A HANDBOOK OF WEAVES

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Translated and revised

by Samuel S. Dale, including

a supplement on the analysis of

weaves and fabrics and 1875 illustrations

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"STRAIGHT LINE" ANALYSIS OF WEAVES, PATTERNS AND FABRICS

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It seems peculiarly fitting that a treatise on weave construction such as the "Handbook of Weaves" should be supplemented by an explanation of the best method of analyzing weaves and fabrics. The "Handbook" explains and illustrates the construction of weaves; that is, the manner in which warp and filling threads are interlaced to produce the effect desired. This supplement to that work will explain how the weave and the fabric construction of a woven cloth are determined, enabling a manufacturer to obtain the details of the layout for any sample of woven goods that may be submitted to him.

WEAVE AND COLOR PATTERN ANALYSIS

The method by which the weave is determined from a given sample is very simple, but the process itself is frequently difficult because of the felted condition of wool cloth, which prevents the separation of the threads in the fabric. Cloths composed of cotton, linen, silk, lightly felted wool, or other textile material ordinarily offer no serious difficulty in determining the weave construction.

A needle, scissors, pencil and cross section paper are the only appliances required. A slender awl, such as is used by machinists, answers well as a needle for this work.

A square or oblong sample of the cloth to be analyzed or, to use a common expression, "picked out" is cut with the edges running as nearly straight with warp or filling threads as possible. Three or four square inches of the fabric is a convenient size to handle and usually large enough to give several complete color and weave patterns.

The threads, usually the filling, are then withdrawn from one side of the sample for one half or three quarters of an inch, leaving the other set of threads (the warp, if the filling is withdrawn) projecting from the edge of the cloth. These projecting threads are clipped close to the filling for about half an inch at the left.

The sample with the face to the operator is then drawn firmly over the index finger of the left hand and held at the right between the first and second fingers. At the left, where the projecting warp has been clipped, it is held between the thumb and first finger, with the projecting warp threads pointing up.

One filling thread is loosened along the clipped edge of the sample and for a short distance beyond, care being taken not to withdraw it completely from the projecting warp threads.

Holding the cloth firmly over the first finger, the operator, beginning with the first projecting warp thread, notes carefully whether these warp threads are above or below the filling thread that has been loosened from the cloth. After the color of the filling thread has been marked at the left of the draft, the position and color of each warp thread are marked on the cross section paper, the color being indicated by a letter at the top of the draft. A cross in a square indicates that the warp is above the filling at that point of intersection, and a blank square indicates that it is below. This operation is continued until a record of the warp threads in one or more complete color and weave patterns for the filling thread has been obtained. This filling thread is then withdrawn

and the same operation is repeated with the next filling thread, the work being continued until a record of the filling threads in one or more complete color and weave patterns has been obtained.

When it is impossible by the ordinary method to determine beyond question the order in which the warp threads lie in the cloth, the object can sometimes be attained by clipping some of the projecting threads and marking the short threads on the draft for identification. In this way a correct record for each warp thread is obtained. If in such a case the warp threads should be marked on the draft in the wrong order, it is often possible to correct these errors when the draft of an entire filling pattern has been obtained. It frequently happens, however, that this difficulty can be obviated by turning the sample quarter way around and raveling the warp instead of the filling thread by thread.

When the weave and color patterns in warp and filling have been determined, the weave draft, drawing-in draft, and color pattern are arranged in the form already explained in the "Handbook of Weaves."

Fig. 1875 shows the weave and thread drafts obtained by "picking out" a cross rib cloaking fabric. The 2-ply worsted warp threads are marked "W". The 2-ply cotton warp threads are marked "C". The marks at the left of the draft indicate the three kinds of filling: "5-p", 5-ply cotton; "2-p", 2-ply cotton; and "B", carded woolen backing.

The warp pattern is:

2 worsted, 2 ply
1 cotton, 2-ply
3

The filling pattern is:

1 cotton, 5-ply
1 cotton, 2-ply
1 carded woolen, single
3

The face weave of this cloth is the full rib weave shown at Fig. 212 and described in the "Handbook of Weaves" under "Cross Ribs". The carded woolen back filling is stitched by the cotton warp in a 3 up 1 down broken twill order in an area of 12 threads square.

THE "STRAIGHT LINE" ANALYSIS OF WOVEN FABRICS

The best method of analyzing woven fabrics is that known as the "straight line," which is based on the convenient relations existing between ounces per yard, square yards per pound, width of cloth in inches, number of threads per inch, and the English basis for numbering yarn. Developed in the mill by the writer, it was first made public in October, 1902, and has since then been extensively adopted in American and foreign mills, always with complete success. The attention of the textile trade and the public in this and other countries was directed to this method of cloth analysis in 1913 when the United States tariff on cotton cloth was revised, with the ad valorem rates adjusted to a sliding scale based on the average yarn number, determined by the "straight line" method.

The essential feature of this method consists in cutting a rectangular sample of the cloth to be analyzed so that it will have an area of $\frac{1}{300}$th square yard (4.32 square inches). This is called the standard sample.

