Oct. 14, 1941. A. H. ADAMS, JR., ET AL 2,259,283

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Fig.1.

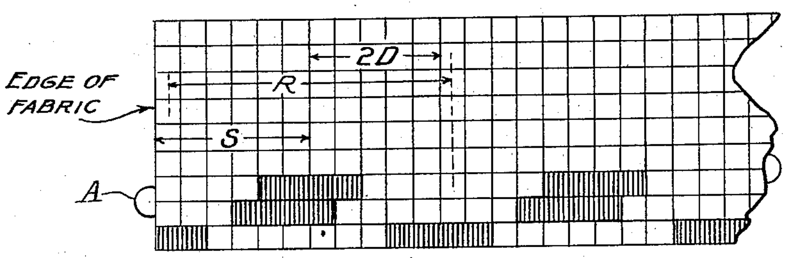

Fig.2.

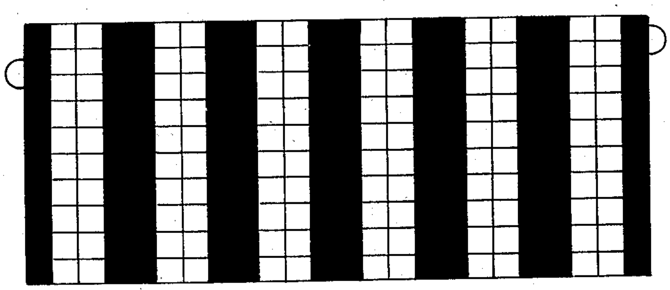

Fig.2a.

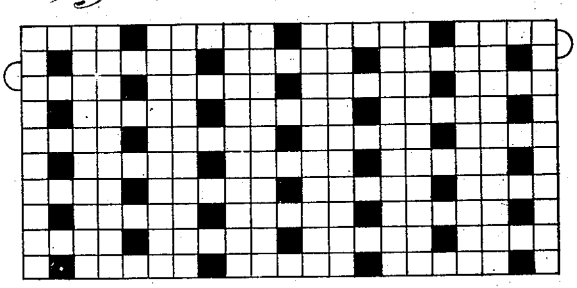

Fig.2b.

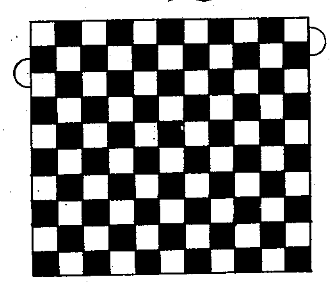

Fig.2c.

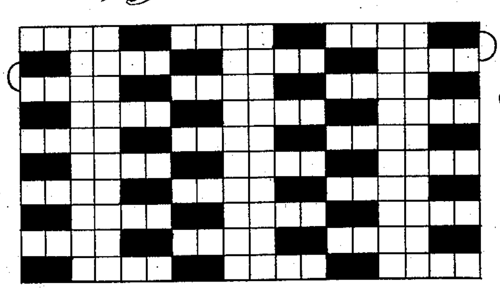

Fig.2d.

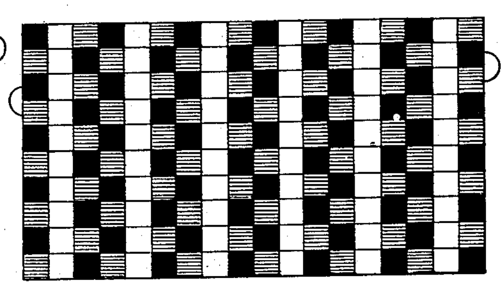

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Fig. 3.

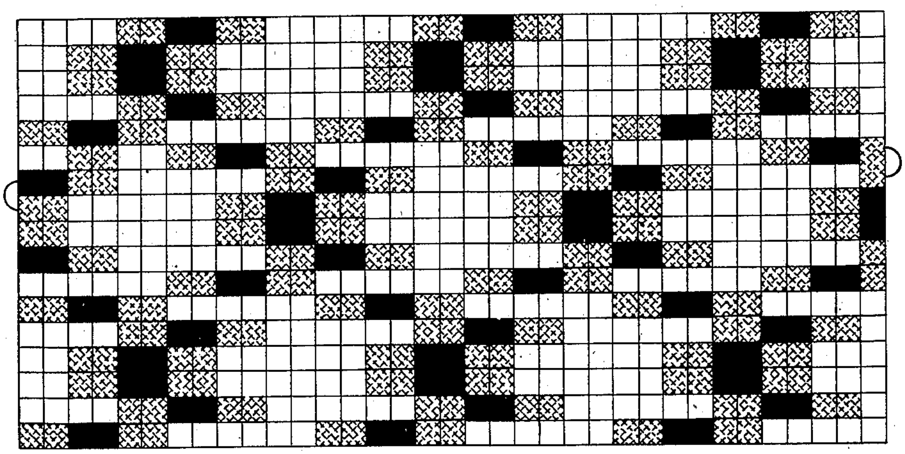

Fig. 3a.

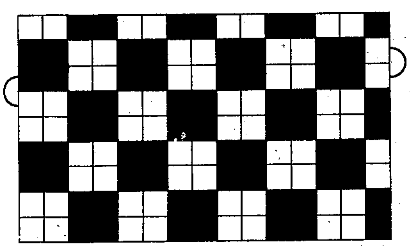

Fig. 3b.

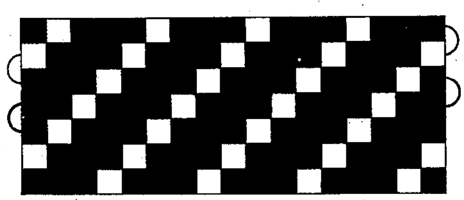

Fig. 3c.

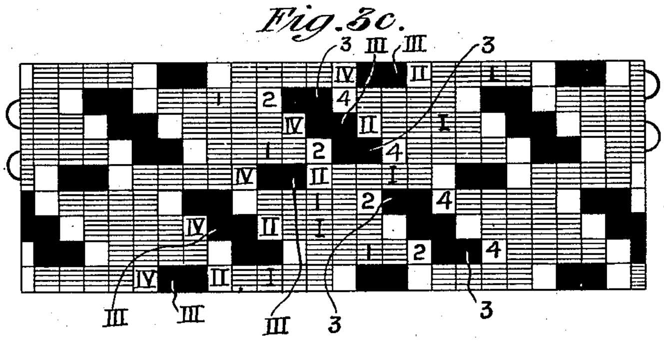

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Fig. 3d.

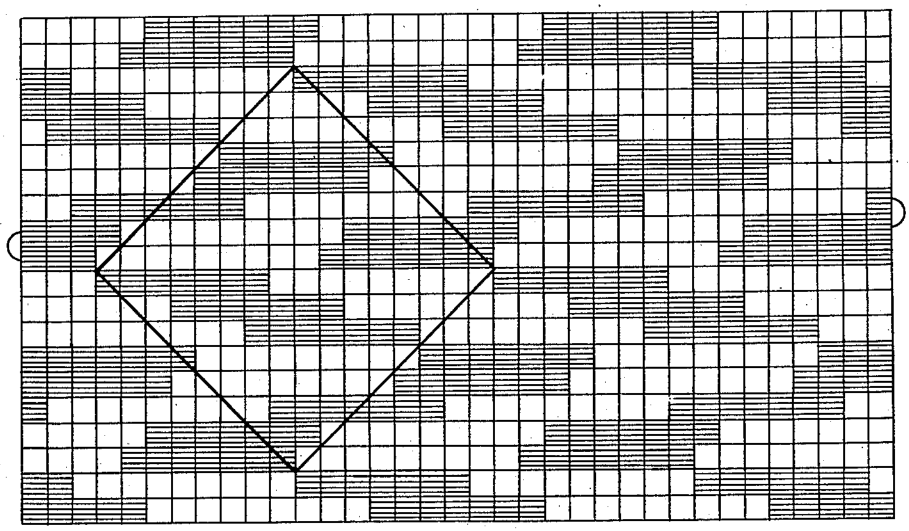

Fig. 3e.

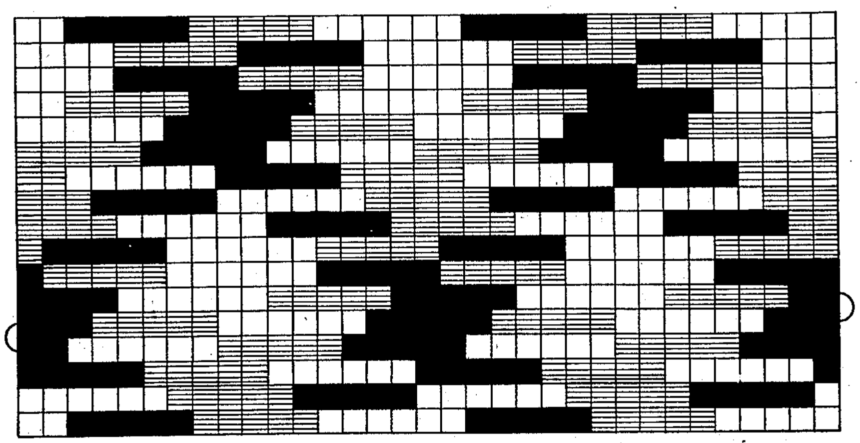

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Fig. 3f.

