# The Nature of the Plain Weave

By Dr. *Fr. Stein*

The plain weave, or, as it is sometimes known in the trade, the tabby, calico, or alpaca weave, is by far the most important of all weaves and the one most commonly met with. Every weaver is well aware, however, that its construction tests more rigourously than any other not only the attention and skill of the operative, but also the proper choice and preparation of the yarn for warp and weft, and their combination, as well as the build and equipment of the loom and its accessories.

The importance of the plain weave makes it worth while to examine the facts more minutely and not merely to be content with the superficial explanation that the plain weave is the most intimate combination possible of two threads, from which all other facts are selfevident. There are not many branches of the textile industry where the practical mill man will find himself confronted by such surprising and often evidently contradictory results as in the manufacture of plain woven cloths.

The plain weave had its origin, like every other weave, in plaiting, but, again like every other type of weave, it differs from plaiting by the peculiar system of stresses which are produced in the warp and weft threads during weaving. These *strains* not only severely test the strength of the threads in the loom, but their importance for the appearance of this finished cloth cannot be overestimated. These tensions are not only unavoidable, but form the chief characteristic of a weave. They are formed at two points, that is to say, in the warp owing to a let off motion actuated by a spring or by a weight, and in the weft by a frictional braking action of the thread as it is wound off the pirns and leaves the shuttle.

The tension of the warp is necessary, because the shed can only be accurately formed and maintained if the threads are taut. The tension of the weft is also indispensable, as it alone causes the correct amount of yarn to be taken from the bobbin and lays it in the shed under more or less tension, as desired. The tension of the warp and weft in the fabric still in the loom soon reaches a certain state of equilibrium under the influence of the *weave angle*, to be described later, and these states of equilibrium together with the weave determine the character and appearance of the cloth, not merely in the loom, but also when finished and cut up. Upon them are also dependent the changes which the fabric undergoes when it is liberated from the tension of the loom.

The field of strains will therefore first of all be considered which is formed in a *plain woven cloth* on the loom when in motion, between the fell of the cloth and the breast beam and which is naturally subject to periodic changes corresponding to the period of the revolutions of the crank shaft.

During the period when the reed does not touch the fell of the cloth the fabric has to absorb the whole of the length given off by whatever let off motion is being used (drag weight, back rest regulator). If it be assumed that the shed forming members do not appreciably influence the extent and direction of this pull and that it exerts a force at the edge of the cloth lengthways amounting to $\Sigma P$ in such a way that an average force P is exerted on each warp thread. If it is now assumed that the fabric has been cut across exactly between two picks, that is to say, in the plane of intersection of the warp threads (Figure 1), then a pull of the order P would have to be exerted at the point of section on each warp thread in the direction of the warp to maintain equilibrium. But the warp threads at the intersections do not by any means run in the general direction of the warp, but are inclined to this plane by the *weave angle* $\alpha$.

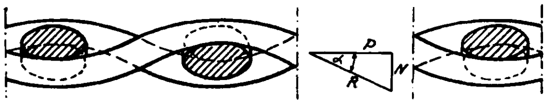

Fig. 1.
Longitudinal section through a plain woven cloth

Therefore there must be present in the direction of the axis of each thread a *resultant pull*

$$R = P \frac{1}{\cos \alpha}$$

one component of which, that is, P itself, takes up the longitudinal strain in the cloth, while the other component, the normal force

$$N = P \cdot \operatorname{tg} \alpha = R \cdot \sin \alpha$$

acts transversely to the plane of the fabric. The *resistance* of the warp and weft threads to being crushed flat counterbalances this force.

But it is also this force N which forces the weft and warp threads, that were originally straight, into a sinuous form immediately after weaving. This *undulation* in its turn, as is well known, is the cause of *more warp* being used than the length of the cloth *(warp contraction)*, and also of the reduction in width. The weft has also an *angle of inclination* at its intersections with the warp a kind of *weft weave angle* $\beta$, and the normal force N produces here too, just as with the warp, except that cause and effect are reversed, tension in the direction of the axis of the weft $S = N \cdot \frac{1}{\sin \beta}$ and then together with this a *transverse pull* across the fabric $Z = N \cdot \mathrm{cotg} \beta$ for each weft thread.

