where there are boxes at both sides of the loom, or for "pick and pick" looms, it is quite useless, as there might be weft at both sides of the loom at the same time. For a long time there was a difficulty in dealing with looms with boxes at each side until the centre weft fork was introduced. The centre weft fork consists of two essential parts, one attached to the shuttle race, whose chief function is to feel for the weft, and the other attached to the inside of the breast beam, and which will be acted upon by the feeler in the case of the weft being absent, and bring the loom to a stand by acting upon the belt fork.

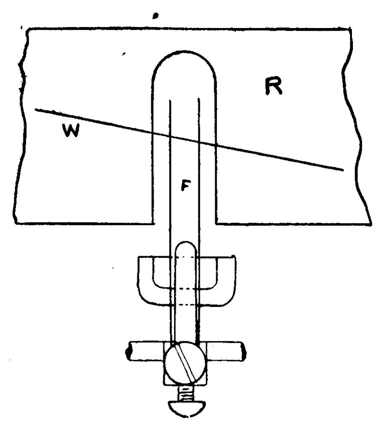


Fig. 266.

In the shuttle race R of the going part (Fig. 266, which shews a plan of that part attached to the going part) a groove is cut, and the fork F having two or more prongs is made to rise and fall, being hinged to a vibrating pin the prongs of this fork are made to feel for the weft. A front elevation of the whole apparatus is shewn at Fig. 267.

The fork F is hinged upon a pin as shewn at the extreme front of the drawing Fig. 266, and carried in brackets on the front of the sley board, or under the shuttle race, and marked B in Fig. 267. A rod T passes through in the flanges of a forked guide, which swings freely upon its holder or bracket arm H, which in turn is fixed upon the bar V which runs across the loom; immediately above the flange the rod T is provided with

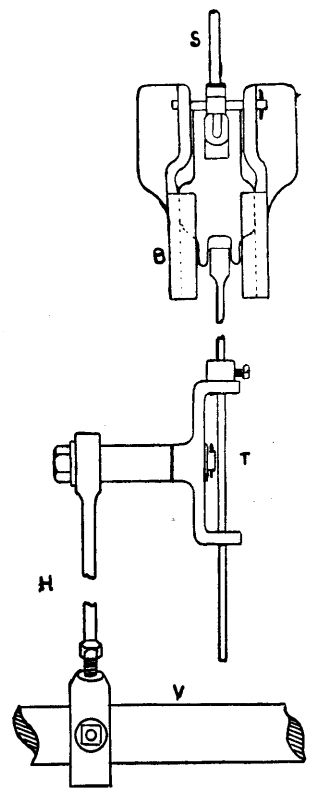


Fig. 267.

an adjustable collar and set screw, which practically rests upon the flange, and so adjusted that when the going part is thrown back the fork F is raised. From the position of the guide below the Fork F and its shifter, which is carried upon the rod T, the fork is acted upon as the sley moves forward in such a manner that the space between the top flange, through which T passes, and the fork F is increased, therefore all these parts, upon, or connected with the spindle T will fall by gravitation. The fork comes in contact with the weft W lying across the groove in the shuttle race and arrests the downward progress, and the fork is held in position until the movement of the going part has carried it forward until

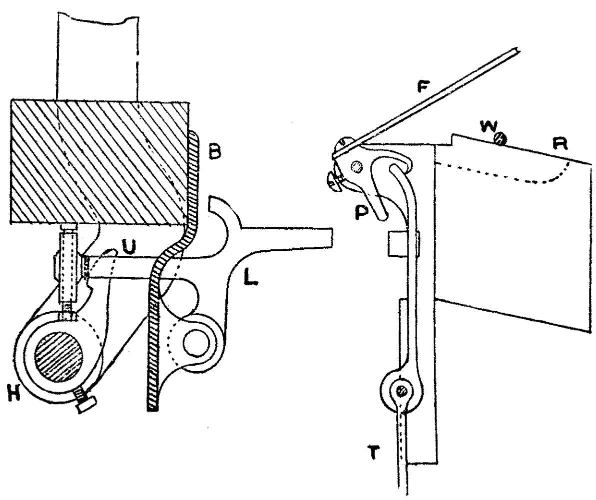


Fig. 268.

the prongs are clear of the weft, when it drops into the bottom of the groove. In the meantime that part hinged to the upper end of the rod T, with its slot, has dropped too low for the peculiarly shaped hook, seen at the lower end of the fork F in Fig. 268, to take hold of it. Should, however, the weft be absent, this hinged arm on T would be caught in the hook, and the downward progress would be at once arrested; then the projection on the front of this hinged arm would be held opposite the lever L under the inside of the breast beam. This lever or finger turns upon a centre placed below as shewn in Fig. 268, and held in position by a bracket attached to the breast beam. Another lever U is attached to a rod under the breast beam at H, and to which is also an arm pressed against by the opposite arm of the lever L, so that should the projection in front of the upper part of T strike the lever P the lever arm U would be pressed back and striking the belt fork handle would throw the belt from the fast to the loose pulley and stop the loom.

Careful adjustment and balancing of parts are absolutely necessary for the successful working of this, as well as the ordinary weft work.

THE BRAKE.

An important adjunct to the stop motions and one which, in fast running looms, is an absolute necessity is the brake, this is illustrated in Fig. 247, page 431. The actual brake itself is simply a piece of iron, shaped so as to embrace a considerable portion of the circumference of the brake wheel, the wheel being placed upon the driving shaft of the loom; from the brake a connecting rod is carried to an L lever; the opposite end of this lever is connected by a second rod to the lever already spoken of in connection with the weft fork resting upon the breast beam of the loom; a weight is placed between the hinge of this lever and the end nearest the belt fork handle. In box looms where there is no stop rod the brake is actuated only by the weft fork and the moment that comes into operation, or when the belt is thrown off by the weaver in the usual course, the brake lever is dropped and assists in bringing the loom to a stop; but where the weft fork is used a pin projecting from the frog, as already described, has practically the same effect. The mechanism of this contrivance is simplicity itself and requires little explanation.

It is only necessary to say that it should be kept always in good working order as it may often save trouble which arises from the loom overrunning when the weft breaks, which as already explained, may cause irregularity in the fabric.

SELVEDGE MOTIONS.

The term selvedge motion may have two distinct meanings, first, where a special arrangement of apparatus is employed for weaving a selvedge of a totally different pattern from the body of the cloth, and second, where it is used for making what is termed centre selvedge, *i.e.*, for binding the sets of threads firmly together at the middle of a wide fabric, so as to permit the fabric being cut at the centre and making two pieces without any risk of the selvedge fraying. In the first category will come such cases as weaving a satin or twill fabric and it is required to have a plain selvedge, or it may be any other pattern. When worked from a dobby or jacquard this is easily accomplished and special selvedge healds or harness cords will be employed, and actuated by their own hooks will permit of any pattern being made at will. In many cases of twilled fabrics a plain, or approximately plain, cloth may be formed on the selvedge by a mere drafting, or arrangement of the threads through the healds, but such a thing could only occur when the number of picks in the ground pattern should be an even one, and the order of succession in raising and depressing the healds such that, by a selection of threads, could be made to alternate with each other. Sometimes one extra heald is introduced, and some of the threads drawn over the tops of some of the mails and threaded through others may serve the purpose, but all these devices are dependent upon the ingenuity of the overlooker or designer. The one thing to avoid is the use of extra tappets for actuating the selvedge motions, and if possible to avoid the use of any special appliances.

To name the different devices that may be resorted to, such as suspending the selvedge healds from two different jack rods, or other devices of that kind would not only be tedious, but it would be impossible to give illustrations which would meet every case. On the other hand to describe all the various apparatus which have been employed from time to time would be equally tedious, one example must suffice for the purpose. This consists of placing upon the lower shaft of the loom a scroll tappet, or cam, as shewn in the illustration Fig. 269. This tappet acts upon one

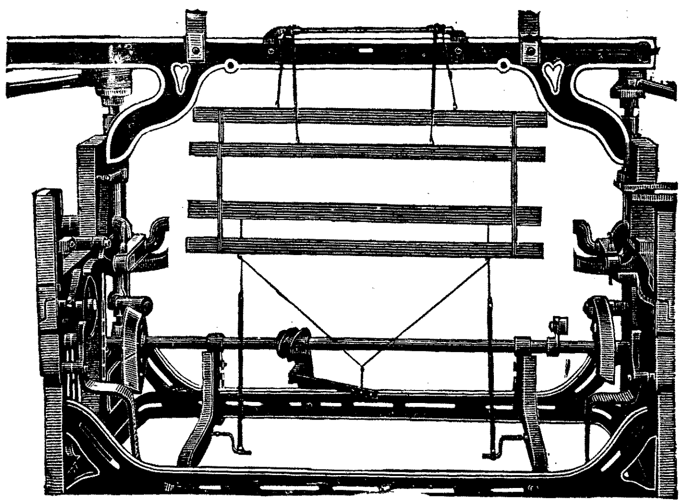


Fig. 269.

arm of the lever which is connected at the opposite extremity to the bottom of the heald; two healds are employed for the selvedge only and are connected by cords passed over a roller, or pulley, in precisely the same manner as described in the plain loom with the under shedding tappets, so that as one is pulled down the other is raised, and so going on alternately; as a consequence with this simple contrivance, which can be applied to any loom at a very trifling cost, a plain selvedge may be woven, no matter what the pattern of the ground. The simplicity and effectiveness of the apparatus is so obvious that it would be idle to waste time in describing it. This is the invention of Messrs. Bracewell Bros., of Shipley.

CENTRE SELVEDGE MOTIONS.

Of all selvedge motions the one which attracts most attention generally is that which is commonly spoken of as the centre selvedge. This is simply an arrangement which is used when two fabrics are woven side by side and cut up so as to form separate pieces. In the ordinary course there would be, on the cut up side, what is termed a raw edge, and one which would be very liable to fray, and the object is to prevent not only the fraying but to make the edge as firm as possible, and present all the appearance of a proper selvedge; strength, neatness, and firmness being important factors. From time to time methods have been resorted to, varying from the commonest attempt at gauze weaving to a system whereby the weft threads were cut immediately they were beaten up, and the next insertion doubled them up and inserted them into the selvedge, so as to give all the appearance of a perfect selvedge. Between the two extremes however, there must be some medium which is not only sufficiently useful but also sufficiently simple for all practical purposes. To again revert to the two extremes let it first be imagined that two pieces be woven side by side and then split up the centre, and have the two inside selvedges woven as firmly as possible; no matter how firm the texture of the selvedge is, a small fringe of weft must be left after cutting, and in all probability some tendency for the warp threads to fray out will exist.

A difficulty in weaving will naturally accompany the extreme firmness of the centre selvedge and also a tendency to curl or cockle. Then to take the opposite extreme, the one just suggested, and which has recently been the subject of a patent, of doubling the cut thread into the centre selvedge, must, although producing an apparently perfect selvedge, have exactly the same effect, in consequence of the crowded condition of the weft threads. After all, in spite of the enormous number of devices that have been attempted from time to time, the best remedies, or the best methods of making a firm centre selvedge is dependent upon one of two means, either the working of a small number of threads at the extreme edge up to the cutting, in gauze fashion, or causing them to twist round each other after the manner of a lock-stitch sewing machine. For the first of these any weaver having sufficiently wide aquaintance with practical weaving will find numerous devices which will answer his purposes. He may rig up an ordinary doup and actuate it either direct from his tappets or treadles, or by means of what may be termed jury jacks; or he may resort to the use of a common bead through which a couple of loose heald threads are passed and attached to ordinary heald shafts of the loom; the warp threads also being passed through the eye of the bead, and as the heald shafts are raised and depressed alternately the bead will cause the thread to cross from side to side of two or more of the selvedge threads, and so bind them so firmly into the fabric that fraying cannot possibly occur; it is then only necessary that the crossing threads should be drawn from a bobbin so as to give the requisite length, for crossing and wrapping round the others. Sometimes the same thing is accomplished by using an apparatus consisting of a fixed needle placed above and pointing down between the warp threads, and a movable needle pointing upwards and passing this one, either by means of a small cam on the lower shaft of the loom, or any other arrangement which will cause it to rise and fall for alternate picks, and at each upward movement pass first on one side and then on the other of the fixed upper needle, so causing a crossing which is identical with that of common gauze. It would be no exaggeration to say that there are scores of devices of this kind in use varying simply in the details of their mechanism, but all having precisely the same movement imparted and producing the same common gauze. Then there are numbers of others also which partake of what has been described as the lock-stitch sewing machine, these also are so nearly akin to each other that I shall only attempt to describe one which is illustrated in Fig. 270, and is the production of Messrs. Boyd, of Glasgow. In this a thread A is caused to be continually wrapped or twisted round another thread B in the course of the weaving. The thread A is wound on a bobbin contained in a shuttle, and which is held loosely, sewing machine fashion, in one of the spaces of the casing C, by a slightly raised rim or socket on the centre sliding piece F. The tension of the thread A is regulated by a small spring and holder on the friction plate of each shuttle, the thread B is wound on a bobbin E and drawn, as represented, round the back of the warp beam and over the slab stop, or back rail, and through one of the eyes in the metal strap D, and through one of the shuttle spaces of the casing. Then along with its respective shuttle thread A it is taken between the healds, and through a space in the reed, at a point where the selvedge is required to be formed. In the working of the mechanism the sliding piece F in the back strap D is made to reciprocate in concert with the healds F, sliding in the casing C, so as to cause the threads A and B to be alternately brought to the top and bottom by means of the two parts D and F, which are connected above and below respectively by the straps passed round two small pulleys, and worked from beneath by a cam, lever and spring, as seen in the illustration. Then as the thread

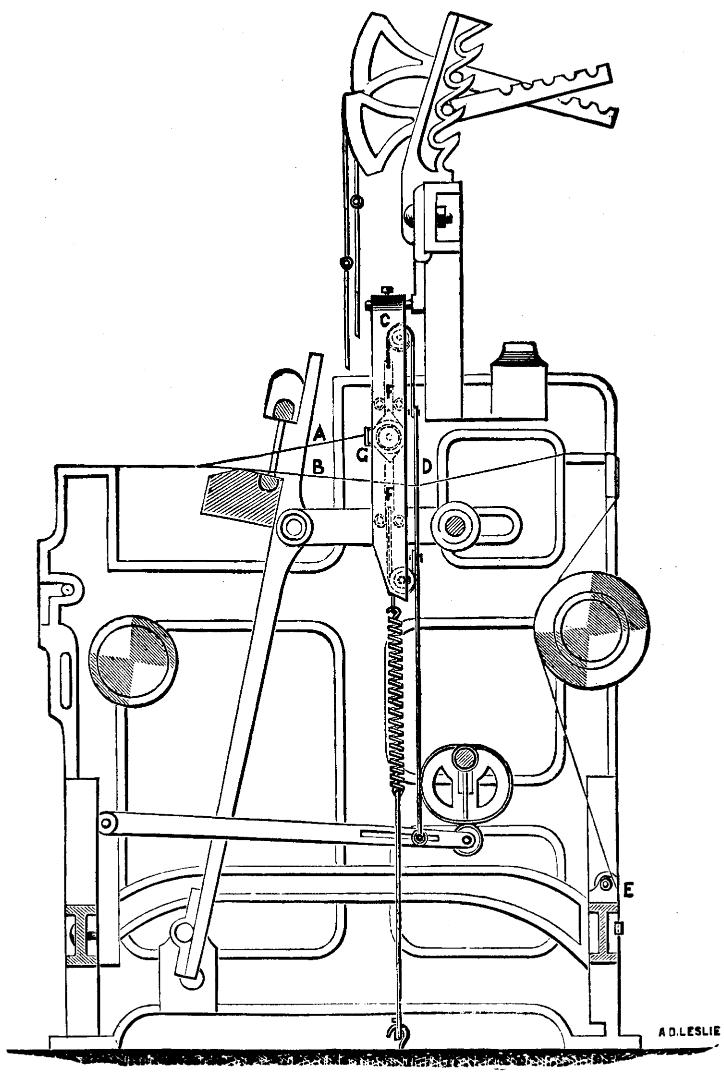


Fig. 270.

B is drawn through the casing in travelling from top to bottom of the shed it passes down one side and returns up the other side of the shuttle G, thus causing the twisting continuously round A, as already described, and binding the threads firmly together and preventing any possibility of fraying, the firmness being dependent upon the amount of tension put upon the two crossing threads. Each selvedge motion has a right and left shuttle answering to the two selvedges to be formed, and, of course, it is necessary [to have them in their proper places, the rule

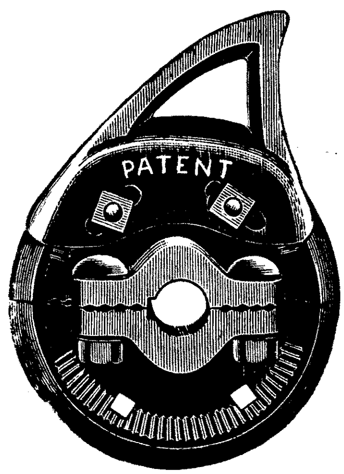


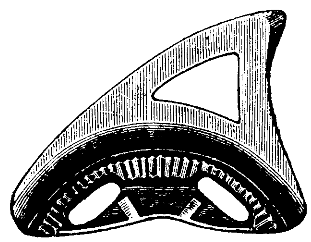
Fig. 271.

being to place the shuttles so that the tension springs are turned outwards and upwards as represented in the illustration.

PICKING MOTIONS.

I must now give a few supplementary details in reference to picking motions. Strictly speaking these should have been included in Lecture 4, but have been overlooked. It will be remembered that in that lecture some attention was given to the arrangement and form of picking tappet for what is known as the cone picking motion. A recent improvement in this connection is illustrated at Figs. 271 and 272. This consists in a form of disc and tappet nose which are readily adjustable, and are said to meet all the requirements of the ordinary picking tappet. The tappet in its complete state is shewn at Fig. 271, and consists of the disc and two parts, bolted together upon the shaft after the manner of a clamp; the tappet nose is bolted to it in somewhat similar manner to the

Fig. 273.



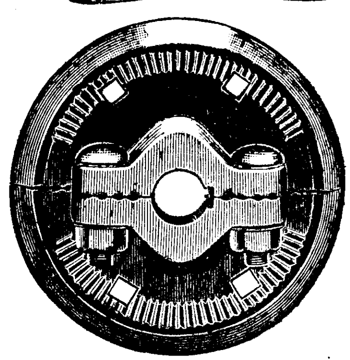


Fig. 272.

ordinary tappet nose, but presenting this difference; a series of teeth are formed in the rim of the disc as shewn in Fig. 272, and a corresponding set inside the rim of the nose at Fig. 273; the tappet nose has two slots corresponding to the bolt holes in the discs, so that it can be adjusted to any position; and it differs also from the ordinary tappet, inasmuch as the disc remains a perfectly true circle, and the whole of the rise for picking purposes is contained within the tappet nose; and it is also contrived so that it is interchangeable and may be placed upon either one side or the other of the disc. It need hardly be said that the shell, or boss, or disc instead of having the bevel formed as suggested in Lecture 4 for tappet drawing is a more rounded surface than a truly bevelled one, and consequently evades, at least in some measure, the principles there laid down. Whether this evasion and the form of the adjustable tappet nose is really advantageous, there are several advantages at least claimed, the one being the readily adjustable character of the tappet nose, the other the fact that the noses are interchangeable, and finally their ready adjustment and easy application either by skilled or unskilled workmen. So far as the advantages of being able to change without having to remove the driving wheels, which always involves the risk of breakage, and the ready facility for adjustment, there can be no doubt, but as to the true form of tappet only the question of application in practice can determine whether the advantages are all that are claimed for it.

Another form of picking arrangement which should have been dealt with in Lecture 4 is dealt with in Fig. 274, and which refers to the Knowles' loom, which has been so often referred to. It will be remembered that something was said as to the use of sliding tappets for what are known as pick and pick looms; this is one of the contrivances based upon the use of the vibrator lever and revolving discs so fully described, both in reference to the box motion and the shedding motion of the Knowles' loom; the vibrator lever V is acted upon in precisely the same manner as the vibrator in the box arrangement, the rod R communicating motion to the lever L, which in turn causes the picking arm P to slide upon the picking shaft and come in contact with a short lever arm which acts upon the picking stick in precisely the same manner as the under pick motions described in Lecture 4. The connecting rod C connects the two tappets so that as

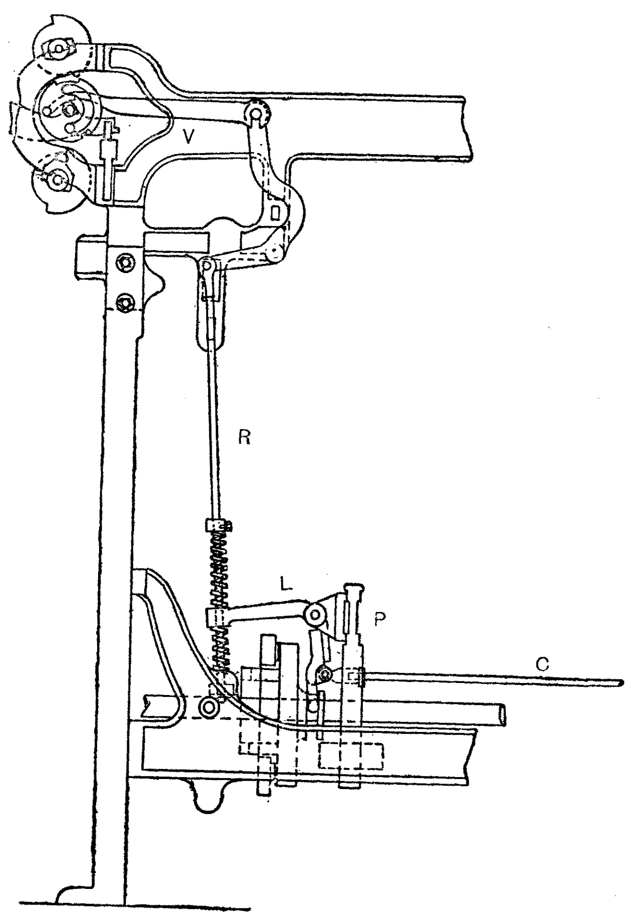


Fig. 274.

one is engaged with the picking lever the other is disengaged, and consequently there can be no liability to mishap by both being brought into action at the same time. To ensure sufficient ease and elasticity of movement the lever L is placed between two springs upon the rod R, each held in position by collars and set screws so that there is sufficient room to give way and prevent any harshness or liability to mishap.

MEASURING MOTIONS ON LOOMS.

I must make some passing allusion to a contrivance which, although not usually necessary may be for some special reasons desirable, that is, the measuring of fabrics as they are being woven. I need not attempt to define all the conditions under which this may become either necessary or desirable, nor shall I attempt to describe all the methods which have been resorted to for attaining the object. One is shewn at Fig. 275, as made by Messrs. Ward Bros., of Blackburn. The apparatus is simple and needs only very brief description; a chain wheel K is mounted upon the taking up beam L, and by means of a chain M motion is communicated to the chain wheel K^1, and on this is mounted a change wheel which gears into another change wheel mounted on the disc N. On this disc are moveable pins N^1 which in rotating come in contact with the upper extremity of the catch J, a slight movement of which will depress the end of the lever L, to which it is attached, sufficiently to lift the catch of the dobby by means of the connecting chain G, and make a change in the lattice barrel of the dobby machine. This, it will be understood, in weaving towels or dhooties, or any bordered article, is of considerable importance as ensuring the exact length of fabric being woven, and in fact takes the place of the border dobby as already described. By means of the chain I which is connected with the swing lever of the dobby the catch J is released from the pin N^1 immediately the change in the lattice barrel has taken place, and is thus brought into position for being operated upon by the next pin; so that the operation goes on continuously, weaving borders and middles alternately, and ensuring accuracy of measuring.

BELT FASTENINGS.

Amongst the trifles which go to make up the sum of the troubles of the power loom overlooker, the methods

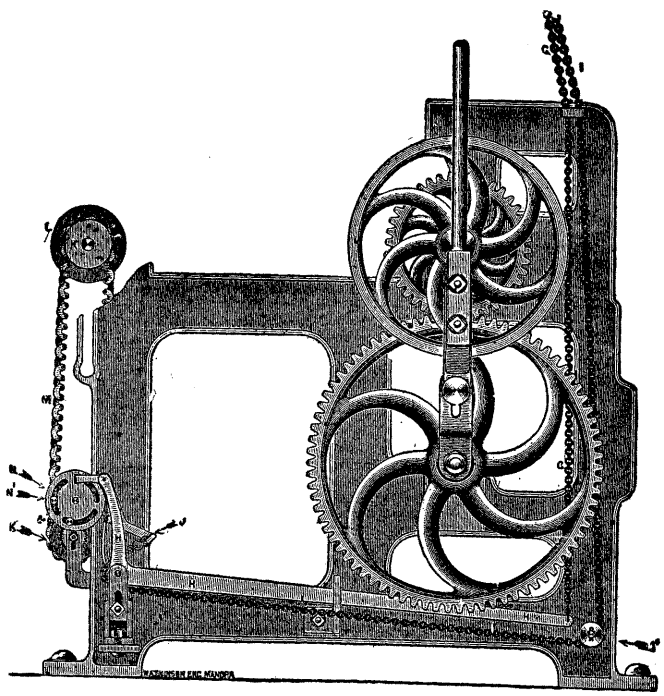


Fig. 275.

of "sewing" or fastening the ends of belts are not to be overlooked or too lightly treated. In heavy looms "sewing" with a proper "lace" was at one time the regular practice; in light looms "sewing" with a bit of wire was considered good enough, and is still practised; but belt fasteners of one kind or another have of late become more general, both on account of the facility with which the ends of the belts could be joined together and the increased security obtained. To enumerate all the various systems would be too much of a task, but one may be referred to. This consists of a species of staple

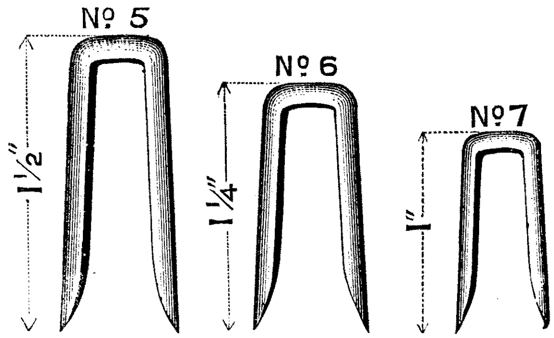


Fig. 276.

having the points slightly diverging and tapered on the inside, as shewn in the illustration Fig. 276, and made, as shewn, in different lengths to suit the thickness of the belt. For the purpose of "sewing" the staple is placed in a holder, as shewn at Fig. 277, and driven by a hammer through the belt, whilst the latter is resting

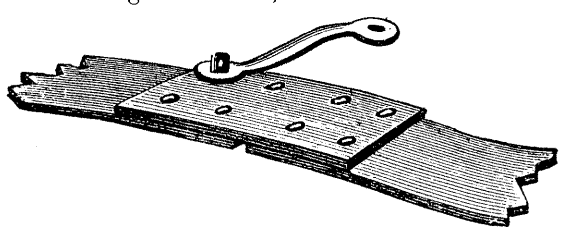


Fig. 277.

on a smooth surface, the result is that as the points of the staple emerge from the leather and come in contact with the metal they immediately begin to turn outwards and upwards and clinch themselves in the leather, as shewn at Fig. 278, thus making a most secure joint. Whenever it is necessary to extract the fasteners for the purpose of shortening the belt, or any other reason, a ready means is provided in the "extractor" hook shewn at Fig. 279. The whole contrivance is the production of Messrs. Davidson and Co.. of Belfast.

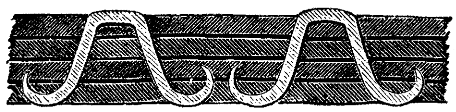


Fig. 278.

REED AND HEALD MAKING.