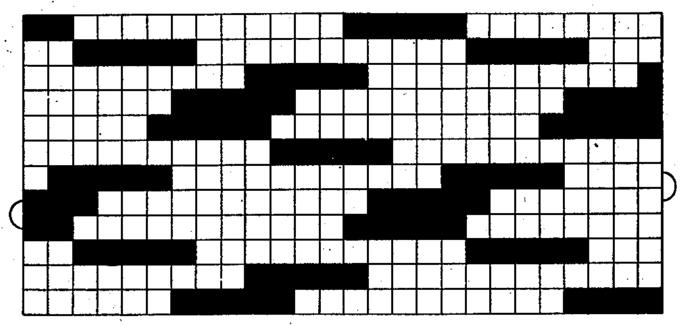

Fig. 3g.

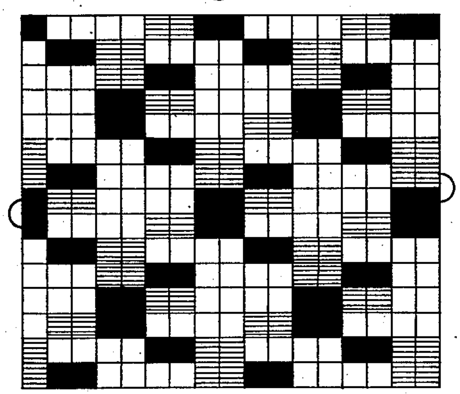

Fig. 3h.

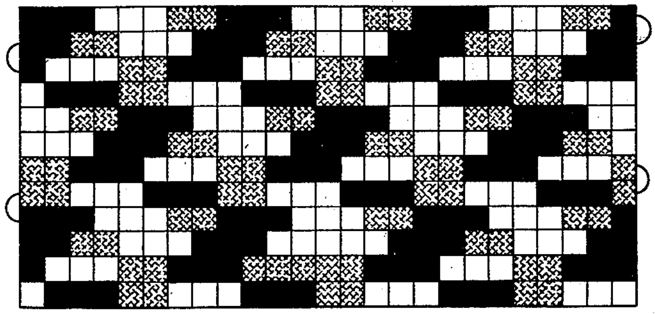

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Fig. 3i.

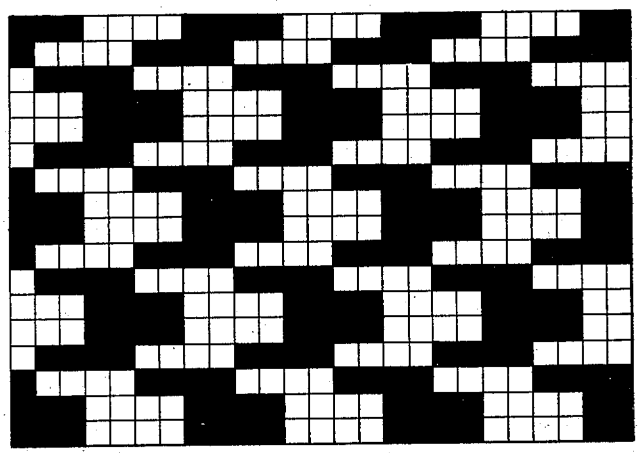

Fig. 4o.

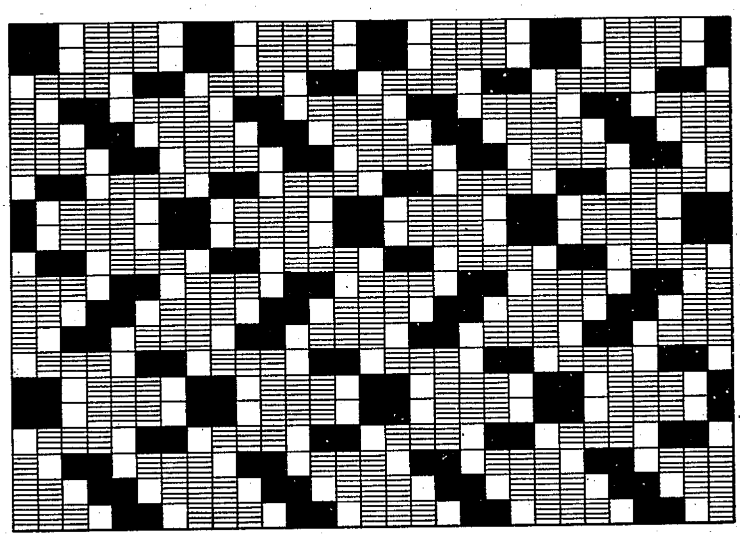

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Fig. 4.

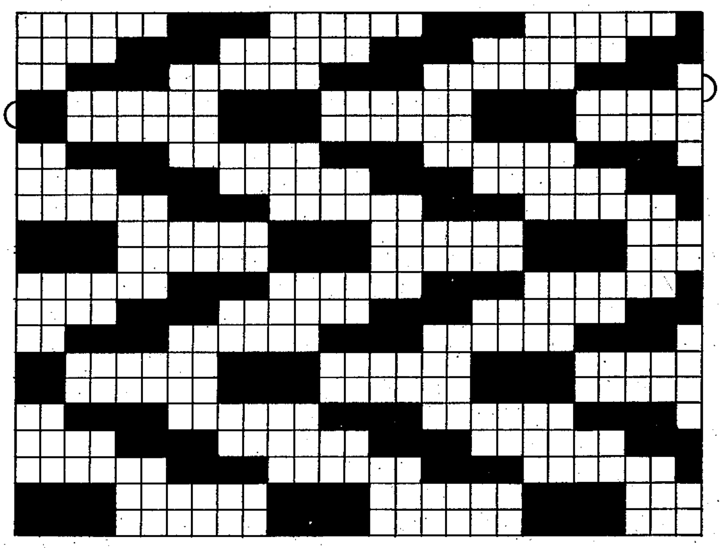

Fig. 4a.

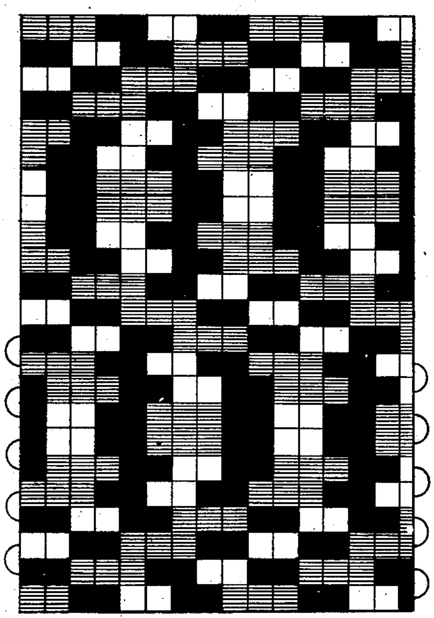

Fig. 4b.

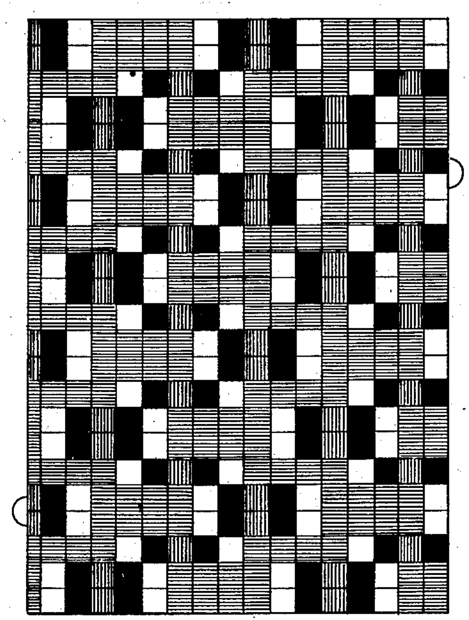

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Fig. 4c.

