to obtain correct conclusions as to the sett and number of hooks available for the production of patterns, it is necessary to find a rule which will give the exact number of threads per inch, and the number of hooks that may be used. The question is one of simple proportion, for when there must be casting out to suit the pattern, the threads per inch are reduced in direct ratio.

For an example, suppose a machine contains three hundred four hooks, and is tied up for sixty threads per inch, sixteen of the hooks being idle. Three hundred four minus sixteen equals

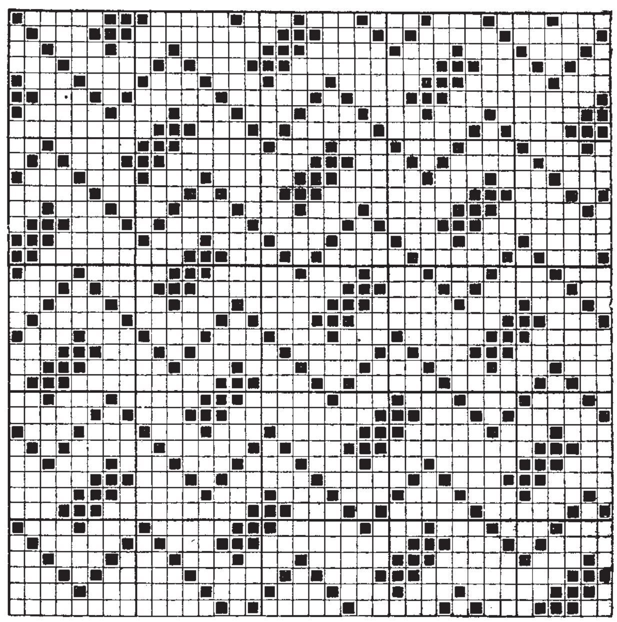


Fig. 285.

two hundred eighty-eight. (304 – 16 = 288.) This means that there are two hundred eighty-eight harness cords, of the three hundred four, available for actual work, and if the full number gives sixty threads per inch, the required number must give less, in the proportion of three hundred four to two hundred eighty eight: or 304 : 288 :: 60 : 56 $\frac{84}{100}$. Consequently the only cloth that could be woven would be one with approximately fifty-seven threads per inch.

This of course would not be a serious matter, if the drawing amounted in the aggregate to a portion of an inch or any other small amount, but if multiplied, as it would be in most cases, it would become quite serious and for this reason the designer must pay careful attention to this question.

To emphasize the results of casting out and the methods and calculations involved, we will take Fig. 284 and find how many

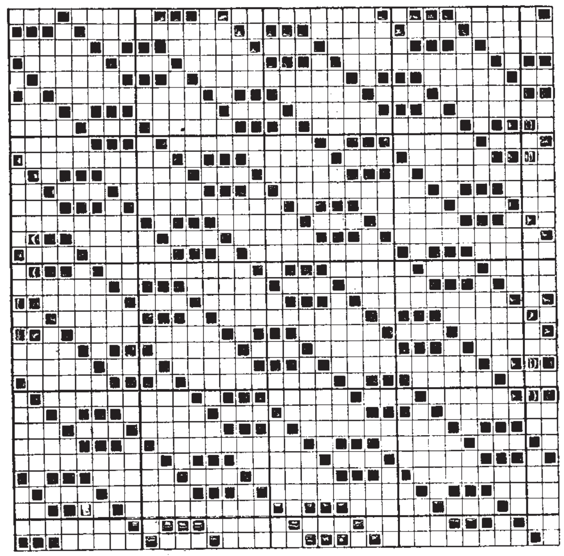


Fig. 286.

hooks must be cast out to weave it on the different machines, and the result upon the number of threads per inch which may be woven in the cloth.

The design shown at Fig. 284 repeats on thirty-five threads, so to weave this on a machine containing three hundred four hooks, it will be necessary to cast out twenty-four hooks; ($304 \div 35 = 8$ and 24 remainder).

If the machine were tied up for eighty threads per inch, a smaller number of threads must be used on account of some of the hooks, and consequently the harness cords, being cast out. The number of threads per inch which could be used bears the same proportion to the number for which the machine was tied up, as the number of hooks in use bears to the total number of hooks in the machine. Substituting the numbers and letting X mean the required number, the calculation would be as follows: 304 : 280 :: 80 : X. It will be found that X equals approximately $73\frac{2}{3}$ threads, which means that that number of threads could be used in each inch of cloth.

If a machine with four hundred and eight hooks were used, it would be necessary to cast out twenty-three hooks ($408 \div 35 =$ 11 and 23 remainder). If this machine also were tied up for eighty threads per inch, it would be possible to have between seventy-five and seventy-six threads per inch in the cloth (408 : 385 :: 80 : $75\frac{1}{2}$).

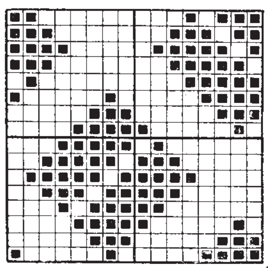


Fig. 287.

Distribution of Pattern. Having dealt with problems of adapting the machine to the pattern, both in extent and texture, it is necessary to deal with the arrangement and distribution of patterns and their arrangement upon the design paper.

In preparing the design upon the design paper, the first consideration must be as to how the figure is to be formed. In the explanations of various kinds of designs previously given, it is explained that there are many ways of changing the order of interweaving the warp and filling threads, which will produce a variety of figures upon the fabric; also that in many cases this production of figures necessitates a change in the structure of the ground cloth.

The design shown at Fig. 287 is an illustration of a simple style of figure prepared for jacquard work. This design could be woven on a dobby loom or head motion, as only sixteen harnesses are required, but it will answer the purpose of illustrating a simple explanation of the subject.

There are two important points to be considered in dealing with a design of this kind: *first,* the nature of the ground fabric; and *second,* the arrangement and disposition of the figures, and the determination of the areas they may occupy.

It will be best first to consider the influence of the ground weave and its probable interference with the figure. It should be understood that the figure is formed by either the filling floating loosely over the warp, or *vice versa*. In the illustration shown at Fig. 287, the blank squares represent the area occupied by the ground weave and the squares which are blocked in represent the figure.

It is apparent that if the filling floats under the squares which are blocked in, and over the blank spaces, as is usually the case in twilled fabrics, the cloth will be very loose in texture, unless very bulky yarn is employed or a large number of threads per inch in each direction are used. Even these would not always meet the requirements of the case, for a light cloth could not be made under these conditions; and furthermore, the figure would not have that

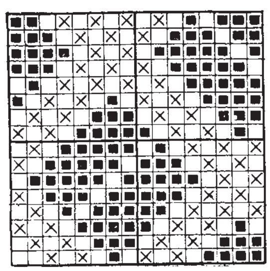


Fig. 288.

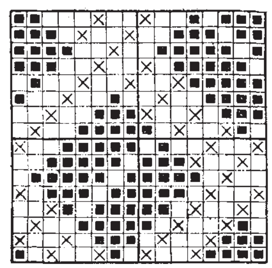


Fig. 289.

degree of prominence which is so desirable. Therefore, there should be a ground weave, and this must be varied according to the character or weave of the cloth to be produced.

For the purpose of making this matter clearer refer to Figs. 288 and 289. In Fig. 288 the ground weave is plain, as indicated by the crosses, and it works around the figure in such a manner as not to interfere with it, but rather to give it additional prominence. Of course, the blocked-in squares and the crosses, in the illustration, both represent risers and are merely varied in form to show clearly which is the true figure and which is the ground. It is perfectly clear that the ground or plain weave never comes in contact with the figure, but works around it without interference, so that the outlines of the figure will be clearly defined and the pattern will be perfect.

To appreciate the significance of the above remarks, refer to Fig. 289. In this design the ground is shown to be a three harness twill, and it will be seen at once that the figure interferes with the clear formation of the main figure, so there could not possibly be that sharp, definite form as at Fig. 288. If this pattern were made with a four harness cassimere twill for ground, the result would be even more disastrous to the prominence which should be given the figure.

From the above it will be understood that the designer must pay particular attention to the ground weave; also that if the design is one which is loose in the order of interweaving, there should be more material, or the cloth should be finer. In all cases, the ground weave must be arranged around the figure in the best possible manner considering the size of the figure and the form required.

EXAMPLES FOR PRACTICE

1. State generally the reasons why casting out in jacquards is resorted to and its effect upon the structure of cloth which may be woven.

2. Determine on which machine Fig. 285 could be woven by casting out the smallest number of hooks. Assume that the machine was tied up for ninety threads per inch and find the number of threads which could be used per inch.

3. Find how many hooks would have to be cast out of a "four hundred" machine to weave the pattern shown at Fig. 286, and the number of threads which could be woven per inch if the machine were tied up for sixty threads per inch.

4. Work out a design similar to that given at Fig. 287, using a plain weave for the ground.

5. Make an original design in which a twill may be used for the ground without interfering, to any extent, with the figure.

Areas. Special attention should now be given to the distribution of the main figures and the areas occupied by them. The design shown at Fig. 287 represents two parallelograms placed side by side in such a position that they form a square. These are placed at right angles to each other in such a manner that they form diagonal lines in both directions. (These lines would be much more pronounced if the design were repeated several times.)

For many purposes, and more especially for this form of figure, this arrangement is an admirable one, but for other purposes and other figures this arrangement is not at all suitable. Moreover, the number of threads occupied by the complete design may not be suitable for the number of hooks in a jacquard machine, or for the number of hooks being used. For example suppose that the design shown at Fig. 288 was to be worked with three hundred hooks instead of with three hundred four hooks, which would be the case if the ground were a three harness twill as shown at Fig. 289. The figure, occupying sixteen threads, is not a factor of three hundred; that is, it cannot be divided into three hundred without leaving a remainder, therefore some change would have to be made. If the ground weave was a five harness sateen, the same rule would apply.

There is still another difficulty to be overcome; the design occupies sixteen threads in each direction and the twill ground weave repeats on three threads, which is not a factor of sixteen. Therefore the design shown at Fig. 289 cannot be repeated on less than forty-eight threads. This creates another difficulty, as forty-eight will not divide evenly into three hundred.

Having conjured up all the difficulties possible, we shall endeavor to explain how easily they may be overcome. It will be understood that some change must be made, but ordinarily all these difficulties could be met by a slight alteration in the cast out. In this instance, however, it will be assumed that the change in the distribution of the figures is for the purpose of changing their positions in relation to each other.

The first matter to be taken up is the order of distribution, and the next is the space to be allotted. The latter will be dependent upon the character of the cloth, and the former upon the position in which it is desired to place the figures in relation to each other. The form of the figures will in many cases affect their relative positions. The most useful methods of distribution and those most commonly resorted to are based upon sateen orders.

To make the foregoing clear, all other considerations should be set aside and several methods of distributing the same figure should be worked so as to ascertain the effects produced, and to determine the methods of procedure. In all probability the altered arrangement would require that the same area should be allowed to each figure; that is, there should be the same space surrounding each figure as there is in the original. Taking this as a basis, the number of threads upon which to work must be ascertained.

In the design shown at Fig. 287 there are two figures occupying sixteen threads and sixteen picks. Sixteen times sixteen equals two hundred fifty-six ($16 \times 16 = 256$), therefore the two figures occupy two hundred fifty-six small squares, which gives an area of one hundred twenty-eight small squares to each figure. Assume

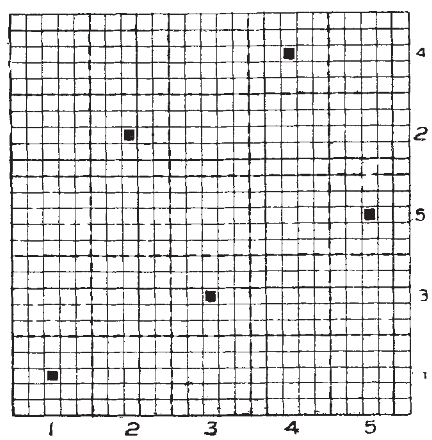


Fig. 290.

now that five figures are to be distributed in sateen order. Then, five times one hundred twenty-eight equals six hundred forty ($5 \times 128 = 640$), or six hundred forty squares will be required for five figures similar to those shown at Fig 287. As the original is on a square space, the new distribution will be arranged in a square, so to find the number of threads and picks the design will occupy, the square root of 640 should be extracted. This being 25, a space upon the design paper of twenty-five squares in each direction is marked off.

This is the area required for five figures similar to those given at Fig. 287 to be arranged in five harness sateen order. Before placing the figures upon this space, it must be divided into five parts in each direction, and when so divided the divisions on one side should be numbered in sateen order and the divisions on the bottom numbered in consecutive order. Then suppose each of these divisions to have lines enclosing a square at the intersection corresponding to the numbers. The process worked up to this point is shown at Fig. 290.

From this point the most convenient method of procedure is to find the center of the figure or some point as near the center as possible. A mark should now be placed at any point within the enclosed square and used to represent the center of the intended figure, (shown at Fig. 290). Care should be used that whatever

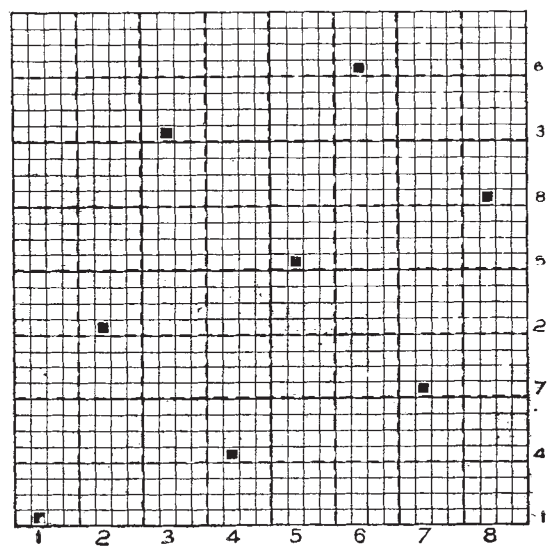


Fig. 291.

position is used for the first figure a corresponding position must be selected for each of the others. The figures are now formed around this mark.

The example shown in Fig. 290 serves as a simple illustration of the methods employed in determining the area, but it would be rather difficult as a first example of the methods employed in arranging the order of figures. For this reason, we will use the same figure as in the previous example and distribute eight figures in eight harness sateen order.

Referring back to the previous example, it is found that one figure occupies one hundred twenty-eight squares, so eight figures will occupy 8 × 128 or 1024 squares. The square root of 1024

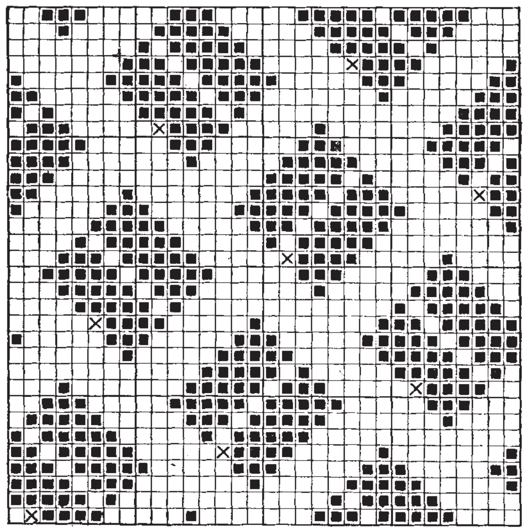


Fig. 292.

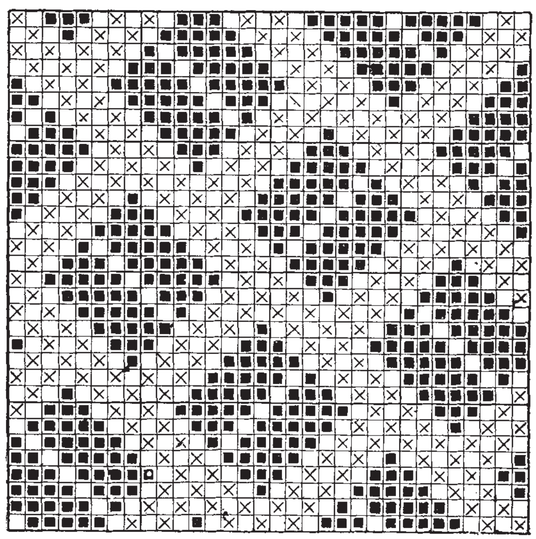


Fig. 293.

is 32, so that the area will be 32 × 32 squares. Marking off this area and dividing it into eight spaces (as there are eight figures), and numbering these divisions in consecutive and sateen order we have Fig. 291. The points around which each figure must be filled in are also shown in Fig. 291.

Fig. 292 shows the figures filled in with relation to the start-

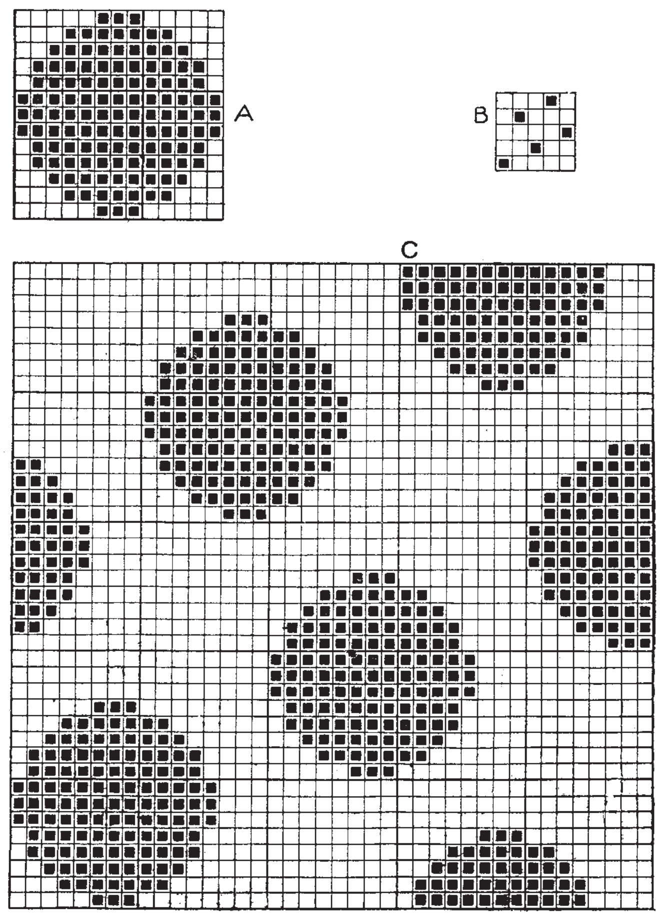


Fig. 294.

ing points; and in Fig. 293 the design is shown completed with the plain weave added for the ground weave.

Fig. 294 shows another design with the spots arranged in very good order. A, is the spot which must be developed in five end sateen order (shown at B) on 40 × 40 squares. Following the methods outlined above the design is worked out as shown at C.

A number of ground weaves might be used with good success in this design, but to get the best effects a filling flush weave should be used, as this would give a greater contrast with the warp figure.

Arrangement of Figure. Following the questions of distribution and the methods of determining the areas, attention must be directed to the arrangements most suitable for figures of different forms, for, as suggested, these affect the appearance of the pattern to a more or less extent, according to the form of the figure.

When the figure forms a perfect square and is placed diagonally upon the paper, as was the case in Fig. 287, there is little

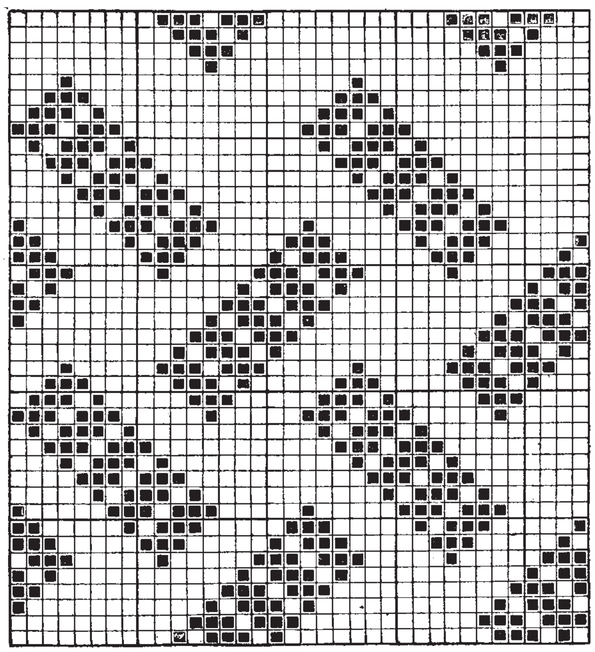


Fig. 295.

difficulty in forming a suitable arrangement, as almost any form will make a very good appearance. Of course, some methods would give better results than others, but the ordinary purchaser would probably not notice such a small difference. This, however, is not the case when dealing with other forms of figures, as in many cases the result would be practically valueless as a design. For instance, if we find the number of threads and picks which would be required for five figures (similar to those shown at Fig.

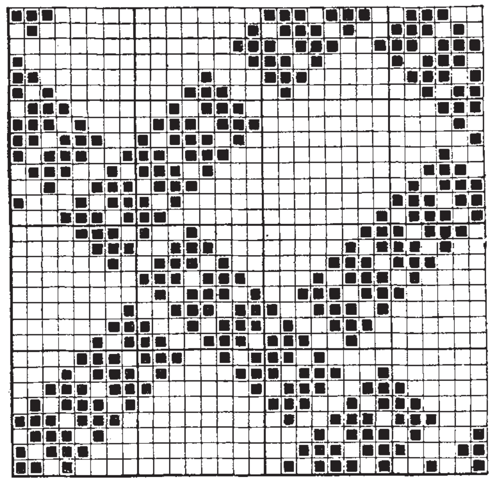


Fig. 296.

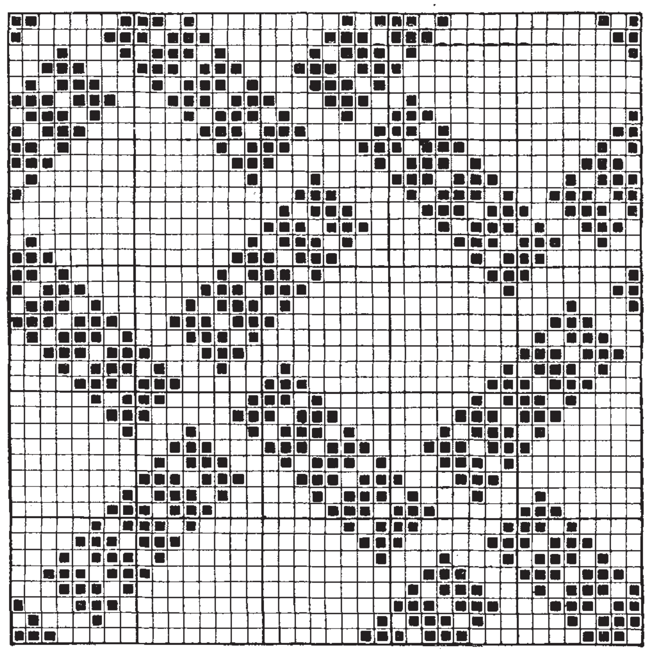


Fig. 297.

295), allowing each figure the same area as is given in Fig. 295 and using the same order of distribution, some of the figures will overlap each other if their positions are reversed, consequently this is an impracticable arrangement.

The arrangement at Fig. 296 shows six figures placed in the best possible order of a broken sateen. Of course, the sateen order for six figures must be irregular, but it is very useful for some purposes. In this case, the figures are almost touching each other. Compare this carefully with Fig. 295 in which there is ample space

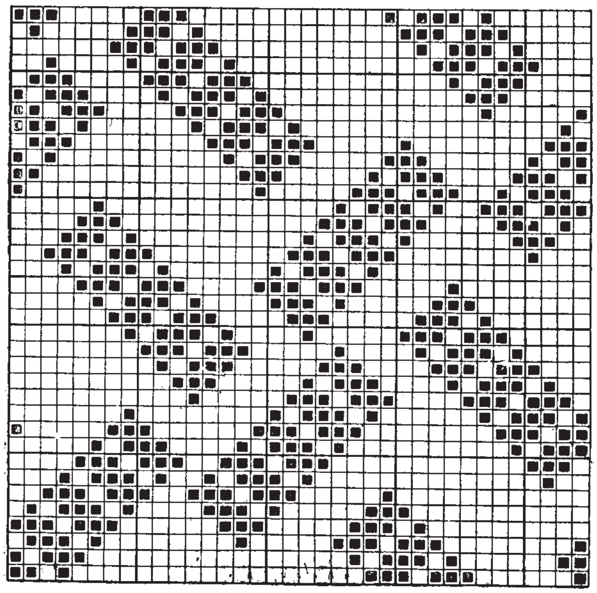


Fig. 298.

all around the figures, yet the area allowed in each case is practically the same. Note also that the plain weave could not be used for the ground in Fig. 296 unless every alternate figure were moved one thread, so as to prevent interference with the ground weave. No arrangement could be made which would be satisfactory, so this arrangement may be condemned as impracticable.

Now study the arrangement given at Fig. 297, which consists of ten figures in sateen order, and contrast this arrangement with the previous example. This arrangement is excellent but it presents a very different appearance to the one given at Fig. 295.

The figures are closer together at their extremities and enclose a larger square of ground cloth. It would, of course, be a matter of consideration which of the two would be best suited to the purpose for which it might be intended, but it is quite clear that neither one could be substituted for the other as the appearance of the two patterns is so totally different.

Still another arrangement is given at Fig. 298. It will be noted that this consists of eight figures in sateen order. This arrangement more nearly approaches in appearance Fig. 295. The area is distributed in almost the same proportions and one might almost be substituted for the other. There is, however, the same fault here as regards the plain weave as at Fig. 296, which arises from the manner in which the total space must be divided. The area occupied is 36 x 36 squares, which, of course, cannot be divided evenly by eight (which is necessary on account of there being eight figures), so the divisions must contain four and five squares alternately. This, of course, makes an irregularity which prevents interference.

The question must be considered as to whether the number of threads occupied is suitable for the number of hooks employed in a jacquard machine. Figs. 295, 296, 297, and 298 occupy such widely different numbers, with the exception of Figs. 295 and 298, that they could not be worked on the same machine, so the designer would have to take this into consideration in determining which of the arrangements it would be best to adopt.

EXAMPLES FOR PRACTICE

1. If two figures occupy three hundred thirty small squares, what is the area of each figure?
2. Make an original design with five figures arranged so that a plain ground weave may be used.
3. Make designs for five, eight, and ten figures, using a figure similar to the one in Fig. 294.
4. How would you proceed to distribute figures in sateen order?
5. Why should a filling flush ground weave be used in a design where the figure is formed by the warp?

Figures Formed With Both Warp and Filling. Attention must now be directed to another feature which is always present in the arrangement of small figures, and for the purpose of explaining this thoroughly the figures given represent the most difficult type of patterns.

In designing figured goods, it is quite common to have figures formed with both warp and filling at the same time, and not with but one material, as is the case in all previous examples. In this case it is essential that the figures be so arranged that there will be no possibility of the pattern forming stripes in any direction; in other words, that there shall be perfect distribution. Take for

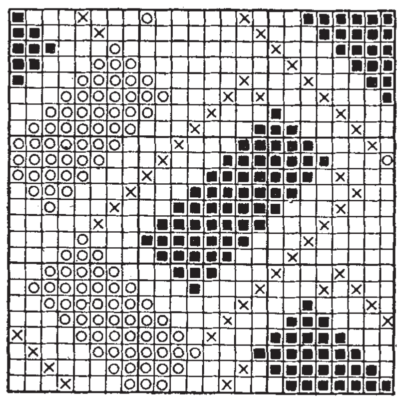


Fig. 299.

example Fig. 299, and assume that the warp and filling are different colors, say black and white, and that the solid black squares of the design represent where the warp comes to the surface, while the circles represent where the filling comes to the surface.

It will be noted at once that were cloth woven from this design, the result would be alternate stripes of black and red running in the direction of the warp. The form of the figure tends to make this defect more prominent. It must be assumed that the filling figure and the warp figure are placed at right angles to each other and must always be in the same relative position to form one figure. For the purpose of alternately placing the figures in reversed positions, and following the plan adopted in previous lessons, the whole figure may be supposed to be contained in a parallelogram, as shown by the crosses. If this is done and the figures are turned upon their centers, the two figures are apparently placed in their proper positions; however, this is not the case as the filling figures will overlap each other to a large extent, while the warp figures also will overlap slightly.

The cause of this is at once apparent from the form and posi-

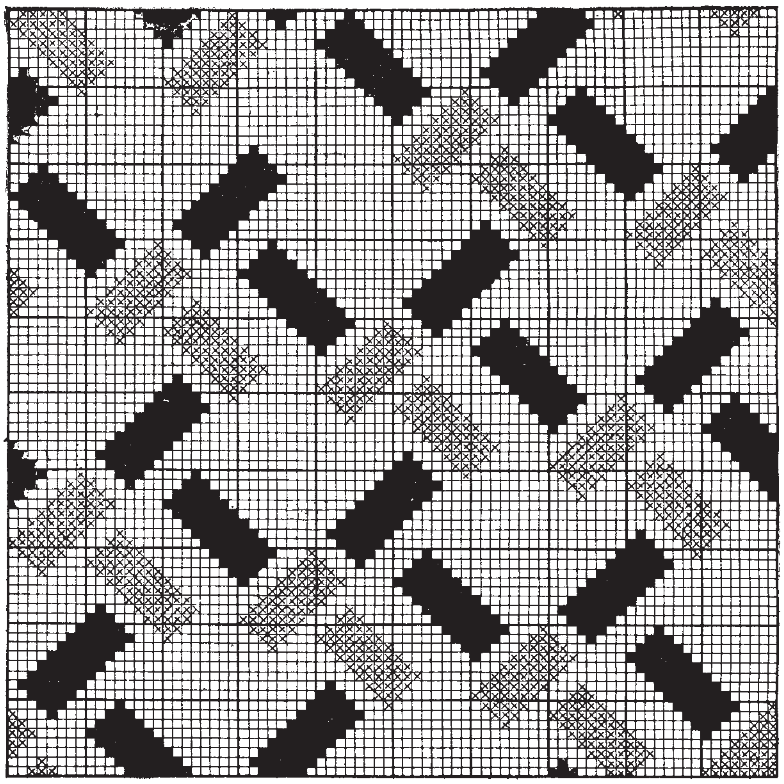


Fig. 300.

tion of the two portions of the figure in their relation to the parallelogram. Thus it will be seen that the arrangement of the figures is very imperfect, while the form of the figure also may be improved. In this arrangement of the two figures the parallelograms are placed as near to each other as possible, thus tending to increase the difficulties when other orders of arrangement are resorted to.

We will now take up the suitability of other orders of arrangement. In Fig. 300 the arrangement consists of five spots in sateen order, which is repeated four times, so as to obtain the best order of reversing the figures. This arrangement is far superior to the one shown at Fig. 299, and for many designs of this class is very suitable, but it is not perfect, as indeed no order of arrangement could be with this type of figure.

It will be noted that the filling portion of the figures, which are indicated by crosses, come together in pairs. This in itself is not necessarily objectionable, in fact, in some cases it gives a good effect to the pattern, but on examining the design closely the

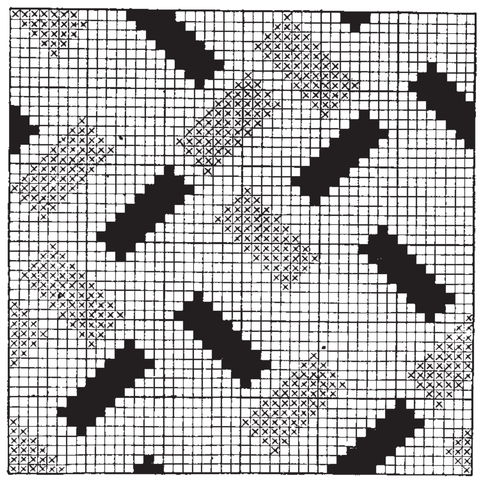


Fig. 301.

appearance suggests the formation of a diagonal pattern. This might be considered an objectionable feature and must carefully be kept in view. It need not in all cases be looked upon as a defect, but should be guarded against in such cases where it might be considered defective.

The design shown at Fig. 301 shows an arrangement of eight figures alternated in pairs. The result of this arrangement is to form groups of three figures, with the filling portions coming together, and two figures which are isolated from the groups. It requires but a glance to see that in this design a distinct stripe would be formed in the cloth, as at some points only the warp comes to the surface over a number of threads, and at other points there is a great preponderance of filling. Other orders of arrangement of eight figures might be adopted, but there would be faults of one kind or another, and most likely stripes would be formed.

If an attempt be made to arrange ten figures in sateen order in a small area, the figures will overlap each other, but if the area be increased, good arrangements may be made. As previously stated, the areas in these examples have been reduced to the lowest possible point, so as to increase the difficulties and thereby assist in making clear the defects which are inseparable from this class of designs. A slight increase in the area would remove many of the difficulties, but they would still exist to some extent.

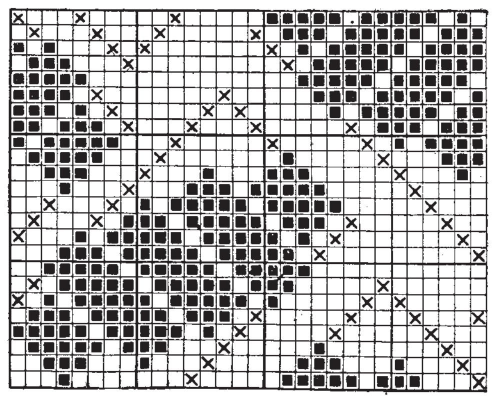


Fig. 302.

Figures Not Square. In the previous examples, the number of threads and picks have been equal, but there are some forms of figures which should not occupy a square space. If the figure shown at Fig. 302 were placed on the same number of threads and picks, the result would be most unsatisfactory, as will be shown later. When the form of the figure is such that when laid upon design paper more threads than picks are occupied, or *vice versa;* and when two figures alternate in the manner shown at Fig. 302, the space occupied by each figure should be a parallelogram of the character shown in the illustration. If this were not so, the figures would overlap at the ends, or there would be a clear blank space between them, caused by one terminating before the other commenced.