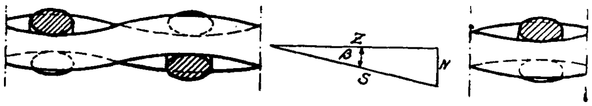

Fig. 2. Cross-section through a plain woven cloth

Within the *zone affected by the temples* the weft is still to some extent on the stretch, that is to say, $\beta$ is small, and the transverse pull of the fabric accordingly rises so high that often a very powerful temple is required.

After having passed the temples, the weft is at liberty to bend, whereby the width of the fabric decreases while the weave angle becomes greater. Here also the transverse pull need not disappear, but it becomes so small that the action of the *selvedge* in the shape of a *polygon of forces* can be transferred without difficulty, on the one hand, to the temple and, on the other hand, to the breast beam which offers a certain amount of resistance owing to its friction. This shows at once the extreme importance of the selvedge. *Owing to this action of the polygon of forces it must withstand enormous additional longitudinal strains over and above the ordinary tension of warp and weft. For this reason it is always strengthened, because, if it were to fail, the width would shrink irregularly and thus the whole of the fabric would be distorted.* (Wavy selvedge.)*)

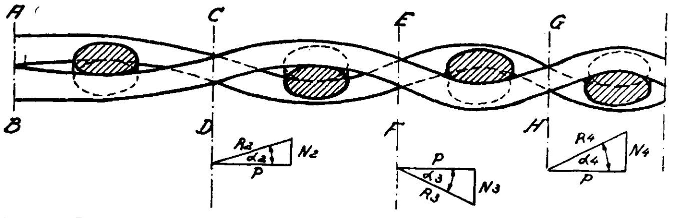

Fig. 3. Longitudinal section through a plain woven cloth during the return of the thread

While the warp between the warp beam and the fell of the cloth is almost continually in motion owing to the play of the shafts, the movement of the back rest, etc., the finished cloth for the eye is only temporarily in motion by the action of the cloth beam taking up motion. (No attention is here paid to the changes in height to which the edge of cloth in which warp and weft float a great deal is subjected, because the present remarks are confined to the plain weave.)

As a matter of fact, however, a great part of the finished fabric is set in motion by the *blow of the reed*, and this motion may often reach to the breastbeam, especially when the *forecloth* (as it may conveniently be termed) *is being formed*, as described below. At this stage the static conditions just described are changed into *dynamic* conditions.

The dynamic conditions are characterized by the fact that the weft tries to create a new state of equilibrium by more or less permanent displacements in the direction of the warp after the beating up of the sley has disturbed the state of tension described in the last paragraph. The first point to be examined below is how the weft behaves at the edge of the cloth just liberated by the reed.

A cursory glance at the warp of a cloth just being woven shows that a varying number of the picks retreat again from the fell of the cloth when the sley retires. This is evidently due to the action of the components of the warp tension as shown in Figure 1, because the tension arising from the warp let off motion exerts its full force on the fabric as soon as the beating up is at an end.

Figure 3 shows a momentary condition to be seen shortly after *beating up with a closed shed.* Assuming that the free warp threads are still parallel to one another, so that the weave angle before the last pick is $\alpha^1 = 0$, then the weft threads would simply act as diverting rollers for the warp threads, *if* there were *no friction at all* between warp and weft. The longitudinal force acting on the axis of a warp thread — which appears at the points of intersection as a force R inclined to

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*) The Machine Works Rüti provide the breast beam of their new cotton loom with outwardly directed fluting, whereby the selvedge can offer more resistance to the transverse pull.

the plane of the fabric—would therefore have to remain uniform over its whole length. The *first weft thread* would accordingly be affected by two equal forces, one in the direction of the warp, and the other inclined thereto. The resultant of these two lines of force in turn would have a component in the direction of the warp ($Dr_1$, Figure 4), which would push the last pick out of the cloth again. The angle $\alpha_2$ would accordingly always tend to become smaller; as soon as it is smaller than $\alpha_3$, an extrusive force would take effect on the second last weft thread also (Figure 5).