I shall now refer, but briefly, to machines which scarcely come within the province of a lecture on weaving and yet have a direct connection with the subject. That is the manufacture of reeds and healds. It is a far cry from the time when reeds, as their name implies, were

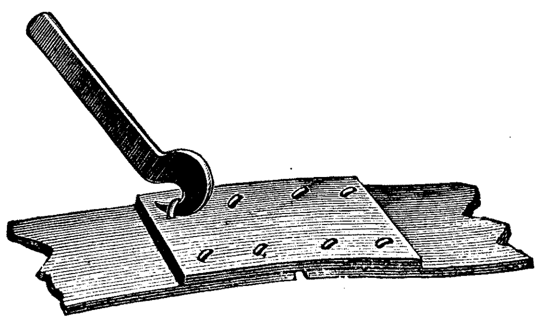


Fig. 279.

made from the split reeds or canes, and placed by the fingers between the ribs which held them together, to the time of fine iron or steel wire placed in position in the ribs by machinery at perfectly even distances apart, and to any degree of fineness. In one sense reeds may be said to be woven. The ribs are placed in holders upon the bed of the machine, as shewn at Fig. 280, and which bears some resemblance in appearance to the mechanic's lathe, and passed through what might be termed the head-stock; the wire, which has already been rolled, flattened and polished, is fed from a reel and inserted between the ribs by a species of automatic pliers in front of the head-stock, and instantly cut off to the proper length. At the same moment a pair of fine steel beaters, which fulfil the same functions as the reed itself does in weaving, press the wire into its position, and simultaneously a bobbin placed upon a species of face plate is made to revolve round each rib and coil a thread round to hold the wire in position. The number of wires inserted per

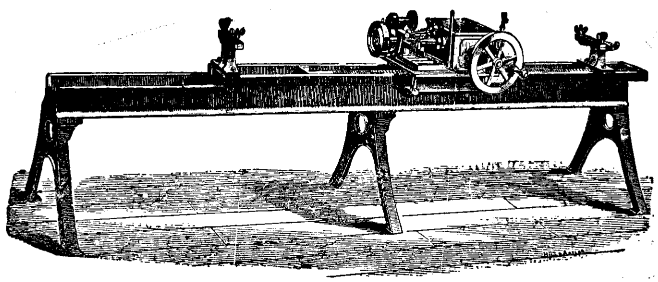


Fig. 280.

inch is determined by a train of wheels, one of which is changeable, somewhat after the style of the taking-up motion of the loom. To ensure the wires being held in position by the cord which is wrapped round the rib the cord is saturated with pitch as it is wound upon the bobbin, and is kept soft during the working by a small gas stove placed immediately under the bobbins as they revolve. Altogether the machine is most ingenious in construction. It must not be supposed, however, that the reed is absolutely perfect when it comes from the machine, some of the wires may not have been inserted quite straight, or may have partly turned; then the work of the "setter" comes in with a pair of fine pliers, every wire which is out of place must be put perfectly straight before the pitch upon the rib has had time to set, otherwise faults would occur in the cloth from the irregularities.

In reed making, just as in cloth making, strict attention must be paid to the size of the wire, and the thickness of the cord wrapped round the ribs, otherwise the wires would be held too rigidly or too loosely, and all good weavers know the value of a proper degree of flexibility in the reed.

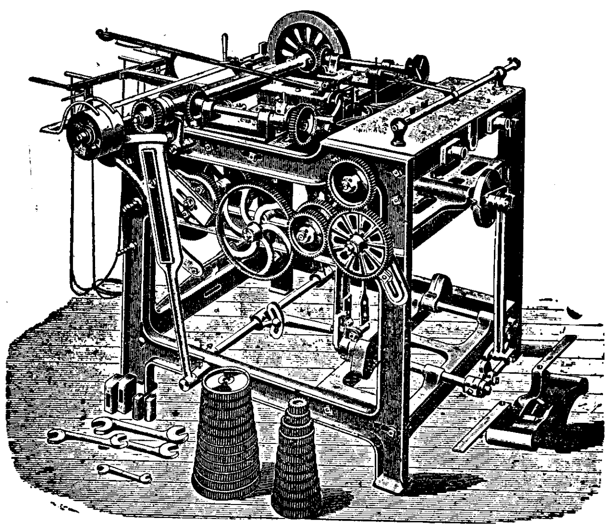


Fig. 281.

HEALD KNITTING.

The term heald knitting is a survival of the days when they were all made by hand, and when the knot fastening the heald thread to the "rig band" was made by the thread itself. In machine-made healds this is different. True in one form of heald, where the eye for the warp thread to pass through is formed by a loop knotted on the heald thread, a species of knitting is resorted to for fastening to the rig band, and the manner in which this is performed by the machine is both ingenious and interesting. A general view of the machine is given at Fig. 281, and without attempting to describe all the working parts it must suffice to say that the knots for the loop or eye are formed by the bobbins being carried round upon a species of spindles and face plates, which with the assistance of sundry hooks in throwing the loops over, perform the work in a most astonishingly short time.

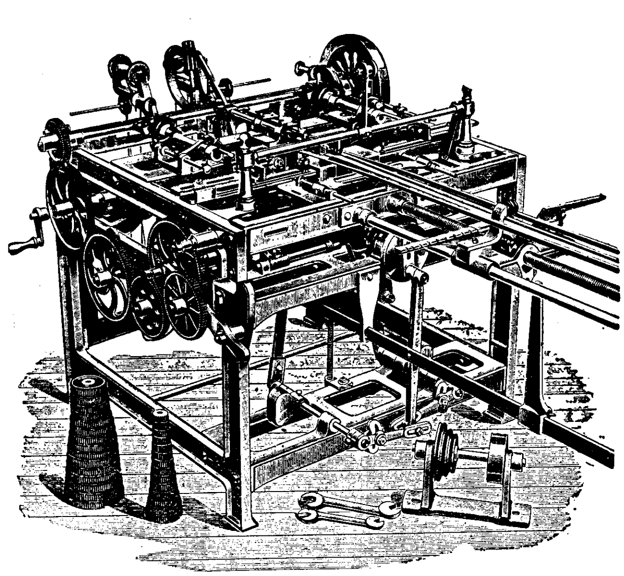


Fig. 282.

Another machine is shewn at Fig. 282, for making healds with mails or metal eyes. In this case the heald yarn is threaded through a large quantity of mails and passed forward to the machine. A species of feeler passes the mails forward one at a time, whilst the thread is at the same moment brought up to the rig bands, the moment this is done a bobbin carrying a fine strong thread revolving upon a face plate through which the rig band is passed coils its thread several times round and thus secures the heald thread; this is repeated continuously.

Again as in the loom, each machine is provided with a train of wheels which determine the fineness of the healds. These machines are made by Messrs J. Kitson & Sons, Bradford.

A few words might be said here which might well have been said in a previous lecture, as to the proper depth of healds for different classes of work. It is matter of common knowledge to weavers that if the healds are too "shallow" it is very difficult to weave some classes of goods, and that it is therefore better to err on the side of having the healds a little too deep—if such a term may be used. The deeper the heald, and, naturally the more elastic it is, and the reverse; and we know that elasticity in the healds will prevent friction on the warp threads, therefore let all the elasticity possible be obtained. I do not mean to suggest that it should be carried to an exaggerated or ridiculous length, but that any tendency to error should be on the safe side. True, the cost of the healds will be greater, but probably it will be more economical in the end.

LECTURE 12.

LOOMS FOR SPECIAL PURPOSES.

In speaking of looms for special purposes, the first difficulty which arises is the selection of those worthy of a description without creating unnecessary repetitions; we may say, for instance, that a loom must be built for any special purpose from the finest silk fabric through the whole range of cotton, woollen, linen or worsted down to that required for weaving the heaviest cocoa fibre matting; but although looms may be built specially for all fabrics within that wide range it need not necessarily follow that any special or new principle of construction will be involved; it might resolve itself simply into a question of weight or power to produce light or heavy fabrics, and consequently what has been said in a general way of loom construction might be equally applicable to any or the whole of the series. It will be necessary then in this lecture to confine attention to looms constructed for the production of special fabrics and pay attention to the methods of ornamenting or constructing fabrics for special purposes. Perhaps the first loom calling for attention under this heading is that generally known as the swivel loom. This loom may be built to serve two distinct purposes, the one being the production of narrow fabrics, such as ribbons or tapes, and the other the production of a figure confined within a limited space on the surface of any ordinary fabric. It will be best to begin by first dealing with ribbon or tape looms, as the principle involved there will cover the whole field of swivel work. The great object is to be able to weave upon one loom a large number of narrow fabrics, each complete in itself, each having a perfect selvedge and made as though they were made upon separate looms; or in other words, a large loom must be made to weave a number of narrow fabrics side by side. In all the looms described up to now a shuttle has been propelled from side to side, but in the swivel loom the shuttle must be driven positively; carried, not thrown across, and for weaving a large number of fabrics at once, we must have a separate shuttle for each fabric, otherwise each cannot have its own selvedges, but we should be compelled to resort to the split-up, or centre selvedge, as described in the last lecture. A general idea of the arrangement of a swivel loom may be gathered

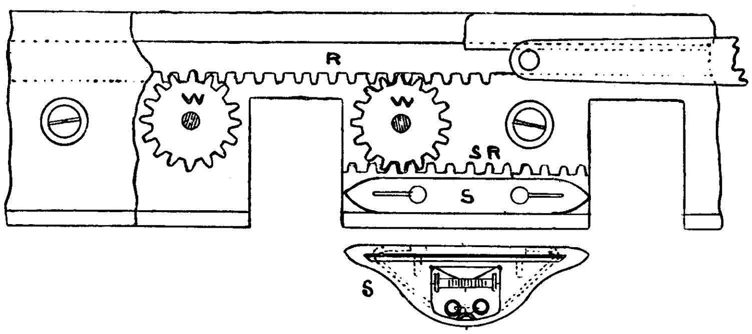


Fig. 283.

from the illustration at Fig. 283. To what is generally termed the handrail of the loom a long rack R is attached, this acts upon a toothed wheel W, which in turn operates the swivel rack SR, which carries the shuttle S. The rack R is actuated from the side of the loom either by means of a cam, or any convenient arrangement, and so carries the shuttle across the intervening space between the wheels W and W, within which the fabric must be formed. The form of the shuttle is illustrated beneath the figure, at S, which is really the plan of the shuttle itself. The yarn is wound upon a small bobbin placed within the shuttle and brought through an eye in the extreme front, and at the back of the shuttle a groove is formed to permit of its being placed in the carrier, or rack at R.

Now suppose we are weaving a large number of tapes we should have a separate shuttle for each one; then occurs the question how many could we put upon one loom, or what are the conditions which will govern the width of the tape and the size of the shuttle. A reference to Fig. 283 will readily enable us to get rid of one or two of the questions. The width of the space between the shuttles must determine the width of the fabric; but it might be said we may make those anything; so we may, within certain limits, say from one inch to four, but whatever the width of the space wherein the fabric is to be formed it must be obvious that the length of the shuttle, and the space between the fabrics, should not be less than double the width of the fabric itself. Suppose, for instance, we are weaving a tape or ribbon, one inch in width, then we should have a space between each of such ribbons of not less than two inches; the wheel W must carry the shuttle by positive motion across the space, and it must carry it forward so far that the next wheel can take hold of it, so that making a moderate allowance between one wheel and the other, from the centre of the wheel itself to the margin of the fabric cannot be less than half the width of the fabric, so that the distance from the centre of one wheel to the centre of the other must be equal to double the width, therefore the length of the shuttle and shuttle rack should correspond approximately to this. Beyond this there are practically no limitations; we may work not only with one shuttle for each fabric but with any number; the usual practice is to work with rising boxes and each having its own rack driven from one common rack behind, so that whichever shuttle is brought to the level of the fabric may be acted upon; for ease and steadiness of working there is probably no loom which works so easily and smoothly as the swivel loom. To those accustomed to ordinary looms, more especially of the fast running type, where the shuttle is thrown from side to side, as it were by a spasmodic effort, it is almost painful at first to watch the slow easy going motion of the swivel; it seems to the unaccustomed eye as though the shuttle will not get clear of the shed in time to avoid being crushed as the reed comes up to the cloth, and this feeling is intensified by the appearance of a huge projection in front of the shuttle which seems to be sweeping the very fell of the cloth as it goes across. The question may naturally be asked, why have this huge projection in front? The answer is obvious and simple. The shuttle is driven slowly and by positive action, no more drag is put upon the thread than is absolutely necessary, and the nearer the shuttle can lay the thread to the fell of the cloth the more certainly it will accomplish its work and make a perfect selvedge at each side; so that the apparent inconsistencies in this class of loom, when compared with the ordinary loom, almost explain themselves when carefully examined.

In many cases, for the purpose of economising space, what is commonly known as the circle, or as it is sometimes called, the circular, or Swiss swivel loom has been adopted. This is shewn in the illustration at Fig. 284, and really consists in placing the shuttle within a species of wheel which carries it through an arc of a circle instead of horizontally, as in the common swivel loom; thus it will be obvious from the angle formed by the shuttle at each side of the fabric, that at least one half the space is economised. And it is also claimed for it that there is a corresponding economy of power. Whatever may be the fact as to the economy of power there is no doubt the economy of space is one of the most important factors. Generally speaking, however, this class of loom is only used for weaving very narrow ribbons or tapes, such, for instance, as those ranging from ½ inch to 1 inch in width. Of course one thing must be obvious in the circle loom that it does not present the facilities for weaving with a number of colours or shuttles as in the ordinary swivel loom, the circles being attached to the handrail precludes, practically, the use of more than one colour; special contrivances may be adopted, but generally speaking, circles are worked with one colour only.

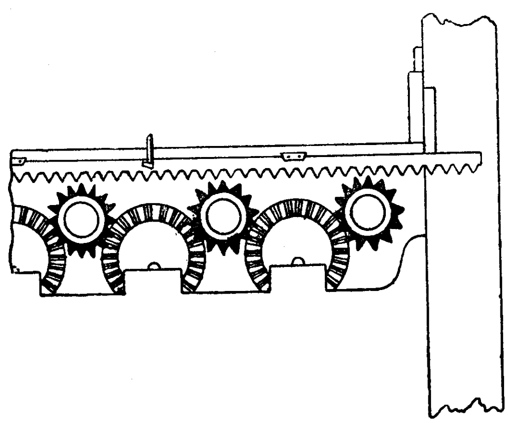


Fig. 284.

The use of the swivel loom for figuring upon solid fabric must receive some attention, and it is only necessary to consider it from two points of view, first where the swivel shuttle is made to act in introducing the extra weft or figuring material during an interval between the passages of the ordinary shuttle, and second where attempts have been made to cause the two to pass across the loom simultaneously. Whichever of the two systems may be adopted, the general arrangement of the swivel shuttle will be practically the same. In the one case a separate shed will be formed for the swivel shuttle in the same manner as the ordinary shed is formed; where the ground and the swivel shuttle are operated simultaneously, two distinct sheds must be formed, one for each. This will be better understood by a reference to a bordered dhooty loom which will have to be described presently. Apart from what has been said of the method of operating the shuttle, there is but one thing requiring special attention in the management of this class of loom, that is, the determination of the space to be occupied by the figures and the distances apart of the figures. As seen in Fig. 283, the size of the figure must be limited to the open space between the several shuttles, and the rack carrying the shuttles must remain stationary until the complete figure is formed; then as one figure is completed, another may be commenced at a different part of the fabric, and for this purpose a rack and frame, made moveable, so that the figure can be formed in any position, so long as it is confined to the amount of space allotted to it, and the distances apart represented by the length of shuttle is used for carrying the shuttle boxes. Of course it must be understood that the mechanism of the swivel apparatus must be made to work in perfect unison with the other parts of the loom and that when the swivel shuttles are being passed across, the ordinary picking gear is altogether disengaged.

LOOMS FOR BORDERED DHOOTIES.

This is a swivel loom of the most improved type, made by Messrs. Platt Bros., Limited, Oldham, of which a full view is shewn at Fig. 285. Fig. 286 shews a section of the loom with the sheds open for the passage both of the ordinary and the swivel shuttle. 1 to 6 represent the healds both for borders and ground work, 1 and 3 carry the border warp, 2 and 4 the ground warp, and 5 and 6 actuate what are termed catch threads. It will be seen that there are two sheds formed at the same time, one for the ground shuttle and one for the swivel shuttle. The ground warp threads W and X pass over the back rail F from the warp beam in the ordinary manner; the border warp threads are brought from the beam H mounted above the loom and are then passed under the rollers G and G and direct to the healds; then catch-threads Y and Z are

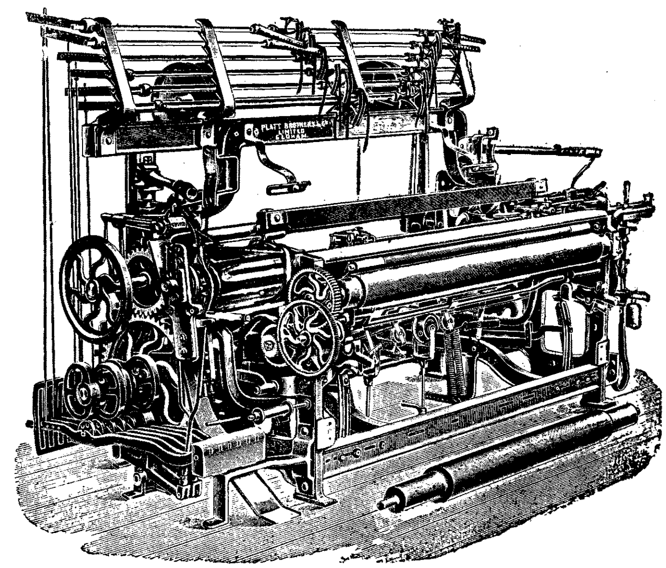


Fig 285.

carried, along with the ground warp, over the back rail F, so that it will be seen that each warp is placed exactly in the proper position for carrying on its work. The picking rods D D for actuating the border shuttles in one direction, in Fig. 287, which is an elevation of the working parts of the loom, are connected together by the rods I I entending from one picking rod operating the shuttle from one border to the next picking rod operating the shuttle for the other border. The picking rods are fulcrumed on a fixed bar or bearer J J at E^1, and one of them is provided with a leg E^2 to which is attached a strap or band K passed over the pulleys L and L^1. The other end of the strap or band is attached to the lever O which is fulcrumed to a bracket on the back rail and actuated by a picking tappet, or cam, fixed on the tappet shaft of the loom in

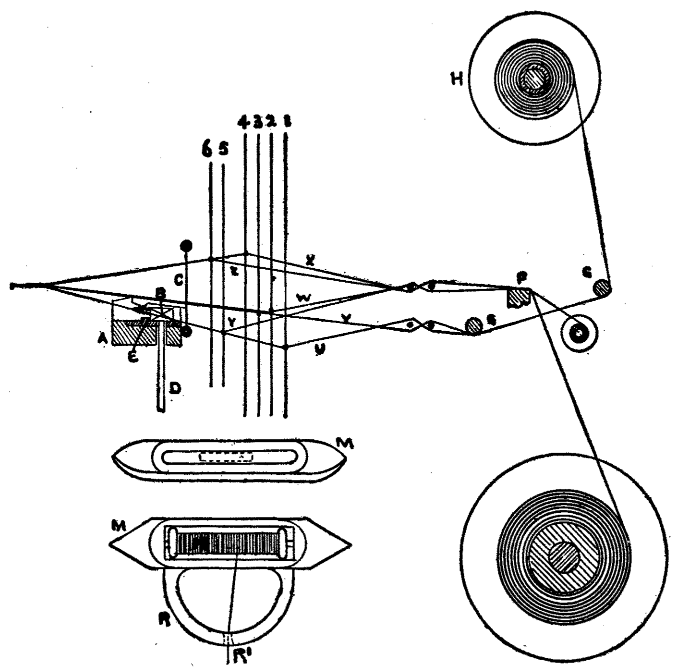


Fig. 286.

the ordinary way. The small shuttle boxes B B, formed for the border shuttles, are fitted into the lathe, or going part, which is recessed for their reception, and stops are formed in the front as shewn at B^1 through which the arc or bow of the shuttle protrudes. E and E represent the small pickers for actuating the border shuttles. A plan and front view respectively of the shuttle are shewn at M and M in Fig. 286, the arc or bow R, having a

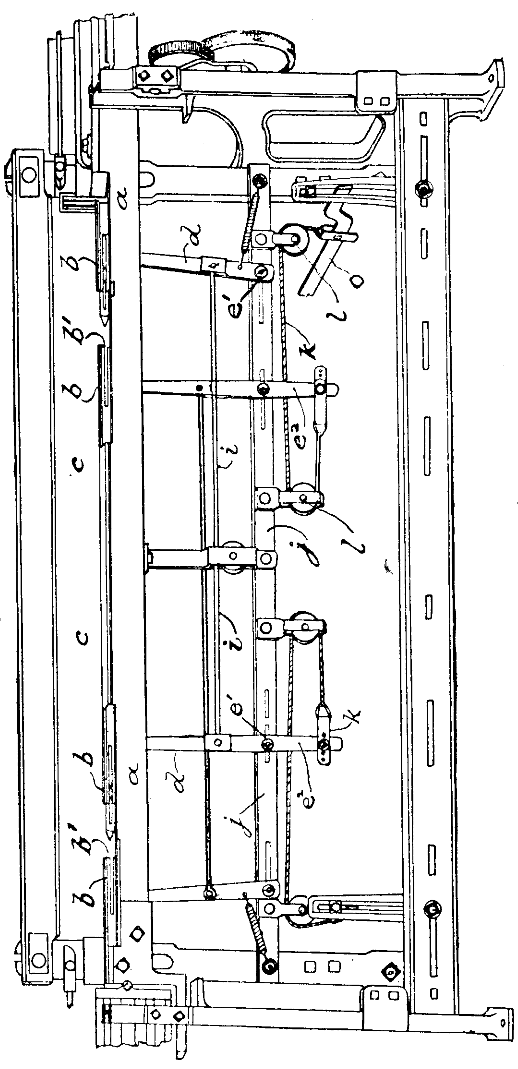


FIG. 4.

Fig. 287.

small opening at R[1], through which the weft passes; the size and form of the bow being, as already described, for the purpose of laying the weft evenly in the shed. The shuttle boxes are provided with springs or box swells for keeping the shuttle firmly in position immediately on its arrival. As will be seen the shuttle boxes for the border shuttles are recessed below the level for the ordinary warp, and the two are so arranged that the lower half of the shed of the ground warp, or the central part of the dhooty, forms the same straight line with the upper half of the border warp; in other words the central warp forms the shed in the normal position, whilst the border warp is placed below it. By this arrangement the shuttle carrying the weft for the centre is always thrown clear over of the warps V and W, as shewn in Fig. 286. So that really the border and the centres are woven as it were independently and side by side but at two different levels. An extra weft fork is provided for each of the border shuttles and to enable them to be operated for stopping the loom when any one of the three weft threads break, or give out, the border shuttles are set to pick always in the opposite direction to that of the main or ground shuttle forming the body or centre of the fabric, and the hammers of the border weft forks operate at the contrary pick to that of the hammer operating the main weft fork, so that only one weft thread will pass in front of any weft fork at the time when motion is communicated to the hammer. Then the binding of the borders to the centre will be understood on reference to Fig. 288.

The catch threads which are marked Y Z in Fig. 286 are here bracketted together at B, and it will be seen that the weft threads A and C of the border and centre respectively are common to all the catch threads; the reason for this will be apparent on following the threads Y and Z in Fig. 286, where they are shewn as forming a shed equal in depth to both the others, so that both shuttles must pass through at the same time. In fact the two wefts forming the border and centre respectively are common to all the catch threads. During the time the loom is weaving the centre part of the dhooty, and until it is required to produce the heading, or cross border, the motion for actuating the shuttle-box pattern cards is kept out of action, and only one shuttle is used for putting in the grey weft; but when the requisite amount of plain cloth has been woven an automatic arrangement worked from the taking-up

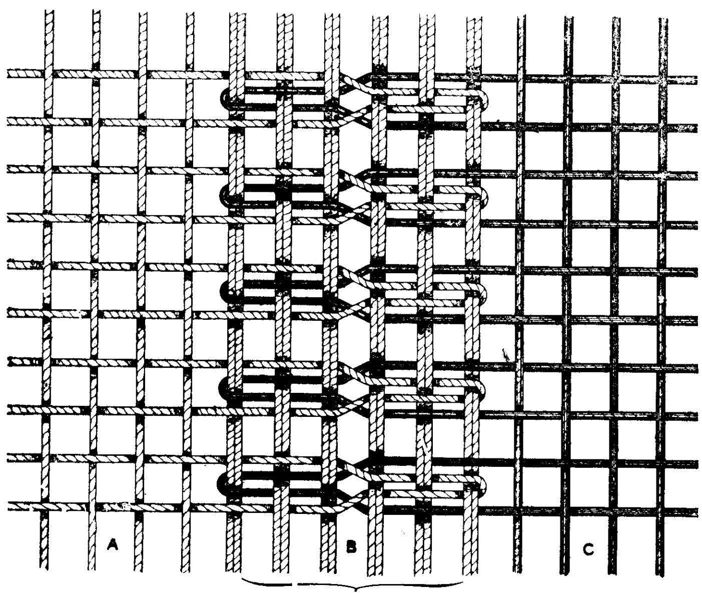


Fig. 288.

or measuring motion allows the catch which actuates the pattern card barrel to engage with the ratchet wheel, and so move the cards forward to select the shuttle forming the cross border. When this is completed the loom is stopped again, automatically, so that the weaver can wind the cloth forward a sufficient distance to form the fringe for two dhooties, then the loom is again restarted, a heading woven for the next dhooty, at the end of which the grey shuttle is again brought into position, and so the operation goes on continuously. This description will probable assist us in understanding the use of the swivel for ordinary figuring purposes.

The principle of all swivel weaving is the same, when used for forming figures on a solid fabric, they differ from those described by being fixed upon a rack attached to the hand-rail, and so that they can be raised or lowered, so as to be out of the way of the ground shuttle as it is thrown across and dropped to the warp level when the swivel shuttles are in use. The rack may be moved from side to side, so that the figures may be formed on any part of the fabric.

LAPPET WEAVING.

The object of lappet figuring is to produce patterns by the introduction of extra material which in some respects is similar in appearance to swivel figures, and by a judicious arrangement and combination of figures may be made to approach very nearly the same appearance. Swivel figures as already shewn consist in the introduction of extra material figuring over a limited space and recurring at intervals across the fabric. So far the general explanation will apply also to lappet figures, but where the figure formed by a swivel consists essentially of weft threads that formed by a lappet consists of warp threads, but carried across the fabric by a series of needles, and stitched into it so as to present all the appearance of pattern being formed by weft. To abbreviate the explanation and make it clear, we may refer to the plan shewn at Fig. 289. In this illustration suppose the vertical and the horizontal line to represent warp and weft threads respectively, and interweaving so as to form a perfectly plain texture. Then a figure is formed by the introduction of an extra thread which is shewn as being carried backwards and forward over the surface of the fabric and stitched into it at every point of turning. A fair comparison might be made between lappet weaving and other modes of figuring, by supposing that a perfectly plain fabric was taken, and with a thread in a needle stitched back and forward

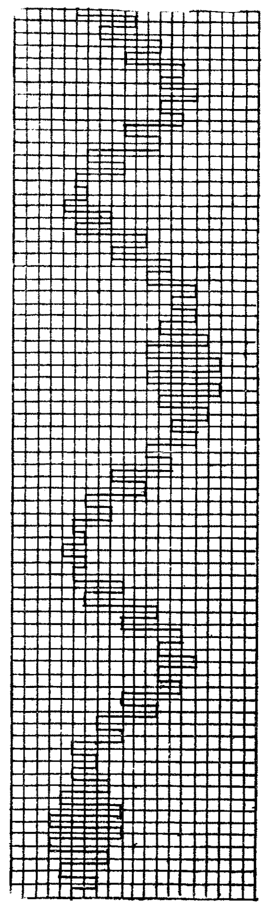


Fig. 289.

exactly in the manner suggested in the illustration. But instead of one figure being stitched in, a series of figures would be worked during the process of weaving, the distances apart only being determined by the distance apart of the needles carrying the figuring threads. I will endeavour to make the process as clear as possible by reference to two illustrations Figs. 290 and 291. 290 shews a front elevation of the loom, and 291 a section shewing all the essential parts of the lappet arrangement. In both illustrations a series of needles N are shewn, those being carried in a

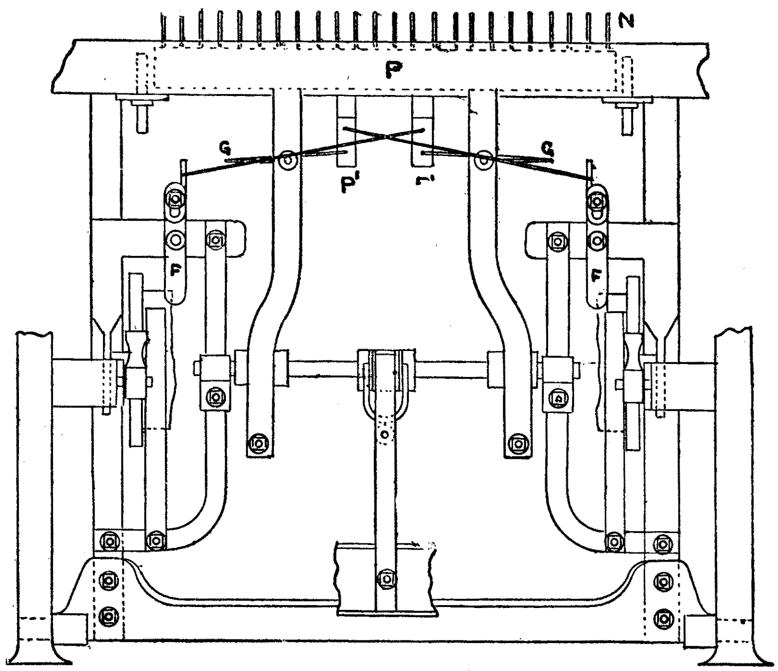


Fig. 290.

moveable frame seen at P in Fig. 290, and in section between the shuttle race and the reed at Fig. 291. Those needles carry the figuring threads which are brought under the sley board from the figuring warp beam over a small roller and through a tension arrangement as shewn at S in Fig. 291. At this point a clear explanation must be given of the arrangement of the whole apparatus; at N in Fig. 291 there are apparently three needles between the shuttle race and the reed R, the front needle of the three is really one of a series for the shuttle to run against; the other two represent two distinct lappet frames, each of which may be forming a figure of its own.