If this rule applies to the space occupied by two figures, it should also apply for any number of figures. This shows the necessity of a rule to calculate the area for any other number of figures than two, and to determine the respective number of threads and picks to be occupied.

There are two methods which might be adopted for ascertaining these particulars. The first one is to find the total number of small squares occupied, in the same manner as if the area were to be a small space. To illustrate this, take Fig. 302 as an example. There are thirty threads and twenty-four picks occupied by two

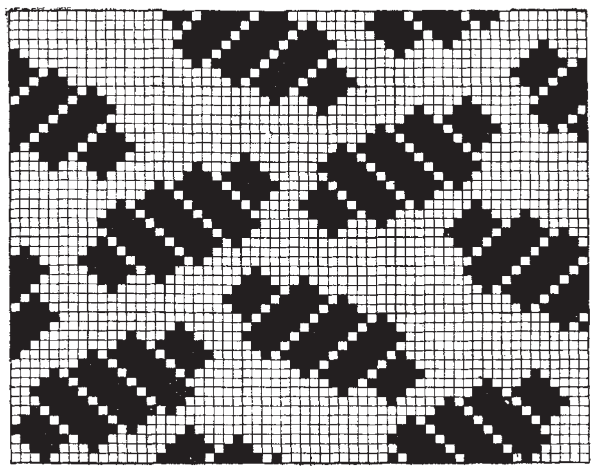


Fig. 303.

figures. Multiplying these together we find that 720 small squares are required for two figures, which is equivalent to 360 squares for each figure. If five figures were to be distributed 1800 small squares would be required (360 × 5 = 1800).

To find the number of threads and picks required it would be necessary to treat the matter as a problem in proportion, as follows: 30 : 24 : : 1800 : 1440. The square root of 1440 is 38, so there will be 38 picks required.

To find the number of warp threads the problem would be 24 : 30 :: 1800 : 2250. The square root of 2250 is 48, so there would be 48 threads required. To prove the above, the number of warp and filling threads may be multiplied together. 38 × 48 = 1824, the slight difference being due to the use of full numbers instead of fractions.

The second method is to square each set of threads separately and treat the problem in the manner shown on Page 203. Following this method the threads would be: 30 × 30 = 900 ÷ 2 = 450. For five figures, 450 × 5 = 2250, which when the square root is extracted gives 48 warp threads.

The picks would be found in the same manner 24 × 24 = 576 ÷ 2 = 288. For five figures, 288 × 5 = 1440, the square root of which is 38, the same as obtained by the first method.

A design for eight figures is shown at Fig. 303. The design is extended in the same manner as in previous lessons, so as to

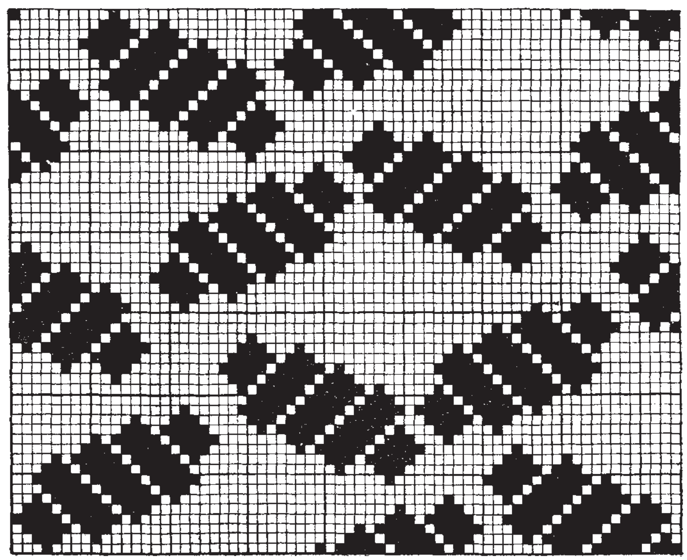


Fig. 304.

alternate the figures. Fig. 304 shows a design of ten figures carried out in the same manner.

A feature of these designs is the different order of arrangement. This must be studied in order to master the principles of making designs of this nature. It will be excellent practice for the student to use the figure shown in these illustrations to form a design on a square space, comparing the results obtained with these illustrations.

Diagonals. With a view to dealing with patterns which run all over the cloth it will be helpful to consider the arrangement of figures which run in a diagonal direction, as in most cases this class of patterns has some definite order of arrangement as its base.

The illustration at Fig. 305 shows a simple diagonal design which repeats on thirty threads and thirty picks. In a design of this kind, the first matter which requires attention is the determination of a complete pattern. This is governed by the relationship of the figure running between the diagonals and the total number of threads occupied by the diagonal. A diagonal pattern running across the paper at an angle of forty-five degrees must occupy exactly the same number of threads in each direction, and if

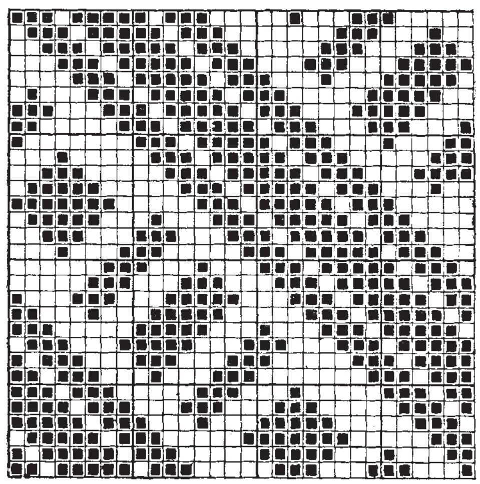


Fig. 305.

extended beyond the number of threads necessary for a repeat, there must be a complete repetition or the pattern will not join properly. It is just as essential that the figure also should join perfectly.

There is one point here to which particular attention is called, so as to facilitate a thorough understanding of the reasons which will be given for determining the completion of the patterns. Knowing that the diagonal must occupy a square space, it is quite immaterial whether the threads are counted in a horizontal, vertical, or diagonal direction, but with the fancy figures running between the diagonal lines, this is not the case, as it is repeated continuously in a diagonal direction only, therefore, it can be counted only in the direction in which it runs.

Referring to Fig. 306, it will be readily seen that there is no

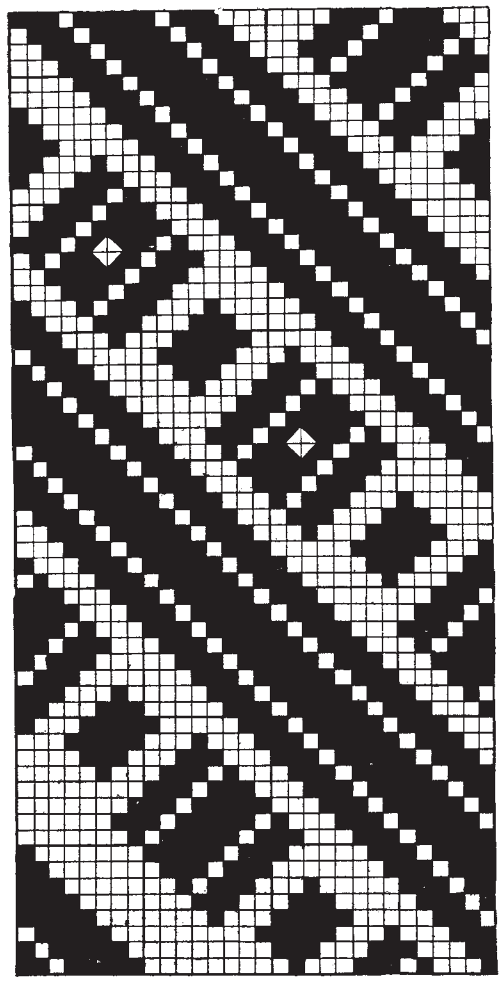


Fig. 306.

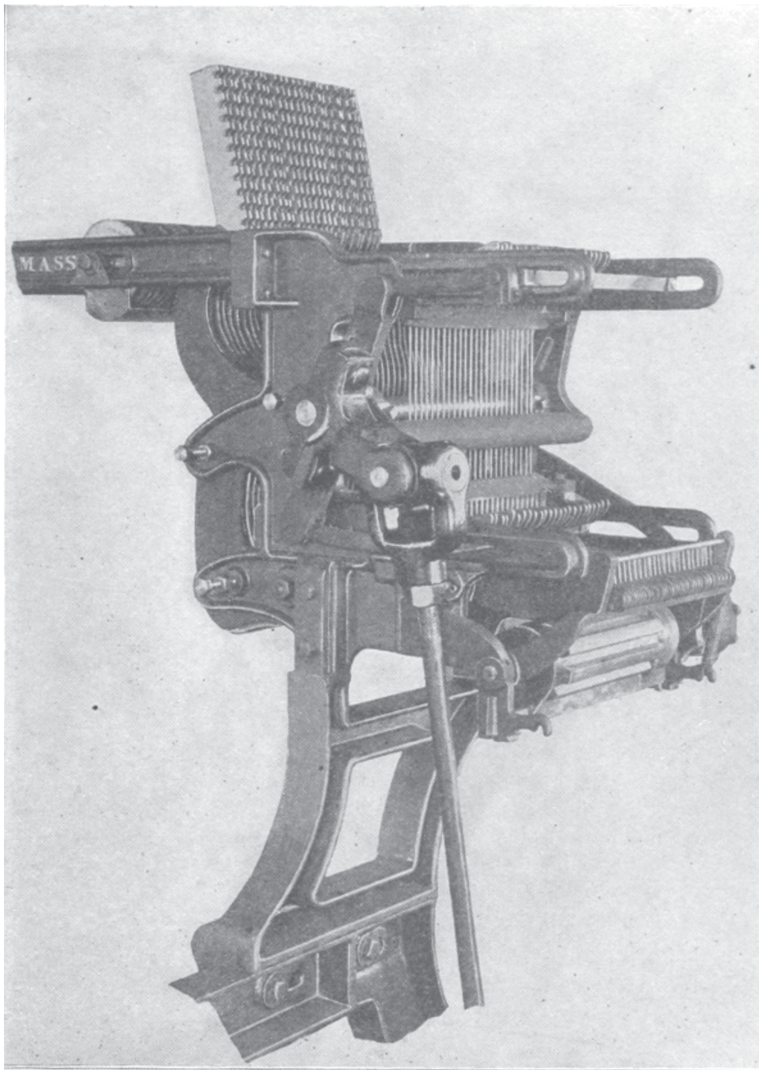
possibility of counting the distance from one figure to another, except in a diagonal line, because there is no repetition in either a horizontal or vertical direction, until the whole design is completed. It should be understood that the meaning of the distance from one figure to another, in a diagonal direction, does not mean the open space between one figure and the next, but it does mean the distance from any point in one pattern to the same relative point in the next repeat of the pattern. This is indicated by the diamond shaped space in the figure.

If the design shown at Fig. 305 be counted, it will be found to occupy fifteen threads from the center of one diamond shaped figure to the center of the next similar figure, and as the diagonal occupies thirty threads each way, and as fifteen is half of that number, the figure is repeated twice within the square occupied by the diagonal, consequently there is no difficulty. But a reference to Fig. 306 will show that the figure occupies twelve threads, and as twelve will not divide evenly into thirty, the design must be carried to a greater extent before arriving at a point where the figure is complete.

Referring back to the statement made above to the effect that if the diagonal is carried beyond one complete pattern it must be carried to another complete pattern, it will be understood why the design does not repeat on a smaller area. In this instance, the design must be extended to occupy sixty squares in one direction or the other.

The foregoing may be stated in this form: Both the figure and the diagonal must be continued until a number of squares has been reached into which both the number of squares occupied by the diagonal and the number of squares occupied by the figure will divide without leaving a remainder. In this case when the diagonal has been repeated twice, the number of picks occupied will be sixty, and as twelve will divide into sixty, the design is complete on that number.

Assuming that the number of threads from a point in the one figure to a similar point in the next figure was fourteen instead of twelve, it would be necessary to carry the design to the extent of two hundred ten squares in one direction and thirty squares in the other. If the distance between similar points was thirteen threads, the design would require three hundred ninety squares in one direction.



MASON DOBBY WITH CAPACITY FOR 24 HARNESSES
Mason Machine Co.

TEXTILE DESIGN

PART V

GAUZE AND LENO

The principle of crossing one set of warp threads over a second set of warp threads—or *cross-weaving*, as it is commonly termed—represents the last and perhaps the highest type of woven-fabric structure. Cross-woven fabrics may easily be distinguished from fabrics belonging to other divisions of woven cloth by their characteristic lace-like texture; in fact, they are termed the connecting link between ordinary woven cloth and lace.

In order to avoid confusion, the whole range of fabrics in which one or more of the warp threads are crossed will be classified as *cross-woven* fabrics; and this general heading will be subdivided into *plain gauze*, *full gauze*, and *leno* fabrics.

PLAIN GAUZE

Construction. The simplest kind of gauze or cross-weaving is termed "plain gauze." Fig. 307 shows the manner in which the threads interlace, the upper diagram being a plan of the cloth, and the lower diagram showing a sectional cut. It will readily be seen that there are two sets of warp threads and one set of filling threads. The warp threads marked A are termed *ground threads*, and those marked B are *crossing threads*. The filling threads are marked H. The straight warp thread A is always under the filling, while the crossing thread B is raised over every pick of filling. The crossing thread passes under the straight warp thread between every two picks; being interwoven on the right side of the straight or ground thread at one pick, and on the left side at the next pick. As the plain gauze weave repeats on two picks, the third and fourth picks are a repetition of the first and second.

To produce this effect, a special arrangement of harnesses and heddles is required. The ground thread A will, of course, require one harness, while the crossing thread B will require a harness to lift it on one side of the ground thread and a standard and doup to lift it on the other side of the ground thread. The standard and doup are shown in Fig. 308; and for comparison, a regular heddle—such as is used on the harness for the ground thread—is shown in Fig. 309. The standard and doup is a combination of a regular harness and a half-harness.

Standard and Doup. The doup is a silk or linen cord made in the form of a loop and attached to the lower frame of a harness shaft. Referring to Fig. 308, it will be noted that one end of the cord is

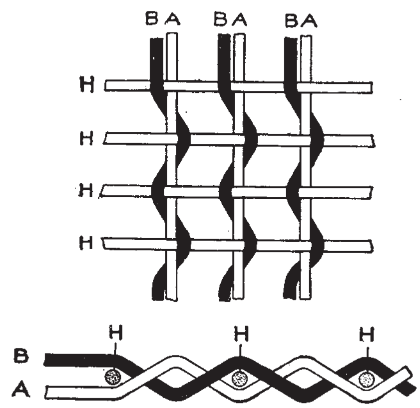


Fig. 307.

fastened to the frame at 3, while the other end is passed through the eye of the standard heddle at 4. It is then passed back through the space 5, which is above the eye, and fastened to the frame at 3. The crossing thread is drawn through the doup as shown by the sectional cut 6.

Fig. 310 shows the threads drawn through the harnesses and illustrates the method of crossing the thread B to the doup and standard harness. Two ground harnesses and a standard and doup are required to weave plain gauze. The warp is first drawn in on the two harnesses marked 1 and 2, then the crossing thread B is passed under the ground thread A and through the loop formed by the doup and standard harness. The two threads are then drawn in the same dent in the reed. This operation is repeated for every pair of threads in the warp.

As the method of drawing in the warp threads is the fundamental principle of cross weaving, it is essential that it be thoroughly understood before any designs can be made; therefore, it will be explained in a different manner, as follows: There are two sets of harnesses. The back set consists of two regular harnesses through which the warp is drawn as required for plain cloth. These are marked 1 and 2. The front set consists of a standard harness S, which is the same in every way as an ordinary harness, and a skeleton or doup harness D. The first thread A is a ground thread and is drawn through the harness 1, while the second thread B is a crossing thread and is drawn

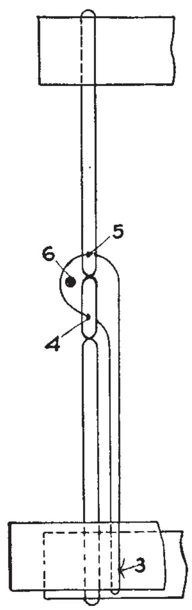


Fig. 308.

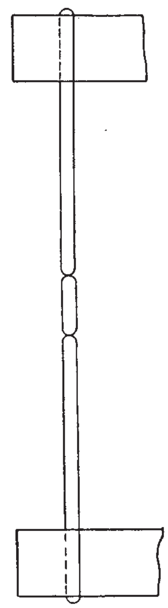


Fig. 309.

through the harness 2. The second thread B is then passed under the first thread A and drawn through the doup, the two threads being drawn in through the *same* dent in the reed. Therefore, all the odd-numbered threads are ground threads, and all the even-numbered threads are crossing threads.

Too much emphasis cannot be laid on the statement that each pair of threads should be drawn in the same dent in the reed, for it is evident that if they are crossed behind the reed and drawn through different dents, the crossing could not take place in the cloth.

It follows that with the arrangement given above the crossing thread B is capable of receiving movement at two places; *i. e.*, at C and at E. If lifted at E, by raising the standard and doup, the thread will be drawn on one side of the ground thread A, while if lifted at C by the harness 2, it will be lifted on the other side of A, or parallel to it.

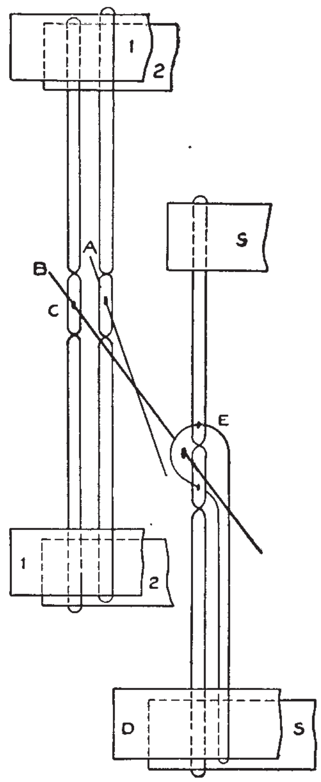


Fig. 310.

But it will be understood that if C is raised, the crossing thread must raise at E, or in other words, it must be released at E, to form the shed for the shuttle to pass through. This is shown at Fig. 311. The crossing thread B is lifted by the harness 2, and the doup also is lifted, which allows E to slide up through the standard heddle with the result that the crossing thread B is parallel to the ground thread A, instead of being crossed under it. H shows the filling which was put into the cloth when the threads were crossed.

The formation of the cross shed (the one in which pick H is placed in Fig. 311) is shown at Fig. 312. It has already been explained that the standard and doup must be raised to cross the threads. The harnesses 1 and 2 are down and the crossing thread B is raised at the point E.

These two movements represent the whole principle of cross weaving and if thoroughly understood will make the explanations of the more generally used and more useful leno fabrics, which are given later on, seem very simple indeed.

As may be seen by referring to Fig. 312 there is a great strain on the crossing thread B when the standard and doup are lifted, by reason of its being passed under the ground thread A. To ease this strain there is an attachment placed on the loom for "easing" the crossing threads on this pick, but as this work does not assume to cover the processes of weaving we shall not take up any more of that subject than is necessary for a thorough explanation of cloth construction and designing.

The harness chain and the drawing in draft for plain gauze is shown at Fig. 313. Letters D and S and numbers 1 and 2 illustrate

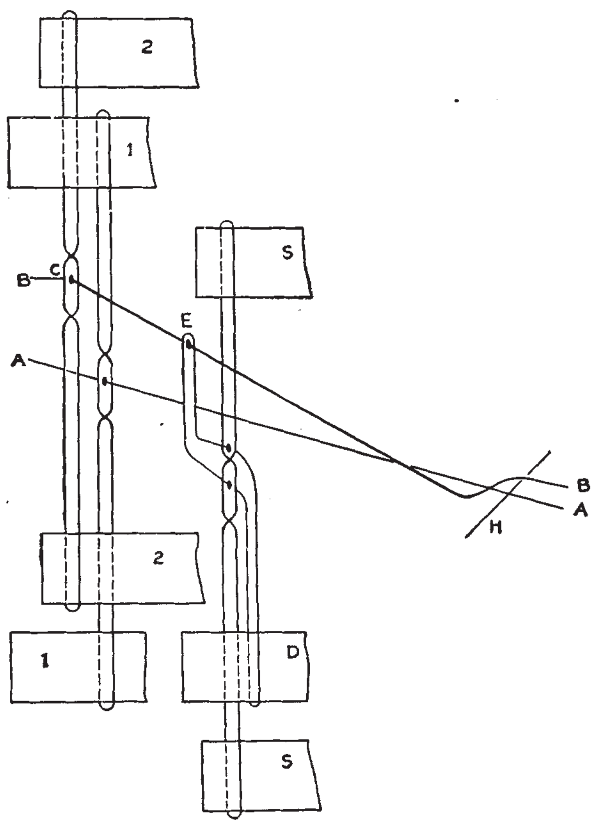


Fig. 311.

the harnesses shown in Figs. 310, 311, and 312, and the crosses indicate which harnesses the threads are drawn through. The ground thread A is drawn through the harness 1 (also shown in Figs. 310, 311, and 312), as indicated by the cross, and the crossing thread B is drawn through the back harness 2, then crossed under the thread A and drawn through the doup.

For the first pick the doup harness and the crossing harness (or No. 2 in the diagrams) are raised, so the ground and crossing threads lie in a parallel position. On the second pick the doup and standard harnesses are raised, so, of course, the crossing thread is drawn under the ground thread to the other side. The third pick is the same as the first, and the fourth pick is like the second.

FULL GAUZE

Construction. In plain gauze, all the crossing threads work in the same direction; every crossing thread is exactly like every other crossing thread, the pattern repeating on one ground thread and one crossing thread. In full gauze, two crossing threads and two ground threads are required for a repeat; one crossing thread being drawn to the left of the ground thread and the other being drawn to the right. The ground threads weave in the same manner as in plain gauze.

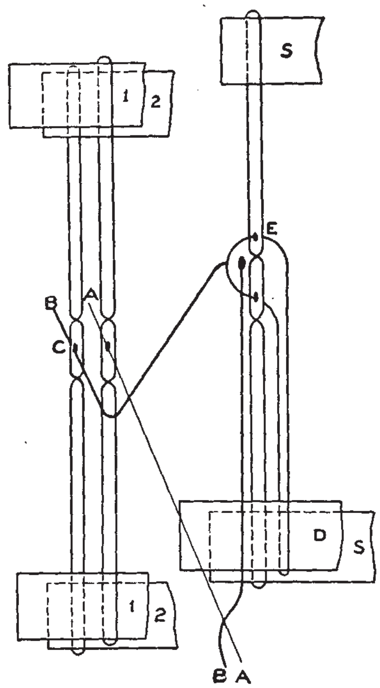


Fig. 312.

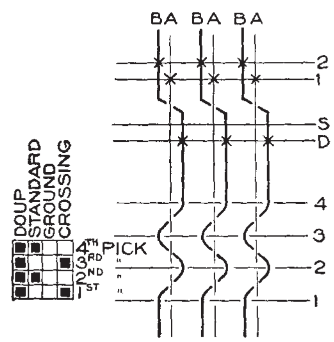


Fig. 313.

The illustration in Fig. 314 is a plan of full gauze, and by comparing it with Fig. 307 the difference between the two cloths may be observed. In plain gauze all the crossing threads pass under the ground threads to the right on the same pick, and pass back to the left of the ground thread on the next pick. In full gauze the first crossing thread passes under the ground thread to the left, while the second crossing thread passes under the next ground thread to the right, on the same pick. On the next pick both crossing threads return to their original positions.

The illustration shown in Fig. 315 represents the drawing-in or harness draft, harness chain, and the manner of crossing the crossing thread under the ground thread to the doup, also the plan of a full gauze cloth. The first thread is a ground thread and is drawn in on the ground harness G. The second thread is a crossing thread and is drawn in on the back harness C, which is the crossing harness. The second thread is then passed under the first thread to the left, and drawn through the doup, D. The third thread also is a crossing thread so is drawn through the back harness C. The fourth thread is a ground thread so is drawn in on the ground harness G. The third thread is then passed under the fourth thread to the right and drawn through the doup. This is a full repeat of the draft.

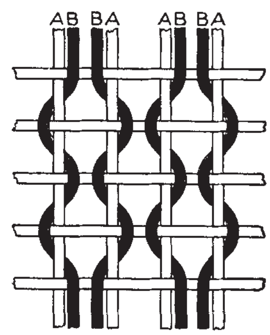


Fig. 314.

When drawing the threads through the reed it will, of course, be necessary to draw the first and second threads in one dent, and to draw the third and fourth threads in another dent, or, as explained in *Plain Gauze,* no crossing can take place. The effect of this cloth is that one crossing thread crosses to the right and the other to the left on one pick, and this order is reversed on the next pick.

This style of weaving is more effective if heavy, or rather coarse, filling is used. Different sizes of warp used alternately or in any systematic method is also very useful in the production of many fancy effects on this weave.

The harness chain shows how the harnesses are lifted to give the effect. For the first pick the crossing threads are on the *doup side* of the ground threads so the standard and doup are lifted. For the second pick the crossing threads are parallel to the ground threads, so the back or crossing harness and the doup are lifted. The third pick is like the first, and the fourth is like the second.

This is exactly the same as the previous example, except that in the plain gauze figure the plan commences with the crossing thread parallel to the ground thread. Thus the only difference between plain gauze and full gauze is that in the latter the threads cross in opposite directions. This result is caused by having the doup and standard at the left of every alternate ground thread and at the right of the other ground threads.

LENO DESIGNS

The combination of gauze and other methods of interweaving is perhaps where the greatest value of cross weaving lies. If plain gauze and full gauze are thoroughly mastered, their combination with

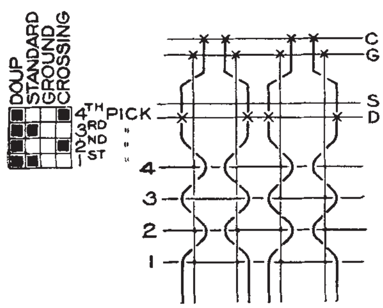


Fig 315.

other weaves to form leno effects will not prove a difficult subject. The illustration shown in Fig. 316 has been selected as an example of a simple leno effect.

Comparing Figs. 313 and 316 the following similarities and differences between plain gauze and leno may be noted: The same number and order of harnesses are used, and the method of drawing in the warp threads and crossing them is practically the same. In Fig. 316 the crossing threads have been crossed to the left, but this is not a serious difference as the crossing threads in Fig. 313 could be crossed in the same manner. Thus the same arrangement of threads and method of drawing-in is used. The plan of the cloth, however, is different, so the method of lifting the harnesses also must be different.

The harness chain shows that the standard and doup are raised for the first pick, which of course raises the crossing thread over the first pick of filling and on the doup side of the ground thread. On the second pick the ground harness only is lifted, and the crossing thread passes under the filling while the ground thread passes over it. On the third pick the standard and doup are again lifted; thus raising the crossing thread over the filling.

The crossing and ground threads have thus woven plain cloth for the first three picks. On the fourth pick the crossing harness and doup are raised which draws the crossing thread under the ground thread to the other side, where it passes over the filling. The next

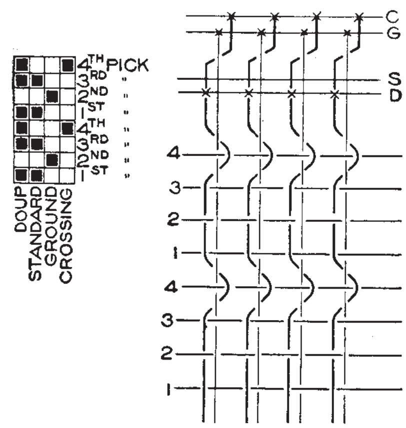


Fig. 316.

four picks are repeats of the first four. The crossing thread is on the right side of the ground thread for only one pick, and weaves plain on the left side for the remaining three picks; thus forming a leno design by combining plain weaving with plain gauze.

Attention is called to the fact that the crossing thread passes over picks 3 and 1, which are on each side of pick 4, where the crossing takes place. If this were not done the gauze crossing would not be so clear and decisive. It may be taken as a general rule for leno designs that to have an uneven number of picks for plain work between the gauze crossings is convenient as it will allow the crossing thread to be raised over the picks on each side of the gauze crossings. This is not absolutely necessary and may not be followed in all cases, but it is a safe rule to follow for the present.

The illustrations shown in Figs. 317 and 318 are variations of the principle of combining the plain weave with gauze.

In Fig. 317 the usual arrangement of harnesses is used and the crossing threads are passed under the ground threads to the left, and drawn through the doups in the usual manner.

Referring to the harness chain, the first pick shows that the crossing and doup harnesses are raised, which of course weaves the crossing thread on the right of the ground thread. On the second pick the standard and doup are raised, which weaves the crossing thread on the left or doup side of the ground thread. The third and fourth picks are the same as the first and second, while the fifth also is like the first. On the sixth pick the ground harness only is raised, so the crossing thread is under the filling. The seventh and ninth picks are the same as the first and the eighth is like the sixth.

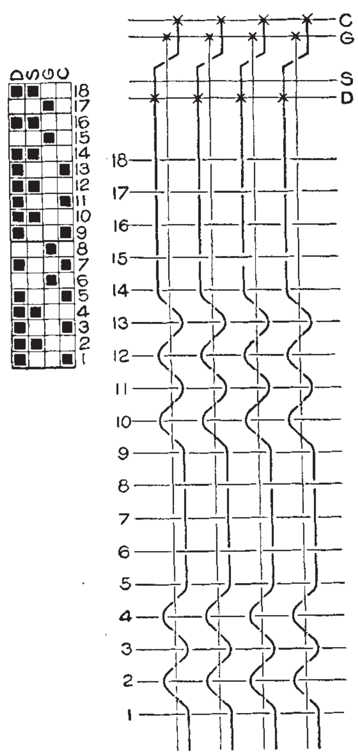


Fig. 317.

Up to this point there have been four gauze crossings and five picks on which the threads have woven plain. The tenth, eleventh, twelfth, and thirteenth picks show crossings, and the plain weave effect is given on the remaining five picks, but the crossing thread is on the left of the ground thread.

Fig. 318 shows the crossing threads weaving plain on the left of the ground thread for three picks and then changing over to the right for three picks, the pattern repeating on six picks. The pattern chain shows how this is accomplished. The explanation will not be repeated for this design as it is the same as in Figs. 316 and 317.

The next question is the power of producing a variety of designs upon the harnesses employed, and with as little trouble as possible by using one doup. It is very clear that if a crossing can be produced so readily, that is, if a gauze crossing can be obtained by the simple lifting of the doup once on each side of the ground thread, there must be a wide field for varying the design, and that the characteristic openness of gauze and leno fabrics can be infinitely varied.

The designs explained up to this point have been ones that would make stripes of plain and gauze across the cloth only. This will be varied and the designs produced which will make patterns in the direction of the warp.

Fancy Leno Designs. There are two methods of forming fancy leno designs, which are as follows; *first*, where the figure is formed by gauze on a plain ground; and *second*, where the figure is formed by plain on a gauze ground. This, however, important as it is, must be considered secondary to the arrangement of patterns for as few doups as possible. The significance of this statement is at once apparent when it is remembered that, among other complications, each doup must have an easing arrangement to reduce the strain caused by the raised position of the standard and doup.

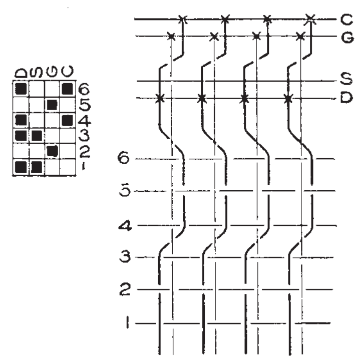


Fig. 318.

The illustration shown in Fig. 319 represents a design that forms a diagonal pattern of gauze across the fabric; and also shows the drawing-in draft and harness chain. The usual method of allowing each thread to work in its normal position, when plain cloth is desired, is adopted, and the crossing thread is lifted by the standard and doup when the gauze crossing is required. By using this method, four doups and four standards are used with eight ground and crossing harnesses.

This seems a large number of harnesses for a simple pattern, especially as there are more harnesses than there are threads in one repeat of the pattern. The number of harnesses, doups, and easing rods would be much more formidable than the pattern, but they are all required to produce the actual effect shown in the figure, because each pair of threads works independently and in no case do two threads cross at the same time.

The first doup and standard marked D^1 and S^1, and the first crossing and ground harnesses marked C^1 and G^1, may be referred to independently of the remainder of the chain and it will be a simple matter to see how the harnesses are raised for the first pair of threads.

On the first pick the first standard and doup are lifted and the first *crossing* and *ground* harnesses are down, which, of course, crosses the thread to the doup side of the ground thread. Reference to the plan will show this to be the case for the first crossing thread is crossed to the right side of the first ground thread on the first pick. On the second pick the doup and crossing harness are raised, which changes the crossing thread to the left again, as explained in previous examples. So each pair of threads may be followed in the plan and in the harness chain independent of the other threads.

Examining the standard and doup S^2 and D^2 in conjunction with the crossing and ground harnesses C^2 and G^2, the manner of lifting the harnesses for the second pair of threads may be followed. Each

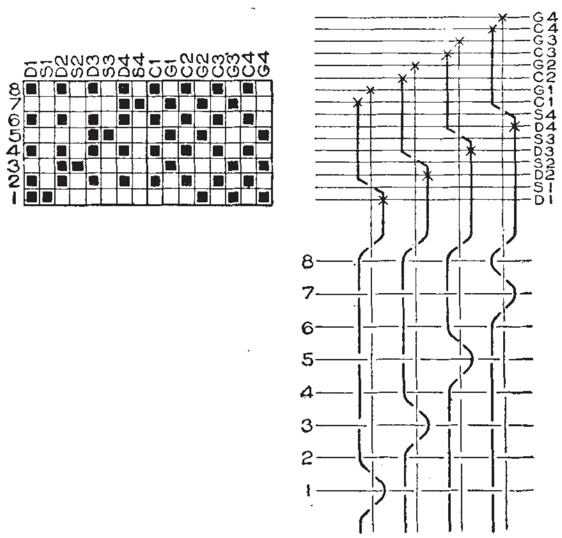


Fig. 319.

of the remaining two pairs of threads may be followed in the same manner by considering them the only threads in the pattern, and their respective harnesses the only ones in the harness chain for the time being. It will be understood that in this pattern each pair of threads requires its individual doup, standard, crossing, and ground harnesses, just as the first example of leno required them.