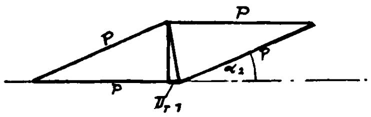

Fig. 4. Diagram of forces

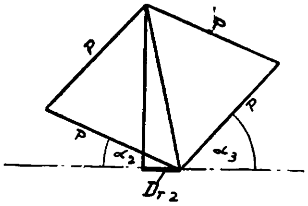

Fig. 5. Diagram of forces

When this thread slipped off, the angle $\alpha_3$ would once more be reduced and in the course of the action the whole of the picks would be pushed out of the cloth into the front shed, so that it would lose its sharp demarcation against the fabric. The longitudinal pull would become less from point of intersection to point of intersection by the difference $D_r$ each time, and this difference would be required to accelerate the weft threads to be pushed out. This action would not be stopped until a new shed had been opened, at which moment the angle $\alpha_1$ becomes finite.

But *in reality* the friction between warp and weft tends to bring the return movement practically to a complete standstill already within a few millimetres, even if the shed remains closed for some time. It is of course true that a certain number of weft threads will by that time have reached a distance from one another which continually increases towards the reed, corresponding to the formula

$$0 < \alpha_1 < \alpha_2 < \alpha_3$$

and so on, but their *acceleration* has become so low that it can be neglected. The differential forces $D^r$ thus disappear and the *same longitudinal pulling force* $\Sigma P$ must obtain everywhere in the cross-sections and each warp thread has its share P.

The tension R exerted in the direction of the thread axis is therefore greater than P within the fabric and rises besides in proportion to the distance of the cross-section of the warp thread being examined from the fell of the cloth, as appears from Figure 3.

$$R_1 = P \cdot \frac{1}{\cos\alpha_1} \quad R_2 = P \cdot \frac{1}{\cos\alpha_3} \quad R_3 = P \cdot \frac{1}{\cos\alpha_3}$$

$$R_4 = P \cdot \frac{1}{\cos\alpha_4}$$

which is to say that $R_1 < R_2 < R_3 < R_4$ and so on.

Each section of warp thread lying between intersections is attacked by two axially directed pulling forces *of different size.* These forces must not cause any more movement, if the retirement of the weft threads is to be regarded as completed. That is to say, their *difference* must be *equalized* by the *friction* of the warp thread upon the weft thread lying between the two points of intersection.

Only suppositions are at present permissible about the nature of the friction; its effect probably rises as the weave angle increases (owing to the weft being more firmly embraced by the warp threads). That is to say, during the period in which the reed is *not* in contact with the fell of the cloth, the weft threads are subject to a friction which is greater the further they have retired from the fell of the cloth. The accurate investigation of this friction would probably yield valuable results for the understanding of the weaving processes.

The increase of the weave angle towards the breast beam cannot proceed indefinitely and a pick soon appears from which on the angle remains constant. This weft thread is the beginning of the finally finished cloth which is not liable to any further change due to the beating up of the sley. The following considerations will show *which weft thread this is* and *how large the weave angle is* in each case.

When the reed starts to beat up, the angle $\alpha_1$ is first of all increased by the new pick's being brought up. Simultaneously a *part of* the tension arising from the warp let off motion returns from the warp threads over the *new* pick and the reed, but only a part, because the fact that the strip of fabric between the fell of the cloth and the breast beam remains taut in normal weaving, even during beating up, permits of the conclusion that a considerable part Q of the warp tension is continued to the cloth on the breast beam and the cloth beam. The strip of fabric becomes only temporarily slack when the so-called forecloth is being formed, as explained below.

