BRITISH STANDARD

BS 5441:1988

Incorporating Amendment No. 1

Methods of test for

Knitted fabrics

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Textiles and Clothing Standards Committee (TCM/-) to Technical Committee TCM/24, upon which the following bodies were represented:

Association of Consulting Scientists
British Polyolefin Textiles Association
British Textile Employers' Association
Confederation of British Wool Textiles Limited
International Wool Secretariat
Man-made Fibres Producers' Committee
Ministry of Defence
SATRA Footwear Technology Centre
Soap and Detergent Industry Association
Society of Dyers and Colourists
Society of Motor Manufacturers and Traders Limited
Textile Institute
Textile Research Council

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Contents

Foreword

This British Standard has been prepared under the direction of the Textiles and Clothing Standards Committee and forms a revision of BS 5441:1977 which is withdrawn.

This standard provides a companion standard to BS 2861 to BS 2866, although this standard goes somewhat further than simple analysis. In particular, the test for assessment of barriness is included and this may also be of considerable use in the evaluation of woven fabrics.

Methods already published as British Standards have not been reproduced, but a list is given in clause **5** of other test methods that may be of use in the assessment of knitted fabrics.

The order in which the tests should be carried out is not covered by this standard since this will depend, to a large extent, on the sample size available.

It is recognized that the methods given for the analysis of knitted fabrics require great skill on the part of the analyst in view of the complex nature of many such fabrics, but it is believed that the standardization of notation will go some way towards easing the difficulties.

At the time of publication of this British Standard no corresponding International Standard exists.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This British Standard describes methods of test for knitted fabrics. Section 1 gives general information relevant to both warp and weft knitted fabrics; section 2 specifies methods appropriate for weft knitted fabrics and section three specifies methods appropriate for warp knitted fabrics.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1
barriness or barré

regularly repeating stripiness in textiles

2.2
barry

exhibiting barriness

2.3
grade

one of five members of the scale (see **3.7**), each exhibiting a different degree of bar/background contrast

2.4
half-grade

an imaginary contrast midway between those exhibited by two adjacent grades

2.5
rating or barriness rating

the number of the grade or half-grade assessed visually as exhibiting a degree of contrast between bars and background similar to that on the fabric being compared with the scale

3 Apparatus

3.1 *Counting glass*, the aperture width of which shall be 2 ± 0.005 cm at all places. The thickness of the base plate at the edges of the aperture shall not exceed 0.1 cm. Other suitable apparatus may be used.

3.2 *Ruler*

3.3 *Dissecting needles, scissors and razor blades*

3.4 *Balance*, capable of weighing to an accuracy of 0.1 mg.

3.5 *Crimp tester*

3.6 *Course length tester*, consisting of a weighted clamp and a rigid base-board adapted for mounting vertically on which are mounted an appropriate number of freely rotating pulleys so positioned that the yarn can be wound round them in a zig-zag manner, and a series of locations for a yarn clamp labelled to show the distance from the clamp to the zero point of a metric ruler. When the yarn is attached to the clamp and wound round the pulleys, the length indicated on the ruler by the weighted clamp is added to that indicated on the appropriate location in use to give the total length of yarn.

Alternatively an electronic course length tester consisting of a measuring wheel with electronic pick ups, a digital display and a tensioning device as well as a hold down device for the specimen of circular knitted fabric may be used.

3.7 *The Hatra barriness scale*, which consists of five numbered black frames, each with a grey card and a hole of equal size. Grade 5 is bar-free, grades 4 to 1 are progressively more barry. A grade is illustrated in Figure 1 and information on the precision of the method and care of the scale is given in Appendix A.

The external dimensions of the black frames are 355 mm × 250 mm. The grey cards (i.e. the actual photographs illustrating the various degrees of contrast between bars and background) are 100 mm × 118 mm and the adjacent holes are the same dimensions. Each grey card has parallel lines 0.75 mm thick and 9 mm apart[1)].

3.8 *Light source,* preferably artificial daylight fluorescent tubes[2)]. The tubes shall be changed after 2 000 h to 3 000 h use because of diminished ultraviolet emission.

NOTE The preferred light intensity is at least 810 lux, likely to be available approximately 300 mm from one or 1 000 mm from two 65/80 W tubes of the previously mentioned type.

A preferred viewing arrangement is illustrated in Figure 2, in which the tubes are at such an angle that the fabric receives most of the light from the tube areas nearest to it at an angle of 45° and the fabric is viewed from a distance of 300 mm. Although the frames of the barriness scale shield the eyes from the surrounding field, it is good policy for viewing areas to be matt neutral grey. Too much black can be depressing and tiring; gloss paint causes glare and fatigue.

[1)] The repeat distances and thickness are typical of 24-feeder interlock fabric, which is both popular and prone to barriness. However, the use of the scale is not specifically tied to any type of fabric.

[2)] These are better than previous attempts to match daylight, particularly with respect to red rendering and the content of ultraviolet radiation (see BS 950-1).

