Oct. 6, 1931. M. D. DEBOUTTEVILLE 1,826,654
PROCESS FOR WEAVING
Filed Feb. 13, 1928 7 Sheets-Sheet 1

FIG. 2.

FIG. 1.

Applicant:
Marcel Deboutteville
By Manus 0 Lewis
Attorneys
PROCESS FOR WEAVING

The present invention has for its object a new process of weaving which allows of realizing with ordinary dobby loom designs of unlimited relation, that is designs independent of the number of the shafts of the loom.

In the known processes of weaving the shafts or hooks are always considered individually, even when—for certain compound mountings—the shafts are divided in groups or “bodies” in which the warp threads are passed, in groups, in repeated succession or in succession with reversal of order.

In the new process of weaving according to this invention, the shafts are no more considered individually, but they are combined or grouped two by two, three by three, four by four... x by x, so that the two, three, four... n shafts of each of these combinations are raised or lowered together.

These combinations are not established in taking the shafts one after the other, that is to say it is not necessary to combine the first shaft with the second one (in the case of combinations 2 by 2), the third shafts with the fourth one, and so on; but the shafts may be combined in any order and a shaft may be comprised in several combinations, i.e. be combined with several of the other shafts of the harness, at will.

The first shaft may be thus combined, for instance, with the second shaft on the one hand, with the fourth on the other hand and further with the seventh one, and it will be possible—in conveniently arranging the treadle (in the case of a hand loom with treadle mounting) or the cards (in the case of a Jacquard)—to always raise together the shafts Nos. 1 and 2, or the shafts Nos. 1 and 4 or the shafts Nos. 1 and 7. In the case of a treadle loom, for instance, it is sufficient, to this purpose, to permanently connect the shafts 1 and 2 to one treadle, the shafts 1 and 4 to another treadle and the shafts 1 and 7 to still another treadle.

With such a loom, I have not as many treadles as shafts, as in the known processes, but as many treadles as considered combinations of the shafts.

Among all the combinations 2 by 2, 3 by 3... x by x which may be realized with the shafts of the loom, a certain number are chosen to make the design and the warp threads are successively passed in the eyes of the shafts of said combinations in such an order that any combination will be preceded and followed by at least one combination which does not present a common shaft with the combination considered. This condition allows—as will be seen below—of maintaining the purity of the design. The passage of the threads into the eyes of the shafts of the combinations suitably ordered may be represented in the form of a “threading diagram”.

Under the said condition any combination may be adopted and arranged in the most suitable succession (as will be explained below) and at last the warp threads passed in the combinations of successive shafts in any desired manner. One will thus obtain a number of different lines or threading diagrams.

Then I may vary the succession of the movements imparted to the combinations of shafts to raise or lower them 2 by 2, 3 by 3... x by x according to the chosen system, at the successive wefts of design. This succession of movements imparted to the combinations may be represented by a “shedding diagram” (or drawing-in draft). Every shedding diagram will give, with a determined threading diagram, a particular design.

To realize the ground of the fabric and to suitably interlace the warp of the same, care must be taken to pick a ground or interlacing weft after each design weft.

For this purpose certain shafts or certain combinations of shafts 2 by 2, 3 by 3, etc., are raised alternatively. These shafts or combinations of shafts must be suitably chosen to insure a rigorous interlacing of the warp, as will be explained below. The interlacing may be effected by calico weaving or other weaving (such as “sergé”) according to the possibility of the system of combinations chosen.

In the following I will explain two samples of realization of the new process with reference to the accompanying drawings.
Figs. 1 and 2 show diagrammatically in elevation an ordinary loom, having four shafts combined by 2 by 2 and having a treadle mounting;

Fig. 3 shows two designs executed on the said loom with one and the same threading diagram but with two different shedding diagrams (I and II);

Figs. 4 and 5 show diagrammatically, in elevation, a loom having eight shafts combined by 2 by 2 and having a treadle mounting;

Figs. 6, 6a illustrate a design obtained on said loom, and Figs. 7, 7a a design likewise obtained on said loom, the same threading diagram being used in both designs but different shedding diagrams;

Figs. 8 and 9 are two graphical views corresponding to the above examples respectively.