A process now sets in (Figure 6) unter the action of this remaining pulling force Q and under the influence of the continual increase in the angle $\alpha_1$, which is the absolute reverse of that shown in Figure 3.

Here also each pick moves towards the *smaller* weaving angle — in this case in the direction of the *breast beam* — until the action of the friction between warp and weft equalizes the differences of the axial pulling forces appearing in the warp threads.

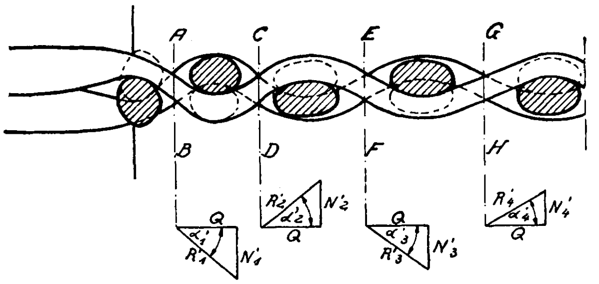

Fig. 6. Longitudinal section through a plain woven cloth during beating up

This establishes a new state of equilibrium which is thereby characterized —

firstly, that the following longitudinal forces are active in each intersection in the direction of the axis of the warp:

$$R_1' = Q\frac{1}{\cos\alpha_1'}\quad R_2' = Q\frac{1}{\cos\alpha_2'}\quad R_3' = Q\frac{1}{\cos\alpha_3'}$$

$$R_4' = Q\frac{1}{\cos\alpha_4'}$$

and secondly by $\alpha_1' > \alpha_2' > \alpha_3' > \alpha_4'$ and so on, so that here $R_1' > R_2' > R_3' \geqslant R_4'$.

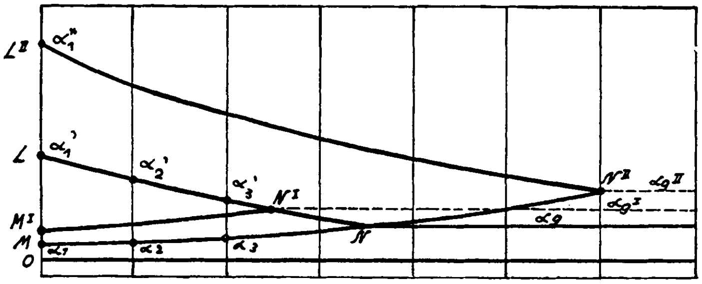

Fig. 7. Graph for finding the final weave angle

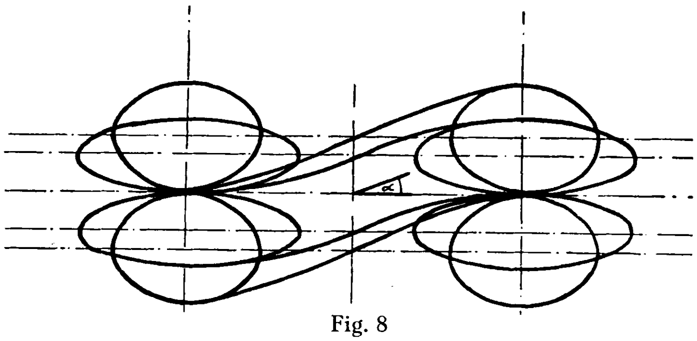

Fig. 8

If the angles $\alpha$ for each of the intersections as shown in Figures 3 and 6, are compared with one another,

$$\begin{array}{llll} AB & CD & EF & GH\,..\,XY \\ \alpha_1 > 0^0 & \alpha_2 > \alpha_1 & \alpha_3 > \alpha_2 & \alpha_4 > \alpha_3\,..\,\alpha\,(_n+1) > \alpha_n \\ \alpha_1' < 90^0 & \alpha_2' < \alpha_1' & \alpha_3' < \alpha_2' & \alpha_4' < \alpha_3'\,..\,\alpha'(_n+1) < \alpha'_n \end{array}$$

a *definite cross-section* UV must finally be reached at which the angles $\alpha_g$ and $\alpha_g'$ are identical, or are so close to one another that $\alpha_h > \alpha_h'$ would occur in the next cross-section.