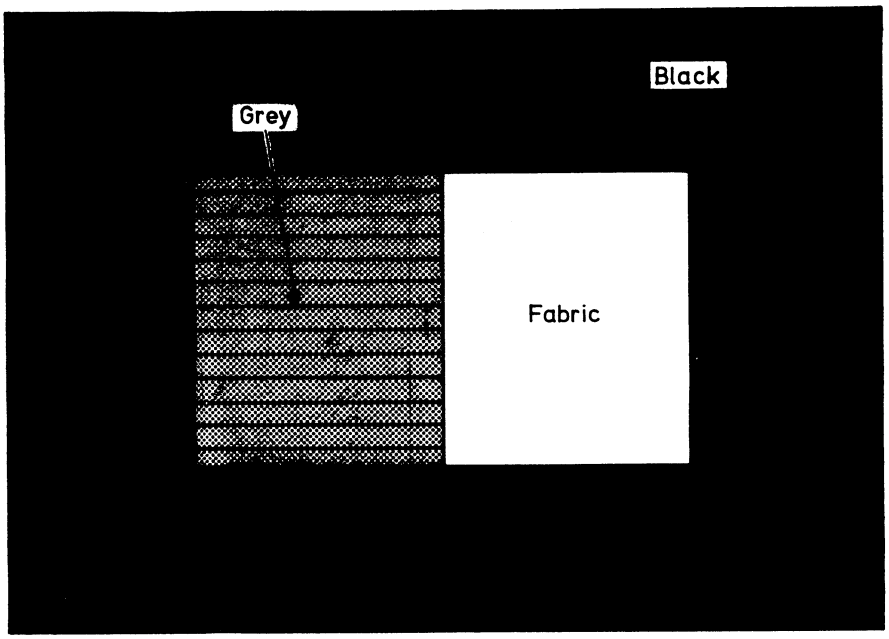

Figure 1 — Grade of barriness scale

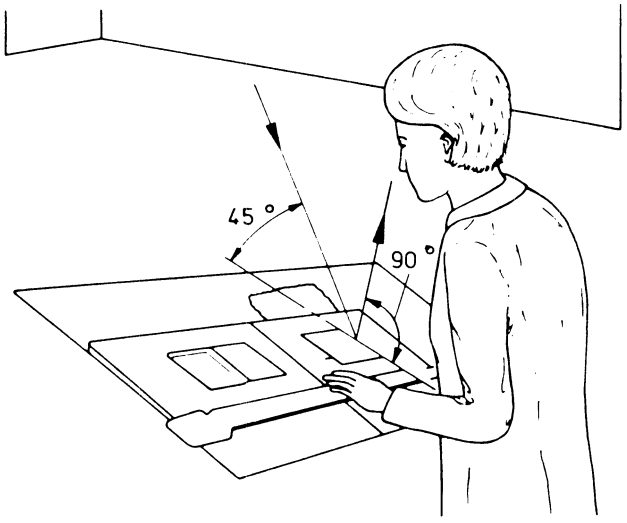

Figure 2 — Viewing and illumination conditions

Table and tube mounting (650 mm above it) are both at 22.5° to the horizontal. The two tubes are within 180 mm of the rear. The "stop" on the table is 500 mm from the rear and 130 mm from the front, which is 850 mm from the floor. At the front of the mounting there is a 140 mm high vertical anti-glare shield, 300 mm proud of the wall. The whole area is well shielded from daylight.

Since special provision of the preferred conditions is required, it may prove convenient to use other conditions, and these should be reported. For instance, it is possible to use commercial colour matching equipment[3]. This reverses the angles in Figure 2 and it is supplied with the recommended tube. Alternative lighting is also possible. This could be an ultraviolet tube, perhaps useful if gross yarn mixing, for instance polyester with nylon, is suspected and ecru fabric is being assessed. Daylight can be used, but is more variable than the tube, even if north light only is used, and it may not always be bright enough for reliable assessments.

CAUTION. Ratings may vary with conditions of use. The recommendations in this standard give maximum agreement between observers. Other conditions can be used in special circumstances. If this is the case, these should be agreed, specified and recorded.

4 Conditioning and testing atmosphere

The standard temperate atmosphere for conditioning and testing textiles as defined in BS 1051, i.e. relative humidity of 65 ± 2 % and a temperature of 20 ± 2 °C, shall be used. Perform all tests in the standard temperate atmosphere for testing textiles.

5 Properties to be tested in accordance with existing British Standards

A number of properties of knitted fabrics can be tested in accordance with other appropriate British Standards, which include the following.

BS 1930 for the determination of width of woven or knitted fabrics when relaxed at zero tension.

BS 1931 for the determination of length of woven or knitted fabrics when relaxed at zero tension.

BS 1955 for the determination of dimensional changes of wool-containing knitted fabrics during washing.

BS 2471 for testing the mass per unit length and per unit area of woven or knitted fabrics.

BS 2544 for the determination of thickness of textile fabrics.

BS 2864 for the determination of twist in yarn removed from fabric.

BS 4294 for testing the stretch and recovery properties of fabrics.

BS 4768 for the determination of the bursting strength and bursting distension of fabrics.

BS 5811 for determination of pilling and change of appearance of fabrics

6 Assessment of barriness

6.1 General

Regularly repeating stripiness in textiles is known as barriness or barré. Goods from all fibres can be affected, but most cases of commercial importance have involved weft knitted multifeeder fabrics from synthetic fibres. These fabrics may be barry because yarns differ in dyeability, physically, geometrically, or in all of these ways. Yarns in different courses may differ in knitting, in crimp frequency or in crimp configuration. A false-twist processing variation may affect both crimp and dyeability. Yarn may be faulty owing to chemical variation or different draw ratios in producer yarn or owing to heater-temperature, twist, or tension variation in false-twisting. A very small proportion of faulty yarn can lead to large proportions of faulty fabric, the more so the larger the number of feeders in a multifeeder knitting machine[4].

This standard specifies a method enabling barriness to be assigned reliably and quickly to any one of nine half-grades, from bar-free to very bad bars, by means of a scale of five grades.

After evaluation of the various methods of producing scales for the assessment of barriness[5], a photographic technique was found to be the most reliable and reproducible. The scale specified is not a series of photographs of any type of textile fabric. It is purely a series of line contrasts produced by differential exposure of photographic paper to light.

The scale is intended primarily for rating repeating contrast, whether on weft knitted fabric or on warp knitted, woven, or bonded-fibre material. The less regularly repeating and the shorter term (i.e. streaky rather than barry) the contrast is, the less tailor-made the scale is for assessing it. The suitability of the scale for short-term variations, say warp streaks in warp knitted fabrics or woollen yarn spinning variations in weft knitted or woven fabrics, has not been investigated in detail.

The grades of the scale illustrate different degrees of contrast and these are compared with the constrast in the fabric being assessed, regardless of any difference in width and frequency of bars in fabric and scale grade.

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[3] For details of sources of supply of suitable colour matching equipment apply to Enquiry Section, BSI, Linford Wood, Milton Keynes MK14 6LE.

[4] Morris, W.J. and Roberts, A.S.*J. Text. Inst*., 1966, 57,219 Hutchings, D.M. *Hosiery Res. Bull*., 1967, 8, 13.

[5] Jaeckel, S.M., *Hatra Production Note No. 17*, November 1976.

Considering interpretation, no single rating, like 3 or 3–4, is an always valid limit of fabric suitability; such limits will vary with fabric construction, colour, end-use, end-use orientation, area visible in end-use, viewing conditions and illumination. More barry (lower rating) fabrics may be acceptable for small end-use areas, particularly if not often viewed obliquely.

Compared with the scale specified in BS 1006, section A02, the contrasts exhibited on the barriness scale are so compressed that the worst degree of barriness exhibited, grade 1 of the barriness scale, is, objectively, approximately equivalent to the contrast of grade 3 of the grey scale. Barriness objectively equivalent to grade 1 or grade 2 of the grey scale was felt to be so bad from a practical point of view that neither these grades nor the distinction between them were of interest to barry fabrics. The relative spacings are approximately as shown in Figure 3.

Figure 4 illustrates how to rate bar/background contrasts intermediate between two adjacent grades.

With a contrast greater than grade 3, but less than grade 2, three ratings are possible, 3, 2 and the imaginary contrast lying midway between these two, 2–3. The rating 2–3 is given only if the barriness of the fabric is judged to be nearer to the midway imaginary contrast than to either 3 or 2. Similar decisions are made about contrast regions throughout the scale. The only irregularity is at the top end of the scale; a rating of 5 is given only when there is no difference. With this exception, contrasts are rated as the whole grade or half-grade to which they are nearest.

The five grades enable any one of nine ratings to be given: 5 (no bars), 4–5, 4, 3–4, 3, 2–3, 2, 1–2, 1.

6.2 Principle

A sample of fabric, regarded as representative[6)] of the textile to be assessed for barriness, is compared visually under specified conditions with grades of a specified scale that differ in the degree of bar/background contrast.