To show how an effect which is practically the same and which is certainly as good, may be produced with one doup and standard. Fig. 320 has been prepared.

A hasty comparison of Figs. 319 and 320 might not show any difference in the two designs; both have the standard and doup lifted over the odd-numbered picks, and the gauze crossings form a sort of diagonal running from left to right. The plain weave is used on all the threads and picks, except where the crossings take place, as may be proved by examining the picks.

On the first pick all the threads are working plain—*i. e.*, one up, one down—except the first pair. All the threads are working plain

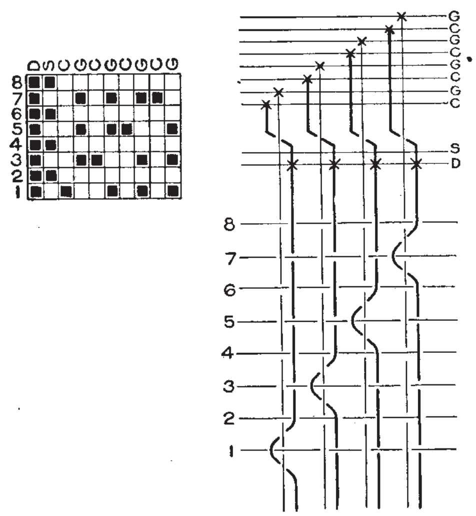


Fig. 320.

on the second pick, just as in a piece of plain cotton cloth. On the third pick the second pair of threads form a gauze crossing, the others weaving plain. The fourth pick is plain; and so on.

In all the above details, the two designs are identical, yet one requires four standards and four doups, and the other is woven on one standard and one doup; consequently, there must be some method of arranging the designs and lifting the harness to reduce the number of standards and doups necessary.

The ground and crossing threads in Fig. 320 are drawn through the harnesses in the usual manner, the crossing thread being drawn to the right the same as in Fig. 319. However, the crossing thread is at the right of the ground thread when weaving plain, and changes to the *left* to form the gauze crossing; while the crossing thread is at the left of the ground thread when weaving plain in Fig. 319, and crosses to the *right* to form a gauze crossing.

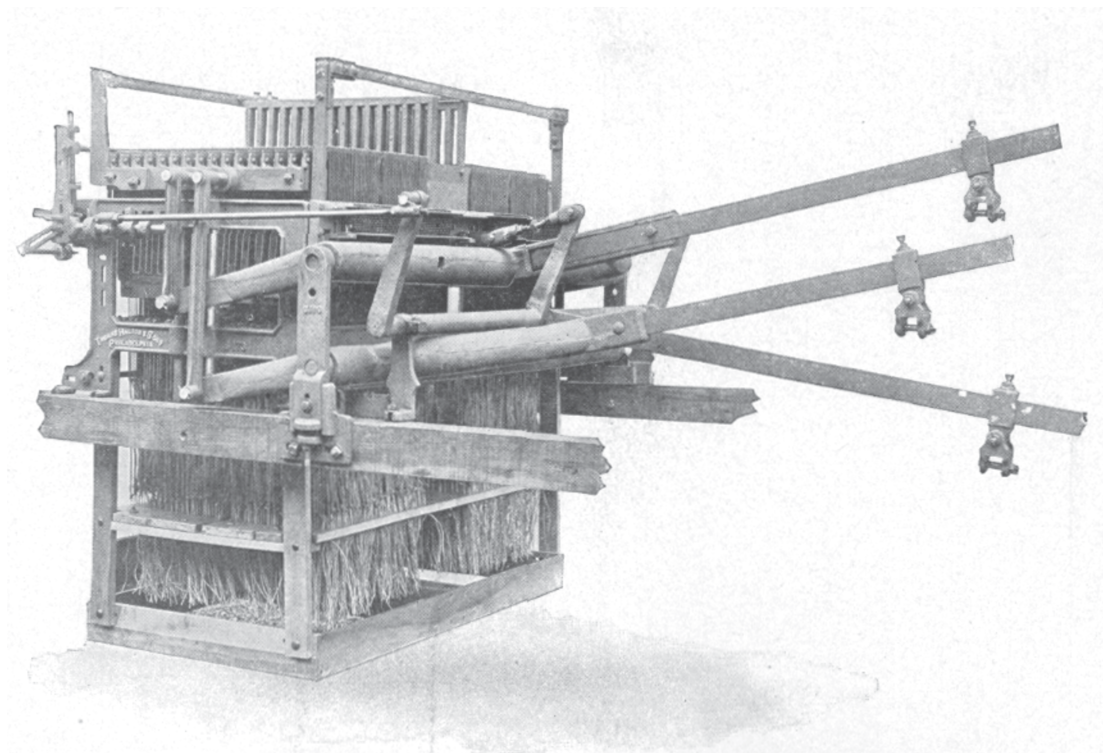
The side on which the crossing thread weaves when making the plain cloth is of no importance so far as the appearance of the design is concerned, but it makes a difference of three doups and standards if woven on the same side as the crossing harness, as will be noted by a careful comparison of the two illustrations; consequently, it is impracticable to make a design like Fig. 319, and use sixteen harnesses for its production, when the same effect may be produced on ten harnesses.

Analyzing Fig. 320 in conjunction with the harness chain, it will be noted that the doup, first crossing harness, and the second, third, and fourth ground harnesses are raised on the first pick, which has the effect of drawing the first crossing thread to the left of the first ground thread (which in this instance is the same side as the crossing harness) and raising the second, third, and fourth ground threads, as shown in the first pick of the plan of cloth.

If the previous explanations have been thoroughly studied, the reason why this is the case will be apparent, but as the construction of leno design is so much different than other divisions it may be profitable to repeat the explanation.

Each ground and crossing thread should be looked upon as a pair of threads, so to speak, and in determining how they are worked, the harnesses on which they are drawn should be considered quite apart from the other harnesses. On the first pick of the harness chain the first crossing harness and the doup are lifted. There are other harnesses lifted on this pick, but these have no connection with the first pair of ground and crossing threads, so should be ignored for the present. As is stated above the first crossing harness and the doup are raised, which has the effect of lifting the crossing thread on the same side of the ground thread as the crossing harness is on, as explained in plain gauze.

Considering the second pair of threads, the ground thread is raised, and the crossing thread is down, so the second crossing harness is not lifted while the second ground harness is lifted, as is shown in the harness chain. The third and fourth pairs of threads are the same as the second; the third and fourth ground harnesses being lifted and the crossing harnesses being down.



REAR VIEW OF FINE INDEX DOUBLE LIFT SINGLE CYLINDER JACQUARD MACHINE

Thomas Halton's Sons

The second pick weaves plain, passing over every ground thread and under every crossing thread. Reference to the second pick of the chain shows that the standard and doup are lifted and all the ground and crossing harnesses are down. In the explanation of plain gauze, a statement is made to the effect that where the standard and doup are lifted, the crossing threads are raised over the filling, and on the doup side of the ground thread. The plan of the cloth shows this to be the case.

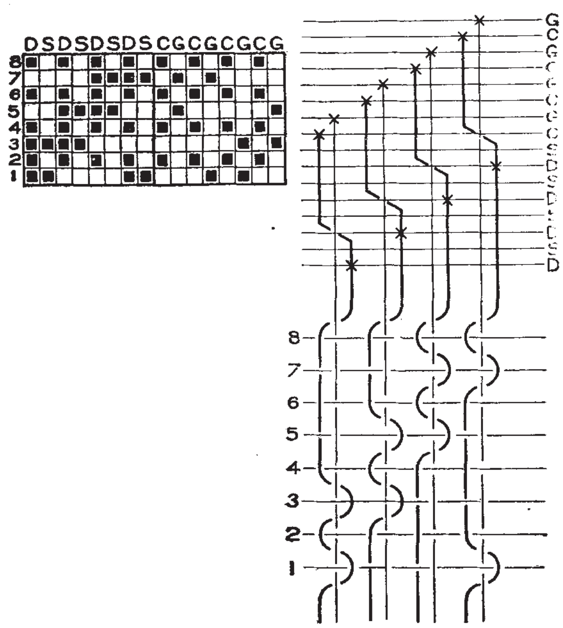


Fig. 321.

On the third pick the first ground thread is raised and the first crossing thread is down. The second pair of threads forms a gauze crossing in the same manner as the first pair of threads formed a crossing on the first pick. The third and fourth pairs of threads are weaving plain. Reference to the third pick of the chain shows that the doup, first ground harness, second crossing harness, third ground harness, and fourth ground harness are raised. A careful study will reveal that the gauze crossing is made by the same method explained in connection with the crossing on the first pick and also in *Plain*

Gauze; *i. e.*, the crossing harness and doup being raised, raises the crossing thread on the side that the crossing harness is on.

The fourth pick is the same as the second, passing over every ground thread and under every crossing thread, the standard and doup being the only harnesses that are raised.

The third and fourth pairs of threads form gauze crossings on the fifth and seventh picks respectively, by having their crossing harnesses raised in conjunction with the doup, in the same manner as

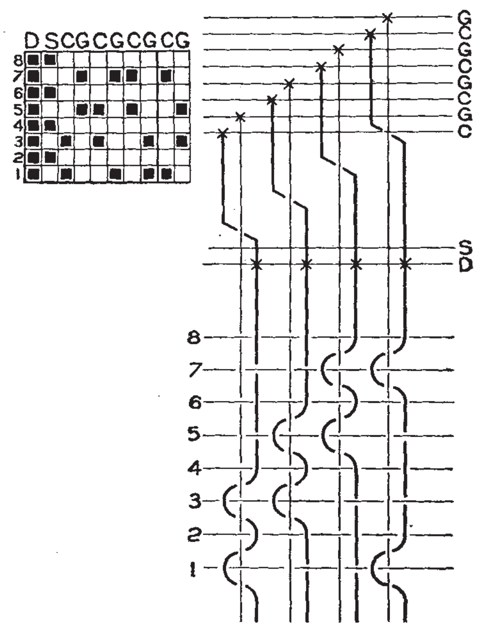


Fig. 322.

explained in connection with the first and second pairs of threads. The sixth and eighth picks are plain.

Summarizing the above, every even-numbered pick weaves plain with the warp threads, and on the odd-numbered picks gauze crossings are made in progressive order. The crossing threads are always on the right or doup side of the ground threads when weaving plain and cross to the crossing thread side, or what was termed the *position parallel to the ground thread* in the simple explanation used in the *Plain Gauze*.

To establish more forcibly the possibility of reducing the number of harnesses employed for an effect, when apparently the number of harnesses cannot be reduced, Figs. 321 and 322 have been prepared. This is almost a parallel case to the one just explained. Fig. 321 occupies sixteen harnesses, and practically the same effect is shown in Fig. 322 on ten harnesses. Both effects are the same, except that the threads weave plain with the crossing thread on the right or doup side in Fig. 322, while they weave plain with the crossing thread on the crossing harness side in Fig. 321.

It will be unnecessary to go into the details of these two designs, as the comparison may be made by the same method used on the two previous figures. Examples of this kind might be multiplied, but in the estimation of the writer this method has been made very clear by these explanations. Further examples will be made with as few doups and standards as possible, as in practical use the doups are a source of considerable expense for repairs, and complicate the weaving operation.

EXAMPLES FOR PRACTICE

1. How do cross-woven fabrics differ from ordinary woven cloths?
2. Describe the interlacings of the warp threads in both plain gauze and full gauze.
3. How are the crossings of the warp threads held in place, or bound into the fabric?
4. Write a description of the doup including the following features: Of what material is it made? How is it connected with the standard harness? Why could not an ordinary heddle be used in its place?
5. Make a sketch illustrative of the method of drawing in the crossing and ground harnesses for full gauze.
6. When reeding a warp, what must receive special attention? Why is this necessary?
7. What effect is produced by lowering the crossing thread and lifting the standard and doup?
8. Make from memory enlarged diagrams of plain gauze and of full gauze.
9. By what is the power of producing fancy patterns limited?

10. In plain work between gauze crossing, should an odd or an even number of picks be used?

Diamond Patterns. The diagonal pattern, formed by the use of one doup and standard, does not limit the variety of fancy effects possible on this arrangement, for with the possibilities of one doup and standard in mind, one may lay out a practically unlimited number of patterns.

The structure of the cloth is limited to plain gauze and the regular plain weave, and it is necessary to lift the standard and doup on every alternate pick and to lift the doup on the other picks so that gauze or plain may be formed, as desired, by lifting either the crossing or ground harness of each pair of threads in conjunction with the doup. Particular attention is called to this, so that the student will not think that the range of patterns made with one doup and standard is unlimited. Extensive and elaborate designs may be made, as shown in the illustrations, but they bear a marked similarity to each other, compared to the infinite number of leno effects that may be made on more complicated arrangements of the harnesses. For instance, one of the most valuable methods adopted by the leno designer to get special fancy effects, is to have more than one pick in the same shed. This cannot be done in the one-doup-one-standard arrangement.

There are innumerable other characteristic features of cross weaving that are not practical on the present arrangement; therefore, it may be stated that the number of patterns, which are possible on one doup and one standard combined with any number of ground and crossing harnesses, is practically unlimited, yet the construction of the cloth must be confined to plain gauze and plain cloth, and composed of a warp or filling figure, if a figure is desired. If a filling figure were being produced, a special arrangement must be made, such as weaving the cloth wrong side up. This is often resorted to, yet in some cases the doup is reversed to weave the pattern right side up. By reversing the doup is meant to have the cord hanging down from a harness placed above the yarn instead of below, as is the common custom.

Perhaps the simplest form of figure next to those of the diagonal character, are the ones in which a diamond outline in gauze is formed. An example of this effect is shown in Fig. 323. The gauze cloth runs diagonally in each direction, and encloses a diamond-shaped space of plain cloth. Of course, if the design were repeated a number of

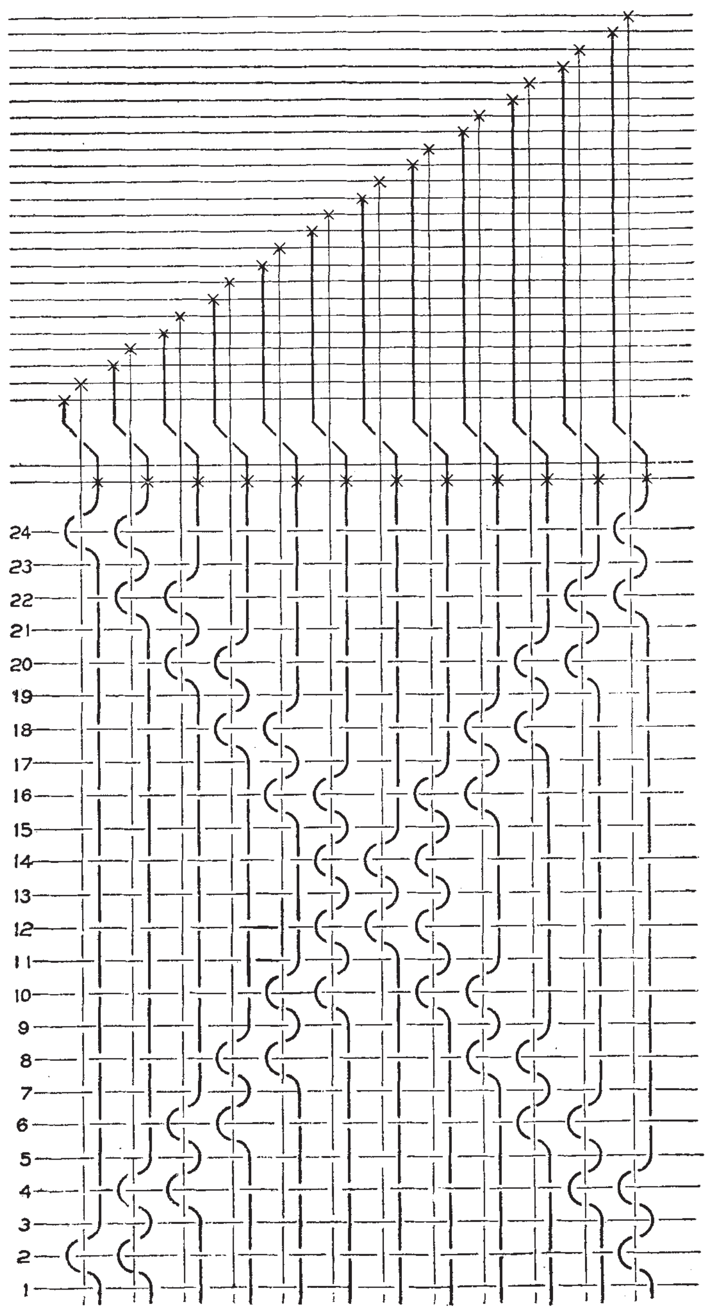


Fig. 323.

times, the figure would be more plainly visible, but little difficulty will be experienced in recognizing the outline of the figure. The design repeats on twenty-four threads and twenty-four picks.

The method of producing these diamond effects is very simple, being a further utilization of the principles employed in Figs. 319 and 320. The ground threads are drawn in on the ground harnesses and the crossing threads are drawn in on the crossing harnesses, as indicated by the crosses. Each crossing thread is then passed under its

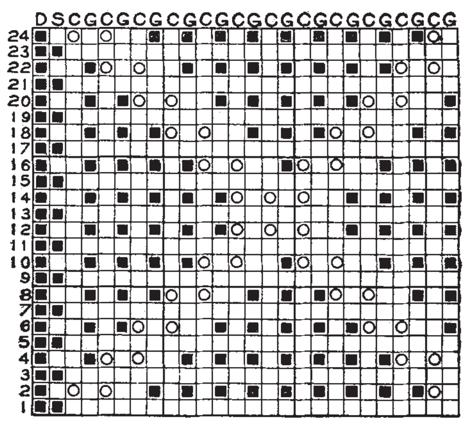


Fig. 324.

companion ground thread (to the right in this instance) and drawn through the doup. Each pair of threads is then drawn through the same dent as previously explained.

The harness chain is shown in Fig. 324. The doup, standard, crossing, and ground harnesses are marked in the manner adopted for previous examples, and the picks in the chain correspond to the picks in the plan. The circles are always on the crossing harnesses and indicate where a gauze crossing takes place. On every pick where a circle is found the doup also is lifted, so the crossing thread crosses over to the left of the ground thread. A careful examination of the disposition of the circles will show an outline like that formed in the plan by the gauze crossings.

Analyzing the harness chain in Fig. 324 in conjunction with the plan in Fig. 323, the following particulars are found. On the first pick of the chain the standard and doup are lifted, which, of course, raises the crossing threads over the filling and on the doup side of the ground thread. None of the ground harnesses is lifted so the first pick is perfectly plain, passing over every ground thread and under every crossing thread.

On the second pick of the chain, the doup is lifted, also the first, second, and twelfth crossing harnesses. This, of course, draws those threads to the left of the ground threads and over the filling. In the remaining pairs of threads: *i. e.*, the third to eleventh, inclusive, the ground threads pass over the filling and the crossing threads pass under it. Reference to the chain shows that the ground harness in each of these pairs is raised, and that the crossing harness is down; therefore, there are three gauze crossings (made by three crossings harnesses and the doup being lifted) and nine pairs or eighteen threads weaving plain, on the second pick.

On the third pick the standard and doup only are lifted, the same as in the first pick, and of course with the same result; the filling passing over every ground thread and under every crossing thread, and the crossing threads being on the doup side of the ground thread.

The fourth pick shows gauze crossings on the second, third, eleventh, and twelfth pairs of threads, the remaining threads weaving plain. Reference to the chain shows that the second and third, and eleventh and twelfth crossing harnesses are lifted in conjunction with the doup, which of course forms gauze crossings. The first, and the fourth to the tenth, inclusive, ground harnesses are raised, so the filling passes over the crossing threads and under the ground threads at this part of the design.

The fifth pick is the same as the first and third, the standard and doup being the only harnesses lifted.

It is so simple to compare each pick in the plan with the corresponding pick in the harness chain, that we will not continue this explanation for each of the twenty-four picks in the design. On every odd-numbered pick the standard and doup are lifted, and on the even-numbered picks, the doup and crossing, and the ground threads required to form the pattern, are lifted.

There is, however, one feature of the chain which might cause unnecessary trouble. Upon close examination, it will be noted that at some points on the even-numbered picks a square and a circle come together, as at the fourth and fifth squares of the fourth pick in Fig.

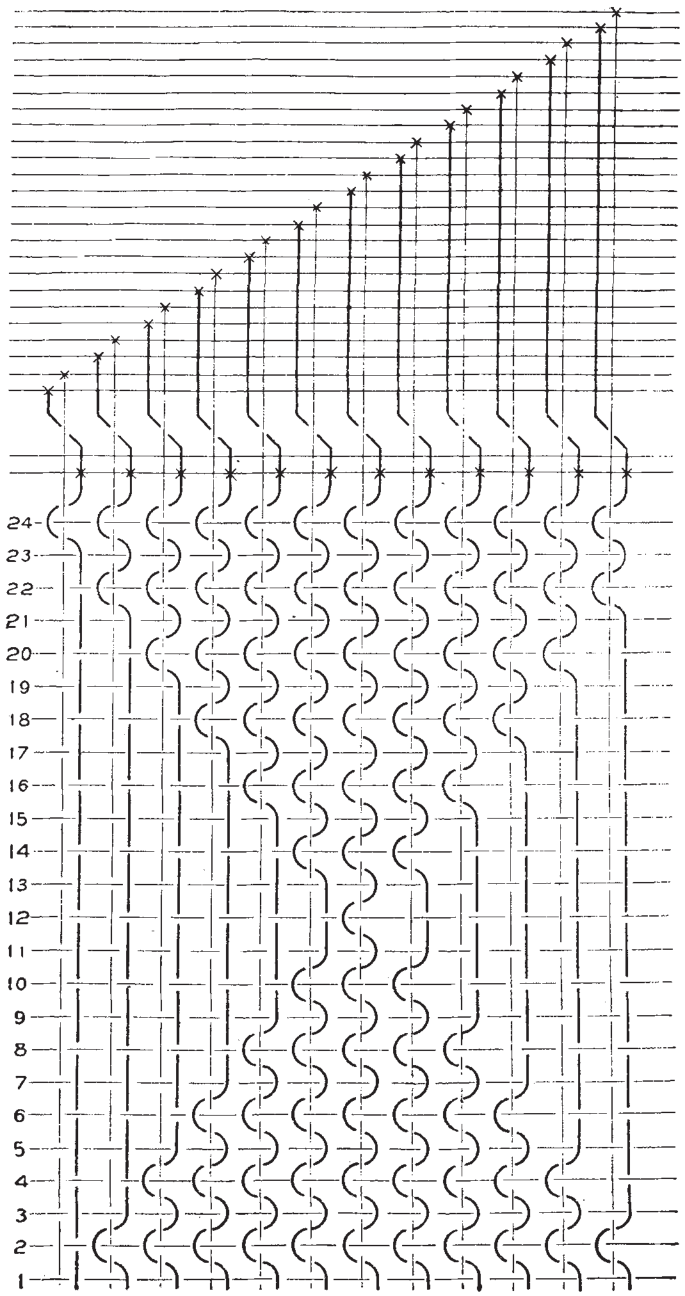


Fig. 325.

324. At other points two blank squares adjoin as in the sixth and seventh squares of the second pick. These would seem to suggest either a break in the plain weave or some sort of interference with the gauze, when as a matter of fact neither is the case.

In the course of various explanations, the threads have been referred to as working in pairs, and it will be found upon carefully examining the design that where two marks or two blank spaces come together, one of the blank spaces or marks belongs to one pair of threads and the other belongs to the next pair of threads, or the ground thread of one pair is lifted and the crossing thread of the next pair, or *vice versa*. It is obvious that it would not be correct to raise both the ground and crossing threads in one pair, or to leave both down; that is, it would not be correct in this design, but it might be done in forming a warp figure. This, however, will come under a different heading, and will be taken up later.

Another design on the same general principles as Fig. 323, is shown in Fig. 325, with the harness chain or design in Fig. 326. In the former instance, a diamond-shaped space of plain cloth is outlined by plain gauze, while in the latter there are two solid diamond-shaped spaces of plain gauze and plain cloth respectively.

We will not take up much space in explaining the method of drawing in the warp, as it is the same in every respect as in Fig. 323. Twelve ground harnesses and twelve crossing harnesses are required with one standard and doup. The design repeats on twenty-four threads and twenty-four picks.

The small circles in Fig. 326 show where the crossing harnesses are lifted, and correspond to the gauze crossings in the plan. The blocked-in squares show where the ground harnesses are lifted, and represent that portion of the plan occupied by the plain cloth.

An analysis of the first two picks of the design, in conjunction with the plan, will be sufficient to show the method of making this effect. On the first pick the standard and doup are lifted, which raises all the crossing threads on the doup side of the ground thread.

On the second pick, the doup, first ground harness, and the last eleven crossing harnesses are raised, which makes the first pair of threads weave plain, and forms gauze crossings on the other eleven pairs of threads.

The third pick is plain; the fourth pick has three pairs of threads weaving plain, and nine pairs forming gauze. The fifth is plain; and so on, till the space occupied by gauze tapers off to a point at the twelfth pick. From this point it gradually widens, until, at the twenty-fourth pick, it takes in every pair of threads in the design.

From the above examples it will be understood that the requirements, when working figured leno of this character with one doup and standard, are to lift the doup and standard on each alternate pick, weaving plain on the doup side of the ground thread; to lift the crossing harnesses and doup on the other picks, to form the crossings; and to lift the ground harnesses when plain cloth is desired.

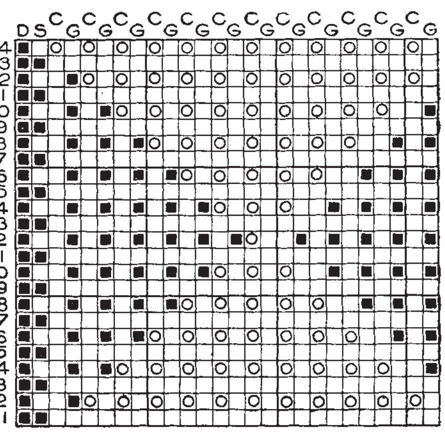


Fig. 326.

When studying any combination of weaves, it is an excellent plan to find the kinds of cloth and the classes of designs they are most suitable for. In this combination of plain cloth and gauze, the very manner in which the pattern is formed seems almost to suggest that the most suitable figures will be ones which have a geometrical base. Although patterns of a more or less floral character may be produced, there is a great tendency to produce an uneven appearance where curved lines are attempted, while this difficulty is wholly avoided in making figures of a geometrical form.

Note that the crossing threads pass over the picks on each side of the gauze crossings, thus forming clear definitions of the patterns.

Warp Figures with Gauze. Considering the designs taken up thus far, the suggestion is implied that in weaving leno designs with one doup and standard, the only effects which may be produced are combinations of plain cloth and plain gauze. This, however, is not the case, for various kinds of figures may be woven between lines of gauze.

For the purpose of producing variety of patterns or designs in leno fabrics, warp and filling figures are produced; *i. e.*, figures where the warp or filling floats loosely on the surface to form the desired figure.

In weaving ordinary spot or figured designs, there is no difficulty in floating either warp or filling threads on the surface of the cloth, but in cross weaving the method is not quite so simple.

As shown in the figures illustrating the methods of combining plain gauze and plain cloth with one doup and standard, the crossing thread works in the crossed position (which is the doup side) to form plain cloth, at all times except where the gauze crossings are formed. The crossing thread then passes from the crossed position to that which it would occupy in ordinary weaving, or if the standard and doup were not used, and passing back again to the crossed position makes a complete gauze crossing.

There is another feature which must be considered before passing further. By this method of working, the doup forms the ground on the alternate picks where the doup and standard are lifted, and the gauze crossings take place, not when the standard and doup are lifted, but on the picks where the standard is down; the object being to make it a matter of choice whether the harness carrying the crossing thread (to which we have previously alluded as the crossing harness, and which is marked C in previous illustrations) shall be raised to form a crossing or whether its companion thread shall be raised to form plain.

From this it will be seen that the doup and standard must be raised together on every alternate pick. There can be no departure from this, consequently a filling figure cannot be formed on the face of the cloth, because it is necessary that a number of threads shall stay down for a number of picks when the filling is interwoven, so that the filling can float over them to make a filling figure. This, of course, is impossible when using a principle where the standard and doup must rise at every alternate pick, so it is clear that a filling figure cannot be formed on the face of the cloth.

Warp figures can be formed, however, so it follows that if the warp is floated over the filling to make a warp figure, the filling must float under the warp to form a filling figure on the back of the cloth; therefore, filling figures can be made by weaving the cloth face down. This being understood, the warp figure will be explained, remembering that a figure of the same characteristics is being formed by the filling floating underneath.

The illustration in Fig. 327 shows a design or harness chain for two diamond-shaped warp figures on a plain gauze ground The arrangement of harnesses, drawing-in draft, and plan of the cloth are shown in Fig. 328. Before making a careful study of the chain and plan, the fact should be firmly fixed in mind that the standard and doup must rise at every alternate pick; of course raising the crossing thread; and for the formation of gauze the crossing thread is raised at the next pick by the crossing harness. For plain cloth the companion or ground thread is lifted by the ground harness, so that the plain cloth and gauze are made in the same manner as previously explained.

Now, in the formation of a warp figure, all threads must be raised so the filling will pass under them. When the standard and doup are lifted, all the crossing threads are raised without lifting any of the crossing harnesses, and the ground threads may be raised by lifting the ground harnesses. On the picks where the standard is not raised, the required threads are lifted by lifting the crossing and the ground harnesses.

This will be made clearer by reference to the third and fourth picks in Fig. 327. On the third pick the doup is lifted, but of course this will not lift any threads if either the standard or crossing harnesses are not also lifted; consequently, the first seven crossing harnesses are lifted as indicated by the small circles. In the figure five ground harnesses are lifted and two more crossing harnesses, making a total of fourteen harnesses, in addition to the doup, that are lifted on the third pick.

On the fourth pick the standard and doup are lifted, so none of the crossing harnesses is lifted, there being as many threads raised by lifting the standard and doup and three ground harnesses as were lifted on the previous pick with fourteen harnesses. This illustrates the reason why the odd-numbered picks in Fig. 327 have so many more risers than the even-numbered picks.

The circles indicate where a crossing harness is raised on the pick where the doup also is raised and shows where gauze crossings take place.

To become familiar enough with this principle to be able to tell at a glance to which set each thread belongs, and whether it is forming plain, gauze, or figure, it will be profitable to examine several picks of Fig. 328, in conjunction with the chain or design shown in Fig. 327.

On the first pick, the crossing threads of the first eight pairs are at the left of the ground thread and pass over the filling. In the

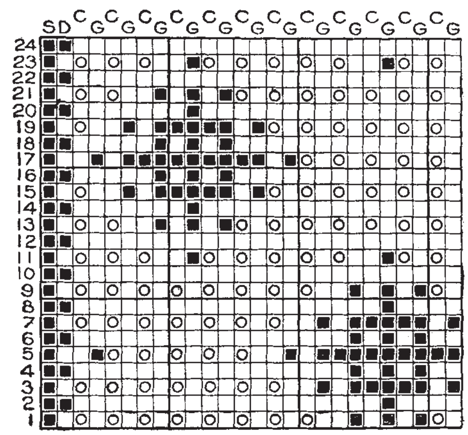


Fig. 327

ninth, tenth, and eleventh pairs, the ground threads are over the filling, and the crossing threads are at the right of the ground threads and under the filling. The last pair of threads is like the first nine. Reference to the first pick of the chain shows how this is brought about. The first eight crossing harnesses, being raised in conjunction with the doup, draw the crossing threads from the doup side and over the filling. The last crossing harness works in the same manner. The ninth, tenth, and eleventh ground harnesses are lifted, so these ground threads are raised, while their companion crossing threads remain down.

On the second pick, the standard and doup are lifted which, of course, raises every crossing thread, and on the doup side of the ground

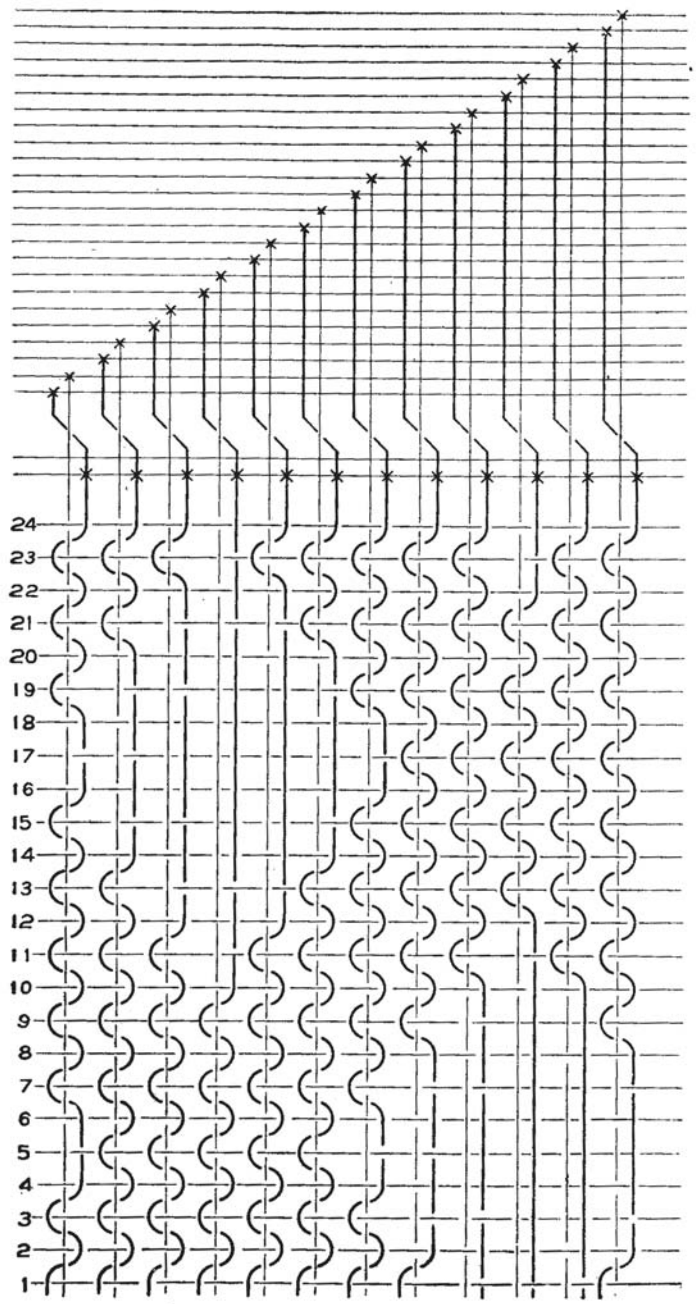


Fig. 328.

thread. The tenth ground harness also is raised on this pick, which lifts the tenth ground thread over the filling.