Every warp and filling thread in 1 square inch of cloth represents 1 inch of yarn, and also represents 4.32 inches of yarn in 4.32 square inches ($\frac{1}{300}$th square yard) of cloth.

If, for example, a woven fabric has 50 warp threads and 40 filling threads per inch, there will be 90 lengths of warp and filling yarn, each 4.32 inches long, in the standard sample of $\frac{1}{300}$th square yard (4.32 square inches). If this standard sample weighs, say 5 grains, it follows that the warp and filling yarn in the sample will have an average of 18 of these lengths (4.32 inches) per grain.

This number, 18, is the cotton yarn number because cotton yarn is numbered in all parts of the world to indicate the number of 840-yard lengths per pound, which is equivalent to the number of 4.32-inch lengths per grain.

It follows that the average number (by the cotton system) of the yarn in a woven fabric is equal to the number of warp and filling threads per inch divided by the number of grains in the weight of $\frac{1}{300}$th square yard (4.32 square inches).

The size or count of any particular kind of yarn in a fabric, for example, warp, filling, back warp, back filling, face warp, face filling, is found by the same method; that is, dividing the number of threads of the yarn in question per inch by the number of grains in its weight.

The result thus obtained indicates the size or count of the yarn (by the cotton system) as it lies in the cloth. To determine the count of the yarn when spun it is necessary to estimate and make allowance for the changes in length and weight in weaving and finishing by reason of the take-up in twisting and weaving, shrinkage of length in finishing, and loss or gain in weight during these processes.

The weight per yard and number of yards per pound are found with equal facility by the "straight line" method. The standard sample ($\frac{1}{300}$th square yard) is equal to a sample .12 yard (4.32 inches) long and 1 inch wide. It follows that multiplying the grain weight of the standard sample by the width of the given fabric in inches will give the grain weight of .12 running yard of the goods.

The number of running yards of cloth per pound is equal to a pound (7000 grains) divided by the weight of one yard or to .12 pound (840 grains) divided by the weight of .12 yard.

It follows that the number of running yards of cloth per pound is found by dividing 840 by the product of

the grain weight of the standard sample and the number of inches in the width of the cloth.

840 ÷ (grain weight of sample × width in inches) = running yards per pound.

As there are $437\frac{1}{2}$ grains in an ounce, each grain in the weight of the standard sample is equivalent to 1 ounce per ($437\frac{1}{2} \times 4.32$) 1890 square inches. This is the area ($52\frac{1}{2} \times 36$) of a running yard $52\frac{1}{2}$ inches wide.

It follows that the number of grains in the weight of the standard sample (4.32 square inches) is equal to the number of ounces per running yard, $52\frac{1}{2}$ inches wide.

The number of ounces per running yard for any other width is found by proportion:

(grains × width in inches) ÷ $52\frac{1}{2}$ = ounces per running yard.

No special apparatus is required for the "straight line" system of cloth analysis. The cloth and yarn are weighed on an ordinary balance, such as is found in nearly every textile mill, with grain weights down to $\frac{1}{10}$th grain or smaller.

The standard sample (4.32 square inches) can be cut by a die, or with scissors or knife around a template of the required size. The sample may be of any convenient form so long as it is of the required area. 1.8 inches by 2.4 inches are convenient dimensions. If a smaller or larger sample is used, it can be made a fraction or multiple of 4.32 square inches.

Following are several sizes and corresponding dimensions:

Standard size ($\frac{1}{300}$ square yard) 4.32 sq. in.	(1.6 inches × 2.7 inches)
	(1.8 inches × 2.4 inches)
Multiples:	
Two (2) sizes ($\frac{1}{150}$ square yard) 8.64 sq. in.	(1.8 inches × 4.8 inches)
	(2.4 inches × 3.6 inches)
	(2.7 inches × 3.2 inches)
Three (3) sizes ($\frac{1}{100}$ square yard) 12.96 sq. in.	(1.8 inches × 7.2 inches)
	(2.4 inches × 5.4 inches)
	(2.7 inches × 4.8 inches)
	(3.6 inches × 3.6 inches)

Fractions:

Three quarters ($\frac{3}{4}$) size ($\frac{1}{400}$ square yard) 3.24 square inches (1.8 × 1.8 inches)
Two thirds ($\frac{2}{3}$) size ($\frac{1}{450}$ square yard) 2.88 square inches (1.2 × 2.4 inches)
One half ($\frac{1}{2}$) size ($\frac{1}{600}$ square yard) 2.16 square inches (1.8 × 1.2 inches)
One third ($\frac{1}{3}$) size ($\frac{1}{900}$ square yard) 1.44 square inches (1.2 × 1.2 inches)
One fourth ($\frac{1}{4}$) size ($\frac{1}{1200}$ square yard) 1.08 square inches (.9 × 1.2 inches)

A convenient method for determining the threads per inch consists in dividing the number of threads on each side of the sample analyzed by the respective dimension. If, for example, a standard sample has 120 warp threads on the 2.4 inch side and 72 filling threads on the 1.8 inch side, the number of threads per inch in the warp and filling is found as follows:

120 ÷ 2.4 = 50 warp threads per inch.
72 ÷ 1.8 = 40 filling threads per inch.