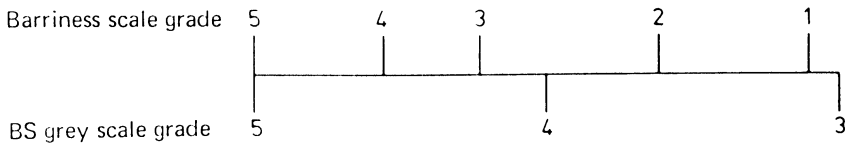

Figure 3 — Barriness scale and BS grey scale spacings

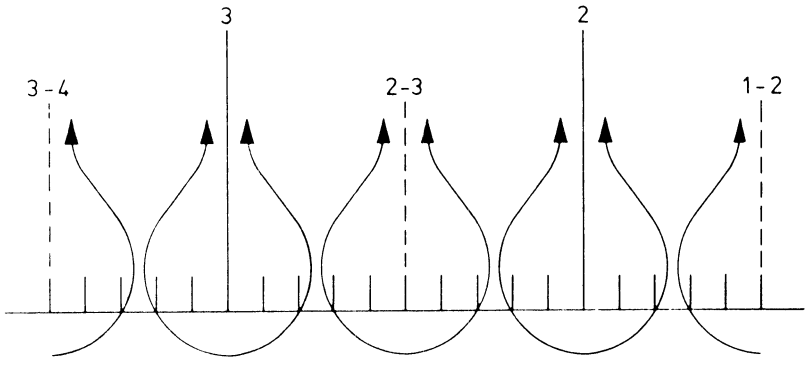

Figure 4 — The half-grade system

6) There are technical reasons why along the length of any one roll of fabric barriness may vary, sometimes abruptly; in such a case a single sample may not be representative of the whole roll.

6.3 Procedure

6.3.1 *Fabric position*. Rotate fabric, use-surface uppermost, to decide the orientation of greatest apparent barriness. In the event of uncertainty as to which face of the fabric will be seen in use, consider both faces. Record the orientation showing greatest barriness.

6.3.2 *Comparison with scale grades*. Put scale frames in turn on the fabric, with the bars on the card and the fabric parallel, and compare bar-background contrasts.

6.3.3 *Comparisons of rated fabrics*. Place together fabrics identically rated and recheck against scale.

NOTE Errors become prominent and fabrics differing in bar/background contrast from most in the group can be compared with adjacent groups and rechecked against the scale.

When a number of fabrics have been assessed and there are, for example, three groups of samples rated 3–4, 3, and 2–3 respectively, it is useful to look at all the ones in the "3" group together, without the scales, and check whether they show similar contrast. If one fabric looks worse than the others, take it out and compare it with the contrasts in the "2–3" group and rerate it against the scale. If another fabric looks better than the others in the "3" group, take it out and compare it with the contrasts in the "3–4" group and rerate it against the scale.

6.3.4 *Modified procedure for fabric in bulk*. Frequently in a warehousing or inspection section there are a series of examining tables close together. Where rolls of fabric slowly moving across the table may have to be assessed, if it is impracticable to rotate either fabric or examiner, specify a standard orientation for all fabrics.

NOTE At 300 mm from the eyes the space encompassed by the frame of the scale grade will occupy most of the field of view, so that surrounding areas, be they more of the same fabric, a contrasting fabric or a table, will have only slight peripheral effects on judgment.

In the case of rolls of fabric much larger areas of fabric than of grey card would be visible, had the black frame not been provided.

If too great a fabric area were to be compared against the scale, it is possible that slightly too low a rating might occasionally be given.

6.3.5 *Modified procedure for small samples*. Place a black mask containing a small hole on top of the scale grade, so that both grey card area and fabric area are equal and suitably reduced in size. The use of similarly reduced areas does not alter the barriness rating.

NOTE In fault investigation it is common to strip cuttings of the faulty fabric and to redye these with sensitive dyes. Sometimes the redyed cuttings may have to be smaller than the grey cards in the scale.

6.3.6 *Procedure for thin fabrics*. If it is customary in the end use to see one layer only of the fabric, look at one layer, below which there is preferably a plain surface, the colour of the end-use background if known, otherwise white or grey.

6.4 Report

Report the following:

a) the illumination and viewing conditions during the assessment;

b) the fabric side assessed and whether the other side had also been considered and judged no more barry;

c) the orientation used and whether it had been selected by rotation as the orientation of greatest apparent barriness;

d) the fabric area visible through any black mask used with a small specimen or any departure from the preferred procedure;

e) the barriness rating.

NOTE In routine inspection operations one consistent observer may suffice. In arrangements between different parties the opinion of one observer may be acceptable to both, or two observers, one from each party, may assess and decide. In complaint investigation and in development work, it is preferable to have multiple assessments. One observer can make repeated assessments, three or five observers can make one assessment each, or both methods may be combined. The implications for precision of a rating are discussed in Appendix A.

Section 2. Weft knitted fabrics

7 Determination of weft knitted fabric construction

7.1 Principle

The path of individual threads is determined during a complete repeat of the pattern.

7.2 Test specimen

The test specimen shall be of sufficient size to enable the complete pattern to be analysed.

7.3 Procedures

NOTE The notation of weft knitted fabric presents difficulties in the sense that no one notation system is convenient for representing all of the weft knitted structures possible.

7.3.1 *General*. Using the appropriate system from **7.3.2** to **7.3.4** note the fabric construction. The path of particular yarns in the structure may be more easily followed if they are stained, or lifted by the dissecting needle, or if the other yarns are cut away.

7.3.2 *Thread path diagrams*. Use printed point paper with suitably spaced small dots to record the thread path diagrams using the symbols shown in the examples (see Figure 5 and Figure 6). Draw a diagram of each successive course as it is unroved.

NOTE 1 The diagrams are suitable for recording plain and rib-based fabrics containing tuck and/or missed loops. The system is machine related, in that each dot represents the site of a loop-producing element. The dots are arranged in parallel rows corresponding to the disposition of the loop-producing elements in rib machines. (Different arrangements are required for rib-gaited machines and interlock-gaited rib machines.) The latter arrangement may also be used to represent purl fabrics. The parallel rows of dots are arranged in pairs, one pair representing a course-producing cycle. The top row of dots of a pair represent the loop-producing elements of the rear bed of a flat machine, or the dial or upper cylinder of a circular machine. When producing plain-based fabrics only one of the rows of dots is used.

NOTE 2 It is sometimes difficult to comprehend the whole of the structural repeat of a fabric when looking at the course by course breakdown. It is to be expected that the information in such instances is transferred to graph paper using either the "Prusa" or the squared-paper systems.

7.3.3 *"Prusa" system*. Use specially ruled graph paper to portray fabrics as shown in Figure 7.

NOTE 1 The paper (see Figure 7) contains alternately thick and thin vertical lines denoting the sites of face or back wales of a basic 1 × 1 rib structure (it is still possible to portray plain fabric or any rib other than 1 × 1 in this paper). Horizontal lines divide the paper between courses.

NOTE 2 Purl fabrics cannot be portrayed by this system, which is also inappropriate either for knit and miss structures or for large scale knit and tuck structures. There are no distinguishing marks between open and closed loops.

NOTE 3 The "Prusa" system is particularly useful for portraying fabrics containing transferred or displaced loops.

