THE CONSTRUCTION
OF
THE POWER LOOM
AND THE
ART OF WEAVING.

FIFTH EDITION.

Mrs. L. Taylor 5/12/36

A PRACTICAL TREATISE

ON THE CONSTRUCTION OF

THE POWER-LOOM

AND THE

ART OF WEAVING

ALL DESCRIPTIONS OF TEXTURE PRODUCED BY LEAVES OF HEDDLES.

Illustrated with Diagrams.

WITH

CALCULATIONS AND INSTRUCTIONS

FOR THE PRODUCTION OF COTTON, WOOLLEN, LINEN, AND JUTE FABRICS.

INTENDED AS A TEXT BOOK FOR THOSE ENGAGED IN THE TRADE.

BY

ALEX. BROWN.

FIFTH EDITION, REVISED.

DUNDEE:
JAMES P. MATHEW & CO.
LONDON: SIMPKIN, MARSHALL, & CO.
EDINBURGH: JOHN MENZIES & CO.
BURNLEY: J. & A. LUPTON.

PRICE THREE SHILLINGS AND SIXPENCE.

Edgar B. Evans
Woodfield
Blackwood
March 14 - 1889

PREFACE TO THE FOURTH EDITION.

WHEN the first edition of this little work was issued in 1875, we could not anticipate the demand it was to create for itself, not only in this country but in every country where the power-loom had been introduced. Since then we have made it our study that every succeeding edition should be brought up to the time of its publication in regard to all the most recent improvements in the art of weaving and the construction of textile machinery.

The present edition forms practically a new book. At the suggestion of many in the trade, it has been made of a more convenient size for the pocket. Prominence is given to the headings of the subjects treated by the introduction of bold type, and the information is otherwise so arranged that any particular detail can be found at a glance. A concise index to the various divisions has been added, which will also facilitate ready reference. There is no detail in the subject matter that has not been reconsidered, and, in many cases, altered or re-written, in order that the work might be as complete as possible at the time of publication.

We have to thank the numerous correspondents throughout the world for the valuable suggestions they have thrown out, many of which have been embodied in the work.

A. BROWN.

DUNDEE, *May* 1883.

PREFACE TO THE FIFTH EDITION.

IN issuing the fifth edition of this work, the Publishers desire to express their pleasure at the success which has attended the publication of previous editions.

The work has been revised by several manufacturers and practical managers engaged in the trade, and a few alterations have been made and illustrations added, but, throughout, the book has been unanimously found to require little addition.

The Publishers trust that this fifth edition will be found helpful to those, who, by the study of Technical science, are endeavouring to gain a more thorough and intelligent knowledge of "The Art of Weaving."

DUNDEE, *November* 1887.

CONTENTS.

INTRODUCTORY AND EXPLANATORY.

RELATIVE POSITION OF THE PRINCIPAL PARTS OF THE LOOM.

PAGE

SHEDDING.

THE PICK.

THE SHUTTLE PROTECTOR.

THE TAKE-UP MOTION.

THE PACE.

HOW THE WINDING AFFECTS THE WEAVING.

THE SPEED OF THE LOOM, DRIVING GEAR, &c.

HOW TO START AND WORK THE LOOM.

TO FIND THE NUMBER OF SPLITS (DENTS) AND THE QUANTITY OF WARP AND WEFT IN A WEB.

THE PREPARATION OF THE YARN FOR THE LOOM.

DRAUGHTS AND TREADING.

INDEX.

A PRACTICAL TREATISE

ON THE

CONSTRUCTION OF THE POWER-LOOM

AND THE

ART OF WEAVING BY STEAM POWER.

INTRODUCTORY AND EXPLANATORY.

Stephenson's remarks on the locomotive applicable to the power-loom.—What Stephenson has said of the locomotive might with equal propriety be said of the power-loom—that it is not the invention of one man, but a race of mechanical engineers. It may be said to represent the growth of the mechanical skill of the last seventy or eighty years. Steam power was first applied to textile manufactures about that time, and has been gradually developed during these years to the advanced state of perfection in which we find the power-loom at the present time.

Reasons of the slow development of textile machinery.—The process of development of the power-loom has been somewhat slow in contrast to other machinery that has been brought into existence and developed to maturity almost at once. But, considering the complicated nature of the power-loom and the difficulty in managing it, the whole of its movements being intermittent, and all more or less reactionary; and the widely diverse nature of the manipulation of yarn and cloth, and the application of machinery to it; and how seldom a capacity for both is to be found in the same individual, an association necessary before any advancement can be made,—considering all this, the tardy progress of the development of textile machinery will be more easily accounted for.

The plan of the present volume.—It is not our purpose at present to trace the history either of the art of weaving or the development of the power-loom: however interesting that might be to the general reader, it would be of no practical value to the student of the art of weaving. We propose rather to take the art as we find it practised at the present time, and endeavour to elicit the principles that are involved and that govern the various mechanical movements employed in the production of cloth. It will be necessary to consider these in connection with the treatment of the yarn in the loom and its preparation for it before we can arrive at any satisfactory conclusion regarding either. This we will endeavour to do in as simple and easy a manner as possible.

Other explanations.—In following out the foregoing plan, we will not tire the reader with any unnecessary descriptions of what may be learned by a mere cursory observation in the factory. But, assuming that those to whom these sketches will be of any service are already in some way engaged in the trade, or at least are acquainted with the names of the different parts of the loom, we will endeavour to bring out those principles that underlie the surface and are not so easily got at without considerable practical experience.

RELATIVE POSITION OF THE PRINCIPAL PARTS OF THE LOOM.

The warp line.—In constructing the frame-work of the loom, the first consideration that demands our attention is the line of the yarn—that is, the line the warp threads form in passing over the back beam and through the heddles to the fell of the cloth. In determining its position we have to consider the two sorts of cloth that are made. The beauty of the one depends on the closeness of the warp threads, and the other on the regularity of their openness. These two kinds of cloth are regulated (although not independently*) by the position of the line of the warp threads.

The warp line for open cloth.—When the warp threads require to be open the warp should form a horizontal straight line from back to breast beams. The reason of this is obvious; when the shed is opened, the one half of it rises just as far as the other half sinks; and as the line of the yarn forms a straight line between them, an equal strain is thrown on both, consequently the two threads that pass through the same split will run into the cloth together, leaving a vacancy, caused by the reed, between them and the splits on each side of them.

The warp line for cloth where the threads require to be spread.—In the description of cloth where the warp requires to be spread, running the threads together in splitfuls must be carefully avoided. Although drawn the same way in the reed, each thread is made to stand out in the cloth equally distant from those on each side of it. To accomplish this the yarn must be sunk out of the straight line at the heddles. To make it clearly understood how this causes so marked a difference in the cloth we will explain it with reference to fig. 1, to show what actually takes place amongst the yarn to bring it about.

What takes place amongst the yarn to cause it to spread.—D fig. 1 represents the yarn passing over the back beam A and the dotted line a continuation of the

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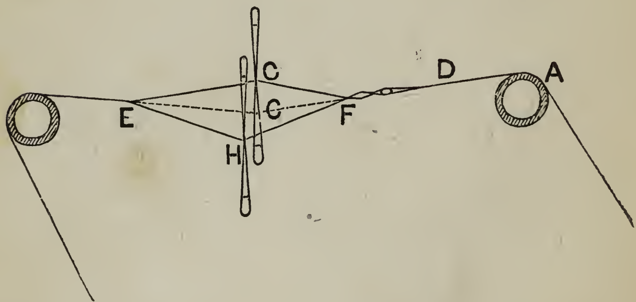
* See Shedding.

same, before the shed is opened. It will be observed that the one half of the shed has risen as far from the centre C as the other half has sunk; but if we measure the distance E G F and the distance E H F we will find that the latter is considerably longer than the former. What follows from this is, that the upper half (that part of the shed represented by E G F) remains loose, while the under half is held tight; and instead of the two threads that pass through the same split being crushed together, as in

Fig. 1



the former example, the one that is loose spreads itself out between those that are held tight on each side of it. Each half of the shed as it comes up repeats the same thing. This is what must take place with all descriptions of cloth where the warp threads require to be spread and a beautiful texture produced.

The strain on the yarn in weaving.—The various operations in weaving cannot be carried on without causing a considerable strain on the yarn, but by a study of the principles of the art of weaving we are enabled to reduce this strain to the least possible in the circumstances. This leads us to the consideration of how this sinking of the warp line affects the strain on the yarn. We may remark here at the outset that anything done in the loom to produce this effect, namely, spreading the yarn, will throw a corresponding strain on it. The opposite is also the case: any effort made to save the yarn has a detrimental effect on the cloth. The question now comes, How can this result be obtained with the strain reduced to a minimum?

To reduce the strain to a minimum.—The strain on the yarn is caused by the shedding, and in this sort of cloth by the beating up of the shot also, and will be in proportion to the angle the shed forms to the direction of these two forces. In proportion, then, as the heddles are lowered will this strain be increased. To diminish the injurious effects, lower the warp line at the heddles no further than what is necessary, and see that the angles formed by the shed are equal on both sides of the heddles. The warp line is generally thrown out of the straight line by raising the back beam alone: now this increases the angle of the shed very much more behind the heddles than in front of them, and consequently the strain is unequally divided over the length of the thread. The proper remedy for this is to raise both breast and back beams, maintaining equal angles, and consequently causing an equal strain on both sides of the camb. With proper shedding the yarn will require to be sunk very little out of the straight line in order to produce the best results; but with imperfect shedding the whole effect of this will be marred. We will notice this more particularly under that heading.

The height of the warp line.—The preceding considerations determine the relative height of the breast and back beams, but they must both be placed at a convenient distance from the ground, so that the yarn may be in a handy position for the weaver attending to it. Two feet nine or two feet ten inches has been found to be a very convenient position from the ground to the top of the breast beam.

How the front and back beams should be made movable.—As the distance the heddles are sunk should be varied according to the closeness of the warp threads, the front and back beams ought to be made movable, to allow of their proper adjustment. Most looms are indeed made in this way to some extent, but most of them are so hampered with bolts and fitted so tight that it requires considerable engineering skill to move them, and renders their proper adjustment in many instances almost an impossibility.

The stretch of the yarn.—The stretch to be given to the yarn in the loom is a matter of no little importance. By the stretch, we mean the length of thread that sustains the strain caused by the operations of weaving. Of course that part of it between the fell of the cloth and the lease rods will receive the greatest strain, but the tension is thrown on it from the time it leaves the yarn beam until it has passed into the cloth. Considerable breakage may be caused by the stretch being either too short or too long; but when we come to consider this point many difficulties present themselves. The proper stretch can only be determined in relation to the fabric of cloth to be produced and the quality, grist, and elasticity of the yarn of which it is to be made. And, moreover, the art of spinning has not yet reached that state of perfection, and probably never will, in which a thread of uniform strength can be produced. Consequently, any mathematical deductions as to a given length of stretch for a particular grist of yarn made of a given fibre are entirely useless, so that we are shut up to the teachings of experience in this matter. We may state, however, that three feet six inches over the breast and back beams, with the yarn beam as low in the loom as is convenient, is considered to give the best length of stretch for coarse linen fabrics, and from four to six inches less for finer yarns. We are not aware that any very reliable experiments have been made with a view to come to any definite conclusions in the matter, although it is worthy of consideration.

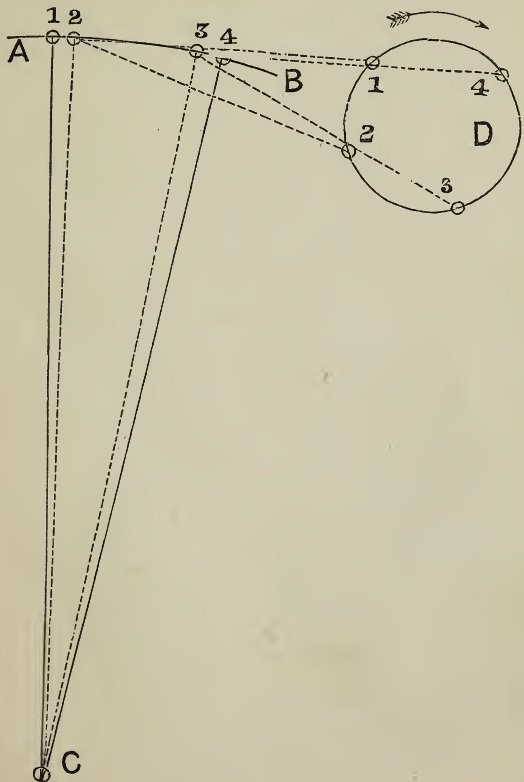
The movements of the lay.—The line of the yarn will determine the position of the lay and the length of the swords. The purposes of the lay are merely to carry the shuttle through the shed and beat up the shot. A smart stroke of the reed, in other than very light work, is necessary for the latter, and a somewhat protracted pause for the former, to give the shuttle time to pass through the shed. This shows us that the movement of the lay, to effect these two purposes, must be eccentric. As it is the crank that imparts the movement to the lay, and its position in relation to its connection with the swords that determines the kind of movement given, we must direct our attention to it.

The pauses of the crank as adapted to the requirements of the power-loom.—In the movements of the crank, when it is connected in a horizontal or perpendicular line with its centre, its pauses are equal at both ends of the stroke: as in the steam engine, for example, the piston begins to move slowly from the end of the stroke, and increases in speed until it reaches the centre, then gets slower in the same ratio until the other end of the stroke is reached. This movement, as we have already seen, is quite unsuitable for the power-loom. The pause where the shot is beaten up must be shortened, and the time given at the opposite pause to the shuttle. This is accomplished by placing the crank shaft in a lower plane than the pin by which it is connected to the sword. The best position for it is a distance equal to half the diameter of the circle it will describe below the point of its connection with the swords. Suppose the circle the crank describes to be six inches, then the centre of the crank should be three inches below the centre of the connecting pin in the sword.

The pauses of the crank illustrated.—The pauses of the crank are fully illustrated by fig. 2. A B is the arc in which the swords move; C the rocking shaft; and D the circle of the crank. The distances between the points 1 and 2 and the points 3 and 4 are the same; and it will be observed that the crank has moved through a larger space in moving the swords backward and forward between the points 3 and 4 than between 1 and 2. The figure also shows that the reed will come up with a smarter stroke when the crank is revolving in the direction of the arrow than in the opposite direction. That accounts for the greater tendency to break the swords when the loom is revolving in that direction; because, the faster the swords and lay are moving when bringing the reed up to the fell of the cloth, the momentum of the stroke given by the pro'ector when the loom knocks off will be proportionally greater.

How the eccentricity of the lay's movements can be varied and adjusted.—The amount of eccentricity obtained by the lay will be in a direct ratio to the length of the connecting rods and the diameter of the circle described by the crank. The shorter the connecting rod, and the larger the circle of the crank, the greater will be the eccentricity obtained; but when this is increased beyond a certain limit, the movement of the lay becomes angular; a hesitancy takes place when the crank is passing the back centre, which requires a momentum in another part of the loom to carry it over that point. This must be avoided as far as possible, as the less momentum the loom can be

FIG. 2.



wrought with the less will be the breakage caused by the action of the protectors.

The broader the loom the more eccentric its movements.—The broader the loom is the greater must be the eccentricity of the lay's movements, as the shuttle has a greater distance to traverse, and requires more time to it. This is commonly obtained by increasing the throw of the crank in proportion to the breadth of the loom.

The length of stroke to be given to the lay.—In considering the throw of the crank, it must be taken in connection with the length of stroke to be given to the lay; and in this, as well as in the other movements of the loom, it must be as small as possible. When too long, the yarn gets chafed in the operation of weaving, the threads having to pass each other more frequently than what is necessary, and are subjected to a greater friction from the reed than if the traverse were shorter. But in reality the length of the lay's stroke must be regulated by the size of the shuttle to be used.* The best length of stroke, and that most generally adopted, is for a medium breadth of loom, say $\frac{6}{4}$, to be equal to three times the breadth of the shuttle; for broader looms a little more, and for narrower ones a little less.

The leverage of the swords.—In considering the length of the lay's stroke, the leverage of the swords, occasioned by their point of connection to the crank being below the line of the race, must be taken into account. The amount of leverage thus gained will be to the distance from the centre of connecting pin to the line of the race, as the distance from centre of connecting pin to the centre of rocking shaft is to twice the throw of the crank.

The bevel of the lay.—When the lay is thrown back, it is bevelled to suit the shed; but the reed and the back of the box are brought back to the square. The box of the lay is thus formed into a sort of dovetail, that prevents the shuttle from rising off the race; and when the front

* See How the winding affects the weaving.

box is thrown in a little at the head, the dovetail is thus made complete, and the shuttle moves much steadier.

The position of the rocking shaft.—To find the place of the rocking shaft, the swords should be in a perpendicular position when the reed is at the fell of the cloth. This allows the swords to work on what is termed the quarter move (in reference to the movements of the pendulum). When the rocking shaft is placed in the centre of motion, the passing and re-passing of the centre of gravity causes a vibration in the swords, that transmits itself to the lay and the crank, as well as the rocking shaft itself. All the best makers of looms place it in the first position we have indicated; but there are others who, either through ignorance or neglect, place it in other positions, with injury to the working of the loom.

The upright picking shaft.—The only consideration that is necessary in determining the position of the upright picking shaft (when the pick is wrought on that principle) is the length of arm necessary to produce the leverage required. It must be placed at a suitable distance back from the lay for that purpose. It should also be placed on the outside of the end frame, to allow the picking wiper to get closer up to the bearing, to make its action firmer.

The wiper shaft.—The wiper shaft should be brought close enough to communicate motion to the upright shaft. The exact position in which the two stand to each other will be determined by the diameter of the picking wiper, the length of the tappet, and the diameter of the cone. Suppose the diameter of the disc to be seven inches, the length of the tappet three inches, and the diameter of the cone two inches, the sum of these will be twelve inches; then the distance from the centre of the wiper shaft to the centre of the upright shaft will be the half of that sum, deducting from a quarter to half an inch to allow for the tear and wear of the cone and tappet.* The shedding wipers should also be brought as close as possible under the camb, that their action may be as direct as possible. These are the considerations that determine the transverse position of this shaft. Its height in the loom will be determined by the diameters of the wheel and pinion that connect it with the crank shaft. We say this advisedly, instead of determining the diameters of these wheels by the distance between the two shafts, for the reason that they should be as small in diameter as they can conveniently be made. The wiper shaft must be brought up in the direction of the crank for that purpose, as the crank shaft cannot be brought down to it, its position being already determined by other considerations.

The momentum of the crank and wiper shaft wheels.—The reason for making the diameters of the wiper and crank shaft wheels as small as may be convenient is, that their momentum may be reduced as far as possible. It is true that there are few machines that require so much accumulated force in their working parts to regulate their movements; but this affects the power-loom very injuriously, and causes a great deal of unnecessary breakage. We will explain this more particularly in relation to the protector, as it is in that connection that it most affects the power-loom.

The end frame.—The foregoing are what may be termed the principal parts of the loom; and now that their proper places have been ascertained, the end frame of the loom must be constructed so that it will hold them in that position. To make it of sufficient strength, without any unnecessary waste of material, its greatest strength should be at those parts that receive most of the strain. Observe

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* For particulars, see The Pick.

at what places and in what direction the various movements affect it, such as the beating up of the shot, the picking, the shedding, and the knock-off movement, and strengthen these parts with additional feathers.

The strength of the loom.—The preceding remarks, as well as what are to follow, are applicable to the power-loom for the production of all descriptions of fabrics; the difference is simply in the strength of the machine suited to the fabric to be produced. In considering the strength of the various parts of the loom, the reactionary nature of the machine must be taken into account. That will be found to be about equal to the power required to work the loom. It should be strong enough to prevent any vibration in any of its parts, a fault sometimes to be met with (frequently caused by the harshness of the pick), which is very detrimental to the working of the loom. When all the movements are devested of any harshness, and made to work quite smoothly (which can easily be done), less strength will be required.