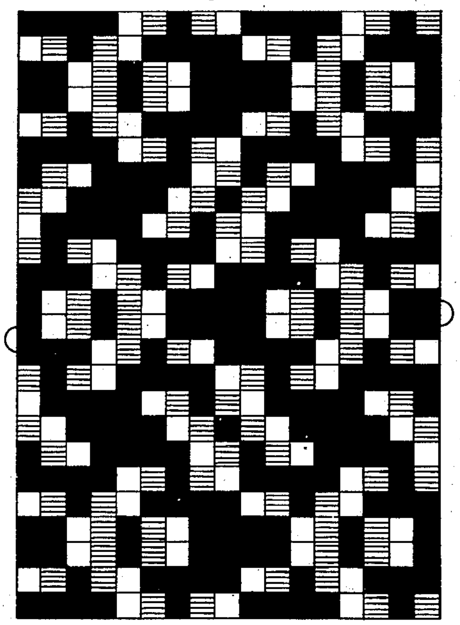

Fig. 4d.

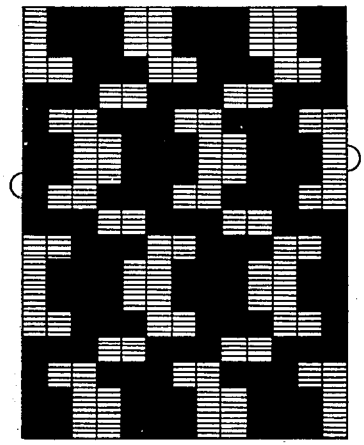

Fig. 4e.

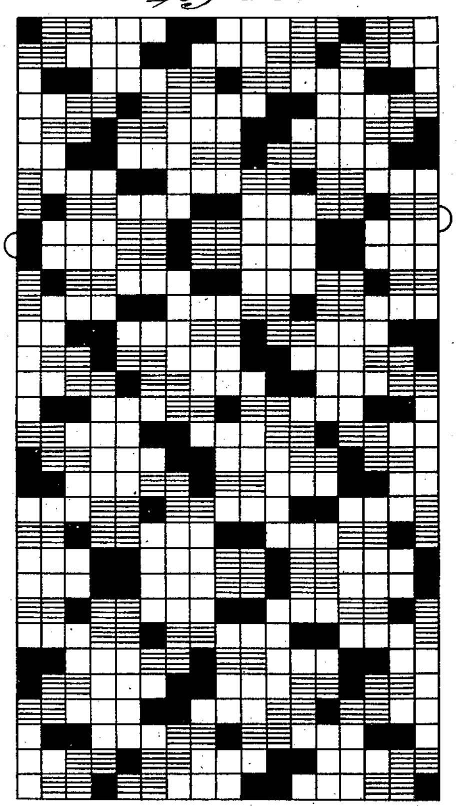

Fig. 4g.

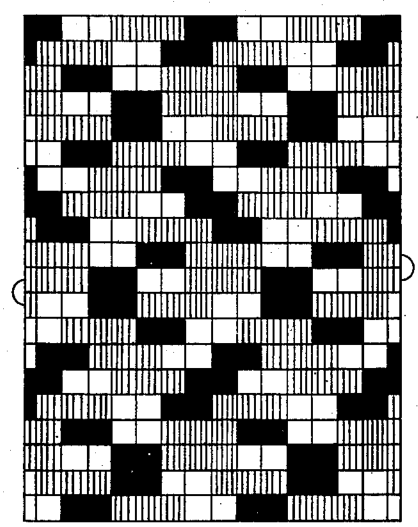

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Fig. 4f.

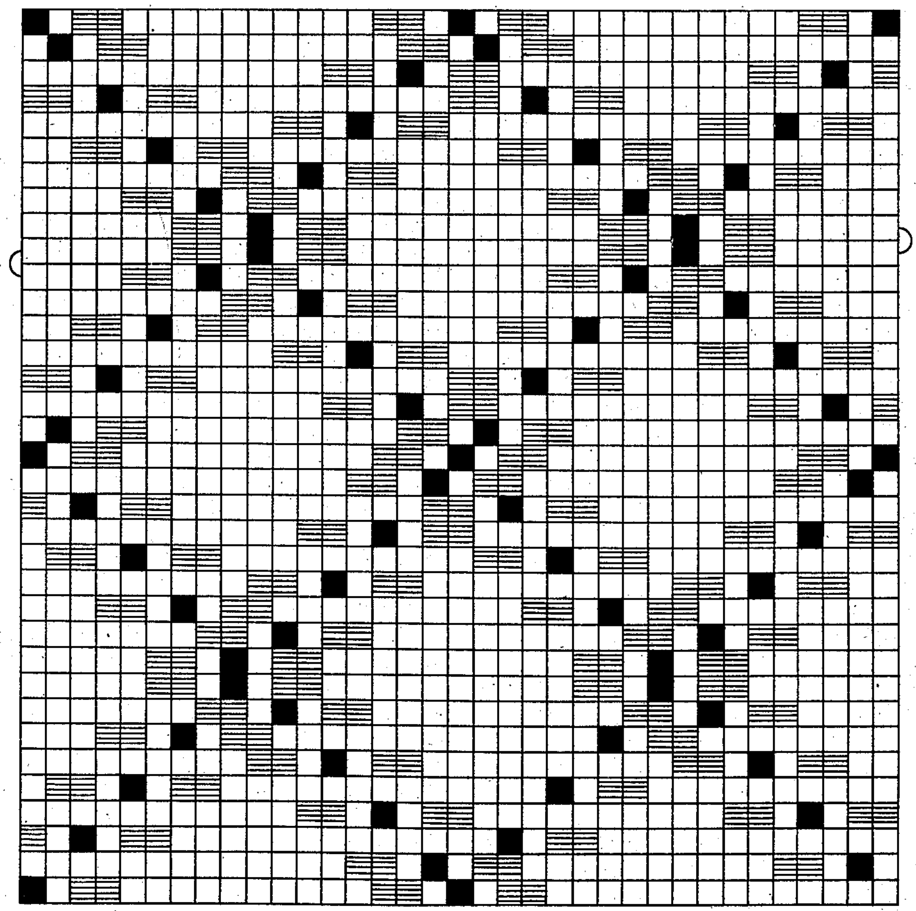

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Fig. 4h.

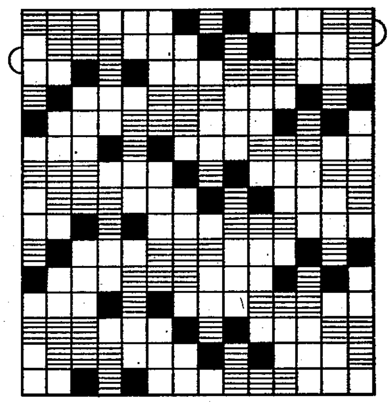

Fig. 4i.

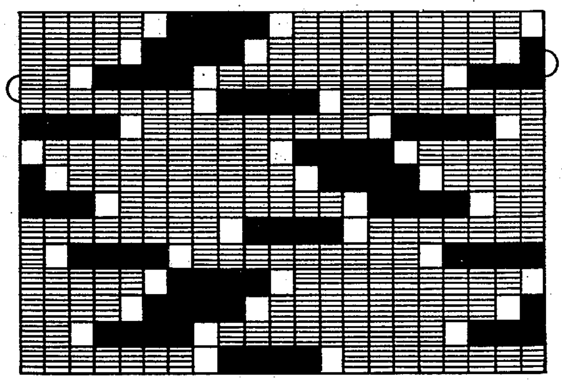

Fig. 4j.

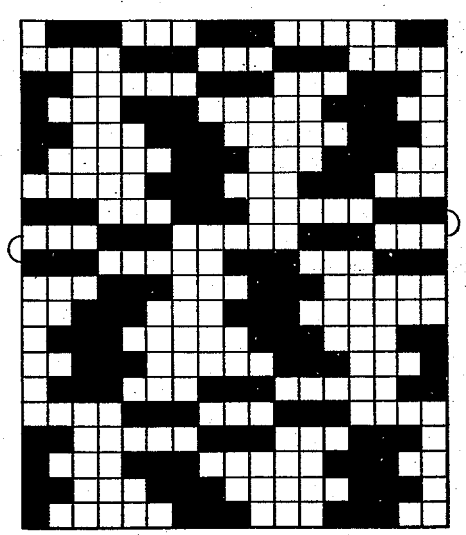

Fig. 4l.

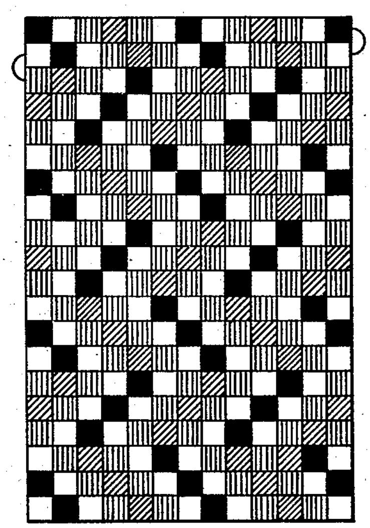

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Fig. 4k.