7.3.4 *Squared paper system*. Use the squared paper system using the graph paper ruled with 2 mm squares described in Figure 8 to portray fabric. Include a key relating the types of loop to the particular symbol, as shown in Figure 8. If possible, represent the most frequently occurring unit by a blank square, with appropriate symbols for the other units being used.

NOTE 1 Each square represents a loop or the site of a loop. A horizontal row of squares represents a knitted course or a design course. A vertical row of squares represents a wale.

NOTE 2 The system may be used to portray fabric of plain, rib or purl basic structure, containing most types of loop modification. It is particularly useful for fabrics containing tuck loops, miss loops and plush loops. It is also used to portray, in abbreviated form, colour jacquard fabric including intarsia, single 2, 3 and 4 colour jacquard and accordion fabrics, reverse-plated fabrics, and 2, 3 and 4 colour rib jacquard, as well as relief or blister fabrics. In all of these the symbols in the squares denote only the colour of the particular knitted loop appearing on the effect side of the fabric.

The system is not capable of portraying other than the most simple of loop transfer fabrics and cannot represent racked-rib fabrics.

7.4 Report

Report the fabric construction by the system chosen. Where symbols are used, ensure that their meaning is explained in a key as shown in Figure 5 to Figure 9.

8 Determination of the number of visible wales and courses per centimetre

8.1 Principle

The number of face wales and courses visible within a minimum measuring distance are counted. The result is expressed as wales or courses per centimetre.

8.2 Minimum measuring distance

The minimum measuring distance over which the number of wales or courses shall be measured shall be as detailed in Table 1.

Table 1 — Minimum measuring distance

Visible wales or courses per cm	Minimum measuring	Accuracy of an individual measurement in wales or courses per cm
	cm	
(a) less than 10	10	0.1
(b) 10 to 50	5	0.2
(C) more than 50	2	0.5

8.3 Test specimen

The test specimen shall be sufficiently large to enable the wales and courses to be counted at five different places, over the minimum measuring distance as specified in **8.2**, selected to represent the fabric as fully as possible.

8.4 Procedure

8.4.1 Condition the test specimen in the standard tamperate atmosphere for conditioning and testing (see clause **4**) for a minimum of 16 h before the test.

8.4.2 Lay the specimen face upwards on a horizontal surface, and apply the minimum tension required to keep the fabric flat. Using a counting glass or ruler and/or low-power microscope, as appropriate, count the number of wales over the minimum measuring distance specified in **8.2**. Repeat this for the courses in the fabric.

8.4.3 Repeat this procedure at five different places on the specimen.

8.5 Calculation and expression of results

Record the number of wales or courses counted over the specified measuring distance. Divide this by the measuring distance and record this as the number of wales or courses per centimetre to the accuracy specified in **8.2**. Calculate the mean value of the five results.

NOTE In complex structures the wales and courses recognized on visual inspection of the fabric may be made up of two or more structural wales or courses. In such cases this will be apparent from the analysis of fabric construction by dissection specified in clause **7**. The figures for visible wales and courses per unit length may be multiplied by the appropriate integers determined from the number of needles and courses in one repeat cycle. The values so obtained may be referred to as structural wales and courses per centimetre.

8.6 Report

Report the measuring distance used and the mean value of the five results.

9 Determination of course length

9.1 Principle

The fabric to be examined is prepared in such a manner that lengths of yarn forming complete knitted courses can be unroved. The lengths of yarn are measured in a straightened state under suitable tension. The straightened state is achieved by removing the knitting crimp and/or yarn or filament crimp as found in textured filament yarns.

9.2 Test specimen

The test specimen shall be sufficiently large to enable lengths of yarn forming complete knitted courses to be unroved.

If the fabric is in tubular form, make a short cut with a pair of scissors down a wale line.

If the fabric is in open width or flat form, carefully cut the edges of the fabric.

9.3 Procedure

9.3.1 Determine the direction from which the fabric unroves and commence unroving until a complete course can be extracted.

9.3.2 If the course length is short (e.g. less than 1 m) determine the length by means of a crimp tester, as described in clause **10**.

9.3.3 If the course length is large, use the course length tester described in **3.6** and proceed as described in **9.3.3.1** to **9.3.3.3**.

9.3.3.1 Fasten the clamp into the appropriate metal plate on the base board (this can rapidly be found by trial and error) and ensure that the pulleys are free to rotate.

9.3.3.2 Attach one end of the yarn to the clamp and unrove the remainder of the yarn over the pulleys in the direction indicated. In some cases, especially where it is difficult to unrove the yarn, it is permissible to unrove the yarn from the fabric before mounting it on the tester, but, in this case, care should be taken to avoid loss of yarn twist.

9.3.3.3 Fasten the weighted clamp to the end of the yarn that hangs over the metre rule. Note the reading on the metre rule and add this to the figure inscribed on the label at the position of the other clamp. This gives the total course length.

NOTE The mass attached to the unroved yarn should be sufficient to straighten it. The weighted clamp provided with the apparatus has a mass of 10 g and has been found suitable for staple yarns of up to 65 tex. (This gives a tension on a yarn of 65 tex of approximately 1.5 mN/tex.)

For staple yarns of greater linear density, additional masses may be added to the spring clamp and the tension should be maintained at approximately 1.5 mN/tex. For most textured continuous filament yarns up to 300 dtex masses giving a tension of approximately 20 mN/tex should be used.

9.3.4 Measure at least 12 course lengths. Where a multifeed machine is known to have been used, and if it is suspected that there is a variation in course length, take at least one course length from each feeder. If more are taken, ensure that the number is a multiple of the number of feeders on the machine.

9.4 Report

In the case of fabrics that have substantially the same course length for each course, report both the individual results and the arithmetic means of the course length in millimetres.

In the case of fabrics that, owing to their construction, have considerably different course lengths, e.g. double jersey fabrics and patterned fabrics, group the course lengths and calculate the arithmetic mean for each group. Again report both the individual and mean results of the course length in millimetres.

10 Determination of stitch length

10.1 Uncut fabrics

10.1.1 *Principle.* The course length is determined and the stitch length is obtained by calculation from the number of needles used in the production of a fabric.

10.1.2 *Procedure.* Measure the course length as described in clause **9**. Determine the number of needles used in the production of the fabric by counting the number of available needle positions.

10.1.3 *Calculation and expression of results.* Divide the course length by the number of needles used and express the result in millimetres.

10.2 Cut samples

10.2.1 *Principle.* If uncut fabric is not available a length of yarn is taken from the sample and measured and the number of needles used to produce the length is determined. Stitch length is obtained by calculation.

10.2.2 *Test specimen.* The test specimen shall be either 25 cm wide or large enough to enable 100 stitches to be cut from one course.

10.2.3 ***Procedure***

10.2.3.1 Condition the sample for 16 h in the standard temperate atmosphere for conditioning and testing (see clause **4**).

10.2.3.2 Cut along one wale of the sample to be tested. Count 100 stitches starting from this cut and again cut along a wale. Alternatively make a second cut 25 cm from the first and count the number of needles used over this distance.

10.2.3.3 Remove a length of yarn from the cut portion and attach it to the clamps of a crimp tester. Set the tension device attached to one of the yarn grips to one of the levels given in Table 2.