SHEDDING.

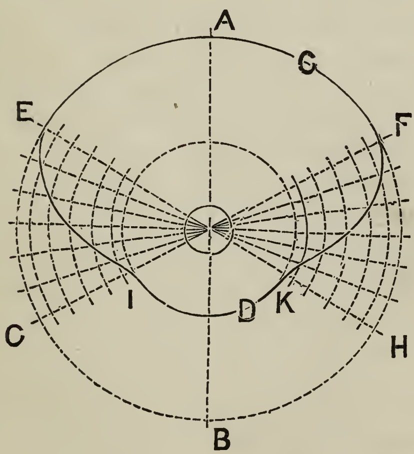
The shedding movement the most important in the loom.—The power-loom is composed of a number of quite distinct movements, working in harmony with each other. The most important of these is that which gives the movements to the camb or leaves of heddles—not only as to the order of succession in which they are raised or depressed to form any particular pattern, but more especially as to the manner in which that is accomplished,—how the shed is formed. Over-shedding and imperfect shedding are the two great causes of nearly all the breakage of yarn that takes place during the process of weaving (that is, if the yarn is of ordinary strength, suitable for the fabric to be produced), as well as a productive source from which much inferior cloth comes. We will endeavour to point out the manner in which the shedding ought to be performed to produce the best quality of cloth with the least injury to the yarn.

The most important points to be attended to in shedding.—The most important points to be attended to in shedding are as follows :—That the shed be no larger than what is absolutely necessary to allow the shuttle to pass through it. Except in the case of very heavy work, it is not necessary that it should quite clear the shuttle. The little extra friction thus caused will be a great deal more than compensated for by a diminution of strain on the yarn. Of course these remarks are not applicable to some woollen yarns wrought with the pile on them. The loose fibres choke up the shed, and consequently it requires to be larger for the same size of shuttle. The movement of the heddle leaves in forming the shed should be eccentric —fastest towards the centre of the stroke, and getting gradually slower until they merge into the full pause. When their movement is uniform, as in most cases it is, the strain comes too sudden on the yarn. The pauses must also be regulated as the warp threads require to be spread or wrought open, and all their movements must be steady, quite free from any surging and jerking movement, and their conjoint action in connection with the beating up of the shot be regulated as the warp threads require to be spread or otherwise. It now remains for us to show how these results can best be obtained. Beginning with plain shedding, we will pass on to the different sorts of tweels, diapers, &c., noticing as we proceed some objectionable methods that are practised in some places.

The delineation of plain wipers.—Fig. 3 is the delineation of a plain wiper constructed to spread the warp; but before proceeding to draw the outline, we must be very careful to ascertain exactly the two principal dimensions—that is, the distance from the centre of the wiper shaft to the point of contact with the friction rollers of the treadles, and the length of stroke to be given to them.

The leverage of the treadles.—In determining the length of stroke to be given to the wipers, we must take the leverage of the treadles into consideration as giving

FIG. 3.



the heddle leaves so much more of a traverse. As the distance from the point on which the treadles move to their point of contact with the wipers is to the length of stroke, the whole length of the treadles will be to the distance the heddle leaves will move.

Plain wipers.—Let us suppose that the distance from the centre of the wiper shaft to the nearest point of the friction roller is 6 inches, and the length of the wiper's stroke 3 inches. Then, after having drawn the diameter A B (fig 3), take the 6 inches, with half the length of the stroke added to it, which will be $7\frac{1}{2}$ inches, for radius, and describe the circle C. Then take the 6 inches again, and subtract half the stroke from it, which will leave $4\frac{1}{2}$ inches for radius, and describe the circle D.

The length of pause necessary to spread the warp.—As the wiper under consideration is to spread the warp threads, the length of pause to be given to it will be equal to two-thirds of a revolution of the crank—that is, from the time the shot is beaten up until the lay has moved back and the shuttle gone quite through the shed. The reason of this may not be quite obvious at first sight; but if we recall what has already been said in reference to fig 1, where the warp line is sunk to cause the upper half of the shed to be a little loose, we will see that the threads must be held in that position, both during the beating up of the shot and the passage of the shuttle through the shed, that these movements may have no influence to disturb or put them out of their position. This is the best length of pause that can be given for that purpose. Then, as the crank shaft makes two revolutions for one of the wiper shaft, the pause will be equal to one-third of the circle described by the wiper; consequently, set off that distance on the circle C in the points E and F. From these points draw diameters until they cut the circle at G and H. Then that part of the circle D from I to K will form the corresponding pause to E F.

How the curves are obtained.—What remains to be done now is to join E I and F K with eccentric curves, to open and close the shed in the manner we have already described. (It will be noticed that there is only a third of the circle left for that purpose. This is another exemplification of the remark we have already made, that any attempt made in the loom to spread the yarn is attended with a corresponding strain on it. Had the threads not required to be spread, a shorter pause would have been sufficient, and more time would have been given to the opening and closing of the shed.) Divide the arcs E G and F H into a certain number of equal parts, say six, by radial lines. Divide one of these radial lines into the same number of parts, but not equal. Where these parts are equal, the movoments of the heddles will be uniform, but in order to give them the eccentric movement required, these divisions must be closer towards the outer and inner circles, and farther apart towards the centre. It is in this way that the eccentric movement is given to them. (The divisions in the figure will be found to give a good movement.) Through these points draw concentric circles, or arcs, and through the points of intersection with the radial lines draw the curve sought.

A defect in shedding; how to remedy it.—We have now given the outline of the shedding wiper so far as it can be mathematically obtained, and, had the treadles moved up and down in a straight line, no more would have been necessary; but, seeing that the treadles at their point of contact with the wipers describe an arc of a circle, which causes a defect, it must be remedied in some way. We must first make that arc part of as large a circle as can be got, that it may approach as near to a straight line as possible, by making the distance between the friction roller and the centre on which the treadle moves as large as the loom will admit of, and keeping the centre of the friction roller perpendicular with the centre of the wiper shaft. When this is attended to, the defect of the movement will be reduced to a minimum. But in order to make it complete, a model of the wipers in wood should be made and put in their place in the loom, when it will at once be seen where the defect is. It is an absolute necessity in good shedding that the treadles be in continuous contact with the wipers throughout the whole revolution. This prevents any surging or jerking movements in the leaves of the camb, and goes a far way to produce a good fabric of cloth, as well as to spread and save the yarn.

How the construction of the wipers affects the spreading of the warp.—How the continuous easy contact of the wipers with the treadles affects the spreading of the warp, and at the same time has a tendency to save the yarn, may require some explanation. A good many shedding wipers are so constructed that, when the shed is open, the treadle leaves the wiper at that part of the circle D from I to K (fig. 3). As most tenters or tacklers insist on tightening the leaves of their cambs, so that their shed will "rise quite clear," the treadle springs up to it, and, of course, takes the leaf of the camb with it, and draws the upper half of the shed quite tight. As we have already seen, in reference to fig. 1, that, in order to spread the warp, the upper half of the shed must be held a little loose, now, when this occurs to draw it tight, the effect of lowering the warp line at the heddles is entirely destroyed. And as any surging and jerking movement of the heddle leaves is prevented when the wipers and treadles are in continuous easy contact during the whole revolution, the tendency to break the warp threads is greatly lessened.

Experience required to know the proper movement of the leaves.—It is one thing to theorize on a subject, and quite another thing to come to actual practice. This is remarkably true in the case before us. One may know all that we have said about shedding, and fail to produce a good movement after all, from the fact that he may not know it when he sees it. It requires an experienced eye to detect the proper movement of the leaves of the camb when seen in operation.

Equalizing the sheds.—Various methods are employed to equalize the sheds—that is, to make them both the same size—and just as frequently with disastrous results to the yarn. In the top mounting a cone with two steps is sometimes employed for that purpose, the back leaf being attached to the step of the largest diameter to force it up farther than the front one ; sometimes one leaf of the wipers is made larger than the other for the same purpose. It will be quite evident with very little explanation that any attempt of this sort will overstrain something ; and, in fact, it overstrains the yarn, as well as the cordings and heddles of the camb. If equal shedding be required, it can be much better produced by the treadles, by making their connection with the leaves at a point that would produce the desired result ; but the sheds of a plain web cannot be made exactly equal without making a loose and tight shed alternately. To understand this more clearly, we will consider it in connection with the lease-rods.

How the lease-rods affect the size of the shed.—The lease-roads, although they seem somewhat insignificant play a very important part in power-loom weaving. As their name indicates, their primary purpose is to keep the lease, so that when any of the threads are broken their proper place may be readily found in the web. In order to maintain this lease, the threads from one leaf of the camb are put under, and those from the other above, one of the rods, and reversed on the other. Consequently, when one shed is opened, the threads open out from between the two rods, and when the other is opened, the yarn closes round the front one—the one next to the camb. This makes it quite impossible for this shed to rise as far as the other one, without putting a greater strain on the yarn. The difference in the leverage of the treadles ought to be made to suit this. What we see from this arrangement is, that the difference of the size of the two sheds will be in exact proportion to the thickness of the lease-rod next the camb. Then by reducing it to its smallest dimensions, and making the leverage of the treadles to correspond with it, and the diameter of the roller for the top mounting as small as will bring the leaves close together without touching each other, will make the difference in the size of the sheds almost imperceptible.

The action of the wipers as to time.—In regard to the action of the wipers as to time in relation to the movement of the lay for spreading the warp, the shed must be full open when the shot is being beaten up. We have already explained why this is necessary when considering the length of pause to be given to the wiper. This is also necessary in heavy work to get on the weft. When the shot is beaten up before the shed has been closed over it, it springs back again; besides, a much better skin is put on the cloth by shedding at the proper time. By causing the shedding to take place a little later, of course, the yarn may be saved a good deal, especially at the selvages, but an inferior quality of cloth will be produced.

Shedding fine yarn not requiring to be spread.—When the yarn is not to be spread, the shed only requires to be open during the time the shuttle is passing through it. The shot must be beaten up when the heddle leaves are even, before any strain is thrown on the yarn by the shedding. The shed should open to receive the shuttle as the lay moves backward. The pauses of the wiper, of course, will be made to suit this. These remarks apply more particularly to delicate yarn, as the best method of saving it.

A fallacy about shedding.—We would seek to direct attention to a fallacy that is very tenaciously adhered to by a great many tenters and managers of power-looms. It is this—that the wipers should be arranged so that the leaf that is pressing down the treadle be nearest to the side from which it is about to pick. It is held that the cloth is much better when the shedding is performed in this relation to the pick. Some say that it affects the selvages most; but we would ask, What takes place in the loom to cause the difference? We think a careful consideration of the whole subject will show quite distinctly that the benefit derived from this arrangement is merely imaginary, although it will do no harm. This method is most commonly practised by hand-loom weavers, and is of some benefit to them, as it is considerably easier to perform the work in this way. By pressing down the treadle with the foot, and throwing the shuttle from the same side, the weaver is exerting himself in opposite directions; and by this means is enabled to maintain the equilibrium of his body much easier than if both forces were exerted in the same direction. This will give a better command of the tools, and through this means may affect the cloth; but, so far as the power-loom is concerned, no such considerations can affect it.

The movements of the heddle-leaves for tweels, diapers, &c., the same as those for plain.—The movements given to the leaves of heddles for tweels, diapers, and every description of cloth produced by leaves of heddles are the same as those we have already described for plain weaving—they must be eccentric in their movements. But the difference in the number of leaves and the patterns of cloth to be produced causes a slight difference in the shape of the tappets and wipers necessary to produce these movements, which we will now consider.

In tweels the greatest number of leaves should be up.

—In tweels, and some other sorts of weaving, it was the universal practice in shedding, some years ago, that the greatest number of leaves were always down and the smallest number up—that is, in the case of a four-leaf, for example, it was always wrought with three leaves down and one up; or in a five-leaf tweel, four were always down and one up when the shed was formed. This practice has been reversed many years ago throughout nearly the whole linen trade; but the old system is still adhered to in some places. This method of shedding causes a greater breakage of the yarn. The friction of the shuttle passing and re-passing over it causes it to get chafed and less able to bear the strain of weaving; besides, there is a greater proportion of it subject to be torn by any "rag" that may be on the shuttle. A greater obstruction is also given to the passage of the shuttle, and the broken threads are not so easily seen in the cloth. But, on the other hand, tweels wrought with the greatest number of the leaves down have generally a better appearance than when they are wrought the opposite way; in fact, the under side of the cloth has always a better "skin," and is more "level" than the upper side. But the advantage thus gained will not balance the disadvantages we have pointed out, except perhaps in very light work.

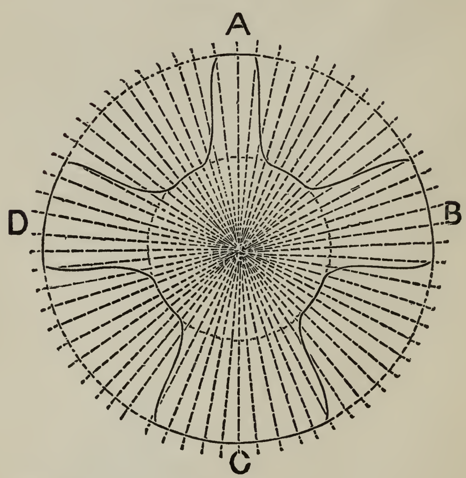
How the length of pause for the different sorts of wipers and tappets is found.—The only thing we have yet to learn regarding the construction of wipers and tappets for tweels, diapers, and other fabrics, beyond what we have already explained in fig. 3, is the proper breadth that will give the exact length of pause the circumstances require, the curves being found as we have already described in fig. 3. We will endeavour to explain very shortly a method by which the exact length of pause of any wiper or tappet can be ascertained:

Multiply the number of threads to be given in one revolution of the shaft on which the wipers are placed by four, and the product will be the number of parts into which the circle is to be divided. Four of these divisions of the circle will represent one revolution of the crank shaft. As the shed in tweels and diapers does not require to be kept open longer than the crank makes half a revolution (except in peculiar circumstances), two of these divisions will form the face of the wiper, and one to close and one to open the shed, and the other parts will form the small circle. Take a four-leaf tweel, for example. As there are four treads in one revolution, then four multiplied by four will give sixteen parts into which to divide the circle, or a five-leaf will require twenty divisions, and so on with any number of threads, always giving two parts of the circle for the pause when the shed is full, and one to open and one to close the shed, and the remaining parts for the small circle. Of course this sort of wiper will only have one leaf down when the shed is open ; but if it is desired to have one up and all the others down, then it has only to be reversed—two parts for the small circle, the same number for each of the curves, and the remaining parts for the large circle.

Power gained in shedding by multiplying the number of treads.—In tweels that require considerable power in shedding, such as heavy sacking, for example, the wipers are sometimes made double, and consequently give double the number of treads in one revolution of the shaft. For example, in a four-leaf, the circle will be divided into thirty-two parts ; for a five-leaf, forty ; and so on ; four parts always representing one revolution of the crank, because the shaft on which the wipers are placed will require to be driven only at half the speed it would be driven at in ordinary circumstances, and power will thus be gained in direct proportion to the loss of motion.

A star for a diaper explained.—What has already been said will make it easily enough understood how the ordinary tweel wipers are made. Fig. 4 is an example of a star for a large diaper pattern, wrought with four leaves and sixteen treads. In this case, the warp threads are flushed on both sides of the cloth. As it takes sixteen treads to complete the pattern, so sixteen multiplied by four gives sixty-four, the number of parts into which the circle has

FIG. 4.



been divided by the radial lines. The tappet marked A only keeps down the leaf until one shot has been put in, consequently two parts of the circle are all that are necessary for the pause on it. Tappets B and D both keep down the leaf until two shots are put in. Then, after the two parts for the first shot, we must add as many as will represent a complete revolution of the crank for the second shot. This will give six parts for the face of each of these two tappets. Tappet C will keep the leaf down during three picks, requiring two parts for the first shot, and twice four for the other two, making ten parts of the circle for the face of this one. These are all shown in the figure. We have constructed these tappets according to rule, but where they are so close together as they are in this example (which is caused by the large number of treads to so few leaves), an allowance must be made to give the friction roller space to work between them, which will depend entirely on its diameter, as well as other considerations.

The top mounting.—The equalizing of the sheds for tweels, diapers, and similar patterns, as far as possible, can be best accomplished with the treadles. To do it with the top mounting is a very harsh way of working, and ought not to be resorted to except in the case of an odd leaf, such as a three or five-leaf tweel, and even with these great care must always be taken that the ball that brings up this odd leaf be no larger than what is necessary, so that nothing may be overstrained. The best top mounting, where it can possibly be applied, is the common rollers. But in large tweels, and some other patterns, springs and elastic bands are employed with advantage; and where the number of leaves are very large, or the pattern very intricate, such as dice and damask tweels, wipers and barrels are dispensed with altogether. Several machines have been invented and patented for working the leaves, which we need not describe here. The examples of treading we give in another place will show whether the rollers can be employed, or what sort of top mounting is most suitable for the particular pattern of cloth under consideration.

To equalize the leverage of the treadles.—If the treadles for more than two leaves are wrought from the back of the loom—that is, at right angles to the camb—their leverage ought to be equalized by levers from the side of the loom directly under the leaves of heddles, and at right angles to the treadles. By connecting the treadles to these levers, and the levers in turn to the heddle leaves, the sheds by this means can be equalized; but by far the best way is to place the treadles themselves right under the camb, and connect them directly with the heddle leaves.

Setting the treadles.—To bring the treadles close enough at the point, it will be necessary to heat them and set to the required distance; but, if there are many of them, a separate pattern may be made for each with the required bend, or one-half of them may be wrought from one side of the loom, and the other from the opposite side. With this arrangement two shafts are necessary, with the half of the wipers on each.

The clasps.—The lease-rods, in other than plain shedding, should be supplemented by what is termed in the trade a pair of clasps—that is, two lease-rods, one above and one below the yarn immediately in front of the lease-rods (that is, nearer to the camb)—so that the sheds may all open from the same point. As they are, or ought to be, equalized by the treadles, this prevents any inequalities in the tension of the yarn.

To find the number of teeth required in the wheel and pinion to drive the wiper shaft.—We have now to consider how these tweel shafts are driven. The ordinary wiper shaft of the loom is only available for plain wipers, as it makes a complete revolution for every two picks, and, consequently can only make two sheds, hence the necessity for a separate shaft when more than two treads are required in one repeat of the pattern; but this is the most convenient shaft from which to drive it. In these circumstances, then, to find the number of teeth required in the wheel and pinion respectively, we have only to consider the relation in which the number of treads in one revolution of the one shaft stands to the number of picks made in one revolution of the other. Take a five-leaf tweel, for example, that will be five treads, and as the other shaft always makes two picks in one revolution, the number of teeth in the wheel and pinion will be to each other as two are to five; or one with ten treads, the wheel and pinion will be to each other as two are to ten, or one to five, which is the same thing. This will give the relative proportion of the number of teeth in each. The easiest method of finding the exact number that each should contain is to take any convenient number and multiply both by it. In the case of eight treads, for example, let eight be the number by which we are to multiply, then eight times two (the number of picks in one revolution of the driving shaft) are sixteen, and eight times eight (the number of treads in one revolution of the shaft that is driven) are sixty-four, then sixteen and sixty-four will be the number of teeth in wheel and pinion respectively. Any other number may be used as a multiplier that will give more convenient dimensions.