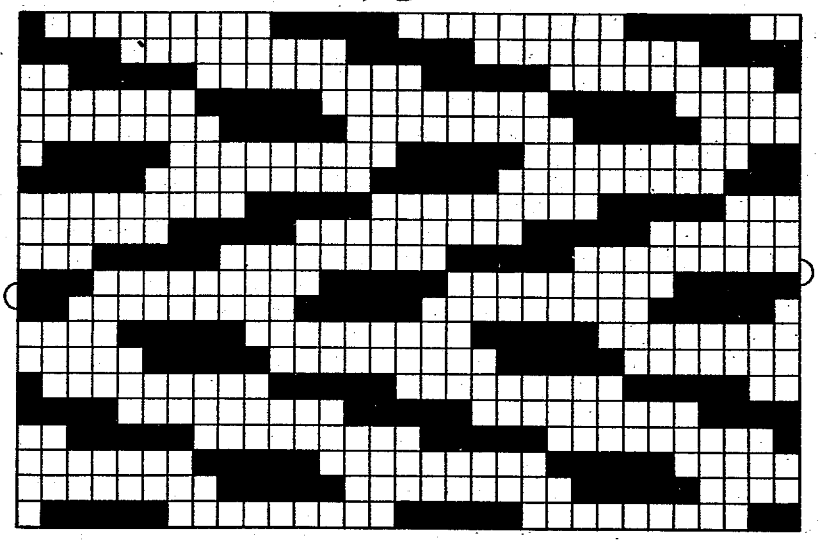

Fig. 4m.

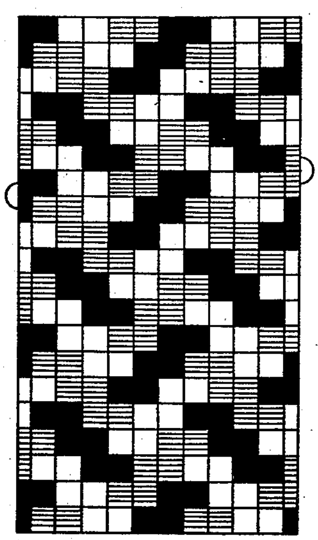

Fig. 4n.

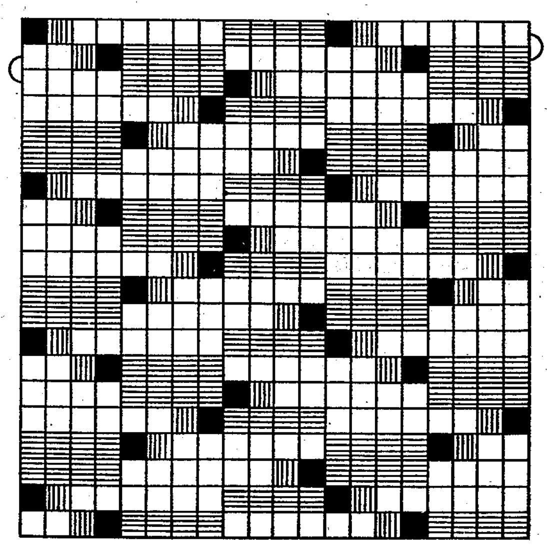

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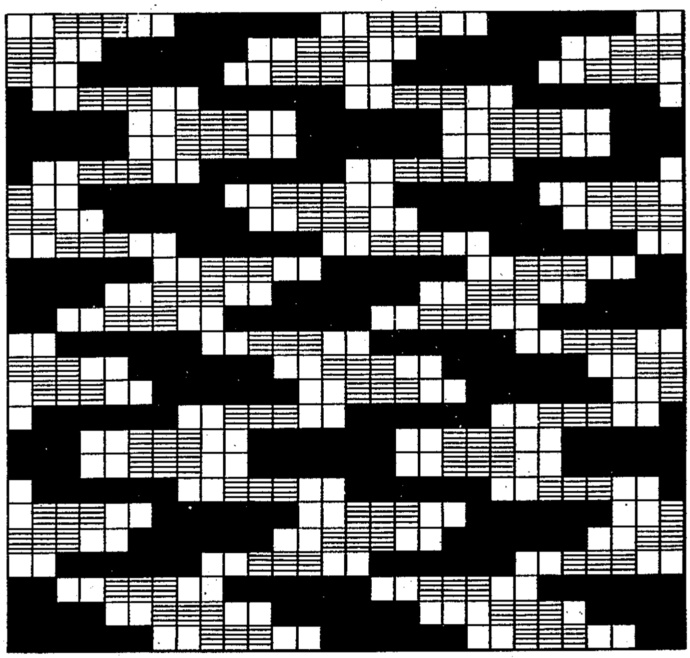
Fig. 4p.



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Patented Oct. 14, 1941 **2,259,283**

UNITED STATES PATENT OFFICE

2,259,283

TEXTILE FABRIC

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Application May 18, 1940, Serial No. 335,938

25 Claims. (Cl. 66—169)

This invention relates to new and useful improvements in textile fabrics, and more particularly in the planning of fabrics knit or crocheted of polychrome yarn.

Polychrome yarn consists of variously colored lengths recurring in cycles. Such yarn may be knit into fabrics having a predetermined design by automatic machines as disclosed in Patent 2,186,814 to A. H. Adams, or manually in accordance with the process disclosed in application Serial No. 327,247, filed April 1, 1940, by Florence D. Leech, now Patent No. 2,228,633. In all the designs to be hereinafter disclosed, we are recommending that the method disclosed in the last mentioned application be followed by controlling in planned relation the length of the cycle and of the yarn used in each stitch and by controlling the color that goes into each stitch.

The object of the present invention is to plan color pattern or designs in flat fabrics knitted or crocheted of polychrome yarn, and to lay down the rules underlying such planning. Whereas, as disclosed in said patent to A. H. Adams with a single yarn only fabrics having continuous or interrupted vertical stripes, and diagonals and zig-zags running in one direction can be produced, by following the teachings of this disclosure many other entirely unexpected designs will be obtained, including intersecting diagonals, true checks (as distinguished from interrupted vertical stripes).

The definite planning of designs is made possible in accordance with the present invention by predetermining the relation to each other of the width of tne fabric, the length of the colored spot cycle on the yarn and the position of this or one spot with respect to the edge of the fabric.

We have discovered that all designs have in common the characteristic that the lateral (i. e., phase) displacement of the colored spot cycle every second row is equal to twice the difference between the width of the fabric and a multiple of one-half the colored spot cycle (given as a number of stitches). Another way of stating this is that all designs consist of some arrangement of two sets of intersecting diagonals, one set being a mirror image of the other, one set occupying the even courses or rows and the other the odd courses as shown in Fig. 3*c*.

These and other features of the invention and specific embodiments thereof will now be explained in detail.

In the drawings portions of knitted or crocheted fabrics are illustrated by colored spots made up of as many stitches as is indicated by the squares. In some of the figures each square represents two adjacent halves of different stitches. In knitting, it is possible to make the simple knitting stitches so that each one-half stitch is separtely colored and each colored spot occupies one-half of each of two adjacent stitches. Each horizontal row of spots represents a course of the fabric.

Fig. 1 illustrates the definitions of the expressions which will be used;

Figs. 2, 2*a*, 2*b*, 2*c* and 2*d* type I patterns;

Figs. 3, 3*a*, 3*b*, 3*c*, 3*d*, 3*e*, 3*f*, 3*g*, 3*h*, 3*i* type II patterns; and

Figs. 4, 4*a*, 4*b*, 4*c*, 4*d*, 4*e*, 4*f*, 4*g*, 4*h*, 4*i*, 4*j*, 4*k*, 4*l*, 4*m*, 4*n*, 4*o*, 4*p* type III patterns.

Referring now to Fig. 1:

R=the number of stitches that can be formed by a color cycle, measured from the center of a particular spot under consideration, to the center of the next corresponding spot. For the same yarn R may be different depending on the colored spot selected for observation. In other words, in the same yarn one might detect several color cycles of different phase or frequency.

In Fig. 1, R=11 for the white spots shown.

D=the difference between the width of the fabric in stitches and a multiple of R/2.

D is positive if the width of the fabric is more than, and negative if the width of the fabric is less than a multiple of R/2 and is normally taken at the smallest possible positive or negative integral value. If R is even, then D will be equal to or less than ±R/4. If R is odd, then D will normally be the difference between the width of the fabric and a multiple of R, and will be equal to or less than ±R/2, (D in Fig. 1, however, is shown not integral).

2D (in Fig. 1=5) will always be equal to the lateral displacement of any colored spot of the yarn in the fabric with reference to the position of the corresponding spot in the second course above or below. These spots will form a vertical row in the fabric if D=0 or diagonal rows of varying slopes depending on the value of 2D.