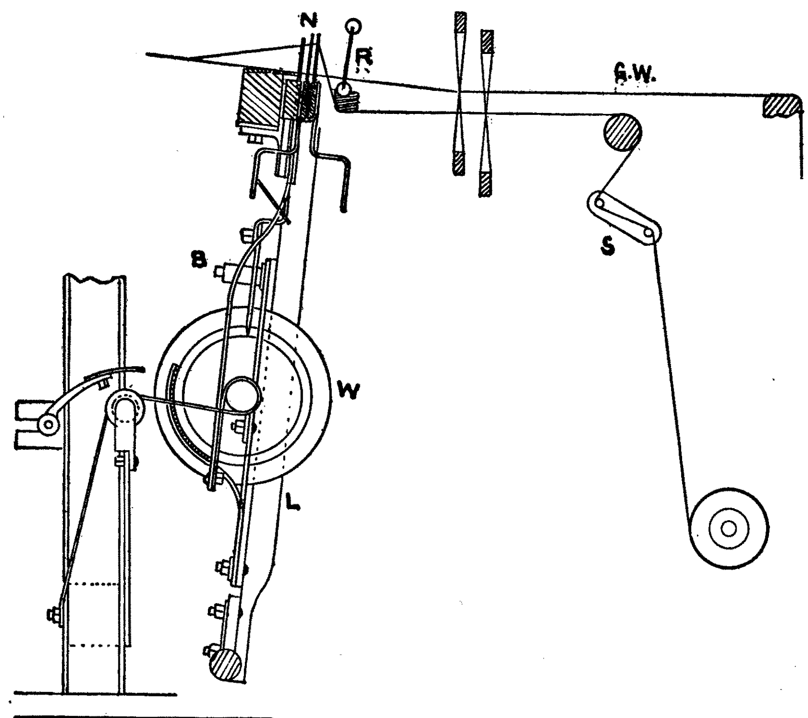


Fig. 291.

To those familiar only with the ordinary loom the introduction of needles between the reed and the shuttle may seem very singular, but a moment's consideration will at once shew that if the warp threads must form a figure by crossing and recrossing of the threads, as shewn in Fig. 289, the figuring must be done in front of the reed.

That being so, the figuring needles must of necessity rise in the fabric between the shuttle and the reed, consequently one series of needles must rise at every pick for the shuttle to run against, and the figuring needles must rise, carrying their figuring threads with them at any point desired for the formation of pattern, between what might be termed the standard needles and the reed. Although I am using the term standard needles here it must be understood that they are standard only in one sense, that they always rise and fall in exactly the same position, and that their sole function is to form a rest for the shuttle to run against, for the moment the shuttle is passed across the loom they must be lowered clear of the warp so as to permit the figuring needles to be moved as required for the formation of pattern, and also to permit of the reed beating the weft up to the fabric.

Now for a moment we might refer to Fig. 290, the needles N are carried in a needle frame P, to which are attached two vertical arms P^1. From each of those vertical arms, cords or straps G are carried to lever arms F, which may be acted upon by rods, governed by the lappet wheel with the pattern cut upon it. Of course it will be understood that P is attached to and carried by the going part and upon the swords L, as seen in both Figs. 290 and 291. I need scarcely stop to describe the whole of the details of the levers or brackets as seen in Fig. 290, as they are simply carriers for so many of the working parts.

Suffice it for the moment to say that the levers F are actuated, and the extent of their movement determined by a pattern groove cut in the wheel W at Fig. 291, and which will have to be more fully described presently. This lever F is hinged upon a bracket in front of the sword of the going part and the true position of which will be better understood by the spindle at B in Fig. 291.

The lower arm of this lever is seen to correspond at its extremity with a groove in the wheel, this groove being the determining agent in the formation of the pattern and which will cause it to move sideways by means of a feeler, and so cause the needle frame P to oscillate from side to side any distance corresponding to the groove cut in the lappet wheel. A cord will be seen passing round a small pulley in the centre of the wheel W, over another pulley attached to the front frame of the loom, and made fast to the loom frame. The function of this cord is simply to raise the needle frame every time the going part moves backward and to allow it to drop as the going part moves forward. In reality there are two systems in use for working the needle frames, the one briefly described here and the other known as the Scotch lappet. In the Scotch lappet loom the frames are raised by means of a series of cams, or by a sort of fixed levers under the loom, upon which vertical rods press as the going part moves, and the horizontal motion is communicated to the figuring frames by means of weighted levers which are operated also by cams. But although there is a difference in the manner in which motion is communicated there is no difference in the principles involved. Then only two things need be insisted upon here as necessary to a clear understanding of the manner in which the work is done. The first is that the needle frame carrying the needles against which the shuttle runs must rise and fall at every pick, that the needles carrying the figuring threads must be moved from side to side at every pick, and exactly the distance required for the formation of the pattern. Those two points being clear, the details of the mechanism for operating them may be varied to any extent, as it is obvious that the time when the needles rise and fall and the time when the figuring needles are made to traverse from side to side will be governed by precisely the same considerations as those which determine the shuttle-box, that is, that the change must be accomplished when the shuttle is in the box, otherwise, of course, disaster must follow. Then before entering into the question of cutting the figuring groove on the lappet wheel I need only refer briefly to the arrangement of the threads as they pass through the needle from the warp beam. In Fig. 291 the ground warp is shewn passing over the back rail, through the healds and the reed in the usual manner. (By the way a mistake in the drawing might easily mislead a casual observer; two healds are employed, one of them shews the ground warp passing through it, the other one from its position, will suggest that the figuring thread passes through it; this is not so, the figuring thread does not pass through a heald at all, but simply through the tension rods S over the roller under the reed and direct to the needles.)

So far as the ground warp is concerned nothing need be said, as the arrangement is almost precisely the same as on any ordinary plain or plain gauze fabric, but so far as the figuring threads are concerned, a few words of explanation are necessary. The figuring threads are carried from the roller through the tension rods, as shewn in the illustration, but the object of those tension rods, as the name implies, is simply to keep the threads at a sufficiently high tension without being too great. To make this matter clear, begin by supposing that the warp is drawn from the roller direct to the needles in the usual manner of drawing the warp from the beam, then it must be considered that the figuring threads at each insertion of the weft pick may have to traverse half an inch, or any other distance according to the pattern, and be stitched into the cloth; there is no system of weighting a warp beam or roller which would give a sufficient amount of elasticity to the rollers to permit of such varying quantities, as, say, from one-thirtieth part of an inch up to half an inch being drawn from it and yet have the threads held at approximately the same tension, hence the necessity for the tension rods. The arrangement of those tension rods is truly characteristic of the early hand loom weavers, there is no elaborate arrangement of springs, we simply have a flat piece of wood of the form shewn at S in Fig. 291 placed, say, within a foot of each side of the loom, the tension rods consist simply of two moderately stout wires; from each end of this piece of wood a piece of strong loom cord is carried either to the loom frame or to a strong spring attached to it, the wood frame is carried round and round until a twist is given to the loom cords and a tendency to the whole framework to spin round; then the warp threads are passed through in the manner shewn in Fig. 291, the result is that a kind of natural spring is formed with the loom cord itself, and whatever distance is taken up by the needles in their crossing and recrossing, the tension rods give it off readily and as rigidly take it off from the warp beam after the weft is beaten up to the fabric; so that there is not that tendency to pull the warp threads of the ground fabric at each point of intersection of the figuring thread that there would be if sufficient elasticity were not given to them. Then it only remains now to explain how the wheel is cut so that the feelers running in the groove may operate the needle frame and produce the pattern.

The cutting of the wheel is the most important item in the production of the lappet figure. The arrangement of the plan is in itself comparatively easy, suppose for instance we refer to the pattern represented in Fig. 289, we should make the design for it upon point paper as shewn at Fig. 292, and of course in this case it must be understood that the dots upon point paper indicate crossing and re-crossing of the figuring thread. Whichever form of lappet loom we are working with the principle remains the same. So that the feelers must pass from side to side of the groove upon the wheel and the length of the traverse of the feeler will determine the distance over which the figuring thread is carried. Then we take a wheel formed of wood, and turned to perfect truth, and allowing a certain space in the centre for the holder or boss, and a corresponding space on the outer

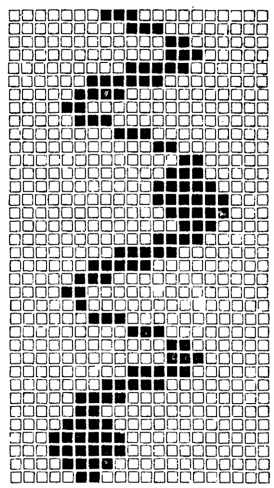


Fig. 292.

ring for formation of the teeth, the intervening spaces are divided by concentric rings exactly corresponding in distance apart with the fineness of the reed. Suppose, for instance, that we had 40 reeds per inch, then the concentric rings must have exactly the same number, because they have to determine by the distance the feeler travels from one side to the other the exact distance the needle frame will travel. Fig. 293 will shew how those rings are dealt with. First we have to take into consideration the thickness of the wire of which the feeler is made, it may correspond with 3, 4, or any number of the divisions, then a space must be assigned to it corresponding with its bulk. That having been done we must take the pattern and lay off the number of the concentric rings corresponding with the number of reeds in the pattern. We must then divide the circle into a

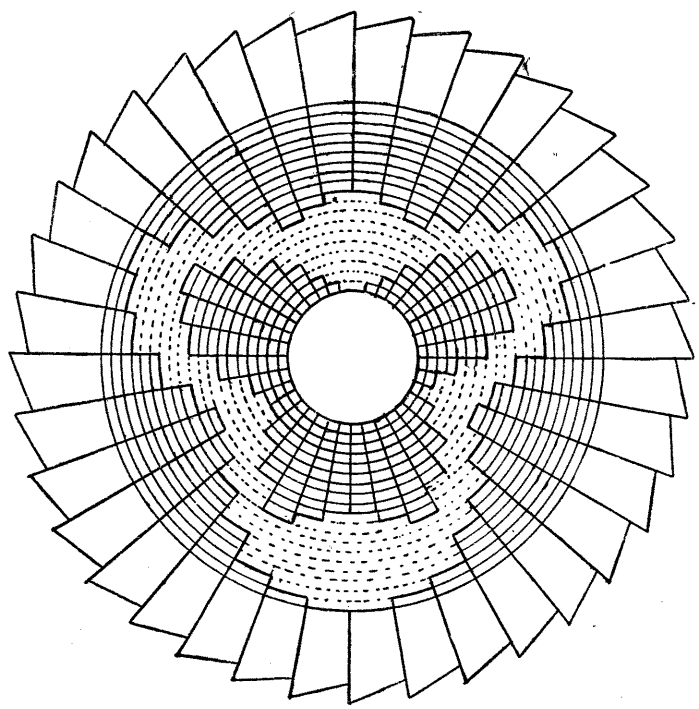


Fig. 293

number corresponding with the picks in the pattern. For instance the pattern we have to deal with here occupies twenty threads and thirty-six picks, so that we lay off twenty divisions with the concentric rings and four added for the size of the feeler wires. The circle is divided into thirty-six parts corresponding with the picks. Commencing then with No. 1 pick of the pattern we find that the thread must cross over the sixth and seventh reeds or ends, and we lay off a space exactly corresponding to that. It must then cross back to the fourth, then in the opposite direction to the seventh, and so on in succession over each pick; all the points over which the feeler must pass are marked in succession, then a deep groove is cut in the wood, such as that indicated on the wheel at Fig. 239, where the dotted lines shew what has been cut away. Then at each pick the feeler can travel from one side to the other of the groove, always being arrested at the exact point where the pattern must be determined.

Although the machine seems an extremely complicated one from the number of parts, yet it will be seen that the principle is clear, and it possesses the one great advantage in looms figuring with extra material of rapidity of production. No extra shuttle is required as in swivel weaving, and consequently no loss of time in passing from side to side. The one important point to consider is, as already pointed out, the exact time when the movement of the needles must take place, and of course it must be obvious, as already shewn, that that must occur exactly as in changing shuttle boxes, when the shuttle is at rest, or in other words, practically when the reed is in contact with the cloth, and that the needles like the ordinary healds must be at their highest point at the moment when the shuttle leaves the box, and remain there until the shuttle has re-entered the box. So that practically everything that has been said of shedding and box motions will apply to the movements of the needle frames. There is one matter in connection with this which may perhaps trouble the beginner, *i.e.*, the determination of the quantity of figuring material required in the production of a piece of fabric. Suppose, again, we refer to Fig. 289, there are thirty-six picks in the pattern, and we should have to determine exactly the number of reeds over which the figuring thread crosses; for instance at the first crossing it goes over two reeds, at the second over three, at the next over four, and so on; then we know the number of reeds per inch, so that adding up the total crossings in the pattern, plus the number of picks or the length of cloth formed, we should have the entire length of yarn required for the formation of one pattern. That multiplied by the number of patterns, or needles, and by the number of patterns per yard would give us the total length of yarn consumed in one yard of fabric. Then from that, following the usual mode of calculation for warps, we should determine immediately the weight or quantity of material used for figuring purposes; so that there is no difficulty in dealing with that beyond what occurs in ordinary figured fabrics.

WEBBING OR BELTING LOOM.

Having already described in detail the swivel loom, what has to be said of the webbing or belting loom is really very little. It is, in fact, the same as the loom for weaving tapes or ribbons, but of a much stronger construction. An illustration of one of the best looms is shewn at Fig. 294. On the front of the loom are seen the taking-up motions for each web separately, and driven positively by a train of wheels, after the manner already described in reference to other looms. Then again the shuttles are seen in front of the sley board and are carried positively after the type of swivel looms, but of course are made large and strong. In the loom which is illustrated here the shuttle is propelled in a slightly different manner from that described by the rack and pinions in the ordinary swivel loom; the interior face of the sley board front is formed with a groove from end to end;

immediately under each warp the groove is lower than that portion between the warps, the two straight portions being connected by inclined grooves; the rod for propelling the shuttles has pegs or bowls fixed upon it which engage with the slot in the sley board. This rod is actuated by a chain which is moved longitudinally, and as it is so moved rises and falls with the grooves; the picking arrangement consists of a double tappet fixed on the ordinary tappet shaft of the loom and operating a pair of levers or treadles which are fulcrumed at the rear of

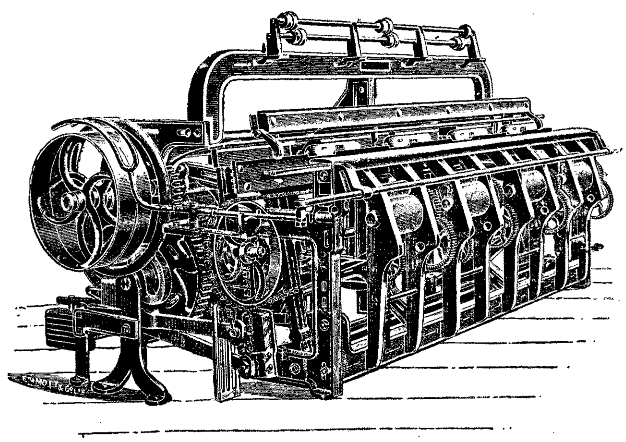


Fig. 294.

the loom in the usual manner. The free ends of the treadles move vertically in the slots of a guide plate at the front and are attached to the ends of a strong flat link chain; the loop of which is passed over and secured to the middle of a small pulley; this latter is fixed to the boss of a larger pulley round which a similar chain is passed and secured, both pulleys are free to rotate on a stud fixed to a bracket on the lathe sword; a similar bracket is also fixed to the lathe sword at the other end of the loom which carries a stud mounted on a carrier pulley, round which another chain is passed; the ends of the two chains are coupled together by the pair of light rods already referred to. The upper rod is connected to the shuttle carrier and enclosed in the sley or race board case, so that the whole mechanism moves forward with the sley as the weft is beaten up. In the top edge of the rod several pairs of pegs are fixed, one pair to each shuttle, and each of these engaged in a corresponding hole in the face of the lower shuttle: the pegs are fixed at such a distance apart, and the space between two warps is of such a length, that the shuttles are engaged by one peg at a time, pushed partly through the shed and then engaged by the other pegs of the series and their traverse, or pick, is completed. The backward stroke is made in precisely the same manner by the operation of the second treadle, so that a considerable saving of time is effected as compared with the use of the rack and pinions. The healds are actuated in practically the same manner as in the ordinary looms. The take-up motion, as already said, is a positive one and the let-off motion of the usual kind, each beam being provided with a grooved flange, round which a heavy chain is passed and attached to a weighted lever, so that the tension upon each separate fabric can be regulated at will. This loom is the production of Messrs. Wilson & Longbottom, Limited, of Barnsley, who claim for it that they can obtain an increased production over the old looms of fully 90 per cent.

Although this is called a webbing loom it may be equally used for weaving belting or heavy girthing bands for conveying mineral or grain and goods of a similar class. It may also, of course, be made applicable to the weaving of hose pipes. It would simply mean that the shedding motions would have to be enlarged so as to form double cloth, allowing the shuttle to pass through the upper and lower cloth alternately, so that it would be continuously forming a circle with the weft, the result of the product being of course a tube.

CIRCULAR BAND WEAVING.

What is really meant by circular band weaving is the formation of a fabric longer at one side than at the other, as for example, that shewn at Fig. 295. It may seem at first sight an extremely difficult matter to weave a fabric which is not perfectly straight; we all know,

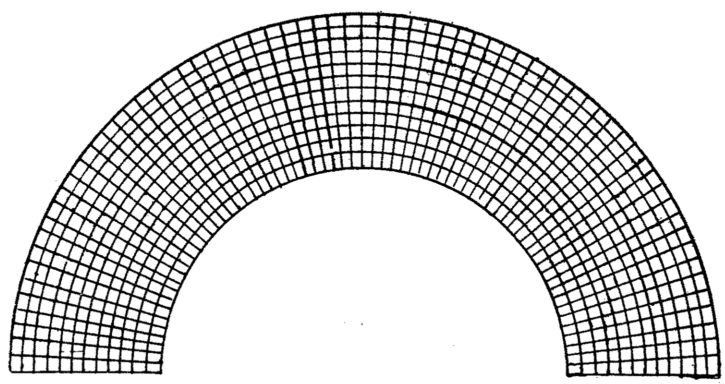


Fig. 295.

for instance, that the reed always comes up to the cloth in exactly the same position, and parallel with what is termed the breast beam, therefore it would seem that at all times the weft threads would be laid exactly parallel to each other in the fabric, but let any one familiar with the looms imagine the weight being off one end of the taking-up beam and he will at once discover that a fabric was being formed something approaching a circular fashion, *i.e.*, the threads on one side would be much tighter than those on the other and consequently the two sides of the fabric would not be equal in length. This of course could not go on very long in an ordinary loom without the results being more or less disastrous, simply because, although the taking-up rollers would be carrying the cloth forward at different rates of speed at the two selvedges the warp beam would be giving off uniform length throughout the width of the fabric. But now suppose that we deliberately not only

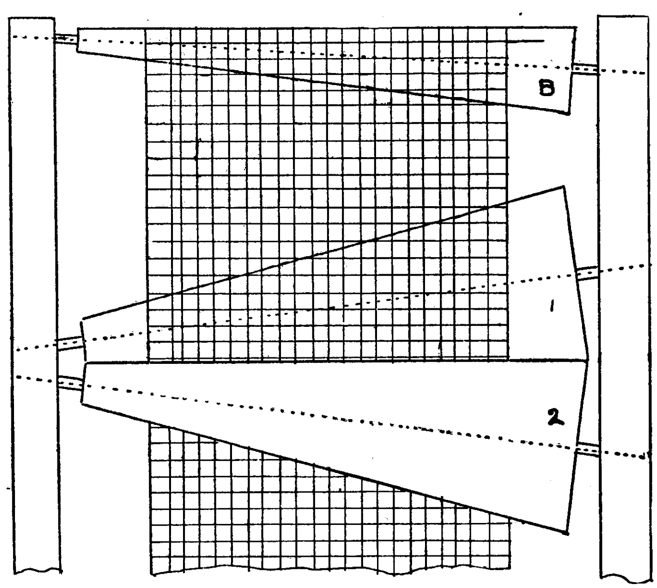


Fig. 296.

take the cloth at one side at a more rapid rate than at the other, but that we also arrange for the warp to be given off at a corresponding rate. This, although it seems at first sight extremely difficult, is in reality very easy. For instance, we will take the arrangement shewn at Fig. 296, where the cloth passes over a conical roller B, which represents the breastbeam in an ordinary loom. It is then passed between two conical rollers 1 and 2, which answers the ordinary purposes of take-up rollers and are driven in precisely the same manner. Those rollers being much larger in diameter at one side than the other must of necessity carry the cloth forward at rates of speed, from one selvedge to the other, varying in the exact ratio of the variation of diameters; consequently instead of the weft threads being placed exactly parallel to each other they would be woven into the cloth radially, as shewn in Fig. 295, and the fabric must therefore assume a circular form with one selvedge much longer than the other; the diameter of the circle so formed will of necessity depend upon the conical form of the rollers. Those fabrics are, or may be, made to serve a variety of purposes, such for instance as skirt bands, or collars, or

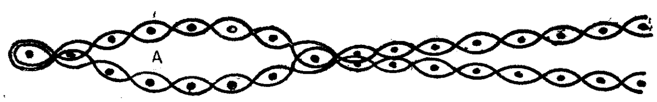


Fig. 297.

for any similar purpose where a circular fabric could be made to serve better than an ordinary straight one; and the structure of the fabric would be suited to the purpose to which it was to be applied.

For instance, we will take the case of the ordinary skirt band, and we should have a section as shewn in Fig. 297; we commence first by forming two distinct fabrics, simply on the ordinary double cloth principle, as already described, and those two fabrics we bind together at one selvedge and at another point a short distance from it. It is desired, for instance, to form a kind of tube at A, through which a cord or tape might be passed, and then it is desired to form two separate fabrics below that between which the body of the skirt might be stitched. Then all we have to do is to make our plan for actuating the healds so as to form two separate fabrics and bind them together at the points indicated; weave this on a loom with conical rollers as shewn in Fig. 296, and we have a band, or binder, for which it is claimed that it will fulfil all the conditions for the purpose to which it is to be applied. In a loom of this kind we have really but two leading considerations; the first is the exact shape of the conical rollers so as to give us the diameter of the circle formed by the fabric; and of course there must be a distinct and definite relation between the cone representing the breast beam and the take-up rollers. Then a second consideration is the delivery of the warp to exactly correspond with the take-up. This implies that one of two methods must be adopted, either that the warp must be drawn from bobbins and delivered through rollers corresponding to the take-up rollers, or it must be drawn direct from bobbins and through tension bars or rods, so that every thread will be kept as nearly as possible at the same tension, no matter at what rate of speed it is taken forward. With a little care and proper arrangement of the rollers this system of weaving may be made useful in producing fabrics of almost any shape. For instance, a system, not exactly like this, is in vogue in weaving ladies' corsets. In the weaving of those articles, of course, there cannot be exactly the same circular form, so that conical rollers would be of no use. What are known as a series of "gussets" are formed both on the upper and lower side of the article, and not only from the varying sizes and varying number of those gussets in one article, but from the varying rate of take-up required by the introduction of cordage or ribs, or for the formation of tubes in which steel ribs may be inserted, it would be impossible to construct a loom which would take-up continuously. To meet this difficulty the article, as it is being woven, is simply held by a clamp which serves the double purpose of a temple and a general holder. For instance, in forming a "gusset" the weaver will begin by throwing his shuttle through a section of the warp which we will suppose to represent a space of 6 inches, and will weave a few picks, then by an arrangement of his dobby machine he will drop one section of the healds and allow the weft to go through, say a space of 5 inches of warp; then he will reduce that to say 4 inches and so on, until he gets down to almost nothing; then he has been weaving all this time a V shaped fabric on one side of the article; he then uncloses the clamp liberating the fabric, presses the fabric forward with his reed until all the sections he has just been weaving are brought into the same horizontal line with which he started; the clamp is closed down upon the fabric, holding it firmly in position, and the process of weaving is continued, either to form a straight piece across the fabric or to form tubes by means of double cloth for the insertion of springs or whalebones, and other "gussets" are formed at will, either on the upper or lower side of the article in precisely the same manner, so that seeing that the "gussets" can be formed of any length, of any width, or of any degree of angularity it necessarily follows that fabric of any shape can be woven by having the healds properly and suitably dealt with, and the use of clamps or suitable shaped rollers so as to make the take-up exactly what is required for the shape of the fabric. It might be interesting to describe many other productions of the loom on the principles suggested here, for instance, almost any article of clothing might be woven in one complete piece, but as to whether it could be done successfully as a commercial undertaking would be another matter.

CARPET WEAVING.

I shall not attempt to deal with all the different classes of looms used in carpet weaving, were I to do so I should have to explain the loom frame of the Turkey and the Indian carpet weavers, which simply consists of a vertical frame with the warp threads stretched and the pile being knotted in with the fingers of the operative, and the weft thrown across and beaten up by hand, and I should have also to deal with the common Kidderminster or Scotch carpets, which simply means the production of a double fabric, the principle of which has already been explained. I shall not attempt either to deal with the so-called Axminster or imitation Turkey, which is nothing more or less than a Chenille carpet made upon the principle which I have already described in my "Treatise on Weaving and Designing"; but I may venture to call attention, although in a very general way only, to the weaving of tapestry or Brussels carpet. The Brussels carpet really consists of a body fabric in which any number of threads from 3 to 6 are embedded, and out of which any one of the series may be made to issue for the purpose of forming pile, and they are brought up in succession according to the order of the pattern. In reality the Brussels carpet loom forms an ordinary pile fabric having its warp threads selected according to colour and brought to the surface over wires to form the pattern.

With the exception of the system of selecting the coloured threads the method of weaving is exactly the same as in ordinary pile fabric, although the structure of the cloth is somewhat different, and therefore the chief item of interest, so far as the power loom is concerned, is the method of inserting and withdrawing the wires.

Tapestry carpet weaving is practically the same as Brussels carpet weaving, so far as the formation of the body of the cloth is concerned, and the formation of the loop pile, but with this one exception, that whereas for Brussels carpets all the differently coloured warp threads are drawn from different bobbins and brought to the surface as required for the formation of pattern, in tapestry the warp threads are printed with the exact pattern which must appear upon the body of the fabric, only very much elongated so as to give sufficient length for the formation of loops, and without the distortion of the figure. A general view of the loom for weaving Tapestry cloth is given at Fig. 298. The ground warp,

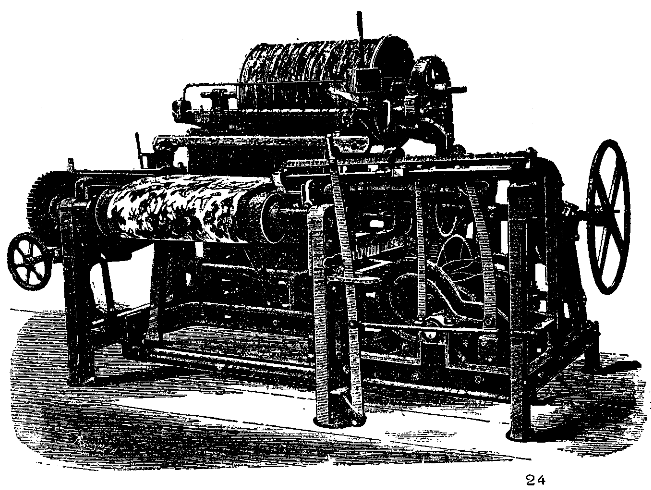


Fig. 298.

or that forming the body of the cloth, is brought through the healds in the usual manner, the pile warp is elevated, as seen at the back of the loom, and weighted in such a manner that on the insertion of the wires the warp threads can be drawn readily away from the beam, and yet the beam be held sufficient rigid when the ground picks are being inserted. The pile warp is printed, as seen in the illustration, and as it is drawn forward forms the proper pattern upon the fabric.

The insertion and withdrawal of the wires is the really interesting feature of this class of looms. To the right of the loom is seen a long kind of holder, and beneath it are two arms hinged to the lower framing of the loom and actuated by a peculiarly shaped cam which is distinctly visible, this cam is so arranged that it throws the two arms in such a manner that they push a wire, held by a species of plier or jaw at their upper extremity, and carried by a guide, through the warp between the reed and the fabric. This is done in this particular loom simultaneously with the throwing of the shuttle across, although in the usual tapestry or Brussels carpet loom the picking is suspended during the time the wire is being inserted; the moment the wire has been inserted the jaws are made to open, and being pressed slightly aside in a slot and frame they are brought immediately in front of a wire end which has already been inserted, and which it is now intended to be withdrawn. For instance, supposing we are weaving with four wires this lever would be moved forward a distance corresponding to the space occupied by four wires in the fabric, and the jaws of the holder being held open up to that point would now be liberated and immediately close upon the wire to be withdrawn. This having taken place the lever is returned by the cam to its normal position, carrying the wire with it, and ready for insertion immediately the requisite number of ground picks has been put in; this process is repeated continuously; if the fabric is an ordinary loop pile of the Brussels or tapestry type the wire is simply pulled out leaving the loops intact, but if it is required to be a cut pile the wire is provided with a species of flanged knife at the end which severs the warp thread as it is withdrawn, and so leaves a velvet surface instead of a looped one. The same principle applies to the production of every class of velvet or pile fabric. There may be numbers of different looms in use, which, except those forming double surface piles, which I shall have to deal with presently, differ from this, but the principle of the mechanism is practically the same in all of them, and therefore need not be dealt with at length. This loom is made by Messrs. Sowden & Sons, Shipley.