In the first example (Figs. 1, 2 and 3) I consider the very simple case of four shafts indicated by 1, 2, 3 and 4.

It is however necessary first to state that this example does not permit fulfilling the condition above stated, i.e., the condition according to which it is necessary that any combination must be preceded and followed by combinations having no common shaft with it. But this example is very simple; it aids to a good understanding of the steps of the new process and shows clearly, precisely, the necessity to realize the above condition.

In the example considered, it is first supposed that the four shafts of the loom are combined two by two. Six combinations are thus possible as well known:

Shaft No. 1 combined with shaft No. 2
Shaft No. 1 combined with shaft No. 3
Shaft No. 1 combined with shaft No. 4
Shaft No. 2 combined with shaft No. 3
Shaft No. 2 combined with shaft No. 4
Shaft No. 3 combined with shaft No. 4

In the operation of weaving I do not raise and lower the shafts 1, 2, 3 and 4 individually as in the actual weaving processes, but I raise and lower the combinations of shafts, such as 1–2, 1–3, 1–4, 2–3, etc.

In other words two shafts are always displaced at the same time. For this purpose

(and if for instance an ordinary hand loom is used, as shown in Figs. 1 and 2) the long bars (French "longs bâtons") of the shafts are connected to the treadles (marches) of the loom. In Figs. 1 and 2, A, A, A, A, A are the four shafts, B, B, B, B, B their respective "long bars" and C the treadles of the loom.

For the purpose above set forth the bars B, B, of the shafts A, A, A are connected to one thread C, C, the long bars B, B, B to another treadle C, C, the long bars B, B, B to another treadle C, C, the long bars B, B, B, B, B, B, B, B to another treadle C, C, etc. The loom thus possesses six treadles C in operation, that is one for each combination of two shafts—and not four only (one for each shaft) as would be the case in the actual processes of weaving.

It is thus to be remarked that, in the process according to the invention, in the case of a system of combinations of 2 by 2, any of the shafts is connected through the intermediary of a treadle to each of the three remaining shafts, and must raise together with each of the three remaining shafts, but never individually or alone.

The fabric to be obtained with a 4 shaft loom comprises a design and a ground which latter must be chosen in a way as to prevent too considerable floats of warp threads.

In the example referred to it is supposed that the ground is a calico weave ground. To make a calico weave the simplest way is, to alternately raise all the odd shafts (i.e., the combination 1–3) and all the even shafts (i.e. the combination 2–4). If the combinations 1–3 and 2–4 are thus reserved for the calico ground, four combinations remain for making the design, i.e., the combinations 1–2, 1–4, 2–3, 3–4 each comprising one odd shaft and one even shaft.

Now the successive warp threads are to be passed through the eyes of the four shafts of the loom. This passage is diagrammatically shown at the top of Fig. 3 and this part of the figure is the "threading diagram" which may vary at will according to the kind of design to be obtained.

In the example considered—and owing to the fact that the calico weave is realized by raising alternately the even shafts and the odd shafts—the warp threads are alternately passed into the even and odd shafts of the successive combinations, that is to say successively in both shafts of any of the four combinations used for the design (as already stated each of these latter combinations comprises one even shaft and one odd shaft).

In the threading diagram at the top of Fig. 3, the four combinations reserved for the shedding are represented by horizontal lines 12, 23, 34, and 41 and on each line the thick dash shows where the warp thread is passed into the shafts.

The warp threads a, b, c, d ... (one thread for a vertical column of small squares) have the direction of the arrow F, and the threading diagram shows that the thread a is passed to shaft 4, the thread b to shaft 5, the thread c to shaft 4, the thread d to shaft 3, the thread e to shaft 2 and so on: the threads pass alternately in the even and the odd shaft as stated above.