Wheels necessary with a large number of treads.— When a large number of treads are required to make the pattern, the wheel necessary to produce the proper speed may be too large for the space at our disposal, or otherwise inconvenient. In this case, it must be made of a convenient size, and the speed regulated by an intermediate wheel and pinion. When the wipers are driven in this way, the product of the two driving wheels and the product of the two that are driven will stand in the same proportion to each other that the two picks stand to the number of treads, as we have seen in the previous example.

To find any wheel in the train when the others are known.—Sometimes when changing from one number of treads to another it is only necessary to alter one of the wheels in the train. The following examples will show how to find any one of them when the others are known.

To find the number of teeth in the barrel wheel for ten treads, the first driving wheel having twenty teeth, the first driven wheel forty-eight, and the second driving wheel thirty-six, multiply the first driving wheel by 5—the barrel wheel moving five revolutions for one of the first driving wheel—and by the second driving wheel, and divide by the first driven wheel as follows :—

```
                              20  teeth in first driving wheel.
                               5
                             ---
                             100
                              36  teeth in second driving wheel.
                             ---
                             600
                            300
                            ----
Teeth in first driven  } 48 ) 3600 ( 75   { teeth required for
              wheel,   }      336         {   barrel wheel.
                             ---
                             240
                             240
                             ---
```

The following will show how to find the first driven wheel, the others being 20, 36, and 75 respectively :—

```
                              20  teeth in first driving wheel.
                               5
                             ---
                             100
                              36  teeth in second driving wheel.
                             ---
                             600
                            300
                            ----
Teeth in barrel wheel,   75 ) 3600 ( 48   { teeth required for first
                             300          {     driven wheel.
                             ---
                             600
                             600
                             ---
```

To find the driving wheels, the operation requires to be reversed, as, for example, to find the first driving wheel for ten treads, the intermediate being 36 and 48, and the barrel wheel 75, we have the following:—

```
                          5 )  75 teeth in barrel wheel.
                               15
                               48 teeth in first driven wheel.
                              120
                              60
Teeth in second driving }  36 ) 720 ( 20 { teeth required for first
               wheel,   }        720      {     driving wheel.
```

We find the second driving wheel in the following manner:—

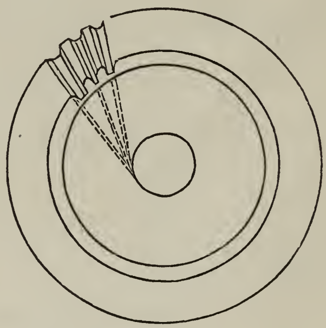
```
                           5 ) 75 teeth in barrel wheel.
                               15
                               48 teeth in first driven wheel.
                              120
                              60

Teeth in first driving }  20 ) 720
               wheel,  }

                               36 teeth in second driving wheel.
```

The proof that they are correct.—To prove that the wheels are all correct, multiply the two driving wheels together, and the two that are driven, and divide the larger number by the lesser. If the answer is 5 without a remainder, then these are the proper wheels for ten treads. Example—

```
                                75 teeth in barrel wheel.
                                48 teeth in first driven wheel.
Second driving wheel,  36      600
First driving wheel,   20     300
                      720 ) 3600 ( 5
                            3600
```

Skewed bevel wheels; how they are made.—The best position for the treadles, in other than plain weaving, is to work them from the side of the loom directly under the heddle leaves. In that case, the shaft on which the wipers are placed will be at right angles to the ordinary wiper shaft (the one by which it is driven), and as they cannot both be in the same plane, the wiper shaft will require to be driven by skewed bevel wheels.

Fig. 5.



In what they differ from the ordinary bevel wheels is shown at fig. 5. The teeth, instead of running in to the centre, are drawn tangent to a circle, the diameter of which is found by taking the distance between the centres of the two shafts and dividing it proportionally to the mean radii of the wheel and pinion, and each division taken as a radius of a circle, to which the teeth of the wheel and pinion respectively are drawn tangent.

THE PICK.

General remarks.—The pick is generally a very harsh movement, that reacts with injurious effect throughout the whole loom. Why it is so we can only account for by the fact that it is so little understood, because any of these movements can be made to work quite smooth and easy, without any of the harshness that too often accompanies them. From among the various movements employed for that purpose, we will select the cone pick for illustration. It is so named, we presume, because the friction roller on which the wiper acts frequently has the shape of a cone. In explaining the action of this movement, we are explaining the action of all the other movements that throw the shuttle (as distinguished from those that carry it through the shed). The same principles govern them all.

The cone pick—an application of a lever of the first order.—The cone pick is simply an application of a lever of the first order. The stud on which the wiper acts and the wooden arm to which the picker is attached are its two arms, and the upright shaft is the fulcrum on which it moves. The length of this shaft is a matter of no importance, so far as its action is concerned, provided it is strong enough to resist the torsional strain thrown on it. The result would be the same if it were reduced to a point. This aspect of it is explained in the plan, fig. 6, where the upright shaft is not seen; A is the short arm of the lever, and B is the long arm that moves through a much larger space, dragging the picker behind it, the picker in turn propelling the shuttle across the loom.

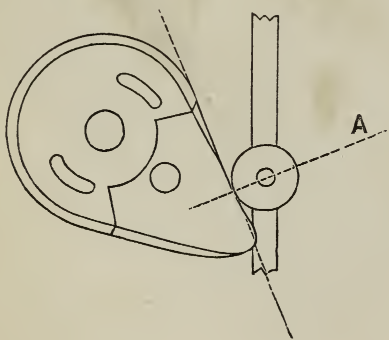
The action of the picking wiper.—The action of the picking wiper imparts a certain amount of force. An impulse is given to the short arm of the lever or stud, that must be proportioned to the amount of work to be accomplished, or resistance to be overcome, within a given time, and in such a manner as will render its action quite smooth and easy. To get at this, then, we have to consider the direction in which this force is applied, its point of contact with the lever, and its magnitude.

Fig. 6.

The direction of the force transmitted by the wiper. —The point of contact of the tappet of the picking wiper with the friction roller on the stud will determine the direction in which the force is conveyed from the former to the latter. This is owing to the end of the lever (as represented by the friction roller on the stud) being circular. The direction of the force thus transmitted will be at right angles to a line drawn tangent to the circumference of the friction roller at the point of its contact with the wiper, as shown at A, fig. 7—the line A extending in the direction of the force.

The true secret of the harshness or smoothness of the pick.—The harshness or smoothness of the picking movement for the most part depends on the angle the

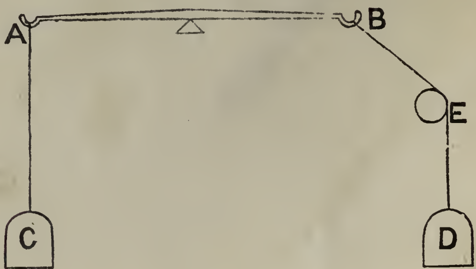
FIG 7.



line A (fig. 7) makes with the axis of the upright shaft or fulcrum, on which the lever moves. The best angle, of course, is right angles, but it is not so easy to transmit the force in that line and at the same time maintain its magnitude. The nearer this can be approached, however, the smoother will be the action of the pick.

The preceding statement illustrated.—We will here illustrate the previous statement in a way to make it more clearly understood by the action of the common balance. Let A B, fig. 8, be a lever, and C a weight attached to it at right angles. It will require more weight at D to balance it, owing to the angle at which it is attached, because a portion of the weight is imparted to the support E, and consequently lost to the lever. It is exactly the same thing that takes place with the pick when the force is transmitted at other than right angles. A greater force is required to throw the shuttle, because part of it is sent vibrating through the loom, and never reaches its proper destination.

FIG. 8.



The verification of the preceding statement.—The statement we have already made regarding the harshness of the pick may be verified by any one who may take the trouble to examine a harsh working pick for himself. The tappet strikes the cone beneath (if the loom is revolving in that direction), and jerks its way round, pressing the stud up as well as pushing it back, consequently that portion of the force expended on the upward pressure is lost to the pick; it merely causes a vibration in the loom and that harshness to the pick so detrimental to the working of the whole machine.

How the direction of the force is regulated.—The direction of the force of the pick is regulated by the relative positions of the wiper shaft and the picking stud. We have already explained what their distance apart should be,* and we must add here that the stud must be considerably lower in the loom than the wiper shaft. But, in order to make a proper adjustment when designing a loom, in the first one that is made the upright shaft should be carried in movable brackets, and the stud made to move either up or down until their proper position has been ascertained. Of course the point of contact between the tappet and the cone will be seen, and from this the direction of the force ascertained.

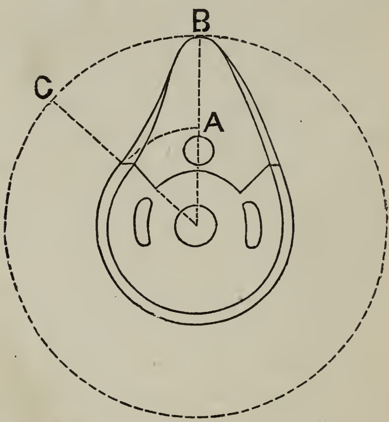
The magnitude of the force.—To find the magnitude or amount of force necessary for the work to be accomplished—a certain amount of matter moved through a certain space in a given length of time—is perhaps the most difficult problem. What makes the difficulty is, that we have no means of measuring it. We would require to ascertain the actual amount of matter contained in the shuttle, and the weft in it; the resistance it has to overcome in its passage across the loom; the space through which it has to move, and the time occupied; and what amount of force a tappet of a given length and shape revolving at a given speed would transmit. The whole movement partakes rather of the character of a blow. The time is a mere fraction of the unit employed in these calculations, which renders any attempt quite impracticable. It can only be ascertained by experiments; and these must be repeated several times, until the most accurate results have been arrived at.

How the proper magnitude may be obtained.—Although we have no definite rule by which we can cut out

* See Upright Picking Shaft.

the exact picking tappet we require just at once, there are certain things by which we can to some extent be guided in this matter. The intensity of the force, then, will depend on the length of the tappet and the part of the circle the working face will occupy. This is illustrated in fig. 9. From A to B is the length of the tappet—let us suppose it to be three inches—and from B to C that part of the revolution the wiper shaft will make during

FIG 9.



the time the impulse is given. This gives us an idea as to time and space. Experience teaches that the shorter the tappet is, its action will require to be more sudden; and as it is lengthened (of course within certain limits), more time may be allowed—that is, the working face will occupy a larger part of the circle, as shown at B C. A considerable length of tappet well timed makes a smoother pick than if short and sharp.

How the picking tappet is proportioned to different breadths of loom.—When the tappet has been properly constructed for one breadth of loom, it will only be necessary to make a slight difference in its length for any other breadth of loom of the same construction. After the proper length has been ascertained for any two different breadths, the length for any other breadth can easily be ascertained. As the difference of the reed space of the two looms is to the difference of the length of their tappets, any other difference in the reed space will require a proportionate difference in the length of tappet; or, to put it in this way, if an additional ten inches of reed space require an additional one-eighth of an inch to the length of the tappet, any other additional ten inches will require the same, or the reverse will be the case if it is ten inches less.

The construction of the picking wiper, and the reasons for it.—A good deal depends on the proper construction of the whole picking wiper. It ought to be made up of three parts—the socket, the disc, and the tappet. The socket should not be fixed quite close to the end frame of the loom, but made so as it can be easily moved either one way or the other for the proper adjustment of the strength of the pick. This is necessary, because the slightest variation of the wiper shaft or the upright shaft from their relative positions affects the strength of the pick; but after its proper adjustment at the start of the loom, it should not be moved again. The disc should be made to move round on the socket for some distance, to secure the proper adjustment of the pick as to time, otherwise the wheels of the crank and wiper shafts may require to be taken out of gear occasionally for that purpose with less favourable results. The disc should not be circular, but cam-shaped, as shown at fig. 9, so that it will draw up the slack of the picker strap quite gently before the tappet comes into action and the shuttle begins to move. This prevents the shuttle being thrown with a jerk. The working face of the tappet, from the point where it begins to move the shuttle, ought to be straight, but skewed so that a proper bearing may be obtained between it and the cone, and made broadest towards the point, as it is most liable to wear at its extremity. It should also be well rounded at the point. When made any way sharp, it soon gets worn; and, of course, the force is weakened and the tappet will require to be replaced sooner than would be otherwise necessary.

Re-dressing the tappets—a mistake.—A practice prevails in almost all power-loom factories of re-dressing the face of the tappets when they get worn. This is in many instances a most mischievous practice that cannot be too carefully avoided, as it is the cause of much of the bad working and knocking off of the loom. It may seem somewhat bold to denounce a practice so universally adhered to; but we have had ample opportunity of testing the truth of what we say. When re-dressed, no matter how skilfully, they cannot be the same as when they were new. Other things often require to be altered to suit the altered condition of the tappet; and when this is repeated, the whole loom very often gets into a perfect muddle. Unless in the hands of experienced men, the result is very bad working looms. When properly made, a tappet should run for years without requiring to be replaced. For proof of this, see actual practice.

The race course of the shuttle.—We have considered the movement of the pick, so far as the wiper and the lever are concerned, and have now to consider the impulse given to the shuttle itself. We have to see that the direction of the force is in the proper line, and that no obstruction is in the way to throw the shuttle out of its course. This implies that the lay must be straight, and the reed and back boxes in line, and the front boxes parallel with them, and that the rod and groove on which the picker moves be parallel with the boxes.

The length of the shuttle box.—To find the proper length of the shuttle box, the length of traverse to be given to the picker must first be ascertained, which will be equal to the space through which the point of the arm will move. Then, suppose the tappet to be three inches long (A B, fig. 9), and that it is situate six inches from the fulcrum, and that the point of the wooden arm measures thirty inches from the fulcrum, it will move through a space of fifteen inches. This resolves itself into a question of direct proportion : as the lengths of the two arms are to each other, the distances through which they move will be in the same ratio ; but to this distance we must add the breadth of the picker, and a little more, that it may move freely. This will be the length of the shuttle box.

The reason that a loom with long shuttle boxes generally works well.—There is an idea prevalent amongst the uninitiated that long shuttle boxes make a smoother pick and in every way a better working loom than when the boxes are short. It is not the boxes that eause this, but long boxes always accompany a good working pick. When they are short, the pick must of necessity be short and sharp, because the picker has but a short space in which to move. It is much better to lengthen the tappet considerably, and give more time for its action ; the shuttle will move steadier, and its chances of being thrown out of the loom will be less.

The time of the pick in relation to the movements of the lay.—The movement of the shuttle must be regulated to work in conjunction with the other movements of the loom. It should just begin to move when the lay is in the centre of its stroke.

A suggestion to reduce the tear and wear in connection with the picking movement.—There is a great tear and wear connected with the picking movement. Considerable expense is incurred for shuttles, pickers, straps, and all the other parts connected with it. Great part of this is caused by the harshness of its action. The easier it can be accomplished, it will not only work better, but it will be less expensive to the owner. Even when the utmost has been done that will render the pick easy in its movement, there will still be a considerable drag on the movement of the shuttle, caused by the weight of the protector pressing on the back of the "swell." This is necessary to prevent the rebound of the shuttle when thrown into the box; but its effects are injurious when it acts on the shuttle at the time of its being thrown out again. A movement of very simple construction might be made to lift this weight off the swell just at the moment the shuttle is being thrown out of the box, and immediately let fall again. It could be accomplished by an eccentric or cam of some sort on the end of the crank shaft, with a connecting rod to the lifter on the back of the shuttle box. We give this suggestion for what it is worth; but it is at least worthy of the attention of those concerned.*

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* We are glad to be able to state that since this suggestion first appeared we have learned, from various correspondents throughout the country, that it has been acted upon with the best results.

THE SHUTTLE PROTECTOR.

The automatic movements of the power-loom.—The three principal movements in all descriptions of textile machinery are the same as those employed in the hand-loom; shedding, picking, and felling—beating up the shot—must take place before cloth can be made, either by hand or steam power. But there is this difference between hand and power-loom weaving; in the former, the weaver can regulate the movements of his loom when he sees it necessary, to suit the varied circumstances in which he may be placed, or cope with any emergency that may occur; but in the power-loom this reasoning and guiding faculty, by which the movements of the hand-loom are regulated, is absent, and hence the necessity of the various automatic movements that form part of the power-loom in addition to the three movements necessary to make the cloth. Perhaps the most important of these is the protector. Its action affects the whole loom in a very important manner.

The action of the protector.—The action of the protector is very injurious to the loom. The latter is brought to a sudden stand when it "chaps off" while all its parts are in full motion, and consequently the united momenta of all the moving parts of the loom are concentrated in the stroke the protector gives. In these circumstances, when the loom is driven beyond a comparatively slow speed, the swords and wheels and all the other parts are broken and disarranged by the increased momentum of the stroke.

By reducing the momentum of the working parts of the loom, we reduce the force of the protector's stroke.—When we reduce the diameters and weight of the wheels and pulleys (more especially the fly wheel, which is only required as a hand wheel to turn the loom), the radius of the swords, and the weight of the lay and its mountings, as far as practicable, we reduce the force of the stroke given by the protector. This is the main object to be gained, but, before it can be accomplished, all the other movements of the loom (on account of their being intermittent) must be divested of any reaction that may require an accumulation of force in the moving parts of the loom to make its motion equable. When this is done, we have only to contend with the beating up of the shot, and, as the momentum is increased to overcome this, the speed of the loom should be reduced.

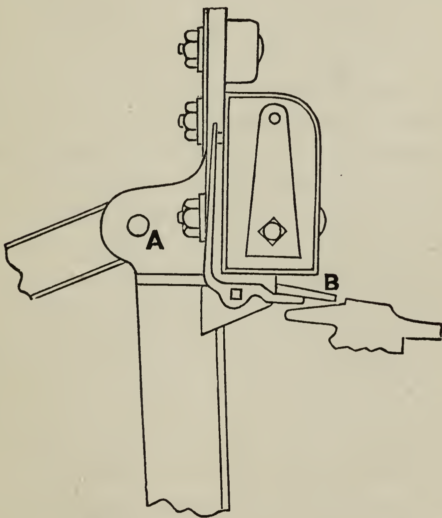
The wheels broken by the concussion of their teeth.—When the loom is knocked off by the protector, the wheels are broken by the concussion of their teeth. This is caused by the crank shaft pinion being brought to a sudden stand, while the wiper shaft wheel has a tendeucy to go on by the force it will have gained; consequently, it can only be stopped by the concussion of its teeth with those of the crank shaft pinion. What we see from this is, that the less play there is between the teeth of these two wheels the force of the concussion will be the less, and their tendency to be broken will thus be reduced.

A cause of the swords breaking.—In some makes of looms, wrought with the protector movement, a considerable breakage takes place amongst the swords, which is often caused by their own leverage—the vertical distance between A, fig. 10, the connecting pin of the sword, and B, the protector, being too great. This will be easily enough understood when we consider that the force of the stroke is applied at A and is stopped at B. The force of A thus stopped at B will affect the swords in a direct ratio to the distance between these two points;

but, of course, the intensity of the stroke has as much to do with the breaking of the swords as this.

Where the protector should be fixed.—The protector is frequently fixed in a bracket attached to the lay. Nothing could be worse for the loom than this, especially if it is of a heavy make. Its action has a tendency to draw the lay round out of its proper position,

FIG. 10.



and the repeated strokes sever the fibres of the wood of which it is made. When the lay gets distorted in this way, the shuttle is interrupted in its passage across the loom, and causes a very harsh movement. The protector should be fixed to the swords below the lay, in some such manner as shown at fig. 10.

The length of the protector.—The length of the protector should be such as will keep the shuttle clear of the warp when it is in the shed, but no more. When too long, it has a tendency to catch the buffer before the shuttle has had time to raise it. It should rise about a quarter of an inch clear of the buffer. When raised too high, it gives more work to the shuttle than is necessary.