LASTING LOOM

I must not omit a passing word for a loom of a special type, which, although, possessing many of the leading

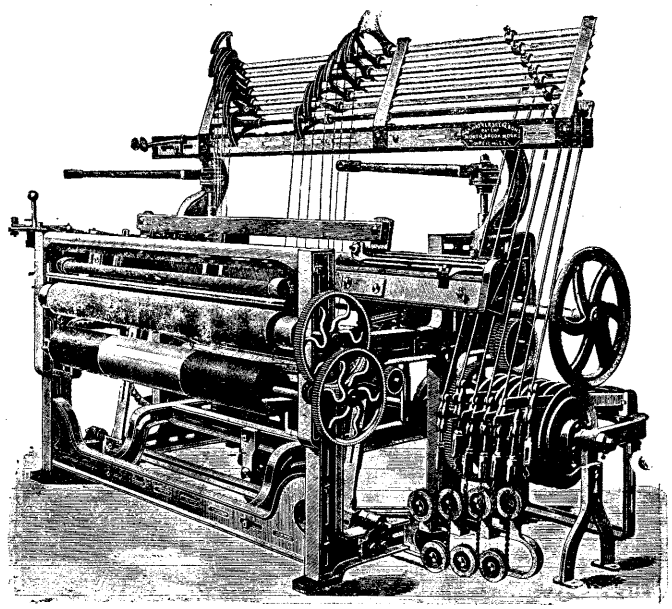


Fig. 299.

characteristics of the ordinary Bradford loom, is built and used for a special work, and for one class of fabrics only, viz.: lastings, or the cloths used for tops of boots or shoes. The lasting is built on the basis of a seven thread satin and from very strong worsted, and must be well put together and firm in structure, therefore a good strong loom is necessary for weaving it. An illustration of a loom for the purpose is given at Fig. 299. So far as one can see from the illustration, the loom differs from the ordinary loom of the Bradford type in having positive tappet plates, and the motion communicated to the healds above by means of the usual jack rods, and below by pulleys and cords. Everything is, however, made strong and rigid. The loom frame is strong in all the parts, and a longer throw is given to the going part than in the ordinary loom. Of course there is no new principle. The loom differs from others in strength suitable to the work it is intended for and the positive action of the healds.

DOUBLE PLUSH LOOMS.

I must now direct attention to a class of loom, which, although not so largely used as some of the special looms which have been referred to, has played an important part in the history of textile manufactures during recent years, that is, the loom for weaving velvets or plush two pieces at a time, face to face, and cutting them asunder.

Serious attention seems to have been directed to this matter, first about the year 1848, and for several years following improvements were made, but in most of those efforts the plush had to be cut after leaving the loom, and considerable difficulty was experienced in keeping the plush even, partly from the imperfection of the mechanism of the cutting machine, and partly from the uneven tension on the pile warp threads, which would cause the distance between the two fabrics to vary; these difficulties have since been overcome, mainly by the exertions of Messrs. Lister & Co., of Manningham Mills, and others who have been from time to time associated with them.

I shall not attempt to go into the details of the structure of the fabric, beyond saying that in all respects it is the ordinary velvet or plush, and that two fabrics are woven face to face and cut asunder, leaving pile on both. A full view of the loom is given at Fig. 300 and a section at Fig. 301. As will be seen the healds are actuated by positive tappets, and levers above and below, and behind the healds are a series of vibrating tension

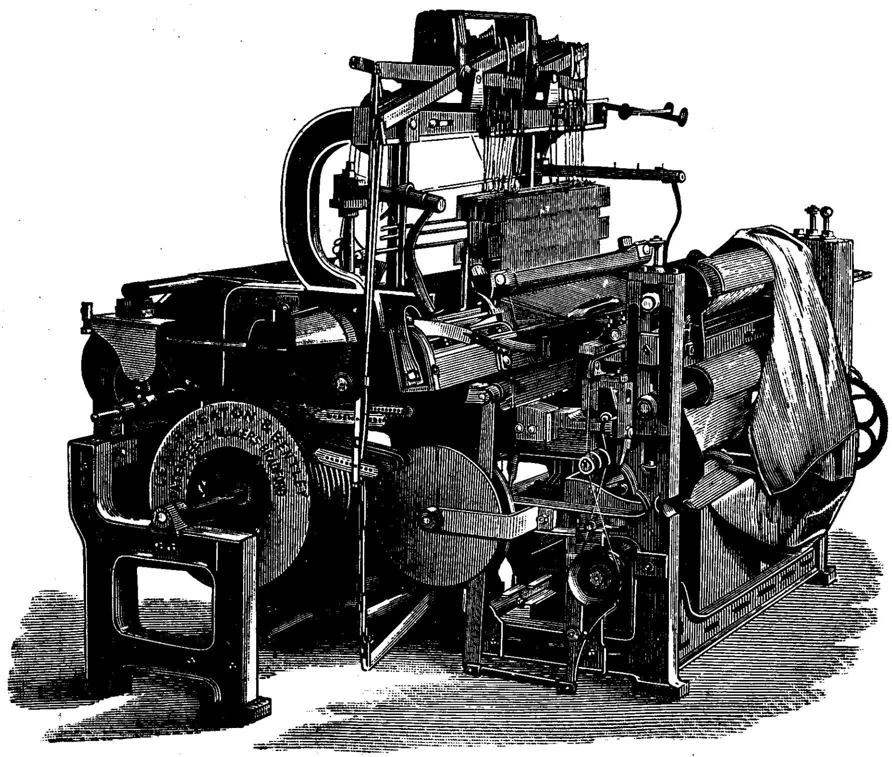


Fig. 300.

rods for the pile warp to pass over. The details will be better understood by reference to Fig. 301. The ground warp is taken from the ground warp beam A, over the back rail of the loom, and through the ground healds in the usual manner; the pile warp is drawn from the two beams B and C, passed under and over guide rollers to the delivery rollers TT, which are driven positively by

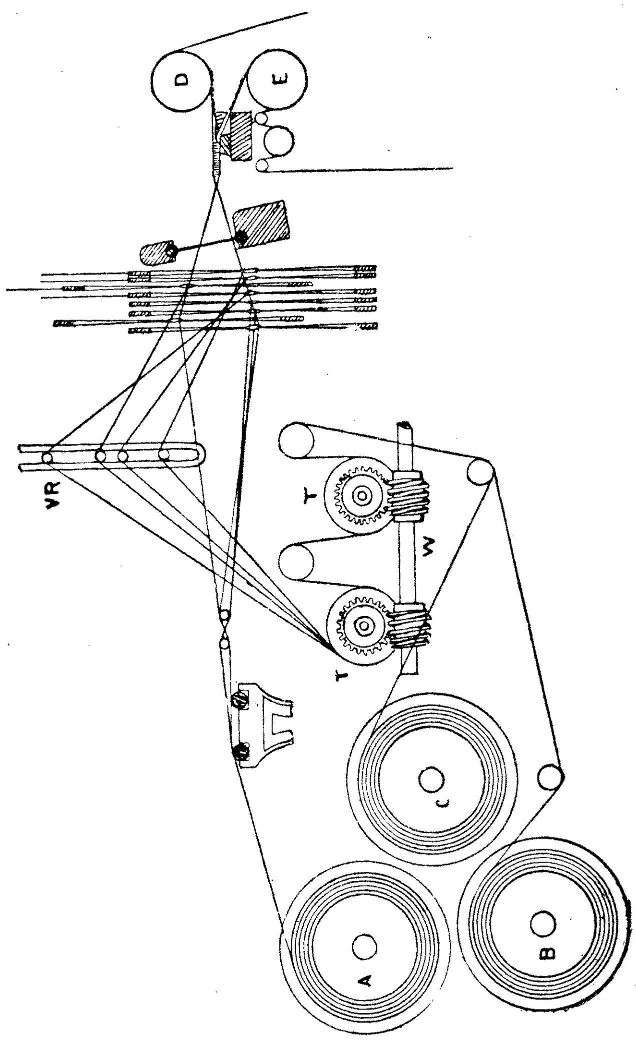


Fig. 301.

worm and wheel, and covered with plush so as to have a sufficient hold on the warp threads. The rate of speed at which these rollers deliver the warp will determine the length and evenness of the plush, and that is controlled by a train of wheels, one of which is changeable. On leaving the tension rollers T, the warp passes over the vibrating tension rods VR, which are placed in slots considerably above the level of the ground warp, and the object of which is to keep the pile warp thread at an even tension. These rods are connected by levers above to the levers actuating the pile warp threads, and as the latter are raised they are depressed, but between those levers and the rods themselves there is a spring which will give to the tension on the warp, and so avoid too great a degree of rigidity.

The warp threads are passed through the healds and the reed in the usual manner, but every care is taken to ensure perfect accuracy of movement of the healds; instead of ordinary cords the healds are suspended, in the best looms, by steel bands, and this coupled with the positive action of the tappets and levers ensures them rising and falling with perfect evenness; the levers are notched so as to permit of variation in the depth of the shed corresponding with the varying length of the pile, and every precaution is taken to obtain regularity. As the cloth is formed it passes forward to the breast beam, and is severed by a knife. Numbers of cutting arrangements have been invented for the cutting, ranging from a V shaped knife, and a circular knife to an endless band, differences of opinion existing perhaps at the present moment as to the relative merits of each. On leaving the cutting knife the two cloths are carried away by the rollers E and D, the lower one E being supplemented by another small roller, and the upper one being covered by a shield which carries the cloth round a great part of its circumference, and then to pass it over the front and drop it into a box in front of the loom.

With the best constructed double plush looms there is always liability to trouble in producing perfect fabrics; it is notorious that there is no class of fabric so liable to disclose faults as velvet or plush, and those arising frequently from absolutely unforeseen causes. There is a tendency to bars across the piece, to mitigate this the pitch of the take-up wheels is made finer than formerly, the result is satisfactory in one sense, but when one fault has been removed another is created; in place of the bars a sort of "watered" effect is produced; this again must be overcome. In the desire to get a good firm edge there is a tendency to produce a peculiar effect due to unevenness of cutting in consequence of the edges of the two cloths being kept too firmly together, which causes the plush threads to buckle and cut unevenly. The general method of obviating this is to keep the top rail well up so as to avoid this cramping, in fact the strictest attention must be paid to every detail of the loom or there is liability to serious faults, and in costly goods this must be avoided.

The take-up motion of this class of loom necessarily forms an important item.

THE DOBCROSS LOOM.

I shall make no apology for introducing the Dobcross Loom here. In the strict sense it is not a loom built for special purposes, except that it is intended, primarily, for weaving heavy woollen goods. I do not think it necessary either to describe it in detail: the principles upon which it is built have been dealt with already under the several heads corresponding with the parts of the loom. The dobby is a centre shed and positive in action; the going part is suspended from above, and the picking sticks work in the vertical plane. The let-off motion

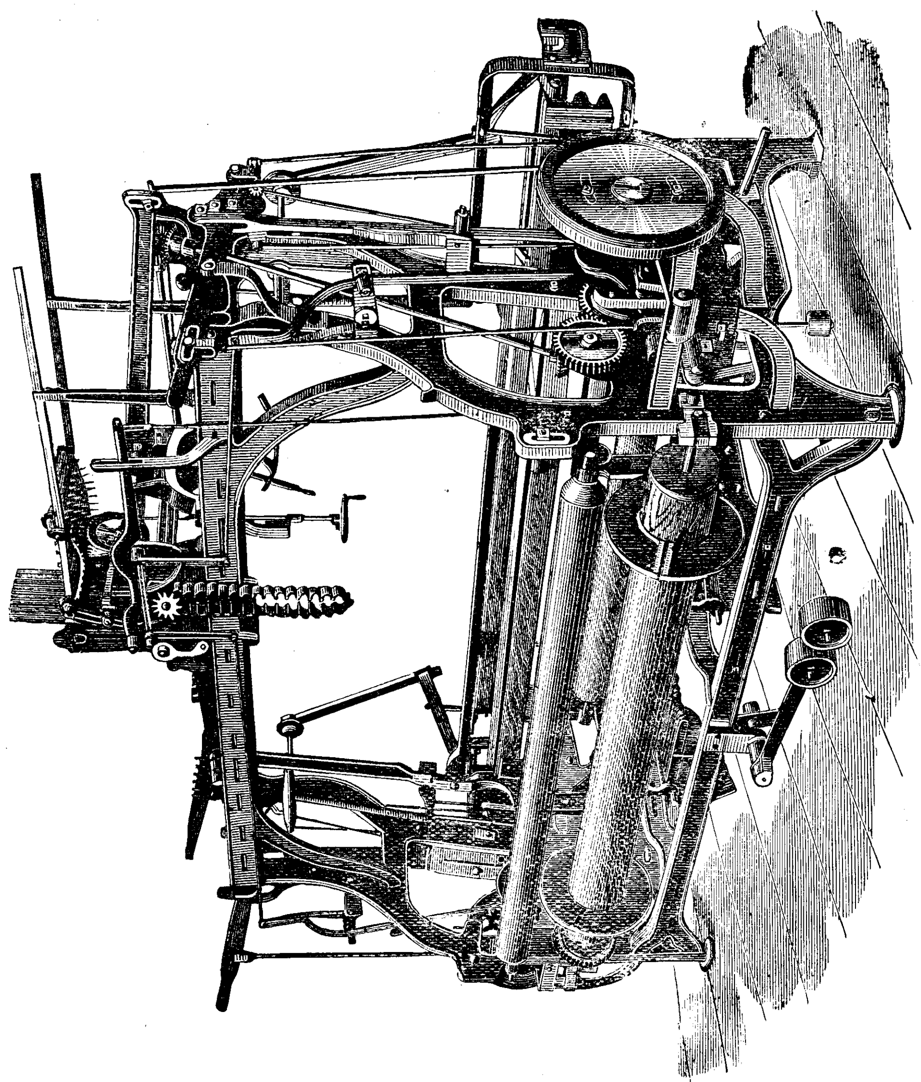


Fig. 302.

is of what is often called the positive kind, governed by a vibrator lever, and the take-up motion is a negative one: the boxes are rising boxes, so that by reference to the several parts dealt with in the previous lectures, the whole of the mechanism will be easily understood. Fig. 302 shows a back view of the loom, disclosing, practically, all the working parts.

LECTURE 13.

GENERAL SUMMARY OF ALL THE VARIOUS LOOMS.

In the previous Lectures I have endeavoured to deal at length with every class of loom, and for weaving all classes of fabric, so that I find myself now with very little to say in analysing and comparing the various looms and their working parts, and I shall not occupy much space in making this general comparison; but I will deal with each leading feature of the several classes of looms in the briefest possible way. Perhaps it would be as well to refer generally to each of the principal working parts, such as the shedding and picking, box motions, and the several adjuncts in succession, as it will not only bring the work into the most compact form but will render comparisons more pointed and easily understood. Commencing, for instance, with the shedding, we might compare the several systems of tappet working. We have first the under tappets, or those placed under the loom and inside the loom frame; second, the outside tappets, and third, the positive tappets, either of what are known as the Woodcroft section or any other positive shedding motion. The under tappets by their direct action are undoubtedly well suited for heavy work, or for goods where the loom may be run at a high rate of speed, but the necessarily restricted space which they occupy, with difficulty of access to them either for changing tappets or making any alterations, render them, though especially suitable for heavy work, most undesirable arrangements in consequence of the difficulty of access for any of the operations of adjustment. The outside tappets on the other hand are always readily accessible, not only permitting of easy adjustment of the sheds by means of the jack rods and side rods, but also admitting the use of any reasonable number of treadles and healds; for instance it is no uncommon thing to work up to ten treadles and ten healds with the outside arrangement, but with the treadles under the loom this would be a practical impossibility; again with the treadles working outside the loom, motion is communicated to the top of the healds instead of underneath, thus rendering it easy to use either what has been described as the under motions, or springs or stocks and bowls. Those additions to the loom could not possibly be worked with any reasonable probability of success if they had to be placed over the healds.

It is quite true that in the earlier days of hand loom work, the pulley boxes, as they were termed, were frequently placed over the loom, but in that case, the hand loom weaver was not only compelled to have his treadles under the loom, and within the loom frame, so that he could operate them with his feet, but he had absolute freedom as to space. He was not encumbered with driving shafts, tappet shafts, or picking arrangements under the loom, and consequently his arrangement permitted much greater freedom of choice of action than can be permitted in the power loom, so that for purposes of comparison the hand loom of former days and the modern power loom do not present, in this respect at any rate, any parallel. Now as to the good working of the various forms of tappet, the under tappet and the outside tappet both being non-positive, present identically the same characteristics; it is only a question of what has been already fully dealt with, the proper construction of the tappet itself; the proper placing of the friction, or anti-friction, roller on the treadle; the relative dimensions of the two, and their direct or indirect action. In all respects except in the matter of convenience of space, the two systems are practically identical, but when we come to the positive kind, either of the Woodcroft or other type, then we have a somewhat different class before us. The non-positive cam may be rendered positive in its action by the use of stocks and bowls, which have been described, but the Woodcroft or similar tappets, are positive in themselves, and therefore must be connected by means of levers both to the top and the bottom of the healds, each treadle to its own heald. It must be obvious then that one risk of difficulty is avoided, namely, that of variation in the tension of the cords which may be brought about by the varying action of the non-positive tappets, which would arise in the majority of cases, from faulty construction, and which may be increased by the improper setting of the tappets in relation to each other, or in relation to the friction rollers on the treadles. In the great majority of positive tappets too little attention is paid to the proper form. In many cases the term "jigger" is unfortunately applied with only too much truth, for instead of a smooth easy motion being imparted to the heald it is often a very jerky one. When weaving strong material such as well spun cotton or linen, this may not be a matter of very serious importance, but with soft threads the case would be very different; there is no reason why positive tappets should not be made to work with almost the same ease as the non-positive ones, but unfortunately the same attention does not appear to be paid to their construction, hence they will often have a bad character given to them when a little more care and attention in their preparation and arrangement would render them quite as valuable as the best of the non-positive motions. These remarks would apply of course only to such as sectional tappets, they could hardly apply to chains which consist simply of links and bowls; here there is no possibility of varying the nature of the movement for the roller, or bowl, being once inserted is incapable of any variation either of form or character, and can only impart one motion. This, of course, applies only when they are made to act directly upon the treadle; in dobbies of any form no matter what may be the character of the internal arrangement, they would not apply in any sense. I must now examine generally the leading features of the several dobbies.

As I have already pointed out in the lecture on dobbies, they may be classified under three distinct heads, open shed, centre shed, and bottom or jacquard shed, as they are severally known. I need scarcely add much to what I have already said as to the relative merits of each for the several classes of work for which they are intended. One remark which may be taken as of a general character would be that in selecting the dobbies there are three things I should look for, first, simplicity of mechanism; second, strength of the working parts, and freedom from liability to get out of order; and thirdly, a ready method of applying the design to the card or lag so that they could not only be cut, or pegged, with facility, but they could be easily read for the purpose of ascertaining or correcting errors. Of course, accompanying those qualifications a necessary condition is that perfect easy motion be communicated to the healds, which prevents either a too sudden strain being thrown upon the warp threads, or too great variation of tension at the different points of the passage of the threads. Again accompanying those conditions we must have the necessary one of being able to form a perfect shed, which means a perfect line of warp thread for the shuttle to run over, and capability of adjustment, the healds forming the upper half of the shed so as to have as nearly as possible the same tension upon the warp threads which pass through the front and back healds respectively.

This is difficult of accomplishment in some forms of machine, but it is a feature which must never be lost sight of. Then again we may discuss the relative merits of positive and non-positive machines. Generally speaking, I should give an unqualified preference to the positive machine, provided that the movement imparted to the healds is sufficiently easy and all other conditions are equally well fulfilled. It must be obvious that unless there is some special reason, either dependent upon mechanical contrivances within the machine itself, or interference with the strength of the working parts, that the use of springs or under motions of any kind must necessarily require a greater amount of power than the motions communicated positively, and when we have increased power required to drive a machine it is necessarily accompanied by increased difficulty, and in many cases by increased wear and tear, all of which it is desirable to avoid.

JACQUARDS.

It seems difficult at first to make analysis, and more especially comparison, of the different systems of jacquards and harnesses. Were we to speak of the machine alone as between the single lift and the double lift, or of the open shed machine in comparison with either, the relative merits might be easily determined. For regular work or for gauze weaving, or for any fabric where speed is not the essential requisite there would be no difficulty as to the merits of the common single lift jacquard, but when we come to the question of speed, under what I have already spoken of as a system of counterpoise harness, then the double lift machine undoubtedly possesses advantages, and in respect of very heavy goods, such as shawls, coatings, or mantle cloths, or other heavy goods, then there can be no question as to the merits of the centre shed machine, or what might be more correctly termed the true counterpoise. When we have done with the actual machine the question of the different systems of harness tying is in itself sufficiently clear that we are bound to admit of the advantages of tying up every harness specially for the work it has to do. Straight harnesses for straight figures, centre or repeat harnesses for their several purposes, pressure, compound or split harnesses for the weaving of goods where the extent of figuring must be accompanied by limited jacquard power; harnesses tied specially with doups for gauze weaving, and all harnesses where special work of any kind compels us, on the ground of economy, to make all our arrangements so that we have not only the harnesss best suited for the special purpose to which it is to be applied, but which will also be most economical in the working. In this aspect of the question we have to include the economy of tying in making the designs; the economy of cards and the labour in cutting them, and, as pointed out, where this can in many cases be reduced to one fourth or even less than would be involved in the use of a jacquard or harness not specially adapted to the purpose to which it is to be applied, the item is too serious to be treated lightly. It will be no exaggeration to say that in some large business concerns the economy of time in the preparation of designs, the labour of cutting cards and the actual saving of cards themselves would, with specially adapted jacquards, or harnesses, amount to a substantial profit to the business. It follows also, from what has been pointed out in reference to harnesses such as the expanding harness, that considerable saving will be effected in cost when changing from one degree of fineness in the fabric to another; and also a proper knowledge of, and adaptation of design paper, which will exactly correspond with the relative degrees of fineness of warp and weft, some influence upon the good working of the business must be at least existing if not predominant. Generally speaking, in fact, a thorough mastery of the whole system of tying harnesses and the different systems of jacquards suitable for the several uses must tend not only to economy in production but to general efficiency.

Then with respect to the several forms of take-up and letting-off motions. Those have been dealt with in Lecture 8, so exhaustively, that it is scarcely necessary to say anything with respect to them. We have the positive and non-positive take-up motions, and we have the so-called positive and friction let-off motions. With respect to the take-up motions it may be said to be a matter of opinion as to the relative advantages of what may be termed the intermittent and continuous positive motions respectively. For instance, the intermittent motion must carry the cloth forward at each stroke of the reed, and it must carry it forward a distance corresponding with the space intended to be occupied by one pick of the weft; the continuous motion does the same thing, but instead of bringing the cloth forward the requisite distance at one movement it is gradually taking it forward in what might be termed a creeping fashion. Really they both come to the same thing in the end; the cloth is moved forward the requisite distance between, or concurrent with each stroke of the going part; but it is claimed for one that by the creeping method the equal tension of the fabric is maintained throughout. Whatever alleged advantage may accrue, in any event there can be very little difference; if the cloth is moved say $\frac{1}{60}$th part of an inch between each stroke of the reed, or during the time the reed is delivering its stroke, it can surely make very little difference whether the motion is a continuous one or intermittent, and more especially when we take into consideration what has been said of the elasticity of movement of the warp beam which must compensate for the variation in tension upon the warp threads by the opening and closing of the shed. If we were simply dealing with the carrying forward of the cloth without the attendant circumstances of the variation in tension by the opening and closing of the shed, and the elasticity of movement of the warp beam, or of the effects of the weft being beaten up to the cloth, then we might at once say, that the continuous take-up motion might possess considerable advantages in consequence of its apparent freedom from variation as compared with the intermittent motion; but when all the facts of the case are taken into consideration it seems extremely difficult to draw a line between the merits of the two systems. As to the negative, or what might perhaps be termed the non-positive motions, something of a more definite character might be said. Here we are dealing with a motion that carries the cloth forward exactly as it is given; the weft may vary in bulk to any extent, but the cloth will be carried forward only just as much as the pressure of the reed upon the weft gives to it. Here an extremely difficult situation might be created or imagined. For instance, let it be supposed that we are dealing with a fabric where there is great variation in the order of interweaving, such for example, as combination of plain cloth and a very loose twill, then the negative take-up motion might give us a result which would be very undesirable. I will suppose a case. We are making a checked pattern in which we have a perfectly plain ground formed, say, with wool or worsted warp; we have a stripe in the warp formed of silk and weaving in twill or satin order. We must have the stripe much finer in the set than the ground, but this degree of fineness is determined as a fixed quantity, say twice or three times as fine. Then we want to cross the fabric with a stripe corresponding to the warp, this also must be in a fixed relation to the ground; in the positive take-up motion we should arrange our change wheel so as to take up the exact rate of speed required for the ground fabric, and when we come to the crossing we should alter that rate of speed by a system of lifting, or operating upon the take-up catch, so that it moves the train of wheels forward one tooth at every second or third pick as required to correspond with the warp stripe. Then in this positive motion we have the power of controlling the relative degree of fineness of the ground and stripe to any extent, but in the negative motion we could not by any means so control it. We should be dependent entirely upon the relative bulk of the two materials forming the fabric, coupled with the relation of the orders of interweaving, which of course, even with the most careful system of calculation, could never be brought to that absolute degree of truth which would ensure the production of a fabric even approximating to perfection. Consequently we may say with the utmost confidence, that the negative take-up motion may be a most desirable one where evenness of bulk in the texture of a fabric produced from uneven yarns is aimed at, but in the production of absolutely even texture where variation of pattern occurs, or where we have a combination either of different orders of interweaving or of different yarns, or both, then unquestionably the positive take-up motion has the advantage. As to the faults caused by irregularity in working, sufficient has already been said to call attention to their general character, and I shall have something more to say in the lecture on cloth dissecting, so that I need not occupy time in speaking further of it at present.

With respect to the stop motions on looms their importance and value cannot be overestimated. In fact the success of the modern power loom may be said to be in a great measure due to the efficiency of those safe-guards which have been applied, for they not only ensure the work being carried on continuously, but also ensure, as far as possible, the freedom from accidents to, and faults in, the fabric. For instance, in weaving with an ordinary fast reed loom, if the shuttle should by any accident remain in the shed as the reed comes up to the cloth, every thread on one side of the shuttle, and for the full length of the shuttle, must be broken by the pressure of the reed upon it if the stop rod is not in existence, or from any accident be non-operative. This means not only a serious fault in the cloth, but in most cases hours of labour in taking up the threads and putting everything into working order again; but with the stop rod in proper working order nothing more serious can happen than the sudden stoppage of the loom with a more or less violent concussion and accompanying noise: so that one cannot insist too strongly upon the necessity of this stop rod being kept in good working condition, and more especially of not neglecting the brake arrangements being in perfect working order. The same remarks will apply also to the loose reed loom, where the arrangement shewn in Lecture 11 for allowing the reed to fly out of the loom when the shuttle is caught; where circular boxes are employed or where from any reason the stop rod cannot be applied; every attention must be paid to the working parts being in such good condition that as the shuttle is being thrown across the reed is held sufficiently firm to resist the pressure upon it, and the moment when pressure would be placed upon the shuttle in the event of this being caught the reed should be as free as possible, and then as the reed comes up to the cloth it should be held as fast, or as firm in its position as it can be by the use of the finger and frog, but should the shuttle be caught it must be at liberty to fly out and with as much ease as can be, and avoid risk of injury to even the most tender warp. The knocking off arrangement and the use of the brake must have the same attention of course as in the stop rod loom.