When the warp threads are passed in the eyes of the shafts 1, 2, 3, 4, the weaving may be realized in alternately raising and lowering the different combinations 2 by 2 of the four shafts and this due to the movement of the six treadles shown in Figs. 1 and 2.

The treadles C, C, and C, are reserved for
the calico weave as already stated (and said treadles will in fact realize the ground owing to the fact that the warp threads have been passed alternately in the even and the odd shafts); the treadles C1,2, C1,4, C2,3, C2,4, are used for making the design.

As to the order of actuating these treadles—

I first actuate one treadle of design, then a weft of design; I then actuate a treadle of ground and pick a weft of ground; then again a treadle of design and a weft of design, and so on (the weft thread realizing the ground is generally different from that realizing the design).

The warp threads will be thus interlaced after each weft of design by a weft of ground.

To pick the wefts of ground I actuate sometimes the treadle C1,2, sometimes the treadle C2,4.

To make the design I alternate actuate the four treadles of design C1,2, C1,4, C2,3, C2,4, in an order which may vary according to the design to be obtained.

On the right hand side of Fig. 3 are shown two orders of succession of the movements of the treadles, in the form of two shedding diagrams I and II corresponding each to a different design, for one and the same threading diagram at the top of Fig. 3.

The four vertical lines 12, 23, 34, 41 of the shedding diagrams I and II represent four treadles of design and the vertical thick dashes represent the treadles to be successively actuated.

The warp threads of design a', b', c', d', e', ... (one for a horizontal line of small squares) have the direction of the arrow E'.

The shedding diagram I shows that for picking the weft of design a', I actuate the treadle C1,4; for picking the weft b', I actuate the treadle C1,3; for picking the weft c', I actuate the treadle C2,4; for picking the weft d', I actuate the treadle C3,4; and so on.

As to the shedding diagram II, I successively actuate: Twice the treadles C1,2 and C1,4 simultaneously, three times the treadle C2,4 alone, etc.

It is understood that after having actuated one treadle of design and picked a weft of design I alternate actuate each time one of the treadles of ground C1,3 and C2,4 and pick a weft of ground in order to interlace the warp threads and to realize the calico weave.

Below the threading diagram and on the left hand side of the shedding diagram, I have shown diagrammatically the two designs obtained, in the form of horizontal thick dashes.

In examining these designs it will be seen that another design is present, which is represented by points. The reason of the secondary design is as follows:

According to the shedding diagram I, when the treadle C1,4 is actuated to raise simultaneously the combination 4—1, all the threads passing to the shaft 4 and to the shaft 1 are raised too. These threads are:

1. The threads passed voluntarily in the grouping 4,1 in order to determine the elements of the design these threads being marked by a horizontal thick dash on the shedding diagram;

2. The threads passed in the shaft 4 as belonging to the combination of shafts 3,4 and those passed to the shaft 1 as belonging to the combination of shafts 1,2; these threads being marked by a cross on the same diagram.

Consequently on raising simultaneously the shafts 4,1 there will be raised not only the warp threads such as a and b destined to make the design but also the warp threads such as c, d, etc., passed respectively to the shafts 4 and 1 as belonging auxiliary to the combination 3,4 or 1,2; these threads are marked by points on the drawing.

By the first weft of design the warp threads such as c, f, etc., give the first line of the design shown in Fig. 3 by horizontal thick dashes, as set out above. The warp threads, such as c, f, etc., give the first line of a "secondary design" indicated by points and which is much less clear than the "principal design".

This secondary design can harmoniously complete the first one, without diminishing the purity of the same and it can at the same time insure an excellent auxiliary interlacing of the warp threads. But the secondary design may disfigure or even destroy the principal one and this is precisely the case in Fig. 3. As a matter of fact it is easy to see that the warp thread c of the secondary design falls beside the warp thread b which belongs to the principal design. The same phenomenon occurs at several places of the designs obtained with the shedding diagrams I and II (Fig. 3), since at several places the warp threads of the secondary design fall against an element of the principal design. The latter thus appears deformed and seems to have lost its purity.