The third pick is similar to the first; the first to the seventh crossing threads being drawn to the left of the ground thread and over the filling, while the eighth, ninth, and twelfth crossing threads are at the right or doup side, and pass under the filling, their companion ground threads being raised. In the tenth and eleventh pairs of threads, however, both the ground and the crossing threads are raised.

Reference to the third pick of Fig. 327 will explain how the positions of the various threads are brought about. The first seven crossing threads in conjunction with the doup cause the gauze crossings on the first seven pairs of threads. The eighth, ninth, and twelfth ground harnesses are raised, while their companion crossing threads are down, which gives the relative positions of these threads, and the tenth and eleventh ground and crossing harnesses are both lifted which raises both ground and crossing threads over the filling, and forms part of the warp figure. The filling floating under these threads will, of course, form part of a filling figure.

The fourth pick is similar to the second, there being three ground harnesses, in addition to the standard and doup, raised on this pick.

The other picks may be followed in a similar manner, comparing the effect, as shown in the plan of the cloth, with the method of lifting the harnesses as shown in Fig. 327.

The principle of floating the warp on the surface may be used to form diagonal patterns, as is shown in the design at Fig. 329 and the plan of cloth in Fig. 330. Twenty-four threads and picks are required for one repeat, and the arrangement of harnesses and drawing-in draft is the same as in the previous example. The small circles on the even-numbered picks are always on the crossing harnesses and show where the crossing thread is lifted to form a gauze crossing, the same as in Fig. 328.

It will be unnecessary to go into a detailed explanation of this design, as it is made on exactly the same principle as Fig. 328. It will, however, be excellent practice for the student to carefully trace the interlacings of each thread and follow the risers in Fig. 329. It should be noted that the standard and doup are raised on the first pick of the design, while Fig. 328 commences with the doup and crossing harnesses raised.

There are other considerations relating to this class of designs which demand attention. It is generally recognized that where a figure is formed by the same warp or filling that forms the ground floating over a number of threads, the texture, or number of threads per inch, should be sufficiently close to produce a compact fabric, or one which will have the appearance of compactness. This makes the use of a large number of threads and picks, or heavy yarn, necessary.

In both Figs. 228 and 230 there are long floats between the series of gauze crossings, so as many threads and picks per inch as possible should be used, but from the nature of cross weaving a large number of threads and picks cannot be used. If a heavier yarn is used, the number of threads and picks per inch will be reduced in proportion to the increased size or diameter of the yarn, because the crossing takes place between the picks and each pick will be separated from the next by at least the diameter of the yarn which is used. This difficulty will be met in making any kind of figures with plain gauze, and care should be used to select designs in which it may be overcome to at least some extent.

Another feature of plain gauze is that one of the chief objects is to produce as much contrast as possible between the gauze ground and the figure. To do this two things are necessary; *first*, to form a close compact figure; and *second*, to have the texture of the ground as open as possible.

It has just been shown that it is not an easy matter to obtain a close figure by any of the methods described up to this point, because of the influence of the crossing. At the same time, it is not an easy matter to obtain the desired degree of openness in the gauze because of the thickness of the yarn, or the attempt to press it closely together to improve the appearance of the part that is not gauze. The fact may be stated generally that, with the method of working just explained, the two important conditions, *i. e.*, openness of gauze and compactness of the rest of the cloth, cannot be obtained with any degree of perfection. It is, therefore, necessary to resort to other means.

There are two distinct methods of obtaining the requisite openness in the gauze, and a close texture in the plain and figure, and they may be employed either separately or combined. The first is to introduce more than one pick of filling into one shed between the crossings, and the second is to cause the crossings to take place with more than two threads, as has always been the case up to now.

It is very practical to take four, six, or almost any other reasonable number of threads and cross two over two, three over three, or in any manner desired to produce the requisite openness, because by so doing there is greater bulk at the point of crossing and of necessity there is a greater space between the threads so crossed than if they had simply been crossed in pairs.

Taking up the first method, it is quite clear that if only one doup is employed, and if that doup has to share in the formation of plain,

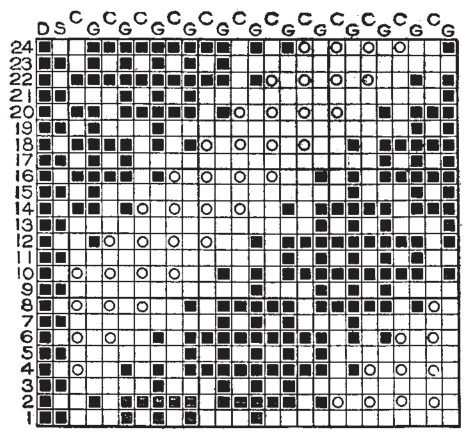
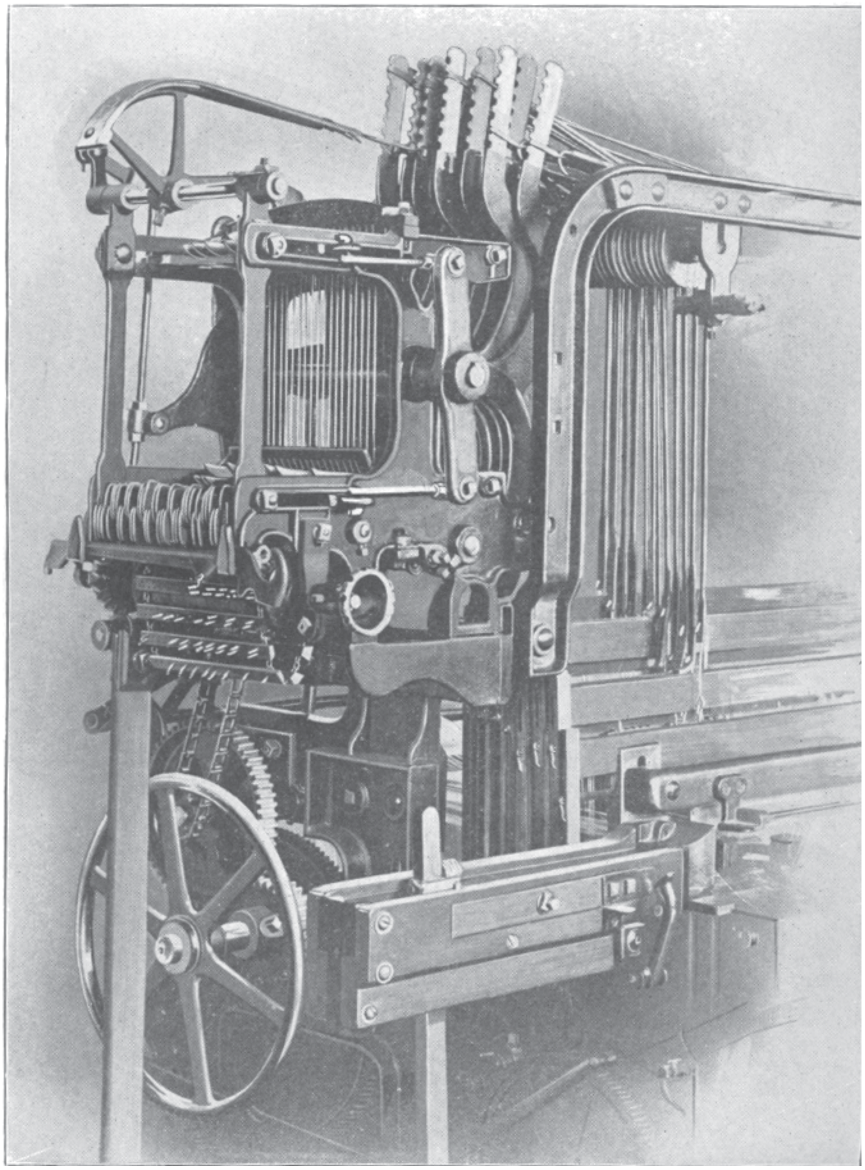


Fig. 329.

that more than one pick cannot be inserted between the crossings, because of the doup having to rise at alternate picks. It is therefore clear that the method of working with one doup crossing one thread is out of the question. It is equally clear that if more than two threads are to cross each other a different system of douping must be resorted to.

The following chapter takes up this matter and explains methods of combining parallel and cross-woven methods of interlacing so as to produce any texture required.

Open-Work Leno Designs. The need of other methods of crossing in addition to the one-thread-crossing-one system has been shown by the effect of this method on the texture. Furthermore,



IMPROVED DOBBY WITH ATTACHMENT FOR LENO WEAVING
Crompton & Knowles Loom Works

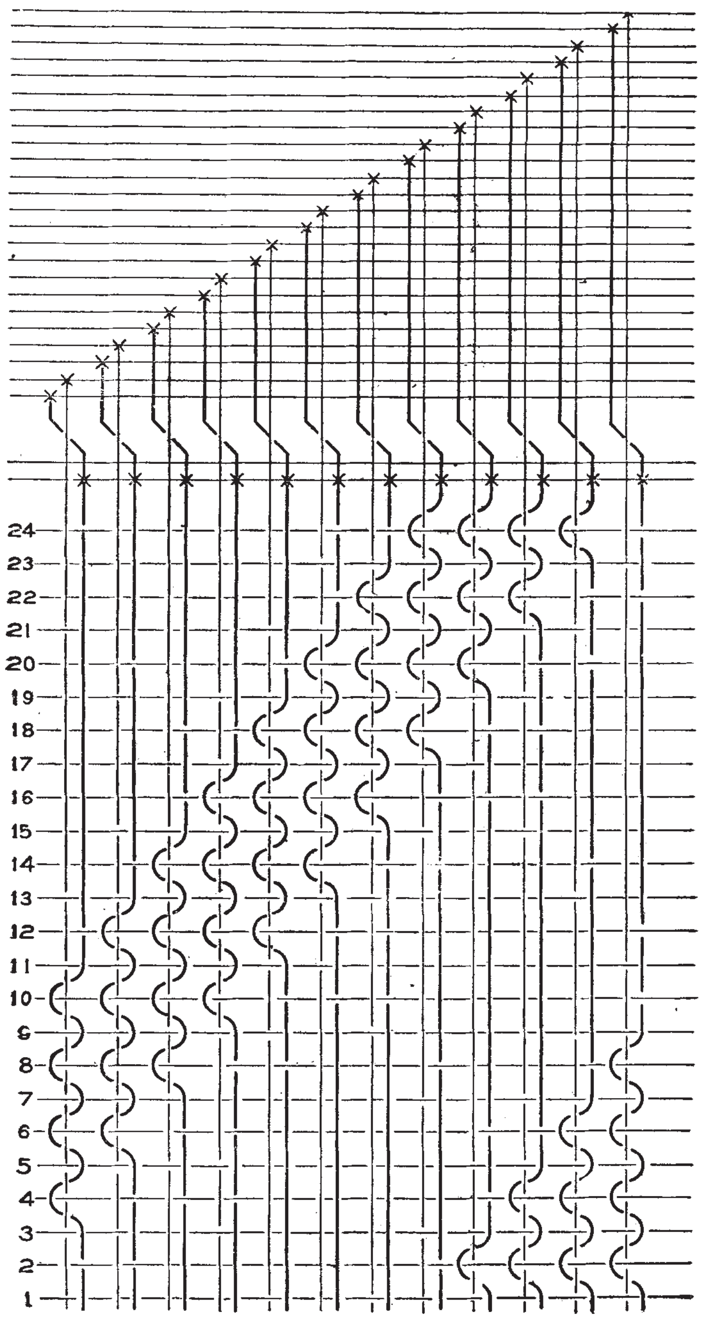


Fig. 330.

many patterns are formed by varying the methods of crossing, no attempt being made to form figures, such as produced by ordinary weaving. This class, however, is the highest type of cross-woven fabric, or any other class of woven fabric, and has the appearance of lace, the filling and warp both being deflected to form the characteristic open work. The largest class of leno designs is between the fine lace-like patterns and those made on the one-thread-crossing-one system.

Crossing threads may pass over or under any practical number of threads, as easily as they cross one thread, and these crossings may be the groundwork for figured cloths, or they may form figures. If they form ground for figures, the latter may have a compact texture, because the threads which are worked together in the crossings may have different methods of interlacing in the figures. This system may be applied equally well when the crossings form the figure and the ground is a compact weave, by running several threads together to form the gauze.

These are perhaps the most useful applications of the one-thread-crossing-more-than-one principle; *i. e.*, to form a compact figure on an open ground or to form an open figure on a compact ground. Other useful features will become apparent in the course of the explanation.

Following the same methods as were used in plain gauze, the system will be taken up in a graded manner, the simplest principles being illustrated and explained with a view to establishing firmly the differences between one thread crossing one, and one thread crossing more than one.

The illustration in Fig. 331 shows one thread crossing three others, which are interlaced in plain order between the crossings. Other illustrations show twills combined with cross weaving. Each individual thread in these designs should be followed, and especial attention should be given to the interlacing of the crossing threads.

Assume that it is necessary to form a pattern in which plain and cross weaving are combined, the effect to be alternate stripes of plain and cross weaving running across the cloth. This pattern is shown in the section on simple cross weaving, but the cross-woven effect in the present instance is to be of a more open character than the previous example. From previous remarks it will be inferred that the open effect can be obtained only by having a larger number of crossing threads, or by having a larger number of threads crossed by them. It may be obtained by one thread crossing two threads, by one thread crossing three, by two threads crossing two, or by any similar arrangement.

For a first example, it will be convenient to deal with one thread crossing three, as by that method the general principles can be brought out in such a manner that the details will be thoroughly understood.

Fig. 331 shows a pattern which consists of five picks of plain cloth and one pick on which the crossing takes place. To make the space

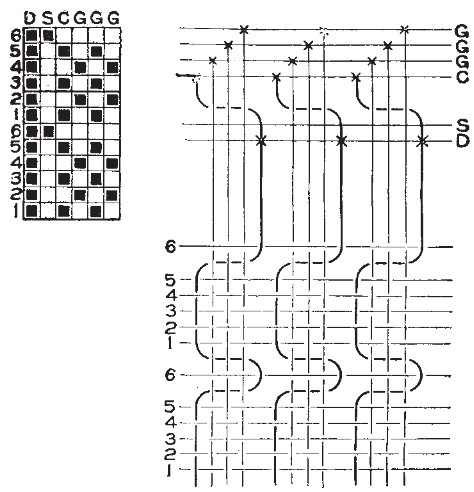


Fig. 331.

between the crossing pick and those on each side of it larger than it would be with one thread crossing one, the crossing thread crosses three threads. To produce this effect, the method of drafting and douping the pattern is different from any of the examples previously explained, and will perhaps require a little study.

The illustration shows a plan of the cloth, also the arrangement of harness, drawing-in draft, and chain. The ground harnesses are marked G, crossing harness is marked C, and the standard and doup are marked S and D respectively. The ground threads are drawn in on the ground harnesses and the crossing thread is drawn in on the crossing harness, then passed under the three ground threads and drawn through the doup.

Analyzing the plan in conjunction with the harness chain, the effect of lifting the harnesses is found to be the same as in previous examples, except that the standard and doup being lifted, draws the crossing thread under three threads instead of under one. This is due to the doup being at the right of three threads instead of being only one thread to the right.

It is equally impossible for the crossing thread, drawn in on the arrangement where the doup is one thread to the right of the crossing harness, to cross under three threads, as it is for the crossing thread drawn in on the present arrangement to cross under only one thread. Therefore, it may be accepted as a general rule that when the crossing thread is drawn under the ground threads, it must be drawn under as many threads as it is crossed under when passed from the heddle on the crossing harness to the doup.

Returning to the analysis of the plan and harness chain, it will be noted that the first pick on the harness chain has the doup, crossing, and the second ground harness lifted, which raises the crossing thread over the filling on the left of the ground thread, and also raises the second ground thread, as this is the one drawn in through the second ground harness.

On the second pick, the doup and the first and third ground harnesses are lifted, which of course lifts the first and third ground threads over the filling. The crossing thread and second ground thread are under the filling, as neither the standard nor crossing harness nor the second ground harness is lifted.

The third and fifth picks are like the first, and the second pick is like the fourth. The crossing takes place on the sixth pick by raising the standard and doup in just the same manner as in plain gauze weaving.

The first pick after the sixth is like the first pick at the bottom of the design, and shows how the crossing thread is drawn back to the left of the ground threads by raising the crossing harness and doup. Two repeats of the pattern are given in the direction of the filling, and three repeats in the warp, the object being to show the continuity of the pattern and to give a better idea of the effect.

There is one feature of this design which merits special attention. In the pages on simple leno effects, it is stated that there should be an uneven number of picks of plain between the crossings so that the crossing thread may pass over both the pick preceding and the pick following the crossing. Note that this plan is followed, as is shown at picks five and one.

Summarizing the operation of making this pattern, and comparing it with others made on the one-thread-crossing-one system,

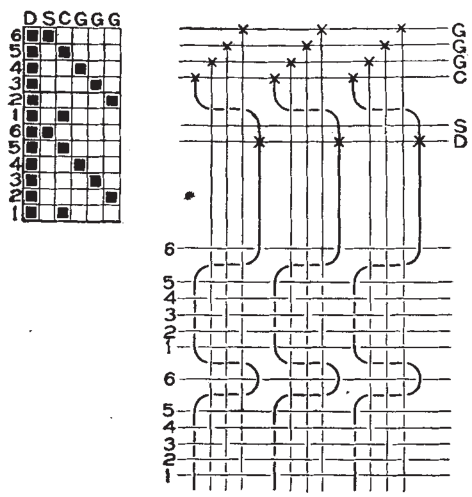


Fig. 332.

the differences are as follows: The arrangement of harnesses and the operation of drawing-in the warp are different, and when the standard and doup are lifted the crossing thread crosses three ground threads instead of one. The latter is a direct result of the former, so practically the only new feature is the method of drawing in the warp threads.

When four harnesses in addition to the standard and doup are employed, as in Fig. 331, it is not necessary to confine the ground to the plain weave, as other weaves may be combined with this principle of crossing. As there are four harnesses, a four harness twill may be used, as shown in Fig. 332, the ground weave in this illustration being the one up three down *swansdown* weave. Note that the crossing thread is over the picks on each side of the crossing, as in previous examples.

A careful study of Fig. 332 shows that the arrangement of harnesses and drawing-in draft is the same as in Fig. 331, the difference in the plan of cloth being due to the harness chain. Referring to the chain we find the one up, three down weave on the ground and crossing harnesses, the crossing being formed by lifting the standard and doup in the usual manner. Of course, the ground weave might be repeated any number of times between the crossings, if this were

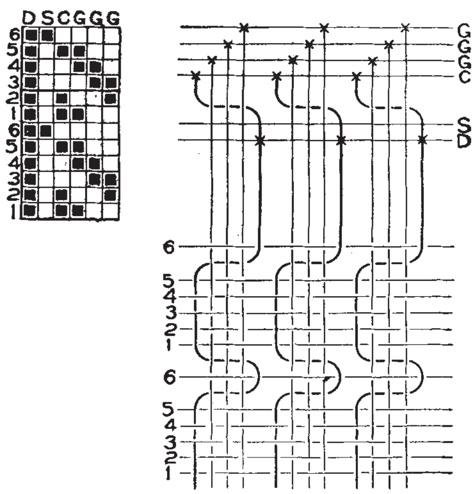


Fig 333.

necessary, but it would be a good plan to have one pick more than even repeats, so that the picks on each side of the crossing would be the same.

The illustration, Fig. 333, is another example of the four harness ground weave combined with a crossing. In this instance the four-harness cassimere twill, two up, two down, is used. The method is the same as in previous examples, so it will be unnecessary to go into details. It will be valuable to study these illustrations comparing the plan and drawing-in draft with the harness chain or design, for the principles illustrated in these three examples are extensively used in leno designing. The method of crossing one thread under more than one may be extended and used in connection with other weaves to produce more elaborate patterns by the use of a larger number of harnesses.

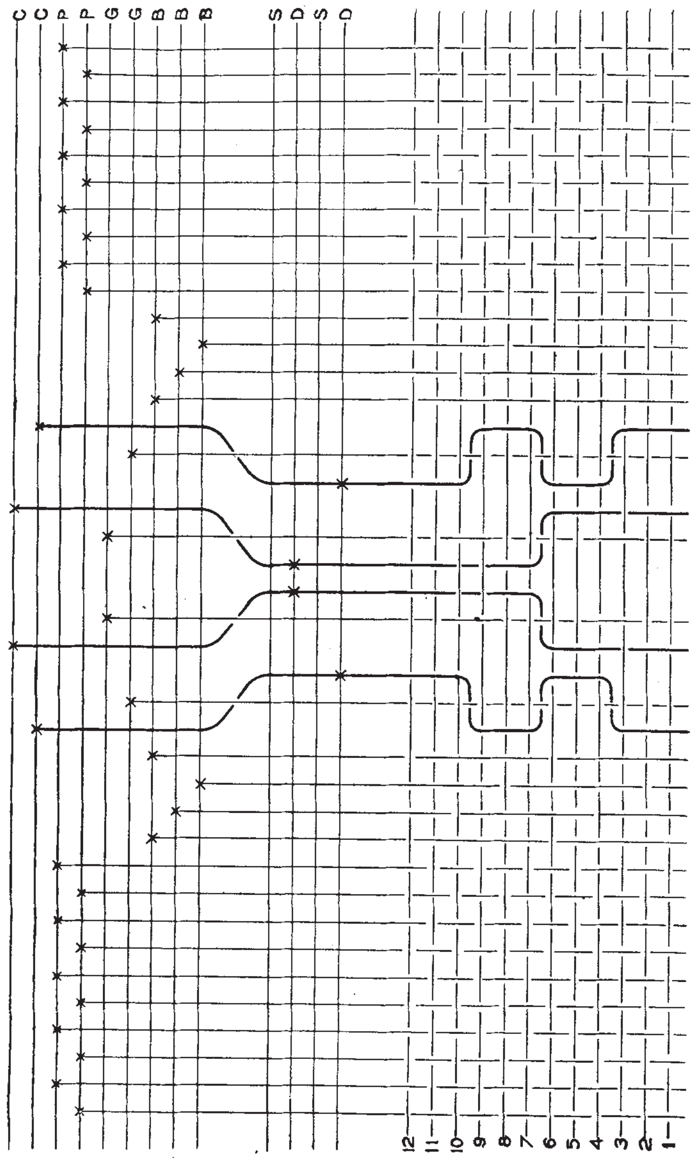


Fig. 334.

Leno Stripes. It has been previously stated that large varieties of patterns can be formed by simply varying the number and position of the ground and the crossing picks, and it is unnecessary to illustrate this further, but most of the patterns formed in this manner would show stripes crossing the cloth. While this is not always objectionable, stripes running lengthwise or in the direction of the warp may be more desirable. These are made by the arrangement shown in Fig. 334.

The threads which are to form the cross-woven portion of the pattern are drafted and douped in the manner shown in the illustration, while the threads forming the ground between the stripes are drawn in on the ground harnesses in the usual manner. This necessitates the use of what are known as stripe harnesses and doups, which are harnesses arranged in such a manner that there will be a number of heddles at specified distances, and then a space in which there are no heddles. The spaces on some of the harnesses correspond to the places where there are heddles on other harnesses, which gives the required number of heddles for each repeat of the pattern.

The plan of the cloth shows a combination of leno, sateen, and plain weaving. The threads forming the leno stripe are drawn in on the doups, ground and crossing harnesses, which are marked D, G, and C, respectively. The threads forming the sateen stripe are drawn in on the harnesses marked B, and the threads for plain are drawn in on the harnesses marked P.

Two doups and standards are required, as the first and fourth pairs of crossing and ground threads do not "work" in the same manner as the second and third pairs. In fact, the first and fourth pairs, although drawn in on the same harnesses, do not work the same, but the difference is merely a difference in the side of the ground thread on which they weave, the first crossing thread being on the right side of the first ground thread when the fourth crossing thread is on the left side of the fourth ground thread, and *vice versa*. This is obtained on the full gauze principle, one crossing thread being drawn through the doup at the right of the ground thread and the other being drawn through the doup on the left of the ground thread.

The same difference will be noted in the second and third pairs of threads. Two harnesses are allowed for the plain weave, and three harnesses are allowed for the threads weaving in sateen order, which makes a total of nine harnesses, in addition to two standards and doups.

The harness chain is shown in Fig. 335. The letters correspond to the letters on the harnesses in the plan, and the numbers correspond to the figures on the picks. A cursory examination of the chain shows nothing unusual, except perhaps that there are no risers on the first ground harness. The ground threads in the first and fourth pairs of threads forming the leno stripe are drawn in on this harness, and a reference to the plan shows that they are never raised over a pick of filling, so of course the harness on which they are drawn is never lifted.

An analysis of the first two picks would show the following: On the first pick of the chain, both doups, the first three harnesses marked B, the first harness marked P, and both crossing harnesses are lifted. The result as shown in the first pick of the plan is that every odd-numbered thread in the first ten, which are weaving plain, is lifted; four threads on each side of the leno stripe are raised; the crossing threads are all on the crossing harness side of the ground threads and lifted over the filling; and the last ten threads weave in the same manner as the first ten.

On the second pick of the chain the doups, second and third harnesses marked B, second harness marked P, and the crossing harnesses, are raised. The effect as shown in the plan is to raise the even-numbered threads of those weaving plain. The first, second, and fourth of those forming the sateen stripe, and the crossing threads on the same side of the ground threads as in the first pick. Other picks may be followed in the chain and plan in the same manner.

The stripes of plain sateen or leno may be varied in width and texture, or other weaves may be added at the designer's pleasure.

In laying out an original design of this nature, it would be necessary to take into consideration the textures of the various weaves. For instance, the leno stripe would, of course, be as open as possible. The plain cloth ought to be quite firm, so would require a medium number of picks per inch, depending upon the size of the yarn. The sateen stripe would be "crowded" in the reed to give the characteristic sateen effect.

In the arrangement of harnesses in Fig. 334, only two harnesses are allowed for the plain weave. In some instances, where there is a large number of threads per inch, consequently a large number of heddles on the harnesses, it might be necessary to increase the number of harnesses used for the plain cloth to four, in order to avoid excessive breakage in the warp.

In combining leno stripes with stripes of other weaves, the crossing thread usually crosses more than one ground thread. When one thread crosses three or five ground threads, better effects are possible, because the chief object is to obtain as much contrast as possible between the openness of texture of the leno stripe and the closeness of the other sections of the pattern. This result is obtained by inserting more than one pick in each shed of the cross weaving, so as to allow a large number of picks to be used, and having the other stripes woven with the twill or any weave which will make a compact texture. This arrangement will give a marked contrast between the cross woven and the ordinary woven stripes.

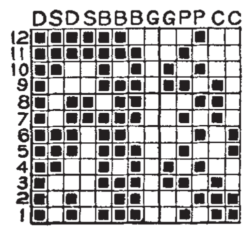


Fig. 335.

The limit of variation has not been reached with varying the texture, however, for the threads which are forming the leno stripe may change from cross weaving to ordinary weaving, and form plain, twilled, or even figured cloth. This simply means that, as shown in previous examples, the crossing harnesses would work in the same manner as regular harnesses, just as though the doup had no connection with the pattern.

The form of cross weaving might also be changed, thus forming different degrees of openness in the leno stripe. It will be understood that the jacquard may be used in the same manner as an ordinary loom, when the patterns are too elaborate to be woven or a practical number of harnesses. The threads would be drawn through the eyes of the harness cords in the usual manner and those which are to form leno would be drawn through a doup, just as if a dobby or head motion were being used.

The jacquard is not used, however, except when it is impossible to produce the patterns on harnesses, on account of the expense of operating the jacquard machine. Patterns which are seemingly beyond the range of harnesses may be woven on them by a judicious arrangement of the harnesses.

The illustration Fig. 336 shows a design which consists of cross weaving, plain cloth, and small figures. The plan of the cloth and the drawing-in draft are shown in Fig. 337. It might be supposed that this design is beyond the range of a dobby or head motion, but by careful arrangement it may be woven on sixteen harnesses with one standard and doup, as shown by the harness chain in Fig. 338.

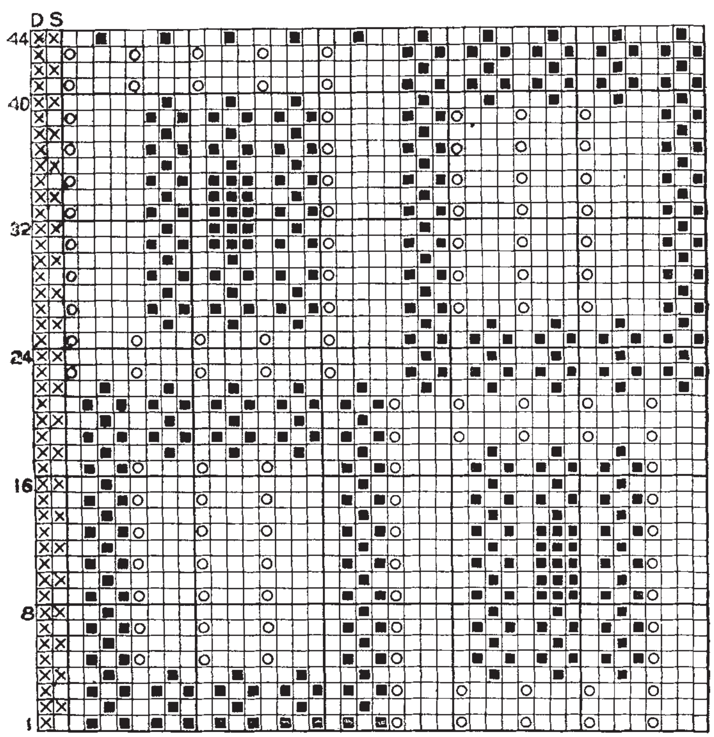


Fig. 336.

Reference to the drawing-in draft shows that every crossing thread is drawn under three ground threads, and the chain shows that the standard and doup are lifted at every alternate pick, to weave plain cloth between the crossing places. This is similar to previous examples, and limits the design to one pick in each shed. Sufficient openness of the texture is obtained, however, by the crossing thread passing under three ground threads.

If this pattern required the crossing thread to be on the crossing harness side of the ground threads when weaving plain, more har-

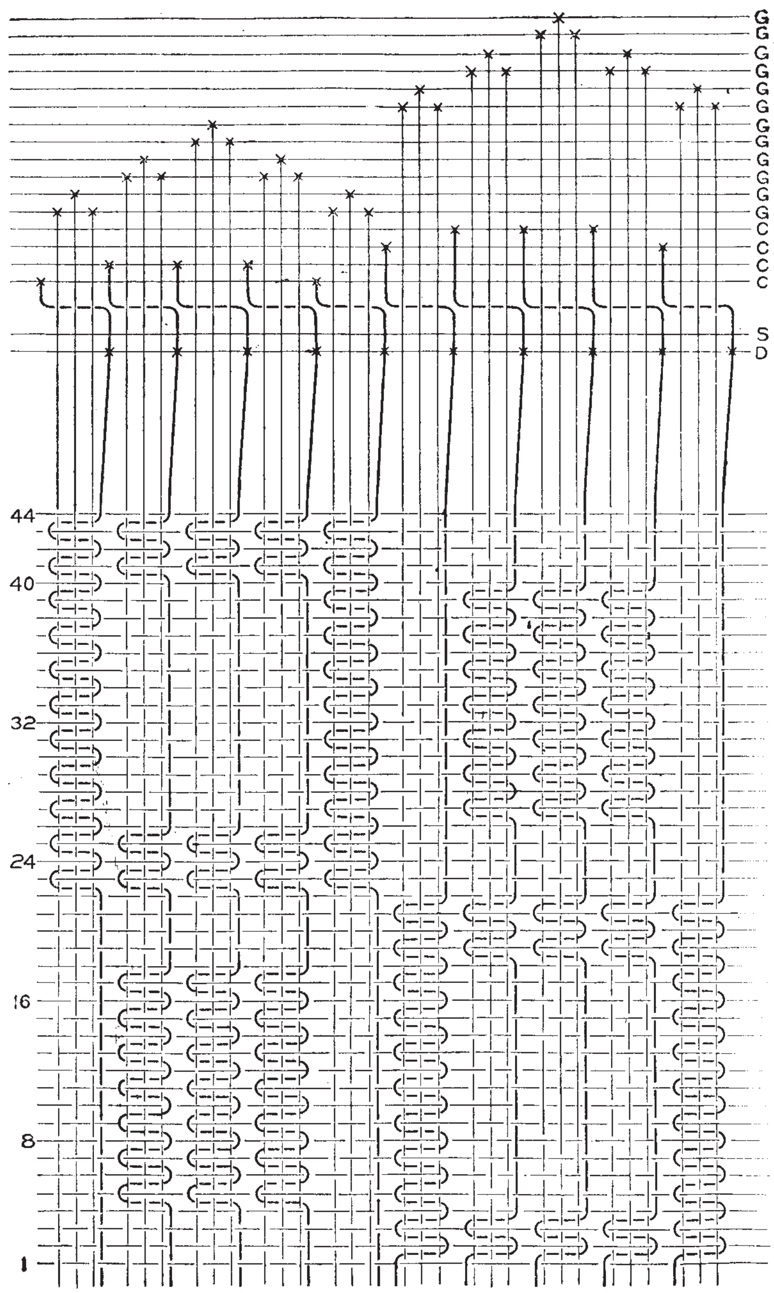


Fig. 337.

nesses would be needed than could be operated by a harness motion, consequently the jacquard machine would have to be used.