Table 2 — Tensions

Type of yarn	Linear density	Tension
Spun yarns	over 100 tex 30 tex to 100 tex 0 to 30 tex	150 mN 100 mN 50 mN
Filament yarns	all	20 mN/tex

Measure the length of straightened yarn in millimetres and repeat the above procedure for 12 different lengths of yarn. Where a multifeed machine is known to have been used, and it is suspected that there is a variation in stitch length, take at least one length of yarn from each feeder. If more are taken, ensure that the number is a multiple of the number of feeders on the machine.

10.2.4 *Calculation and expression of results.* Calculate the stitch length in millimetres and also the arithmetic mean of the individual results.

10.3 Report

Report both the mean and the individual results.

11 Determination of linear density of component yarns

11.1 Principle

Lengths of yarn are removed from the fabric and their mass is determined. The linear density in a unit of the tex system is then calculated.

11.2 Test specimen

Use the same test specimen as described in **9.2** for course length or **10.2.2** for stitch length.

11.3 Procedure

11.3.1 Determine the straightened length of 12 lengths of yarn, as described in **9.3** or **10.2.3**, and then remove at least 38 more lengths of yarn.

11.3.2 Remove any added matter using the methods given in BS 4407.

11.3.3 Dry the lengths of yarn at 105 ± 2 °C to constant mass (to an accuracy of 0.5 %). Determine the mass of the 50 lengths of yarn to an accuracy of 0.5 % and add the recommended allowance given in BS 4784-1.

11.4 Calculation and expression of results

Calculate the linear density in a unit of the tex system from the total calculated length and total mass of the 50 lengths of yarn.

11.5 Report

Report the linear density of the component yarns in a unit of the tex system.

Section 3. Warp knitted fabrics

12 Determination of warp knitted fabric construction

12.1 Principle

The path of one representative thread from each guide bar is determined during a complete repeat of the pattern and this is supplemented by the threading arrangement of the guide bar.

Warp knitted fabric can be made with one or two sets of needles. In the latter case the fabric is either tubular or has loops on both faces, as with double-jersey weft knitted fabric. The procedures given here refer only to fabrics produced on one set of needles, but may be applied with caution to circular fabrics.

If a lace fabric is under examination, and has been produced on a hexagonal or square background, it may be preferable to use paper with spaces of the same shape as the ground. The method specified here would not necessarily be applicable to lace fabrics, and similar considerations apply to embroidered patterns.

12.2 Test specimen

The test specimen shall be of sufficient size to enable the complete pattern to be analysed.

12.3 Notation

12.3.1 *Guide bar motions*. Plot the thread path on point paper. Each point represents a needle in the machine. A vertical column of points represents a wale and a horizontal row represents a course.

Number the spaces between the points from right to left starting with zero, and numbering subsequent spaces with successive integers unless the fabric is obviously a raschel fabric, in which case they may be numbered with the even integers.

An overlap is indicated by an arc of a circle above a dot and the underlap of a knitting thread connects two consecutive arcs or overlaps. The underlap of a non-knitting thread connects needle spaces.

NOTE The spaces are numbered according to the type of machine for which the draft is being prepared, generally with successive integers on tricot machines, but on raschel machines it may be:

a) (0, 1, 2, 3, 4, 5, etc.) for high speed raschel; or

b) (0, 2, 4, 6, 8, 10) for raschel lace; or

c) (0, 4, 8, 12, 16, 20), or (0, 8, 16, 24, 32, 40) for coarse gauge raschel.

Some machines even use two systems, for example:

(0, 2, 4, 6) for the ground; and

(0, 1, 2, 3) for the pattern.

12.3.2 *Guide bar threading*. Represent the threading of a partly threaded guide bar by the symbol / for a threaded guide and a full stop (.) for an empty guide. When different types of yarn are used in the same guide bar, give them in sequence for a pattern-repeat, moving from left to right viewing the fabric from the technical back. Position the threading schemes for the various bars under one another so that they represent the state of the machine at a particular point of the pattern. This point shall be specified in terms of the notation or of the pattern chain links if these are known.

12.4 Procedure

12.4.1 The path of particular yarns in the structure may be more easily followed if they are stained, or lifted by the dissecting needle, or if the other yarns are cut away.

12.4.2 Start the analysis by determining which yarns are nearest to the surface on both sides of the fabric, but particularly on the technical back. These will usually be from the front guide bar while threads from the other guide bars will usually be in sequence, with back guide bar threads at the centre of the structure.

12.4.3 Complete the notation for the front guide bar threads before analysing the next set and continue in this fashion until the last set of threads is examined. The total number of guide bars used in the structure will then be known.

12.4.4 Commence the notation of the guide bar motions at the same course on the technical back for each guide bar in turn. Threads from the same guide bar normally follow identical or parallel paths through the structure, and as guides are usually of the same gauge as the needles, a full threaded guide bar will provide one thread for each wale. Partly threaded guide bars are often recognized by open work and corded construction.

12.5 Report

Record the results under the headings of thread path, notation and guide bar threading for all the guide bars. Examples of typical notations are given in Figure 10.

13 Determination of the number of visible wales and courses per centimetre

Determine the numbers of wales per centimetre and courses per centimetre using the method specified in clause **7**. If the fabric contains tuck loops (mis-pressing) or knitted-in pleats, report this fact and take account of them in the number of courses in the measured length. Do not count closed fall plate loops unless they are unsupported by normal knitted loops.

14 Estimation of run-in

14.1 General

Many warp knitted fabrics cannot be dissected since they are either too complex or partially destroyed by finishing. In these cases it will not be possible to determine run-in or linear density of the yarn and these values can only be estimated.

14.2 Principle

A length of yarn is removed from a fixed number of courses from each guide bar, straightened in a crimp tester and its length measured.

The length corresponding to one rack (i.e. 480 courses) is then calculated.

14.3 Test specimen

The test specimen shall contain a sufficient number of courses (see **14.4**) and shall contain at least the number of wales corresponding to the guide bar with the longest underlap.

14.4 Procedure

NOTE Decide on the number of courses to be examined. This number should be a factor of 480, but at least 20.

14.4.1 *Unroving procedure.* Slightly stretch the fabric and pin it down on a board. Trim the top edge along one course. Count down the number of courses to be unroved from the top edge and mark the final course with ink or a pen.

Using a counting glass and two dissecting needles, unrove the loops course by course by pulling at the underlap and thus drawing out the previous overlap. The number of wales unroved shall be at least the number of needles traversed by the guide bar with the longest overlap.

When the marked course is reached, cut out the yarn and measure its length using a crimp tester, as described in clause **10**.

14.4.2 *Cutting procedure.* Using a razor blade or fine scissors cut a strip up the fabric one or two wales wide, corresponding to the smallest underlap, in effect cutting out one warp thread. Measure its length using a crimp tester, as described in clause **10**.

In some cases, it may be possible to remove the second smallest underlap. Thread a long needle between the loops so as to protect the thread of the second smallest underlap. Then shave off the loops on the opposite side of the needle, taking care not to damage the thread that is being removed. Measure its length using a crimp tester, as described in clause **10**.