The twofold purpose of the protector.—The protector serves a twofold purpose. Besides protecting the warp from being "smashed" by the shuttle, it also stops the rebound of the shuttle when thrown into the box of the lay. If it had not the "belly" of the swell to push back, to retard its motion, something else would require to be provided for that purpose.

Advantages obtained with the protector constructed on correct principles.—We can gather from what has already been said on this subject that the principal things to be attended to in the construction of the protector are—to make its stroke as light as possible, by reducing to a minimum the momentum of all the working parts of the loom, making the leverage of the stroke on the swords as short as can be, and throwing the stroke on that part of the loom where it will be least felt; and just as these objects are attained will a higher speed be possible, and much breakage prevented.

The fly reed.—By the fly reed movement most of the evils attending the common protector are remedied. No stroke is given to knock off the loom and keep back the reed from knocking the shuttle through the warp; the reed flies back, and this is not necessary. The handle of the loom is put off quite gently, as the lay turns the fore centre, and the loom continues to revolve until the power is withdrawn; but, unfortunately, the fly reed as it is at present is not applicable to heavy or even medium work. The reed is not firm enough to give a sufficient stroke when beating up the shot. Under these circumstances, we must continue to use the protector where the fly reed cannot be applied, until something better has been got to fill its place; but a knowledge of its action, and the principles that are involved, will enable us to reduce its bad effects to a minimum.

THE TAKE-UP MOTION.

How it operates.—This is another of the automatic movements that are necessary in the power-loom. By it the thickness of the cloth is regulated—that is, the closeness of the weft threads—the closeness of the warp being determined by the fineness of the reed. Although it is by this movement that the number of shots on the cloth is regulated, it is not by it that the yarn is drawn from the beam. It takes away what has been brought forward by the action of the reed, and, as the warp is drawn tight, the forming of the next shed and the beating up of the shot draw the yarn from the beam, to be taken away in cloth by the take-up motion.

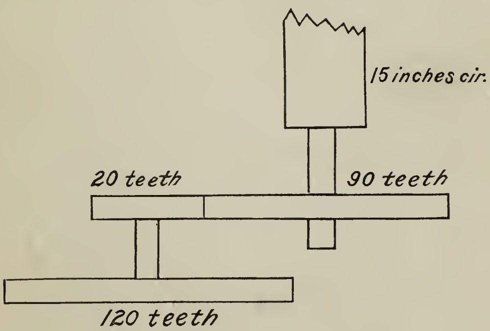
The drag and positive motions.—There are two descriptions of take-up motions—the drag and the positive motions. The drag motion is wrought by a lever, weighted to suit the fabric of cloth to be produced, the weight being changed frequently to lessen the speed of the cloth roller, as its diameter increases by the winding of the cloth on it. The distinctive feature of the positive motion is the introduction of the feed roller. As it is not affected by any alteration in its diameter, the cloth being wound on a separate one, its movement is the same throughout the whole time the same fabric of cloth is being wrought; consequently, this admits of its being driven by a train of wheels, and it will thus require less attention and produce an evener fabric of cloth.

The fabrics for which the drag motion is best adapted.—The positive take-up motion is now almost universally adopted; but there are a few fabrics for which the drag motion is better fitted: this is owing to the feed roller being a greater distance from the fell of the cloth than the cloth beam of the drag motion. The feed roller requires to be low in the loom, that it may carry the roller on which the cloth is wound above it, its weight keeping it in contact with the feed roller. In the long stretch from the fell of the cloth to the feed roller, the cloth has a tendency to get drawn in passing down to it, thus altering the fabric of the cloth after it has passed the breast beam. This is more particularly the case in heavy work, the tension of every shed being thrown on it; the greater the tension the greater tendency will it have to get drawn. This is the principal reason that government canvas and duck is seldom if ever wrought with the positive motion. The hackles required in the feed roller for fabrics of that sort would also be injurious to the cloth.

The wheels of the positive motion.—The number and pitch of the teeth, and the diameter and even the number of wheels in the train for the positive motion, will depend entirely on the fabrics to be wrought, as well as on the construction of the movement itself; but in any case, it should be capable of producing considerable variety. What seems to be the only thing requiring explanation here is the change pinion, to find the number of teeth required to produce any given number of shots.

Rule to find the number of teeth required to produce a given number of shots.—The rule to find the number of teeth required in the change pinion to produce a given number of shots on the inch of cloth is as follows:—Multiply the number of shots on one inch by the circumference of the feed roller in inches; divide the product by the number of teeth in the ratchet wheel, and by the quotient thus obtained divide the number of teeth contained in the feed roller wheel. The answer will be the number of teeth required in the change pinion. Take the following as an example:—With a ratchet wheel with 120 teeth, and the feed roller wheel with 90, and the circumference of the roller 15 inches; required the number of teeth in the change pinion to produce 36 shots per inch.

Fig. 11.



Shots on one inch, ...		36
Circumference of feed roller, ...		15 inches.
		180
		36
Teeth in ratchet wheel,	120)	540 (4·5
		480
		600
		600

The number of teeth in the feed roller wheel is now divided by 4·5, as follows:—

$$4{\cdot}5\ )\ 90{\cdot}0\ (\ 20 \text{ teeth in change pinion.}$$
$$\underline{90{\cdot}0}$$

There is sometimes a remainder, but the nearest whole number is the pinion required.

The calculation may also be expressed thus:—

$$\frac{120 \times 90}{36 \times 15} = \frac{10{,}800}{540} = 20 \text{ teeth.}$$

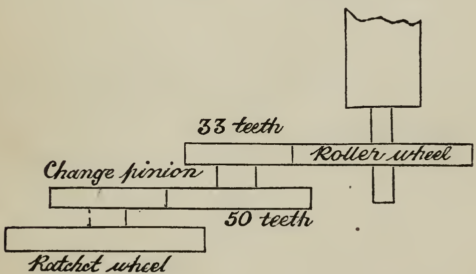
Explanation of the preceding example.—It will be seen from the above calculation that the number of shots on one inch, multiplied by the circumference of the roller in inches, gives the number of shots on one revolution of the roller; and as the rachet wheel moves one tooth for every shot put into the web, to divide the number of shots on one revolution of the roller by the number of teeth in the ratchet wheel will give the number of revolutions it will make for one of the roller. The change pinion being attached to the same spindle with the ratchet wheel, it makes the same number of revolutions. This is what we really wish to get at. Now, in the example just shown, the change pinion makes 4·5 revolutions for one of the roller wheel, and it will be quite obvious that to divide the number of teeth in the latter by the revolutions of the former will give the number of teeth required in the change pinion. For a constant number, multiply the number of shots by the pinion found, and this result divided by the number of shots wanted will give the pinion. For example, pinion required for 24 shots—

$$36 \times 20 = 720$$
$$720 \div 24 = 30 \text{ pinion.}$$

An example under other conditions.—Sometimes it is inconvenient to have the feed roller wheel of the dimensions required for the particular fabric to be wrought, but instead one of a convenient size is put on, and a wheel and pinion introduced to regulate its speed. The tenter's glass, too, is sometimes an inconvenient fraction of an inch, and moreover it is also necessary on occasions to move the ratchet wheel more than one tooth for each shot. Perhaps these conditions may not be all combined in one loom at the same time; but we will give an example including them all:—

Given a take-up motion with a ratchet wheel with

FIG. 12.



eighty teeth, moving two teeth for every shot, the roller wheel with eighty-three teeth, and the intermediate wheels with fifty and thirty-three teeth respectively, the roller measuring $14\frac{1}{2}$ inches in circumference; required the number of teeth in the change pinion to give ten shots on the glass, the glass measuring nine-tenths of an inch. Fig. 12 shows the connection of the wheels, which will make it easier understood.*

* The figures we are using are of no importance beyond showing the method of calculation.

First find the number of shots that will be put into the web during one revolution of the roller. Perhaps the best way to state it will be as follows:—If ·9 of an inch contains 10 shots, how many shots will be on 14·5 inches? Thus—

$$
\begin{array}{l}
\cdot 9 : 14\cdot 5 :: 10 \\
 10 \\
\hline
\cdot 9)\,145\cdot 0 \\
\hline
\,161\cdot 1
\end{array}
$$

161·1 shots on circumference of roller.

To find the number of teeth that will be required in the roller wheel, with the intermediate wheels omitted. It will be obvious, with a little consideration, that to multiply the number of teeth in the roller wheel by those in the one geared with the change pinion, and divide by the one geared with itself, will give the number required. We have thus—

$$
\begin{array}{r}
83 \\
50 \\
\hline
33\ )\ 4150\ (\ 126 \\
33 \\
\hline
85 \\
66 \\
\hline
190 \\
198 \\
\hline
\end{array}
$$

126 number required.

As the ratchet wheel has 80 teeth, and moves two for every shot, that will be equal to a wheel with 40 teeth.

We have now what is equivalent to a ratchet wheel with 40 teeth—a roller wheel with 126 teeth, and 161 shots on the circumference of the roller. Then divide 161 by 40, thus—

$$
\begin{array}{r}
40\ )\ 161\ (\ 4 \\
160 \\
\hline
1 \\
\hline
\end{array}
$$

and 126 by 4, as follows:—

$$
\begin{array}{r}
4\ )\ 126 \\
\hline
31\cdot 5
\end{array}
$$

which gives 31 or 32 teeth in the pinion required.

When changing from one count to another, the pinion can be found by inverse proportion. Thus, if 20 teeth give 36 shots, how many teeth will be required to give 40 shots. Example :—

$$
\begin{array}{rl}
40 : 36 :: & 20 \\
 & \underline{36} \\
 & 120 \\
 & \underline{60} \\
40\,)\, & 720\,(\ 18 \text{ teeth.} \\
 & \underline{40} \\
 & 320 \\
 & \underline{\underline{320}}
\end{array}
$$

The foregoing calculations may be more clearly expressed as follows :—To find the change pinion for 161·1 shots—

$$\frac{40 \times 50 \times 83}{33 \times 161{\cdot}1} = \frac{166{,}000}{5{,}316{\cdot}3} = 31{\cdot}22 \text{ teeth in change pinion.}$$

And to find the shots on the circumference of the roller by a pinion of 31 teeth, giving 10 shots in nine-tenths of an inch (= the glass).

$$\frac{40 \times 50 \times 83}{31 \times 33} = \frac{166{,}000}{1{,}023} = 162{\cdot}2 \text{ shots in circumference.}$$

What number of teeth would be required in the roller wheel, if the intermediate wheel and pinion were thrown out?

$$\frac{31 \times 162{\cdot}2}{40} = \frac{5{,}028{\cdot}2}{40} = 125{\cdot}7, \text{ or } 26 \text{ teeth.}$$

The result would then be found thus :—

$$\frac{40 \times 126}{31} = \frac{5{,}040}{31} = 162{\cdot}2 \text{ shots as before.}$$

If the ratchet wheel were to be worked as with 80 teeth, it would give double the number of shots; it might then be necessary to change the roller wheel to 63 teeth, thus:—

$$\frac{80 \times 63}{31} = \frac{5,040}{31} = 162 \cdot 6 \text{ shots.}$$

For changing from one count of yarn to another, we find a pinion of 31 teeth gives 162 shots. What pinion will 120 shots require?

$162 \times 13 = 5,022$

$5,022 \div 120 = 41 \cdot 85$, or 42 teeth in pinion.

THE PACE.

The tension of the yarn.—By the pace is meant that slow movement by which the warp is drawn from the beam during the operation of weaving. The beauty of the cloth depends very much on the tension at which it is held: when too slack, it presents a very raw, unsightly appearance that no amount of finish can remedy. All descriptions of cloth should be wrought nearly as tight as the strength of the yarn will admit of, but when too tight, besides breaking the yarn, it gives to the cloth a hard corded-like appearance. Very little observation will enable the tenter to know what pace will give it that "skin" so desirable in all descriptions of cloth.

The uniformity of the tension.—A uniform tension must be secured throughout the breadth of the web. This implies that all the beams and rails of the loom over which the yarn and cloth passes must be parallel with each other, and that the yarn be wound on the beam with an equal tension, no tighter at one side than the other. If any of these are neglected, the result is, one part of the web is tight and the other slack, which produces unequal cloth—it also causes the leaves of the camb to "wink," which breaks the yarn, and makes the loom "chap off," and is very detrimental to loom, yarn, and cloth altogether.

The different methods of pacing.—There are several ways of applying the pace cord according to the tension required. In heavy work, to gain power without having recourse to much weight, several plies of the cord may be taken round the friction pulley on the beam; but in light work the cord should not be taken round the pulley at all. It has a tendency to cause irregularities in the cloth. Two or three ply of it should be hung over the pulleys. Of course the friction of these pulleys will be in proportion to their diameter and size of cord put over them. The greater the friction surface the less weight or leverage will be required.

An objectionable method of pacing.—A very objectionable method of pacing is sometimes resorted to in some places. An iron strap is thrown over the friction pulleys on the beam, and held in a fixed position by means of a lever secured by screws. This is intended to prevent the weaver altering the pace of the web unknown to the overseer. That it has effected this purpose no overseer who has had the experience of it will affirm. Be that as it may, however, its effects on the cloth are what concern us at present. If the yarn beams and their friction pulleys could be kept perfectly true, this method might do for heavy work; but a short time often suffices to warp and otherwise distort these beams; then their unequal movements are transferred to the cloth in slack and tight places alternately. It is thus rendered almost impossible to produce an even fabric of cloth.

HOW THE WINDING AFFECTS THE WEAVING.

The diameter of the pirn or cop.—The winding affects the weaving in a very material manner, in proportion to the dimensions of the pirns or cops that are used. Many manufacturers and others engaged in power-loom weaving endeavour to make them as large as possible, that the stoppages of the loom, to change the shuttle when the weft runs down, be as seldom as possible. There is a certain limit to this beyond which it is unwise to go. We have already explained in another place that the larger the shed is, the greater is the strain thrown on the yarn. Now, as the shed must be regulated in size by the width and height of the shuttle, and the dimensions of the shuttle in turn determined by the diameter of the pirn or cop to be placed in it, it follows as a matter of course that the diameter of the pirn cannot be increased beyond a certain limit without disastrous consequences to the warp threads. What that limit is must be learned by experience in relation to the yarn to be woven. It is quite evident, however, that the shuttle can be changed several times during the time required to mend one broken thread; and if by increasing the size of the shed to admit of a larger pirn one thread is broken during the working of a single pirn or cop, instead of saving time, a very decided loss has been caused.

The length of the pirn or cop.—As long shuttle boxes are a necessary accompaniment of a good working pick when cops are wrought with, the full advantage of this should be taken to make them as long as may be practicable. This cannot be said of pirns, because as they get empty the friction of the weft thread on the pirn increases, and; consequently, the tension at which the thread is held. This causes an uneven selvage on the web, and has a tendency to break the selvage threads when the pirn is getting empty. No matter what length the cop is, it produces a uniform selvage throughout, and a very superior one in every respect to that made even by the shortest pirn.

The size and momentum of the shuttle.—Perhaps the most important aspect in which we can look at the above subject is the size of the shuttle itself. When we increase the size we increase the weight also, and, consequently, its momentum while moving across the loom. It also requires a broader lay, and heavier mountings; and, as the one movement is so connected with all the others, everything must be proportionally increased in strength. The strength of the pick must also be increased in proportion to the size of the shuttle; in fact, the strength of the whole loom requires to be regulated as much to the size of the shuttle as to the fabric of cloth to be woven. And, moreover, large shuttles do not work so well as smaller ones; they are much easier thrown out of the line of their movement, and there is a greater tear and wear in almost all the movements of the loom. All this shows that we should be very judicious in determining the size of pirns, cops, and shuttles to be used in the power-loom.

THE SPEED OF THE LOOM, DRIVING GEAR, &c.

What determines the speed at which the loom is to be driven.—What is the most profitable speed at which the power-loom can be driven? is a question that does not always get the attention that its importance demands.

It is one of considerable consequence to the manufacturer, and will always be getting more so. As time goes on, the principles of economy will require to be more rigidly investigated, and applied to all branches of industry. In the cotton trade, the highest speed attained is 200 picks per minute, the finer linen 180. In the jute trade, and also some woollen fabrics, 125 picks per minute is about the maximum speed yet reached ; but the highest speed that can be wrought at is not always the most profitable. The loom may be driven faster than is compatible with the strength of the yarn, or than the loom itself will stand. If frequent breakages occur among the yarn or the parts of the loom, caused by an extra speed, then the loss is much greater than the gain. These evils, however, do not arise from the speed at which the shuttle moves across the loom. The cause may either be imperfect shedding, an inferior quality of yarn, or an imperfect construction of the loom itself, or these all combined. We have already explained these points in the previous chapters. When these have been attended to, the loom may be driven as fast as the strength and elasticity of the yarn will admit of. We have also explained how a high speed can only be obtained with the fly reed ; but when the protector movement is constructed on proper principles, a comparatively fast speed may be obtained.

To increase the speed of hessian looms.—We believe that many fabrics are still wrought with the old loom, to which the fly reed might be applied with advantage. Common hessians, for instance, require no great stroke of the reed, and the yarn is generally such that, with proper shedding, 160 picks per minute might easily be obtained, while the old loom could be constructed to give 140 picks. But, judging from the construction of most looms employed in the *jute trade*, anything seems good enough for so coarse a fabric. The shed is commonly formed with a jerk, and when the loom knocks off there is freduently something broken. These errors cannot be too carefully avoided. A little care will always remove them to a great extent.

Speed of broad looms.—Broad looms are driven slower than narrow ones, but not in proportion to their reed space. The greater breadth of the leaves of the camb makes their movements much steadier, and a comparatively high speed less injurious to the yarn. But the loom itself is of necessity much heavier, and the reaction of its movements much greater; and, moreover, the shuttle requires a little more time to pass through the shed, having a greater distance to traverse.

Hints as to how to obtain a uniform speed of the looms in small factories.—Next to the proper speed of the loom, its uniform motion is of the greatest importance. In large manufactories a steady movement can be obtained; but in small factories—of which there is a large number—a uniformly steady drive is not so easily got. The loom, unlike spinning and other machinery, requires to be frequently stopped to change the shuttle and tie broken yarn. In small places sometimes they are nearly all off at one time. This allows the engine to run off at a great speed with the looms that are still going. During this time it will be somewhat checked by the action of its valves, or the engineer shutting off the steam, and when the looms are put on again its speed is brought down below what it should be, in consequence of the steam being shut off, and some time must elapse before it can be brought up again. This is what is going on every day in many small establishments. Perhaps it cannot be altogether remedied, but it can in great measure be helped by having a sufficiency of boiler power, and a plentiful supply of steam always ready to prevent the speed being too far or too long reduced, and by driving the engine at a pretty high speed its motion will be more equable. As engineers are still divided on what speed the engine should be driven at to give the best results, we will not attempt to decide. Another great cause of much of the unsteadiness of the speed of the looms in many of these small places is that of driving a calender or other heavy machinery with the same engines the looms are driven by. The putting on and stopping of these heavy machines affects the speed of the engine for the time being most materially. These and the looms should be driven by separate engines.

The strength of the shafting.—The shafting must be strong enough to transmit a uniformly steady movement without any vibration. When any vibration occurs in the shaft it transmits itself to the loom, and the consequences to both loom and yarn are not desirable. The following is the usual formula for the strength of wrought iron shafting, remarking that for looms it should be a little stronger on account of the reactionary nature of the machine:—With D equal to diameter of shaft, in inches; H, the number of nominal horse power to be transmitted; N, the number of revolutions per minute; and K, the constant number, we have—

$$D = \sqrt[3]{\frac{H}{N} \times K}$$

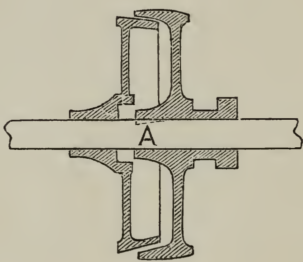
K, in prime movers, is 320; in second motion shaft, 200; in ordinary shafting, 100. It may be expressd thus:—Divide the number of horse power transmitted by the number of revolutions of the shaft per minute, multiply the quotient by the constant number—if a prime mover, 320, second motion 200, &c.—and extract the cube root, which will be the diameter required, in inches.

