certainly in the finished state; again the fault is difficult to trace to its source. In all probability the one most serious fault and the one most difficult to deal with in the actual process of weaving is that which has already been referred to when dealing with temples, namely, the curling

of the weft. Nothing but a thorough mastery of the system of shedding suitable for different patterns and different materials; a careful adjustment of every part which can influence it; a proper tension upon the weft as it leaves the shuttle, and the adjustment of good temples can avoid it. But there is no fabric made, where, with proper regard to those conditions, curling cannot be avoided.

I shall not attempt to deal with the faults which occur in fabrics which might be properly described as structural faults. I have nothing to do at present with the structure of cloths, but in speaking of the faults arising from the imperfect preparation prior to weaving I may have something to say of the structure of threads without necessarily discussing the merits of the several classes of threads for the production of any class of fabric.

First then we will go back to the very beginning of the work, imperfect winding, either for the purpose of warping or on the spools or bobbins from which the yarns are woven; hard and soft bobbins mixed together, which is equivalent to saying unequal tension upon the threads, would produce their faults, but the effect in the warp is very different to that in the weft. In the warp a slack thread would run in at intervals corresponding with the number of threads put up on the warping mill, or creel, at once, and would occur at perfectly regular intervals across the fabric, and a corresponding stripe would appear; a stripe produced by this means is readily detected as compared with that which I have been describing as produced by a crossed thread, or a thread run into a warp from a bobbin. In the one case the fault appears regularly all across the fabric, and can be easily traced; in the other case there is either a single stripe in the whole piece, or if there are more they will probably occur at most irregular intervals. Then in dressing, or beaming the warps preparatory to going into the loom, stripy

goods may be easily produced, simply by unevenness of tension on the several parts or separate warps which may be put together to form one. And this, like the slack thread, will occur with perfect regularity, and therefore can be easily discovered. But one of the greatest causes of imperfections is that which I have dealt with under the head of yarn testing due to the mixture of yarns of either different quality, different counts, different twist, or differing in age. Any of those causes is readily discoverable by the methods of testing I have endeavoured to describe, but it is only by the exercise of great care with properly adjusted instruments for testing that the cause of the fault can be brought home. There is but one other cause I will refer to, and this is so simple that even though I have had to demonstrate it numbers of times in the presence of manufacturers, I have found it difficult to persuade them of the truth of the theory which I have advanced. If we examine yarns, whether of woollen or worsted, more especially of the worsted type, we shall find the fibres pointing outwards from the thread, practically, all in the same direction, or what is termed by spinners the lay of the fibres; that is as the fibres are drawn from the delivery rollers of the spinning frame and passed down through the guide eye to the bobbin, and twist being put in at the same time, the free ends of the fibre will all point outwards in one direction. Now suppose that we make the warp from this yarn, and from any cause a bobbin has been re-wound; it is no uncommon thing for a bobbin to get broken, and so render it impossible to warp the yarn from it; it is then re-wound upon another bobbin, and placed in a creel along with the others. When this is done the lay of the fibre is reversed. Now let the warp be taken to the loom and woven; as the weft beats up to the fabric it will either lay down the free ends of the loose

fibres, or it will tend to ruffle them; whatever it does with the bulk of the threads it must be exactly the reverse with the re-wound one, and although, to the weaver, nothing is visible, more especially in grey fabrics; when the cloth comes to be finished that one thread will form a stripe of its own and stand out distinct from the rest as though it were a different colour. Whenever a fault of this kind appears, it can only be distinguished from those I have referred to as being due to yarns newly spun, and well set respectively, by a microscopical examination, simply because it is of precisely the same nature and character as its companion threads, and therefore subjected to the same tests will give precisely the same results, but if the two threads are placed side by side under a microscope of moderate power then the lay of the fibres will at once disclose the cause of the imperfection.

There are numbers of faults which it would be impossible to anticipate, but practically, leaving the question of faults of structure aside, the more troublesome ones will come under the heads and be discoverable by the tests I have suggested.

APPENDIX.

The principal reagents required for the micro-chemical examination of fibres are the following :—

1.—Sulphuric Acid (concentrated and diluted) : This is necessary and valuable for dissolving and enlarging the membranes of the cells; and for giving a blue colour to the cellulose it may be mixed with iodine.

2.—Nitric Acid : For rendering the striations and the structure (as well as the scales) of the natural fibres more distinct.

3.—Chromic Acid : The best dissolvant for the inter-cellular substances, it constitutes by far the readiest and most rapid means of isolating the cells. It frequently occurs that the cells are enlarged and dissolved at the same time by this acid ; it is seldom employed in its pure state, but it is generally necessary to prepare a mixture of chromic acid and sulphuric acid, which is made after Wiesner's method, with an addition of bi-chromate of potash in excess of the sulphuric acid. When dissolved, the chromic acid alone is mixed with an equal volume of water.

4.—Solution of Alcholic Iodide (dilute) : With this preparation the cellulose is moistened, this will give a blue tinge on the application of dilute sulphuric acid.

5.—Ammoniate of Copper : Is obtained by dissolving copper metal in ammonia, and serves for dissolving and enlarging the membranes of the cells.

6.—Sulphate of Analine : For ascertaining the striations after the fibres have been coloured an intense yellow.

7.—Caustic Potash (Dilute) : For rendering the tissues more transparent and isolating or separating them from each other, the fibres are also more thoroughly enlarged by this reagent.

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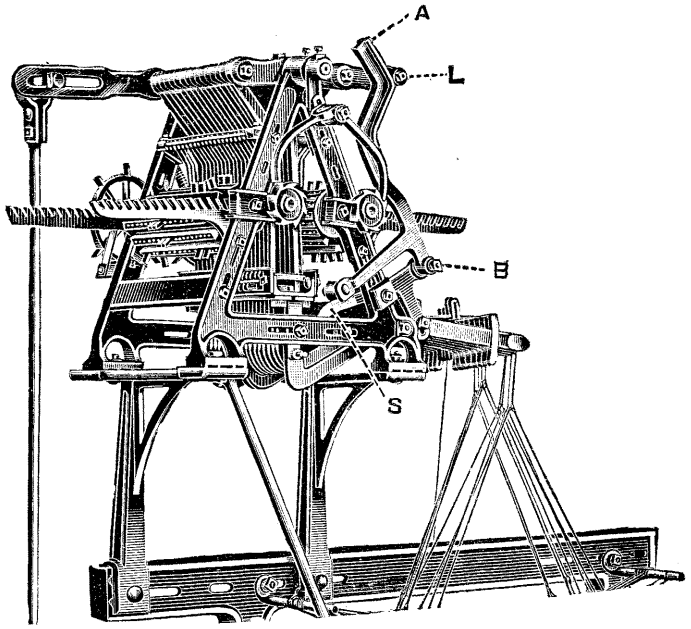

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