*And this cross-section is the one from which on the cloth can be looked upon as being at rest, in such a way that all weave angles from this point on have the same value $\alpha_g$ which is not changed any more, even temporarily, either by beating up or by shedding. It is the so-called "final weave angle".*

Figure 7 shows diagramatically the course of the weave angle in the various cross-sections of the intersections.

A knowledge of these conditions is important because there exists a close relationship between weave angle and the number of picks per inch. The cross-section of the weft can be drawn into any given weave angle, whereby the flattening of the pick is not of extreme importance at all for the closeness of the picks. This is at least true for large weave angles (Figur 8).

The size of the angle $\alpha_g$ (Figure 7) is thus mainly dependent upon the final density of the weft threads. They can be very close only by having the angle $\alpha_g$ as large as possible. But the height of the $\alpha_g$ line as shown in Figure 7 is determined by the course of the curves LN and MN. The points LM represent the maximum value of $\alpha_1'$, or the minimum value $\alpha_1$.

The rise of the curves is clearly a function of the *friction* between warp and weft which has not yet been accurately determined. For as soon as the movement of the picks is completed and equilibrium has been established, this friction must take up the whole of the differences between the forces.

$$R_1,\ R_2,\ R_3,\ R_4,\ \dots\ R_n,$$
$$\text{and } R_1',\ R_2',\ R_2',\ R_4',\qquad R_n',$$

Now since

$$R_n - R_{(n-1)} = P\left[\frac{1}{\cos\alpha_n} - \frac{1}{\cos\alpha_{(n-1)}}\right]$$

and

$$R'_{(n-1)} - R'_n = Q\left[\frac{1}{\cos\alpha'_{(n-1)}} - \frac{1}{\cos\alpha'_n}\right]$$

therefore a greater rise or fall not only of the rows of force R and R', but also of the angle rows $\alpha$ and $\alpha'$ corresponds to a greater friction.

That is to say, if an increase of the coefficient of friction between warp and weft makes the curves of Figure 7 steeper, its reduction flattens them.

The point N and with it the $\alpha_g$ curve could be *raised*, for instance, if the friction of the threads during *beating up* could be *made less* than during the return of the sley, for then the curve LN would be made flatter than shown in Figure 7, but MN, on the contrary, steeper. There are as yet no means of doing this at disposal.

It is quite practical, however, to raise the point M and with it the whole of the curve which starts there (curve M', N', Figure 7), whereby a new much higher point N', and thus a higher $\alpha_g$ line are produced. This measure therefore proceeds from an enlargement of the angle $\alpha_1$, that is to say, it is found in practice in the shape of a soon shed.

The shedding motion here works so that the *next shed* is already almost opened at the moment when the sley beats up. From the foregoing it will be evident why this method of shedding is so much used just for the plain weave.

The best means, however, of influencing the final weave angle is to be found in point L. When it is raised to $L^{II}$, that is to say, through an enlargement of the angle $\alpha'$, the angle $\alpha_g$ II is much greater than $\alpha_g$. A subsidiary result of this procedure, however, is that the zone of the fabric affected by beating up becomes greater, the limit $N^{II}$ moving towards the breast beam. The use of the soon shed has besides the *contrary* effect (Figure 7).

The angle $\alpha_1'$ can *practically* be enlarged in the following way.

First of all the *forward movement* of looms with the usual positive clothbeam mechanism is made smaller, so that *less cloth* is pulled forward from pick to pick. It is, however, not certain whether this measure *alone* is sufficient. Of course the reed at the moment when it beats up can now press the new weft thread *further* into the fell of the cloth than before, whereby at first, it is true, the angle $\alpha_1'$ is enlarged as desired, but it must not be forgotten that as $\alpha_1'$ increases a *continually greater share* of the tension arising from the warp let off motion is *directly transferred to the reed* through the new pick, as can be seen from Figure 6.