With respect to the shuttles, little more need be said than has already been said in Lecture 11, beyond impressing the necessity for keeping the shuttles in good condition, for instance a few of the points may be enumerated which are liable to cause trouble. The point of the bobbin must neither be too high nor too low, otherwise constant breakage of the weft will be occurring as the bobbins become empty, which means loss of time, faulty cloths and broken picks, and general irritation. The shuttle peg must not be too loose or the point of the bobbin may rise above the shuttle and tear down the warp threads. It is no extraordinary thing in weaving light fabrics, if the point of the bobbin should rise, to see threads torn down by it for almost the entire width of the fabric; again attention must be paid to the strength of the shuttle, so that the pegs shall not split the wood and render them useless. The grain of the wood and the proper seasoning of it are matters of no small importance, for if a shuttle should split in weaving, the results to the warp are disastrous. The tension of the yarn accompanied with proper regard to the power exercised in picking, will have no small influence upon the production of a good fabric and more especially good selvedges, and it is a recognised fact both in the factory and the warehouse, that a good selvedge adds considerably to the value of a piece of fabric. The use of this expression might be misleading, as it carries with it the suggestion that a good selvedge simply lends smartness to the appearance of a piece by the fact of its being straight and even; but there is much more involved, for it implies at once that if the tension of the threads had been sufficiently even to make a good selvedge, that it must have ensured a corresponding evenness in the fabric itself; consequently the question must be treated as a whole, and regard paid to the selvedges with a view to ensuring the fabric being good and even throughout. The temples form no inconsiderable item in the production of a good selvedge and consequently in the production of a good even cloth, Wherever the tendency of the fabric is to contract, either in consequence of the open texture, the character of the pattern, or the natural elasticity of the weft threads, temples must be employed, and the more perfectly these are adjusted, so as to keep the cloth at an even tension and perfectly straight in front of the reed, the better this work will be done: and even where the tendency to contraction is very slight the temples may be of considerable value.

Then with respect to the weft fork little need be said beyond what has been already said, as every one must recognise, that for efficiency of working, the chief items for consideration are proper timing of the several parts, and more especially the perfect balancing of the fork so as to avoid any risk of breakage of the weft, and to ensure sufficient sensitiveness for the fork to act and avoid stopping the loom unnecessarily. With regard to selvedge motions they are in themselves important as enabling us to make a firm selvedge, which in many cases may really be a necessity for the protection of the body of the cloth. Simplicity of arrangement must always be aimed at; the loom is sufficiently complicated without adding to it unnecessarily, but efficiency must never be cast aside for the mere sake of simplicity, though as a rule the two accompany each other. I have dealt pretty fully with the principle of shuttle guards although I have not attempted to describe more than a few of those which have come into use, and although they may be desirable, or may be necessary in weaving some classes of goods, such for instance as very heavy fabrics, or fabrics made from strong fibrous yarns and where great force is exerted in picking, yet I would again repeat that the most efficient shuttle guard is a thoroughly competent overlooker.

With respect to looms for special purposes, it is scarcely necessary to take up time in what would be simply the reiteration of what I have said in reference to them. Every manufacturer and every loom maker must take special pains to adapt his loom to the work it has to do, to avoid unnecessary complication in the machinery; to have his looms sufficiently well balanced in parts that there is no unnecessary power required to drive them, and to have them sufficiently strong and well built to withstand the strain and bear the force of the concussion in the process of weaving.

As to the special advantages which each loom may possess, that would be at once determined by an examination of the strength and weight; for instance the light looms shewn in the early part of the lectures on plain weaving when compared with the lasting loom described in Lecture 12, will at once shew that the light loom would not be suited for weaving heavy lasting goods nor the lasting looms for weaving light goods. Again the heavy Dobcross loom although eminently suited for woollen goods is too pondrous for weaving many other classes.

Coming to the looms for very special work such as the swivel and the lappet loom, their functions are for producing in the one case either very narrow fabrics, or fabrics ornamented with extra material at intervals, or they are devoted solely to the production of fancy fabrics, each having a characteristic of its own. So that we may sum the whole thing up by saying that the manufacturer must first possess a general knowledge of the principles of weaving, of the different systems of ornamentation and a special knowledge of the requirements of the looms for special purposes.

LECTURE 14.

CLOTH DISSECTING.

Under the head of cloth dissecting I propose to treat the whole subject of analysis and testing, so that we may not only be able to copy a pattern from one fabric and reproduce it in another, or similar fabric, but also to be able to analyse a cloth thoroughly and completely, and determine everything which may lead to a thorough understanding, not only of how the cloth is made, but what it is made from. For instance, we may have to dissect or analyse cloths for various purposes; the most common use of analysis is for the purpose of reproduction, either of the same or the making of a similar fabric. It may be for the purpose of discovering a fault or cause of imperfection existing. In any case the term analysis or dissection should embrace every known test and every known method of examination which will enable us to discover either, what is vaguely termed quality of threads of which a cloth is composed, or the quality of the material, or the quality of the fabric itself. It involves the calculation or determination of the weights or counts of yarn, the tensile strength of both yarns and fabrics; the twist of yarns and elasticity, evenness and general characteristics. The question may be asked, how can we carry out tests which will enable us to determine all those qualities? The leading characteristics can, as I shall be able to shew, be well defined and determined, but there are certain qualities which must of necessity be matters for judgment. What I might term the determinable qualities, or characteristics of quality, I will endeavour to take in order and shew how each one may be treated as follows:—

A. for counts. B. for evenness. C. for strength. D. for elasticity, and E. for twist. I will then endeavour to illustrate how each one of those elements of quality or quantity may have an influence upon the structure of a fabric, and tend to produce either good or bad results. Before entering into the details however, I must make it clear that for a proper analysis of the cloth the analyst must be able to determine with absolute accuracy any or all of the characteristics which have been referred to. Guessing, estimation, or approximation may sometimes serve useful purposes, and an expert may arrive at almost absolute truth from a knowledge gained by long experience, but even the most experienced should never place too much reliance upon either a rough comparison or an estimation, or what is sometimes termed a judgment, of cloths or yarns for any important matter at stake. Undoubtedly a sound judgment based upon a long experience and careful observation may go a long way, and may not only support the most careful analysis, but will unquestionably in the face of difficulty suggest the direction in which experiments or tests should be made. I will endeavour to shew as I go along in dealing with each of the several tests what influence any one of the qualities which have been referred to may have upon the fabric, as a knowledge of the influence will be of value to the analyst in two directions, first in the determination of the structure of a cloth which is intended to fulfil any given condition, and second in the discovery of any mixing of yarns, or the use of yarns in the production of fabric differing, either from the original pattern after which it may have been made, or from the original intention of the designer. It is no uncommon thing after a designer has made out his particulars of a fabric, specified the exact counts, quality and character of the yarn to be employed, for the fabric to come up altogether different to that which he anticipated. The differences may be apparently so trifling as not only to be undiscoverable to the ordinary observer, or even the expert, which properly examined, and with a proper knowledge of the influence will at once render an explanation of what otherwise appears to be a mystery.

TESTING FOR COUNTS.

In going over the system of yarn testing for the purpose of ascertaining the counts I will take first the one in common use in the mill, and where large quantities are available, because by doing so I shall be able to make the whole system more intelligible and point out the necessity for absolute accuracy, both in the apparatus employed and in the methods adopted for the purpose of securing the best results. There are two considerations which must in the first place be thoroughly looked into, the one is the method of indicating the counts in the yarn we are dealing with, and the other the condition of the yarn itself. If we are dealing with worsted yarns the determination of counts is based upon the number of hanks of 560 yards each contained in one lb., but in cotton the number of hanks of 840 yards each, and in woollen and other materials varying according to practice of the district. The general principle however being once laid down will be equally applicable to all of them. It will be only a question of varying the formula to correspond with the relative lengths of the various systems. As to condition, we may test a yarn, for example as it comes "red hot" from the spindle; we may test it after it has been kept in a cellar for a sufficient length of time to be conditioned, and then we may test it after it has been made into a cloth and subjected to the processes of dyeing and finishing; but we should have in each case to consider if any, and what allowances should be made for the state of the yarn in which we find it. For instance for some purposes the testing of the yarn as it comes from the spindle would be utterly misleading; the fibres would be absolutely dry, at least so far as moisture is concerned, although they may have some oil upon them; they would in many cases be charged with electricity, the fibres would be projecting from them in every possible direction: any test made of the strength or elasticity would be unreliable; an examination for evenness would not necessarily give the best possible results. The yarn must be placed in the cellar or other damp place for the purpose of discharging the electricity; it will then acquire a certain amount of moisture and the question of proper condition is dependent upon this amout of moisture. The regulations of the conditioning houses say that this amount of moisture, is for worsted 1 oz. $4\frac{1}{4}$ drs. per lb., or a regain from absolute dryness of $18\frac{1}{4}$ per cent.; for cotton a regain of 1 oz. $4\frac{1}{4}$ drs. per lb., or a regain of $8\frac{1}{2}$ per cent., and silk 1 oz. $9\frac{1}{4}$ drs., or a regain of 11 per cent.; so that for a proper estimation of the counts of yarn it should be brought to one standard condition which may, of course, be either absolute dryness or with a regulation amount of moisture. Then again in estimating yarns taken from a cloth there is another element; after a thread has been woven into a cloth, and subjected to dyeing and finishing, there is a greater or less amount of curvature, or perhaps they might be termed corrugations in the thread; so that the thread taken from a cloth which represents one inch in length may be anything from $2\frac{1}{2}$ to 20% greater than one inch: then the question should be, how should we measure this individual thread? The natural answer is by pulling it straight, but in doing that we are liable to make an error even greater than the one we are correcting ; pulling straight may mean a great deal of stretching, especially if the yarn is of a very elastic nature. To attach any fixed weight for the purpose of stretching the thread to its normal condition would again be misleading, as the same weight could not possibly serve for yarns differing in strength, in weight and in the nature of the fibres of which they are made; consequently judgment must be exercised, and, as I shall have to point out later, it is better in most cases to take the length of the yarn as being equal to that of the cloth from which it is extracted and make an allowance

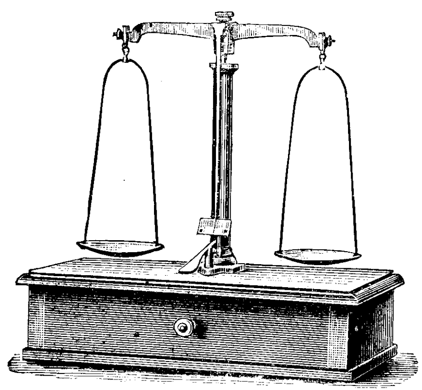


Fig. 303.

for loss or shrinkage on the one hand, and the length due to the corrugations on the other. Then suppose all those general conditions to be settled, we may proceed to the actual discovery of the counts of a given yarn. In dealing with the yarn in the bulk there are several rough and ready methods adopted. For instance a hank may be weighed, or any fractional part of a hank, with a recognised standard weight, and the weighing may be done either upon an ordinary balance or by what is commonly known as the quadrant. A simple balance sufficiently good for weighing either a hank, or say anywhere from forty yards upwards, is shewn at Fig. 303, but it would not be sufficiently fine to weigh any small

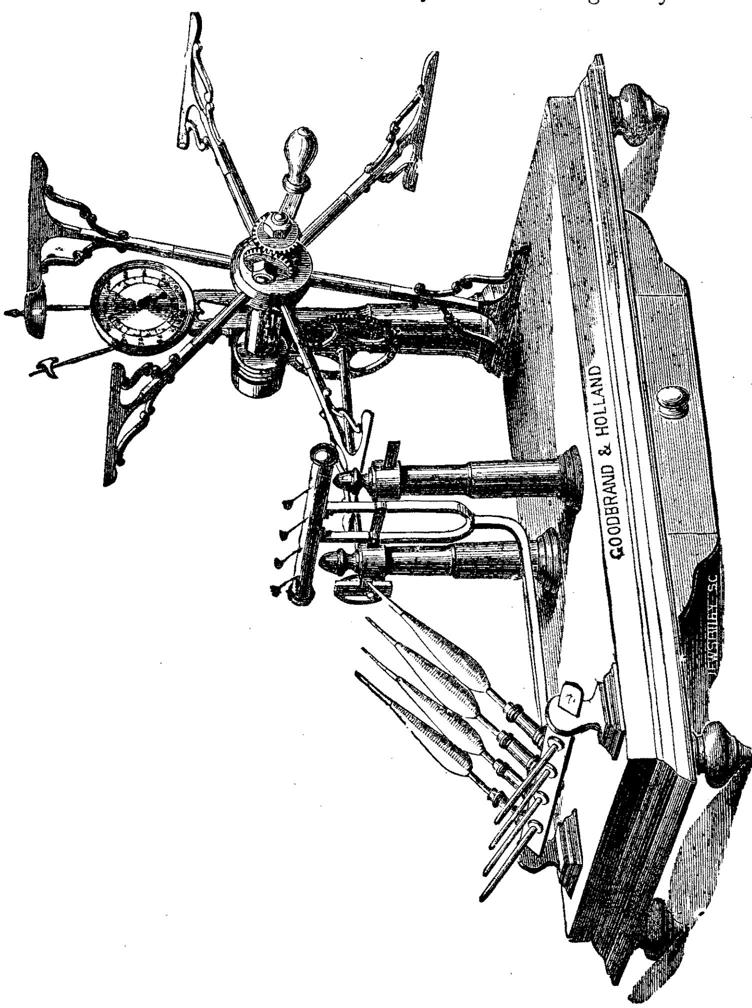


Fig. 304.

quantities; then the mode of procedure is to reel from the cop, or the hank, a given number of yards on an apparatus illustrated at Fig. 304. Here a wrap reel, as it is termed, is shewn, with which we can draw the yarn either from cop, bobbin or hank. The circumference of the reel itself is usually one or one and a half yards, and a dial driven by a worm wheel indicates the number of yards put upon the reel, and if we are reeling a full wrap of say 80 or 120 yards, an indicator bell placed over the dial gives warning the moment that length is put upon the reel. Suppose, for instance, we are reeling from four cops, as shewn in the illustration, we might make any length from each cop, and then weigh them either separately or collectively. An important matter in connection with reeling is the proper distribution of the yarn upon the reel. For the purpose of ensuring this being done in the best possible manner the guide eyes through which the threads are passed are placed upon a rail which is made to move from side to side by means of a worm and wheel and a short counter shaft, as seen in the illustration, so as to spread the thread evenly over the surface of the reel, the object being to prevent any overlapping, as it must be obvious that when overlapping does occur some of the threads must be longer than others; this must interfere with the absolute accuracy of the measurement, although no allowance is made for it in the trade, the overlap being recognised as part of the actual length. Then of course the tension upon the thread will also have an influence, and this tension will vary when the yarn is drawn from a cop, a bobbin, or a hank, and the velocity at which the reel is revolved will also influence it. The recognised velocity in the conditioning houses being at the rate of 560 yards per 120 seconds. Then after the requisite number of yards have been reeled the question of weighing comes in, the usual practice is to reel, as I have already said, a fixed number of yards and weigh by standard weights, sometimes the standard weights being made and numbered to represent the actual counts. Suppose for instance, our standard weight is made for one hank, then that indicating the counts of 30's yarn would be equal to $\frac{1}{30}$th part of a lb., that indicating 20's yarn would be $\frac{1}{20}$th part of a lb., and so on. If on the other hand we reel a fraction of a hank, as say 40 yards, which would be $\frac{1}{14}$th part of a worsted hank, then this weight would be divided by 14, or in other words we should have it represented in grains; that for indicating counts of 30's yarn would be equal to $\frac{7000}{30 \times 14} = 16\frac{2}{3}$ grains, and the same formula would answer also for any other count. Another system is to reel a number of yards corresponding with the alleged counts of the yarn. Suppose, for instance, that the yarn is said to be 30's, then 30 yards of yarn would be reeled off and weighed, if worsted against a weight of $12\frac{1}{2}$ grains, simply because there are 7000 grains in 1lb. and 560 yards in one hank, therefore if one hank weighed 1lb. one yard would weigh $12\frac{1}{2}$ grains, hence it follows that whatever number of yards weigh $12\frac{1}{2}$ grains the same number of hanks must weigh 1lb. In the same manner we should divide 7000 by 840 for cotton and obtain a standard weight of $8\frac{2}{3}$ grains, and so on for any other material. Then by this process it follows that if a surmise as to the counts of yarn is not correct that more must be added, or some taken away, as the case may be, this being usually done in $\frac{1}{2}$ yards or $\frac{1}{4}$ yards, so that although when dealing with bulk this system of determining the counts of yarns may be sufficiently near accuracy, for practical purposes, it must be evident that for purposes of analysis it is not accurate.

Before entering into finer analysis it will be necessary to deal with another method of ascertaining the counts, that is by the use of what is known as the yarn quadrant. One form is shewn at Fig. 305, it is commonly known as the hank quadrant, and is graduated for the purpose of weighing one hank at once. As will be seen it consists of a pillar with an adjustable foot, and fixed firmly to this pillar is the quadrant, from which it takes its name; hinged to the centre of the quadrant is, what might be properly termed, a balanced lever, having a hook at one

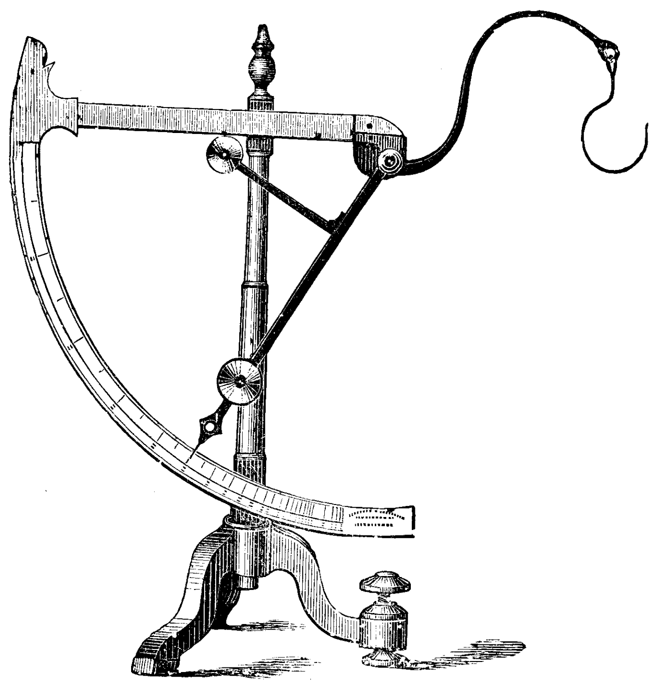


Fig. 305.

end upon which the hank may be placed for the purpose of weighing, and an indicator at the opposite extremity which shall point to the exact counts of the yarn upon the graduated dial of the quadrant. This lever is so balanced, and the indicator so graduated, that the moment a hank is placed upon the hook the counts of yarn will be at once determined.

Another and a more delicately balanced one is shewn at Fig. 306, and which is made for weighing a much smaller quantity of yarn than that shewn at Fig. 305. On the face of it it seems as though very little need be said as to those two pieces of apparatus, for the simple reason that the dial is graduated, and the lever balanced, so that the counts of yarn, or the weight of cloth will be indicated at once, and therefore apparently the analyst need not trouble himself any further. But to the student

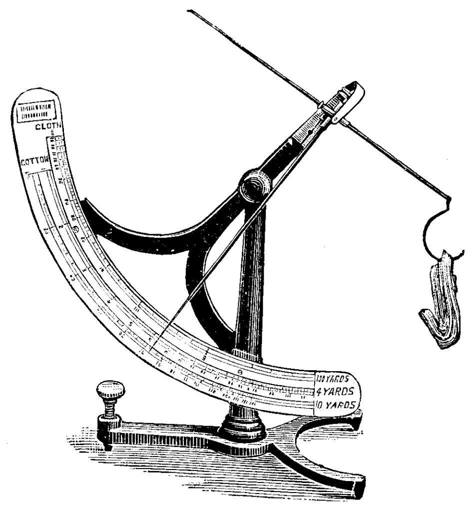


Fig. 306.

there are two questions of importance, first, how, and upon what principle is the dial graduated? And the second, what would be the influence of temperature upon the accuracy of the balance? I will deal briefly first with the principle of graduation. I have made a line diagram at Fig. 307, which will enable me to explain briefly the principle. One arm of the lever with the hook attached to it as shewn at H and the corresponding arm pointing to the dial would, with the hook in its present position, be opposite the point 7 on the large quadrant, the two thus being at right angles to each other. We have to consider first that the arm H and the arm I, are so balanced in relation to each other that when the arm I is placed in a horizontal position, it would require a weight of say 10lbs. upon H to keep it there. And on the other hand, if the arm I is brought into the vertical position and H to the horizontal position they would exactly balance each other. We then know their exact relations to each other in respect

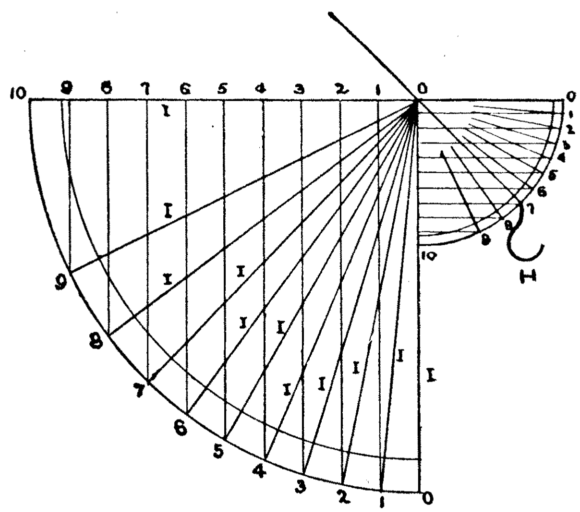


Fig. 307.

to weight, and of course leverage. Now then, assuming that the two lever arms are placed at zero or at the point O, then if they are balanced in the manner suggested, a weight of 1lb. placed upon the hook H will bring the lever I to point 1 on its quadrant, the weight of 2lbs. would bring it to the point 2, and so on in succession up to 10; the long lever approaching horizontal and the short lever approaching the vertical line in precisely the same ratio. The reason of the graduation then becomes obvious; when the arm I is in a vertical position, and the arm H in the horizontal, the length of I may be said to be nothing, but if it is moved a distance corresponding to one tenth of the radius of the quadrant, then it ranks as a lever of 1 inch length, assuming the radius of the quadrant to be 10 inches, for it must be obvious that the length of the lever is represented not merely by the distance it travels through the arc of the circle, but by the distance which would be represented by a vertical line dropped from the horizontal radius; consequently for the purpose of graduating the quadrant we should first divide the horizontal radius into the number of equal parts corresponding to the weights intended to be represented—I have taken in this case 10 as a matter of convenience—then drop a vertical line from each division to the circumference and it must be obvious that as the lever arm I travels from one point to the other in succession that the length of lever arm it represents will correspond to the number on the dial and consequently assuming, as I have done, that the divisions represent lbs. it would indicate lbs. weight required to bring it to each point in succession. The weight of the corresponding lever arm H must of course be taken into account and I have graduated the arc through which it travels for the purpose of shewing that the two would necessarily coincide; then what appears to be a third element in the matter is the third lever arm shewn as being at right angles to the arm I. This is simply a balancing arm, and it may be so arranged, either in its position or as to its weight, as to be an exact counterbalance to the hook arm H: or it may be used as a means for varying, or of producing what might be an equalisation of the graduation on the dial. The first suggestion is probably the one most generally acted upon, but in either case of course its position, the arc through which it travels, and its influence upon the relation of the two arms at every point of movement must be carefully estimated, otherwise graduation could not be perfect.

So far the principle of graduation is easily understood; we have then only to look at it from another point of view. In Fig. 306, there are three indicatory dials on the quadrant, one graduated for weighing 10 yards, one for 4 yards and one for cloth. The two yarn dials will be seen to be graduated in precisely the same manner as the rough diagram I have shewn at Fig. 307, but the cloth dial is graduated in the opposite direction; a little reflection will explain the reasons for this. The heavier the yarn the lower the counts, and consequently as the weight increases then the number decreases, so that although there is no actual difference in the method of graduation, there is a difference in the order of numbering, so that the counts are indicated with the highest numbers at the bottom, but the weight of cloth is indicated by the highest number at the top. Of course the difference in the scales in relation to each other will be explained and understood by the difference in the weight. In dealing with cloths or yarns where a fair quantity is available, and where absolute accuracy is not necessary, but a sufficient degree of accuracy for general commercial purposes, the quadrant is a very convenient instrument, but where the quantity available is variable, or where absolute accuracy must be obtained, then of course its disadvantages appear. Each scale must be graduated for a fixed length and only that length can be weighed with certainty upon it. Then there is another element of inaccuracy of such a nature that the Board of Trade will not sanction it as a trustworthy indicator of counts in any official department; the well known influence of temperature upon the metals causing expansion and contraction which must of necessity interfere with the absolute truth, but yet it may be sufficiently accurate for the general mill purpose.

KNOWLES' PATENT YARN BALANCE.

This is a yarn balance which although differing in structure from the quadrant is intended to serve the same purpose and to ensure a greater degree of accuracy. As will be seen at Fig. 308, the general arrangement is after

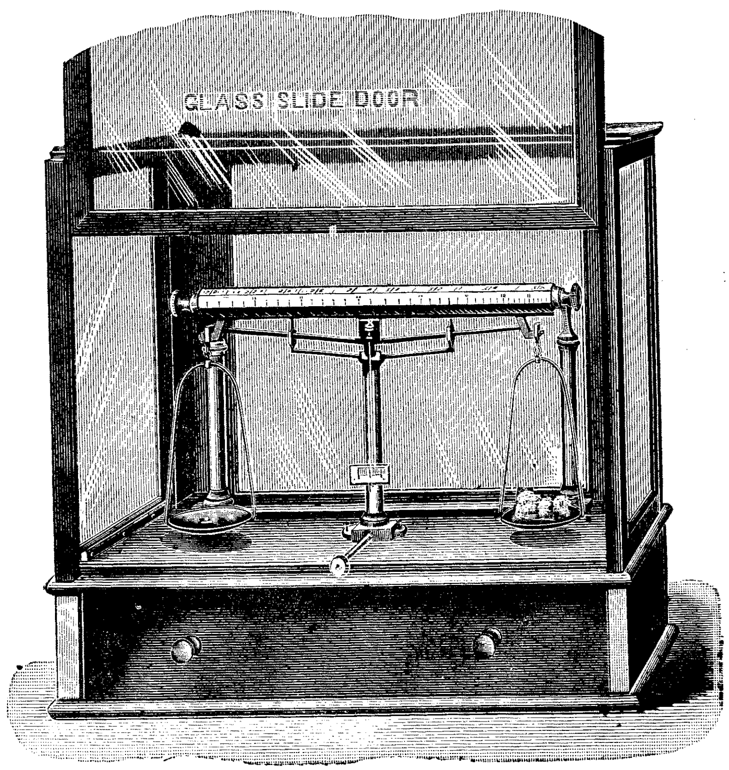


Fig. 308.

the character of an ordinary chemical balance; there are two pans, the one to the left on which a weight of a given denomination must be placed, and the one to the right upon which the yarn must be placed. The balance during the operation of placing the weight and the yarn in the pans is at rest in precisely the same manner as a fine chemical balance; behind the beam a graduated bar is placed, having a number of flat surfaces, each surface being graduated to correspond with the varying counts of yarn; suppose, for instance, the surface A is graduated to represent from 20's to 40's, and B might be graduated from 40's to 60's, C from 60's to 80's and so on; then a weight corresponding and marked with each of the several graduations would be placed in the pan, just as one or the other scale is brought to the front: an indicator sliding along the beam points to the number of the yarn being weighed. Then for the operation of weighing, the moment the weights and the yarns are placed in their respective pans, the lever in front of the pillar is pressed down and the indicator is moved along the beam to balance the scales, and when they come to rest will point to the exact counts of yarn. The machine is finished in a very fine and delicate manner, so as to ensure accuracy, and is enclosed in a glass case to prevent dust getting into the joints. Possibly some objection may be raised to this as to other forms of automatic balance in consequence of the variation caused by temperature, but it must be obvious that it cannot be affected in the same degree as the ordinary quadrant.