It is easy to see that such a deformation of the principal design is due to the fact that the combination of the shafts 3, 4 which precedes the combination of the shafts 4—1, for instance, comprises a common shaft (the shaft No. 4) with the latter combination.

The same can be said as to all the combinations (1—2, 2—3, 3—4, 4—1) used for making the design: every combination is preceded and followed at the same time by a combination presenting a common shaft with the combination in question. Thus if I actuate the treadle which simultaneously controls the shafts 2 and 3 for instance, to make an element of the principal design, I will have
inevitably on one or both sides of said element an element of the secondary design which will defigure the first one.

In order to prevent this defiguery of the principal design by the secondary design, care must be thus taken that the combinations of the shafts which precede and follow a given combination, do not comprise any shaft of said combination.

But this is impossible with four shafts 2 by 2, for there only exist one combination of four shafts 2 by 2 (among the four combinations 1–2, 2–3, 3–4, 4–1 capable for the design) containing a common shaft of a given combination. For example to 1–2 corresponds only the combination 3–4.

It may be stated that for this combination corresponds only one “degree of freedom” or that the “degree of freedom” is equal to 1 for four shafts combined 2 by 2, if by “degree of freedom” in a selected system of combinations is understood the number of combinations of shafts not containing any shaft of any of the remaining combinations chosen by chance.

In order that a design should be pure, it is thus necessary that each of the combinations selected for the design should be so ordered as to be limited within at least two combinations containing none of the shafts of the combination considered. In other words it is necessary that the system adopted possesses two “degrees of freedom” at least.

In the second example shown in Figs. 4 to 7α, this condition is fulfilled and the principal design is not destroyed by the secondary design which, on the contrary, completes harmoniously the first one.

In the example of Figs. 4 to 7α, I consider the case of an eight shaft loom: 1, 2, 3, 4, 5, 6, 7, 8 combined 2 by 2.

If the ground is made as in the preceding example (calico), in raising sometimes the even shafts, sometimes the odd shafts—i.e. sometimes the shafts 2.4, 6.8 and sometimes the shafts 1.3, 5, 7, it is easy to calculate that among the 28 possible combinations:

\[
\begin{array}{cccccc}
1 & 2 & 3 & 4 & 5 & 6 \\
2 & 3 & 1 & 4 & 5 & 7 \\
3 & 4 & 2 & 1 & 6 & 8 \\
4 & 5 & 3 & 2 & 7 & 8 \\
5 & 6 & 4 & 3 & 1 & 2 \\
6 & 7 & 5 & 4 & 2 & 8 \\
7 & 8 & 6 & 5 & 3 & 1 \\
8 & 1 & 7 & 6 & 5 & 4 \\
\end{array}
\]

there are only 16 combinations (those in italic) containing simultaneously one even shaft and one odd shaft and which may be used for the design. The combinations containing two even shafts (such as 2–4, 4–6, etc.) or two odd shafts (such 1–3, 3–5, etc.) are excluded by the conditions chosen for making the calico weave ground.

On the other hand it is easy to see that this system of combination possesses nine degrees of freedom, i.e. nine combinations of design containing none of the shafts of any combination chosen by chance. For instance if I consider the combination 1–2, there are nine combinations: 3–4, 5–6, 7–8, 4–5, 6–7, 2–3, 3–5, 4–6 and 5–7 which contain neither the shaft 2 nor the shaft 1.

In the first example of realization (Figs. 1–3) all the combinations 2 by 2 of four shafts have been used, owing to their small number, for the design and the ground. In the case of the second example (Figs. 4–7α) it is possible to use for the design a part only of the 16 combinations. I choose 8 combinations, for instance, to make the design and these 8 combinations are classed or ordered from a horizontal line of the threading diagram to the other, in such a manner that any combination is always preceded and followed by the greatest number possible of combinations having no common shafts with the combination considered, in order to profit of the maximal number of available degrees of freedom. In the case of Figs. 4 to 7α, I have chosen the combinations: 9–1, 1–3, 3–5, 5–7, 7–9, 2–4, 4–6, 6–8 for the design, the calico-weaving being realized, as already stated, by raising alternately the shafts 2, 4, 6, 8 and 1, 3, 5, 7. The eight combinations thus chosen are then classed or ordered the one with relation to the other, on the horizontal lines of the threading diagram, in a way as to satisfy as best as possible the preceding condition. This “order” of the combinations is indicated at the right hand side of the threading diagram.