It is unnecessary to explain how each crossing is formed, as the full design, chain, and drawing-in draft may be compared, and the result observed by studying the enlarged plan of cloth. The circles show where the crossing harnesses are lifted and the crosses in the full design, Fig. 336, are on the standard and doup, as these are not, strictly speaking, a part of the design.

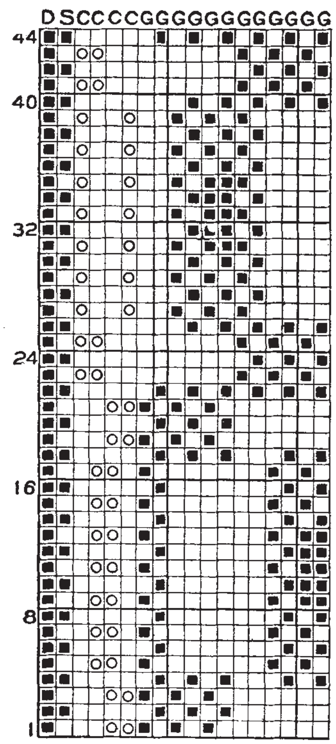


Fig. 338.

On the first pick of the harness chain, the doup, third, and fourth crossing harnesses and the first, third, and seventh ground harnesses are raised. The result shown in the first pick of the enlarged plan is as follows: The crossing threads drawn in on the third and fourth crossing harnesses—the sixth, seventh, eighth, ninth, and tenth—are raised over the filling at the left of the three ground threads with which they work. The ground threads drawn in on the first, third, and fifth ground harnesses (shown in the drawing-in draft at the top of Fig. 337) are raised to form plain cloth. All other threads are under the filling and the crossing threads which are not crossed; *i. e.*, those drawn in on the first and second crossing harnesses, form part of the plain cloth.

On the second pick, the standard and doup, and the second, fourth, and sixth ground threads are raised. The effect shown in the second pick of the plan is as follows: All the crossing threads are on the doup side of the ground threads and raised over the filling. The ground threads drawn in on the second, fourth, and sixth ground harnesses also pass over the filling. The third pick is like the first and the fourth is like the second.

From this point other crossing and ground harnesses are raised with the effect shown in the plan. Each thread should be carefully followed and the two small warp figures, on the third and ninth sets of threads respectively, noted in their relation to the harness chain.

TEXTILE COLORING

Up to this point, with the exception of a few pages in Part I in which the method of forming simple stripe and check effects by combing various colored warp and filling threads with suitable weaves, the weave or combination of weaves used in textile designing have received most of our attention. The manner of interlacing the threads does not, however, represent all that requires attention, for in many cases the colors are quite as important as the texture or form.

By most textile writers the elements of woven patterns are stated as *weave* and *color*. The first is the basis of cloth manufacture and relates to the build or structure of the fabric. Though weave may be regarded in textile designing as a constructive and not an ornamental component of the pattern, there are numerous examples in which it possesses both these characteristics. For instance, the gauze and leno designs explained in previous pages do not rely upon schemes of color for their effect. The structural plan of the cloth is such that a firm and even cloth, which is decorated with a pronounced and decided pattern, is produced. Common twills, piqué designs and other combinations of weaves also have this combination of constructive and ornamental powers.

Color is very differently related to textile design. Its specific province is to brighten and improve the qualities of the design produced by the weave.

An analysis of woven cloths will show the extensive use of color in textiles. In some branches, such as woolen goods, it is the distinguishing element of the cloth. To remove color from such goods as cassimeres, shawls, or rugs would remove the chief qualities of the cloth, so in this instance, color is at least as important as weave. In other instances color is a supplementary element giving precision to the composition of the weave.

Theory of Color. The science of color teaches the nature and causes of color, their distinctions, their relations to each other, their classification, the mental effects that attend them, and the causes and laws of color harmony.

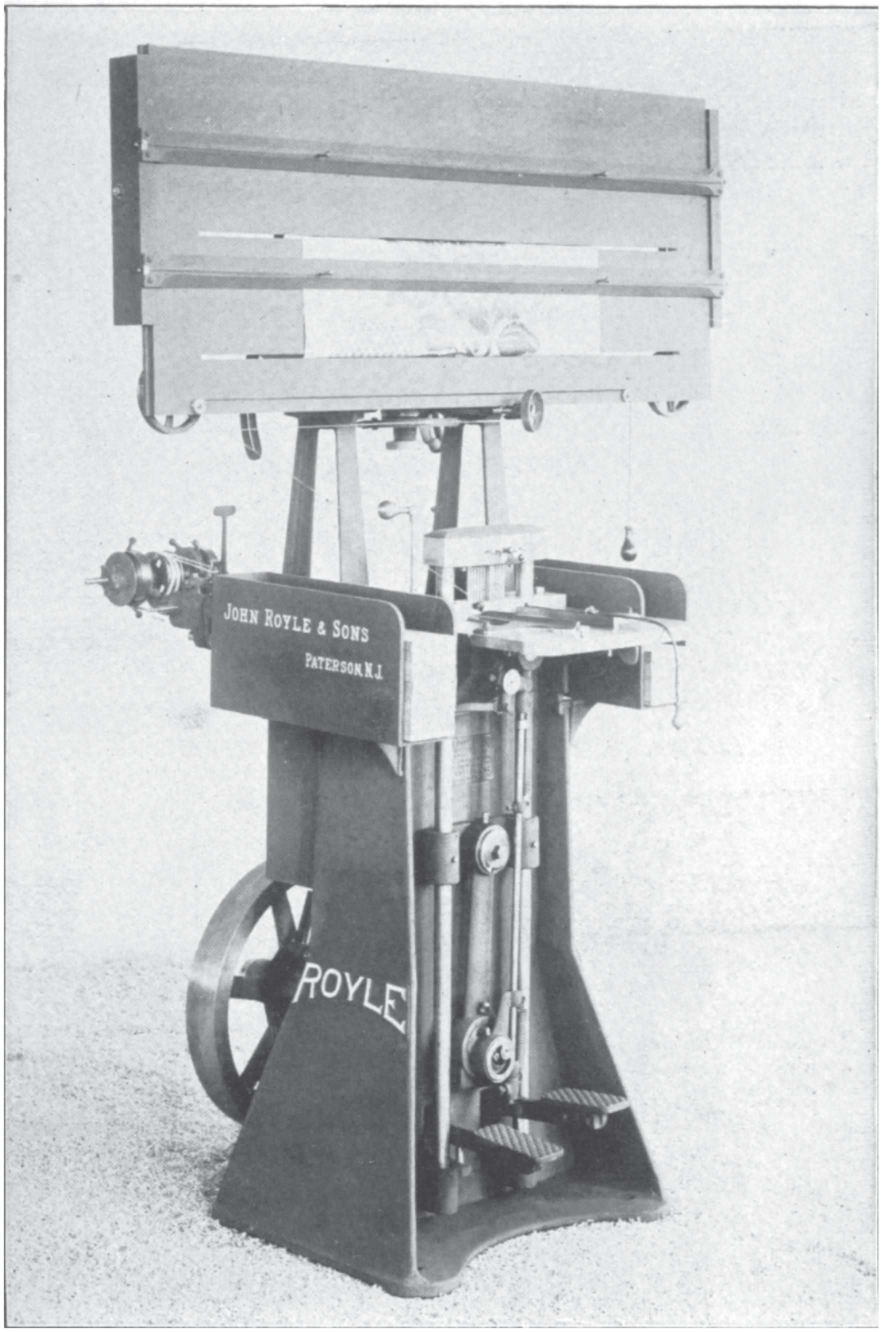
There are two important theories of color: *i. e.*, the pigment theory and the light theory. The light theory will be explained first for it deals with the phenomena of color and explains the laws which control the modification of the intensity, tone, and hue of colors.

In the light theory, white light is said to be pure light and to contain all colors. By a simple and inexpensive experiment it is possible to acquire a useful knowledge of the composition of white light. A glass prism is fixed in a darkened room so that a ray of light may pass through it. This gives an analysis of light which shows it to be composed of different colors. Thus, when the ray of light passes through the prism it is bent out of its path, and thereby decomposed, producing what is termed a spectrum. The spectrum shows every gradation of color but the following division is generally accepted as most satisfactory: red, orange, yellow, green, blue, and violet.

The results obtained by this prismatic experiment form profitable and suggestive exercises in color combinations. They are always harmonious and the colors are much richer than those obtained by pigments.

The pigment theory deals with color as an active element in decorative design and is adopted in the applied arts. It is the theory that can be worked out in practice. According to its principles, red, yellow and blue are separate pigments and by mixing them in variable proportions, and, of course, toning and tinting with white and black, every possible tone and hue of color may be obtained. Thus yellow and blue give green; yellow and red give orange; and red and blue give violet.

Classification of Colors. All colors belong to one of two distinct classes: *i. e.*, *Simple Colors* and *Compound Colors*. Simple colors cannot be divided into other hues or colors; in other words they are individual colors. Compound colors, being the result of combining two or more other colors, may be divided into their constituent colors. Various writers on the subject do not agree on the classification of colors, but when the color is considered with a view to its practical application it is necessary to base all combinations on New-



ROYLE'S POWER PIANO CARD CUTTING MACHINE ton's theory, that red, blue, and yellow are simple colors and all other colors are the result of mixing these three in various proportions.

There are two classes of compound colors, namely, *Secondary Colors* and *Tertiary Colors*. The Secondary Colors are green, orange, and violet; and the Tertiary Colors are russet, citrine and olive. The constituent parts of these colors will be taken up later.

The principles and classification of colors being understood we will confine our attention to the color pigments in their relation to textiles. To know the value of color it is necessary to learn something of the laws which govern color harmony. The influence of one color over another as to whether the effect is pleasing or otherwise is the subject which occupies the attention of the textile designer, for the success of his patterns depends upon a judicious selection and use of materials.

There are two reasons for applying colors: *first*, to give objects a better appearance; and *second*, to assist in the separation of objects, or parts of objects, thus giving assistance to form. The truth of the first reason is self-evident and need not be discussed. The value of the second reason is evident, but a brief explanation may make it clearer.

If objects of the same, or nearly the same, color are placed near one another, there will be more or less difficulty in determining the boundaries of each object. If widely different colors are used, there will be no difficulty in determining the extent of the figures or objects.

Thus color assists in the separation of form, or renders form apparent. In textile goods, this applies to almost all patterns where there is a ground fabric with some form of ornamentation.

The following axiomatic statements will serve to explain the subject of color and make following statements clear.

(*a*) Regarded from a scientific point of view there are but three colors; *i. e.*, blue, red and yellow.

(*b*) Blue, red and yellow are termed primary colors, as they cannot be formed by the admixture of any other colors.

(*c*) All colors except blue, red and yellow result from the admixture of the primary colors.

(*d*) By mixing blue and red, purple is formed.

(*e*) By mixing red and yellow, orange is formed.

(*f*) By mixing yellow and blue, green is formed.

(*g*) Colors resulting from the mixture of two primary colors are termed secondary colors. Thus, purple, orange, and green are secondary colors.

(*h*) Colors formed by mixing two secondary colors are termed tertiary colors.

(*i*) By mixing purple and orange, russet, the red tertiary, is formed.

(*j*) By mixing green and purple, olive, the blue tertiary, is formed.

(*k*) By mixing orange and green, citrine, the yellow tertiary, is formed.

The diagrams A, B, and C in Fig. 339 will be found useful in studying the various colors. Diagram A represents the primary colors. Diagram B shows the secondary colors in their relation to the primary colors. For instance, orange is formed by the mixture of red and yellow, so that orange is represented between red and yellow. Diagram C shows the secondary and tertiary colors in their proper positions with relation to the manner in which they are formed.

Relation of Color to Textiles. There are peculiarities of textile manufacturing which make impracticable many of the rules which apply in ordinary surface decoration. The structure of the cloth and the purpose for which it is to be used determine the coloring and the systems of distribution. An arrangement of colors might be excellent for a rug or carpet which would hardly become fashionable in clothing.

The effects of the various animal and vegetable fibers on colors also are interesting. On cotton colors are dull; on woolens color has a peculiar depth; on worsteds they are bright and definite; while on silk they are brilliant. These results are due to the properties of the various fibers, therefore, it is clear that while ordinary surface decorating has laws which are impracticable in textile designing, the latter also has laws which do not apply to the former.

In addition to the method of forming simple stripe and check effects, as explained in Part I, by employing various colored threads in the warp and filling with suitable weaves, there are three other methods of employing color as follows:

(*a*) By blending various colors of material in the raw state.

(*b*) By combining colors to form twist and novelty yarns.

(*c*) By using an extra set of warp or filling threads.

In the first method, the materials are combined before carding, being thoroughly mixed in the carding operation. This system of

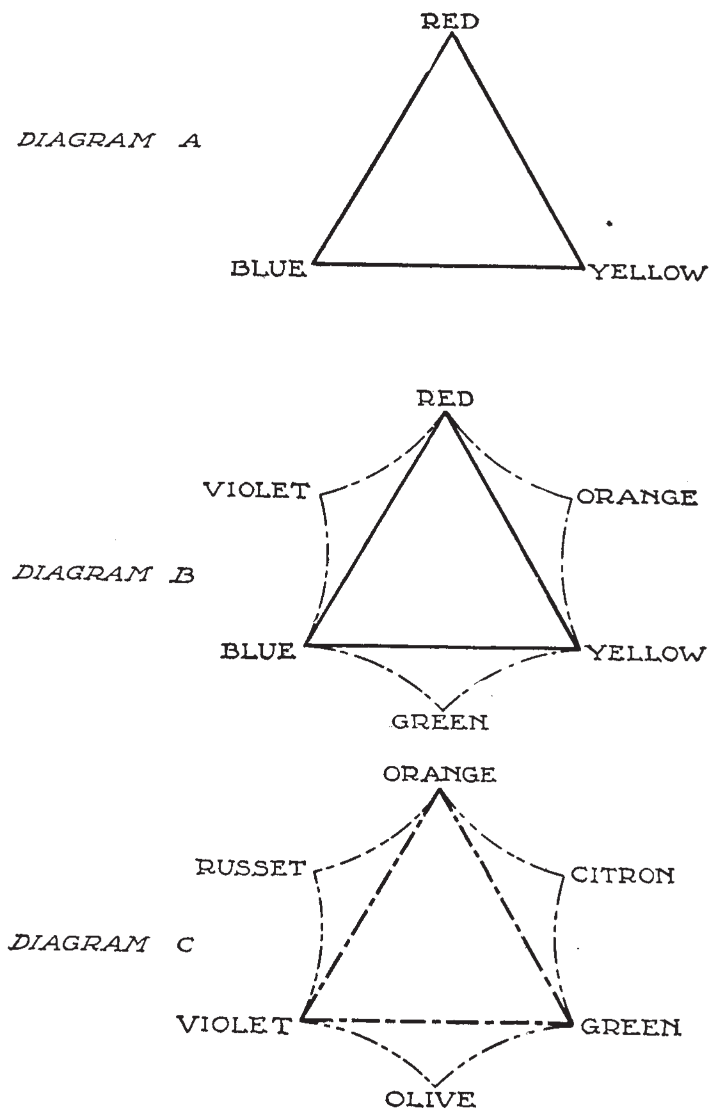


Fig. 339.

forming mixtures produces yarns in which the separate particles of color are uniformly distributed. The mechanical arrangement of carding offers every facility for obtaining perfectly mixed and soft-toned blends.

The second method produces yarns in which distinct colors are visible, while the third method is used in making spot designs by employing extra yarns.

To become a good colorist one must have the ability to discriminate between good and inharmonious combinations, and one of the best methods of acquiring this quality is to form collections of the best fabrics of each season. This method is helpful also because a designer is, to a large extent, governed by fashion, and fashions move in cycles.

The primary and secondary colors are very potent and are generally mixed with white or black to reduce their intensity. They are seldom used for the ground work patterns, their chief use being in the form of *fancies* to give additional tone to the pattern.

A list of the characteristics of the various colors will be given to guide the efforts of those who are not familiar with the qualities of colors in woven fabric structure.

Colors of the Spectrum. By passing a beam of light through a glass prism a spectrum is formed, as previously explained, by the white light being divided into its constituent colors. These colors are the primary and secondary colors, previously explained on the pigment theory. As it is necessary to adopt a standard of color, the six colors of the spectrum, *i. e.*, red, orange, yellow, green, blue, and violet, are sometimes referred to as colors, and all variations in tints, shades and hues are considered modifications of these six colors.

The colors of the spectrum are referred to by different writers as standard, spectral, positive, pure, full, and saturated colors. The name normal is generally accepted as it expresses the natural condition of color when affected by light.

Tones. The term tone covers the entire scale of color from the darkest shade to the lightest tint, so in a perfect scale of tones the grading from one shade to another or from one tint to another, would be so slight that it would be almost imperceptible. A scale of tones ends in white in one direction and in black in the other direction. It follows that tones are produced by adding white or black to the normal color.

Tint is a tone which is lighter than the normal color. Tints are produced by adding white to the normal color. Shade is a tone which is darker than the normal color. Shades are produced by adding black to the normal color.

Hue. This term is applied to a color when the normal color has been modified or changed by the addition of another normal color. For example, if a small amount of blue is added to red, a blue-red would be formed. This blue-red would be a hue of red. If a small amount of green is added to blue the result would be a green-blue. The last name indicates the normal color in the scale and the prefix is the color added.

Broken Colors are the normal colors dulled more or less by the addition of a gray.

Value is the luminous intensity of a color, tone or hue in its relation to other colors, tones or hues. It is very necessary to keep the values of the various colors used in composition to produce a harmonious balance of tone or intensity so that the combined effect will not be injured by an excess of any color.

For example, a light blue and a pink will combine and harmonize as far as values are concerned. However, equal quantities of a normal red and light blue would not harmonize in value because the greater intensity of the red would overpower the light blue. When the intensities differ the quantities used must be in proportion. It is very seldom that equal quantities of two or more colors can be used in combination to produce a harmonious effect.

Potentiality is the power of a color, tone, or hue to affect other colors, tones, or hues, when associated with them. The degree of potentiality of the six normal colors is in the following order: yellow, orange, red, green, blue and violet.

Scaling is the arrangement of colors in the order of their intensity. It may be by colors, tones, or hues, or by these combined. The scale of the normal colors consists of their regular spectrum arrangement; *i. e.*, red, orange, yellow, green, blue, violet. A scale of tones would be as follows: lighter blue, light blue, blue, dark blue, and darker blue.

While the term tone covers all the variations of a color that may be produced by adding black or white to the normal color, but one of these may be added otherwise the result will be a broken color. A scale of hues consists of a normal color and its hues. The scale of hues of red would be violet-red, red, and orange-red.

Luminous Colors are those that reflect light in large quantities.

Yellow, orange, red, and green reflect the largest quantity of light and of these yellow is the most luminous color.

Neutral Colors. The effect of these colors is most important. Assume that alternate stripes of red and green are used, or that red figures are used on a green ground, or *vice versa.* The result would be a blurring sensation if the combination were looked at for several minutes. But if the two colors are separated by black or white, or by a tertiary or neutral color, the sensation of blurring will be avoided. In the same manner, if blue and orange are placed next to each other, a blurring sensation will result. The use of dividing lines of neutral colors will prevent this. If violet and yellow are placed together the effect is not so unpleasant, because the two colors although complimentary are more nearly allied to darkness and light respectively. Yet even in this instance the effect is improved by the presence of tertiary or neutral colors.

In addition to this quality of modifying the effect of complementary colors, neutral colors also possess the property of modifying the effect of other colors, possessing the same common element. As is stated above, colors placed side by side have the effect of detracting from each other, but if separated by black or white, or by neutral colors, this mutual detraction is prevented or modified. If, for example, green and blue are placed together, one color will partly destroy the other and the point of junction of the two will hardly be discernible, but if separated by a suitable method the effect is improved, In the same manner any other powerful or bright colors may be dealt with, with the same result.

Combination of Colors. A study of the following combinations will be helpful, and will at least serve as a basis for a more extensive knowledge of the effects produced by various combinations of color.

Red and Blue. In small quantities this is a useful combination, but if used in large quantities the good effect is spoiled. The action of the colors upon each other is that red assumes a bluish cast, or what is termed crimson, while the blue assumes a greenish cast.

Red and Yellow. This combination is very powerful, and great care and skill is needed to use it successfully. Red appears scarlet and yellow assumes a greenish color.

Yellow and Blue. Each color increases in luminosity, lustre and depth. Being contrasting colors, yellow and blue do not suffer much change in hue by association. In such combinations one color gives precision to the qualities of the other.

Red and Green. Red appears exceedingly bright, the lustre and fullness of the hue being emphasized. The softness of hue is emphasized in the green. Being complementary colors, they also give precision to the qualities of each other.

Red and Violet. Red becomes more scarlet and assumes a yellowish cast, while the violet assumes a greenish cast. This combination cannot be used to good advantage.

Red and Orange. This is a very powerful blend, and therefore is little used. Red becomes more violet and orange becomes yellowish.

Yellow and Violet. This is an excellent combination, both colors gain in lustre, luminosity, and strength, and form a perfect or complete contrast.

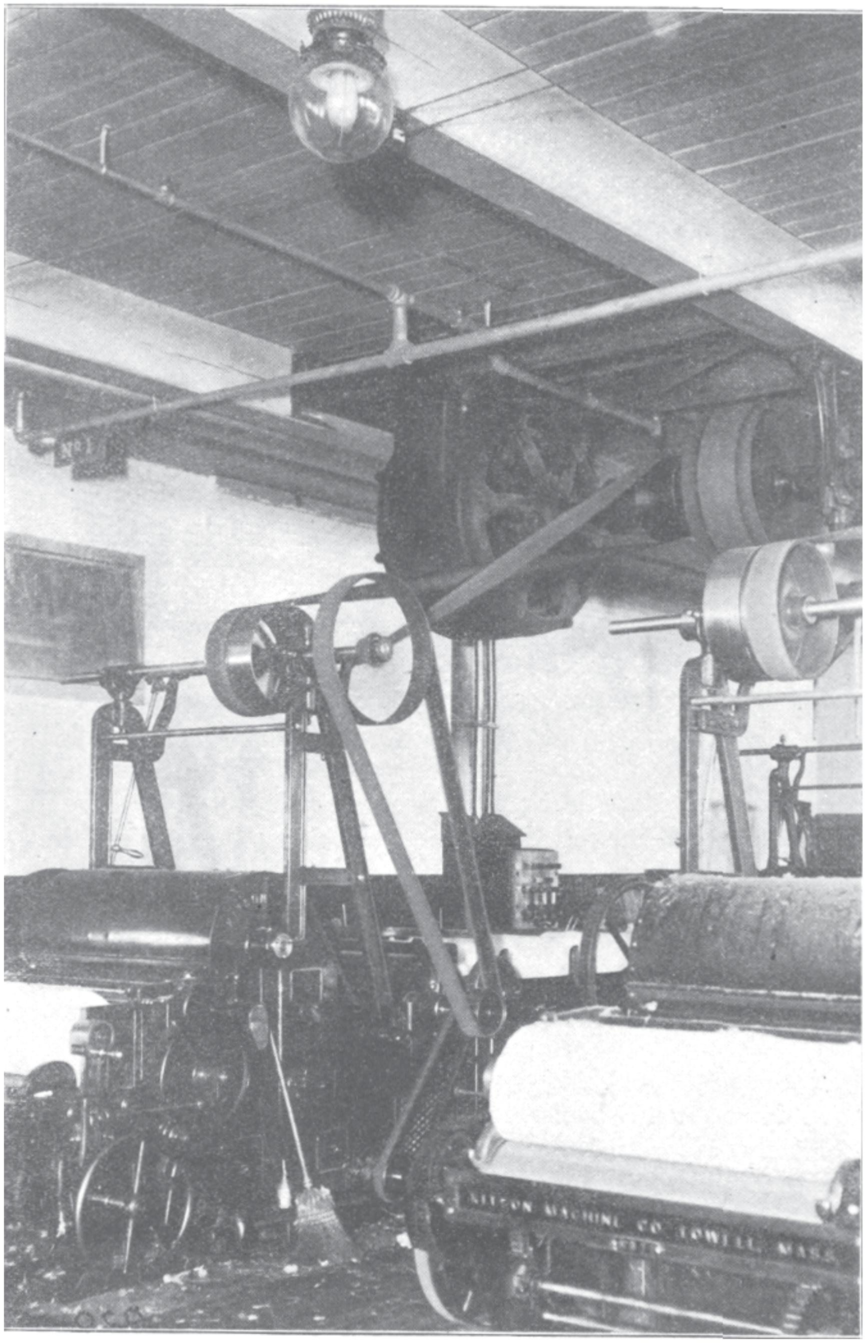
Blue and Orange. Both colors are increased by association, but must be used with great care.

Orange and Green. This is a very strong contrast; orange appears scarlet, and the green assumes a violet cast.

Violet and Green This is not a good combination, although it is used to a great extent. Violet assumes a reddish cast, while the green appears yellowish and much flatter in tone.

Violet and Orange. This is considered an excellent and effective combination. The violet is slightly greenish and the orange becomes more luminous or yellowish.

The following qualities of colors should be kept in mind when they are being used. Blue is a cold color and appears to recede from the eye. Red is a warm color and is exciting; it remains stationary as to distance. Yellow is the color nearest to light and appears to advance to the eye. At twilight blue appears much lighter than it is, red appears much darker, and yellow appears much darker. By ordinary gaslight, red becomes brighter and yellow becomes lighter. Thus it will be noted that the color is determined by the nature of the light and the physical properties of the material to which the color is applied.



150 H. P. INDUCTION MOTOR DRIVING LAPPERS

Manomet Mills

COST FINDING

One needs but a casual acquaintance with the industrial world of the present day to be aware that the astonishing progress of the past few decades is due to the application of scientific and exact methods. One of the latest manifestations of this spirit is in the attention paid to, and the interest shown in, accurate and economical systems of accounting, and precise methods of determining costs of production or operation. Nor can the latter be separated from the former. It must be stated at the outset and with emphasis, that *a proper and accurate system of book-keeping lies at the foundation of any reliable cost determination.* It is therefore fitting to preface a study of cost finding in textile mills by some consideration of the methods of keeping books and accounts.

It is a primary purpose, in keeping the accounts of a business, to maintain a record of its receipts and expenditures, its assets and obligations, so that a statement can be made as often as necessary, showing the condition of the business, the quality and nature of its resources and liabilities, and the amount and source of its gains and losses.

These records may also be so extended as to be useful in showing the particular sort of product which is most profitable, the exact department where economy or extravagance is practiced, the present costs of departments or products as compared with former costs of similar work, the places where expense should be curtailed, and a basis on which to estimate new work.

When the Interstate Commerce Commission began its work, before any substantial progress could be made, it was found necessary to prescribe for the use of all railroads a method or system of keeping accounts which should be made obligatory in the preparation of reports, as no comparison could be made under the various systems formerly in practice. For instance, in the classification of operating expenses there are now four main divisions, and fifty-three headings of accounts. Some other kinds of business making government reports are similarly standardized; and, as these systems have been devised by experts in consultation, they are doubtless effective in accomplishing the desired object. If we were to compare methods of bookkeeping in textile mills, we should find equally various ideas worked up, and doubtless some curious evolutions.

To illustrate this, take the manner of charging up the purchase of oils. Some mills carry an Oil account, into which are charged purchases of castor oil, cylinder oil, lard oil, dynamo oil, spindle oil, and perhaps others, every one of which may be used for a different purpose and in a different department. Another mill will charge them all to supplies and perhaps charge to each department the amount used of various kinds. Another will reason thus: Cylinder oil is used in producing power and is as properly chargeable to Power account as the labor of the engineer or the fuel used. Lard oil is used on cutting tools in the repair shop, and therefore chargeable to repairs. Dynamo oil is used only on dynamos and therefore should be put into Lighting account. And so on. Of course, if all oils are charged to Oil account or under any other title, and a record kept of the quantities and kind delivered each department, these amounts may be charged against such department and the same ends will be served.

It is a valid principle that materials and supplies should be charged to the operations or departments in which they are used, rather than to an account of their own. For example, in a mill finishing its own goods, and buying starch for that purpose and for warp sizing, the starch purchased and used should be charged to each operation in either of the ways suggested above, rather than to a Starch account without proper division.

Perhaps the bills embracing the widest variety of accounts are those for freight, and they are also those which can be most certainly and satisfactorily divided and charged. A general Freight account is an abomination, and freight on a mill's *product* should in particular be separated from all other items, as it is not a charge upon manufacture but upon distribution.

The same principle applies also to labor. If in the outside yard department, one man is kept busy packing waste, a second is engaged in the care of tenements, two more in unloading coal, while another set is handling cotton, the cost of this work should be charged to Waste account, Tenement Maintenance account, and Cotton account, or whatever titles may represent these accounts, rather than be charged in a lump sum to Outside Labor account. The ascertainment of such charges is one of the purposes of bookkeeping.

The number of expense accounts which a mill should carry on will depend upon the character of its product. A mill making an ordinary variety of goods may make at least such divisions as follows and as many more as desired: Cotton, Waste, Manufacturing Labor, Supplies, Repairs, Sizing Materials, Taxes and Insurance, Lighting, Power (with subdivisions Fuel, Supplies, Labor), Salaries and Office Expense, General Expense. There are always some unclassified minor expenses which may be charged thus with propriety, but the temptation to make the Expense account a refuge for carelessness in analyzing expenditures should be resisted.

A cash book with separate columns for each of the principal accounts will save labor in posting, and the accompanying table (See pages 4 and 5) shows how one may be arranged.

It will be noticed that there are two sets of columns on both the debit and credit sides. One set is for a record of the cash, and the other is for the distribution of the charges and credits to the various ledger titles and accounts. One column in the cash record is for the cash in the drawer, and the other one (or as many more as may be necessary) may be used for a check register. No check book with stubs is needed, as checks are entered directly on the cash book.

The second set of columns is for such accounts as may have a considerable number of entries each month. On the debit side there are illustrated one for Rents and one for Cloth Sales. On the credit side are a number, such as Advanced Payments to Employees, Cotton, Sizing Materials, etc. The columns are footed and carried forward to the end of the month, when the footings of these columns are posted to the ledger.

It is not worth while to provide a column for any account in which the labor of posting each entry would be less than that of carrying forward the footings. One or more columns may be left vacant in the heading to be used when any account is receiving temporary money charges, such as Construction or Machinery.

CASH

Manf'd Goods	Rent	Trans-fers	Sun-dries	Local Bank	Cash Drawer	Date	Vou. No.	Account	Explanation	Folio	(1)
47 53	65 41	796 40	947 16	8947 82	241 60	Oct. 5		Amounts	Brought forward		(2)
			1000 00	1000 00		6		To John Smith	Deposited to our Cr.	347	(3)
	5 40				5 40			" Sundries	Jas Kent to Date		(4)
10 41					10 41			" "	Cloth Sold		(5)
						7	963	By "	B. & M. Ry to 6th		(6)
								" Machinery			(7)
							964	" J. Russel	On Account	361	(8)
		100 00			100 00		965	" Cash	Withdraw for Drawer		(9)
							966	" Sundries	Paid J. Wagner		(10)
							967	" "	" B. Colvin		(11)
			5000 00	5000 00				To Bills Payable	Discounted Note No. 15	103	(12)
							968	By Sundries	Local Bank 4 mos.		(13)
							969	" "	Eastern Coal Co.		(14)
		1400 00			1400 00	8	970	" Cash	Drew for Pay Roll		(15)
							971	" Sundries	Pay Roll to Oct. 1		(16)
								" Mfg Labor		47	(17)
			69 33					To Adv. Pmts	Collections on Pay Roll	142	(18)
4 60	51 50							" Rent %	" " " "		(19)
											(20)
62 54	122 31	2296 40	2016 49	14.947 82	1757 41			Amounts	Carried forward		(21)

RECORD

(1)	Cash Drawer	Local Bank	Sundries	Transfers	Adv. Pmts.	Power	Repairs	Supplies	Expense and Salaries	Interest	Freight on Goods	Cotton
(2)	124 40	5955 40	346 18	796 40	46 13	842 12	540 00	176 72	250 00	120 00	241 12	2721 13
(3)												
(4)												
(5)												
(6)		261 20				87 62	17 20	5 40			123 10	
(7)			27 88									
(8)	50 00		50 00									
(9)		100 00		100 00								
(10)	13 20				13 20							
(11)	10 00				10 00							
(12)												
(13)		100 00								100 00		
(14)		321 10				321 10						
(15)		1400 00		1400 00								
(16)	1450 57					30 16	49 21		25 00			
(17)			1346 20									
(18)												
(19)												
(20)												
(21)	1648 17	8137 70	1770 26	2296 40	69 33	1281 00	606 41	182 12	275 00	220 00	364 22	2721 13

The sum of the footings of account columns on the credit side should equal the sum of the cash footings on the same side. The work may thus be checked for accuracy as it proceeds. In order to maintain this equality, however, it is necessary to provide a column for Transfers of Cash from Drawer to Bank, or *vice versa*.

The debit side of the cash may be proved in the same way, but due allowance must be made from the cash columns for the amount on hand when the month's business was begun.

Many mill men never realize the difference in the nature of the accounts of expense and income, which they carry upon their books. Probably a majority of establishments have at least three, and sometimes more of these various kinds of accounts.