S=the position of the center of symmetry of the color cycle relative to the left edge of the fabric in a course which at the right doubles back to form the course above and at the left doubles back to form the course below (A). If the color cycle selected is not symmetrical then S refers to an arbitrarily selected point in the color cycle. In this connection it should be borne in mind that any sequence of colored spots, continuous or discontinuous, may be considered as a color cycle; even a single recurring spot.

S is a symbol having several discrete values in any one pattern. For instance, in Fig. 3*a*, S measured to the center of the black spot is =1, 3, or 5, etc. In other words, since S is the position of the center of symmetry of the color cycle relative to the left edge of the fabric in a course which at the right doubles back to form the course above and at the left doubles back to form the course below, and since there are often many such courses not alike, and many centers of symmetry of the color cycle in each course, S has therefore several discrete values. S still serves a useful purpose. In Fig. 3*a* for example, S is definitely an odd integer, 1, 3, 5, etc., which distinguishes this pattern from Fig. 3*b* in which S is=½, 2½, 4½, etc.

This difference makes Fig. 3*a* a double check, and Fig. 3*b* a diagonal.

The lowest value of S, as in Fig. 3*a* the value 1, and in Fig. 3*b* the value ½, are most convenient to use.

There may be several S values in a fabric, and the pattern can be identified by any S value. To any S value one can add at will $\pm n$(2D) and/or $\pm n'$(R/2) without changing the pattern except as related to the edges. The pattern will merely shift. The following S values all give the same pattern except for shifts or reversals: S=x, R−x, R/2±x, D±x, R/2+D±x, and any of the above ±2D.

N=the greatest common divisor of R and 2D.

The number of courses in a normal fabric pattern repeat will always be 2R/N, or 2.

"Normally"=assuming the pattern is planned as an integral number of equal stitches, each stitch solidly colored, R, D, and S being integral.

Fabric patterns are made of an elementary unit which is repeated, the same side up. The elementary unit may contain parts which repeat within it, or parts which are similar but inverted. Elementary or unit repeating areas are, therefore, the smallest areas into which a pattern can be subdivided, all these areas being exactly alike in all respects (appearance, orientation, etc.).

One should never take these only one or two courses in height. Patterns which are composed of continuous straight stripes have indefinite unit repeating areas. The unit repeating area for the pattern formed by one color or several colors in a fabric is the smallest area into which the fabric can be subdivided, all these areas being identical in respect to the pattern of that color or colors.

By "area" of the pattern is meant the product of the width in stitches by the height in courses.

The vertical repeat length for any color pattern is the smallest vertical length into which it can be subdivided, each such length along a vertical path being identical. In a fabric that has several detectable patterns superimposed, the vertical repeat length for one color or several colors is the smallest vertical length into which the pattern can be subdivided, each such length along a vertical path being identical in respect to the pattern of that color or colors.

180° symmetry: The pattern may be turned at an angle of 180° without being altered.

Top-bottom mirror symmetry: The pattern may be horizontally divided into mirror image halves, the reversal being from top to bottom.

Right-left mirror symmetry: The pattern may be horizontally divided into mirror image halves, the reversal being from right to left.

We have divided into three types the patterns that can be planned in accordance with the present invention.

Type I

Assuming that each stitch uses up one inch of yarn a multi-colored yarn having, say alternate black and white spots, each two inches long, can be knit into a fabric illustrated in Fig. 2. There will be vertical black and white stripes, each two stitches wide. R=4; S=0 in every course; and D=0. The pattern has all the three symmetries.

Variations of this striped pattern are possible by making S=R/2, by varying the colors and lengths of the spots. All striped patterns repeat vertically in every course.

Any pattern that repeats every course or every two courses is a type I pattern. A few are shown in Figs. 2*a*–*d*. All type I patterns have the three symmetries, and D=0.

It will be noticed in these and particularly in the designs to follow, that each stitch of the fabric (each square) is sufficiently large to constitute a noticeable portion of the design but in many cases the diagonal or vertical rows of spots disappear as visual elements of the pattern. The relative positions of the spots in the odd and even courses will be such that entirely new and unexpected patterns will emerge.

In Fig. 2*a* R=6, D=0, S for the black spot=1½; in Fig. 2*b*, R=2, D=0, S for the white spot=1½; Fig. 2*c* is a zig-zag pattern in which R=6, D=0, S for the black spot=1; and Fig. 2*d* is a vertical white stripe combined with a black and a blue zig-zag, and in which R=3, D=0, S for the black spot=½.

Type II

This is illustrated in Figs. 3–3*e* in each of which the length of the pattern repeat, taken vertically is a multiple of four courses. Any pattern in which the length of the repeat is a multiple of four courses is a type II pattern. All of these except Fig. 3*b* consist of a regularly repeating figure corresponding points of which may be joined in a diamond as indicated in Fig. 3*d*. When in a type II pattern (or any pattern) S equals 0, or R/2, or D, or D+R/2, then it has top-bottom mirror symmetry and either both or neither of the other two symmetries. When in a type II pattern S does not equal 0, nor R/2, nor D, nor (D+R/2) then the pattern has either no symmetry or only 180° symmetry. The unit repeating area in type II patterns is R^2/N.

The normal formula for type II is: R/N is even and D is not equal to 0. This makes the length of the pattern repeat come out a multiple of four courses.

Fig. 3 is a pattern having a repeating figure in a diamond spacing, with top-bottom mirror but no right-left mirror nor 180° symmetry. One color, e. g., yellow, occupies in the pattern two spots symmetrically placed about the center from which R is measured (e. g., the center of either the black or white spot). R=12; D=−1; S (for black)=1.

Fig. 3*a* is a double-check, i. e., a check in which each square occupies two courses. This is the only pattern of type II that has right-left mirror symmetry, R=4; D=R/4=1; S for the black spot=1. Double checks can be produced with S=0 or R/2 or (D+R/2) or D. The formula for a double-check is: D=R/4 and S=0, R/2, D, or D+R/2.

Fig. 3*b* is a diagonal. R=4; D=1; S for either the white or the black spot=½ (not in the same courses). The general formula for such diagonals is $R=4n$; $D=\pm n=\pm R/4$; $S=\pm n/2=\pm R/8$ n denotes any chosen integer.

Fig. 3*c* has 180° symmetry only, and is characterized by strong diagonal accents on the two diagonals. It may be called a broken diagonal. The centers of the repeating figure form perfect diamonds. R=8, D=1; S for the blue spot=1½.

Fig. 3*d* has 180° symmetry only and the centers of the repeating figure form perfect diamonds although the general appearance of the pattern is different from Fig. 3*c*, and is much more like the unrelated Fig. 4*k*. In this pattern R=16; D=3; S for the blue spot=½.

Fig. 3*e* is a black with 180° symmetry and strong diagonal accents (like Fig. 3*c*). The black and blue are similar in spacing but with different S producing a blue pattern which is the image of the black but inverted from top to bottom. The resulting combined pattern has no symmetry but the centers of the repeating figure form diamonds. R=16; D=1; S(black=½, S(blue)=5½, S(white)=11 (in the same course).

Fig. 3*f* is unsymmetrical but has the diamond spacing. R=16; D=2; S for the black spot=½.

Fig. 3*g* is a black C pattern having top-bottom mirror symmetry only, combined with a blue similar to the black pattern in yarn pattern spacing but having S different by an amount=2D, which is therefore similar to the black pattern but displaced vertically. This can also be regarded as a black pattern, combined with a white C pattern of different S, both on a common blue ground. In common with all other figures, it can also be regarded as consisting of intersecting diagonals of three colors. The combined pattern has no symmetry but has the diamond spacing. R=8, D=1, S(black)=0, S(blue)=2, S(white)=5.

Fig. 3*h* is a black broken diagonal pattern having 180° symmetry only combined with a white which is its image inverted from top to bottom, both on a common yellow ground. The pattern may also be regarded as the black of 180° symmetry combined with a yellow C pattern (i. e., yellow spots forming the letter C) of top-bottom mirror symmetry only, on a common white ground. The combined pattern has no symmetry, but it has the diamond spacing. R=8; D=1; S(yellow)=1; S(black)=6½, S(white)=3½ (all in the same course). In a different course S(white)=1½, which is=R−6½.

Fig. 3*i* is a C pattern. R=8, D=1, S=0.

Type III

Any pattern in which the length of the pattern repeat, taken vertically, is not a multiple of four courses nor is it every course or every two courses, is a type III pattern. When S=0, or R/2, or D, or (D+½R), then these patterns have all three symmetries. The unit repeating area in type III patterns is $2R^2/N$.