The driving pulleys.—There are two sorts of driving pulleys in use—the tight and loose pulleys, where the belt is shifted from one to the other, and the friction pulleys. For light work, perhaps the loose and tight pulleys are the best; they are least expensive, and much easier kept up. But for heavy work the friction pulleys are the most effective; for this reason, that when the loom is put on with the loose and tight pulleys, one pick at least must be given before it has reached its full strength. This necessitates a much stronger pick than what in the other case would be necessary. But with the friction pulleys the full power and speed are attained at once. Where the belt is short the friction pulleys are best adapted, because short belts require to be wrought at a much greater tension than long ones, and in consequence of this they are not so easily moved from one pulley to the other. We have a case in point in the loom sheds, where the shafting is placed in tunnels below the floor. To place them low enough to give a long belt would incur considerable expense, and render them quite unmanageable.

An example to be avoided of a bad construction of friction pulleys.—The friction pulleys, although the best for power-looms on account of their instantaneous action, when imperfectly constructed, are attended with great expense and labour in keeping them in proper repair. In fig. 13 we have given an example to be frequently met with. It will be noticed that the "boss" is all on one side of the pulley. Now, as the clearance between the tight and loose pulleys does not exceed one-sixteenth part of an inch, as soon as the corner A is worn a sixteenth part of an inch, as indicated by the dotted line, the pulleys are in contact when the loom is off, and sets it a-jerking so that the weaver cannot get the broken yarn taken in; consequently the pulleys or the crank, or perhaps both, may require to be replaced. When the pulley is fairly constructed and a fair clearance given much trouble and expense is saved. The boss of the loose pulley should be, as nearly as possible, equal on both sides, and the tear and wear would take place equally all over.

How the length of the belt affects the motion of the loom.—A medium length of belt is the best, and most effective. When too short it requires to be so tight that

Fig 13.



the pulleys and crank shaft soon get worn out, besides straining the whole loom. On the other hand, when the belt is too long, it imparts a very irregular movement to the loom. We have seen looms driven from shafts a considerable distance off, with the belts running over guide pulleys; their surging movement will cause them to run off fast for a minute or two, then slow, and fast again, just as the surge of the belt affects them. This way of working makes uneven cloth, besides bad working looms.

Examples showing the method of calculating the speed of wheels and shafting.—We will give a few examples showing how to calculate the speed of wheels and shafting. To begin at the first movement: let us suppose the engine makes 35 strokes per minute—which can easily be ascertained by counting them—and the wheel on the crank shaft to have 130 teeth, and the pinion in which it gears to have 35 teeth, required the number of revolutions it will make in one minute. To find this, multiply the number of teeth in the driving wheel by the number of revolutions it makes in one minute, and divide by the number of teeth in the pinion, and the answer will be the number of revolutions the pinion will make in one minute. Thus—

$$\frac{35 \times 130}{35} = 130 \text{ revolutions.}$$

Number of teeth in driving wheel, 130
Strokes of engine per minute, 35

$$\begin{array}{r} 130 \\ 35 \\ \hline 650 \\ 390 \\ \hline \end{array}$$

$$\text{Teeth in pinion, } 35)4550(130 \text{ speed of pinion.}$$

$$\begin{array}{r} 35 \\ \hline 105 \\ 105 \\ \hline \end{array}$$

It is best to bring up the speed at the first motion from the engine, and drive the other shafting by mitre wheels.

Suppose the drum shaft is revolving at 130 revolutions per minute, we wish to drive the looms at 150 picks per minute, what diameter of drum will be required, the pulleys on the loom being 14 inches diameter? In this case we have to multiply the number of picks, which is equal to the number of revolutions of the crank shaft, by the diameter of the pulleys, and divide by the number of revolutions of the drum shaft. We may remark here, that by the same rule the speed of the large drums that are now substituted on the first motion shafts instead of toothed wheels, and the grooved pulleys for rope gearing, are found. Example:—

$$\frac{150 \times 14}{130} = 16{\cdot}15'' \text{ diam.}$$

```
Speed of loom per min., 150 picks.
Diameter of pulley,      14 inches.
                        ---
                        600
                       150
                       ---
Speed of shaft,   130)2100(16·15 diam. of drum in inches.
                      130
                      ---
                       800
                       780
                       ---
                        200
                        130
                        ---
                         700
                         650
                         ---
                          50
```

If we know the number of revolutions the drum shaft is making, and the respective diameters of drum and pulleys, and wish to know the number of picks the loom is making, we will find them as follows:—

$$\frac{130 \times 16{\cdot}16}{14} = 150 \text{ picks.}$$

```
Diameter of drum in inches,   16·16
Speed of shaft per minute,      130
                              -----
                              48480
                             1616
                             ------
Dia. of loom pulley in ins., 14)2100·80(150 picks per min.
                                14
                                --
                                 70
                                 70
```

The fraction here is not worth taking into account.

HOW TO START AND WORK THE LOOM.

The preceding chapters a counterpart of this.—In the preceding chapters we have dwelt more particularly on the construction of the loom, and will now consider some of the principal matters that exercise the mental as well as the physical capabilities of the tenter and the mechanic in putting new looms into position and proper working order, and keeping them in that condition after they have been set agoing. But we may remark, that a knowledge of what has already been stated with regard to the construction and arrangement of the various parts of the loom is necessary, in order that the following may be rightly understood. Without some such knowledge, we cannot decide what is actually right or wrong, but instead of repeating what we have already said, we merely direct attention to the preceding chapters as the counterpart of this.

A fixed line between the mechanical and tenting departments necessary.—We would suggest that a proper division of labour be carried out in the factory with regard to the mechanical and tenting departments. In our introductory remarks, we have said that it is seldom a knowlege of the intricacies of the art of weaving are to be found associated with a knowledge of the capabilities of machinery. This is strikingly exemplified in the two trades we have just named. It is seldom indeed that we find a tenter with any but the merest idea of the mechanical department of the trade, or a mechanic with anything beyond the merest knowledge of cloth. When the one presumes on the domain of the other, the results are not always of the best description. These facts are not always recognized as they should be, but where the work is large enough to keep both a mechanic and tenter, this division of labour should be carried out. It should be the mechanic's business to keep the loom going, and the tenter's to make the cloth.

A well cousidered plan necessary before putting down looms.—The first thing that should be done by those about to fix and start looms, is to make themselves thoroughly acquainted with the plan of the factory. No one ought to put down machinery anywhere in these days without some well considered plan, with a view to work it with the least expenditure of labour and power, and that every inch of space may be economized. Of course, the circumstances of each place will be peculiar to itself, according to the texture to be produced, the locality and position of the factory, &c., but what we have more particularly to do with at present are facts that are common to all.

How the looms should be arranged to the driving shaft.—In arranging the looms, the broadest, or, if they are all much about the same breadth, those that are adapted for the heaviest fabrics, ought to be driven from that part of the drum shaft nearest its connection with the main or driving shaft, and the lightest ones farther out on the end of it. When the heavier looms are placed towards the end of the shaft, the leverage they exert on it is in proportion to the power they require to drive them, and causes a vibration on the shaft that is detrimental to the proper working of the looms. This vibration, of course, could be prevented by making the shaft much stronger, but there is no necessity for this extra outlay when it can be remedied by the proper arrangement of the machinery.

The looms grouped in fours.—To economize space and keep the belts from being spread over the factory as little as possible, the looms ought to be grouped together in fours, with all their belts running beside each other.*

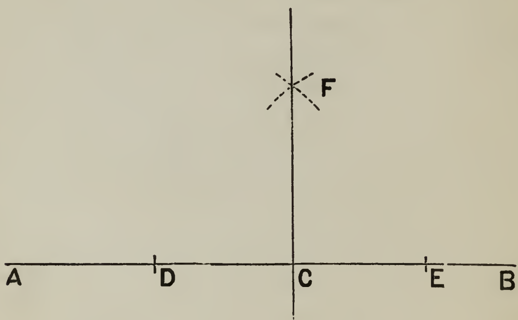
How to arrange the looms in line with the shaft.—The looms must be arranged in a parallel line with the shaft by which they are driven, otherwise the belts will not work well. They will have a tendency to run off the pulleys or drums, or run on their edge, and consequently part of the power will be lost. The best plan of procedure is to draw a line on the floor the whole length of the shaft, and parallel with it. Drop a plummet from the shaft, first at one end and then the other, and making a mark at each place just where the point of it touches the floor. Then take a line rubbed over with chalk, stretch it along the floor, taking these two points in its line; hold it tight at both ends, then raise it in the centre, and let go, and it will leave a chalk mark along the floor parallel with the shaft. The same should be done with each shaft separately, as much greater accuracy is obtained in this way than by measuring one line from another. If it is necessary to make these lines permanent for a time—as sometimes it is—lay a straight edge along them, and draw them in with a draw-point or some other sharp instrument. Set the rows of looms parallel with these lines, by measuring an equal distance from them, to both feet of the loom.

The line to which the ends of the looms are set.—The ends of the looms must also be in line, that there may be some sort of order; and to facilitate this another line must be drawn on the floor, at right angles to the one we have already got. That we may explain this quite clearly, let us suppose the line A B, fig. 14, to be the line we have already drawn on the floor, and C the point from which

* See paragraph—"The line to which the ends of the looms are set."

we are to set off the line at right angles to it. We may extemporize a pair of beam compasses, by taking a piece of wood, say four or five feet long, and driving a nail or draw-point through each end of it, leaving the points protruding.* Place the point of one of these on the point C on the line we have already made, and with the other mark off the points D and E; then, with these points as centres, with the same or any other radius large enough to secure accuracy, describe the two arcs till they

FIG. 14.



cut each other in point F; then through points C and F draw a line, in the way we have described previously (see page 81), extending it as far as may be necessary. To this line set the ends of the looms.

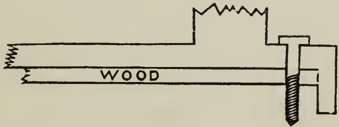
How the looms are arranged to clear the belts.—The ends of the looms are not set in a line; every alternate one must be set at a distance equal to the breadth of the pulleys, and one inch more, to clear the belts, farther

* Sometimes a piece of cord is used instead of the wood.

from the line than the others. This is owing to two looms being driven from the same drum. Some makers of light looms place the pulleys this much farther out on the crank shaft of every alternate one, to get the looms in line; but this is a very objectionable practice, as it causes a greater strain on the crank that can be avoided by the other method we have named.

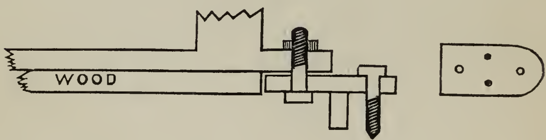
Fixing the looms to the floor.—The looms ought to be firmly fixed to the floor by batts or rag screws; and in order that a proper bearing may be obtained by the looms on the floor, and also to facilitate the process of "levelling," pieces of wood should be fitted below the feet of the end frame. No matter whether the floor be of wood or stone, a much better bearing is obtained in this way. If one part

FIG. 15.



is bearing harder than another, which can easily be ascertained by trying the lift on each corner with a short lever, you will feel if you have the whole weight of the loom; or if there is a rocking movement when it is raised at one point, take out the wood, and plane it down under the place that is bearing hardest, until you have got an equal bearing throughout. The best method yet adopted of securing looms, more particularly if the floor is of stone, is to have cast on, under the end of the sole plate of gable, a toepiece 2 inches deep and the same breadth (as shown in fig. 15), allowing $\frac{7}{8}$ of that depth for wood and $1\frac{1}{8}$ let into the floor, and secured in the usual way by screws and lead. Looms already working can be supplied with a toepiece to put on all the four corners, or at the back only, as desired, by a plate 5 inches long, the same breadth as the gable soleplate, and $\frac{3}{4}$ of an inch thick. One-half of it is bolted to the soleplate, and the other half, extending beyond the plate, is secured to the floor by another screw. In the middle of the plate two nipples are cast, 2 inches long and $\frac{3}{4}$ inch diameter, and let into the floor $1\frac{1}{8}$, the same as the former toepiece. The accompanying figure will make it understood.

Fig. 16.



It is apparent that the steadiness of the loom does not depend upon the screws at all, but upon the toepiece in the one and the nipples in the other, the screws remaining permanently secure.

Levelling the loom.—When we are securing a firm footing for the loom, we must see that it is level, by trying the spirit-level along the lay. If one foot is bearing hard at the side, the level indicates it is highest; take out the wood, and dress it down until you have got it to a proper bearing and quite level. If the lay is level, we may be sure the other parts are level also.

Setting the loom.—When the loom has been properly secured in its place, we may proceed to the arrangement of the different parts of it, so that they will work in harmony. Each movement must come into operation at the proper time. First examine the crank and wiper shaft wheels to see if they are properly geared, so that the pick will come in with the proper movement of the lay.* If not, put it right, taking the opportunity to examine the keys of the wheels to see if they are properly fitted. When the wheels get loose when in motion they are in danger of being broken, and perhaps may break something slse.

How to set the wipers.—The shedding wipers must be set (if the warp is to be spread) so that the shed will be fully open when the reed is at the fell of the cloth. To accomplish this, turn round the crank until it has reached the fore centre (if a web had been into the loom, the reed would now have been at the fell of the cloth), then turn round the wipers on the shaft in the direction in which they will move when the loom is in full operation, until the point presses down one treadle to the full extent, and fix them there. If the yarn does not require to be spread, then the shed will only require to be full open when the lay is half-way back, just in time to let the shuttle pass into it. Turn the crank round to that position, and the wipers on the shaft, until they press down the treadle as in the other case we have named. Of course the wipers will be made to suit this arrangement.†

To find the proper length of the picker strap.—In putting on the pickers, take care that they move freely in their place. The exact length of the picker strap is ascertained by throwing the lay back as far as it will go, and when in that position the arm must move the picker backwards and forwards quite freely on the spindle without being either too tight or too loose. The arm should be set so that the picker will rest at the end of the box until it is the proper time to begin to pick.

How to set the pick.—We are now in a position to

* This has already been explained under the heading Pick.

† See Shedding.

adjust the pick as to time. The shuttle should just begin to move when the lay is half-way back. Hold the picker at the back end of the box with one hand, and turn round the crank with the other until the picker begins to move; at that point the crank should either be on the top or under centre, according to the direction in which the loom is to revolve.

The check-strap.—The check-strap is considered by many to be of little importance; but it is a very valuable part of the loom, and is too often neglected, to the detriment of the whole machine. Its use is to stay the rebound of the shuttle. The action of the swell in some measure secures this; but when for this purpose the swell is weighted independent of the check-strap, the shuttle gets jammed, and comes out of the box with a jerk. The shuttle must be allowed free play in the boxes, and the length of the check-strap and its traverse regulated to the requirements of each particular case. When the traverse is too long, it may prevent the shuttle going full back into the box; but when too short the shuttle may rebound again, and in either case the power may be lost to throw it across the loom, and the consequence will be that the loom will be knocked off. It should be put on when the picker is being put on, and the spindle will not require to be loosed again for that purpose; but its proper adjustment can only be made when the loom is in motion.

Gauging the shuttles.—Before fitting the shuttles into the boxes they must be carefully sized with a pair of callipers, to see that they are exactly the same, and gauged to fit the bevel of the lay. They must be fitted to work in the boxes quite easily, the boxes being about a tenth of an inch wider than the shuttle, and both back and front box-sides almost parallel.

The position the tip or point of the shuttle should occupy.—The position of the point or tip of the shuttle is a matter of considerable importance, and ought to be carefully considered. When it is too low—too near the race of the lay—it has a tendency to dip under the yarn when entering the shed, and makes what is called a "scob"; but when it stands too high the consequences are much worse,—a thread sometimes breaks and gets entangled in the shed, causing an obstruction to the passage of the shuttle; the shuttle will go over this obstruction, and be thrown out of the loom altogether, the consequences of which may be dangerous to the workers. When the tip gets under these obstructions the loom may be knocked off, but the shuttle will be kept on the lay. This shows us that these tips should be as low in the shuttle as they can possibly be wrought with.

The protector.—Ascertain if the protector is working quite freely, If it is inclined to stick, it may cause a smash in the web. When the shuttle is among the yarn, the protector should be in a position to knock off the loom, and when the shuttle is into the box, it should rise about a quarter of an inch clear of the buffer.

How to find the length of the belt, and how it should run.—To find the proper length of the belt, stretch a cord over the drum and the pulleys of the loom, cut it to the exact length, lay the cord and the belt down on the floor together, and cut the belt from one inch to two inches—according to its length—shorter, as it will stretch a little when put on. When putting it on, it must be seen that all the joinings will run with the pulleys and the drum. When the joinings run against them the belt will very soon get torn up. Beginners should be made aware of this, as they commonly make mistakes with it.

How to adjust the pick as to strength.—Put the reed into the lay, and put on the loom, letting it run for some time to ascertain that everything has been properly adjusted. The pick can only now be set to the required strength when we see how the shuttle moves. If a cone pick—as we have already described in another place—it may be regulated by moving the wiper nearer to the upright shaft, to give more strength, or farther out, to reduce it. If any other make of a pick, on the same principle, it must be adjusted to give more or less of a traverse to the point of the wooden arm that propels the shuttle.

The process of looming the web.—In the preceding notes we have seen the loom fixed, and its parts arranged and set agoing. The tenter now comes with his web. We will go over the process of starting it in the proper order, that the beginner may see the best method of facilitating the progress of his work. The beam is put into its place in the loom, the heddles hung up as nearly as possible in their proper place, and the reed put loosely into its place in the lay. The treadles are now attached to the camb, as they can be quite easily got at before the web is tied up. They must also be adjusted at this stage as nearly as can be. With a little practice a tenter should be able to make a pretty correct adjustment of his camb. The pace cords and weights are put on, or if paced with strings they must be fixed. A piece of cloth, or two cords with a rod fixed to the end of them, is brought up from the cloth roller, and the ends of the warp threads tied on to it. In doing this, it must be seen that all the slack threads are drawn in (when necessary a brush may be used for that purpose, as in the case of woollen yarns), and an equal tension preserved on each tie up. The exact position of the reed can now be ascertained and fixed into its place. The lease rods are then put in, raising the back leaf of the camb for the first, and the front one for the second, placing them at their proper distance apart from the heddles. The pinion required to give the number of shots wanted may be obtained, in the manner we have described in another place,* and put on its place in the loom. The sheds must now be carefully adjusted, bringing each half down in succession, so that they will touch the race of the lay without pressing on it with an equal tension on each. By this we do not mean that both halves of the shed will bear an equal tension, but that each shed as it is formed will bear an equal tension to the one preceding it. This can be more particularly observed and adjusted after the loom has been set agoing. By placing the hand on the yarn beam, you will feel if both sheds affect it to the same degree; if not, then readjust the cordings of the camb until they are both brought equal. This is what is called "levelling" the cloth. When wrought with a tight and loose tread, the cloth presents a corded appearance that no amount of finishing can fully remedy. After all has been got right, a few shots should be thrown with the hand to make sure that it is so, then put on the loom.