1. Costs of Manufacturing, including Material, Labor and Supplies.

2. Costs of Distribution, such as Commissions and Freight on Product.

3. Expenses and Income not directly connected with manufacturing, such as Repairs to Tenements, Rent, Storage, etc.

It is not an unusual sight to see mill statements with these accounts reported upon in a confused manner. For instance, Rent account may be made to appear as a profit on Manufacturing.

For a proper system of cost finding it is necessary in addition to the books of debit and credit to maintain careful records of machinery. In each department there should be a permanent daily record of the amount and kind of machinery run on each class of work, and of the amount of work of each kind produced thereon. There should also be a record of all material used, such as cotton, yarn, etc., and of all the kinds of waste made and the amount of each kind. The pay-roll should be properly classified and the occupation of each employee designated. There will, of course, be a record of the product invoiced from the mill, but there should also be a record of its weight before any finishing or aging operation has added to or reduced it.

With these preliminary observations, we may take up the actual work of applying to the results of a period of manufacturing the necessary methods of examination and analysis of the expenses to approximate the costs of manufacture.

As by a mere description, without illustration, it would be difficult to explain the working out of the various processes with sufficient clearness, it will be best to take an imaginary mill, which we will name the Enterprise Cotton Mills, and a supposititious statement of its operations and expenses. These mills had been recently started, and run only about three months, when the manager directed that an inventory be taken of the stock in process of manufacture and of the supplies, fuel, packing, oil, repairs, cotton, waste, etc.; that all bills be paid; that the books of account be closed, and a statement of expenses and income be prepared, and also a statement of the financial condition of the mill.

The bookkeeper was without former experience in cotton mill accounts and some time after the inventory had been completed he came to the manager with an anxious face and reported that while he had not completely closed the books, he had made a few figures in advance and believed the mills were doing business at a considerable loss.

The manager replied that it was quite possible as expenses were heavy in starting up, but that he had expected that there would be a slight profit. He asked the bookkeeper to go over with him the work done in closing the books that he might set a few prices on stock in process.

The bookkeeper replied that he had taken the stock in process at the value per pound of the cost of the cotton used.

"That is not fair," replied the manager, "because for every ninety pounds of roving now on hand, we have used over a hundred pounds of cotton, and every eight hundred and fifty pounds of yarn has taken nearly a thousand pounds of cotton from the warehouse. So that your books show that cotton used cost us about ten cents a pound, while the cotton in every pound of yarn on hand is worth more than that, for it took nearly fifteen per cent more cotton to make it. It has lost that in waste."

"But," replied the bookkeeper, "we have sold the waste for money or we have it on hand, and I have it also in the inventory."

"That is true," was the reply; "but the value of the waste is small as compared with its cost. The balance of the cost of the cotton used in making the stock in process should be added to the inventory value of the stock in process. Do it this way: In setting a value on the stock in process, make it, say, twelve per cent per pound more than the cost of the cotton. Take fine roving at, say, ten per cent above cotton, and the balance of the card-room stock at five per cent per pound above cost of cotton. The full value of the cotton or stock in process should be charged to Inventory, and credited to Cotton account. More than that, we started four months ago with no work in process. We now have a mill full of partially manufactured stock. Some nearly ready for market. Some scarcely advanced from the raw material. We must make an estimate of the cost of labor bestowed on the unfinished material and make it a part of the inventory. Furthermore a considerable amount of power has been expended in bringing this cotton to its half-completed stage. Also make an entry covering this, crediting Power and charging Inventory account for its estimated cost. There have been other expenses, but they are of less importance, not so easily estimated, and we shall neglect them."

"This will make a decided difference in our statement," said the bookkeeper, "but I see that it is right and shall make entries to effect the change."

This having been done, the mill showed results of the three months run as follows:

PRODUCTION—406,840 lbs. No. 25 warp yarn, made and sold in warps.

COTTON—472,635 lbs. costing 9.80 c. per lb., or			$46, 318.23		
Less waste on hand and sold, value			1,584.63		
Net cost cotton used			44,733.60		10.96c
MANUFACTURING LABOR,	Carding	$3,091,90		.76c	
	Spinning	3,336.08		.82	
	Spooling	1,749.41		.43	
	Warping	876,42		.24	
			9,053.81		2.22
POWER	Fuel	1,938.50			
	Supplies	162.70			
	Labor	361.40			
			2,462.60		.61
INSURANCE AND TAXES			825.00		.20
REPAIRS AND SUPPLIES,	Material	1,265.20			
	Labor	512.00	1,777.20		.44
SALARIES AND EXPENSE			1,375.00		.34
INTEREST			750.00		.19
FREIGHT			3,017.62		.74
COMMISSION AND DISCOUNTS			5,887.60		1.45
Total cost per pound					17.15c

As there was but one kind of product, and practically all of this sold, it is only necessary to divide the items of expense by the product in pounds to obtain the cost per pound of each item, and to add these together, or to divide the total expense, to get the total cost per pound.

Such simplicity of conditions is not often met with, however. Even yarn mills commonly have a diversity of product, and when another six months had rolled around, an inventory had been taken, and the accounts were ready to close, the bookkeeper called on the manager for directions, presenting the following statement of operations, after having charged to Inventory the value of the cotton, and the labor on stock in process.

PRODUCTION OF ENTERPRISE MILLS.

Six months ending June 30th.

YARN MADE AND SOLD	No. 25 warp, Chains	325,000 lbs.
	$\frac{2}{30}$ Skein	120,000 "
	No. 36 "	50,000 "
	$\frac{2}{28}$ "	175,000 "
	No. 25 "	380,000 "
	$\frac{2}{25}$ Chain	150,000 "
	$\frac{2}{10}$ "	30,000 "
CLOTH MADE,	Print Cloth 64 x 64	230,000 "
		1,460,000 lbs.

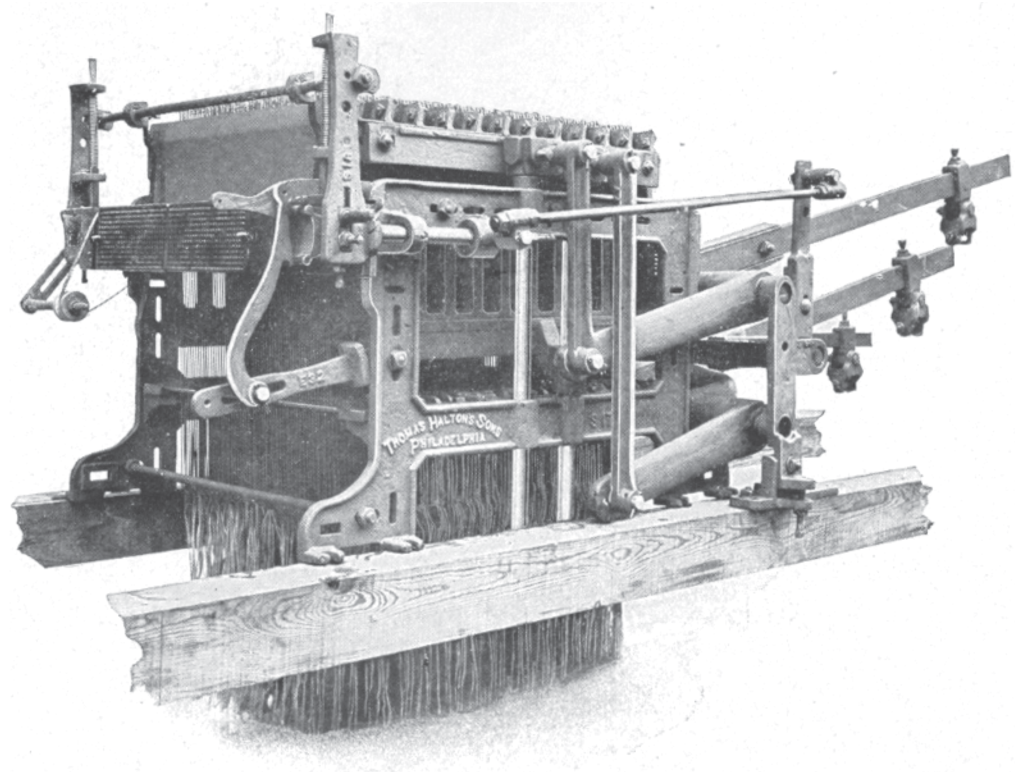
COSTING:

COTTON: $144,500.00. VALUE WASTE SOLD $6,100.

LABOR,	Carding	$11,680.00	
	Spinning	13,140.00	
	Spooling	4,527.60	
	Warping	1,026.46	
	Twisting	3,230.00	
	Reeling	2,950.00	
	Dressing	690.00	
	Weaving	7,228.94	
	Packing Room	1,825.00	
	Repairs	3,000.00	
	Power	1,850.00	
	Yard	1,675.00	$52,823.00

The manager called for the superintendent and showed him the sheet saying "We want now to find out what we have made on these yarns which we cannot do until we know what each cost. Can you show us how to get at it?"

"Why I think it is easy to do that," was the answer; "the estab-



DOUBLE LIFT SINGLE CYLINDER JACQUARD MACHINE
Thomas Halton's Sons

lished method of distributing cost is from the basis of the average number. *First,* ascertain what processes and expenses are common to all the varieties of the product, such as Carding, Spinning, Repairs, Insurance, etc. These are termed Costs in Common. *Second,* separate the processes and expenses undergone by portions of the product alone, such as reeling for the skein yarn, sizing materials for cloth, different commissions for yarn and cloth, etc., and find how many pounds have been submitted to each special cost. *Third,* ascertain the average number of the mill product submitted to each special cost. *Fourth,* divide the sum total of the costs in common by the total pounds produced. This is the cost per pound in common, of the average number. This cost per average number is thus distributed over the whole product: each kind of product bearing the cost per pound in proportion to the number of the yarn. The special costs are divided in the same manner over the kinds of product they affect, through the medium of the average number of the products affected."

Following this method these costs must be rearranged, and some of them, as Power, Repairs, and Commissions must be divided. They are common to all, but Power and Repairs have a special cost for weaving, which we will estimate and set apart as a special cost, deducting it from the totals, and consider the remainders as common costs.

The Manufacturing Costs may then be listed as follows:

Costs Common to all the Product of the Mill

Labor, Carding		$11,680.00
" Spinning		13,140.00
" Packing Room	$1,825.00	
Supplies, Packing Room	625.00	2,450 00
Labor, Repairs, 94%	2,820.00	
Supplies, Repairs, 94%	7,322.00	10,142.00
Labor, Yard		1,675.00
" Power, 96 %	1,776.00	
Supplies, Power, 96 %	7,055.00	8,831.00
Insurance and Taxes		2,800.00
Interest		3,000.00
Salaries and Office Expense		2,900.00
Expense Account		975.00
		57,593.00

The total costs in common to all the product was $57,593.00 ÷ 1,460,000 (pounds produced) = 3.9447 cents per pound of yarn of the average number (26.866).

We proceed on the hypothesis that the cost of making yarns varies in the same ratio as the number. If the costs in common for No. 26.866 = 3.9447 cents per pound, then to find the cost for No. 10 yarn

26.866 : 3.9447 cents :: 10 : 1.468 cents per pound.

In the same way we find the costs in common per pound to be:

For No. 25 Yarn	3.670 cents
" 28 "	4.110 "
" 30 "	4.404 "
" 36 "	5.285 "

The special costs may be classified as follows, and the pounds subjected to each operation are tabulated for convenience of analysis, with the exception of the special costs on print, which are dealt with in bulk.

Special Cost on Chain Yarn, Ply Yarn, and Warp of Print Cloth		
Spooling		$4,527.00
Special Cost on Chain Warps and Warp of Print Cloth, Warping		1,026.46
Special Cost on Ply Yarns, Twisting		3,230.00
Special Cost on Skein Yaans, Reeling		2,950.00
Special Cost on Print Cloth		
Dressing	$ 690.00	
Weaving	7,228.94	
Repairs, Weaving, Labor (6%)	180.00	
" " Supplies (6%)	468.00	
Power Weaving, Labor (4%)	74.00	
" " Supplies (4%)	295.00	
Sizing Materials	506.00	9,441.94

The rule for finding the average number of a plain fabric, is based upon the principle of reducing the yarns to an equivalent weight of number one yarn, and then dividing again into the same number of threads, as the previous counts, but all of an equal size.

The rule is expressed as follows: Divide the threads per inch of warp, by the number of the warp yarn, and add the quotient to the picks per inch divided by the number of the filling yarn. Divide the sum of the picks and sley by the sum of the two quotients, above described, and the result will be the average size or number of the yarn.

The same idea will enable us to find the average number of the mill product as follows:

No. 10 Yarn			30,000 lbs. x 10	300,000
" 25 "	Warp Chains	325,000 lbs.		
" 25 "	Skeins	380,000 "		
" 25 "	$\frac{2}{25}$ Chains	150,000 "	855,000 lbs. x 25	21,375,000
" 28 "	$\frac{2}{28}$ Skeins	175,000 "		
" 28 "	Print Cloth Warp	128,800 "	303,800 lbs. x 28	8,506,000
" 30 "	$\frac{2}{30}$ Skeins		120,000 lbs. x	303,600,000
" 36 "	Skeins	50,000 "		
" 36 "	Print Cloth Filling	101,200 "	151,200 lbs. x 36	5,443,200
			1,460,000 lbs.	39,224,600

39,224,600 ÷ 1,460,000 = 26.8662 = Average number spun.

	Spooling	Warping	Twisting	Reeling
$\frac{2}{10}$ Skein Yarn as $\frac{1}{10}$	30,000 lbs.	lbs.	lbs.	lbs.
" $\frac{2}{10}$			30,000	30,000
25 Warp Chains	325,000	325,000		
$\frac{2}{25}$ Chain as $\frac{1}{25}$	150,000			
" $\frac{2}{25}$	150,000	150,000	150,000	
25 Skeins				380,000
$\frac{2}{28}$ " as $\frac{1}{28}$	175,000			
"			175,000	175,000
28 Print Cloth Warp	128,800	128,000		
$\frac{2}{30}$ Skein as $\frac{1}{30}$	120,000			
" $\frac{2}{30}$			120,000	120,000
36 Skein				50,000
	1,078,800 lbs.	603,800 lbs.	475,000 lbs.	755,000 lbs.

The cost per pound of each of these operations on each variety of product is estimated after the same manner, as the cost in common. This we will illustrate in the cost of spooling. It will be noticed that the two-ply warps undergo spooling twice, first as single yarn, and again as double yarn. In determining costs, ply yarns are considered single yarns of equal weight, that is $\frac{2}{28}$s is treated as single 14s.

SPOOLING

No. 10 Yarn		30,000 lbs.	×	10 =	300,000
" 25 Warp Chain	325,000 lbs.				
" $\frac{2}{25}$ Chains as $\frac{1}{25}$	150,000 "	470,000 "	×	25 =	11,875,000
" $\frac{2}{25}$ " " $\frac{2}{25}$		150,000 "	×	12.5 =	1,875,000
" $\frac{2}{28}$ Skein as $\frac{1}{28}$	175,000 "				
" 28 Print Cloth Warp	128,800 "	303,800 "	×	28 =	8,506,400
" $\frac{2}{30}$ Skein as $\frac{1}{30}$		120,000 "	×	30 =	3,600,000
Total Pounds Spooled		1,078,800 "			26,156,400

26,156,400 ÷ 1,078,800 = 24.246 Average Number Yarn Spooled.

The total cost of spooling was $4,527.00 which divided by 1,078,800 equals the cost per pound of spooling the average number or .4196 cents per pound for spooling No. 24.246 yarn.

.4196 cents ÷ 24.246 = .017306 cents cost per unit of number, or cost per hank of spooling number one yarn.

.017306 × 10 = .17306	cents	cost	of	spooling	No.	10	Yarn
.017306 × 25 = .43265	"	"	"	"	"	25	"
.017306 × 12.5 = .21632	"	"	"	"	"	$\frac{2}{25}$	"
.017306 × 28 = 48457	"	"	"	"	"	28	"
.017306 × 30 = .51918	"	"	"	"	"	30	"

The correctness of these figures can be proved as follows:

30,000	lbs.	of	No.	10	Yarn	Spooled	at .17306	Cost	$ 51.92
475,000	"	"	"	25	"	"	" .43265	"	2,055.08
150,000	"	"	"	$\frac{2}{25}$	"	"	" .21632	"	324.58
303,800	"	"	"	28	"	"	" .48457	"	1,472.12
120,000	"	"	"	30	"	"	" .51918	"	623.02
									$4,526.62

By the same methods we find the cost of the special costs of Warping, Twisting and Reeling to be as follows:

Cost	of	Warping	No. 25	Yarn	.1886	cents	per pound
"	"	"	" $\frac{2}{25}$	"	.0943	"	" "
"	"	"	" 28	"	.2112	"	" "

Cost	of	Twisting	No. $\frac{2}{10}$	Yarn	.2573	cents	per pound
"	"	"	" $\frac{1}{25}$	"	.6434	"	" "
"	"	"	" $\frac{2}{24}$	"	.7206	"	" "
"	"	"	" $\frac{2}{30}$	"	.7720	"	" "

	2-10 Skeins	25 Skeins	25 Chains	2-25 Chains	2-28 Skeins	2-30 Skeins	36 Skeins	Print Cloth 56.2% Warp 43.8% Fill.
Cotton	5.000	1.0000	10.000	10.000	10.000	10.000	10.000	10.000
Strippings	3.000							
	8.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000
Less Waste Value	.242	.484	.484	.484	.484	.484	.484	.484
	7.758	9.516	9.516	9.516	9.516	9.516	9.516	9.516
								2.309 wp
Costs in Common	1.468	3.670	3.670	3.670	4.110	4.404	5.285	2.314 fill
Spooling as Single Yarn	.173		.433	.433	.485	.519		.273
" " Double "				.216				
Warping			.189	.094				.119
Twisting	.257			.643	.721	.772		
Reeling	.083	.412			.231	.248	.594	
Dressing etc., Print Cloth								4.105
	9.739	13.598	13.808	14.572	15.063	15.459	15.395	18.636
Freight	.591	,591	.591	.591	.591	.591	.591	.650
	10.330	14.189	14.399	15.163	15.654	16.050	15.986	19.286
Commissions	1.018	1.399		1.494	1.542	1.581	1.575	.375
Full Cost of Each Product	11.348	15.588	14.399	16.657	17.196	17.631	17.561	19.661

Cost	of	Reeling	No. $\frac{2}{10}$	Yarn	.0825	cents	per	pound
"	"	"	" $\frac{2}{28}$	"	.2310	"	"	"
"	"	"	" $\frac{2}{30}$	"	.2475	"	"	"
"	"	"	" 25	"	.4125	"	"	"
"	"	"	" 36	"	.5940	"	"	"

Cost of Special Operations for Print Cloth 230,000 lbs. \$9,441.94.
\$9,441.94 ÷ 230,000 =4.1052 cents per pound.

The stock used in these yarns and goods is the same, excepting that the $\frac{2}{10}$ Skein Yarn has been made one-half of cotton and one-half card strippings.

The balance of Cotton account showing the cost of cotton for the mill is therefore divided by the total product, less one-half the amount of $\frac{2}{10}$ skein made.

1,460,000 − 15,000 lbs. = 1,445,000 lbs.

\$144,500.00 ÷ 1,445,000 = 10 cents per pound for cotton for each pound of yarn made, excepting $\frac{2}{10}$ skeins. The $\frac{2}{10}$ skeins were one-half strippings worth 60 % of the cost of cotton, or for the whole amount of yarn made:

15,000 lbs. @ 10 cents for cotton	\$1,500.00
15,000 " " 60 % of 10 cents	900.00
30,000 lbs, at an average price of 8 cents =	\$2,400.00

The value of the strippings used should therefore be added to the value of waste sold. That much of waste used not having been credited to waste account, previously, it should now be credited to the products made from clean cotton.

A deduction for the value of waste may now be made from the cost of cotton.

Waste sold \$6,100.00 plus \$900.00 waste also made but used = \$7,000.00. \$7,000 ÷ 1,445,000 = .484 cents credit to cost cotton per pound of product for waste sold. (Only one-half of this per pound of $\frac{2}{10}$ skein.)

The only two items now remaining undistributed are the Freight on product and Commissions.

The freight paid in this case is more on the print cloth than on the yarn, per pound, being 65 cents per hundred, and the balance divided among the other products, equally. Of commissions it should be said, before the division of the cost, that those on the print cloth amount to above 2 % of the cost, the No. 25 chain warps were sold direct, and no commissions were paid on these, while the balance amounting to about 9.85 % was divided among the other products on a percentage basis of the cost as shown below.

At this stage the proof of the accuracy of the mathematical work may be had thus:

30,000	lbs.	of	$\frac{2}{10}$	Skein	at	10.330	cents	per	pound,	cost	$ 3,099.00
380,000	"	"	25	"	"	14.189	"	"	"	"	53,918.20
325,000	"	"	25	Chain	"	14 399	"	"	"	"	46,796.75
150,000	"	"	$\frac{2}{25}$	"	"	15.163	"	"	"	"	22,744.50
175,000	"	"	$\frac{2}{28}$	Skein	"	15.654	"	"	"	"	27,394.50
120,000	"	"	$\frac{2}{30}$	"	"	16.050	"	"	"	"	19,260.00
50,000	"	"	36	"	"	15.986	"	"	"	"	7,983.00
230,000	"	"	Print Cloth		"	19.286	"	"	"	"	44,361.80
											$255,547.75

Cost of Cotton	$144,500.	
Less value of Waste sold	6,100.	
	$138,400.	
Labor	52,823.	
General Charges, without Commissions	34,746.	$225,969.00
This discrepancy might be avoided by carrying the work to further decimals.		421.25

The bookkeeper having worked out the costs of manufacturing as above under the supervision of the superintendent, the processes and results were shown to the manager. The costs of some of the yarns were more and of others less than he expected, and after an examination of the tables, the manager once more sent for the superintendent.

"I have examined the way you get at the cost of the different numbers of yarn, etc., and think I understand it, and believe it is about right. But there are one or two inquiries I wish to make. *First*, the idea underlying the whole operation seems to me a mere assumption that the cost will vary as the number or fineness of the yarn. This may be so or it may not. I do not see anything to prove it. How do you know this, or don't you know it? There may be some reason for believing so; if there is, I would like to know it, but I confess that it seems to be taking a great deal for granted."

"The average number system of cost finding," replied the superintendent, "was not original with me. For many years it has been used by mill men as a convenient and ready way of reckoning costs and making estimates on cotton goods. I have been told that early New England manufacturers adopted it after a careful examination in detail of the cost of various operations on different organizations of goods. I suppose they were satisfied of its approximate accuracy. Some justification is afforded by such figures as the following, which represent actual results in a large mill in New Hampshire for the six months ending May 2, 1885. This company operated three mills, making various organizations, and you will note that the total manufacturing labor costs vary very nearly as the average numbers. In fact, do not vary from this standard more than the same mill might vary its own record in the changing vicissitudes of continuous operation."

	No. 1 Mill	No. 2 Mill	No. 3 Mill	Average
Average No. of Product	26.83	22.93	18.12	21.64
Labor, Carding	1.131 cts.	1.004 cts.	.757 cts.	.919 cts.
" Warp Spinning	.566 "	.394 "	.331 "	.406 "
" Filling "	.465 "	.438 "	.385 "	.420 "
" Dressing etc.	.517 "	.454 "	.348 "	.420 "
" Weaving	2.779 "	2.527 "	1.825 "	2.260 "
	5.458 "	4.817 "	3.646 "	4.425 "

Based on the cost of the average number for the whole plant, the costs would be as follows:

	5.487	4.680	3.705

By these figures it will be seen that the variations of the actual cost from the estimated cost by the average number is as follows.

No.	18.12	.059	cents	per	pound
"	22.93	.128	"	"	"
"	26.83	.029	"	"	"

The greatest variation is therefore less than three-tenths of one per cent.

"Further than this, I think I can show you why this method has some basis of reason in it. As you are well aware, a most important element in the cost of any product is the amount that can be produced in a given time. If I were spinning, say, number 30 yarn, and some one should come along with an invention which would enable me, other factors remaining the same, to double the production per spindle, the cost of spinning would be reduced nearly one-half. So, if I should change to a coarser yarn the production would be increased, and the cost per pound decreased. Not proportionately decreased, but in *nearly* that ratio. As the amount of product increases, however, there is so much more material to be handled, so that there is more expense for labor in attendance and handling.

"If you examine the tables of production of spinning frames you will find that the pounds per spindle decrease as the yarn grows finer, in a ratio somewhat exceeding the reverse ratio of the change in number. For example, one of the production tables in common use gives the production in pounds per spindle per day as follows:

No. 8 Yarn	1.082 lbs.
" 16 "	.497 "
" 24 "	·294 "
" 32 "	.200 "
" 40 "	.152 "

"It will be noticed that 8 (yarn) is one-fifth of 40 (yarn) but the production of No. 8 is rather more than five times as great. This increase in ratio approximately covers the increased cost of attendance and handling of the coarser yarns. It is thus that it comes about that the cost of manufacture varies in nearly the same ratio as the number. To be sure the spinning frame is not the only machine in a mill, but it is to a considerable degree the gauge of the production, and the elementary principle holds in all departments that the higher the number of yarn the greater the cost of production and manipulation. Labor Costs are not the only ones affected by production. The cost of Power, Taxes, Insurance, Salaries, Repairs, Interest, and some other items of expense are similarly affected by the rate of production.

"The same New Hampshire mill I have mentioned had a practice of charging Interest, Insurance, Taxes, General Expense and Salaries at an equal amount per pound whether the average number were 17 or 27, and whether the production were consequently greater or less. This seems to me denying the principle in its most evident application. For an increase or loss in production would not affect the gross amount of these expenses, but the more pounds produced the more to divide them among and proportionately the less per pound."

"I concede the force of much you have said," answered the manager, "and I imagine that for numbers of a moderate range such a system might be very convenient and as efficient as any that could easily be devised. I can also see that it might find a widespread and proper application in mills under the circumstances apparently prevailing in the mill you instanced where there are a number of organizations not widely dissimilar, and without a wide range in the numbers of yarns spun. Its weakness lies in there being no means of proving its results, no certainty that its limitations have been observed, and no recognition of varying conditions.

"As an illustration of my first objection, you cannot, in any way, prove that the costs of Reeling, as distributed by you over the yarn made into skeins the last six months, are just. In fact they do not very well agree with the prices per pound we paid for the work. This also illustrates my second point. Further, I do not suppose you would claim that making number 100 yarn would cost just ten times as much as making number 10 yarn. That is, there is a limit to the average number method of reckoning costs.

"And lastly, suppose two sateens, woven, one with a warp face, and another of a similar organization but with a filling face. They would both have the same average number, but would both cost the same? And two fabrics of utterly dissimiliar organization might have the same average number and according to your theory would have the same cost per pound, which I do not think probable.

"Furthermore, the changes and extensions we propose in this plant will bring in such varying factors, that our past methods will be crude and incomplete. It has been so, to some extent, already, for our weaving has introduced an element which along with, and in addition to, our yarn, makes the separation of expenses of operating the departments a problem for serious study.

"I have been thinking and enquiring about this matter for some time and I propose in another six months to install a system by which I may *know* what our goods cost, prove the estimates to my own satisfaction, and challenge any one to dispute their accuracy.

"In the first place, I propose to separate the Manufacturing and the Distributing expenses. We have been fortunate in our short experience in disposing of our product as fast as made, but this will not always be our happy lot. Under these past circumstances the expense of Freight and Commission might, with fairness to the results, be considered costs along with other expenses, but they are different in their nature, belonging to the commercial department of our business along with such charges as advertising and bad debts. If we, in the next six months, find ourselves with a lot of unsold goods, on which we have paid no freight or commissions, the amount of these charges which we have paid must not be charged into manufacturing, with labor and supplies, but kept in a separate account.

"We shall have a plant selling a part of its product as yarn, and weaving the remainder of its yarn into cloth. We may even be compelled to purchase some yarns. Under these conditions the apportionment of the expense of Repairs, Supplies, Power, Insurance, Taxes, etc., should not be left to guesswork, even though we style the guess an estimate, but should have some basis in accounting of the amount chargeable to each department. This the method we have just followed does not afford."

The manager at once put in operation a series of reports for the purpose of affording detailed information regarding the cost of each operation, which were placed on record, and made a basis for making up the estimates of cost at the end of another six months' period.

In the meantime there had been completed some changes and additions for the purpose of putting a part of the mill on colored work, and a coarse cheviot was made in this portion of the mill, so as to utilize the waste.

Product of the Enterprise Cotton Mill

Six months ending Dec. 29, was as follows:

102,000	lbs.	Cheviot
160,000	"	Print Cloths
250,000	"	Madras
100,000	"	1–25 long chain Warp Yarns
120,000	"	1–28 Skeins
80,000	"	2–28 "
812,000	"	Total

The organization of the cloths was as follows:

	Warp Yarn	Filling Yarn	Sley	Picks	Widths	Yds. Per lb.	% Warp	% Filling	% Sizing on Warp
Cheviot........	8	12	66	45	29	2.15	70	30	6
Print Cloth....	28	36	64	64	28'	7.00	56	44	6
Madras........	25	32	56	60	28	6.00	60	40	6

The weight of the cloth given above is as it comes from the looms. There are several factors tending to modify this weight, as compared with the weight of the yarn originally consumed in the making of the cloth.

The principal of these are, the weight added by sizing, the effects of coloring and bleaching, and the loss in waste.

If the mills were making but one grade of goods, these would be of no special importance. But comparing the weight of woven goods with the weight of yarns, it is worth while to consider whether some allowance should not be made in order to put the yarns sold on a just footing with the cloth woven.

As concerns the sizing, the weight of starch and other compounds used equals about six percent of the weight of yarn dressed. This is equivalent to approximately four percent of the weight of the cloth. And if no other factor entered into the calculation it would be necessary to reduce the weight of warp yarn used in weaving by this six percent, in order to place it on a parity with other yarns. But since spooling, in the operation of warping, beaming, dressing, drawing-in and weaving, there has been a further loss of weight in waste. This loss has been greater on the warp yarns than on the filling, because of the more handling of the chains and the chafing of the warp. This loss is greatest on the yarns which have been sized, and may have amounted to one and one-half percent in weave room sweepings alone; a loss partly of warp and partly of sizing. On the whole, the waste in operations subsequent to spooling, is sufficient to largely offset the gain in sizing, and we make no allowance for the weight added in sizing.

Furthermore, dyeing and bleaching affect the weight of cotton. The madras is largely white with colored stripes. This white yarn or cotton is bleached, which causes a loss in weight.

But there has been an increase of weight in dyeing the colored yarn, varying according to the nature of the dye, and the depth of shade. In this instance we will estimate that one offsets the other, so that no allowance need be made either way for dyeing or bleaching. In the case of the cheviots, there is no bleached stock of consequence used in them, but the colors, both warp and filling, are mostly heavy or dark ones, and it is thought well to make an allowance of two percent from the weight of the cloth, in estimating the amount of gray yarn or cotton used in their manufacture.

The cheviots for purposes of cost estimate will therefore be 100,000 lbs. instead of 102,000 lbs.

The cheviots were a coarse colored fabric, manufactured to utilize card strippings and flyings. The yarn being composed of about seventy percent waste of this character, with some cleanings from picker motes. These were dyed in the loose cotton or waste, and spun thus, into colored yarns. The goods were finished and shipped in bales.

The print cloths were the same organization as before and shipped in rolls.

The madras were a medium grade fabric, with bleached and colored warp yarns. The bleached warp was spun from bleached cotton, but the colored warp was spun in the gray and made into long chain warps, dyed, beamed again, and dressed on a slasher. A portion of the warp yarn for these goods was of printed yarn, and as the mill did not care to purchase a machine for this purpose, the yarn was bought, printed, in long chain warps, amounting to 10,000 pounds. A portion of these goods, also, was woven on drop box looms for the purpose of making check patterns. The filling in all the stripes was bleached, and this with the bleached and colored filling in the checked patterns was spun from bleached or colored cotton. Only a small amount of colored filling was used, as the filling stripes of color were mostly small. The warp in these goods was irregular, some of the patterns having small cords where several warp threads were woven as one.

For the goods described above, and the yarns sold, the following yarns were required:

No. 8 Yarn, Cheviot Warp	70,000 lbs.
" 12 " " Filling	30,000 "

No. 25	"	Madras Warp	150,000 lbs.	
" 25	"	Warps Sold	100,000 "	
" 25	"	Total		250,000 lbs.
" 28	"	Print Cloth Warp	89,600 lbs.	
" 28	"	1–28 Skeins	120,000 "	
" 28	"	2–28 Skeins	80,000 "	
" 28	"	Total		289,000 "
" 32	Filling for Madras			190,000 "
" 36	"	" Print Cloth		70,400 "
				810,000 lbs.

We may divide the cost into three divisions,

1st, The Stock or Material.
2nd, The Labor in Manufacturing.
3rd, The General Charges, Supplies, Power, Etc.

We will take these up in the order named.

The Stock or Material put in process for these yarns and goods was, as previously stated,

1920 Bales of Cotton,	903,614 lbs.	costing	$72,289.12
77 " " Strippings,	35,000 "	"	1,820.00
No. 25 Printed Yarn	10,000 "	"	2,500.00

Passing by for the present the Printed Yarn, we recall that seventy percent of the cheviot, and all of the other output of the mill, are made from the same general quality of cotton. We may therefore separate the stock used into these two classes, and on the assumption that the proportion of waste made has been the same in both classes, proceed to find the percentage of waste, and then work back by means of this to estimate the amount of waste and cotton originally put in process, in each class of stock. For it has not been practicable under the circumstances to keep an accurate weight of it. We then approximate the value of the waste used which was made in the mill, and credit the cost of clean cotton with this amount. The waste used has been from clean uncolored cotton. This value of the waste sold is then credited to each class. This value is either divided according to records of waste made, or on a percentage basis in absence of data.

The details are worked out as follows:

The Stock in process, Dec. 29	94,100 lbs.
" " " " July 30	76,700 "
Excess Stock in Process Dec. 29	17,400 lbs.
Product (Less Yarn Purchased)	800,000 "
	817,400 lbs.