14.5 Report

Report the results for each guide bar in millimetres per rack. This gives the run-in in the finished state and may be less than the original run-in.

15 Determination of linear density of component yarns

Using the lengths of yarn obtained by the method specified in clause **14** determine their linear density in accordance with clause **11**.

Appendix A Precision of, and additional information concerning, the Hatra barriness scale

NOTE A background paper giving fuller details on this topic was published in the August 1975 issue of "Textile Institute and Industry"; it provides guidance on whether and when to use more than one observer.

A.1 Precision of the method

Three examinations of the precision and applicability of the method involving the Hatra barriness scale have been reported, the initial one at Hatra[7] and later independent ones in France[8] and in the United States of America[9]. The mean standard deviation between observers that may be derived from these studies are 0.35, 0.36 and 0.63 of a barriness grade. A standard deviation for observers of 0.35 about the true rating for a fabric implies 95 % confidence limits of the mean of one assessment each by one, two, three or five different observers of ± 0.7, ± 0.5, ± 0.4 or ± 0.3 of a grade.

Critical differences at the 5 % level of significance valid for two single test results obtained under repeatability or reproducibility conditions were derived from the initial Hatra validation[7] according to BS 5497-1.

Concerning within-observer repeatability, when two assessments are made by the same observer using the same scale within a short interval of time, they shall be deemed suspect if they differ by more than r.

Concerning between-observer within-laboratory reproducibility, when two different observers each make a single assessment, both assessments shall be deemed suspect if they differ by more than R.

For ratings approaching 1 and 5, ranging from 2 to 3–4 and from 3 to 4–5 respectively, r = 0.1, 0.7 and 0.5 respectively and R = 0.5, 1.3 and 1.3 respectively.

A.2 Care of the scale

The colour of the frame is similar to that of the surround of the BS 1006, section A02 grey scale. On the three sides of the grey card the frame is 67 mm wide but on the far side of the hole it is 89 mm wide. The provides visual isolation of the fabric area being viewed from surroundings irrelevant to the assessment. The black frame also protects the grey card from being fingered, soiled and scratched. The hole and the grey card in each grade are of the same size because, to obtain the most realistic results, it is necessary to compare scale grades and fabric areas of similar size. Each scale grade has the essential details of use printed on the back.

The cards within the frames of the grades should not be touched, because they are photographs with a working surface consisting essentially of a very thin film of silver. Mishandling can cause grease marks and scratches that introduce unwanted contrast and eventually interfere with efficient use of the cards. When not in use, the scale should be stored away from light.

A.3 Barriness scale, BS grey scale and colour difference

The spacings shown in Figure 3 are based on many visual assessments, against the grey scale, of the contrasts between additional uniform panels of photographic card that were a feature of the original Hatra production of the scale. For each scale grade other than 5, one such panel consisted of background only and the other uniformly of "solid" bar, i.e. bar plus background. Uniform pairs of panels cannot ensure that the physical appearance of the actual bars corresponding to the panels is either appropriate or consistent enough to provide the desired visual impact. However, the relation between barriness-scale contrast and Adams-Nickerson colour difference in AN40 units, may be calculated, using the definition of barriness-scale contrast in Figure 3 and assuming that the relation between BS grey scale and AN40 units corresponds to the relation between the barriness scale and AN40 units, by applying the equation, for the grey scale range 5 to 3,

AN40 colour difference units = 7.5 to 1.5 (grey scale equivalent)

The results obtained are given in Figure 3.

[7] Jaeckel, S. M., *Hatra Production Note No. 17*, November 1967.

[8] Federation Française de l'Industrie de la Maille et de la Bonneterie, *Maille Informations*, 1974, No. 2, 69.

[9] Haeger, L.W., and Wright, W. D., *Textile Chemist and Colorist*, 1975, 7, 1/17.

Table 3 — Barriness, grey scale contrast and colour difference

Barriness scale grade	5	4	3	3	1
Grey scale equivalent	5	4.6	4.2	3.6	3.1
AN40 colour difference	0	0.6	1.2	2.1	2.85
CIELAB colour difference	0	0.68	1.36	2.38	3.23

The tolerances laid down for the grey scale range 5 to 3, corresponding to the barriness scale range 5 to 1, are ± 0.2 AN40 units.

Grade 5 of the grey scale, which should be generally equivalent to grade 5 of the barriness scale, is defined as neutral grey in colour and having a reflectance of 12 ± 1 %.