The normal formula for type III is R/N is odd, D is not equal to 0. This includes all R's not multiples of 4 if D is not equal to 0, and also multiples of 4 if D is even, multiples of 8 if D is multiple of 4, etc.

Fig. 4 is a herringbone in two colors which has all three symmetries. R=10; D=2; S for the black spot=0.

The normal formula for a herringbone is: R=4D±N, S=0, or R/2, or D or (D+R/2). Another normal formula is $R=N(2n+1)$, $D=\pm Nn/2$ or $\pm N(n+1)/2$ and S=0, or R/2, or D, or (D+R/2) (n has the same value in these three expressions).

When S does not=0, or ½R, or D, or (D+R/2), then type III has right-left symmetry and may have 180° symmetry, but have not top-bottom symmetry.

Fig. 4*a* is a herringbone in three colors having all three symmetries, though it differs in appearance from Fig. 4. The black forms two spots in each repeat, grouped symmetrically about the center from which R is measured (e. g., the center of either the blue or white spot). R=9; D=2; S(blue)=6½=D+R/2. The fabric shown in this figure is 15½ stitches in width; 9+4½+2. Another way of stating this would be that the width is a multiple of one-half of 9,+2. By adding 4½ more stitches of width to the drawing at the right-hand side and continuing the same pattern, one will obtain the whole piece of fabric which can exist separately and of which Fig. 4*a* shows only the pattern and R, D and S values.

Fig. 4*b* is a similar herringbone giving a different optical effect. It has all three symmetries. R=9; D=3; S(red)=0. The fabric shown in this figure is 16½ stitches in width, i. e., 9+4½+3. Another way of stating this would be that the width of the fabric is a multiple of one-half of 9,+3. By adding 4½ stitches of width to the right-hand side of the drawing and continuing the same pattern we would obtain an illustration of the whole piece of fabric of which only the pattern and the R, D and S values are shown in Fig. 4*b*.

Figs. 4*c*–*f* are patterns with all three symmetries, related to a herringbone (i. e., type III patterns with S=0) illustrating the widely different optical effects that can be attained.

Fig. 4*g* is a black pattern with all three symmetries on a red ground combined with a white pattern like it in yarn pattern spacing but with S different by an amount=2D, which is therefore similar but displaced vertically. The pattern can be described also as black and red combined on a white ground. The combined pattern has only right-left mirror symmetry. R=7; D=1; S(black)=3½, S(red)=1, S(white)=5½.

In Fig. 4*h* S for the short blue spot is not = to 0, R/2, D, or (D+R/2), but to 2½ with R=12 and D=2. The pattern has only right-left mirror symmetry.

In Figs. 4*i*–*l* S is not = to 0 or R/2, or D, or (D+R/2) but the patterns have both 180° and right-left mirror symmetry. Fig. 4*i* should be compared with Fig. 3*c*, and Fig. 4*k* with Fig. 3*d*. In Fig. 4*i* R=15, D=6, S for the blue spot = 5; Fig. 4*j* R=14, D=3, S for short white spot = 1½; Fig. 4*k*, R=14, D=3, S for the black spot = ½; Fig. 4*l*, R=6, D=1 S for the black spot = 1½.

Fig. 4*m* is a basket weave pattern like 4*l* combined with a similar white pattern on a blue ground. The combined pattern has only right-left mirror symmetry. R=6; D=−1, S(black)=½, S(white)=2½, S(blue)=4½.

The blue part of Fig. 4*n* is a herringbone pattern containing S=R/2. R=12; D=2;

S(black)=3½,

S(blue)=6, S(white)=11, S(red)=2½. S=0 would give the same blue pattern in a different lateral position. The black pattern has only right-left mirror symmetry, but the white has both 180° and right-left mirror symmetries. The combined pattern has only right-left mirror symmetry.

4*o* is a herringbone derivative. R=7, D=1, S=0.

4*p* is another herringbone derivative with R=13, D=2, S=0.

The following is a partial lift of typical patterns obtained with various R and D values. It includes all R's up to 20, with all integral D values. Many other patterns are possible besides those mentioned from the same R and D values.

The following additional general remarks apply to all three types of patterns:

To determine or classify patterns having fractional R, D, or S values one must reduce to a common denominator, and take the values of the numerators.

Changing R, D and S in proportion does not change the pattern except the proportion of height to width.

To get S=½, etc., normally requires a spot with which 1, 3, 5, etc., stitches can be formed. To get S=1, 2, etc., normally requires a spot with which 2, 4, 6, etc., stitches can be formed. However, note Fig. 4*m*.

TYPE I

R:D	Number of courses in pattern repeat measured vertically (2R/N in types II and III)	R/4D (take *D*=R/4 or less)	Characteristic types of pattern (other patterns are possible also)
R any value *D*=0 or R/2	2	∞	Vertical stripes and zig-zags and checks. (See Figs 2-2*d*.)
TYPE II (In all these there are at least two patterns for each with diffe rent ½ or whole number S values)			
4:1 or 4:3, 8:2, 16:4, 20:5, etc	4	1	Double checks (Fig. 3*a*) + diagonals (Fig. 3*b*) and others according to S.
8:1, 8:5, 16:2, etc	8	2	C's (Figs. 3*h*, 3*g*) broken diagonals (Figs. 3*c* and 3*b*) and others (Fig. 3*f*), according to S.
12:1, etc	12	3	Plaids (Fig. 3) derivatives of the above, taking more definitely the appearance of intersecting diagonal stripes (plaids, Fig. 3*e*) as R/4D increases. Other patterns.
16:1, etc	16	4	
20:1	20	5	
(24:1)	(24)	(6)	
16:3	16	4/3	Others (not plaids) (Fig. 3*d*).
20:3	20	5/3	
(24:5)	(24)	(6/5)	
TYPE III (In the narrow patterns given first in each line below, the same pattern is obtained with all ½ or whole number S values)			
3:1, 6:1, 6:2, 12:2, 9:3, 15:5, etc	6	3/2	The narrow patterns given first in each line—herringbones (Fig. 4). Other patterns give herringbones or basket weave patterns (4*k*, 4*l*) according to S. The slope of the herringbones and baskets becomes more horizontal and the patterns less interesting as value of D increases. The herringbones and baskets are obtained with a color cycle consisting of a single alternation of color. With more complex cycles other patterns are obtained.
5:1, 10:2, 10:3, 15:3, 20:4, etc	10	5/4	
7:2, 14:3, 14:4, etc	14	7/6	
9:2, 18:4, 18:5, etc	18	9/8	
11:3 (22:5)	22	11/10	
13:3 (26:6)	26	13/12	
15:4 (30:7)	30	15/14	
17:4	34	17/16	
19:5 (38:9)	38	19/18	
5:2, 10:1, 10:4, 20:2, 15:6, etc	10	5/2	Derivatives from the first herringbone or basket (Fig. 4*i*). The first one gives the most novel patterns. Plaids with all except the first one. Also other patterns.
7:3, 14:1	14	7/2	
9:4, 18:1	18	9/2	
11:5, (22:1)	22	11/2	
13:6, (26:1)	26	13/2	
15:7, (30:1)	30	15/2	
17:8, (34:1)	34	17/2	
19:9, (38:1)	38	19/2	
7:1, 14:2, 14:5, etc	14	7/4	Derivatives from the second herringbone or basket. The first three give the most novel patterns. Plaids can be made with the last four. Also other patterns.
9:1	18	9/4	
11:1	22	11/4	
13:1	26	13/4	
15:1	30	15/4	
17:1	34	17/4	
19:1	38	19/4	
11:4, (22:3)	22	11/6	Derivatives from other herringbones and baskets. Patterns are complex. Plaids can be made from the third and fourth.
13:5, (26:3)	26	13/6	
17:7, (34:3)	34	17/6	
19:8, (38:3)	38	19/6	
11:2	22	11/8	
13:2	26	13/8	
15:2	30	15/8	
17:2	34	17/8	
19:2	38	19/8	
13:4, (26:5)	26	13/10	
17:6, (34:5)	34	17/10	
19:7, (38:5)	38	19/10	
17:3	34	17/12	
19:3	38	19/12	
17:5, (34:7)	34	17/14	
19:6, (38:7)	38	19/14	
19:4	38	19/16	

In general plaids can be made when R>(10 or 12 D), D being taken at its smallest value. The slope of plaids tends to become more horizontal as D increases.

When R is rhythmically divided into approximately equal parts the pattern tends to become like that which would result from the smaller R with that same D value.

Starting with any pattern:

(*a*) If sign of S is reversed (i. e., a new S is used which is equal to R less the original S) and the direction of the yarn pattern is reversed, one gets the mirror image of the original pattern inverted from top to bottom.

(*b*) If the sign of S is reversed and then the amount ±D added to S, and the direction of the yarn pattern reversed, one gets the original pattern turned 180°.