Cotton Put in Process	903,614 lbs.
Waste Purchased and Put in Process	35,000 "
Total Material Put in Process	938,614 lbs.
Less Product Plus Gain in Process	817,400 "
Gross Waste	121,214 lbs.

Gross Waste Equals 14.83% of 817,400 lbs.

Product of Cheviot	100,000 lbs.
In Process Dec. 29, Cheviot Stock	9,000 "
	109,000 lbs.

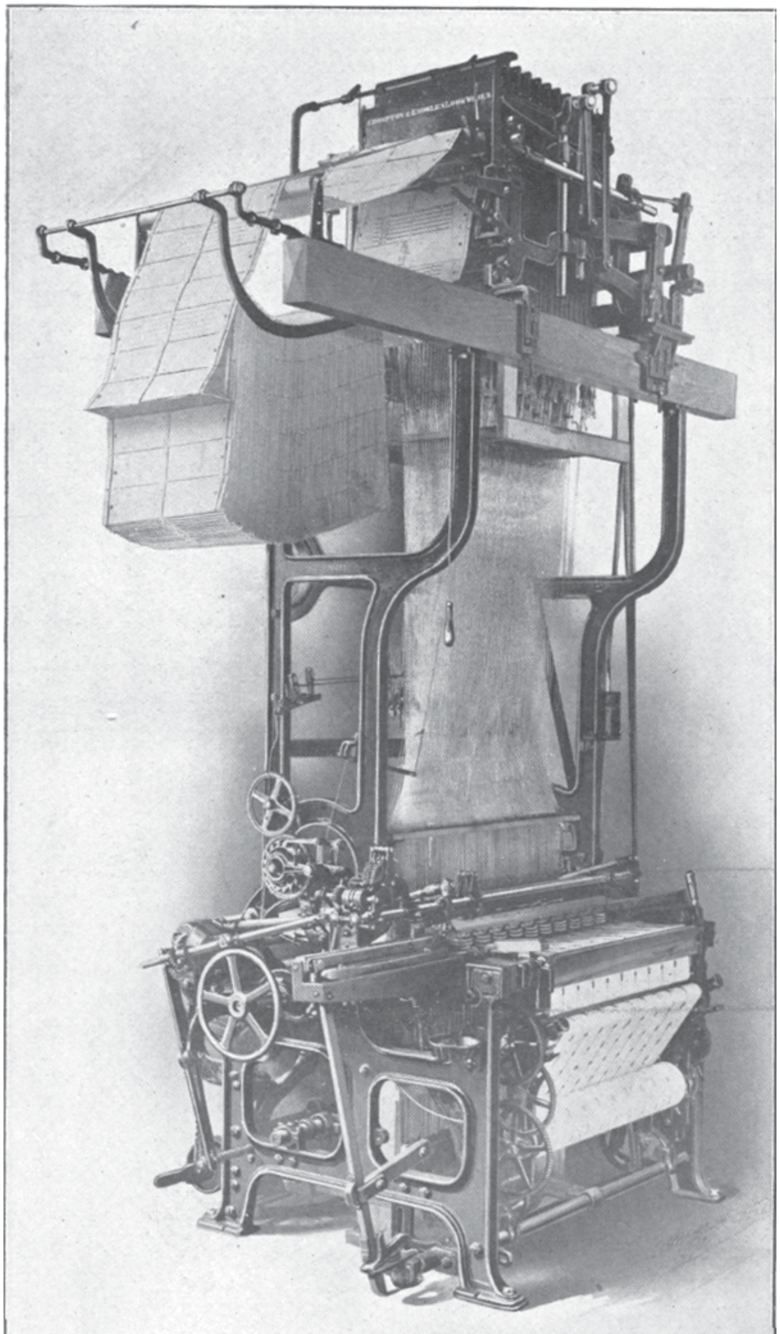
109,000+14.83% = 125,164 lbs. estimated amount of stock, made up of good cotton (30%), purchased waste and in the mill (70%) both together making the 125,164 lbs. estimated as started in process for the cheviots.

Total Cheviot Stock	125,164 lbs.
Less Good Cotton (30%)	37,550 "
Waste Used—Purchased, and Made (70%)	87,614 lbs.
Waste Purchased	35,000 "
Waste Made and Used in Cheviots	52,614 lbs.

Stock in Process July 1, all Good Cotton			76,700 lbs.	$ 8,437.00
Cotton Put in Process, for Goods other than Cheviot			866,064 "	69,285.12
			942,464 lbs.	$77,722.12
Cotton Used for Cheviot	37,000 lbs.	$3,004.00		
Waste Purchased	35,000 "	1,820.00		
" Made and Used	52,614 "	2,735.93		
	125,164 lbs.	$7,559.93		
" Made and Used, Cr			52,614 "	2,735.93
			890,150 lbs.	74,986.19
On Hand in Process Dec. 29	9,000 "	543.60	85,100 "	7,488.80
	116,164 lbs.	7,016.33	805,050 lbs.	67,497.39
Waste accounted for and not	16,164 "	323.28	105,050 "	2,101.00
Total net Cost of Stock	100,000 lbs.	$6,693.05	700,000 lbs.	$65,396.39

By these processes we arrive at 6.693 cts. per lb. as cost of material for Cheviot, and (65,396.36÷700,000) 9.342 cts. for all other product, excepting Madras, to which there is a further charge for 10,000 lbs. of Printed Yarn costing $2,500.00, used only on this work. This is equivalent to 1.00 cts. per pound of all Madras; but as only 8,000 lbs were consumed, 2,000 pounds being in process, the cost for yarn was .800 cts. per pound.

This yarn has been neglected heretofore, because in this instance it is a small amount in proportion, and the waste made from it, is inconsiderable. If large amounts of yarn were purchased in different shapes, it might be necessary to separate the different departments, charging to each its material used and waste made and crediting the output.



KNOWLES SWIVEL LOOM FOR WEAVING A SURFACE FIGURE ON A PLAIN GROUND

Crompton & Knowles Loom Works

THE MANUFACTURING LABOR

The basis for the apportionment of the labor cost, consists of a series of weekly reports from each department, covering the amount of machinery running and the amount of product, and the cost of each operation as computed immediately upon the making up of the pay-roll. These reports are tabulated, and at the end of the six months, or other period, when the costs are made up, their totals are compared with the amount of work ultimately produced by the mill. The costs are based upon the production of the room; but on account of the loss by waste and other causes, the final output of the mill, upon which the cost must be reckoned, is less than the room product. The reported costs are, therefore, less than the actual costs, and are subject to the revision noted above.

Pay-rolls are subject to change, and the total labor cost of each department on the reports, is corrected by the actual amount expended.

This is exemplified in the case of the Card Room as follows: A single weekly report is shown, and the summary of the work for the six months.

ENTERPRISE COTTON MILLS

Cost of Roving for............week ending Oct. 3d, '06.

Hank Roving....................	1.00	1.50	5.20	6.00
Fly Frame Spindles Run				
Pounds Roving Made..............	3180	1272	25400	4770
Picking.........................	$ 2.25	.90	18.00	3.37
Carding and Drawing.............	$ 6.00	2.52	50.40	9.45
Slubber..........................	$ 1.50	.90	28.60	7.85
Inter. Frames....................	$ 2.60	1.50	45.16	11.10
Fly Frames.......................			77.48	19.92
General Room Expense...........	$ 1.60	.75	41.20	8.20
Total Wages.....................	$13.95	6.57	260.84	59.89
Cost per pound, cents.............	.440	.517	.103	.152

SUMMARY FOR THE SIX MONTHS

Hank Roving	1.00	1.50	5.20	6.00
Total pounds made, from reports	80,720	32,800	650,900	109,200
Total pounds yarn and cloth from above	70,000	30,000	600,000	100,000
Add Inventory Dec. 29	6,100	900	58,800	3,300
	76,100	30,900	658,800	103,300
Deduct Inventory June 30			54,700	
	76,100	30,900	604,100	103,300

The sum of the cost from the weekly reports, during the six months is	$350.16	$156.58	$6,680.27	$1,230.26
These make a total of $8,417.27. The corrections and changes in the card-room payroll after leaving the room, have been such as to make the corrected total as shown by the account books $8,263.36 and the necessary correction reduces the costs to	$348.16	$155.68	$6,536.36	$1,223.16

The revised cost of making the roving should be obtained next, and if these total costs are divided by the sum of the goods sold plus the increase of the stock in process the results will give the actual cost per pound.

$ 348.16 ÷ 76100 =	.457c	Cost	per	Pound	of	No. 1.	Hank	Roving
155.68 ÷ 30900 =	.504	"	"	"	"	" 1.50	"	"
6536.30 ÷ 604100 =	1.082	"	"	"	"	" 5.20	"	"
1223.16 ÷ 103300 =	1.184	"	"	"	"	" 6.	"	"

The value of the labor on the roving and yarns in process at the end of the six months is now computed.

6100 lbs.	1.	Hank	Roving @	.457c =	$ 28.38
900 "	1.50	"	"	.504 =	4.53
58800 "	5.20	"	"	1.082 =	636.21
3300 "	6.	"	"	1.184 =	39.07
					$708.19

This, with the value of labor in subsequent operations bestowed on the stock in process, as disclosed by the inventory, is credited to Manufacturing Labor in closing the account books, or retained as the balance of the account, before charging off the remainder into Manufacturing Account.

The further uses of the cost of rovings in the yarn and cloth output of the mill, will be illustrated later.

A table should be prepared showing the stock in process in each department, of the amount of stock of each kind on hand, both at the beginning and end of the period, but is omitted from this illustration.

The summaries of the Labor Costs in each department or operation must be treated in a similar manner. It will not always be the case that the yarn on hand at the end of the period will be greater than at the beginning. They are as often less. By the system outlined above this will adjust itself.

It will be noticed that the pounds of roving made, obtained from the weekly reports, vary about six percent from the roving accounted for by the product of the mill plus the inventory, but in later operations where there is less subsequent waste, this difference should be considerably reduced.

TABLE G.

ENTERPRISE MILLS. SPINNING ROOM REPORT.

Cost per pound of Spinning for week ending September 22.

Number of Yarn	28 Warp	8 Warp	12 Fill	25 Warp	32 Fill	36 Fill	Total
Spindles Run	8,000	448	224	5,600	3,600	2,688	20,320
No. of Pounds Spun	11,200	2,600	900	9,600	4,200	3,000	31,500
Wages							
Spinners	$65.80	$3.60	$2.07	$40.45	$21.60	$18.00	....
Doffers	23.40	2.06	1.87	14.36	7.20	7.20	....
General Room Expense	32.48	2.83	1.80	24.67	13.50	9.60	....
Total Wages	$121.68	$8.43	$5.74	$79.48	$42.30	$34.80	$292.43
Cost per pound, cts	1.086	.324	.638	.828	1.010	1.160	....

TABLE H.

ENTERPRISE MILLS. WEAVING ROOM REPORT.

Cost per pound for weaving, week ending September 22, 1906.

Kind of Goods	Cheviot	Print	Madras Plain Looms	Madras Check Looms	Total
Looms Run	27	150	150	75	402
Pounds Woven	4,000	6,400	7,350	3,333	21,083
Cuts Woven	200	3,100	735	330	....
Wages					
Weavers	$47.90	$175.60	$230.85	$119.54	....
Other Hands	6.10	22.83	31.15	29.92	....
Total Wages	$54.00	$198.43	$262.00	$149.46	$663.89
Cost per pound, cts	1.35	3.10	3.56	4.48	....

Weekly cost reports of the same general discription are made for each department. Samples of these for the spinning and weave rooms are given in Tables G and H.

Passing over for the present the further consideration of Labor Costs, we take up the cost of Repairs, Power, etc., and find the following charges to be divided among the product and the inventoried stock.

LABOR	Repairs Machinery	$1368.20	
"	Boilers and Engine Room	1286.93	
"	Repairs Buildings	60.00	
"	Watch	350.00	
"	Electric Lights	212.50	
"	Moisteners	20.	$ 3,297.63
MATERIALS	Repairs Machinery	$1182.37	
"	" Buildings	120.	
"	Fuel	7000.	
"	Fire Protection	70.	
"	Supplies, Store Room	1576.32	
"	" Special	6895.33	16,844.02
TAXES			5,500.
INSURANCE			900.
SALARIES AND OFFICE EXPENSE			4,000.
EXPENSE, MISCELLANEOUS			500.
YARD			600.
INTEREST			3,600
			$35,241.65

In addition to these there should be a sum set aside or charged off for depreciation of the Machinery and Buildings which will be estimated later.

An analysis of these expenses for the purpose of classification will disclose that they may be fairly grouped in three general divisions.

First: Those which are incurred in maintaining the plant in good repair and condition, protecting it from danger of fire and robbery and providing the necessary supplies for operation, Maintenance, Protection and Supplies.

Second: Expenses incurred in the generation and transmission of Power, and of Steam for other uses than Power.

Third: The cost of administration of the general conduct of the business.

Under the heading Maintenance and Supplies, we collect first the cost of Maintenance in general, dividing between Machinery and Buildings and excluding the particular repairs of which a separate account has been kept. These include, Taxes on the value of Machinery, Insurance on Machinery, Fire Protection and Watchmen in their proportion, and Depreciation.

For the purpose of subdivision of these expenses make a detailed list of machinery in the form shown in Table M, giving in appropriate columns the value of each machine, and of the total value for each operation. By this means we find the grand total value of machinery to be $250,000. A conservative estimate for depreciation may be set at four percent, or $10,000. This completes the items of General Maintenance, which are placed in the box at the head of the columns, and foot up $15,000. This amount is divided upon the machinery in proportion to the value of each operation. The percentage this bears to the total is set in Column 5, and the amount of the corresponding percentages in Column 6. This adds up the same amount as the sum in the box at the top, showing the work to be correct.

We next take the items chargeable to the Maintenance of Buildings, including the furnishings. These items of expense are made up of the due proportion of those which have just now been charged to Machinery, with the addition of Repairs in Material and Labor, an account which is supposed to have been kept. In the distribution of these items, first set down the approximate floor space occupied by each operation, next the estimated or known cost per square foot of construction, adding the accessories, automatic sprinklers, humidifiers, piping, wiring, etc. The cost of building will vary considerably, and some departments will have more or less furnishings than others. The Dye House will have a cost for piping, but no humidifiers, and the store house will have neither one, nor wiring for lights. The floor space is then multiplied by the total cost per square foot, and the products put down in Column 13. By the footing of this column, the total value of construction, etc., is found to be $100,000. To the items charged at the head of the column, we now add one percent for depreciation, making a total of $3,000. The percentage of this amount to each operation is then added in Column 14, and the actual charge, obtained by taking the percentage of $3,000, is set in Column 15. This column is then footed to prove the work correct.

In the Repair Shops, a detailed account has been kept through the six months of the labor and material expended or used for each department and operation. (Total Labor $1,094.56. Total Material $1,074.88.) This cannot include the supervision of the work ($273.64), so that at the end of the period, having ascertained the percentage which the whole bears to the hitherto recorded cost in

TABLE M.

MACHINERY.

Taxes	$ 4,000
Insurance	700
Repairs Fire Protection	50
Watch	250
Depreciation 4%	10,000
	$15,000

BUILDINGS.

Repairs { Material	$ 120
Repairs { Labor	160
Taxes	1,500
Insurance	100
Fire Protection	20
Watch	100
Depreciation 1%	1,000
	$3,000

Operation.	Description.	Price.	Total Cost.	Per Cent.	Distrib.	Sq. Feet. Floor Surface.	Construction.	Automatic Sprinkler.	Humidifying.	Piping.	Wiring.
1	2	3	4	5	6	7	8	9	10	11	12
Picking	2 Openers with Feeders	$1,000.00									
	3 Intermediates	800.00	$6,800	2.720	408.00	4,000	1.20	.03			.01
	3 Finishers.	800.00									
WastePicking	1 Waste Picker & Feeder		750	.300	45.00	800	1.20	.03			.01
Carding and Drawing	44 Cards	675.00	37,380	14.952	2,242.80	8,200	.70	.03	.03		.01
	96 Del. Drawing	80.00									
Slubbers	6 Slubbers, 312 sp.	13.50	4,212	1.685	252.75	1,500	.70	.03	.03		.01
Intermediates	8 Intermediates, 912 sp.	9.50	8,714	3.486	522.90	2,500	.70	.03	.03		.01
Fly Frames	24 Fly Frames, 4,032 sp.	6.75	27,216	10.886	1,632.96	7,500	.70	.03	.03		.01
Spinning	90 Frames, 21,600 sp.	3.50	75,600	30.240	4,536.00	31,000	.70	.03	.04		.01
Spooling	10 Spoolers, 1,200 sp.	3.25	3,900	1.560	234.00	2,600	.70	.03	.04		.01
Reeling	15 Reels	200.00	3,000	1.200	180.00	2,000	.70	.03	.04		.01
Warping	10 Warpers	325.00	3,250	1.300	195.00	3,500	.70	.03	.04		.01
Twisting	10 Frames, 1,600 sp	4.25	6,800	2.723	408.00	2,000	.70	.03	.04		.01
Dyeing Stock	1 R. S. Dyeing Machine	1,100.00									
	1 Extractor	350.00	2,750	1.100	165.00	1,500	1.00	.03		.03	.01
	1 Drying Machine	1,200.00									
	1 Fan and Piping	100.00									
	Cotton Bins										
Dyeing Chain	1 Boiling Box	650.00									
	1 Doubler	250.00									.01
	4 Scotch Tubs	250.00	3,150	1.260	189.00	2,000	1.00	.03		.03	
	1 Splitter	250.00									
	1 Set Dry Cans	1,000.00									
											.01
Beaming	1 Dry Splitter	150.00	550	.220	33.00	1,500	1.00	.03			
	4 Beaming Frames	100.00									
Dressing	2 Slashers	1,200.00									.01
	1 Size Tub	125.00	2,615	1,046	156.90	3,000	.70	.03		.04	
	6 Drawing Frames	15.00									
	Beam Storage										
Weaving	330 Plain Looms	65.00	21,450	8.580	1,287.00	16,000	.70	.03	.04		.01
	75 Drop Box Looms	120.00	9,000	3.600	540.00	4,000	.70	.03	.04		.01
Sewing	1 Sewing Rolling Mach		250	.100	15.00	200	1.05	.03			.01
Brushing	1 Shear & Brushing Mach		750	.300	45.00	200	1.05	.03			
Tentering	1 Sewing Machine	25.00									
	1 Tentering Frame	3,000.00	3,050	1.220	183.00	1,600	1.05	.04		.02	.01
	1 Size Tub	25.00									
Calendering	1 Calender		1,000	.400	60.00	300	1.05	.03		.02	.01
Folding	1 Folder		250	.100	15.00	200	1.05	.03			.01
Winding	1 Winding Machine		80	.032	4.80	100	1.05	.03			.01
Pressing and Packing	Cloth Racks										
	1 Power Press for Cloth		1,000	.400	60.00	3,000	1.05	.03			.01
	1 " " " Yarn		800	.320	48.00	500	1.05	.03			.01
Steam Plant	5 150 H. P. Boilers, &c	1,200.00									
	1 Feed Water Heater	300.00	9,600	3.840	576.00	4,000	1.20	.03		.03	.01
	2 Boiler Feed Pumps	400.00									
	1 Injector	100.00									
Power Plant and Shafting	1 Engine	12,550.00	13,200	5.280	792.00	3,000	1.20	.03		.03	.01
	1 Condenser	650.00									
Light Plant	2 50 K. W. Dynamos	450.00	1,100	.440	66.00	200	1.20	.03			.01
	1 Switchboard	200.00									
Repair Plant	Lathes, &c		1,000	.400	60.00	1,000	1.20	.03		.01	.01
Humidifying	1 Pump, &c		783	.313	46.95	100	1.20	.03			
Cott'n Storage						10,000	.40	.03			
Goods and Yarn Storage						5,000	.40	.03			
			$250,000	100.000	$15,000.00	123,000					

Total Cost	Per Cent	Distribution	REPAIR SHOPS: Labor	REPAIR SHOPS: Materials	Storeroom Supplies	Supplies	LIGHT	HUMIDIFYING	STEAM AND POWER: H. P.	STEAM AND POWER: Per Ct.	STEAM AND POWER: Distrib.	TOTAL
			Material 1074.88 Labor. Spec. 1094.56 General La. 273.64 General Mat. 107.49 Power 40. Maintenance & Protection of Machinery 60. " Buildings 37.50		Including Oil Belting Pickers Sticks Brooms Travelers Crayons Shuttles Strapping Packing	Roll Covering Card Clothing Bobbins Spools Harness & Reeds Cans Lamps Carbons Starch Bands Wires	P. M. ......$ 66.00 R. & S. ...... 7.44 Labor ...... 146.68 Power 212.50 $432.62 385.74 $818.36	P. M. ......$46.95 R. & S. ...... 3.69 Power ...... 28.30 Labor 25.00 20.00 $123.94	STEAM / POWER Fuel ...... $7,000.00 / $640.00 Labor ...... 646.93 / 485.62 Repairs ...... 498.00 / 792.00 Main. Mach'y 576.00 / 114.27 Main. Build. 152.37 $8,873.30 / $2,031.89			
13	14	15	16	17	18	19	20	21	22	23	24	25
$4,960	4.959	$148.77	$31.02	$25.60	$40.10	$.......	$22.73	$.........	54	7.714	$694.26	$1,370.48
992	.992	29.76	2.40	4.68	3.80	....	5.05	....	3	.429	38.61	129.30
6,314	6.312	189.36	23.00	18.26	60.42	283.16	62.10	11.40	67	9.571	861.39	3,751.89
1,155	1.155	34.65	15.19	16.70	25.60	4.20	12.28	2.25	7	1.000	90.00	453.62
1,925	1.925	57.75	25.30	31.10	60.40	36.50	20.46	3.75	13	1.857	167.13	925.29
5,775	5.774	173.22	42.10	33.20	120.00	15.31	61.38	11.25	34	4.857	437.13	2,256.49
....	....	....	....	....	....	191.68	....	....	....	....	....	....
24,180	24.173	725.19	237.60	181.58	324.00	275.90	253.69	50.08	314	44.857	4,037.13	10,812.85
2,028	2.028	60.84	13.10	7.60	22.00	315.78	20.28	3.90	5	.714	64.26	741.76
1,560	1.560	46.80	2.00	1.50	15.00	....	16.37	3.00	3	.429	38.61	303.28
2,730	2.729	81.87	8.40	28.75	2.50	24.12	28.64	5.25	3	.429	38.61	413.14
1,560	1.560	46.80	16.20	42.00	35.20	65.20	16.37	3.00	30	4.286	385.74	1,018.51
1,605	1.605	48.15	50.20	35.50	47.10	1,809.10	10.27	....	5	.714	64.26	3,054.48
....	....	....	....	....	....	....	....	....	....	....	825.00	....
2,140	2.140	64.20	40.20	20.00	28.70	810.00	13.37	....	5	.714	64.26	1,504.73
....	....	....	....	....	....	....	....	....	....	....	275.00	....
1,560	1.560	46.80	1.10	2.60	4.20	....	12.27	....	1	.143	12.87	112.84
2,280	2.279	68.37	12.00	15.30	107.10	736.23	24.55	....	6	.857	77.13	1,597.58
....	....	....	....	....	....	....	....	....	....	....	400.00	....
12,480	12.476	374.28	343.13	300.10	205.60	133.12	149.40	24.06	82	11.714	1,054.26	3,870.95
3,120	3.119	93.57	110.20	132.05	71.30	33.03	39.23	6.00	19	2.714	244.26	1,269.64
218	.218	6.54	....	....	16.80	....	1.64	....	1	.143	12.87	52.85
216	.216	6.48	3.50	18.40	2.20	....	1.64	....	3	.429	38.61	115.83
1,792	1.792	53.76	25.60	22.00	24.20	450.00	13.09	....	5	.714	64.26	1,240.36
....	....	....	....	....	....	....	....	....	....	....	404.45	....
333	.333	9.99	13.60	2.20	2.20	....	2.45	....	4	.571	51.39	141.83
218	.218	6.54	....	....	.60	5.00	1.64	....	¼	.036	3.24	32.02
109	.109	3.27	....	....	1.00	280.00	.82	....	¼	.036	3.24	293.13
....	....	....	....	....	....	Ch. 180.00	....	....	....	....	....	....
....	....	....	....	....	....	Pr. 112.00	....	....	....	....	....	....
....	....	....	....	....	....	Mad. 806.00	....	....	....	....	....	....
3,270	3.269	98.07	3.50	1.25	3.20	25.10	24.55	....	¼	.036	3.24	1,316.91
545	.545	16.35	....	....	1.20	Yarn 210.00	4.09	....	¼	.036	3.24	282.88
5,080	5.079	152.37	150.00	287.00	60.90	....	....	....	....	....	....	....
3,810	3.809	114.27	160.00	75.00	250.62	....	....	....	....	....	....	....
248	.248	7.44	18.00	2.50	32.18	94.00	....	....	30	4,286	385.71	....
1,250	1.250	37.50	....	....	....	....	....	....	3	.429	40.00	....
123	.123	3.69	11.50	8.60	8.20	....	....	....	2	.285	25.00	....
4,300	4.299	128.97	6.24	4.20	....	....	....	....	....	....	....	139.41
2,150	2.150	64.50	3.12	2.10	....	....	....	....	....	....	....	69.72
$100,026	100.004	$3000.12	$1368.20	$1319.87	$1576.32	$6895.33	$818.36	$123.94	700	100,000	$10,905.19	$37,541.77

detail (25%), the same is added to the cost of repair labor expended on each operation in the mill. In this supervision is included also the labor on the repair department itself. These amounts are then entered in their proper place in the table (Column 16) amounting to $1,368.20.

There is also an unaccounted-for balance of charges ($107.49) for material, but before this is distributed there may be added a charge of $40.00 for power. This is estimated and will be deducted from Power account before distributing, later.

By the portion of the table already constructed, we find the cost of Maintenance of the Repair Plant to be $60.00 for Machinery, and $37.50 for Buildings, etc. These three items, with the unaccounted-for balance of Repair account, are then added to the detailed materials cost, on a percentage basis, in the same manner as the general labor, and the amounts set down in Column 17. These amount to $1319.87, and prove the work correct.

From the Storeroom there have been delivered miscellaneous supplies, oil, brooms, crayons, loom strapping, pickers, picker sticks, shuttles, travelers, packing, etc. An account of these has been kept, and the value delivered to each department entered in Column 18.

In addition to these lighter supplies from the Storeroom, a large amount of money has been spent in paying bills for supplies of a heavier nature, such as card clothing, bobbins, spools, harnesses, roll covering, starch, and the like. In the column in which these are also included some items especially applied to particular classes of costs, may be disposed of, such as packing cases, bands, burlaps, cloth boards, cones, etc., with a notation of the amount. The amount of all the items chargeable to each department or operation, may perhaps be most easily ascertained by an inspection at the end of the period of the bills charged to this account.

In Column 20 are the expenses of Lighting ($818.36) as summarized in the box at the head of the column. The items include Maintenance of Machinery $66.00, and Buildings $7.44, as taken from Columns 6 and 15 of this table. Repairs and Supplies from Columns 16, 17, 18 and 19 amounting to $146.68, and the cost of Power as later ascertained $385.74 and Labor $212.50 from the division of general Labor, already given. This cost is divided among the departments in proportion to the light or current used, omitting the Power and Repair departments, as these cannot be closed and divided up, until after all items have been determined. On the other hand the cost of Lighting cannot be settled until the expense of Repairs and Power has been ascertained. As the costs of these latter are more important than the former, the lighting of Repairs and Power Departments is passed over.

The cost of Humidifying is determined and distributed in a similar way. It will be noticed that this expense applies to but a portion of the mill.

The costs of Power and Steam are next worked up. As a considerable amount of the steam generated at this plant is used for dyeing, drying, warp dressing, and finishing, a separation is made between the Boiler and Engine Installations, and with the cost of running the latter is included the care and maintenance of shafting.

The cost of Steam is made up of Fuel $7,000.00, Labor $646.93 (both taken from the records). The Repairs and Supplies as taken from this table amount to $498.00, and the Maintenance of Machinery $576.00, and Buildings $152.37. Of the total $8,873.30 thus obtained, estimated amounts are apportioned in Column 24, to Dyeing, Dressing and Finishing, to cover the cost of these processes.

The remainder of the cost of Steam is added to the cost of Labor $640.00, Repairs, etc., $485.62 and Maintenance of Machinery $792.00, also Buildings $114.27, applicable to the Power Plant.

In Column 22 is set down the estimated average power consumed in each operation. The total is 700 horse power. The percentage of each operation is extended in Column 23. The total cost of Power, including the balance of Fuel is then divided according to the percentage of power used and carried out into Column 24. This column, including the amounts already allotted for Steam, will now foot up to the sum of cost of Steam and Power, $10,905.19.

Excluding Steam, Power, Lights, Repairs, and Humidifying, which have been redistributed, the General Expense of Maintenance, Supplies, Power, etc., are then added across the page, horizontally and enumerated in Column 25.

We have now the means of uniting the Labor Cost with that of Maintenance, Supplies and Power, hereafter abbreviated to M.S.

and P., for the same departments, and dividing the combined amounts among the various kinds of product. This is accomplished in a series of forms such as follow:

Semi-Annual Cost Sheet, Card Room.

Total lbs. carded stock in Yarns and Cloth made.									
No. of Hank or Roving..........	Total.	1.		1.50		5.20		6.00	
Total lbs. carded stock in Yarns and Cloth made.		70,000		30,000		600,000		100,000	
Add Inventory Dec. 29..........		6,100		900		58,800		3,300	
		76,100		30,900		658,800		103,300	
Deduct Inventory June 30..........						54,700			
	814,400	76,100		30,900		604,100		103,300	
		Total.	Per lb.	Total.	Per lb.	Total.	Per lb.	Total.	Per lb.
Labor Costs, corrected..........	$8,263.36	$348.16	......	$155.68	......	$6,536,36	......	$1,223.16	......
Picking, Maintenance, Sup. and Pow............	1,370.48	128.14	......	52.21	......	1,015.89	......	174.24	......
Waste Picking, Maintenance, Sup. and Pow..	129.30	91.90	.....	37.40	......	....	......	....	......
Carding, Maintenance, Sup. and Pow............	3,751.89	350.39	......	142.36	......	2,783.24	......	475.90	......
Slubbers, Maintenance, Sup. and Pow............	453.62	42.39	......	17.21	......	336.48	......	57.00	......
Intermediate, Maintenance, Sup. and Pow..	925.29	....	......	....	......	790.37	......	134.92	......
Fly Frames, maintenance, Sup. and Pow........	2,526.49	....	......	....	......	2,157.60	......	368.89	......
	$17,420.43	960.98	1.263c	$404.86	1.310c	$13,619.94	2.254c	$2,434.65	2.357c

As a basis of division of cost, at the top of the form are given the pounds of roving contained in the finished product of the mills, and this is then corrected to the amount passed through the card room, by adding the inventory at the end of the period and deducting that at the beginning. The corrected labor costs are then inserted.

The total cost of M.S. and P. of Picking is then entered from Table M, and divided according to the pounds of each hank roving made. The M.S. and P. of Waste Picking is entered and divided among the two rovings containing waste. The M.S. and P. of the various processes of roving frames are then taken separately, and divided according to the spindles occupied on each roving. By this means the cost of 1. hank roving in the department of carding is found to be 1.263 cents per pound.

1.50 hank roving....1.310
5.20 " " 2.254
6. " " 2.357

By a similar method, the tabular forms for the Spinning Room, Spooling Room, Reeling Room, Warping Room, Twisting Room, Raw Stock Dyeing, Chain Dyeing, Beaming Room, Dressing Room, Weaving Room, Finishing Room and Storage are entered up and figured out.

Semi-Annual Cost Sheet, Spinning Room.

No. of Yarn.		No. 8.	No. 12.	No. 25
Average Spindles run.....	21,000	500	310	6,133
Lbs. Spinning in Cloth and Yarn................. Add Inventory Dec. 29.....	800,000 24,300	70,000 4,900	30,000 100	240,300 18,500
Deduct " June 30....	824,300 8,900	74,900	30,100	258,500
	815,400	74,900	30,100	258,500
Labor Costs, corrected .... Maintenance, Sup. and Pow.....................	$ 6,999.90 10,812.85	$214.70 .300c 257.43 .330	$195.65 .650c 159.61 .530	$2,197.25 .850c 3,157.63 1.223
	$17,812.75	$472.13 .630c	$355.26 1.180c	$5,354.88 2.073c

No. of Yarn.	No. 28.	No. 32.	No. 36.
Average Spindles run..................	8,126	3,400	2,531
Lbs. Spinning in Cloth and Yarn....... Add Inventory Dec. 29..................	289,600	100,000 800	70,400
Deduct " June 30.................	289,600 8,100	100,800	70,400 800
	281,500	105,000	69,600
Labor Costs, corrected................. Maintenance, Sup. and Pow...........	$2,533.50 .900c 4,184.45 1.487	$1,058.40 1.050c 1,750.52 1.737	$ 800.40 1.150c 1,303.21 1.872
	$6,717.95 2.387c	$2,808.92 2.787c	$2,103.61 3.022c

Semi-Annual Cost Sheet, Spooling Room.

No. of Yarn..........		8	25	28
Average No. Spindles run.................	.	50	600	350
Pounds spooled yarn in cloth and yarn... Add Inventory Dec. 29	479,600 44,500	70,000 4,700	240,000 25,500	169,600 14,300
	524,100	74,700	265,500	183,900
Less Inventory June 30..................	28,500	....	5,000	23,500
	495,600	74,700	260,500	....
Labor cost, corrected Maintenance, supplies and power.....	$ 1,775.63 741.76	$ 112.05 .15 c 37.09 .049	$ 989.90 .380c 445.05 .171	$ 673.68 .420c 259.62 .162
	$ 2,517.39	$ 149.14 .199c	$1,434.95 .551c	$ 933.30 .582c

Semi-Annual Cost Sheet, Reeling Room.