It will now be necessary to enter fully into the use of balances and weights for testing the smallest possible amount of yarn. The first, and most important, apparatus is a first class balance, such as the one shewn in Fig. 309 enclosed in a glass case so that it will not only be kept free from dust but from draughts when in use; with adjustable screw feet so that it can always be set perfectly level, and the firmer the table on which it is placed and the better; in fact in careful weighing, if there is the least vibration the accuracy cannot be depended upon. As will be seen, the balance is provided with rests, and also with a steadier for the pans, so that when the material or the weights are being placed in the pans they are not swinging but are held perfectly steady. In addition to those provisions there are a pair of rods, as seen projecting from each side, each carrying a small hook for the purpose of placing riders on the beams when it is desired to work to a degree of accuracy beyond the limit of the usual weights. The first thing to do is to take care as to the

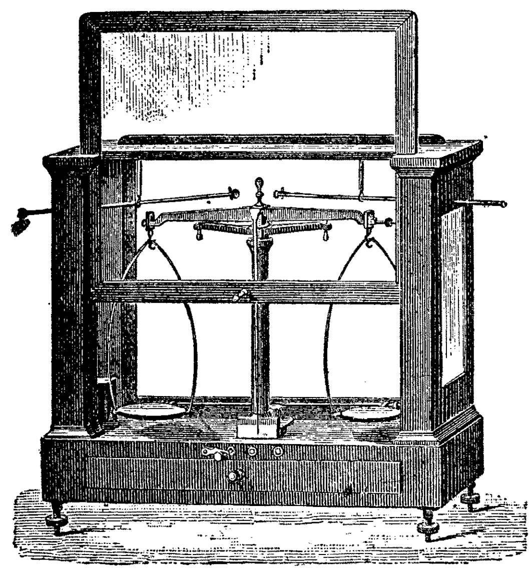


Fig. 309.

accurate adjustment of the balance; place it on a firm stand or table, level it by means of the screw feet, then close down the front of the glass case and test it with a view to adjustment. A small adjustable screw at the end of the beam to the right permits of this operation being carried out perfectly; but the balance must not be considered as adjusted until it will stand with the pointer exactly opposite the centre of the ivory indicator at the base of the pillar; this having been done it is ready for use. The next thing is to secure a set of good weights, those may vary in extent from anything representing say 1000 grains, or from 100 grains down to one-hundreth part of a grain. The grain weight is to be preferred for ordinary determination of counts, as it can be readily worked into the English systems, but if the work should be for the simple purpose of determining percentages, such as for loss in treatment, or the relation of one material to the other in a fabric, then the gramme weight is most convenient, being based on the decimal system. Then taking the grain weight, what we should have would be a set ranging from 100 grains down to 1/100th. As following:

100 grains	6 grains	·6 grains	·06 grains
60 ,,	3 ,,	·3 ,,	·03 ,,
30 ,,	2 ,,	·2 ,,	·02 ,,
20 ,,	1 ,,	·1 ,,	·01 ,,
10 ,,			

and with such a series as this the test can be carried out to almost any degree of nicety. A box is shewn at Fig. 310. For the present I shall speak only of ascertaining the counts of yarn, the questions of shrinkage, gaining by stretching and other matters must be left until a later stage. Then assuming that we have only a very small length of yarn available, say, for example, a few inches; we must weigh it and ascertain the exact number of grains it will weigh; suppose, for example we have 6 inches and it weighs ·25 grains, then 1 yard would weigh 1·5 grains, and as there are 7000 grains in one lb. there would be $4666\frac{2}{3}$ yards or $8\frac{1}{3}$ hanks per lb. Suppose we put it another way we might find the counts by a direct formula, for instance there are 7000 grains in a lb., and, as already pointed out, if we divide 7000 by 560 we have a standard weight of $12\frac{1}{2}$ grains, which corresponding with the yards in one hank will give the counts, so that, let L represent the length of yarn weighed, W the weight in grains, we should have the formula: $\frac{L \times 12{\cdot}5}{W} =$ counts, or in this case $\frac{1 \text{ yard} \times 12{\cdot}5}{1{\cdot}5} = 8{\cdot}33$, or if 6 inches be taken it would be $\frac{6'' \times 12{\cdot}5}{36 \times {\cdot}25} = 8{\cdot}33$.

In the weighing of these small quantities too much care cannot be exercised, as the most minute fraction in the weight will make a difference in the counts of fine yarns

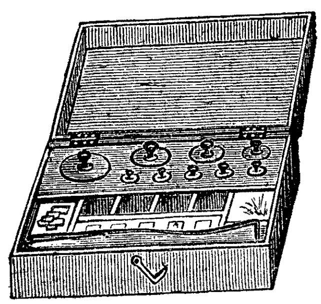


Fig. 310.

of several numbers. In many cases perhaps only a few inches may be available, whilst in others a yard or two may be obtained. The analyst should always get as much as he can so as to reduce the error to the lowest point.

In addition to the weights mentioned there are riders or small weights of fine platinum wire to place on the beam, the beam is graduated as a scale so as to indicate the value of the rider from the position in which it is placed, so that the same balance may indicate the weight to the 1000th part of a grain.

For those who can afford it is best to buy a good balance, which may cost anything from 7 to 20 guineas, but good, and fairly reliable ones may be had for from 2 to 3 guineas.

TESTS FOR EVENNESS.

So far the tests have been applied only to the determination of the counts in yarns, but we have now to come to tests which cannot be measured with the same degree of scientific accuracy, but which are in themselves quite as important in the production of good fabrics. We cannot look at the production of threads in the same manner as we might look at the production of say a brick; absolutely evenness and straightness may, in many cases, be the chief thing aimed at, but there are instances where this is not the final consideration, although no doubt in the great majority of fabrics it is one to which the closest possible attention must be paid. In any case we must have some means of ascertaining, or judging as it is termed, of the degree of evenness in any yarn. Sometimes this is done in a rough and ready manner by drawing a thread from a bobbin and casting the eye along it. The practised eye can form a very good opinion but it is sometimes difficult by this means to obtain a sufficiently reliable one; again sometimes the sense of touch is cultivated by running the thread through the fingers, and here a considerable degree of proficiency may be acquired, but something of a more tangible character is required of the kind shewn in Fig. 311, where a blackboard with a perfectly even surface is placed in a frame, the yarn being distributed by guide eyes, and driven by a screw from the main shaft of the apparatus in such a manner as to distribute the threads with perfect evenness upon the board, so that the bulk of one thread can be compared with that of another. Of course it will be understood that in making comparisons of this kind a number of threads will be seen side by side, so that all the variations in bulk may come within the range of vision at once. The question of evenness of yarn carries with it a good deal more than might appear at first sight, not from the mere fact that any unevenness in the yarn would cause unevenness in the fabric, but also because of the inequality in strength, and our methods of estimating must be reduced to that which would give us the most reliable results. But the

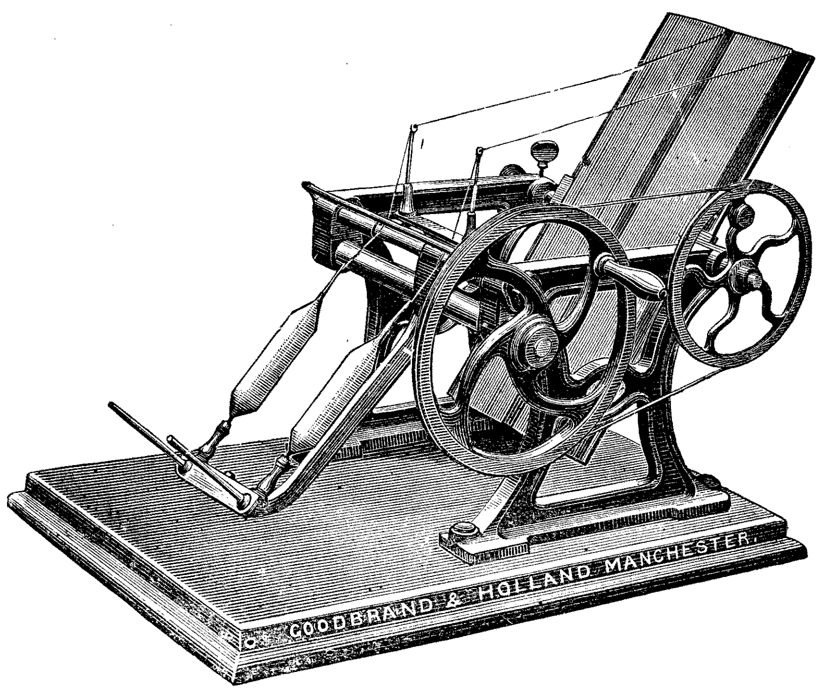


Fig. 311.

question naturally arises, what degree of inequality may exist in yarns, for instance a spinner may give a guarantee that his yarns will not vary more than from 1 to 2 per cent., and when tested hank by hank he may keep well within the guarantee, but in the average yarns of commerce the difference in the bulk as would be determined by micrometrical measurement would give vastly different variations. In a large number of experiments which I have made from time to time I have found in very good yarns indeed, variations in the thread drawn from the same bobbin to amount to not less than 30 per cent., although the average variation as tested by the usual tests for counts would not exceed in all probability 2 per cent.

STRENGTH TESTS.

In testing for strength of yarns there are many reasons why very strict attention should be paid, not only to the absolute strength, but to the degree of elasticity in the thread, and although I am proposing to deal first with the strength and elasticity of the yarn in the hank I shall have a good deal to say presently of the value of testing single threads for the purpose of discovering defects in fabrics, or of ascertaining the suitability of yarns for special purposes. The operation, whether taken in the hank or single thread, is both an important and delicate one, and although the apparatus appear, especially the hank testers, to be capable of a considerable amount of rough treatment, yet carelessness in their handling must have a most prejudicial and misleading effect upon the results. First, we may be asked what should create the necessity for a knowledge of this strength, or more especially elasticity. There may be many important operations or results dependent upon a thorough knowledge either of what a yard would stretch, or what may be its breaking strain, so that we may be able to determine either the absolute strength of the cloth; what may be the result of a certain process of treatment, either in the weaving or finishing, and what may be the ultimate result to the fabric as it will affect the application for which it is intended. Even in the simple process of weaving there are considerations which render it necessary that we should at times be able to determine the degree of elasticity and the strain the threads will bear. For instance, in many cases, if the yarn is lacking in elasticity, although it may have ample strength, we shall have some difficulty in dealing with it in weaving into some classes of fabrics.

In the hank tests there are several machines in use, driven either by hand or power, and having either a dead weight or a spring. The simplest of these is shewn at Fig. 312, which is driven by hand, and having a dead weight for determining the breaking strain. As will be seen the hank is placed upon two hooks, one immediately under the dial and the other near the base of the apparatus; a handle driving a worm which causes the lower hook to recede, pulling at the same time the upper hook, which acts upon a lever with a heavy weight attached will cause the weight to rise; at the same time the pointer on the dial is made to travel and indicate the strain upon the face of the dial; to the right is placed a rod which is made to travel with the hook and indicate the stretching of the hank before breaking, so that the moment the hank breaks the indicator on the dial is arrested, and so is the elasticity rod at the side, and the results can be read off at leisure. So far the apparatus will appear to be perfect, but the results obtained from it may vary considerably. In the first place it must be obvious that the yarn must be very evenly reeled, otherwise the test for elasticity would be of no value, as a considerable allowance must be made for the slack threads to come to the same degree of tension as the tight ones, and it is only after that that the real test of elasticity commences. Then again the rate at which the wheel is driven, whether it be perfectly regular or irregular, will have an important influence upon the test. Suppose, for instance, the moment the hank is brought to tension, the wheel be allowed to revolve very rapidly, then it would be brought to the breaking strain before a real test of elasticity could be obtained; on the other hand, if it is revolved slowly the yarn may be made to stretch in a degree beyond its

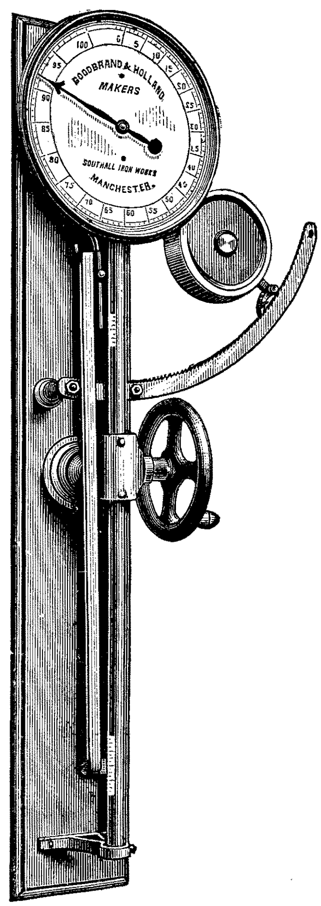


Fig. 312.

natural tendency, simply by subjecting it by a series of easy stages to a strain which is neither sufficient to break it nor to test its strain bearing qualities in the ordinary way, or its elasticity in a proper degree; in fact it would be a point where the endurance of the yarn may be more correctly said to be on trial. Inequality in driving will have a somewhat similar effect, for it may cause undue stretching at one point, and by too abrupt movement, a sudden fracture at another before the true breaking point is reached. What I wish to convey by this comparison is that tests applied to yarns in any irregular or spasmodic manner can have no practical value, as they neither indicate the real strain bearing qualities of the thread or its proper degree of elasticity; and the same yarn subjected to a number of tests under different conditions would give a variety of results, whereas good yarns tested under the same conditions for any number of times would give practically the same results. It is on this account that the power driven testing apparatus illnstrated at Fig. 313 is always preferred, the speed is uniform and is fixed to be driven at what might be termed a medium rate; the operator cannot play any tricks with it, as it must be obvious that in the hands of either an incompetent or unscrupulous operator the hand machine may be made to prove almost anything which he desired it to. In conditioning houses, a standard rate of speed of 5 inches in 15 seconds between hook and hook is imposed, so that the tests should be of one uniform character.

For the purpose of testing, the hank is placed upon the upper and lower hooks in the same manner as in Fig. 312, and the belt is thrown from the loose to the fast pully communicating motion to the bevelled gearing at the side of the machine, causing the lever and weight to travel up the rack, at the same time indicating in the same manner as in the previously described instrument the strain, by the pointer and figures on the dial. When the hank breaks, the catches seen at the end of the lever hold firmly in the rack, thereby causing the pointer to stop and indicate the number of lbs. at which it broke. The top hook descends a little as the lower one descends, and an

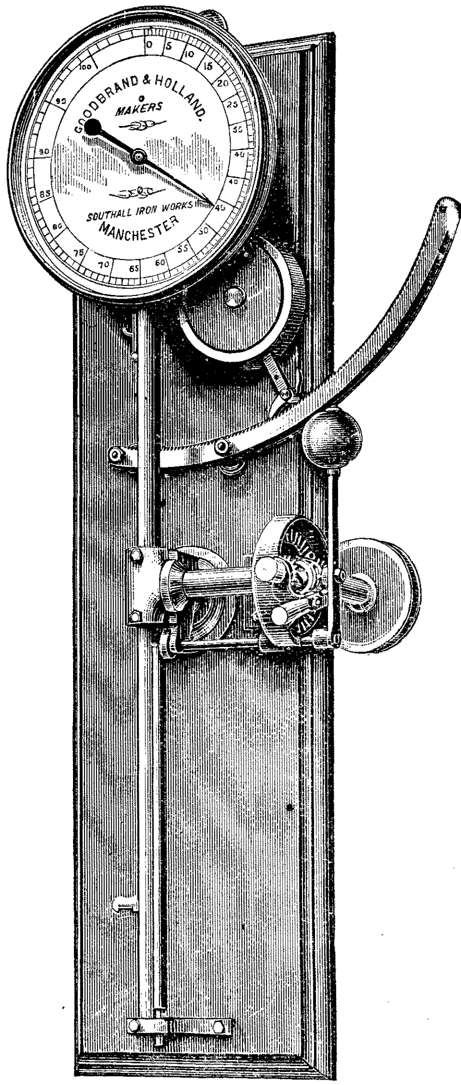


Fig. 313.

indicator is attached to it, which measures the exact amount of the descent on a scale on the upper tube which is divided into inches, and a corresponding indication is made on the lower tube; then to ascertain the amount of elasticity, the figure denoted on the indicator of the upper tube is deducted from that upon the lower one, the difference being the exact number of inches the yarn is stretched. The self-acting stop motion is very simple; when the yarn or hank breaks, a catch acting upon the levers pushes the strap from the fast pulley to a third pulley, causing the machine to run back to the starting point, *i. e.*, it takes the upper hook back to the top after which the strap may be brought to the middle or loose pulley again, where it remains until it is required to be put in operation. For hank testing this is unquestionably a good machine.

Another important machine is that for testing the strength and elasticity of single threads. I should like here to lay very great stress upon the necessity of paying strict attention to tests of single threads, and at the same time to give one word of warning as to the unreliability of tests made in a careless manner. A single test of a single thread either for strength or elasticity can possess no practical value; every thread varies not only in its diameter as I have already said, anything up to 30%, but it varies also in the amount of twist, and as is well known, and as I shall have to demonstrate at a later stage, the thinner the thread and the greater amount of twist will run into it. Then in the thick parts the fibres may have a tendency to slip from each other, and instead of the thread breaking, it would be simply drawn asunder, or it might break at any thin or weak part; in the one case there would be a clear fracture of the fibres, but in the other the bulk of the fibres would remain intact. In neither of those two cases could the breaking strain or the elasticity be taken as a fair record, and accidents of this kind are always liable to happen in ordinary threads. Of course in hard spun threads the tendency to variation will not be so great, still it would have some existence: but without looking at the extreme cases there must always be a variation, consequently it is never safe to rely upon one test, but a number of tests should be made and the average taken of the results. Ten to twelve tests is not unreasonable and I should not like to place any reliance upon any experiments of less than that number. These remarks will apply not only to strength, but elasticity as well.

Now I would wish to point out the necessity of applying single thread tests for the purpose of discovering any inequalities in yarns, more especially when taken from cloths. I will give one or two illustrations for the purpose of impressing this. Supposing the warp for a cloth to be made from yarns spun from the same counts, having the same number of turns per inch, and to all appearances in every respect the same; one possesses a great deal more elasticity than the other, or a greater tendency to shrinkage; then in the process of finishing they will behave differently, and as a consequence, the fabric will present the appearance of stripiness, and the stripes may be of the most irregular character, the irregularity being dependent of course upon the manner in which the threads have been mixed. Then how is the fault to be traced to its source? Threads are taken out of a cloth and tested for counts and proved to be exactly the same; they are tested for twist and are proved to have the same number of turns per inch; they are examined for quality, but the question of quality is a matter of opinion or judgment; there is nothing to prove it, and as a matter of fact two yarns may be of precisely the same quality and yet possess a different degree of elasticity; the difference either being due to their treatment after spinning, or to one having been spun a long time and become set, and the other, as I have already explained, come fresh from the spinning frame. A proper test of the elasticity, or of elasticity and strength combined, would disclose at once that there is a difference in the yarns. If the difference is in elasticity only then probably the fault will lie in the treatment

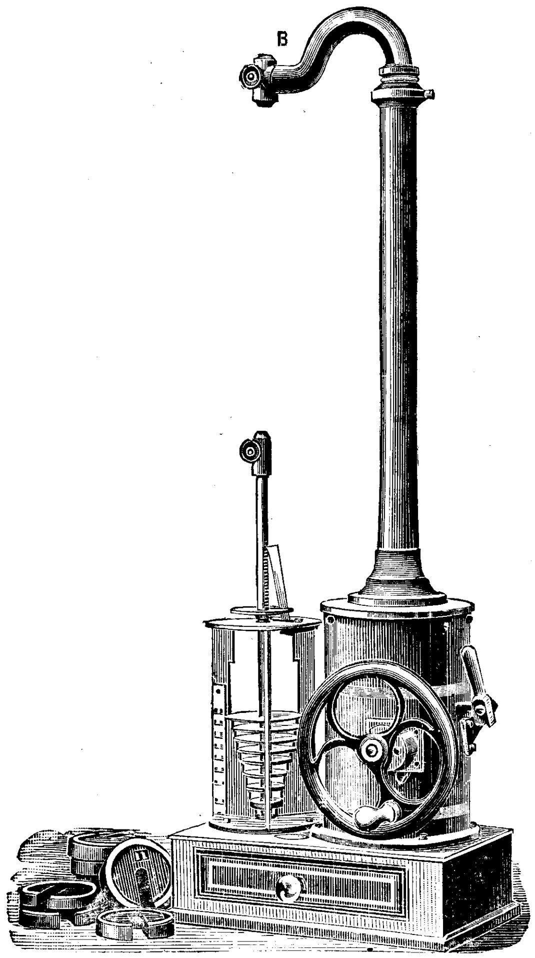


Fig. 314.

after spinning, but if in both elasticity and strength it would probably indicate a difference in quality. I have had many cases come under my observation where a single thread test for elasticity alone has led to the ascertaining the cause of the fault, consequently I feel disposed to lay considerable stress upon it.

One machine for testing strength with elasticity of single threads is shewn at Fig. 314. The apparatus is extremely simple. A vertical pillar carries a small clamp at the end of a bent arm at its upper extremity; immediately beneath this a vertical spindle is placed with a corresponding clamp; this spindle passes down into a sort of holder for weights, and upon one side of it is a rack which may be engaged with a catch as it rises. Then the thread to be tested is screwed firmly into the two clamps, and a handle at the base of the pillar operates a toothed wheel, which, being engaged in a rack raises a spindle with the upper arm; this gradually lifts the small spindle and weights suspended by the thread; as this spindle rises it lifts one weight after another until the breaking point is reached, when the breaking strain will be indicated on the dial placed alongside the weights, and the degree of elasticity indicated upon the spindle held, as it is, rigidly by the catch engaged in the rack. To all appearances this machine would be perfect, but there is one fault which must not be overlooked, that is the variation of tension at which the threads are screwed into the clamps, if the thread is left slack, of course, the degree of elasticity would appear to be very great, whereas if it is pulled tight it appears slight in comparison. Only practice and judgment can determine what shall be the proper tension before proceeding with the test.

Another machine for testing single threads is shewn at Fig. 315, and for reliability I should prefer this, where the question of elasticity only is concerned, to the one already described. In this case the threads are screwed into a clamp on the horizontal tube to the right and passed through another clamp at the top of a pillar to the left, then over a horizontal bar and fastened to a small weighted lever; the object of this latter part of the apparatus being to ensure that each thread tested shall be held at exactly the same tension, for it is not made fast in the clamp on the pillar until the weight behind has brought it to its proper degree of tension. This weight is, of course, capable of variation to suit the different counts of yarn. Then all being in readiness, a little wheel is revolved and acting upon a rack upon the tube, gently carries it along until the thread breaks; a most ingenious stop arrangement comes into action; on one side of the tube a long wire is hinged, having a small pulley at its free extremity, the pulley resting upon the

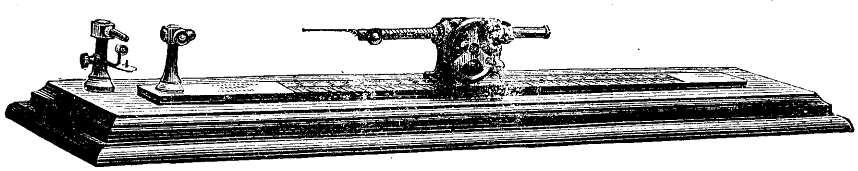


Fig. 315.

thread being tested, but having no appreciable weight; the moment the thread breaks this wire drops, and engaging a catch falls into a notch on a ratchet wheel and arrests the further progress of the tube. This stand carrying the tube is moveable upon a species of bed plate marked in inches. The tube itself is also marked in a corresponding manner, so that we can see at once the length of the yarn being tested, as also the length it is stretched before breaking, and can easily ascertain the degree of elasticity. Suppose, for instance, we set the apparatus to test 10 inches, and it stretches one before breaking, we know at once, and can express in figures the degree of elasticity as being 10 per cent., that is, it will stretch 10 per cent. of its length before it breaks; but in testing single threads, as I have already pointed out, we must take a number of tests and then take an average. Again we must make a careful examination before recording a test, first, to ascertain whether a fracture, properly speaking, exists, or whether the fibres have been drawn asunder, and we must look whether the fracture has occurred close to the jaws, because if so, it is not a proper fracture, but is a cut by the jaws being screwed too tightly upon it. Then if at each test the fracture is what may be termed a proper one, the average of the tests being taken would give a fairly reliable result. There is one feature of the case here which may perhaps have some interest as bearing upon the question of the relations of elasticity and strength; threads spun to the same counts, and from fibres of the same quality, will, presumably bear the same weight and strain, but may differ considerably in the degree of elasticity. There will be presumably the same average number of fibres in the thread throughout its length, but if the thread is very softly twisted there would be a tendency in the test to draw out, and therefore the elasticity would appear to be greater than it really is; but assuming that they are sufficiently firmly twisted to fracture all at the same time, then a difference in breaking strain, or a difference in the degree of elasticity would suggest a difference in quality. But the thread which is hard twisted must of necessity stretch more and break at a higher point than the soft twisted thread, properly speaking, because of the firmness with which the fibres are held together and the necessity of drawing them to nearly a straight line before a fracture actually occurs.

In respect to the question of quality it is often assumed that the yarn which possesses the greatest degree of elasticity has the most "quality;" that may be true or not, if both are twisted in the same degree it is probably true, but the twist must be taken carefully into account.

As regards quality there is another factor, namely, the fineness of the fibre of which the thread is composed; fineness of fibre and quality would be in most cases synonomous terms, but the term quality implies even more; the fibre must be in good condition, evenly grown, and possessing all the qualities of loftiness, and with those conditions present there would be no difficulty in determining the quality.

THE TWIST OF YARNS.

In dealing with the question of twisted yarns we must approach the subject from a point of view beyond that merely involved in methods of testing. The first question one is naturally inclined to ask is, what number of turns should there be in the yarn? The answer would depend naturally upon the purpose to which the yarn is to be applied. In the first place, it would be generally the relations between the warp and weft. There may be general rules which are sufficient for the guidance of spinners when no special conditions are laid down or required; any departure from those general rules, or what we might term standard twists, would produce hard or soft twist yarns, just as the departure had been made in one direction or the other. For instance, in cotton spinning, there is a general empirical rule for determining twists of any count of yarn, viz.:—to multiply the square root of the count by $3\frac{3}{4}$ for warp and by $3\frac{1}{4}$ for weft, the product being the number of turns per inch required. This comes out very well in general practice but it is not exactly true, although sufficiently near to serve all the purposes, especially in yarns of lower counts. The twist must be varied according to the square of the counts on the well-known principle that the areas of circles vary, not in the ratio of the diameters, but as the squares of the diameters. Consequently if we treat the threads as representative cylinders, the variation in the counts will determine the variation of the number of turns in the ratio of their square roots, in consequence of the counts going higher as the thread becomes finer, or in other words of the counts and the diameters being in inverse ratios. This may be demonstrated immediately by drawing two lines parallel to each other at a distance of say one inch apart, and drawing lines diagonally at any angle to represent the twist; suppose for convenience of illustration lines be drawn at an angle of 45°, that would illustrate one turn per inch in a thread of one inch in diameter; now draw another thread of $\frac{1}{2}$ inch in diameter and draw diagonal lines at 45° also to represent the twist; then there will be two of those diagonal lines in one inch of the thread; but although the threads have diameters of 2 to 1 relatively, their weights will be as 4 to 1, simply because of their weights being in the ratio of the squares of the diameters. Then we say that the twist varies as the square roots of the counts, and if we call the one inch yarn in this case 1's counts and the $\frac{1}{2}$ inch yarn 4's we have the exact ratio of the weights. Then the square root of 1 is 1, and the square root of 4 is 2, therefore we have one turn per inch in the 1's and two turns per inch in the 4's yarn; then this rule must of necessity hold good in any number. But to return to the empirical rule before referred to, Dr. Ure makes reference to it in his "Cotton Manufacture," and gives the correct method for working it out. But here as in everything else we must have a starting point, and this starting point he takes what he alleges to be the standard used in some of the Scotch mills, where he says they make "25 turns per inch for 50's warp yarn and the same number for 60's weft." Then if we have this as the starting point we can readily determine the number of turns for any count; it would simply resolve itself into the formula, as $\sqrt{50} : \sqrt{36} :: 25 : x$ or as $50 : 36 :: 25^2 : x^2$, assuming the yarns to be 36's; then the same rule will hold good for any other yarn. Of course from this base, or from any other base adopted, we may make the yarn hard or soft and we should only have to consider its influence upon the fabric and the influence of take-up in doubling or twisting, and afterwards the methods of testing.

THE TAKE-UP OR CONTRACTION IN YARN TWISTING.

When yarns are being twisted together what is known as the "take-up" or contraction will have a material influence in determining both the length or counts of the folded yarn, and also the character of the thread, and in analysing cloths the determination of the character of the thread is important. The importance may have bearings in two directions, first, the influence of the character of the thread upon the fabric, and second, the influence of the twist, or the method of twisting upon the counts. Suppose we are twisting two threads together of equal counts and quality in any material, as for example 60's cotton, we should be said to be making a two-fold 60's yarn. Really we should be doing so, but the yarn would not be of the value usually expressed by the term 2/60, and which would be equivalent to single 30's, but it would be heavier than that, there has been some "take-up" in the twisting. Now let us see if we can discover the value of this take-up.

Assuming the two threads to be equal in every respect, and held at the same tension during twisting, each will form a diagonal across the other, and each will be bent out of the straight line a distance equal to the diameter of the thread, as shewn in the illustration at Fig. 316, so that there would be two diagonal lines for each turn or twist, and each of those diagonal lines must represent a distance equal to half the diameter of the two threads combined, as shewn from A to B and from B to C, With this data, coupled with a knowledge of the diameter of the thread the take-up or contraction should be readily discoverable. For instance, the cross section of the thread, and a line drawn equal to the length of the half twist, may be treated as two sides of a right angled triangle, and the line of the twist as the hypothenuse, as shewn from A to C. Then as pointed out in my "Treatise on Textile Calculations," the diameter of the thread may be found either by reference to the tables given there or by extracting the square root of the yards per lb. of the yarn, which is really a deduction from these tables. For instance, suppose the yarn to be 20's cotton, thus $20 \times 840 = 16800$ yards per lb., and the square root of 16800 is 130 nearly, or the diameter of the thread is

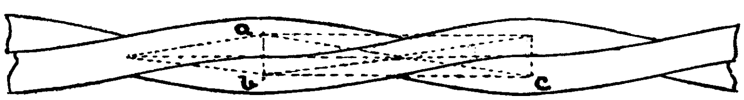


Fig. 316.