In view of the eight combinations chosen, the shafts 2, 1 are connected to a thread Cα, the shafts 4, 3 to another thread Cβ, and so on. There will be as many threads as combinations. The loom will thus possess (Figs. 4, 5) eight threads for the design, and two threads for the ground, to which threads are respectively connected the shafts 1, 3, 5, 7 and 2, 4, 6, 8. The total number of threads will be 10 (instead of 8 as would be the case in the known processes in which the shafts are considered individually).

Figs. 6, 6α of the drawings shows a threading diagram a shedding diagram and the corresponding design. Fig. 7, 7α shows another design obtained with the same threading diagram but with a different shedding diagram.

It is easy to see that the principal designs obtained (represented again with horizontal thick dashes) are absolute pure and that they are never destroyed by the respective secondary designs (represented by points). As a matter of fact any combination of the order chosen is always preceded and followed by at least two combinations containing none of the shafts of the combination considered.

The elements of the secondary design are thus always sufficiently distant from the elements of the principal design so that the latter is not destroyed and keeps all its purity.
Between each weft of design I pick a weft of ground in actuating the thread C_{5,5,5}, or the thread C_{4,4,4} alternately, to make a calico weave.

Instead of making the ground or insuring the interlacing of the warp by calico weaving, in raising sometimes the even shafts, sometimes the odd shafts (as this leads to the necessity of passing successively and alternately the warp threads through the heads of shafts of even and odd number) it is possible to realize the calico weave with a loom with eight shafts as follows:

1. One shaft against seven; for example the shaft 1 against the shaft 2, 3, 4, 5, 6, 7, 8, i.e. by causing all the warp threads to pass successively and alternately through the head of the shaft 1 and through the head of one of the shafts 2, 3, 4, 5, 6, 7, 8; then at the moment of interlacing in raising and lowering alternately the shaft 1 and the group of shafts 2, 3, 4, 5, 6, 7, 8.

2. Two shafts against six: for example the shafts 1, 2 against the shafts 3, 4, 5, 6, 7, 8. I.e. by causing all the warp threads to pass successively and alternately through the head of one of the shafts 1, 2 and through the head of one of the shafts 3, 4, 5, 6, 7, 8, then at the moment of interlacing in raising and lowering alternately the shaft 1, 2 and the group of shafts 3, 4, 5, 6, 7, 8.

3. Three shafts against five: for example, the shafts 1, 2, 3, against the shafts 4, 5, 6, 7, 8, (the explanation being the same as the above).

4. Four shafts against four: for example the shafts 1, 2, 3, 4, against the shafts 5, 6, 7, 8 (explanation the same as the above).

In the first case it can be said that the shaft No. 1 is specialized to make a calico ground; in the second case the shaft Nos. 1, 2; in the third the shafts Nos. 1, 2 and 3 and so on.

For any given system it would then be possible to specialize a variable number of shafts as required to make a ground of linen weaving or any other weaving assuring a sufficient interlacing of the warp.

If I now consider again both examples of realization, that of Figs. 4-7 a on the one hand and that of Figs. 4-7 a on the other hand, it is clear that:

1. In the first example (loom with 4 shafts 2 by 2) the design is made with the combinations 1-2, 2-3, 3-4, 4-1, and the ground or interlacing with the combinations 2-4 and 1-3.

2. In the second example (loom with 8 shafts 2 by 2) the design is made with the combinations 2-1, 4-3, 6-5, 8-7, 2-3, 4-1, 6-7, 8-5, and the ground or interlacing with the combinations 1-3, 5-7 and 2-4, 6-8.

In both cases the “order” or classification of the combinations chosen for the design and for the ground may be diagrammatically represented as shown in Figs. 8 and 9, respectively.