No. of Yarn..........	....	....	28		2/28	
Average reels run....	....	....	12		3	
Pounds reeled yarn, in yarn sold........	....	....	120,900		80,000	
Add Inventory Dec. 29	....	....	900		800	
	....	....	120,000		80,800	
Deduct Inventory June 30..............	....	....	1,000		500	
	....	....	119,900		80,300	
Labor Costs, corrected...............	....	$ 876.64	$575.52	.480c	$301.12	.375c
Maintenance, Supplies and Power....	....	303.28	242.62	.202	60.66	.075
	....	$1,179.92	$818.14	.682c	$361.78	.450c

Semi-Annual Cost Sheet, Warping Room.

No. of Yarn..................	....	8		25		28	
No. of Machines run.........	....	5		5		1.5	
Pounds Warped Yarn in Cloth and Yarn............	....	70,000		240,000		89,600	
Add Inventory Dec. 29.......	....	3,700		22,500		10,500	
		73,700		262,500		100,100	
Deduct Inventory June 30...	....	....		....		20,000	
		73,700		262,500		80,100	
Labor Costs, corrected.......	$1,097.24	$92.12	.125c	$708.75	.270c	$296,37	.370c
Maintainance, Supplies and Power......................	413.14	29.51	.040	295.10	.112	88.53	.110
	$1,510.38	$121.63	.165c	$1,003.85	.382c	$384.90	.480c

Semi-Annual Cost Sheet, Twisting Room.

No. of Yarn............................	....	....	2128	
No. of Spindles ran....................	....	....	....	
Pounds Twisted Yarn, in yarn sold.....	....	....	80,000	
Add Inventory Dec. 29..................	....	....	800	
			80,800	
Deduct Inventory June 30..............	....		500	
			80,300	
Labor Cost, corrected.................	....	....	$ 521.95	.650c
Maintenance, Suppliles and Power......	....	....	1,018.51	1.268
			$1,540.46	1.918c

Semi-Annual Cost Sheet, Raw Stock Dyeing.

Pounds cotton dyed in raw stock in cloth made..............	....	....	....	298,500	
Add Inventory Dec. 29	....	....	....	23,500	
	....	....	....	322,000	
Labor cost, corrected	....	....	....	$ 644.00	.200c
Maintenance, supplies and power....	....	....	....	3,054.48	.948
	....	....	....	$3,698.48	1.148c

Semi-Annual Cost Sheet, Chain Dyeing.

Pounds of dyed stock in cloth made....................		67,000
Add Inventory Dec. 29.................................		10,700
		77,700
Labor Cost...	$ 293.10	
Maintenance, Supplies, Power..........................	1,504.73	
	$1.797.83	

$1,797.83 ÷ 77.700 = 2.314c per lb. cost.

Semi-Annual Cost Sheet, Beaming.

Pounds of Beamed Yarn in Cloth Made................		75,000
Add Inventory Dec. 29.................................		8,700
		83,700
Labor Cost...	$669.60	
Maintenance, Supplies, Power..........................	112.84	
	$782.44	

$669.60 ÷ 83,700 = .800 per lb. Cost Labor.
112.84 ÷ 83,700 = .135 " " M., S. and P.

$782.44 ÷ 83,700 = .935c Total Cost per lb.

Semi-Annual Cost Sheet, Dressroom.

No. Slashes run...............	....	....	....	....
Kind of Warp.................	Total.	Cheviot.	Madras.	Print.
Pounds dressed yarn in cloth made......................		70.000	150,000	89,600
Add Inventory Dec. 29........		2,500	17,000	9,000
		72,500	167,000	98,600
Deduct Inventory June 30....				18,000
		72,500	167,000	80,600
Labor cost.....................	$1,685.83	$253.75 .350c	$1,085.50 .650c	$316.58 .430c
Maintenance, Supplies, Power	1,597.58	273.25 .377	948,11 .568	376.22 .460
	$3,283.41	$527.00 .727c	$2,033.61 1.218c	$722.80 .890c

Semi-Annual Cost Sheet, Weave Room.

Kind of Goods....	Total	Cheviot		Print		Madras		Check Madras	
No. of Looms run	....	27		153		150		75	
Pounds of Cloth woven...........	....	100,000		160,000		170,000		80,000	
Labor Cost, corrected...........	$15,860.00	$1,380.00	1.380c	$4,880.00	3,050c	$6,120.00	3.600c	$3,480.00	4.350c
M. S. & P. Plain looms...........	3,870.95	316.71	.318	1,794.69	1.122	1,759.55	1.030	....	
M. S. & P. Check looms...........	1,269. 64	....		....		....		1.269.64	1.587
	$21,000.59	$1,696.71	1.698c	$6,674.69	4.172c	$7,879.55	4.635c	$4,749.64	5.937c

Semi-Annual Cost Sheet, Finishing Room.

Kind of Goods....	Total.	Yarn.		Cheviot.		Print.		Madras,	
No. of Pounds....	810,000	300,000		100,000		160,000		250,000	
No. of Yards......				215,000		1,120,C00		1,500,000	
Labor Cost........	$2,090.00	$600.00		$150.00		$240. 00		$1,100.00	
Sewing, Main., Sup. and Power	52.85	......		4.00		22.00		26.85	
Brushing, Main., Sup. and Power	115.83	......		8.40		46.20		61.23	
Tentering, Main., Sup. and Power	1,240.36	......		......		......		1,240.36	
Calendering, M'n., Sup. and Power	141.83	......		......		60.48		81.35	
Folding, Main., Sup. and Power	32.02	......		.....		13,80		18.22	
Winding, Main., Sup. and Power	293.13	......		......		......		293.13	
Cloth Pressing, Main., Sup. and Power..........	1,316.91	......		225.11		173.00		918.80	
Yarn Pressing, Main., Sup. and Power..........	282.88	282.88		......		......		......	
	$5,565.81	$882.88	.294c	$387.51	.388c	$555.48	.347c	$3,739.94	1.496c

Semi-Annual Cost Sheet, Storage.

Kind of Goods Stored............	Cotton.	Cheviot.	Madras.	Skein Y'rn	Total.
Percentage of Space Used......	100%	20%	60%	20%	
Pounds Stored....................	......	......	......	......	......
Cotton Warehouse..............	$139.41	......	......	......	......
Goods "	......	$13.95	$41.83	$13.95	$69.72
Cost per pound Finished Goods.	.018c	.014c	.017c	.005c	

It is unnecessary to follow in detail all the calculations of these forms. Concerning the distribution of M.S. and P. it should be understood that as a rule it is to be divided according to the proportion of machinery run, rather than the pounds produced. For example, in the Spinning Room, one thousand spindles will require about the same floor space, oil, and power whether run on No. 8 yarn or on No. 36 yarn, but the production in pounds will be far different. It is, therefore, contrary to good reasoning, to divide this expense on the basis of so much a pound, but rather should it be on so much a spindle, and the pound cost will take care of itself. The force of this is seen again, in the Weave Room, where the madras is divided into two portions: that woven on plain looms, and that woven on drop box looms—with a decided increase in cost of the latter—and again in the contrast of the cost of the cheviot and print cloth.

The last expression of the Cost is made on the Assembling Sheets, of which we may conveniently make two, one for yarn and one for cloth. As the name implies the departmental costs are here assembled under proper headings to obtain the full gross costs of manufacturing.

Assembling Sheet Yarn.

Number	25 Warp	28 Skein	$\frac{2}{28}$ Skein
Carding	2.254c	2.254c	2.254c
Spinning	2.073	2.387	2.387
Spooling	.551	.582	....
Warping	.382	....	....
Twisting	....	....	1.918
Reeling	....	.682	.450
Finishing	.294	.294	.294
Storage, Yarn	....	.005	.005
Storage, Cotton	.018	.018	.018
	5.572	6.222	7.326
General Expense and Interest	.598	.672	.832
Cotton	9.342	9.342	9.342
	15.512	16.236	17.500
Freight	.252	.330	.336
Commission	1.600	1.680	1.760
Total Cost Yarns	17.364	18.246	19.901

Taking the case first of No. 25 warp yarn; we find this to be made from 5.20 hank roving, and the department cost of carding this, from the Semi-Annual Cost Sheet, is found to be 2.254, which is set down in the proper space. The other sale yarns are also made from the same size roving, and are similarly entered.

From the Spinning Room Cost Sheet we find the cost of spinning No. 25 yarn to be 2.073 cents, now to be entered below the carding.

After the same manner we obtain and enter the costs of Spooling, Warping and Finishing. We omit Twisting and Reeling as having no part in the cost of single warp. We omit also Storage of Yarn as this yarn was shipped promptly upon being packed. The storage of cotton, however, is a part of the cost, and is included.

Following the same steps with all the yarns, we find the sum of the costs, thus far attained, to be

No. 25 Yarn	5.572 cts.
No. 28 Skein Yarn	6.222 "
No. $\frac{2}{28}$ " "	7.326 "

These figures include all the costs of manufacturing proper except the stock, and certain general expenses which are not assignable to any department, nor can they be divided among the products by any system by which it is possible to say: "We know that so much money was expended for Salaries, Postage, or Cleaning up the Yard, and the expense is directly caused by such a kind of goods or yarn, and chargeable to it."

These unassignable expenses as shown by the mills accounts, are

Salaries and Office Expense	$4,000.00
Miscellaneous Expense	500.00
Yards	600.00
Interest	3,600.00
	$8,700.00

This sum is found to be $11\frac{1}{3}\%$ of the amount of other expenses, excluding cotton and yarn purchased, and is divided among the products on this percentage plan. It may fairly be assumed that those departments having a higher labor cost and using more supplies, will call for more supervision, more correspondence and office expense, more general labor and money borrowed. Charges of interest on money used in the purchase and carrying of cotton, may previously be calculated and added to Cotton account, or the cost of interest on funds invested in cotton and finished goods may be added to the Semi-Annual Storage Report, if thought more convenient.

This percentage of general expense should be added before the inclusion of the cost of stock, since the latter bears no relation to it and, varying from season to season, would vary the proportion of expense to each product without good reason.

We have already found the cost of stock used in all yarns sold to be 9.342 cents, and having added this to the previously ascertained cost, the full manufacturing cost, with the exception of the important one of profits, is completed.

As the purpose of all manufacturing is gain, and the utility of cost investigation lies in showing where, and how much of that gain has resulted or will result, profits may be considered legitimately an element of cost. It is often easier to determine what it ought to be, than to obtain it under adverse market conditions, and it is occasionally obtainable to a greater degree than is necessary for an average return on capital invested. The return on capital investment, however, is the only basis, when considered as a *cost*. If there is no wide variation in product, such as would be the case if the yarns already considered were the only product, the necessary profit might be reckoned from the production per spindle of each kind of yarn, but in such a combination of departments and processes as arise in a spinning and weaving mill, a better rule is to calculate the gross profit desired, and add the necessary percentage to the costs, again excluding the stock used.

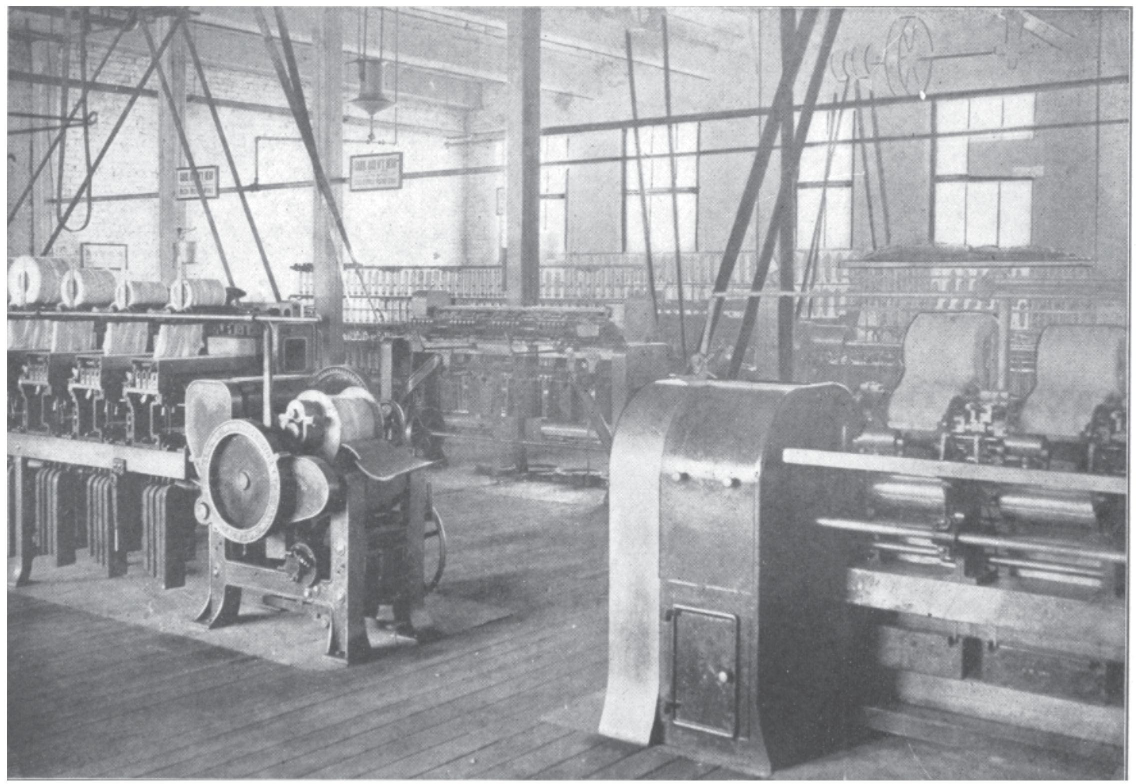
The cost of the stock used should be omitted because it is such a variable element. Depending upon conditions of the crop and markets, it may vary fifty per cent in price, while the margin necessary for fair returns would be unchanged. Of two kinds of goods having a very different cost of stock, the one costing more might, on account of greater production per unit of loom or spindle, require less margin of profit than the other.

The Manufacturing Costs having now all been obtained, the additional expense of marketing and distributing goods must be had. These include Freight, paid on goods shipped, Commissions, for selling, and sometimes Advertising, Traveling Expense, and other items.

In these tables the net Commissions are added as a percentage, varying according to the contract with the selling house, or with trade custom. The estimated amount which will have to be paid for freight is added. It must be borne in mind that these items are based on the actual cost per yard or pound of the product under estimate.

Unlike other factors this cost per pound cannot be taken from the net expense incurred during the periods. It is quite usual for goods to be stored in large quantities, so that the expense of distributing is a very variable one, so far as amount of charges in any length of period is concerned.

Goods which it took most of the time for six or nine months to manufacture, may be stored and then cleared out in one or two



VIEW IN TEXTILE DEPARTMENT OF CLEMSON COLLEGE SHOWING COMBING, DRAWING AND ROVING MACHINERY months, and all the charges for selling and shipping, concentrated in a short time.

ASSEMBLING SHEET, CLOTH.

	Cheviot			Print Cloth			Madras		
	Warp No. 8 No. 1h.r. Fill No. 12, 1.50 " Yards, per lb., 2.15			WarpNo.28,No.5.20h.r Fill No. 36, 5.20 " Yards, per lb. 7.00			WarpNo.25,No.5.20h.r Fill No. 32, 6.00 " Yards, per lb. 6.00		
	Cost per pound	Per cent used	Cost per pound Cloth	Cost per pound	Per cent used	Cost per pound Cloth	Cost per pound	Per cent used	Cost per pound Cloth
Labor Cost, corrected									
Carding warp	1.263	70	.884	2.254	56	1.262	2.254	56.8	1.279
Carding filling	1.310	30	.393	2.254	44	.992	2.359	40.7	.942
Spinning warp	.630	70	.441	2.387	56	1.337	2.073	56.8	1.177
Spinning filling	1.180	30	.354	3.022	44	1.330	2.787	40	1.115
Spooling warp	.199	70	.159	.582	56	.326	.551	56.8	.313
Warping	.165	70	.106	.481	56	.269	.382	56.8	.217
Beaming							.935	30	.281
Raw Stock Dyeing	1.148	100	1.148				1.148	70	.794
Chain Dyeing							2.314	26.8	.620
Dressing	.727	70	.509	.897	56	.502	1.218	60	.731
Weaving			1.698			4.172			4.635
Finishing			.388			.347			4.496
Storage, Cotton			.018			.018			.018
Storage Goods			.014						.017
Total Mill Expense			6.112			10.555			13.635
General Expense and Interest 11⅓%			.693			1.203			1.565
			6.805			11.758			15.200
Cotton			6.693			9.342			8.968
Yarn									.800
			13.498			21.100			24.968
Freight			.560			.240			.720
Commissions			.850			.350			1.500
			14.908			21.690			27.188

The above cost of Madras is for 170,000 lbs. woven on plain looms. The 80,000 lbs. woven on drop box looms cost (per Weave Room Cost Sheet) 5.937 cents per pound for weaving instead of 4.635 cents as above. The total cost of manufacturing the check goods was therefore 28.490 cents per pound instead of 24.968 cents.

In the assembling sheet for woven goods, we have a similar work to that on yarns, with additional elements. The Cheviot is made of 70% warp and 30% filling, made from different rovings, and therefore having different card room costs. The warp carding 1.263 cents per lb., and each pound of cloth contained 70% warp. The cost per pound of cloth for carding warp, was therefore, 70% of 1.263 cts., or .884 ct. per lb. The cost per pound of cloth for carding filling is 30% of 1.310 cts., the cost of the filling. For convenience these assembling sheets for cloth are provided with separate columns for each of these three items, and each process is entered up for the extent to which it enters into the make-up of the fabric. There is no division of the cost of weaving and subsequent operations.

In the cost of warp for Madras it will be noted that only 56.8% of the cloth is carded and spun for warp. The filling is 40% of the cloth. The balance, 3.2%, is the yarn purchased which did not pass through the carding and spinning in the Enterprise Mills, and therefore is eliminated from the labor costs of those departments.

Only one half of the warp is beamed, the other half being warped from yarn spun from bleached cotton. One half the warp makes 30% of the cloth.

The yarn purchased was dyed previously, and amounted to 3.2% of the cloth. As already stated 60% of the Madras was warp. One half of this, or 30% of the cloth, less 3.2% purchased, equal to 26.8% of the cloth, was dyed by the long chain system. The balance or 70% was dyed in raw stock.

The addition of General Expense, etc., is also on the same plan, as with the cost of yarn, and also the cost of Stock, excepting that in the Madras the item of the additional cost of the yarn purchased solely for these goods. Deducting the value of the inventory of yarn the amount used was equal to .800 cent per pound.

There were also two kinds of Madras, one woven on plain looms, and one on drop box looms, but alike in all other respects, and having the same cost except for weaving.

Having summed up the Manufacturing Costs, we may add Freight and Commissions. These differ from the Manufacturing Cost items in that they should equal the expense that has been, or will be incurred in the distribution of the goods, whether it has already been paid out or not.

The total costs per pound for cloth, less margin for profit, are:

Cheviot	14.908 cts. per lb.
Print Cloth	21.690 " " "
Madras, plain looms	27.188 " " "
Madras, drop box looms	28.490 " " "

As 170,000 lbs. of Madras were woven on plain looms, and 80,000 lbs. on check looms, but were all sold at the same price, we are interested to find the average price of Madras:

(27.188 cts. × 170,000) + (28.490 × 80,000) ÷ 250,000 = 27.604 cts. per lb.

The cost per yard may be obtained from the cost per pound by dividing by the yards per pound, as follows:

Cheviot 14.908 ÷ (2.15 + 2% = 2.193) = 6.80 cts. per yard.
Print Cloth 21.690 ÷ 7 = 3.10 cts. per yard.
Madras 27.604 ÷ 6 = 4.60 cts. per yard.

These yards per pound are the figures obtained by dividing the pounds from the loom by the finished yards. And 2% is added to the cheviot because 2% has been gained in weight in process through the mill above the original proportion of stock, as previously noted.

The computations have been long, complicated and laborious, and it is well to prove the substantial accuracy of the mathematical work, which may be done as follows:

100,000 lbs.	No. 25 Warp	at	15.512	cts. per lb	$15,512.00
120,000 "	" 28 Skein	"	16.236	" " "	19,483.00
80,000 "	" $\frac{2}{28}$ "	"	17.500	" " "	14,000.00
100,000 "	" Cheviot	"	13.498	" " "	13,498.00
160,000 "	" Print Cloth		21.100	" " "	33,760.00
170,000 "	" Stripe Madr.		24.968	" " "	42,445.60
80,000 "	" Check Madr.		26.270	" " "	21,016.00
					$159,714.60
Additional value Labor, and M. S. & P., inventory of stock in process					1,439.19
Total Cost of Products, as computed					$161,153.79

Total Value, Mfg. Labor, from semi-annual cost sheets	$40,777.25
" " Repairs, Labor, Material, Taxes, etc., see page 28	35,241.65
Depreciation allowed	11,000.00
Cotton, less increased inventory, see page 24	65,396.39
Waste, " " " " " 24	6,693.05
Yarn, " " "	2,000.00
Total Expenses Manufacturing	$161,108.34

The manager of the Enterprise Mills, having devised in outline the method above described, had it carried into effect, at the end of the half year. He discovered, however, that the bookkeeper, though efficient, was not sufficiently informed upon the mill work and processes to carry out the scheme, without his own personal, strict supervision, and that on the other hand the clerical work was far too great for him to do alone.

One afternoon he called the superintendent and showed him the results, and asked him what he thought of them.

"Well!" was the reply, "I reckon they are all right, but it seems to be a mighty lot of work."

"Yes," replied the manager, "it is. But I think in our condition it is worth it. I would not bother with such fine points if we were making only a few yarns, as we began. But I want now, not an *estimate* of what goods have cost, but a *computation*. And while this method is not perfect, and we may yet improve it, no one can say that we have not considered practically all the items of cost in a rational way. Moreover, it has proved an "eye-opener" to me in many ways. We strive to keep down the labor costs, and rightly, and think the card room pay-roll a heavy one, but do you realize that the Depreciation, Maintenance, Supplies and Power cost equally as much. Spinning Room labor cost is considerable, but its Maintenance, Supplies and Power are half as much again. In the light of these facts, how important it is to obtain and maintain the highest efficiency and *production* of our machinery and help.

"We direct our energies to keep down the cost of supplies for the weave room, but their importance dwarfs in comparison with a ten per cent increase in the spinning room production, and, if this new method teaches us something of true values, it will not be in vain."

REVIEW QUESTIONS.

PRACTICAL TEST QUESTIONS.

In the foregoing sections of this Cyclopedia numerous illustrative examples are worked out in detail in order to show the application of the various methods and principles. Accompanying these are examples for practice which will aid the reader in fixing the principles in mind.

In the following pages are given a large number of test questions and problems which afford a valuable means of testing the reader's knowledge of the subjects treated. They will be found excellent practice for those preparing for Civil Service Examinations. In some cases numerical answers are given as a further aid in this work.

REVIEW QUESTIONS

ON THE SUBJECT OF

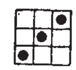
TEXTILE DESIGN.

PART I.

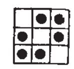
*** PROBLEM 1. Make the following designs:**

The complete design is on 24 threads × 12 picks.

12 threads	× 12 picks	No. 1 B.
3 "	" 12 "	" 2 "
6 "	" 12 "	" 1 "
3 "	" 12 "	" 2 "



/B



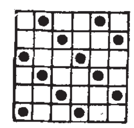
2B

Mark No. 2 B with red, and the risers on the 5th and 6th threads with blue.

PROBLEM 2. Stripe Trousering.

24 threads × 12 picks.

12 threads	× 12 picks	No. 1 B.	
6 "	" 6 "	" 2 "	
6 "	" 6 "	" 1 "	Twill to left; commence with the 1st thread.
6 "	" 6 "	" 1 "	
6 "	" 6 "	" 2 "	



/B LEFT

Mark No. 2 B with red, and the risers on the 6th and 7th threads with blue.

NOTICE These problems are made from warp flush and filling flush weaves. Take particular notice how they join. Make two original stripe designs, using B No. 1 and B No. 2.

PROBLEM 3. Stripe.

48 threads × 12 picks.

12 threads	12 picks	No. 1 B.	
3 "	12 "	" 2 "	
6 "	12 "	" 1 "	
3 "	12 "	" 2 "	
12 "	12 "	" 1 "	
6 "	6 "	" 2 "	
6 "	6 "	" 1 "	twill to left.
6 "	6 "	" 1 "	twill to left.
6 "	6 "	" 2 "	

Mark No. 2 B with red, mark the 6th, 8th, 30th and 32nd threads with blue.

* See page 44.

PROBLEM 4. **Check Trousering and Coating.**

48 threads × 48 picks.

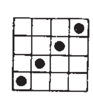
6 threads	36 picks	No. 1 B.				
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	twill to left.			
6 "	36 "	" 1 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	36 "	" 1 "				
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	36 "	" 1 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	36 "	" 1 "				
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	36 "	" 1 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				
6 "	6 "	" 1 "	"	"	"	
6 "	6 "	" 2 "				

Mark No. 2 B, red. No. 1 B. to left, green.

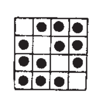
PROBLEM 5. **Woolen or Worsted Stripe.**

24 threads × 8 picks.

12 threads	8 picks	No. 1 C.
4 "	8 "	" 2 "
4 "	8 "	" 1 "
4 "	8 "	" 2 "



1C



2C

Mark No. 2 C with red, mark the 5th and 6th threads green.

REVIEW QUESTIONS

ON THE SUBJECT OF

TEXTILE DESIGN.

PART II.

---

1. Sketch a black and white color effect, weave $\frac{2}{\quad 2}$ Cassimere twill. Warp and filling, 2 black, 2 white, 2 black, 2 white, 4 black, 2 white, 2 black, 4 white.

2. Design a herring-bone stripe, the weaves to make a perfect cut when they come together. Dimensions of stripe, 48 threads per inch. Use Shalloon twill, $\frac{1}{2}$ inch to right, $\frac{1}{4}$ inch to left, $\frac{1}{8}$ right, $\frac{1}{8}$ left.

3. Use the following weaves, Crow, Swansdown, Crowfoot, warp-flush, and Crowfoot filling-flush, and design a cut figure or check, each thread in the warp to have an equal number of risers on the face, and each pick of filling to have an equal number of risers on the face, each check to be 8 × 8.

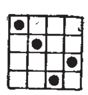


Fig. 1.

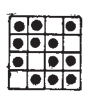


Fig. 2.

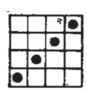


Fig. 3.

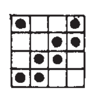


Fig. 4.

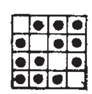


Fig. 5.

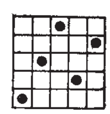


Fig. 6.

4. Design an overplaid for worsted dress goods; use Cassimere twill. Fig. 1 is commonly known as the Crowfoot weave filling-flush. Fig. 2 is the warp-flush Crowfoot weave.

5. What is a warp-flush and what is a filling-flush weave?

6. What are the technical names for weaves in Figs. 3, 4, 5 and 6?

7. What are the chief characteristics of weaves in Figs. 7, 8, 9 and 10?

8. Make a herring-bone stripe on 12 threads and 12 picks.
9. Make a 27-degree twill. Make a 45-degree twill. Make a 52-degree twill. Make a 63-degree twill. Make a 70-degree twill all from Fig. 11, first pick.

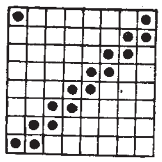


Fig. 7.

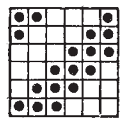


Fig. 8.

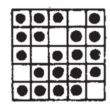


Fig. 9.

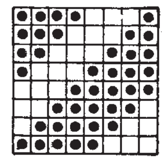


Fig. 10.

10. Write in your own words an explanation of the use of design paper.

11. Make a stripe design, using weaves Figs. 12 and 13. The design to be 24 threads by 12 picks.

12. Make a cut section of the first pick of design of Question 2.

Fig. 11.

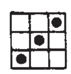


Fig. 12.

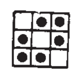


Fig. 13.

13. Weave at Fig. 12; twill this weave to the left, commencing with the third thread. Weave Fig. 13; twill this weave of the right, commencing with the second pick. Each design to be 12 threads by 12 picks.

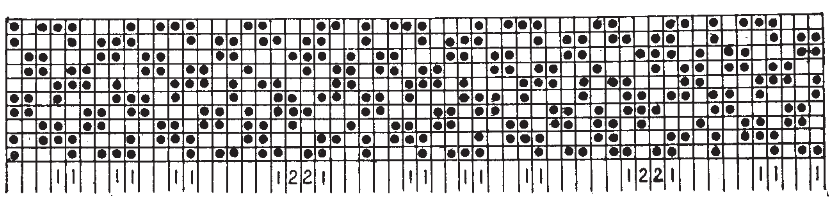


Fig. 14.

14. Design an oblique rib weave on 16 threads and 16 picks.

15. What are the chief characteristics of the regular and irregular rib weaves? Give two examples of each; warp and filling ribs.

REVIEW QUESTIONS

ON THE SUBJECT OF

TEXTILE DESIGN.

PART III.

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1. Give your opinion on the subject of why cloths are backed, and explain the good features of each system.

2. Explain why it is necessary to bind the back yarn as taught in the lesson on backed cloths.

3. Name and explain the important steps in the construction of a double cloth design.

4. How many threads and picks would be required for each of the following double cloth designs; or in other words, what would be the extent of each design ; all designs to be constructed on the plan of 1 face, 1 back: 5 end sateen for face, 4 end twill for back; 6 end twill for face, 3 end twill for back; 8 end twill for face, 3 end twill for back. 16 end fancy weave which repeats on 16 ends and 12 picks for face, and a 4 end twill for back.

5.. Give the extent of the following double cloth designs constructed on the 2 face, 1 back principle: 4 end twill for face and back; 8 end twill for face, 4 end twill for back; 12 end twill for face, 8 end twill for back; fancy weave repeating on 24 ends and 48 picks for face, and 8 end twill for back.

6. Give the extent of the following triple cloth designs constructed on the principle of 1 face, 1 middle, 1 back; 4 end twill for face and middle, 2 end plain weave for back; 6 end twill for face, 4 end twill for middle, and 6 end twill for back; 16 end twill for face, 8 end twill for middle, and 4 end twill for back.

7. Give the several important steps in the production of a triple cloth design.

8. Can the relative position of the binders, or the system of binding used, affect the number of harnesses on which a design may be woven?

9. Explain why the binding should be distributed evenly.

10. Make an original filling backed design and bind the back filling perfectly.

11. Make a filling backed design which if woven with a cotton warp and two wool fillings would hide the cotton; in other words, make a filling flush reversible.

12. Make an original design to show a fancy twill on the face, and backed with filling, on the 2 face, 1 back system. This design to repeat on 18 picks or more.

13. Make an original warp back design, using the 1 face, 1 back system. Bind perfectly, and give the drawing in and chain drafts.

14. Back the design shown at Fig. 171 with warp on the 1 face, 1 back system. Give drawing in and chain drafts.

15. Back the design shown at K, Page 128, with warp using 2 face, 1 back system. Give drawing in and chain drafts.

16. Make an original double cloth design; warp—1 face, 1 back; filling—1 face, 1 back. Give chain and drawing in draft, also a cut section of the first two picks.

17. Make a double cloth design on the 2 face, 1 back system, using Fig. 17, Page 123, for face weave, and the three harness prunella twill for back weave. Bind in the best possible manner.

18. Make a double cloth on 2 face, 1 back system, using Fig. 2, Page 122, for both face and back weave. Bind in $\frac{1}{4}$ twill order. Give drawing in and chain drafts on lowest possible number of harnesses.

19. Make an original triple cloth design. Give chain and drawing in drafts, also a cut section of the first three picks.

20. Make a triple cloth design on 1 face, 1 middle, 1 back system, using Fig. 205, Page 138, for face weave; Fig. 12, Page 125, for middle weave; and Fig. 19, Page 123, for back weave. This design should be perfectly bound.

REVIEW QUESTIONS

ON THE SUBJECT OF

TEXTILE DESIGN.

PART IV.

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1. Explain the method of making double plain designs, illustrating your explanation with an original design.

2. Name the different methods of making spot designs and give an example of each method.

3. Write about 200 words, discussing the various kinds of pile fabrics, giving at least four original designs.

4. Make a spot design on 32 x 32 squares on the extra warp principle; effect to be two spots arranged in plain order. Give drawing-in draft and harness chain.

5. (*a*) Give a comparison of piqué cloth and other fabrics. (*b*) Make an original piqué design using face and back warps, and face, back, and binder fillings.

6. Why is it necessary to continue a jacquard design until it repeats on even squares?

7. (*a*) How many hooks would have to be cast out of a "*three hundred*" jacquard machine to weave the design shown at Fig. 293? (*b*) How many would be cast out to weave Fig. 294?

8. Give a complete description of the method you would follow in distributing figures in sateen order.

9. Make a diagonal jacquard design similar to Fig. 306, being careful to make the figures and the diagonal repeat.

10. Make an original design showing both warp and filling figures. Give the number of hooks on which it could be woven, and the number of hooks which would be cast out if a "*four hundred*" machine were used.

REVIEW QUESTIONS

ON THE SUBJECT OF

TEXTILE DESIGN.

PART V.

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1. Give a general classification of cross-woven fabrics. In what respect does each division differ from the others?

2. How many picks are there in one repeat of plain gauze, and what are the positions of the harnesses on each pick?

3. Give twelve threads and eight picks of a plain gauze design, showing chain, harnesses, drawing in draft, and plan of cloth.

4. In what respect does a full gauze differ from a plain gauze?

5. Make a design with alternate stripes of plain gauze and full gauze. Each stripe should be at least eight threads wide.

6. Give the chain and plan of an original leno design similar to Fig. 316.

7. Write about three hundred words on the respective merits of Figs. 321 and 322.

8. Make an original design similar to Fig. 322, but occupying a larger number of threads and picks.

9. Make a design similar to Fig. 325, but limiting it to a smaller number of threads and picks.

10. What is the chief object of crossing the crossing thread under more than one ground thread?

11. Make an original design on the one-thread-crossing-more-than-one principle.

12. Make an original design combining a leno stripe with stripes of plain or twilled cloth.

13. How many methods are there of using color in textile designing?