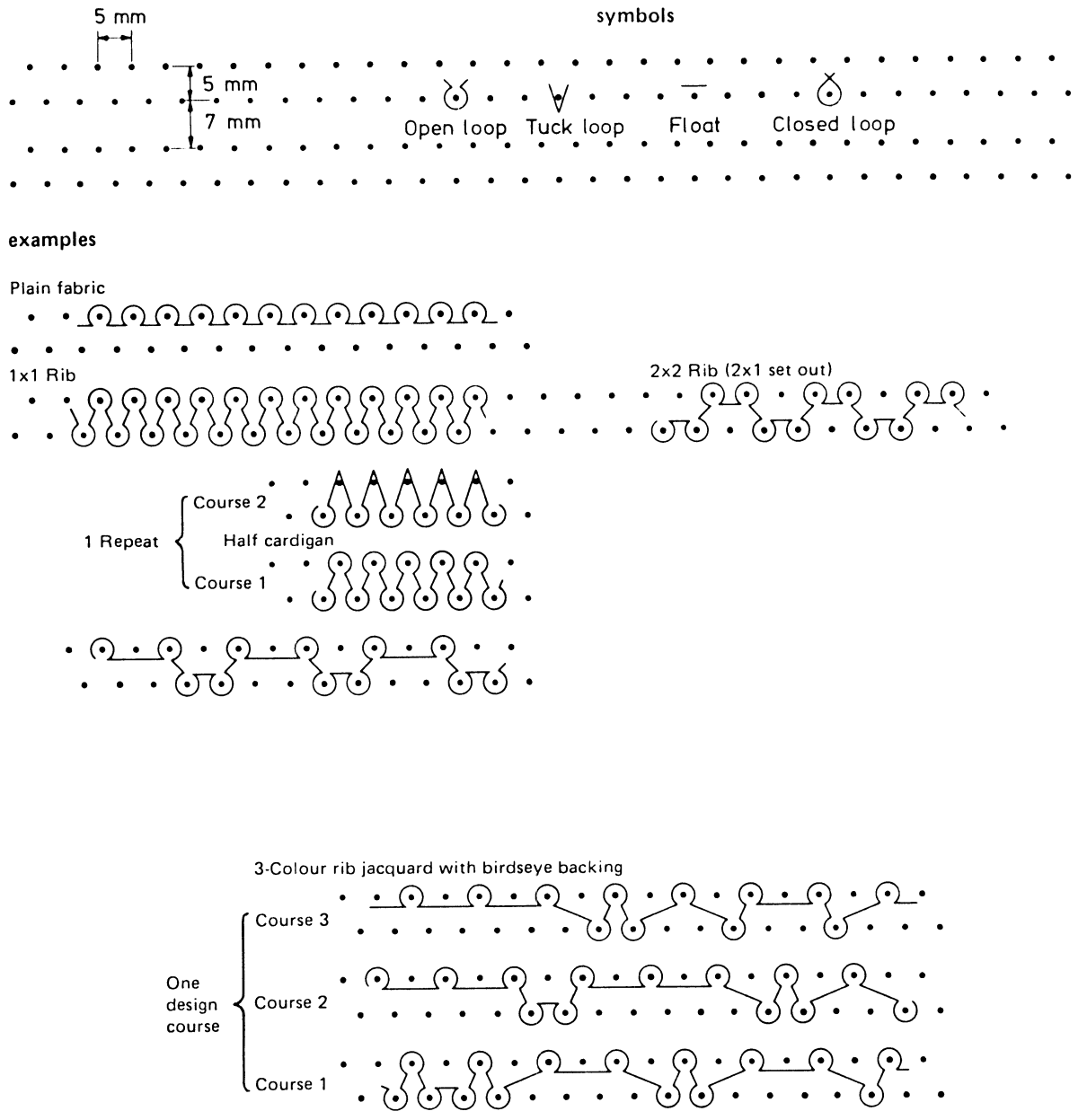

Figure 5 — Rib-gaited thread path diagram system

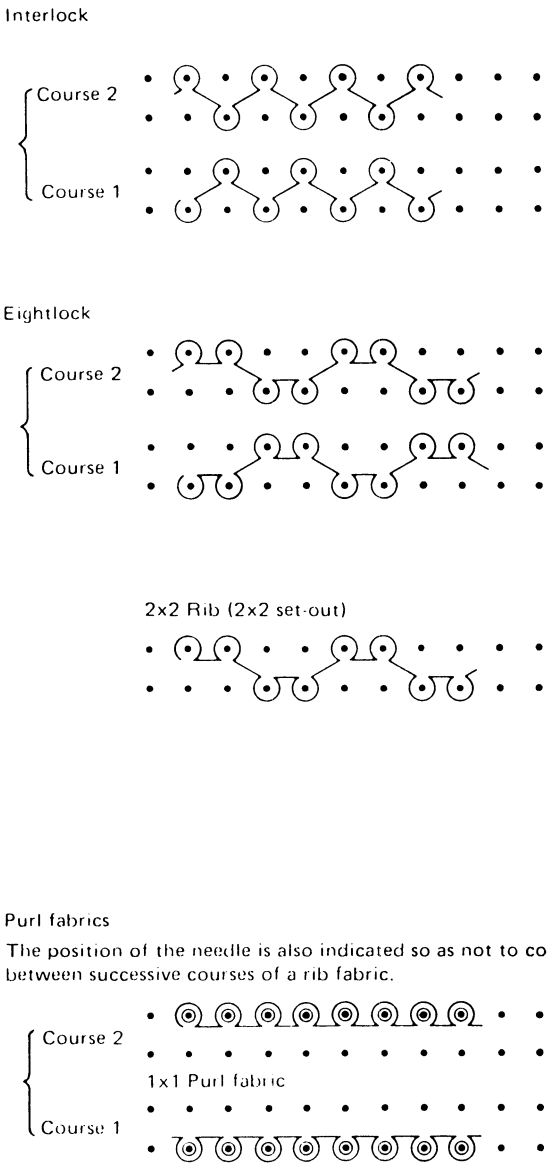

Figure 6 — Interlock-gaited thread path diagram system

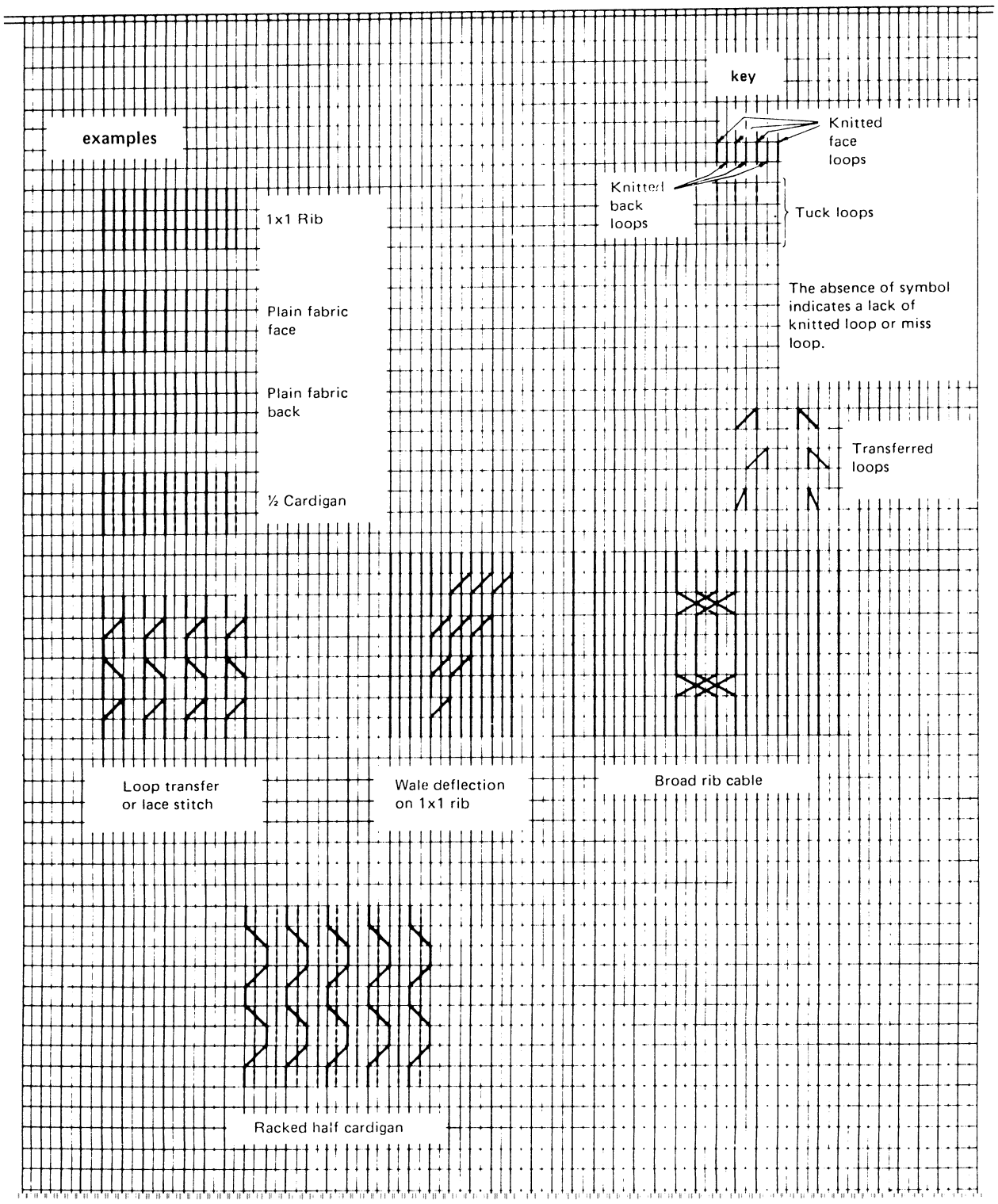