(*c*) If the amount ±D is added to S, one gets the original pattern reversed from right to left and displaced vertically.

(*d*) If the sign of S is reversed and then the amount ±D added to S, and the direction of the yarn pattern reversed, and D reversed (by changing the width of the fabric), one gets the original pattern unchanged, except in its position in relation to the edges of the fabric.

Reversing the direction of the yarn pattern means keeping the spots by which S is measured unchanged, and reversing the rest of the pattern around these spots. If the yarn pattern is symmetrical reversing has no effect.

By means of *d*, the fabric width can be varied without changing the pattern. For continuous construction of fitted fabrics (i. e., where the fabric width must vary) this is useful and can be done by: (1) using symmetrical yarn patterns, and (2) controlling S by tightening or slackening the yarn and/or by choosing in which course and at which side of the fabric to add or drop the stitches.

By combining *b* and *d*, if the sign of D alone is reversed, one gets the original pattern turned 180°.

By combining *c* and *d*, if the sign of S is reversed, and the direction of the yarn pattern reversed, and the sign of D reversed, one gets the original pattern reversed from right to left.

By combining *a* and *d*, if S is increased by the amount ±D, and the sign of D is also reversed (by changing width of fabric), one gets the original pattern inverted from top to bottom.

A fitted garment can be made by using small R and D values and changing the width of the fabric from nR/2−D, to nR/2+D, to (n+1) R/2−D, or, if R is odd, changing from nR−D, to nR+D, to (n+1) R−D, etc. This will give a series of patterns which will be the same if the yarn pattern is symmetrical and S is suitably controlled by adding the stitches in appropriate positions in the fabric, and/or by tightening or slackening the yarn. The series of patterns can also be made to be right-left of top-bottom mirror images of each other, or to be alike but turned 180°.

The above rules determine the pattern that will be formed by any one repeating spot. For purposes of any one repeating spot R can be considered as the distance between its repeats. The same rules also apply in determining the type of symmetry and general character of the pattern if R is chosen as the distance between centers of a repeating symmetrical group of spots.

Any two patterns with the same R and D but different S can be superposed using a single yarn. Any two with one R a multiple of the other can be superposed.

The rules determining the type of symmetry are based either on a single repeating spot, or on a repeating group of spots symmetrical about a center, R being measured from the center. Therefore, starting with any pattern, the variations which can be produced without altering the type of symmetry include any shifts, and additions or removals of spots that are symmetrical about the point from which R is measured. However, an exception is if spots are so added or shifted as to produce a smaller R, such as half the original R. Then the pattern may take on additional symmetries. This may be true for one color only in the pattern, or for the whole pattern.

Other possible variations (which usually alter the type of symmetry) are unsymmetrical about the center from which R is measured. These may be considered as new groups of spots having (usually) the same R and D, but different S superposed on the original spots. These variations tend to destroy all symmetry except right-left mirror symmetry. The fabric pattern made of two combined fabric patterns has never any more types of symmetry than the symmetry that is common to the two, and may have less.

Where two patterns are combined which are similar in the spacing of the colored spots but in which S is different by a multiple of 2D measured in any one course, the result will be a fabric having two similar but vertically displaced patterns. This is illustrated in Figs. 3*g*, 4*g* and 4*m*.

Where two patterns are combined which are similar in the spacing of colored spots but have one S the same in any one course as the other but reversed in sign (±2nD, and/or ±nR/2 can be added at will to the two S's together. S is considered reversed when one S=R less the other S), the result will be a fabric pattern one part of which is inverted from top to bottom from the other. This is illustrated in Fig. 3*e*.

Obviously, it is impossible to illustrate more than a few examples of the knitted or crocheted fabric designs that can be produced according to the present invention.

In the claims, the fabrics formed will be described as "looped" and the method of forming the fabric as "looping" to define knitted and crocheted fabrics and the method of knitting and crocheting as distinguished from woven fabrics and the method of weaving.

What is claimed is:

1. The method of planning the looping by hand of fabrics from polychrome yarn comprising, predetermining in relation to each other the width of the fabric, the length of the color cycle, and the position of the cycle with respect to the edge of the fabric.

2. A flat fabric looped by hand of a single polychrome yarn which has definite and predetermined R, D and S values, R being the number of stitches that can be formed by a color cycle, D the difference between the width of the fabric and a multiple of R/2, and S the position of the color cycle relative to the edge of the fabric.

3. The method of planning the looping of fabrics from polychrome yarn comprising, predetermining in relation to each other the length of a color cycle in the yarn, the width of the fabric, and the position of the color cycle with respect to the edge of the fabric, so that R, D and S require for their expression only whole numbers and halves, and D is not greater than ±6 for double crocheting and ±3 for single crocheting or knitting, where R is the number of stitches that can be formed from one color cycle, D is the smallest difference between the width of the fabric and a multiple of R/2, and S is the distance from the edge of the fabric to the center of symmetry of the color cycle.

4. The method of planning the looping of fabrics from polychrome yarn comprising, predetermining in relation to each other the width of the fabric, the length of the color cycle, and the position of the color cycle with respect to the edge of the fabric remembering that the number of courses in a fabric pattern repeat will always be 2R/N, so planning that 2R/N will be a reason-

ably small number, where R is the number of stitches that can be formed by a color cycle, N is the greatest common divisor of R and 2D, and D is the difference between the width of the fabric and a multiple of R/2.

5. A flat fabric looped of a single polychrome yarn which has definite and predetermined R, D and S values, R being the number of stitches that can be formed by a color cycle, D the difference between the width of the fabric and a multiple of R/2, and S the position of the color cycle relative to the edge of the fabric, and in which 2R/N is a small number, N being the greatest common divisor of R and 2D.

6. The method of planning flat looped fabrics to be made from continuous polychrome yarn containing a repeating cycle of colored spots, comprising planning in relation to each other the length of a detectable cycle in the yarn, the width of the fabric, and the phase of the cycle in relation to the edge of the fabric, whereby the colored spots occur in the fabric in diagonal or vertical rows, each row consisting of spots in the odd or in the even courses, planning the stitches sufficiently large and so that the diagonal or vertical rows of spots will at least partly disappear as visual elements of the design, and by the relation of the position of individual spots in the odd courses to individual spots in the even courses new and unexpected configurations are formed whose outlines are more compelling to the eye than the diagonal or vertical rows.

7. A flat fabric looped of a single polychrome yarn containing a repeating cycle of colored spots, in which the colored spots occur in the fabric in diagonal or vertical rows, each row consisting of spots in the odd or in the even courses, D/R being sufficiently large so that the diagonal or vertical rows of spots at least partly disappear as visual elements of the design, and the individual spots in the odd courses form with the individual spots in the even courses new and unexpected configurations whose outlines are more compelling to the eye than the diagonal or vertical rows, where D is the smallest difference between the width of the fabric and a multiple of R/2, and R is the number of stitches that can be formed from one color cycle.

8. The method of planning the looping of fabrics from a single polychrome yarn and containing simple geometrical patterns other than intersecting or vertical stripes, comprising predetermining in relation to each other the length of a color cycle in the yarn, the width of the fabric, and the position of the color cycle with respect to the edge of the fabric, so that R is a multiple of D less than eleven D, where R is the number of stitches that can be formed by one color cycle, and D is the difference between the width of the fabric and a multiple of R/2.

9. The method of planning the looping of fabrics containing noticeable double check patterns from a single polychrome yarn comprising, predetermining in relation to each other the width of the fabric, the length and sequence of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that $R=4n$, $D=\pm n=\pm R/4$, and $S=0$, or $\pm D$, where S is the position relative to the edge of the fabric of a center about which a detectable color cycle is symmetrical, R is the number of stitches that can be formed by the color cycle, and D is the difference between the width of the fabric and a multiple of R/2.

10. The method of planning the looping of fabrics with a single polychrome yarn and having readily noticeable diagonal stripes comprising, predetermining in relation to each other the width of the fabric, the length and sequence of a repeat in the yarn, and the position of the yarn pattern with respect to the edge of the fabric so that $R=4n$, $D=\pm n=\pm R/4$, $S=\pm n/2=\pm R/8$, where R is the number of stitches that can be formed by a certain detectable symmetrical color cycle, D is the difference between the width of the fabric and a multiple of R/2, and S is the position relative to the edge of the fabric of a center about which the chosen color cycle is symmetrical.

11. The method of planning the looping of fabrics from a single polychrome yarn and containing zig-zag vertical rows of spots of like color as elements of the design which in alternate courses are identical, comprising predetermining in relation to each other the width of the fabric, the length and sequence of a color cycle of the yarn, and the position of the cycle with respect to the edge of the fabric so that the width of the fabric is a multiple of R/2, and S is not equal to 0 or R/2, where R is the number of stitches that can be formed by a certain color cycle, and S is the distance from the edge of the fabric to a center, if any, about which that color cycle is symmetrical.