$\frac{1}{130}$th part of an inch; but for the diameter of the doubled thread we must not add the two diameters together, but treat them as a folded yarn, on the assumption that the two together would make one of exactly double the weight, but not of double the diameter. That has already been explained. Then the diameter of the compound yarn would be equal to $\sqrt{10 \times 840} = 92$ nearly or $\frac{1}{92}$nd part of an inch. Now suppose we have eight turns per inch in the yarn we have to ascertain what will be the length of yarn required to make one-eighth of an inch of the twisted yarn, or in other words, what will be the amount of the take-up. It will resolve itself practically into the question of the length of the hypothenuse representing the length of yarn required to make the length of folded yarn equal to the altitude of the triangle. Then the formula for working is, hypothenuse H is equal to base B^2 + altitude A^2, therefore there being two hypothenuse for each twist in the thread it will be $\sqrt{\frac{1}{92}^2 + (\frac{1}{8} \div 2)^2} = \frac{1}{8464} + \frac{1}{256} = \frac{8720}{2166784} = \frac{1}{247}$ and $\sqrt{\frac{1}{247}} = \frac{1}{15 \cdot 64}$ and $\frac{1}{15 \cdot 64} \times 16 = \frac{16}{15 \cdot 64} =$ 1·0294 or nearly 3°/₀ take-up. There would then be a little more gain in getting the jaw into condition.

When the threads are not of the same bulk, the bending would take place in a greater degree in the thin than in the thick thread, and the allowance of length would have to be varied proportionately, but in what are known as the corkscrew yarns one thread is held perfectly straight to form a core, and the other twists round it, as shown in Fig. 317. Then taking the two threads as A and B, the length of yarn of A will not be varied, as there is no take-up, but the length of B will be

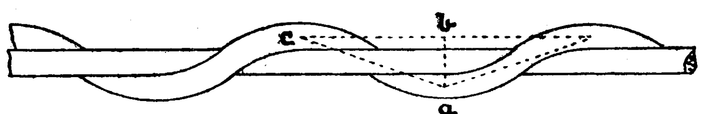


Fig. 317.

varied as the length of the hypothenuse C, and to find this we should have to add the diameters A B to find the base, and proceed as before thus, taking the counts as 10's worsted for both threads, we should have $\sqrt{560 \times 10} = 74$ nearly as the square root or $\frac{1}{74}$ as the diameter, then say with 6 turns per inch, and to find the length of yarn for one inch we should have $\sqrt{(\frac{1}{74} + \frac{1}{74})^2 + (\frac{1}{6} \div 2)^2} = \frac{1}{37}^2 + \frac{1}{12}^2 = \frac{1}{1369} + \frac{1}{144} = \frac{1513}{197136} = \frac{1}{130 \cdot 3}$ and $\sqrt{\frac{1}{130 \cdot 3}} = 11 \cdot 4$ and $\frac{1}{11 \cdot 4} \times 12 = \frac{12}{11 \cdot 4} =$ 1·052, or an increased length of the bending thread of 5·2%.

This formula is not absolutely correct, for it treats the threads practically as though they were flat bodies instead of cylinders, so that to the length of the hypothenuse should be added the difference between the diameter and half the periphery, as representing the length of yarn taken up in bending round the core thread, and which would be equal to the diameter multiplied by $\frac{3 \cdot 1416}{2}$. Then to reduce the fractions to decimals for ease of working, $\frac{1}{7 \cdot 4} = \cdot 135$ the diameter, and $\cdot 135 \times \frac{3 \cdot 1416}{2} = \cdot 212$ and $\cdot 212 - \cdot 135 = \cdot 077$ as the length taken up in bending: then the length of the hypothenuse is $\frac{1}{11 \cdot 4}$ or $\cdot 88$, and $\cdot 88 + \cdot 077 = \cdot 957$, and $\cdot 957 \times 12 = 1 \cdot 1484$, or a gain of nearly 15 per cent.

In the actual process of twisting there would be some compression of the threads and consequently this would be reduced considerably in most cases. As pointed out in my "Textile Calculations," the influence of bending is in the direct ratio of the cubes of their diameters if the threads are held at the same tension, but this tension is varied by spinners in accordance with the character of yarn it is desired to produce, so that the take-up would be between the two extremes I have demonstrated.

Then as to the methods of testing twisted yarns; there are many methods in use, some of a reliable character and others very unreliable; of course it must be understood that in testing single yarns there is always considerable difficulty because of the almost impossible task of following the number of turns through the individual fibres, and even in the best twist testing apparatus the length to be tested must be carefully considered in relation to the length of the fibre, otherwise if too great a length is attempted, the moment the whole of the twist is taken out the thread will fall apart. One method sometimes resorted to is to place a magnifying glass and count the number of turns per inch, this is a most unreliable one, not simply on account of the difficulty of counting the number of turns per inch, but also on account of the difficulties attending an equalisation, or supposed equalisation of the threads, and the fact that only a very short length can be measured by any magnifying glass of reasonable power;

consequently one test may be made upon a very thin part of the thread, and the next upon a very thick one, so that to obtain any reliable result a large number of tests must be made, and an average taken. It is best, wherever possible, to test as great a length as is available, say 10 or 12 inches, and even then a number of tests should be made to find an average. A very good instrument is shewn at Fig. 318; this consists of a base board with a brass plate upon it marked off in inches; to the extreme left of the plate is a little upright pillar with a pair of jaws or clamps at its upper extremity; sliding along the plate is a pedestal carrying a short shaft with a worm

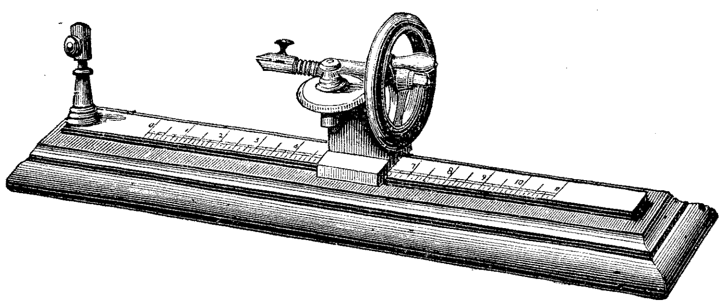


Fig. 318.

upon it made to revolve a disc placed horizontally. To the left of the shaft is a clamp, or pair of jaws, holding one end of the thread, and at the opposite extremity a small wheel to be revolved by hand. The horizontal disc or plate is simply a dial divided round the circumference so as to indicate the revolutions of the horizontal shaft and worm; in fact there are two dials, one inside the other, one indicating the number of turns when the wheel is revolving in one direction, and the other when revolving in the opposite direction, so as to ensure accuracy of counting. Then the pedestal is moved along the plate to a position corresponding with the length of yarn to be tested; one end of the thread made fast in the jaws on the horizontal spindle, and the other made fast in the jaws of the small pillar.

At this point perhaps attention should be called to what was said in relation to the question of elasticity. If a thread is drawn to tension after being fixed in one jaw by means of the fingers, it is liable to great variation, and no test could be considered absolutely reliable, therefore it is better to have a weighted lever, as shewn in the elasticity test at Fig. 315, for the purpose of ensuring all the threads of one series being held at one tension. This having been done, and the thread secured in the clamps, the wheel is made to revolve, until the twist is entirely taken out of the thread; the surest method of determining when the twist is entirely removed is to insert a dissecting needle between the two threads close to the pillar at the extreme left, and gradually slide it along as the threads are untwisted from each other until it comes to the jaws on the horizontal spindle, when of course the threads must be absolutely free from twist. Then the number indicated on the dial will be the number of turns for the whole length of thread, and that divided by the number of inches tested will represent the number of turns per inch. Suppose, for instance, we are testing 5 inches, the dial indicates 45 revolutions of the spindles, then 45 divided by 5 will give us 9 turns per inch. That of course is an average for 5 inches only, but it must be obvious that an average of 5 inches can scarcely be taken as a true average for a large quantity of yarn; in fact I should scarcely consider a series of tests reliable unless I have taken averages representing at least from 60 to 100 inches, varying of course with the bulk and quality of the yarns under examination.

There are several forms of twist testers, but the principle is the same, the difference being mainly in the mechanical arrangements for facilitating the work; such for example as making the jaws revolve at each extremity of the thread in opposite directions, or by the use of gear, making the spindle revolve twice for each revolution of the handle wheel. But in any case there is no difference in the principle, it is only a difference in the mechanism.

A few words may be said with reference to the necessity for testing yarns to ascertain the number of turns per inch. To enumerate all the irregularities in cloth which have been brought about by uneven yarn and the difficulties of detecting it would be an almost impossible task; for instance, for some purposes it is necessary that the yarn should be very hard twisted, and it is equally essential that each succeeding lot must be absolutely up to the standard of twist, then just as it is necessary to test the counts to ensure the yarns being equal in weight it is equally necessary that we should be able to test for twist so as to have the quality of the fabric even throughout. Of course the question may naturally be asked, why all these precautions? There may be many reasons. For instance, the spinner may have instructions given to him specifying that his yarns must have so many turns per inch, but to increase his production, or to save labour, he may easily alter the wheels of his spinning or twisting frames so as to produce a little less number of turns but an increased quantity in bulk. So that the manufacturer may be at the mercy of a dishonest spinner or the honest spinner at the mercy of a dishonest workman; again, of course, variation in twist may be the result of accident, and faults in cloth arise. I have seen numbers of cases where in consequence of a slack band on the spinning or twisting frame, or from one of a multitude of causes, either one bobbin has been spun, or doubled, with less twist than the rest, or variation in the thread upon the same bobbin which has proved most disastrous to the fabric; consequently, although the matter appears to be trivial, yet it is one of the most important points to be watched in the preparatory stages.

HOW TO DISSECT CLOTHS.

The actual dissection of fabric with which we have now to deal means, first, the determination of the weight of any cloth actually submitted; second, the ascertaining of the pattern of such cloth; third, the nature of the materials from which the cloth is made, and the actual proportions of each material in the case of its being a compound fabric; and fourth, the determination of the existence of foreign matter, such as size, &c., and the exact quantity. Then first as to the determination of weight, counts, &c., I will endeavour to describe the best modes of procedure. The simplest method is first to weigh a given quantity of the cloth, such as one square inch, and after having ascertained the weight of that, in grains, to work out the weight, either of one square yard, or of one lineal yard, by the width of the fabric usually made. Suppose, for example, we are dealing with woollen goods, or heavy worsted goods, we have a constant expression used, that the cloth weighs so many ounces per yard; a yard means usually 54 inches wide by 37 inches long, the odd inch being an allowance by the manufacturer to the merchant, and by the merchant to the retailer, for leakage in measuring; sometimes by special arrangement the yard is 38 inches, and again in others there are extra allowances beyond this for leakage; sometimes for the purposes of declaration in shipment to foreign countries, for the purposes of duty assessment the weight must be declared per square yard. No matter which of the systems it is necessary to act upon the principle involved is the same, and I am merely calling attention at the present moment to the variety, so that what I shall have to say presently as to the use of plates or dies will be better understood. I will suppose first that we are working strictly to the square inch. We must have some method of cutting out this inch of cloth with absolute accuracy. Really there are but two methods of doing this, one by the use of a steel die, which encloses exactly one square inch, the outer edges being bevelled for the purpose of grinding or keeping sharp so as not to interfere with the actual area enclosed: this steel die is placed upon a cloth, struck with a wooden mallet so as to cut the piece of fabric out. There are objections to the use of the die; the use of the mallet unless in very skilful hands is not certain to make a clean cut all round, and any little irregularity will interfere with the weighing when it is desired to obtain absolute accuracy. I have generally found it better to place the die upon the fabric, hold it down firmly with the left hand and with a very sharp knife cut round it; but what is much better than this, as permitting one to see exactly what they are doing, is to have a piece of plate glass cut exactly to one square inch, and it can be laid upon the cloth and the operator can see that the edges are parallel with the warp and weft threads respectively, and can also see when a clean cut is made, so that there need not, at any time, be any mishap or failure to make a clean cut, everything being distinctly visible. For the purpose of cutting either a specially made V shaped knife, something like the common erasers used by bookkeepers, or what is even better, an old razor blade fixed firmly in a handle will serve all the purposes.

Another advantage of the use of glass plates is that a number could be made at a comparatively small cost which will serve the purpose of determining the weights per yard of any given cloth. For instance, I have had occasion to recommend to manufacturers and merchants the use of glass plates which enable them to determine at once the weight per yard of any given fabric for a fixed width without a second weighing or calculation. We are dealing with cloths 54 by 36 inches, and it is desired to have a plate which will enable us to determine the weight of cloth in ounces at once. 54 by 36 will give us 1944 square inches; there are 7000 grains in one pound; therefore if we divide 7000 by 1944 we should have 3·6 inches as a quotient. Now suppose we have a glass plate made which covers 3·6 square inches, whether it be 3·6 inches in length by 1 inch in width, or in any other proportion we can cut out a piece of cloth which we may weigh, and the number of grains this bit weighs will exactly correspond with the number of ounces per yard. This at once saves not only the use of any reference tables, or the system of calculation necessary to be followed for determining the weight, but also ensures readiness, and perfect accuracy of results. With the balance such as has been described, and with glass plates, ground as they might be to perfect accuracy, and readily obtainable from any good glass cutter or scientific instrument maker, there is no further trouble; but assuming these not to be immediately available, then the most convenient method is to weigh 1 square inch, and having ascertained the weight of 1 inch we can easily ascertain the weight per yard. Suppose, for example, that the square inch weighs 4 grains, and we want to find the weight of the square yard. Then the calculation would simply be $\frac{36 \times 36 \times 4}{7000} = \frac{648}{875}$ or very nearly three-fourths of 1 lb. Of course the calculations should be worked out to perfect accuracy in ounces and fractions of an ounce. Then for complete analysis a number of weft threads must be taken out, not necessarily out of the square inch, but preferably out of a larger piece of cloth, weighed and the counts of yarn ascertained in the manner already described. The counts of warp must also be determined in the same manner ; then the number of threads per inch in both weft and warp must be discovered. In some cases this is a somewhat difficult matter, and in others perfectly easy. For instance in closely milled fabrics it is difficult to pull the threads asunder, and in consequence of the fibrous character of the threads, it is equally difficult to count the number per inch; with a comparatively open fabric, and smooth threads, the usual practice is to use what is termed a piece glass; these are well known in form, having a stand or base with a hole cut in it, sometimes ½ inch by ¼ inch, sometimes 1 inch by ½ inch, and sometimes 1 inch square. When working with ¼ or ½ inch, great care must be taken to count the threads accurately, as it must be obvious that the error of a fraction of a thread per inch would prevent the agreement of the calculation from the counts of the yarn to the total weight of the fabric. It may be said that when the counts have been discovered and the number of threads per inch in both warp and weft ascertained that the whole process is complete; practically that is true, but it is always better to work out the calculation to the weight of a yard from the counts of the yarn and the threads per inch, so that it can be verified by the actual weighing of the cloth.

A very good method of counting the threads per inch is to make an inch gauge, which can be done by any one simply by inserting two needle points in a small piece of wood at exactly one inch apart. Place the cloth down upon the table and insert the needle points, then with a sharp knife or scissors cut away the warp threads from each side leaving only those enclosed within the inch guage; then with the weft threads pulled away from them say to the extent of ¼ of an inch, as shewn in Fig. 319, the threads per inch can be counted with perfect accuracy, either with the naked eye or with a magnifying glass, If the fabric is a very fine one I generally find it more convenient to use what is known as a watchmaker's glass than the naked eye, *i.e.*, a glass which I can place and hold in my eye, and taking the fabric in my left hand lay off the threads from the left with a dissecting needle point and hold them between the finger and the thumb as they are counted off. By this method it is very seldom that a mistake could be made as the eye is not compelled to follow each thread and keep it in view as it is with

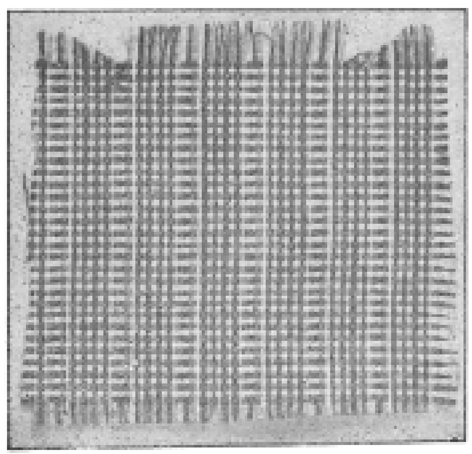


Fig. 319.

an ordinary piece glass in counting across a whole inch of cloth. If the fabric is a twilled one and the twill is visible, then it is perhaps easier, after ascertaining the number of threads in each pattern, to count the number of patterns per inch; or what is better still for ensuring accuracy to count the number of twills over several inches and from that reduce it to the threads per inch. I need hardly say that too much care cannot be exercised in counting the threads, because just as in the ascertaining of counts a fraction of error in counting the threads may make a very great difference in the calculation of the actual weight of cloth.

We now come to a question which is perhaps the most difficult to deal with of any one connected with the analysis of cloths. That is, what allowances should be made for shrinkage, what amount of loss or gain will occur in the process of finishing *a*, of the fibre lost in treatment, *b*, of loss by the removal of foreign matter, such as grease or dirt, and *c* the gain in bulk caused by the shrinkage of the fibres, or perhaps more correctly speaking, the shrinkage in the cloth by the fibres becoming more closely incorporated. First as to the fibres lost in treatment. Before this can be estimated we must know the character of the fibre itself; we must know the character of the thread, and the treatment it is subjected to in finishing. Suppose, for instance, we are dealing with very long wool, there is no loss in the process of weaving by what is known in some branches of the trade as "fly," that is, there are practically no loose fibres detaching themselves from the fabric, and consequently we may say that the whole of the calculation weight of the yarn goes into the cloth. Then in the process of finishing unless the cloth is subject to severe raising, or cropping, or cutting, again there is comparatively little loss; if the surface must be a clear one, as we find in bright lustre goods, then the whole loss of fibre would be due to the cutting and singeing of the stray ends projecting from the piece, which would be very trifling indeed, and the loss by the removal of foreign matter would also be very slight. On the other hand the amount of shrinkage in the threads would be slight, as the strong bright wools shrink very little. If we then come to the other extreme and deal with wools made from very short fibres, and more especially if we have a good deal of what the French very aptly term "*laine régénérée*," or what we vulgarly term "shoddy," then we may expect a considerable loss from fly, *i.e.*, loose fibres dropping from the yarn in the process of manufacture. We may also expect a good deal of loss in finishing, no matter what be the character of treatment to which it is subjected, and there may also be a fair amount of shrinkage in the width and length. If we are using good wool of a fine quality, whether spun into woollen or worsted yarns, the loss from fly would be comparatively small, the loss from foreign matter would be less than in shoddy, but greater than in yarn from lustre wools, and the shrinkage would be greater than either; then we should have to consider carefully what would be the relative counts of the yarn as it comes from the finished and the grey cloths respectively.

One general rule will hold good, although it must never be taken as being absolutely true, viz.: that the counts of yarn discovered in a finished cloth will be equal to the counts in the grey cloth; the loss occasioned in scouring by the removal of foreign matter, and in finishing by the raising and cropping will, in the majority of cases, approximately balance the gain in shrinkage. So that put very broadly, the grey counts and the finished counts will be practically the same; the loss on the one side and the gain on the other neutralising each other in the average.

METHOD OF COPYING PATTERNS.

I must now turn for a short time to the method of copying the design from a piece of cloth. This in itself is, with most people, the most difficult system of cloth dissecting; in reality there should be no difficulty at all about it. The common practice is to take out the threads from the fabric one by one and make a record by laying it down on design paper. This is laborious, and quite as uncertain as it is laborious. Generally speaking, the extraction of two or three threads, either of warp or weft, is quite sufficient to give a clue to the whole pattern; suppose, for instance, we have a common twill cloth, such as that illustrated in Fig. 320. We first proceed to remove a few threads of both warp and weft so as to leave a fringe; we then draw one thread away from the fabric as seen in the illustration, and ascertain how many threads the warp and weft passes under and over respectively;

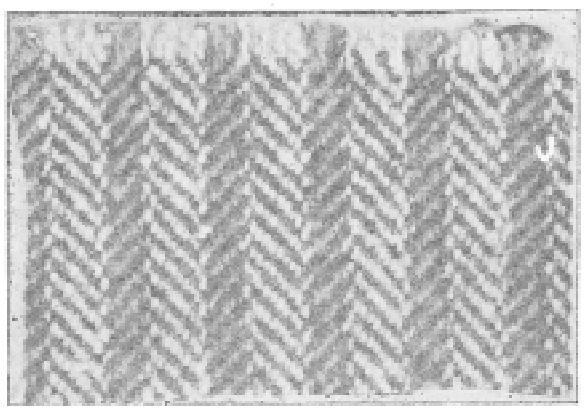


Fig. 320.

then having sufficient knowledge of the making of twills, and seeing from the succeeding pick that the order of the pattern follows consecutively, we can put the design down on paper without the removal of another thread.

Before going further I might say one word as to the method of ascertaining the order of interweaving; the simplest plan is to remove the threads of weft or of warp so as to make a fringe, then by means of a dissecting needle bring one thread from the body of the fabric as shewn in Fig. 320, and if the eyesight is sufficiently good, holding the cloth in the left hand with the threads pointing outwards, examine them with the point of the dissecting needle to ascertain how the weft and the warp interweave, or in other words, how many weft threads the warp passes under and over in each repeat of the pattern; if the cloth is so prepared that there is a fringe at one side, and at the top of the small sample being examined, then count continuously from the left, or from the right, as the case may be, and the moment the first thread has been put down on paper remove it from the cloth so as to prevent any liability to confusion; bring out the next thread with the dissecting needle in the same manner and copy it, and so on until a sufficient number has been copied to indicate the exact order of the pattern. Now I must assume that the analyst has some knowledge of pattern making to begin with, if so, in dealing with twilled cloths he will discover first whether the twill follows consecutively in the order of interweaving, or whether it is a combination of two or more twills. If it is a combination, then of course he will have to take out several threads, find the order of interweaving of each in succession, and from that determine the order of succession. Suppose, for example, the pattern should prove to be a combination of two simple twills, such as shewn at Fig. 321, he would first discover the order of interweaving of what we will term pick No. 1, then he will discover the order of pick No. 2, then he would take pick No. 3, and finding that No. 3 is like No. 1, and advancing only one thread in the order of succession, and that No. 4 is like No. 2, advancing also one thread in the order of succession, he will at once determine the nature of the combination, and it is not necessary to examine another thread in the pattern to ascertain what the whole is. Again, supposing we take a pattern as illustrated in Fig. 322, which is a combination of the same two bases, but taking alternate picks of each of the two component parts instead of taking them in consecutive order, the same rule will hold good, and the same mode of procedure would be followed. He finds each of the two parts of the pattern advancing two threads instead of one, therefore it is at once obvious that it is a combination of two patterns, taking alternate instead of consecutive picks. In arriving at a definite conclusion as to the nature of the combination or composition of the pattern he would be assisted by the general appearance of the pattern, for the angle at which the twill runs will indicate, generally, the character of the combination. Of course there are patterns which cannot be determined so

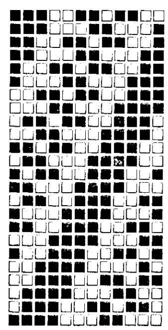


Fig. 321.

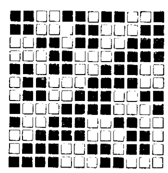


Fig. 322.

readily as either simple twills or combinations of simple twills, but most of those are based on twills and their order of succession may be determined almost as easily. For instance, there are such as what are termed crapes, which is a general term for a pattern which appears to have no regular order of succession ; in reality it is generally a twill re-arranged or transposed, either in satin or some other equally regular order ; then it is only necessary to take out two or three threads to see whether the order of interweaving of each in succession is the same, and the distance apart from each of the starting points, then the order of the arrangement will be determined and the remainder of the pattern can be carried out at once. The basis of these orders of arrangement I have already sufficiently laid down in my "Treatise on Weaving and Designing," and in "Design in Textile Fabrics" to render it unnecessary to deal with it here.

In dealing with striped or checked patterns the same system of treatment may be observed, but it will generally be simply a question of determining the number of threads occupied by the twill running in one direction and then in the opposite direction, or in the case of a re-arrangement or combination, ascertain the extent of each ; the actual analysis and the following of the individual threads in the orders

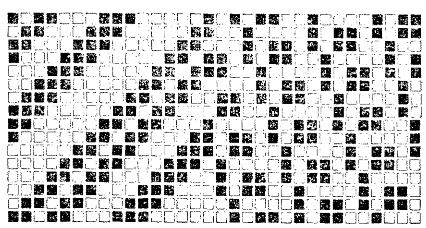


Fig. 323.

of interweaving need not, in most cases, go beyond that already illustrated, but a general survey of the surface of the fabric will enable one to complete the pattern without any further examination. For instance the pattern in Fig. 323 will give a general indication of what I mean by this, consisting, as it does, of a combination of two orders of interweaving, each being sufficiently visible on the surface and the order of succession readily followed; as a matter of fact it only requires in the analysis of a pattern of this kind a good general knowledge of the arrangement of designs and the exercise of that faculty of observation, which is usually termed common sense.

One difficulty often arises with the analyst as to the determination of which is warp and which is weft. The experienced analyst is not often troubled with this difficulty; he determines as it were by instinct; at the same time it is well to suggest to a student some general guiding indications even if they cannot be termed rules. First of all if the piece of fabric submitted has a portion of the selvedge attached to it there is sufficient indication as to which is warp and which is weft. Failing that he should examine the characteristics of the two sets of threads; it is well known that the warp is usually much harder twisted than the weft, so as to facilitate the process of weaving. Any Lancashire weaver will determine this at once, for their practice is not to speak of weft and warp yarns respectively, but to speak of twist and weft yarns; the term twist yarn is invariably associated with warp threads. Then again, the difference in the degree of thickness, if any should exist, will almost infallibly indicate which is warp, as the weft threads are generally, even in what is termed a square cloth, slightly thicker than the warp threads, and even if not actually heavier in counts the difference in the degree of twist will indicate at once the weft and warp respectively. In some fabrics, such as Cheviots for example, or worsted serges, the difference is so slight that it may be difficult to discover by a casual observation, for the pattern is usually such that the order of interweaving in both warp and weft is the same. On the other hand if it is a finished, or faced cloth, as we term it, the warp threads may be ascertained by the lay of the nap; then again, if we are dealing with a union fabric, such as cotton warp and woollen, or worsted, weft we may take it for granted that the warp is cotton; or supposing we have one all cotton to deal with, and one of the two materials is sized, both being single yarn, then the sizing will indicate the warp threads, the size having been applied for the purpose of facilitating the weaving; again we may have the evidence of reed marks where the threads have not been absolutely evenly distributed in weaving; and we may often be guided also by the character of the pattern, more especially if the fabric is closely set and there is a well defined twill which will run in the direction of the warp, and many other little evidences which perhaps would only be visible or noticeable to a close observer, but above all we must depend upon the faculty of observation, and we might almost say instinct, on the part of any one engaged in the industry coupled with a proper use of common sense.

In dissecting double cloths the work is more difficult than with an ordinary single fabric, because of the tendency to confuse the threads forming the back with those forming the face fabric. Two methods may be adopted, the one to examine each of the two cloths separately, or in some cases it would have to be the examination of the two surfaces separately; for instance, the so-called double cloth may be merely a double faced one, *i.e.*, there may be two wefts and one warp, or two warps and one weft, as the case may be; then in taking off the face pattern always remove the back thread, so as to leave the face perfectly clear, and in the same manner in copying the back pattern remove the face thread, and having got the pattern of the face and the back respectively gently draw a thread of each from the body of the fabric into the fringe, so as to discover the exact relations of the two patterns at the point of binding, and whatever the relations may be of the first two picks they must necessary follow throughout. In most cases without even taking the trouble to count the threads the relations of the two patterns, face and back respectively, may be determined because the rules governing the combination of two materials forming the surfaces are so definite that they can hardly be mistaken. The points of intersection must always be so arranged that the covering on both sides is perfect and the order of succession of the two patterns must be so as to retain this perfect position throughout. Consequently, whether the relations between the two are discovered by careful analysis, or whether they are surmised, the order must be maintained throughout; and it will be easy to determine almost at a glance, for the two patterns must always bear a definite relation to each other. For instance, a four end twill must either have a 4, 8, or 12 end backing, a five end twill must usually have a 5 or 10 end backing, and if the picks are alternate face and back, then both the patterns must either be twill or satin arranged upon the same base; but if there are two or more picks of face to one of back, then the relations of the two are determined whether the backing shall be a satin or any other order, and what shall be the basis of the satin. If the two cloths are separate, that is, one distinct cloth for the face and one for the back, then the pattern of each should be taken separately, following the same principle as before, and placed together in such a manner as to ensure good positions for binding. In many cases it is convenient to cut the two cloths absolutely asunder and after examining each for the pattern, then to follow the threads to discover the exact point of binding. Of course it must be understood that a successful analyst must have a sound knowledge of the principles upon which patterns are made and he must bring this knowledge to bear in the copying of the pattern from the fabric. Any attempt at slavish copying trhead by thread is liable to lead to mistakes, besides occupying an enormous amount of time, but possessing a sound knowledge of the principles to begin with any tendency to error would be discovered as the work proceeds, and consequently would be corrected on the spot.