The cotton count found by the "straight line" method may be reduced to any other system of numbering desired. Following are a number of formulas for such reductions:

Cotton No. × .52½ = Woolen Runs.
Cotton No. × 1½ = Worsted No.
Cotton No. × 2⅝ = West of England No.
Cotton No. × 2.8 = Linen No. (woolen cuts)
Cotton No. × 3.28 = Yorkshire skeins
Cotton No. × 840 = Yards per pound
Cotton No. × 1.693 = Metric No.
Cotton No. × .846 = French Cotton No.
5315 ÷ Cotton No. = Deniers (for silk)
305 ÷ Cotton No. = Drams (for silk)
1000 ÷ Cotton No. = Grains per 120 yards
417 ÷ Cotton No. = Grains per 50 yards
167 ÷ Cotton No. = Grains per 20 yards
17.1 ÷ Cotton No. = Dundee No. (for jute)

The "straight line" method of cloth analysis is illustrated by the following analysis of a heavy cross rib cloaking fabric composed of cotton, worsted and carded woolen yarn and the weave draft of which is shown at Fig. 1875.

ANALYSIS OF A RIB FACE CLOAKING

Made of cotton, worsted and carded woolen yarn

Counting the threads and weighing the different kinds of yarn in a standard sample of the cloth give the following results:

Warp,	2-ply worsted	61.2 ends per inch,	4.8 grains
	2-ply cotton	30.6 ends per inch,	2. grains
Filling,	2-ply cotton	18.3 picks per inch,	1. grain
	5-ply cotton	18.3 picks per inch,	5.2 grains
	Single woolen	18.3 picks per inch,	13.6 grains
	Total weight of standard sample,		26.6 grains

The loss of weight after the yarn is spun is estimated as follows: Worsted, 10 per cent; cotton, nothing; carded woolen back filling, 28 per cent.

The warp take-up is estimated at 12 per cent. No change in length of cloth in finishing. Slack of filling in loom, 5 per cent. Loom width, $66\frac{1}{2}$ inches for 55 inches finished. The shrinkage of filling yarn in length is, therefore, 21.4 per cent.

From the foregoing data the weight of the cloth and sizes of the yarn are calculated by the "straight line" method as follows:

Weight of Cloth

$(26.6 \times 55) \div 52.5 = 27.8$ ounces per yard, 55 inches wide
$840 \div (26.6 \times 55) = .574$ yard, 55 inches wide, to the pound
These results are verified as follows:
$27.8 \times .574 = 16$, ounces per pound

Sizes of Warp Yarn

$61.2 \div 4.8 =$ No. 12.7 cotton = 2/38.1 worsted
$38.1 \div .88 = 43.3$
$43.3 \times .90 =$ 2/39 worsted, spun yarn
$30.6 \div 2 =$ No. 15.3 cotton = 2/30.6 cotton
$30.6 \div .88 =$ 2/35 cotton, spun yarn

Sizes of Filling Yarn

$18.3 \div 1. =$ No. 18.3 cotton = 2/36.6 cotton
$36.6 \div .786 =$ 2/46.5 cotton filling, spun yarn
$18.3 \div 5.2 =$ No. 3.52 cotton = 5/17.6 cotton
$17.6 \div .786 =$ 5/22.4 cotton, spun yarn
$18.3 \div 13.6 =$ No. 1.34 cotton = .7 run woolen
$.7 \div .786 = .89$
$.89 \times .72 = .64$ run woolen, spun yarn

Summary of Results

Weight of Cloth:	27.8 ounces per yard, 55 inches wide .574 yard, 55 inches wide, to the pound
Warp:	61.2 ends per inch 2/39 worsted, spun size 30.6 ends per inch 2/35 cotton, spun size
Filling:	18.3 picks per inch 2/46.5 cotton, spun size 18.3 picks per inch 5/22.4 cotton, spun size 18.3 picks per inch single .64 run carded woolen yarn, spun size

Set of Finished Cloth: 91.8 ends per inch; 54.9 picks per inch

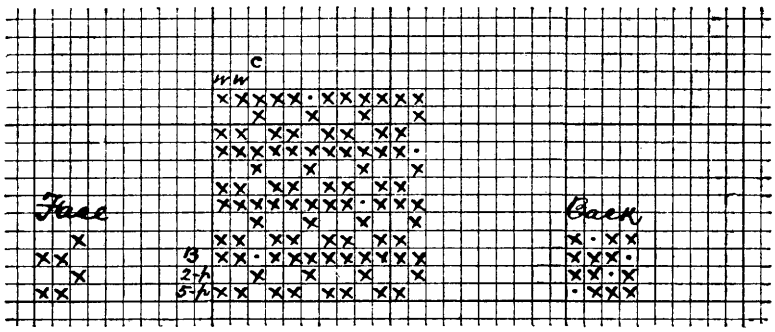

FIG. 1875.