The position of the lease rods.—The position of the lease rods is a matter of importance, as their position in the yarn—that is, their distance back from the camb—affects both the strength of the yarn and the quality of the cloth very materially. When they are too far apart from the camb, the yarn is liable to get chafed; and when too near, a much greater strain is thrown on it, consequently some medium position must be found for them. This will be found, in most instances, to be

* See Take-up Motion.

nearly as far behind the camb as the fell of the cloth is in front of it. With soft yarn, it makes a clearer shed to bring them closer to the camb. To make this clearly understood, we would refer again to fig. 1, where we explained that, when the warp threads require to be spread, the upper half of the shed was loose. Now, when the lease rods are near to the camb, the space is lessened on which the difference of tension on the two halves can be made; and as they are brought closer to the back of the camb, so will the tension of the two halves of the shed be equalized. This shows us at the same time how it affects the quality of the cloth where the warp threads require to be spread. We have already explained that to spread the warp threads the two halves of the shed must be held at unequal tension; and as we have seen that by bringing the lease rods near to the camb we prevent this, consequently the cloth wrought with them in that position will be "reed-marked." When this is understood, it will be quite an easy matter to find their proper place; their position can be changed, and the effect noted both on the yarn and the cloth.

The reactionary nature of the loom.—When the loom has been fairly set in motion, we may leave it in charge of the weaver, whose duty is merely to change the shuttles and repair broken yarn; but, owing to the reactionary nature of the machine, it frequently gets out of order and knocks off, or, as it is said in Scotland, "chaps off." It is sometimes a little puzzling to discover the cause of this, and always a difficult matter to describe it. The most that we can do is to lay down some broad general principles that may be of use in that particular branch of the trade.

The causes of "chapping off."—The causes that result in the loom "chapping off" may be classed under three heads—First, the power may be insufficient to throw the shuttle across the loom in time to raise the protector before it strikes the buffer; second, some obstruction may intervene to retard the protector's action, or to obstruct the progress of the shuttle across the loom; third, something may be wrong with the knock off movement itself, causing a stoppage of the loom, otherwise all right. It is evident that, if a sufficient force be applied to the shuttle, it will reach the opposite box all right, if it meet with no obstruction by the way; and with the protector in good working order, little cause will be left for the loom to "chap off." We will now go over these three distinctive features separately, and show some of the causes from which they may arise, and the symptoms (if we may so speak) that appear in the loom, by a knowledge of which we may find the proper remedy.

1*st*. *When the power is insufficient.*—This may arise from the belt getting too slack and slipping on the pulleys; or, if it be a loose and tight pulley, some derangement of the belt fork may prevent the belt from getting full on to the tight pulley. If they are friction pulleys, they may not be pressed tight enough on each other, or some oil may have got between the bearing surfaces, causing them to slip. These defects will show themselves in the loom by a slower speed than usual, or a tendency to get slower at times. In the latter case it may not be so easily noticed; but, by holding the hand on the end of the lay when the loom is in motion, you will feel when the deficiency takes place. When this occurs just at the time the pick is in action the loom will "chap off." When we make sure of this, we must examine the belt and the pulleys, to see what is actually wrong and have it put right.

2*d*. *When the power is deficient in the pick: How to find it out.*—The power may be deficient in the picking wiper by the tappet being worn, or ruts cut in the friction roller on which the tappet acts. When the point of the tappet gets into one of these ruts, it has the same effect as if it were so much shorter; or the pick may be too late, caused by something getting loose. This makes very harsh work, and causes a loss of power besides. The picker strap may also get stretched until it is too long, which will have the same effect. Supposing the pick to be properly arranged at the start of the loom, what we have pointed out is what is most likely to go wrong in the course of working. By placing the hand on the top of the upright shaft, you will feel the action of the pick, and be able to tell if the defect is there; and not only that, but, with experience, you will be able to feel from that point the action of nearly all the working parts of the loom. If it will work a few shots without "chapping off," you can detect in what part the deficiency lies, and thus be enabled to go to it at once; but this is one of the points on which we can give no particular instructions. Each must learn it for himself by personal observation and study, but is worth the attention of those engaged in that particular capacity.

3d. *The effect of the picker strap being too tight.* The causes that make the loom "chap off" when an obstruction occurs are very numerous, perhaps more so than it will be necessary for us to notice. The picking strap, when to tight, is perhaps the most deceptive of these, because, when the loom "chaps off" under these circumstances, it has all the appearance it has when the power is awanting altogether. The friction of the picker on the spindle absorbs the force communicated to it, and is not transferred to the shuttle at all; consequently the power is awanting when it comes that length, and the shuttle may not be thrown more than half-way across the loom. It appears quite natural for a beginner to imagine that the tighter he makes his straps the more power he gets; but, whenever they are tightened beyond what we have already indicated, the power is lost.

Obstructions caused by the friction of the shuttle on the shed.—An obstruction may be caused by the cordings of the camb stretching, and causing the shed to be too small, or the pick may take place too soon, and throw the shuttle into the shed before it is open to receive it. This not only retards the movement of the shuttle, but it will break the yarn as well.

Obstructions that throw the shuttle out of the loom.—The worst class of obstructions are those that throw the shuttle out of its course. That may be occasioned by the lay getting bent or twisted, or thrown off the proper bevel. If the spindle is not in line with the back box and reed, or the shuttle box too wide at the entrance, the same thing may happen. The reed should always be kept straight; a single split protruding into the course of the shuttle will throw it out of its path. Dust gathered about the box or the race of the lay, or an obstruction in the shed, caused by a broken thread, will bring about the same result. The shuttles themselves in the course of a short time get worn, as also do the swells. Both shuttles and swells should be dressed occasionally to keep them in proper working order. When the pick is too strong, or the shuttle jammed in the box, the least obstruction will throw it out, and sometimes without any obstruction at all. Under these circumstances, when the shuttle is not thrown out altogether, it goes rattling into the box, and is frequently the cause of something being broken. The shuttles themselves are broken, and very soon rendered useless.

The protector.—The loom may be in good working order, and still "chapping off" from a defect in the protector movement. Under these circumstances, when we examine the loom working, or feel its movements through the upright shaft or the lay, there is no apparent cause for the "chapping off" at all. The shuttle is going up smartly at both sides with a steady movement, and the loom stops just at a time we least expect it. This is enough in itself to raise a suspicion that the cause is in the protector, which should therefore be examined. The stoppage may be occasioned by the swells getting worn, and not lifting the protector high enough or soon enough; or the boxes may be too wide for the shuttle, which will have the same effect; or the lifters of the protector may be broken, or worn or bent—that can easily be ascertained on examination. The protectors may be worn or out of order, which would cause a smash in the warp when the shuttle is thrown in amongst it. But prevention is better than cure—these annoyances can be prevented in great measure by keeping the protectors in good repair.

TO FIND THE NUMBER OF SPLITS (DENTS) AND THE QUANTITY OF WARP AND WEFT IN A WEB.

Different scales used in different localities.—To find the number of splits, or the quantity of warp and weft yarn to make any given piece of cloth, we must have some recognized standards of measurement for the yarn and the fineness of the reed on which to base our calculations. These are somewhat different in different localities; but it will be found that the principle with which we have to deal is the same in all the varieties of scales or sorts of yarns.

The yarn measures.—The following are the commonly recognized yarn measures, that for linen alone being determined by Act of Parliament:—

COTTON AND WOOLLEN YARNS.

54 inches	=	1 thread	=	$1\frac{1}{2}$	yards.
80 threads	=	1 skein	=	120	„
7 skeins	=	1 hank	=	840	„
18 hanks	=	1 spindle	=	15,120	„

What is meant by a thread.—We may explain that, in the preceding table, as well as in all others that are to follow, the thread is the circumference of the reel on which it is reeled. 80 threads in a skein means that the reel has got 80 turns, and that these threads are tied together to distinguish them, and that so many of these hanks are tied together in turn to make the next higher count, and so on.

Explanation of the cotton table.—The fineness of cotton yarn is determined by the number of hanks in one pound avoirdupois, and spoken of as No. 18's, or No. 20's, as the case may be, meaning that 18 hanks or 20 hanks weigh one pound respectively.

Explanation of the woollen table.—Woollen yarn is sometimes reckoned in the same way as cotton yarn, only that it is one-third heavier. No. 12's in woollen yarn contains only 8 hanks, whereas in cotton it contains 12, but both are the same weight. Woollen yarn is also frequently reckoned by the number of pounds weight in the spindle, and spoken of as two pounds yarn or three pounds yarn, &c., meaning that the spindle weighs two pounds or three pounds, as the case may be.*

* See the following scales.

LINEN YARN.

90 inches	=	1 thread	=	$2\frac{1}{2}$	yards.
120 threads	=	1 lea	=	300	"
10 leas	=	1 hank	=	3,000	"
20 hanks	=	1 bundle	=	60,000	"

This standard of measurement is used for the finer sorts of linen yarn. It is reckoned by the number of leas in one pound, and spoken of as 50 lea or 30 lea, &c., implying that 50 leas weigh one pound, or 30 leas weigh one pound, and so on.

COARSE LINEN AND JUTE YARNS.

90 inches	=	1 thread	=	$2\frac{1}{2}$	yards.
120 threads	=	1 cut	=	300	"
2 cuts	=	1 heer	=	600	"
6 heers	=	1 hasp	=	3,600	"
4 hasps	=	1 spindle	=	14,400	"

It will be seen that the cut in this table measures the same length—namely, 300 yards—as the lea in the preceding table, but this yarn is reckoned by the number of pounds in the spindle, as seven pounds yarn, &c.

How jute is called linen.—Of course, jute is not linen, but it has taken the place of some sorts of linen yarns, and answers the purposes for which they were applied equally as well, and is classed among the coarser linen goods, and is spoken of as such.

The various reed scales.—The following are the three principal standards of measurements for the fineness of the reed:—There is the 37-inch standard; 37 inches is the old Scotch ell, and the reed is reckoned by the number of splits contained in it. It is reckoned by hundreds. For example, if 300 splits are contained in 37 inches, it is called a three hundred, written thus, 3^{00}; if 500, it is called a 5^{00}, and so on, for every 100 more, one set finer.

In some parts the reed is counted by porters. A porter is 20 splits, and it is reckoned by the number of porters contained in 37 inches. If twenty-five times twenty splits are in 37 inches, it is called a 25 porter reed; and if thirty times twenty, it is called a 30 porter; and for every 20 splits more, 1 porter finer.

They are reckoned in some places by the number of splits in the inch. It is obvious that this is the best plan. There is no complication whatever in finding the number of splits in any given breadth of web.

Number of threads in a split.—The fineness of the reed may not at all times determine the fineness of the cloth, as it may be wrought with either 1, 2, 3, 4, or any other number of threads in the split. But 2 threads are always reckoned for the split when not otherwise specially mentioned.

When we know the standards we have to go by, we may proceed to our calculations. We will give an example of the different calculations required in each of the four different sorts of yarn we have named, which will be sufficient to show how the whole thing is done.

The various calculations for a cotton web.—In a 10^{00} 33-inch cotton shirting, 100 yards long, with 11 shots on the glass, required the number of splits, and the quantity of warp and weft required to make it, allowing about 2 inches for shrinkage on the breadth, and 7 per cent. on the length.

To find the number of splits in any web calculated on the 37-inch scale, multiply the count of the reed by the breadth in inches, and divide by 37.

In the example we have chosen, the count of the reed is 100^{00}; and if we allow 2 inches for shrinkage, it will measure 35 inches in the reed. Then what we have to do is to multiply 1000 by 35 and divide by 37, as follows:—

```
                          1000 count of the reed.
                            35 breadth in the reed.
                          ----
                          5000
                         3000
                        ------
Scale of reed, 37) 35000 (946 splits.
                   333
                   ---
                    170
                    148
                    ---
                     220
                     222
```

To find the quantity of warp yarn that will be required to make the web, multiply the number of splits by the number of threads in each, and by the length in yards, and divide by 840, being the number of yards in a hank, and the answer will be the number of hanks required to make the web.

In this example we have seen that there are 946 splits; then if we multiply that number by 2 and 107—that is allowing 7 per cent. for shrinkage—and divide by 840, we will find the number of hanks required. Thus—

```
                              946 spits in web.
                                2 threads in split.
                             ----
                             1892 threads in web.
                              107 length of piece in yards.
                            -----
                            13244
                           18920
                          -------
Yards in hank, 840 ) 20244 ( 241 number of hanks.
                     1680
                     ----
                      3444
                      3360
                      ----
                        844
                        840
                        ---
                          4
```

To find the amount of weft required in the foregoing example multiply the number of shots on the glass by 200 (the glass used in the cotton trade is the 200th part of a yard), and by the length of the piece in yards, and by the breadth in inches. This will give the number of inches of weft thread; then divide by 36 to bring it to yards, and by 840 for hanks, as follows:—

11	shots on the glass.
200	repeats of glass in yard.
2200	shots on a yard.
107	length of piece in yards.
15400	
22000	
235400	shots on the piece.
35	breadth of piece in inches.
1177000	
706200	

Inches in a yard, 36) 8239000 (228861 yards, divided as follows:—

72
103
72
319
288
310
288
220
216
40
36
4

```
Yards in hank, 840) 228861 (272 hanks.
                    1680
                    ----
                     6086
                     5880
                     ----
                      2061
                      1680
                      ----
 Yards in skein, 120) 381 (3 skeins.
                      360
                      ---
                       21
```

The various calculations for a woollen web.—The following is an example of a piece of woollen cloth 25 inches broad in the reed, 50 yards long, with 5 shots on the glass; required the number of splits—10 to the inch —and the quantity of warp and weft.

In the present instance, to find the number of splits we have merely to multiply the number in one inch by the breadth in inches (being reckoned by the inch scale), which amounts to 250.

To find the warp proceed as in the preceding example, thus:—

```
                       250 splits in the web.
                         2 threads in the split.
                       ---
                       500 threads in the web.
                        50 length of thread in yards.
                     -----
Yards in spindle, 15120) 25000 (1 spindle.
                         15120
                         -----
   Yards in hank, 840)  9880 (11 hanks.
                        840
                        ----
                        1480
                         840
                        ----
  Yards in skein, 120)  640 (5 skeins.
                        600
                        ---
                         40
```

The amount of weft, with 5 shots on the glass, is also found by the method shown in the previous example.

```
         5 shots on the glass.
       200 repeats of glass on one yard.
      ----
      1000 shots on the yard.
        50 length of piece in yards.
     -----
     50000 shots on the piece.
        25 breadth of piece in inches.
    ------
    250000
   100000
   -------
36) 1250000 (34722 yards of weft, divided as follows:—
    108
    ---
     170
     144
     ---
      260
      252
      ---
        80
        72
        --
         80
         72
         --
          8

        15120) 34722 (2 spindles.
               30240
               -----
           840) 4482 (5 hanks.
                4200
                ----
            120) 282 (2 skeins.
                 240
                 ---
                  42
```

The various calculations for a linen web.—The next example is a 54-inch 30 porter three-leaf linen tweel, 100 yards in length, with 35 shots on the inch, allowing $4\frac{1}{2}$ per cent. for shrinkage on the breadth, and 8 per cent. on the length.*

To find the number of splits in the foregoing example add the $4\frac{1}{2}$ per cent. to the breadth, which will make it about $56\frac{1}{2}$ inches; then multiply the breadth in inches by 30 (the count of the reed), and by 20 (the number of splits in a porter), and divide by 37 (the scale of the reed), as follows:—

```
                        30  count of the reed.
                       56½  breadth of piece in inches.
                      ----
                        15
                       180
                      150
                      ----
                      1695
                        20  splits in a porter.
                     -----
Scale of reed, 37) 33900 (916 splits.
                   333
                   ---
                     60
                     37
                    ---
                    230
                    222
                    ---
                      8
```

The warp is found by the same process as the previous

---

* We may explain here that we have based our calculations on the actual number of splits in the reed, no matter how many threads they contain, as being to our mind the most reasonable method. It will at least be much easier understood by beginners than the method adopted by some of calling two threads a split, no matter how many threads may be in the split of the reed.

examples, only the standards of measurement are different. Multiply the 916 splits by 3 (there being three threads in the split), and by 108 (the length of the piece in yards, with the shrinkage added), and divide by 3000 for hanks, and the remainder, if any, by 300 for leas, thus:—

```
        916 splits in the piece.
          3 threads in a split.
       ----
       2748 threads in the piece.
        108 length of piece in yards.
      -----
      21984
     27480
    -------
3000) 296784 (98 hanks.
      27000
      -----
       26784
       24000
       -----
 300)  2784 (9 leas.
       2700
       ----
         84
```

To find the weft we have simply to multiply 35 (the number of shots on the inch) by 36 (the number of inches in a yard) to give the number of shots on one yard, and the product by 108 (the length of the piece in yards) to give the number of shots on the whole piece, and the product of this again by $56\frac{1}{2}$ (the breadth in inches) to give the number of inches of single weft thread on the whole piece; then divide by 36 to bring it to yards, and the yards by 3000 for hanks, and the remainder, if any, by 300 for leas.

```
          35  shots on the inch.
          36  inches in a yard.
         ———
         210
        105
        ————
        1260  shots on the yard.
         108  length of piece in yards.
       —————
       10080
      12600
      ——————
      136080  shots on the piece.
         56½  breadth of piece in inches.
      ——————
       68040
      816480
     680400
    ———————
36) 7688520 (213570 yards, divided as
    72                   under :—
    ——
     48
     36
     ———
     128
     108
     ———
      205
      180
      ———
       252
       252
       ———
        3000) 213570 (71 hanks.
              21000
              —————
               3570
               3000
               ————
         300) 570 (1 lea.
              300
              ———
              270 yards.
```

The various calculations for a jute web.—In a 16 porter 40-inch jute hessian, 100 yards long, with 18 shots on the inch, required the number of splits and the quantity of warp and weft, the shrinkage on the breadth being in the proportion of 2 inches in the 37, and 10 per cent. on the length.

When the shrinkage on the breadth is reckoned in this way we have merely to subtract 2 from the divisor as used in the previous example, instead of adding a percentage to the breadth of the web, when making the calculations for the number of splits.