In this way the active pulling force $\Sigma Q$ still remaining in the fabric can be so far reduced that it no longer suffices to disturb the weft which has already been beaten up. Then, however, the enlargement of $\alpha_1'$ cannot lead to an enlargement of $\alpha_2'$, $\alpha_3'$, etc., nor can $\alpha_g$ for the present be raised further. This condition is known as the *forecloth limit.*

If the angle $\alpha_1'$ is enlarged still further by again setting the regulator still smaller, then the forecloth is actually produced, that is to say, the fabric between the fell of the cloth, the breast beam, and the cloth beam *loses all tension* when the sley beats up. The closeness of the weft is not raised in the least as compared with that reached at the forecloth limit. Thus more fabric is woven than the cloth beam takes up, and the length of the goods before the breast beam continually grows further into the path of the beat up. The reed touches the fell of the fabric more and more before the dead point and leaves it later and later. The whole of the warp during the beating up is plucked hither and thither by the distance to which the cloth has grown into the path of the sley, whilst the warp beam is being vigourously rolled and jerked to and fro. No warp will stand treatment like that for long.

To sum up. In order to make the weft closer, it suffices to increase the angle $\alpha_1'$ by setting the regulator lower only until the forecloth limit is reached. Beyond this limit an enlargement of $\alpha_1'$ is only effective when at the same time the *rest tension* $\Sigma Q$ is kept sufficiently high, *by increasing the tension arising from the warp let off motion, that is to say, for example, by raising the drag weight.*

It can now be supposed for a given material for warp and weft that the proportion $\Sigma Q : \Sigma P$ is definitely settled by the size of the angle $\alpha_1'$. If this proportion is zero, then raising the drag weight will have no effect. The *actual* forecloth limit must therefore really be much lower, at a point already where the proportion $\Sigma Q : \Sigma P$ is still finite. It is evidently to be found at the point where the *absolute value* of $\Sigma Q$ is compensated by the

*bending strength of the material used for the warp.*

This bending strength strives at least to flatten the undulating curves of the bending line of the warp, since it is not elastic enough to stretch it completely, as can be seen from the form of a thread taken from a sample of cloth. This flattening tendency produces *pressure strains* in the intersecting cross-sections A—B, C—D, E—F, and so on which are in themselves extraordinarily low, but which are able to negative a very weak Q tension. By strengthening $\Sigma P$, however, $\Sigma Q$ will rise in the same proportion and in this way it is possible to give the low pulling tension a preponderance over the low pressure tension again.

The effect of the *bending strength* solves at least temporarily the question as to the action of the *brittleness* of the material on the attainable closeness of the weft, for it tends to reduce the friction of the warp upon the weft, its effect being greater, the smaller the pulling forces are that act in the direction of the warp. Consequently the bending strength will exert a *more flattening* effect on the curve MN in Figure 7 than on LN and therefore lower the point N and with it $\alpha_g$ a little, and that the more for the same reason the smaller $\Sigma Q$ is, that is to say also $\Sigma P$. *Just for this reason artificial silk which is of extreme bending strength reacts so sensitively* to the drag weight, that is to say, to the tension which *proceeds from the back rest regulator of the warp let off motion.*

The alternating play of forces of the weave is not without its effect upon the position of the *warp threads* in relation to one another also. In the first place, the transverse tension $Z = N \cdot \cot g\beta$ mentioned above strives to pull the warp threads together. Besides this, forces may appear which try to equalize any inequalities in the spacing of the warp threads, such as can readily occur when the reed wires are comparatively thicker than the warp threads. This tends to produce irregularities in the weave angle of the weft also and then differential forces appear corresponding to the forces $D_r$ in Figure 5 which tend to push the warp threads towards the smaller weave angle of the weft.