When the materials of the face and back cloths respectively differ from each other, the analysis is very much easier, simply because the threads, face and back respectively, can be more readily identified; but in any case the two sets may be kept from each other sufficiently to prevent any confusion by the exercise of a little care. Occasionally for some special purpose a white thread may be drawn through between the coloured threads representing each fabric so as to hold them asunder, either for the purpose of ascertaining the order of interweaving or for determining the number of threads per inch. It is not often necessary to resort to this expedient, but it is a very useful one in cases of difficulty.

Probably the greatest source of trouble to analysts is the dealing with woollen cloths or cloths which have been heavily milled, or made from very fibrous threads. It is almost impossible either to pull the threads asunder or to distinguish them from each other, consequently the determination of both pattern and the number per inch is extremely difficult. Again, if they are in very dark colours, such as blacks, blues or browns, the difficulty is increased. There are two methods of dealing with this, the one is the application of an acid to remove the colour, and the other is the removal of the fibre by burning. In treating with acids very great care must be exercised, more especially if there is any cotton present, or the cloth will be utterly destroyed if the acid is too strong. Some people keep by them standard solutions of sulphuric, nitric or hydro-chloric acid according to their own particular fancy; in the use of any one of them there is an element of danger. Admittedly, if the colour is removed the fabric is better to see, but by far the best plan is to have the acid very dilute and make repeated applications, as in that case there is less liabilty to injure the fibre; exactly the same may be said of the method of burning or singeing. Some make use of a red hot poker, with the result that it will probably burn half through the fabric. The best and surest method is to use a small Bunsen burner which can be had anywhere for about 1/-. Get a small flame, but let it be a pure Bunsen flame, so that there shall be no smoke—anyone can discover whether this is sufficiently good without much previous training, the intense blueness of the flame will shew whether it is sufficiently good,—then pass the cloth gently over it and with a brush remove the singed fibres. Repeat this operation a few times until the threads are made quite bare. With care and a little skilful treatment even very closely milled fabrics may be analysed with considerable ease, for the simple reason that the Bunsen flame not merely removes the loose fibre from the surface, but will penetrate the cloth and burn away the fibres even in the smallest interstices betwen the thread, consequently leaving them free for examination. Of course this operation, like any other operation in analysis of any kind must be conducted with care. There must be no hurry over it, and at each singeing and brushing, or shaking, the cloth should be examined carefully to see whether sufficient has been removed; and with the exercise of care and skill even the most refractory fabric may be analysed. In some cases cloths are very bulky, such for example, as some of the thick roller covers made from wool; those it is impossible to penetrate either with flame or acid without destroying the outer surfaces; very frequently the pattern may be discovered by what I might term sectional analysis, that is, take a very sharp knife, such as I have already described for cutting fabrics for weighing, make a clean sharp cut down the side of the fabric, then another cross section, and in the majority of cases the order of interweaving will be distinctly visible. But by this method of analysis there must be no attempt to disturb the threads otherwise the counting will probably be misleading. But to ensure arriving at accurate results several sections may be made in succession, and comparison will at once shew whether the work has been correctly done.

COPYING FIGURED PATTERNS.

The copying of figured designs from the fabric is probably the easiest part of the Analysts' work. In the great majority of figured single cloths the threads are of what might be termed the easily distinguishable character, *i.e.*, the fibres are laid as straight as possible, the threads are made as smooth and even as possible and everything is done, both in the manufacture and finish, to give a clear definition to the pattern, consequently by the aid of an ordinary magnifying glass the order of interweaving of each successive thread can be followed with ease, as seen in Fig. 324. Consequently the analyst is not under the necessity of taking the threads out one by one as in the previous case, but simply placing his piece glass upon the fabric and first copying the outline upon his design paper, then he can easily follow each individual twill in each part of the pattern instantly, so that the reproduction of a design of this kind can scarcely be spoken of as analysis, but would be more correctly described as a copying of figures or patterns from one cloth to another; there is no very great skill required, it is simply a matter of patient plodding on the part of the copyist. If he is dealing with very large patterns, or in very fine material where it is difficult to follow the individual threads or in fabrics formed on the principle of double cloth, such as quilts and similar articles, then his best plan is to make a sketch of the design upon his paper and to follow it in the usual manner as though he were making an original design; in this case of course it can only be termed copying in the ordinary sense; there really is no analysis except in so far as may be required to ascertain the exact character of the twill in each of the several parts, or whether the fabric is double, single or extra figuring material may have been introduced. In many cases to assist in the drawing, or where it is desired to enlarge or reduce the figure, the designer adopts a method which will ensure a reasonable degree of accuracy; his design paper, as already pointed out, must be ruled to

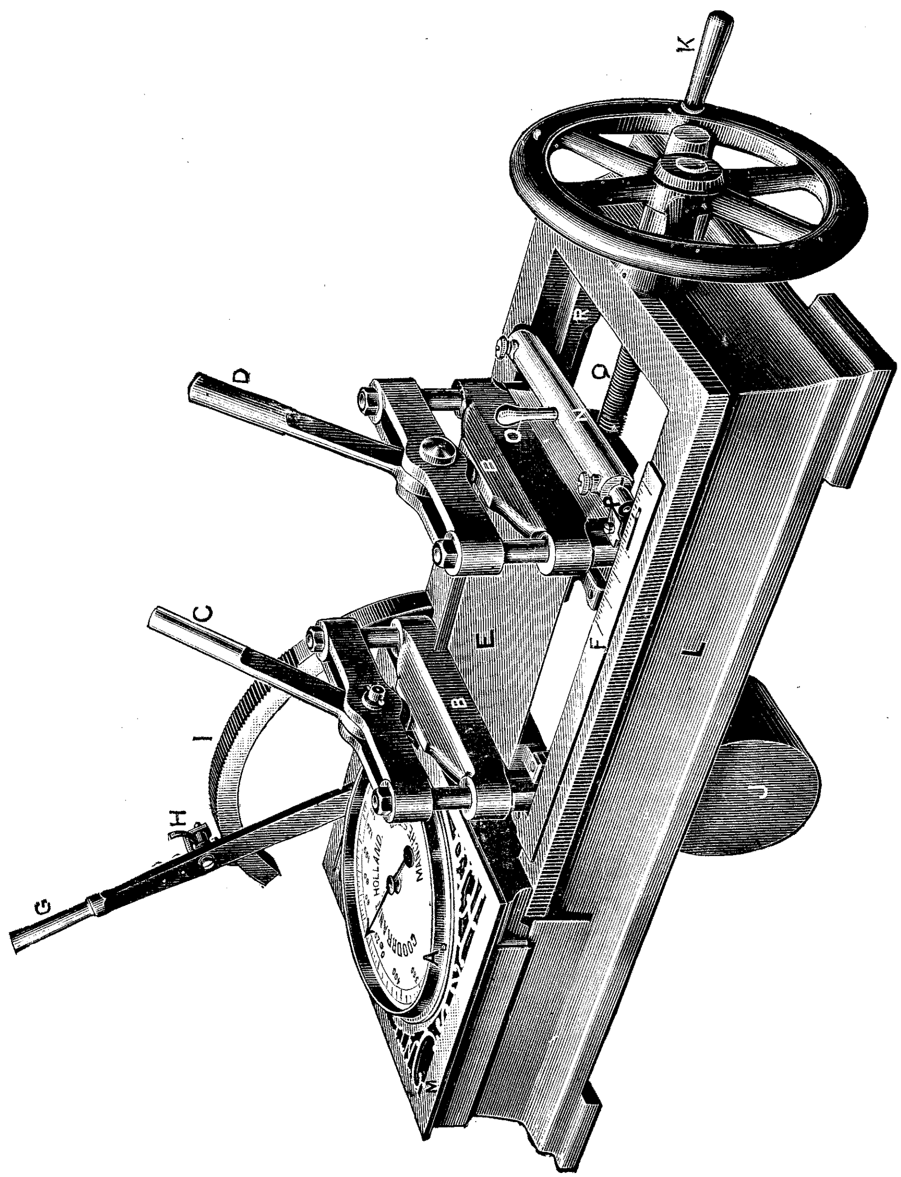
Fig. 324.

correspond with the number of hooks in the row of his jacquard. Therefore he has only to line his cloth in squares corresponding with the ruling of his paper, or increasing or decreasing it in size as he may wish, and then he takes a literal copy from the smaller to the larger, and thus ensures accuracy of form at least. This mode of procedure is so simple and self-evident that anyone may carry it out without any previous special instruction.

TESTING FABRICS.

In the manufacture of a large variety of fabrics it becomes a matter of imperative necessity to be able to test for strength and elasticity. For instance all the fabric supplied for military clothing must be tested to ascertain that they are equal to the quality specified; strength and elasticity tests usually being specified in the contracts. Cloths intended for special purposes, such as sail cloths, linings, tapes, sheetings, beltings and webbings, should all be subjected to a test to ascertain not only what is their breaking strain but what degree of elasticity they will possess. Of course those tests may be varied so as to ascertain the nature of the fabric for the purpose to which it is to be applied. For instance, in testing woollen goods our great object is to ascertain its actual strength, and whatever degree of elasticity it may possess will in some measure indicate the quality of the material of which it is made, the structure of the threads or the treatment to which it has been subjected in finishing. We may, for some purposes, require the cloth to possess very little elasticity although made from very good material; for other purposes we may require it to be very elastic, and the degree of strength, of course will depend upon the amount of strain to which it is liable to be subjected. If we are testing sail cloths, bindings, or sheetings, we want not only the breaking strain, but what we might term a test for endurance, that is, the cloth brought to a great degree of tension somewhere near the breaking strain and see how long it will bear that, and what effect it will have on the elasticity. To make a comparison, we will suppose a cloth to break at a given weight, under what might be termed a normal test, and we bring it gradually to a point very near the breaking strain and allow it to remain there. How long would it bear it without fracture; or, what degree of elasticity would it display? If it shews some degree of elasticity then the period before breaking would be prolonged. To shew what I mean I will suppose three cases, first, we test the cloth by a rapid motion of the jaws of the machine, and we bring the cloth to the breaking point before it has had any opportunities of stretching properly, and consequently it will present, apparently a very high tensile strength, but with comparative little elasticity. We then test it at a moderate rate of speed and we find that it displays greater elasticity but less tensile strength. This is the natural outcome, for the threads will have been drawn into a straight line by a very gradual process; any tendency to slip in the fibres will have had every opportunity possible, and any excessively tight fibres or threads will have been gradually fractured, consequently we might look upon the test as being a test of strength which would occur under ordinary conditions, whereas the rapid movement might be looked upon as a test under extraordinary conditions. Now to take the other extreme, the cloth may be stretched to a given length and allowed to remain at rest; then a little more and allowed to remain at rest again, and so on by degrees until the breaking strain is actually reached. The tensile strength in this case must of necessity appear to be very much less than in either of the previous cases, properly speaking, it would be a test of endurance. For instance, let any one compare, say a sail cloth, subjected to the variety of treatment it is liable to; it will bear a great strain under ordinary conditions, but a sudden gust of wind, or any sudden strain put upon it may cause the sail to split in the most unexpected manner; that may in many cases be due to a cause which would not come in under any properly conducted test; the sudden strain may have been thrown upon some part instead of upon the whole at once, and of course, that does not give the fabric a proper chance of settling into what might be termed a normal position. I will endeavour to illustrate this presently by reference to the testing machine. At Fig. 325 we have an illustration of the recognised tester, an enamelled dial at A is divided in such a manner that the pointer will indicate the actual breaking strain in the same manner as in the previously described machines. A pair of jaws marked BB are so arranged as to clip the fabric firmly between them. Now in the preparation and fixing of the fabric in those jaws depends entirely the success of the experiment.

Suppose we are testing for the strength of cloth in the direction of the warp, we must have the cloth cut perfectly straight and parallel with the warp threads, all loose threads being removed from each side; and the cloth must be placed in the jaw B in a line perfectly parallel with the weft, then made fast there; then the fabric is drawn through the second jaw B, and pulled to an easy tension when it is again made fast. In the illustration given here the jaws are operated by a cam and lever C and D on each jaw respectively, so that the fabric E once placed in position is instantly gripped and held firmly. But even now, supposing the cloth has been carefully cut to the regulation size, the government test being 9 inches by 7 inches, and is placed in the first jaw under lever C in the most perfect manner, it is not so easy to place it in the jaws under D, as the operator, either from carelessness or intent, may render the test utterly useless. Suppose he has it tight at one edge, it will commence to tear then and follow across the fabric; but an expert would at once repudiate this as an improper test, as it is evident the fabric is not to be torn but to be broken; a tear from the edge is easily followed, but a complete fracture takes place almost instantaneously. Something however may be taken from the value of the test without



Fig, 325.

being readily detected; instead of having the tight at the edge let it be a little tighter in the middle than at the edges, and it will break there first and with all the appearance of producing a fracture across all the fabric at the same time. There is a guide bar against which the material is placed to assist in setting it evenly. The cloth being secured the handle K is turned, and by means of the screw Q the jaw B nearest the wheel is gradually drawn away from the other, and at the same time the dead weight on the lever G is raised, the pointer on the dial travelling at the same time to indicate the strain. A brass plate is engraved from 1 to 7 inches for showing the stretch or elasticity before breaking. When the fabric

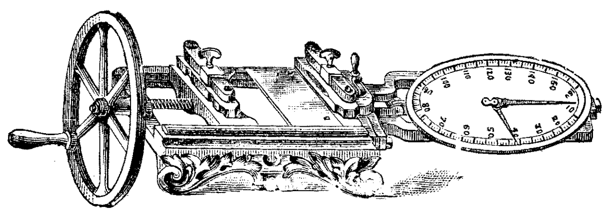


Fig. 326.

breaks the pointer remains stationery as in the yarn testers, and to release it and return to zero the catches, or pawls H, are lifted, and the handle G, and the weight returned to their original positions. The regulation rate of speed adopted by the conditioning and testing houses both in England and on the Continent is 5 inches in 20 seconds from jaw to jaw. The machine illustrated here is by Messrs. Goodbrand and Holland.

Another is shown at Fig. 326 by Mr. J. Nesbitt, of Market Street, Manchester. The principle is the same, but the strength is tested by springs instead of dead weight, and the jaws are worked with a screw instead of a lever and cam. Some prefer this system as giving better opportunities for accurate setting of the cloth;

by means of the lever the cloth is gripped instantly, but with the screw it can be made just fast and examined for evenness of tension, and if not correct, it can be adjusted.

TESTS FOR WOOL, COTTON, &c.

Perhaps some of the best tests for discovering the characters of fibres are the simplest, certainly the two most reliable ones are the microscopic tests and the simple tests by burning. If we try the microscopic test we must know beforehand the appearance of the fibre, and that is easily discoverable by any one. Put broadly, wool has a characteristic peculiar to itself, consisting, as it does, of a hollow fibre or tube, and covered with scales, which in some measure resembles the scales of a fish, but forming rings, and not quite so clearly defined as the fish scales; the rings will vary in number and definition as well as in the sharp points on the rings themselves. A knowledge of this will be best acquired by collecting a series of samples ranging from the finest merino to the strongest English wools; then to these may be added a few samples of mohair and alpaca. The finer the wool the more frequent the markings until we get down to the very coarsest wools, when the markings are only just perceptible, and not very frequent, whilst in some mohairs and alpacas of extremely bright surface they are only just visible. A simple method of examination is, instead of mounting them in the usual elaborate manner, simply to place them upon an ordinary micro-plate, and place a thin cover over it, or if it is to be kept for permanent use mount it in a dry cell, but with a very thin rim between the plate and the cover glass, otherwise only a very small portion can be brought into focus at once. If they are mounted in Canada Balsam it seems to fill up the pores, and consequently instead of appearing with their characteristic structure visible they present almost the appearance of glass rods. To bring the scales into greater prominence the wools may be washed so as to relieve them of foreign matter, or even boiled in clear water for a short time and then thoroughly dried. They are often treated with re-agents for the purpose of both removing foreign matter and causing a slight expansion in the scales at the same time, but there is a danger in doing this of allowing the treatment to go too far. For instance, if the fibre is treated with dilute caustic potash it will spread its scales out considerably more then if simply washed; it is quite interesting to place a few fibres upon a slide and drop a few drops of caustic potash on the plate, place it instantly under the microscope and watch the action of the re-agent, and if a specially good fibre is wished for preservation for future reference, it should be watched very carefully, and as soon as the development has gone far enough, dropped into clean water and washed off; then allow it to dry and be prepared for mounting. In the same way cotton fibres may be examined; they present simply the appearance of collapsed tubes and more or less twisted, due to their collapsing; flax or jute present microscopically something of the appearance of long grasses or reeds, the flax having a knotted character, very similar to the knots upon the bamboo cane, and jute, a straight fibre in layers, something like a reed. Silk, on the other hand, presents the appearance of a continuous filament without any structure, just as you would expect to see a glass rod, so that the characteristics of each of the leading fibres may be very readily discovered. If a microscope is not available, then what is termed the burning process is fairly reliable. Let a few fibres be burnt, say of cotton, there is only a very light fine ash left at the end, but if wool is burnt it forms a little hard cinder, which, if pressed between the fingers will be reduced to a fine powder.

Accompanying those characteristics the smell is a most reliable guide; wool, for instance, has the smell of a burnt horn, being itself a horny substance, whereas cotton has scarcely a perceptible smell. Silk, so far as burning is concerned, presents the same characteristics as wool, although it is little more inflamable in consequence of its lightness, and, of course, it will be easy to discover, once the horny smell is present, the difference between woollens and silks from the brightness alone. Linen and jute both burn readily, but not so readily as cotton, and they leave an ash also somewhat similar to cotton, but not of so light a character either in weight or appearance. Of course one would scarcely take cotton for jute or linen in consequence of the difference of the strength of the fibres apart from the microscopic appearance, but it will not be so easy to discriminate between linen and jute. In those two one must be guided in a very great measure by the general appearance and length of the fibre unless the microscope is resorted to. Burning or chemical tests will give almost the same results.

Then for the chemical tests. There are two distinct modes of procedure, although I am not going to attempt to deal exhaustively with this subject, only the tests in ordinary use and which can be applied by any one who is not a chemist. Vegetable fibres will be readily dissolved in sulphuric acid, but if this is used too strong it will also attack and dissolve the wool, consequently it should be applied in a dilute state, and a sufficient length of time given for the vegetable matter to be carbonised and then washed off. On the other hand wool is readily dissolved in caustic soda, more especially if it is boiled. A common test is to boil the fabric in a 5°/₀ solution of caustic soda, if it is intended to dissolve wool and leave cotton intact, in the case of a union cloth, for thirty minutes, when the wool will be entirely dissolved and the cottton left practically untouched. If a rapid test is required, and it is not desired to ascertain the exact quantities, it may be boiled for three minutes in a strong solution of caustic soda, but if the analysis must be a quantitative one care must be taken in every test. For instance, a piece of cloth may be taken and weighed, either in its ordinary state or in a state of absolute dryness, boiled in caustic soda, say 5°/₀ solution, for thirty minutes, then washed clean, or boiled for a short time in distilled water, thrown upon a filter paper and carefully filtered, the filter paper having been previously weighed. Place the filter paper in a drying oven at a moderate heat and allow it to remain until absolutely dry. If it has been weighed at absolute dryness in the first instance the residue should be weighed in the same condition, and the difference will represent the quantity of wool which has been dissolved out of the fabric, but if the cloth is weighed in its normal condition then the residue should be left exposed to the air at a normal temperature for 24 hours, when it will have regained the amount of moisture natural to it; and the exact percentage of loss, or in other words, the amount of cotton and wool respectively will be determined. Now I will suppose another case where we have a compound fabric and cotton heavily sized, wnich means the addition of a considerable amount of foreign matter. In all probability in a case of this kind the two sets of threads could be easily separated from each other, then it is best to separate them and weigh each one in the condition in which it comes from the fabric. That being done take the cotton first and wash it in clean water, then it may be boiled, say for thirty minutes in a 2°/₀ solution of caustic soda, or some prefer to boil it an hour in a 1 per cent. solution. Wash it off again and boil it for thirty minutes in a 2°/₀ solution of hydro-chloric acid, wash again and boil in distilled water for thirty minutes, after which it is again washed, submitted to a moderate heat in a drying oven for an hour and left loose in the air for 24 hours to regain its normal condition as to moisture. Then the wool may be simply boiled for thirty minutes in distilled water, as the size will probably be confined to the cotton, then washed off, dried, and completed as before. The weighing of the two sets of fibres will now disclose the exact weight of pure cotton and wool respectively in the original sample, and the missing quantity will represent the exact amount of sizing, or foreign matter, removed from the fabric.

FAULTS IN FABRICS.

In dealing with this branch of the subject I shall confine myself to faults of two distinct classes, first, those which occur in the actual process of weaving, and second, those which are the result either of improper preparation of the yarns prior to weaving or in the mixing of yarns. In the one case we shall have to look to the details of the loom for the purpose of discovering the causes of imperfections, and in the other we shall have to test the yarns after the manner which I have already described. Suppose we first turn to those which are most liable to occur in the bad working of the loom. We have the common term uneven cloth, this must be due either to imperfect letting-off or imperfect taking-up, and either of the two will produce approximately the same results. Suppose for instance, we are working with the ordinary friction rope; we find it sticking from any cause such as damp; the beam would allow the warp to go off, as it were, in a spasmodic manner, at one moment held very tight and then a sudden slip of the beam gives off a considerable amount of slack; no matter how perfectly the take-up motion may be working, the irregularity in the tension will produce uneven fabric. In the same manner if the let-off motion is of a positive type any imperfection in its working, such as the vibrator levers or the escapement motions, whatever form they may assume, failing in their action will produce the same result. In the take-up motion irregularity in the action of the catches; improper weighting of the cloth beam; slipping or sticking of the teeth of the take-up motions, or anything which will either push the take-up motion forward at one point or retard it at another will produce unevenness of practically the same kind, although perhaps it may sometimes appear of a more definite character, as that produced by a let-off motion. Then again the weft fork not working properly will cause the same kind of fault, and we have first what is generally called a broken pick; broken picks may be due simply to the carelessness of the weaver, *i.e.*, the yarn is broken or the bobbin run empty and the loom stops; if she simply puts in a fresh bobbin and starts the loom, either without taking the precaution of finding the proper place for the pick, of letting back the cloth a distance corresponding to that taken up without any weft, then a thin place will result. Again, if the weft fork has failed to act and the loom has run over two or more picks before the weaver has noticed it there will be a thin place, unless exceptional care is exercised, simply because the weaver is unconcious of the fact that the weft fork has not been acting properly and takes the ordinary precautions only, instead of taking the extraordinary precautions which are necessary in such a case.

Then another class of fault may be produced by imperfect shedding, that is, the healds are not forming a sufficiently straight line for the shuttle to pass over, or the upper half of the shed is so badly formed that the shuttle passes over some which should be passed under. Again we have what is commonly known as stitching; stitching of course may arise from other causes than this; from the sheds not opening at the proper time; from excessively loose fibre between the reed and the healds, causing, occasionally, threads to hold together and the shuttle pass over or under wrong ones. Or it may be caused by an occasional broken thread, but in that case it produces a fault which is commonly known as "feltering" as distinguished from stitching. It is hardly necessary to speak of the faults caused by ends being allowed to run down, as that is not only a preventible fault but one due to gross carelessness; there are sometimes other imperfections produced, not so readily traceable, such for example, as when a weaver crosses a thread from one part of the warp to another without taking care that the tension shall be properly equalised with the rest, or where an extra thread is introduced and run from a bobbin, when the same fault will arise. In each case it would simply shew a perfectly straight line all through the piece and there is no known test which could discover it except an examination of the loom in work, so that should the fault not be discovered until the warp has been finished there are no posible means of tracing it. Again a similar result will be produced by having heald threads which have been broken down improperly tied up; they are tied too tight, with the mail too high or too low, causing the shuttle to be constantly rubbing upon the thread in a greater degree than the rest, and, in fact, making that one thread shed differently from the rest; the effect will be apparent in the fabric; sometimes perhaps in the grey or unfinished state but almost certainly in the finished state; again the fault is difficult to trace to its source. In all probability the one most serious fault and the one most difficult to deal with in the actual process of weaving is that which has already been referred to when dealing with temples, namely, the curling of the weft. Nothing but a thorough mastery of the system of shedding suitable for different patterns and different materials; a careful adjustment of every part which can influence it; a proper tension upon the weft as it leaves the shuttle, and the adjustment of good temples can avoid it. But there is no fabric made, where, with proper regard to those conditions, curling cannot be avoided.

I shall not attempt to deal with the faults which occur in fabrics which might be properly described as structural faults. I have nothing to do at present with the structure of cloths, but in speaking of the faults arising from the imperfect preparation prior to weaving I may have something to say of the structure of threads without necessarily discussing the merits of the several classes of threads for the production of any class of fabric.

First then we will go back to the very beginning of the work, imperfect winding, either for the purpose of warping or on the spools or bobbins from which the yarns are woven; hard and soft bobbins mixed together, which is equivalent to saying unequal tension upon the threads, would produce their faults, but the effect in the warp is very different to that in the weft. In the warp a slack thread would run in at intervals corresponding with the number of threads put up on the warping mill, or creel, at once, and would occur at perfectly regular intervals across the fabric, and a corresponding stripe would appear; a stripe produced by this means is readily detected as compared with that which I have been describing as produced by a crossed thread, or a thread run into a warp from a bobbin. In the one case the fault appears regularly all across the fabric, and can be easily traced; in the other case there is either a single stripe in the whole piece, or if there are more they will probably occur at most irregular intervals. Then in dressing, or beaming the warps preparatory to going into the loom, stripy goods may be easily produced, simply by unevenness of tension on the several parts or separate warps which may be put together to form one. And this, like the slack thread, will occur with perfect regularity, and therefore can be easily discovered. But one of the greatest causes of imperfections is that which I have dealt with under the head of yarn testing due to the mixture of yarns of either different quality, different counts, different twist, or differing in age. Any of those causes is readily discoverable by the methods of testing I have endeavoured to describe, but it is only by the exercise of great care with properly adjusted instruments for testing that the cause of the fault can be brought home. There is but one other cause I will refer to, and this is so simple that even though I have had to demonstrate it numbers of times in the presence of manufacturers, I have found it difficult to persuade them of the truth of the theory which I have advanced. If we examine yarns, whether of woollen or worsted, more especially of the worsted type, we shall find the fibres pointing outwards from the thread, practically, all in the same direction, or what is termed by spinners the lay of the fibres; that is as the fibres are drawn from the delivery rollers of the spinning frame and passed down through the guide eye to the bobbin, and twist being put in at the same time, the free ends of the fibre will all point outwards in one direction. Now suppose that we make the warp from this yarn, and from any cause a bobbin has been re-wound; it is no uncommon thing for a bobbin to get broken, and so render it impossible to warp the yarn from it; it is then re-wound upon another bobbin, and placed in a creel along with the others. When this is done the lay of the fibre is reversed. Now let the warp be taken to the loom and woven; as the weft beats up to the fabric it will either lay down the free ends of the loose fibres, or it will tend to ruffle them ; whatever it does with the bulk of the threads it must be exactly the reverse with the re-wound one, and although, to the weaver, nothing is visible, more especially in grey fabrics; when the cloth comes to be finished that one thread will form a stripe of its own and stand out distinct from the rest as though it were a different colour. Whenever a fault of this kind appears, it can only be distinguished from those I have referred to as being due to yarns newly spun, and well set respectively, by a microscopical examination, simply because it is of precisely the same nature and character as its companion threads, and therefore subjected to the same tests will give precisely the same results, but if the two threads are placed side by side under a microscope of moderate power then the lay of the fibres will at once disclose the cause of the imperfection.

There are numbers of faults which it would be impossible to anticipate, but practically, leaving the question of faults of structure aside, the more troublesome ones will come under the heads and be discoverable by the tests I have suggested.

APPENDIX.

The principal reagents required for the micro-chemical examination of fibres are the following :—

1.—SULPHURIC ACID (concentrated and diluted): This is necessary and valuable for dissolving and enlarging the membranes of the cells; and for giving a blue colour to the cellulose it may be mixed with iodine.

2.—NITRIC ACID: For rendering the striations and the structure (as well as the scales) of the natural fibres more distinct.

3.—CHROMIC ACID: The best dissolvant for the inter-cellular substances, it constitutes by far the readiest and most rapid means of isolating the cells. It frequently occurs that the cells are enlarged and dissolved at the same time by this acid; it is seldom employed in its pure state, but it is generally necessary to prepare a mixture of chromic acid and sulphuric acid, which is made after Wiesner's method, with an addition of bi-chromate of potash in excess of the sulphuric acid. When dissolved, the chromic acid alone is mixed with an equal volume of water.

4.—SOLUTION OF ALCHOLIC IODIDE (dilute): With this preparation the cellulose is moistened, this will give a blue tinge on the application of dilute sulphuric acid.

5.—AMMONIATE OF COPPER: Is obtained by dissolving copper metal in ammonia, and serves for dissolving and enlarging the membranes of the cells.

6.—SULPHATE OF ANALINE: For ascertaining the striations after the fibres have been coloured an intense yellow.

7.—CAUSTIC POTASH (Dilute): For rendering the tissues more transparent and isolating or separating them from each other, the fibres are also more thoroughly enlarged by this reagent.

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