To find the number of splits in the example under consideration multiply the count of the reed (16) by the breadth in inches (40), and by 20 (the number of splits in a porter), and divide by 35, as follows:—

```
         16
         40
        ---
        640
         20
      -----
35) 12800 (365 or 366 splits.
    105
    ---
     230
     210
     ---
      200
      175
      ---
       25
```

To find the amount of warp multiply the number of splits by 2 (the number of threads in a split), and the product by 110 (the length of the piece in yards, with the shrinkage added), and divide by 14400 for spindles, and the remainder, if any, by 600 for heers, thus :—

```
              366
                2
              ---
              732
              110
             ----
             7320
            732
            -----
14400) 80520 (5 spindles.
       72000
       -----
   600) 8520 (14 heers.
         600
        ----
        2520
        2400
        ----
         120
```

To find the amount of weft we have to multiply 18 (the number of shots on the inch) by 36 to give the number of shots on the yard, and by 110 (the length of the piece in yards) to give the number of shots on the whole piece, and by 42 (the breadth in inches, with the shrinkage added) to get the amount of weft in inches, then divide by 36 for yards, and the product by 14400 for spindles, and the remainder, if any, by 600 for heers, as follows :—

```
     18
     36
    ---
    108
    54
    ---
    648
    110
   ----
   6480
   648
  -----
  71280
     42
 ------
 142560
285120
-------
2993760
```

```
36) 2993760 (83160yards, divided as follows:—
    288
    ---
     113
     108
     ---
      57
      36
      ---
      216
      216
      ---
        0
      ===

14400) 83160 (5 spindles.
       72000
       -----
   600) 11160 (18 heers.
        600
        ---
        5160
        4800
        ----
    300) 360 (1 cut.
         300
         ---
          60
         ===
```

Rules to find the splits and warp and weft by proportion.—The foregoing rules and examples show the method of finding the number of splits and the quantity of warp and weft to make any piece of cloth of a given length and breadth; but it is not always necessary to go through the whole of these calculations to find them, because all that requires to be known concerning one fabric of cloth may frequently be gathered from another by the rule of proportion. The following are a few examples showing how this is done:—

If 33 inches of a 11^{00} reed contain 946 splits, how many splits will 39 inches contain?

```
33 : 39 : : 946
              39
          ------
            8514
           2838
        --------
   33 ) 36894 ( 1118 splits.
         33
         ---
          38
          33
          ---
           59
           33
          ----
           264
           264
          ====
```

If a 16 porter 40-inch hessian contain 366 splits, how many splits will be in a 20 porter of the same breadth? thus—

```
16 : 20 : : 366
             20
         -------
   16 ) 7320 ( 457 splits.
        64
        ----
         92
         80
        ----
         120
         112
        ----
           8
        ====
```

Suppose a 16 porter 40-inch, 100 yards long, require

$5\frac{1}{2}$ spindles of warp yarn, how much will be required to make a 20 porter of the same length and breadth?

$$
\begin{array}{r l}
16 : 20 : : 5\tfrac{1}{2} & \\
20 & \\
\hline
10 & \\
100 & \\
\hline
16\ )\ 110\ (& 6 \text{ spindles.} \\
96 & \\
\hline
14 & \\
4 & \\
\hline
56\ (& 3 \text{ hasps.} \\
48 & \\
\hline
8 & \\
6 & \\
\hline
48\ (& 3 \text{ heers.} \\
48 & \\
\hline
\end{array}
$$

If a 16 porter 40-inch hessian, 100 yards long, require $5\frac{1}{2}$ spindles of warp yarn, what warp will be required for a 16 porter 40-inch, only measuring 70 yards in length?

$$
\begin{array}{r l}
100 : 70 : : 5\tfrac{1}{2} & \\
5\tfrac{1}{2} & \\
\hline
35 & \\
350 & \\
\hline
100\ )\ 385\ (& 3 \text{ spindles.} \\
300 & \\
\hline
85 & \\
4 & \\
\hline
340\ (& 3 \text{ hasps.} \\
300 & \\
\hline
40 & \\
6 & \\
\hline
240\ (& 2 \text{ heers.} \\
200 & \\
\hline
40 & \\
\hline
\end{array}
$$

If a 16 porter 40-inch, 110 yards long, with 18 shots on the inch, require 6 spindles of weft, how much weft will be required for the same sort of web with 16 shots on the inch?

$$
\begin{array}{r l}
18 : 16 : : 6 & \\
6 & \\
\hline
18\ )\ 96 & (\ 5 \text{ spindles.} \\
90 & \\
\hline
6 & \\
4 & \\
\hline
24 & (\ 1 \text{ hasp.} \\
18 & \\
\hline
6 & \\
6 & \\
\hline
36 & (\ 2 \text{ heers.} \\
36 & \\
\hline
\end{array}
$$

THE PREPARATION OF THE YARN FOR THE LOOM.

General remarks.—The preparation of the yarn for the loom is a most important matter. It has engaged the attention of manufacturers and others capable of investigating the subject ever since the introduction of the power-loom, with a view to facilitate the process and lessen the expense attendant on dressing the yarn, in order to meet the demand for machine-made cloth. But to treat this branch of textile manufactures exhaustively would involve a treatise on the chemistry of the subject—a branch of science somewhat out of the way of the present volume—consequently we will only notice some of the more prominent features in connection with it.

How dressing or sizing is necessary.—The reason that some sort of preparation is necessary, more particularly with the finer qualities of warp yarn, before they are fit for the loom, is that the strength of the yarn when it comes from the spinner is quite unequal to the strain of weaving, and the woolly nature of the threads subjects them to a greater friction in weaving than they are capable of sustaining. This is occasioned by the centrifugal force of the thread, revolving on its axis in the spinning frame, throwing off the ends of the fibres of which it is composed, and weakening it in a corresponding degree. It will be evident that, if woven in this condition, the yarn would have a greater tendency to get chafed, and become still further weakened by the friction it sustains in the process of fabrication.

The effect of dressing on the thread.—The design of dressing and sizing the warp yarn is simply to lay the ends of the fibres thus thrown off in the process of spinning in a line with the threads, and in some measure combine them, thus adding to their strength, and at the same time rendering the surface of the threads smoother, and by this means diminishing their friction on each other and on the reed during the process of weaving.

How the flour starch is made and used.—The material of which the dressing or paste is made should be that which would give the greatest tenacity and pliability to the thread and be as far as possible colourless. It is commonly made of the best American flour. It is mixed in the proportion of two pounds of flour to one gallon of water, and is allowed to steep for a few days, and then boiled until it reaches a proper consistency, and allowed to stand till it sours before using it. By allowing it to stand for some time after it is made, it gets more tenacious and glue-like, and gives greater strength to the yarn than if used immediately after it cools down.

Farina as dressing.—There is a preparation very extensively used for dressing yarn, termed farina; it is the starch taken from potatoes. It has some advantages over flour—it is cheaper, is quite transparent and colourless, and is not seen on the yarn; but, on the other hand, its strength is much less, consequently it is not adapted for yarns that depend on the paste for any considerable addition to their tenacity. This dressing may be made as follows:—Have a barrel to hold about 244 gallons of water, which in point of economy may be got from condensed steam of dressing machines or condense water from engine. Put 220 gallons into this barrel, and with perforated steam-pipe into and around the bottom bring it to the boil, which will be known by the noise of the condensing steam ceasing. Then put in 2 lbs. of tallow and 1 lb of alum. Have ready in a smaller barrel, about 3 feet × 24 inches, 14 gallons of cold water, into which put 1 cwt. of farina, and stir until any lumps have disappeared. Let this barrel empty itself by a 1-inch hole into the larger barrel, stirring the latter briskly with the steam on until it again shows signs of boiling up, when the steam should be shut off. The dressing is now ready for use, and can be kept for ten days or more quite fresh if covered to keep out the air and prevent evaporation from drying the surface and forming a thick skin, which would have to be thrown away. If it has to be made every second or third day, the old material would require to be stirred about when the new is added, in order to prevent lumps, as it will settle into a jelly, and is not so workable for pumps; but if conjealed lumps are of no consequence, it is not necessary to keep the new entirely separate from the old. The tallow prevents the starch from getting too hard and breaking on the thread, while the alum retains the weight given in the process of starching.

Dressing for woollen yarns.—There are various preparations used for wool yarn, but the most common is glue. The fibres of wool, being hard and ill to lay, require something stronger than common paste.

How the dressing is put on.—The dressing is put on cotton and linen yarns with a revolving brush; but this method is not suitable either for woollen or jute yarns, although the former are sometimes dressed in this way. The filaments of these two yarns are much harder than the former; and, instead of laying them, the brush has a tendency to tear them up. They are run between two rollers, covered with plaiding or other soft substance to take in the dressing and allow the thread to sink in it, so that it will receive a coating all round.

Drying the yarn.—The drying apparatus of the dressing machine should be very carefully attended to, because when the yarn is allowed to run on the beam in a damp state it comes off in a worse condition than if it had not been dressed at all.

Sizing.—The preceding remarks apply to dressing, that well-known process by which all the strength and smoothness that can be imparted to the yarn is given; but in stronger yarn, where this is not so much required, a less expensive process is adopted, called sizing. The yarn is merely dipped in the paste while in the hank or the "chain." When in the chain it is drawn through a box filled with paste—perhaps several times—until it has been brought to a satisfactory condition. But the dressing is frequently put on in a very irregular manner by this process, which neither gives the strength nor smoothness obtained with the dressing machine.

The preparation yarn requires previous to being dressed.—Most yarns require some preparation previous to dressing, as they will not take on the paste so well if there is any oily substance in or about them. In cotton there is an essential oil in the plant that perhaps facilitates the spinning to some degree, but which must be taken out by boiling before it is prepared for the loom. Jute is of a dry, hard nature of itself, and requires to be oiled to fit it for being made into yarn. Woollen yarns require their oily substances and other impurities expunged from them by a process of scouring.

Weft that requires to be dressed.—There are a few cases in which the weft requires some sort of starching. In ordinary circumstances this would be against the appearance of the cloth. The weft is made with rather less twist on it than the warp, to give a filled-up appearance to the cloth; but there is a very inferior quality used for some purposes that requires to be starched to hold it together. It is certainly not worth much; but, seeing there is a market for it, the demand will be supplied.

DRAUGHTS AND TREADING.

How the patterns are made.—It is by the order and succession in which the warp threads are raised and depressed, to be interwoven with the weft, that the different patterns of cloth are produced. In these about to be considered, where the threads are raised and depressed by leaves of heddles, the patterns that can be produced are of necessity limited to a certain class; but the greatest variety of pattern of that particular class can be made by the order in which the threads are drawn through the heddles, and the order in which the treading is performed, the variety being only limited by the imagination and skill of the operator. To the consideration of this we will now direct our attention; and in doing so our object is not to give designs for new patterns, but simply to explain the principles by which they are produced.

Setting the heddles.—The following is the method of "setting" the heddles. The camb is reckoned in the same way as the reed, by the number of heddles or porters contained in 37 inches. The reed is fitted to the fabric of cloth to be woven, but it is not necessary that the camb should be so. Any fabric of a less count than the camb can be wrought in it by leaving out (at regular intervals) the extra heddles. For example, a 30 porter web can be wrought in a 36 porter camb by leaving the extra 6 porter of heddles empty, dividing them in such a way that they will not interfere with the threads.

Rules for finding the heddles to be set.—Subtract the number of the reed from the number of the camb, and the difference will be the number of heddles to be set; and by dividing the number of the reed by it, the quotient will be the number of heddles to be filled before setting; or by dividing the number of the heddles by the same divisor, we get the heddle that is to be set, as in the following example.

Examples when the number will divide without a remainder.—Suppose a 12^{00} camb to be set to a 10^{00} reed.

1200 heddles.
1000 reed.

Difference, 200) 1000 (5 draughts to be filled and 1 set.
1000

Or 200) 1200 (6, every sixth heddle to be set.
1200

For another example, suppose a 36 porter camb is to be set to a 30 porter reed.

36 porter camb.
30 porter reed.

Difference, 6) 30 (5 draughts to be filled and 1 set.
30

Or 6) 36 (6, every sixth heddle to be set.
36

When there is an odd half hundred, either in the camb or reed, the whole must be reduced to half hundreds. Suppose a 1200 camb to be set to a 1050 reed.

24 half hundreds in the camb.
21 half hundreds in the reed.

Difference, 3) 21 (7 draughts to be filled and 1 set.
21

When the number to be set will not measure exactly either the camb or the reed.—It sometimes occurs that the number of heddles to be set will not measure exactly either the count of the camb or the reed, but leaves a remainder. The following example will explain the mode of procedure in these circumstances. Suppose a 40 porter camb to be set to a 31 porter reed.

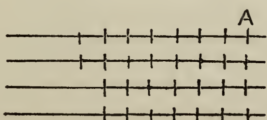
40 porter camb.
31 porter reed.

Difference, 9) 31 (3 draughts to be filled and 1 set three
27 times in succession, and 4 draughts
4 to be filled and 1 set four times in
succession, and repeat.

In the preceding example, we have 9 in 31 three times and 4 of a remainder. We fill three draughts and set one three times in succession, and then add one of the remainder to it, which makes four; we then fill four draughts and set as many times in succession as the remainder indicates in the example under consideration. The remainder is four, consequently it will be four times.

An easy method.—There is quite a simple method of finding the heddles to be set that requires no arithmetic whatever. It is as follows :—Find the difference between the count of the camb and the reed in hundreds, half hundreds, or porters, as we have done in the preceding examples, then for every hundred, half-hundred, or porter of difference, draw a line and mark off on these lines a point for every hundred, half-hundred, or porter in the

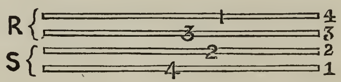
Fig. 17.



reed, beginning at the right hand and counting down, which will show the number of draughts to be filled before setting. Suppose, for an example, a 34 porter camb to be set to a 30 porter reed: draw four lines as shown in fig. 17, because the difference between the count of the reed and camb is four porter. Then begin at A and count down the lines until 30 points are made (30 being the count of the reed), which will show that eight draughts are to be filled and one set twice in succession, and seven draughts filled and one set twice in succession, and repeat.

Draughts and treading of a plain web.—Four leaves of heddles are generally employed in plain weaving, to prevent overcrowding of the heddles on the shafts, but two are fixed together, and raised and sunk as one. Fig. 18

FIG. 18.

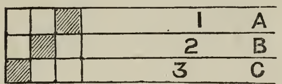


explains the draughts and treading of a plain web; the lines marked 1, 2, 3, 4, on the right hand, represent the leaves of heddles, 1 being the leaf next to the lay. The order of the draughts is indicated by the figures on the lines,—the fourth leaf is drawn first, the second is second, the third is third, and the first fourth. R and S indicate the leaves that rise and sink together.

The distinction between plain and tweeled cloth.—Tweeling differs from plain weaving in this, that in plain work the warp and weft threads are interlaced with each other every shot; but in what may be called regular tweeling, they are only interwoven with each other at intervals according to the number of leaves employed. In a three-leaf tweel the warp is interwoven with the weft every third shot, in a four-leaf every fourth, and so on.

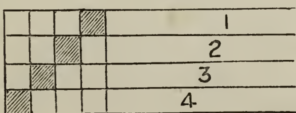
Draughts and treading of a three-leaf tweel.—Fig. 19 shows the draughts and treading of a three-leaf tweel. The letters A, B, C, between the lines, represent the leaves of heddles. C is the front leaf, or the one next to the lay. The figures 1, 2, 3, are the order of the draught; the first thread is drawn through a heddle on the back leaf, the second on the mid leaf, and the third on the front leaf. The squares on the left represent the warp and weft threads as they are interwoven with each other. If we suppose the weft to be black and the warp white—the

FIG. 19.



first thread being drawn on the leaf A, and it being the first to be sunk, the black weft is shown over it, then the other two in succession. This shows that the treading is performed in the same order that the web is drawn in the camb: all regular tweels are the same. If these remarks are properly considered the principles of regular tweeling will be easily enough understood; no matter what number of leaves are employed, the principle is the same.

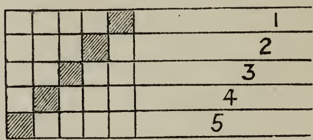
FIG. 20.



Draughts and treading of four and five leaf tweels.—Fig. 20 is the draughts and treading of a four-leaf, and fig. 21 is that of a five-leaf tweel, the draughts and treading of both beginning on the back leaf, then each succeeding one in regular rotation until they have all been gone over.

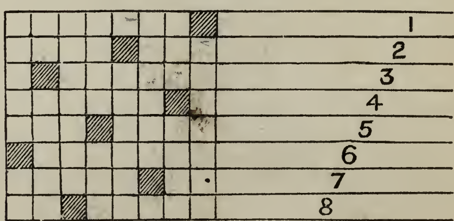
The broken tweel.—In large tweels the draughts and treading seldom follow each other in the same order. It gives to the cloth rather a flimsy-like appearance, the threads being so much and so regularly flushed. This is remedied by altering either the order of the draughts or

FIG. 21.



the treading, and producing what is called a broken tweel. Fig. 22 is an eight-leaf broken tweel; the draught is straight across the leaves, as shown in the figure. The squares on the left show the order of treading. A tweel should not be broken unless the number of the leaves will admit of its being broken at regular intervals. It will be

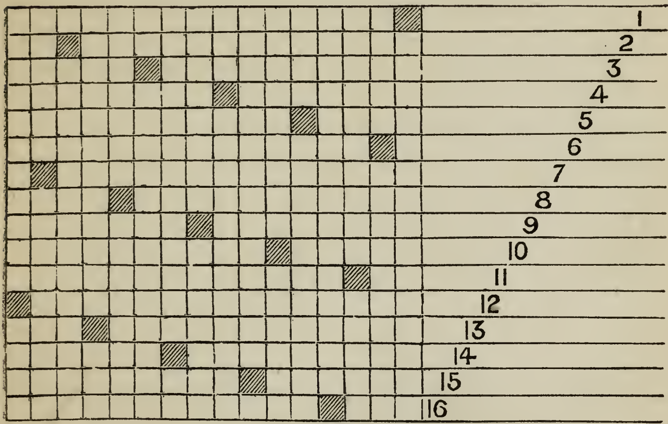
FIG. 22.



noticed in fig. 22 that between every tread two leaves are passed over.

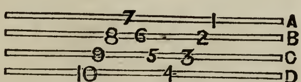
The full satin tweel.—Fig. 23 is a sixteen-leaf tweel—the draughts and treading are shown. This is what is called a full satin tweel. It will be seen that four leaves are passed over between each tread.

FIG. 23.



The herring-bone tweel.—There is a kind of ornamental tweel produced by reversing the draughts, which is ealled the herring-bone tweel, on account of its resemblance in the cloth to the back bone of that native of the deep. The tweel runs first in one direction and then in the opposite direction. Fig. 24 shows this draught in a four-leaf tweel—the tread-

FIG. 24.

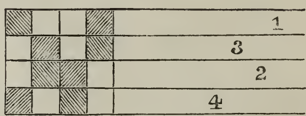


ing is performed in the same way as shown in fig. 20. It will be noticed that there is only one thread drawn on A and D leaves for two on the others. This is the best way of turning the draught, and makes the neatest pattern.

The method of working the leaves that is easiest for the yarn.—In the preceding examples we have assumed that one leaf is sunk and all the others up when the shot is put in. We have explained, under the head Shedding, how this is a better method of weaving tweels than the reverse, with one up and all the others down. The warp is flushed on the one side and the weft on the other, and you can make the tweel to run in any direction by the order either of your draughts or treading.

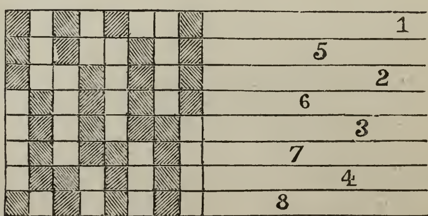
The serge tweel.—We now come to a sort of ornamental tweel where the warp and weft are equally flushed on both sides of the cloth. It is commonly called serge, and can only be wrought with the leaves of an even number, such as 4, 6, 8, &c. Fig. 25 shows the

FIG. 25.



draughts and treading of a four-leaf of this sort, commonly known as the blanket tweel, and fig. 26 is the draughts and treading of an eight-leaf of the same description of

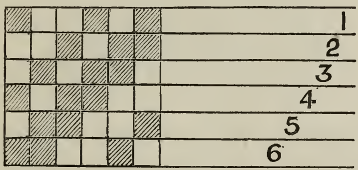
FIG. 26.



tweel. It will be seen that the draught begins on the back leaf, and is continued on every alternate one until half the number has been gone over, then returning to the second back one, and proceeding on every alternate leaf until a thread has been drawn on each. The treading is performed in the same order, the leaves remaining down during half the number of treads and up during the same time, one moving down and another up every tread.

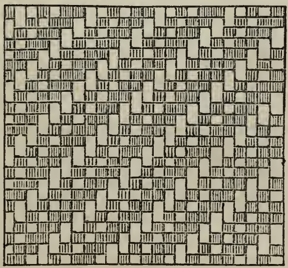
Ornamental tweels.—There is another description of fancy twill somewhat analogous to the preceding one, but differing in this, that the threads are not always equally flushed on both sides of the cloth. Fig. 27 is the

FIG. 27.



draughts and treading of a six-leaf tweel of this description. There is absolutely no limit to the number of patterns that can be produced in this way, simply by altering the order of the draughts or treading, or both.