Complete equalization can never occur, because the *friction* between warp and weft stops the lateral movement of the warp threads even before they have adjusted themselves to the same distance from one another; consequently the *reed marks* make themselves noticeable and the cloth is reedy.

When weaving smooth yarns, such as silk and artificial silk, the position of the warp threads can be improved by an aftertreatment of the cloth (cross-brushing). Rougher yarns, in particular cotton and wool, require an arrangement for use during the weaving to equalize the spacing of the warp threads.

This is already done to a certain extent by arranging the shafts so that the middle of the shed lies below the tangential plane of the breast beam and the back rest. Then in shedding the threads of the lower shed absorb much the greater part of the tension of the warp, while the upper shed is just taut enough to permit of the shuttle passing through easily. Thus at each change of shed most of the tension of the warp is transferred from one half of the warp threads to the other. This tends to produce continual shocks and disturbances of equilibrium in the newly formed fabric which are often strong enough to negative the resistance offered by the friction and thus to remove the reed marks. If the yarn is *very* rough, however, the action of the "loom fulling" to be effective must be enhanced by a *positive motion of the lease rods*, which thus act as rocking beams.

The rocking beams move in the same way, swinging up and down so that alternately one half of the warp threads absorbs the greater part of the tension of the warp and the other half the smaller part. Now if the warp is drawn in *two threads* through the rods, i. e. in such a way that each two adjacent threads run in the same direction through the lease rods and weaving is done at the same time with a *loose warp*, then Figure 9 shows the situation at *each* shedding.

One-fourth of all the warp threads (a in Figure 9) has a very high tension which is due to their position in the lower shed together with the rise of tension caused by the rocking beams. Two other fourths (b and c in Figure 9) are under a lower tension because either the strain in the lower shed is equalized by a lowering of the tension in the rocking beams, or the strain in the upper shed by raising the tension. The remaining fourth of the warp threads (d in Figure 9) is tensioned very weakly because the strain in the upper shed coincides with a very weak pull in the rocking beams. The order in which the four degrees of tension are distributed among the four groups of warp threads changes with each change of shed, as is shown by Figure 10.

The higher or lower tension of each warp thread now affects the ends which have already been woven in by causing them to set a greater resistance to the compulsion to undulate, the higher the tension they are under. Thus in the strip of fabric between the fell of the cloth and the breast beam, warp threads alternate with quite different degrees of undulation. Since further each pick must cross all the warp threads, an artificial, so to speak, periodic irregularity of the *weft weave angle* is produced throughout the whole of the fabric.