12. The method of planning the looping of fabrics from a single polychrome yarn and containing a color pattern of diagonal stripes at least partly broken longitudinally and inter-connected transversely, every fourth course, comprising predetermining in relation to each other the width of the fabric, the length and sequence of a color cycle of the yarn, and the position of the cycle with respect to the edge of the fabric so that $R=\pm 8D$ and $S=\pm D/2$, where R is the number of stitches that can be formed by a detactable symmetrical color cycle, D is the difference between the width of the fabric and a multiple of R/2, and S is the distance from the edge of the fabric to the center about which the chosen color cycle is symmetrical.

13. The method of planning the looping of fabrics from a single polychrome yarn and containing color patterns having right-left mirror symmetry, of which the repeat length measured vertically is not a multiple of four courses, and the unit repeating area is equal to R times this length, in which corresponding color pattern points in these unit areas form horizontal and vertical rows comprising, predetermining in relation to each other the width of the fabric, the length of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that R/N is odd and D is not equal to zero, where R is the number of stitches that can be formed by a certain color cycle, N is the greatest common divisor of R and 2D, and D is the difference between the width of the fabric and a multiple of R/2.

14. The method of planning the looping of fabrics from a single polychrome yarn and containing color patterns without right-left mirror symmetry, of which the repeat length measured vertically is a multiple of four courses, and the unit repeating area is usually equal to R/2 times this length, in which corresponding color pattern points in these unit areas form a diamond spacing, comprising predetermining in relation to each other the width of the fabric, the length of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that R/N is

even, and D is not= 0, and if D is $=\pm R/4$, S is not = 0, R/2, D, or D+R/2, where R is the number of stitches that can be formed from a certain color cycle, D is the difference between the width of the fabric and a multiple of R/2, N is the greatest common divisor of R and 2D, and S is the position with respect to the edge of the fabric of a center if any exists about which the chosen color cycle is symmetrical.

15. The method of planning the looping of fabrics from a single polychrome yarn and containing color patterns with 180° symmetry but without right-left mirror symmetry and top-bottom mirror symmetry of which the repeat length measured vertically is a multiple of four courses, the unit repeating area is usually R/2 times this length, and corresponding points in these areas form a diamond spacing, comprising predetermining in relation to each other the width of the fabric, the length and sequence of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that R/N is even and D is not equal to 0 and

$$S \text{ is } =\frac{nR+D\pm 2n'D}{2}$$

where R is the number of stitches that can be formed from a certain detectable symmetrical color cycle, D is the difference between the width of the fabric and a multiple of R/2, N is the greatest common divisor of R and 2D, n and n' are any integers, and S is the position of the center of symmetry of that color cycle measured from the left edge of the fabric in a course which at the right doubles back to form the course above, and at the left doubles back to form the course below.

16. The method of planning the looping of fabrics from a single polychrome yarn and containing a herringbone color pattern comprising, predetermining in relation to each other the width of the fabric, the length of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that $R=\pm 4D+N$, S=0, or R/2, or D, or (D+R/2), where R is the number of stitches that can be formed by a certain detectable symmetrical color cycle, D is the smallest difference between the width of the fabric and a multiple of R/2, N is the greatest common divisor of R and 2D, and S is the position relative to the edge of the fabric of the center about which the color cycle is symmetrical, measured from the left edge of the fabric in a course which at the right doubles back to form the course above, and at the left doubles back to form the course below.

17. The method of planning the looping of fabrics from a single polychrome yarn and containing a herringbone color pattern comprising, predetermining in relation to each other the width of the fabric, the length of a color cycle, and the position of this color cycle with respect to the edge of the fabric so that $R=N\ (2n+1)$, $D=\pm N\ n/2$, or $\pm\ N(n+1)/2$, and S=0, or R/2, or D, or (D+R/2), where R is the number of stitches that can be formed by a certain detectable symmetrical color cycle, N is the greatest common divisor of R and 2D, S is the position of the center of symmetry of that color cycle measured from the left edge of the fabric in a course which at the right doubles back to form the course above and at the left doubles back to form the course below, n is any integer, and D is the smallest difference between the width of the fabric and a multiple of R/2.

18. The method of planning the producing of a mirror image, inverted from top to bottom of a given pattern of a fabric looped from polychrome yarn, comprising predetermining in relation to each other the width of the fabric, the length and sequence of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that S is equal to R less the S of the given pattern and the direction of the color cycle is reversed, and R and D are the same as in the given pattern, where S is the position of any spot of a color cycle relative to the edge of the fabric measured from the left edge of the fabric in a course which at the right doubles back to form the course above and at the left doubles back to form the course below, and both S's being measured to corresponding spots, R is the number of stitches that can be formed by the color cycle, and D is the difference between the width of the fabric and a multiple of R/2.

19. The method of planning the reversing from right to left of an original pattern of a fabric looped from polychrome yarn comprising, predetermining in relation to each other the width of the fabric, the length of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that $\pm$D is added to S and D and the color cycle are the same as in the original where D is the difference between the width of the fabric and a multiple of R/2, R is the number of stitches that can be formed by a certain color cycle, and S is the position of any point in the color cycle measured from the left edge of the fabric in a course which at the right doubles back to form the course above and at the left doubles back to form the course below, both S's being measured to corresponding points in the color cycle.

20. The method of planning the looping of two fabrics of different width from a single polychrome yarn, both fabrics having similar patterns, comprising predetermining in relation to each other the width of the fabric, the length and sequence of a color cycle, and the position of the color cycle with respect to the edge of the fabric so that S in one fabric is equal to R less S and in the other $\pm$D, the color cycles in the two fabrics correspond when examined in opposite directions, and the value of D in one fabric is equal but opposite in sign to that in the other, where R is the number of stitches that can be formed from the color cycles, D is the difference between the width of a fabric and a multiple of R/2, and S is the position of any point of the color cycle measured from the left edge in a course which at the right doubles back to form the course above and at the left doubles back to form the course below and measured to corresponding spots in the two cycles.

21. The method of planning a fabric containing two superimposed similar but vertically displaced patterns looped from a single polychrome yarn comprising, predetermining in relation to each other the width of the fabric, and the length and phase of two color cycles, so that S measured to any point in one cycle of spots in the yarn as it lies in any course will differ from S measured to the corresponding point in another similar cycle of spots in the same course by a multiple of 2D, where S is the position of any point of a color cycle relative to the edge of the fabric, and 2D is the lateral displacement of any colored spot of the yarn in the fabric with reference to the position of the corresponding spot in the second course above or below.

22. The method of planning the looping of

fabric from polychrome yarn having a pattern part of which is similar to but inverted from top to bottom with respect to another part, comprising predetermining in relation to each other the width of the fabric, the length, sequence, and phase of two color cycles, and the position of the cycles with respect to the edge of the fabric so that two cycles are combined which are equal in length and similar in the spacing of colored spots, but reversed with respect to each other, and so different in phase that one S is equal to R less the other S in any one course, where S is the position as laid in the fabric of any point in a color cycle relative to the edge of the fabric, both S's being measured to corresponding points, and R is the number of stitches that can be formed by one cycle.

23. The method of planning the looping of fabric from polychrome yarn having a pattern part of which is similar to but inverted from top to bottom with respect to another part, comprising predetermining in relation to each other the width of the fabric, the length, sequence, and phase of two color cycles, and the position of the cycles with respect to the edge of the fabric so that two cycles are combined which are equal in length and similar in the spacing of colored spots, but reversed with respect to each other, and so related in phase that corresponding points in the two cycles coincide with the left edge of the fabric in the same course.

24. The method of planning the looping of fabrics from polychrome yarn comprising, predetermining in relation to each other the length of a color cycle in the yarn, the width of the fabric, and the position of the color cycle with respect to the edge of the fabric, so that R, D, and S require for their expression only whole numbers and halves, and D is not greater than —6 for double crocheting and —3 for single crocheting or knitting, where R is the number of stitches that can be formed from one color cycle, D is the smallest difference between the width of the fabric and a multiple of R/2, S is the distance from the edge of the fabric to the center of symmetry of the color cycle, and every stitch will be formed of a solid color.

25. The method of planning the looping of fabrics from polychrome yarn comprising, predetermining in relation to each other the width of the fabric, the length of the color cycle, and the position of the color cycle with respect to the edge of the fabric remembering that the number of courses in a fabric pattern repeat will always be 2R/N, so planning that 2R/N will be a reasonably small number, where R is the number of stitches that can be formed by a color cycle, N is the greatest common divisor of R and 2D, D is the difference between the width of the fabric and a multiple of R/2, and every stitch will be formed of a solid color.

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