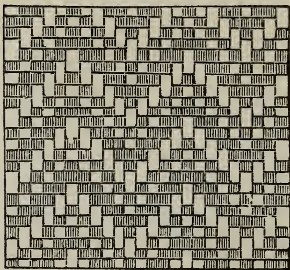
FIG. 28.



The greater the number of leaves, the greater is the scope for the imagination of the operator.

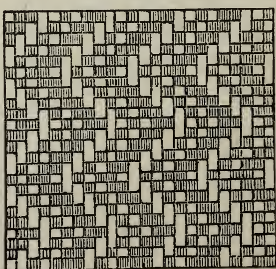
Diaper.—The diaper is produced simply by reversing the draughts and treading. This can best be explained by figures. Let us suppose we have a piece of cloth wrought with the same draughts and treading we have given

FIG. 29.



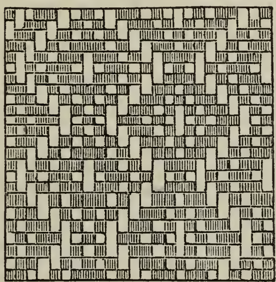
at fig. 27; supposing the warp to be white and the weft black, it would have the appearance shown at fig. 28. Now, if we reverse the draught in the manner we have described in a previous example, the pattern is altered to

FIG. 30.



that shown at fig. 29. Then, if we reverse the treading (that is, go over all the leaves in the order we have arranged, no matter what that order may be, then go over them again, but in exactly the opposite way), and do not reverse the draught, we have the pattern shown at fig. 30. By reversing both the draught and treading they combine and form a diamond, as shown at fig. 31. This is what is called diaper. This is a six-leaf, and it will be observed that it takes ten treads to complete the pattern, beginning, say, at one, and going straight over them till we come to six, then beginning at five and going back to two—this will make ten treads in all. As the

Fig. 31.

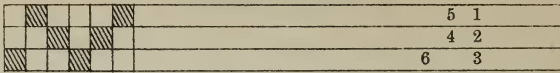


pattern is turned on the first and sixth tread, they can only be counted once in one repeat of the pattern. These patterns can be increased or diminished almost to any size by increasing or diminishing the number of treads and reversing the draughts at a point to suit them, always allowing that it can be counted an equal number of times across the web, that the edges of the cloth may join without spoiling the pattern.

Diamond patterns.—The following are outlines of diamond patterns from a three-leaf to an eight-leaf diamond, showing the draughts and treading. They can be woven with either a barrel or a dobbie machine.

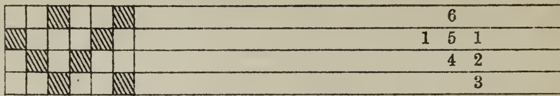
3-Leaf Diaper.

Fig. 32.



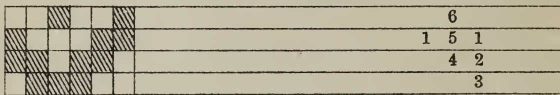
4-Leaf Diaper.

Fig. 33.



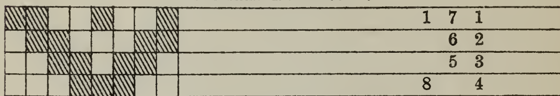
4-Leaf Diamond.

Fig. 34.



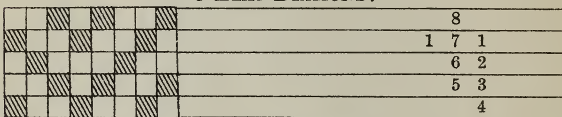
4-Leaf Diamond.

Fig. 35.



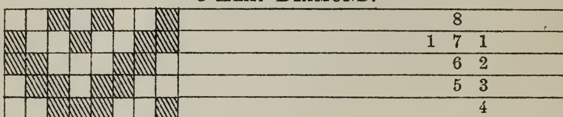
5-Leaf Diamond.

Fig. 36.



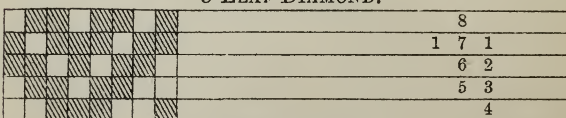
5-Leaf Diamond.

Fig. 37.



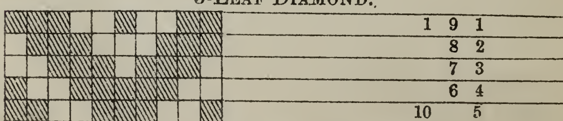
5-Leaf Diamond.

Fig. 38.



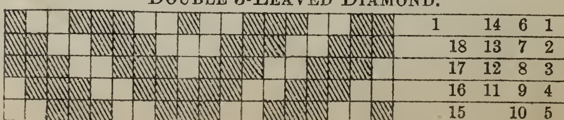
5-Leaf Diamond.

Fig. 39.



Double 5-Leaved Diamond.

Fig. 40.



6-Leaf Diamond.

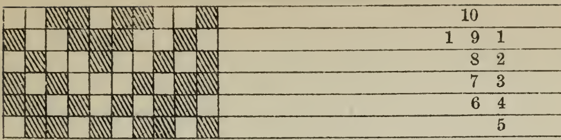


Fig. 41.

6 Leaf Diamond.

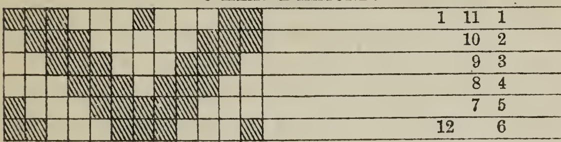


Fig. 42.

7-Leaf Diamond.

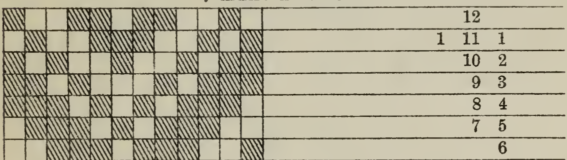


Fig. 43.

7-Leaf Diamond.

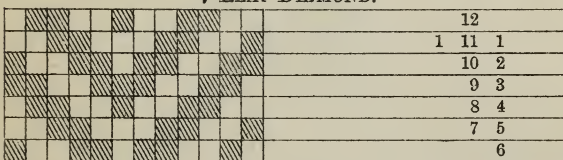


Fig. 44.

8-Leaf Diamond.

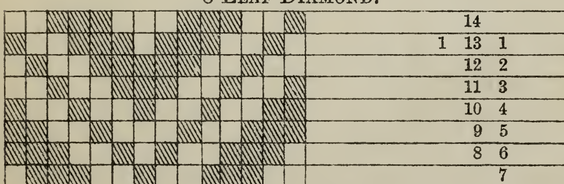


Fig. 45.

8-Leaf Diamond.

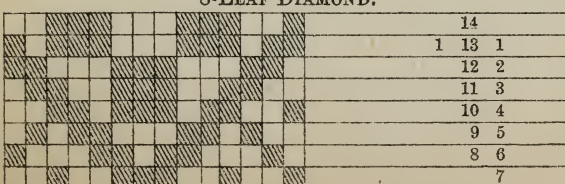
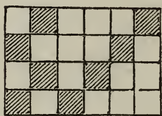


Fig. 46.

The junction of plain and tweeled cloth.—We will now consider those patterns that are produced by two or more sets of leaves of heddles. The junction of plain and tweeled cloth is effected by two sets of leaves. This description of texture is frequently made striped, the body of the cloth plain, and the stripes tweeled, that the colours may show better. The plain parts are in one set and the tweeled parts in another, each of them being spaced to allow the threads of the other to pass. The one set of leaves is mounted to work a tweel, quite independently of the other that is mounted for plain work, but their action is simultaneous, and they are drawn through the same reed, and thus their junction is complete. Fig. 47 shows

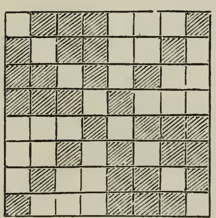
Fig. 47.



the treading of a plain web with stripes of a four-leaf tweel. The draughts are the same as in ordinary plain or tweeled fabrics.

Diced work.—Diced work is the most complicated of all the patterns produced by leaves of heddles; two, and sometimes three, sets of leaves are employed. They are not wrought with tappets, however, the same as diaper and other patterns are wrought. Various machines have been introduced for working the heddles, which it is not our present purpose to describe. It will suffice that we show the principle on which the various dice patterns are produced. We have already shown that, to produce a diamond pattern, we have but to reverse the draught and treading; but in the case before us, where the pattern forms a square—square with the edge of the cloth—it is brought out by reversing the tweel,—that is, the warp is flushed in one square, and the weft in the next. The simplest of these is what is called the draught-board pattern. Fig. 48 is a sketch of it on the smallest scale that can be produced by a four-leaf regular tweel—that is, one draught over the leaves and one tread over the leaves; but it can be extended to any size by which the breadth of the web can be equally divided, up to half the breadth of the web. Each set of leaves is spaced to the size of the pattern; and when the one set is flushing the

FIG. 48.



warp on the one side, the other is flushing the weft. This is continued until the pattern is wrought square, then their action is reversed. The set that was throwing up the warp now throws up the weft, and the one that was throwing up the weft now throws up the warp. Fig. 48 fully explains this. When the warp and weft are of different colours, the squares stand out in bold relief. These squares can be broken up in a great variety of ways, or surrounded by other smaller ones or stripes, by a slight variation in the draughts, or treading, or the addition of another set of leaves.

Two and three-ply cloth and two and three-fold cloth and tubular cloth wrought on the same principle.—There are yet other three sorts of weaving to describe, which will be easier explained and better understood if we consider them as but three grades of the same style of weaving, which in reality they are. We mean two and three-ply cloth, the principle on which two and three-ply carpets are woven (but we may mention here that but very simple patterns can be produced by leaves of heddles alone); and two and three-fold weaving (that is, the principle on which, say, cloth four or six yards wide can be wrought in a two-yard-wide loom); and tubular weaving. These three sorts of cloth are widely different, although they can all be produced in the same sets of leaves, with the draughts and treading slightly altered. They may either be wrought plain or tweeled. Although the leaves are spoken of as in sets, they are not spaced in any way as the dice or the plain and tweeled cloth; but the yarn is drawn in the heddles as one web, all the yarn being on one beam, and in every way treated as a single piece of cloth. It is the draughts and treading alone that make the difference. The heddle leaves are commonly wrought with the double barrel from the side of the loom. with levers attached to raise and depress the leaves. But we believe most of them could be much easier wrought with the ordinary tappets or wipers and the spring-top mounting. Plain cloth can at least be wrought with little trouble in this way.

Tubular weaving.—We will now consider the draughts and treading of a plain tube for bagging. Fig. 49 represents the four leaves. Suppose A and B to work the under half of the tube, and C D the upper half. The shuttle passing from one side of the loom puts a shot into the under half, and when passing from the opposite side a shot is put into the upper half, and repeat. To accomplish this, we may sink A, and raise B, C, D, for the first shot; and sink A, B, C, and raise D, for the second;

then sink B, and raise A, C, D, for the third; and sink A, B, D, and raise C, for the fourth, and repeat. It will be seen that there are three leaves up and one down, and three down and one up, alternately. This is obvious from the fact that when a shot is being put into the under half of the tube, one of the leaves of it and both the leaves of the upper half must be up; and while a shot is being put into the upper half, one of the leaves of it and both leaves of the lower half must be down. With this treading, and the draughts as shown by the figures at fig. 49, we

FIG. 49.

produce double cloth joined at the selvages. That the treading of this may be clearly understood, we append the following table:—

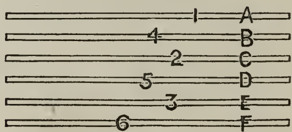
		Sunk.	Raised.
First shot,	-	A.	B, C, D.
Second shot,	-	A, B, C.	D.
Third shot,	-	B.	A, C, D.
Fourth shot,	-	A, B, D.	C.

Two-fold weaving.—Two-fold cloth is the same as tubular, only joined at one selvage. All that is necessary to produce this is but a slight alteration in the treading. In tubular cloth the shuttle passes through the under and the upper half alternately, but in this two shots are put into each in succession. Thus, if we wish to join the cloth at the left-hand side of the loom, we may throw the first shot from the right in the under fold, and the second from the left in the upper fold; and then reverse the next two, throwing the third shot from the right in the upper fold, and the fourth from the left in the under fold, and repeat. It will be seen that four treads complete this pattern. The following table shows the order of the treading, with reference again to fig. 49. The draught is the same as that for the tube :—

		Sunk.	Raised.
First shot,	-	A.	B, C, D.
Second shot,	-	A, B, C.	D.
Third shot,	-	A, B, D.	C.
Fourth shot,	-	B.	A, C, D.

Three-fold weaving.—For three-fold cloth we require three sets of leaves. Fig. 50 represents them, and the figures indicate the order of the draught. Then suppose

FIG. 50.



we join the under to the centre fold at the left hand, and the centre to the upper fold at the right, the first pick will go into the under fold from the right, and the second into the centre fold from the left, and the third into the upper fold from the right, and reverse the order of the next three, thus making six treads in the pattern. The following table will show the order of treading more clearly, A B representing the under, C D the centre, and E F the upper folds :—

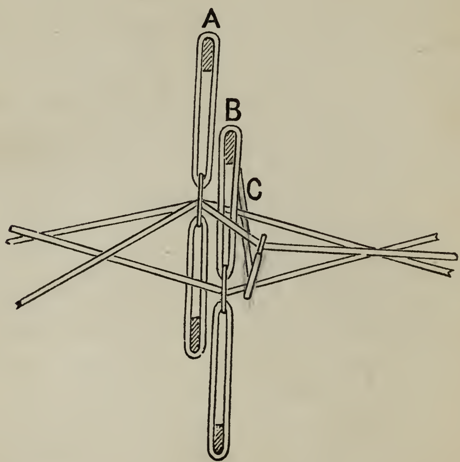
		Sunk.	Raised.
First shot,	-	A.	B, C, D, E, F.
Second shot,	-	A, B, C.	D, E, F.
Third shot,	-	A, B, C, D, E.	F.
Fourth shot,	-	A, B, C, D, F.	E.
Fifth shot,	-	A, B, D.	C, E, F.
Sixth shot,	-	B.	A, C, D, E, F.

Two and three-fold and tubular tweels.—These examples we have given are for plain cloth; but they can be wrought in any sort of tweel, simply by substituting sets of tweel leaves for that of the plain, and putting a shot into each fold in the same order we have observed with the plain fabrics.

Two and three-ply cloth.—The difference between the two and three-fold and tubular weaving we have just been describing, and two and three-ply cloth, is, that the latter two are always joined at both selvages, and the plys interwoven with each other at intervals, or change places with each other. When each is of a different colour, they can be displayed in succession on both sides of the cloth. This style of weaving is most commonly employed for throwing up flowers of a quite distinct colour from the ground of the cloth; but the harness is required for that. It is only in extremely simple patterns that leaves of heddles alone are or can be employed. The method of doing so may easily be gathered from what has been stated concerning the two and three-fold weaving.

To construct and arrange the wipers or tappets when the treading is known.—After what has already been said in another chapter on shedding, and in this on draughts and treading, little more is required to enable any one with a little experience to construct and put up the camb mounting for any pattern of cloth that can be wrought with leaves of heddles. To find the number, shape, and arrangement of the wipers, or tappets, we must first know the pattern of cloth to be made, and make a drawing of it in some such way as is shown in the preceding figures. To do this we must be able to design the pattern for ourselves, or "read" the pattern that may be given us; but we may remark that it requires experience to be able to do either. After the figure showing the treading has been got, the length of the pause of the wipers, or tappets, will be found from the number of black squares in succession, counting from top to bottom; as in fig. 19, for example, there is only one, consequently the pause will require to be for one pick. In fig. 25 there are two dark squares in succession, requiring the leaf to be kept down during two picks; and in fig. 26 the

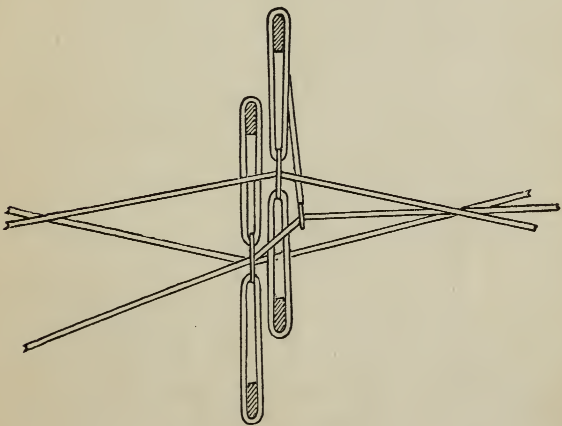
Fig. 51.



pause will require to be made for four. How this is done is explained with reference to fig. 4. Then, as to their arrangement—they follow each other in the order also indicated in the figure. Take fig. 22, for example, where two leaves are passed over between each tread, we have 1, 4, 7, 2, 5, 8, 3, 6, as the order of the treading. The arrangement of the wipers will also show what sort of top mounting will be required.

The centre selvage explained.—By the method of centre selvaging, two or three breadths of narrow cloth can be wrought in a broad loom. This selvage is much inferior to the ordinary one made by the turning of the weft thread; but where great strength is not required it makes a very good substitute. It is formed by a very simple process, illustrated by figs. 51 and 52. They show the shed formed by the leaves of heddles A and B and the looping heddle C. One thread is drawn on the back leaf and another on the front leaf; the looping thread that binds them together with the weft threads is drawn through a heddle on the back leaf, and also through the

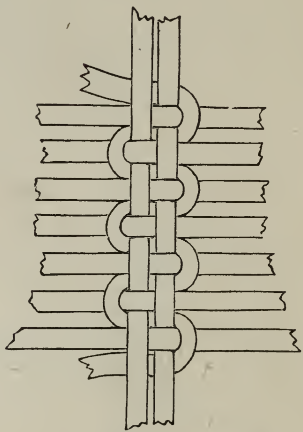
FIG. 52.



flying heddle which is attached to the front leaf. Fig. 51 shows the position of these threads when the front leaf is sunk, and fig. 52 when the back leaf is sunk. Fig. 53 is an enlarged view of the selvage itself, showing how the threads are bound together. By a careful examination of how the threads pass each other, and the heddle leaves in these figures, the whole process will be easily understood.

It will be noticed that the looping thread just rises to about the middle of the shed. The reason of this will be quite evident on examining its position in the two figures; it is always above the weft threads, and under the other two selvage threads, as shown at fig. 53. The length of

Fig. 53.



the flying heddle must be adjusted to make the most of both sheds. This is the only difficulty connected with it, and real difficulty it is with beginners. When this heddle is not of the proper length, an unequal tension is thrown on the thread, and the selvage spoiled, or the thread or heddle itself broken. Of course a little experience will put this all right. The mail or ring through which the thread passes on the fly heddle should be as small as can be wrought with, at the same time large enough to prevent its being entangled in the splits of the reed. It will also be seen from the figures that the looping thread does not pass over the lease rods, but comes directly to the heddles from the bobbin on which it is wound, and which is paced by weights to keep the thread at the required tension. The tighter the thread is, the stronger will be the selvage.

Various machines have been brought into use for this purpose which make very good work, the threads being interwoven in the same way. But when it can be easily enough done without them, their expense may be saved.

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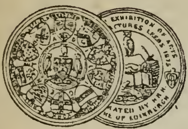

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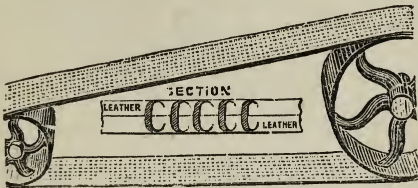

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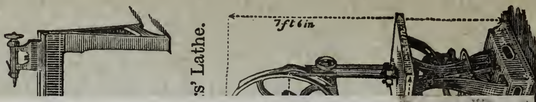

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