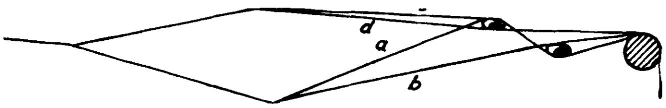

Fig. 9

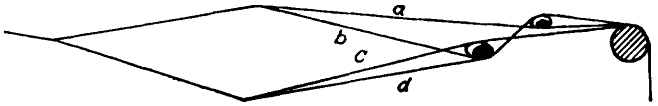

Fig. 10

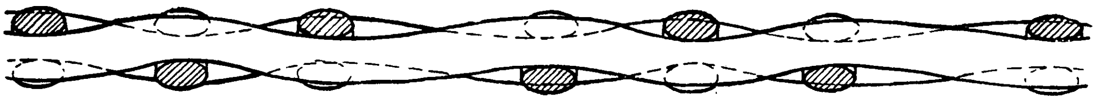

Fig. 11

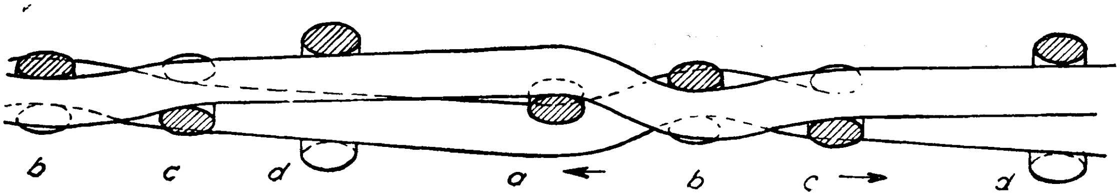

Fig. 12

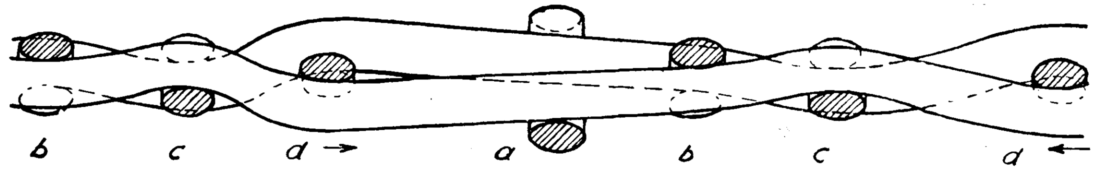

Fig. 13

Upon this is based the action of the rocking action upon the distribution of the warp threads. Figure 11 shows a cross-section of the warp of a fabric every *three threads* of which are reeded through a very coarse reed and therefore is strongly reed marked. The materials may even be so rough that the differences of the weft weave angle caused solely by the irregular spacing between the warp threads cannot afford compensation. Figure 12 shows the same fabric (the area between fell and breast beam) under tension in the loom, weaving being done loosely with the lease rods in action. It can be seen how the different bending through of the warp threads has so enlarged the small differences of the weft weave angle that the friction of the material can be overcome and the *reediness* of the finished cloth disappears. Figure 13 again shows the same fabric *after* the change of shed, and it is evident from it that the corrections for distance which have not been able to be done in the one form of shed most certainly take place after the change of shed.

The lettering of the warp threads is the same as in Figures 9 and 10, that is, Figure 12 corresponds in the position of the shed to Figure 9, and Figure 13 to Figure 10.

When the cloth is taken from the loom, all strains disappear from it which are due to the action of the tension of the warp let off motion and the braking action of the weft. On the other hand, all those strains become conspicuous which owe their origin to the last remains of the elasticity of the material woven, and strive partly to flatten the undulating curves of the threads, partly also to strengthen again the outline of the undulations; in particular the tendency of the threads which have been pressed flat partly to recover their original cross-section acts in this direction and is the cause, among other effects, of the shrinkage in length of the finished plain woven cloth. This effect must be considered as taking place in the following way. The weft swells up and compels the warp, which is now freed from the tension of the beam, to assume a strongly undulating form again, while the fabric shrinks only slightly in the width.

After cloths woven heavily *twisted* yarn have been removed from the loom, forces are freed which *tend to reverse* the twist and which, especially if they are supported by a wet chemical aftertreatment, exert a powerful influence on the position of warp and weft, and produce the *crepe effects* nowadays so much admired. If a number of short sections of the weft are afterwards drawn together, this disturbs considerably the inner equilibrium of the finished plain woven cloth. It occurs under certain conditions in silk and artificial silk articles and gives them a crumpled or crinkled appearance. On the other hand, it will seldom be found that plain woven cloth curls as, for instance, sateen woven fabrics often do after having been stored for a long time. Since all the ends and the picks are equally distributed on *both sides* of the cloth, all strains also are equally distributed on both sides, and there is no strain present which could cause curling.

One other point fundamentally distinguishes the plain weave from the sateen weave and that is that neither warp nor weft has an opportunity of forming a cover either on the face or on the back of the cloth. They cannot cover each other and consequently there is no cloth in which all weaving mistakes appear with such terrible distinctness as in the plain weave. And that is one reason more why the weaving of a perfect plain woven cloth, of whatever material, has always been considered as *the* masterpiece, redounding to the credit of weaver, overseer, and designer alike, no less than of the preparation and finishing.