In Fig. 8 (4 shafts 2 by 2) the shafts may be divided into two “sections” each corresponding to a vertical column of Fig. 8:

The section of the shafts 2-1

The section of the shafts 1-3

and these two sections correspond exactly to the two combinations which are used to make the ground.

The same can be said for the case of Fig. 9 (8 shafts combined 2 by 2).

In Fig. 8, moreover, the succession of the shafts from one section to the other is such that the combination 1-2, 2-3, 3-4, 4-1 used for the design are repeated.

In Fig. 9 the succession of the shafts from one section to the other is such that the combinations 2-1, 4-3, 6-5, 8-7, 2-3, 4-1, 6-7, 8-5 used for the design are repeated.

It is easy to see how the operator may represent graphically and very clearly the combinations chosen for making the design and the ground. The operator will divide the shafts of the loom into two, three or more sections; in each section the succession of the shafts will be disposed in any order desired (in repeated succession or in succession with reversal of order); then the operator will dispose the sections relatively to each other in such a manner that the shafts are transversely combined in any order desired (in repeated succession or in succession with reversal of order). With the aid of the graphical table thus established he can easily effect the threading of the warp threads, in passing them successively to a shaft of one section, then to a shaft of each of the neighboring and successive sections, in the order adopted for the transversal combinations and in arranging the latter in a determined succession (given by the threading diagram).

When these operations are effected:

1. the operator—to make the ground—actuates sometimes all the shafts of a section (or of several sections), sometimes all the shafts of another section (or several other sections) in the order given by the ground to be realized;

2. the operator—to make the design—actuates successively the shafts of the combinations judiciously ordered by the threading and according to an order based upon the shedding diagram.

What I claim is:

1. Process of weaving permitting the realization on an ordinary loom of designs of unlimited relation, i.e. independent of the number of the shafts of the loom, consisting in choosing among all the possible systems of combinations of the shafts 2 by 2, 3 by 3, 4 by 4, . . . a determined number of these combinations for making the design; in ordering or classifying the combinations thus chosen.
in such an order that each given combination is preceded and followed by at least one combination which does not contain any of the shafts of the combination considered; then in passing successively the warp threads in the healds of the shafts of the chosen and classified combinations, according to an order of succession and of repetition depending on the kind of the design to be obtained; and lastly in raising and lowering, before each weft, successively—and in a determined order of succession and of repetition depending on the design to be obtained—the shafts belonging to each of the combinations thus chosen.

2. Process of weaving consisting, in choosing among all the possible systems of combinations of the shafts 2 by 2, 3 by 3, 4 by 4, . . . a determined number of these combinations for making the design; in ordering or classifying the combinations thus chosen in such a determined order that each given combination is preceded and followed by the greatest number possible of combinations which do not contain any of the shafts of the combination considered; then in passing successively the warp threads in the healds of the shafts of the chosen and classified combinations, according to an order of repetition depending on the kind of the design to be obtained; and lastly in raising and lowering, before each weft, successively—and in a determined order of succession and of repetition depending on the design to be obtained—the shafts belonging to each of the combinations thus chosen.

3. Process of weaving consisting, in choosing among all the possible systems of combinations of the shafts 2 by 2, 3 by 3, 4 by 4, . . . a determined number of these combinations for making the design; in ordering or classifying the combinations thus chosen in such a determined order that each given combination is preceded and followed by at least one combination which does not contain any of the shafts of the combination considered; then in passing successively the warp threads in the healds of the shafts of the chosen and classified combinations according to an order of repetition depending on the kind of the design to be obtained; lastly in raising and lowering before each weft successively—and in a determined order of succession and of repetition depending on the design to be obtained—the shafts belonging to each of the combinations thus chosen, and in the course of performing the foregoing steps picking a weft of interlacing or of ground after each weft of the design by raising and lowering alternately the combinations of even and odd shafts.

In testimony whereof I have affixed my signature.

MARCEL DELAMARE DEBOUTTEVILLE.