Figure 7 — "Prusa" system

examples

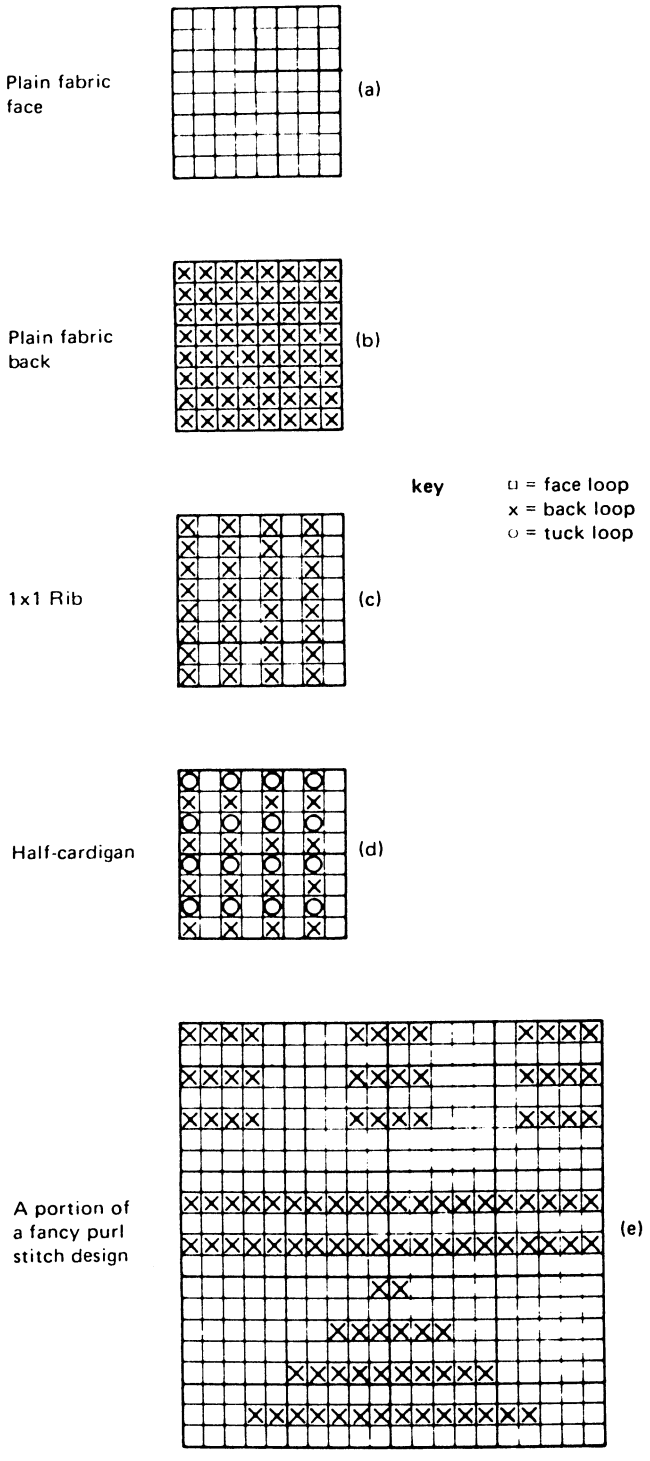

Figure 8 — Square-paper system (I)

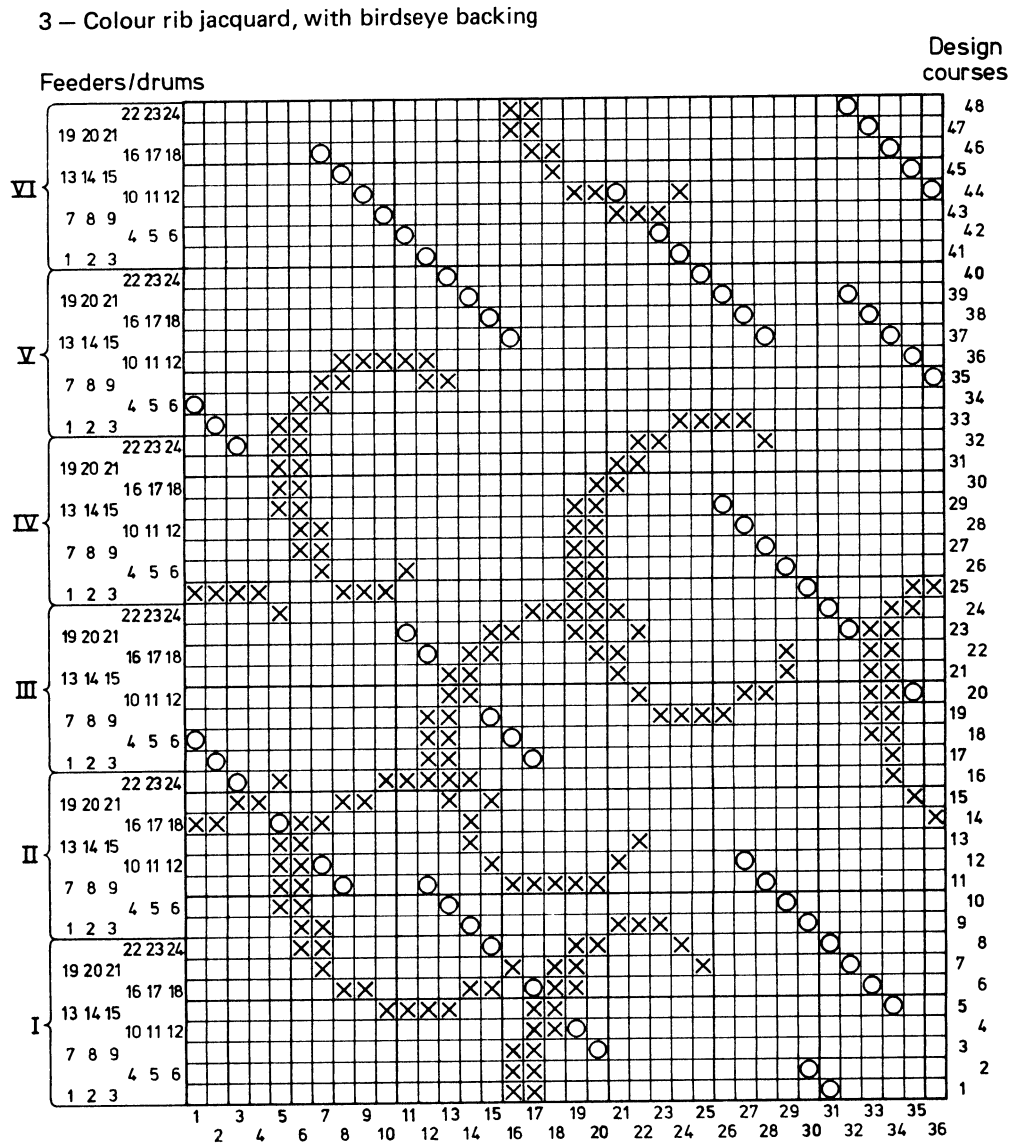

Figure 9 — Square-paper system (II)

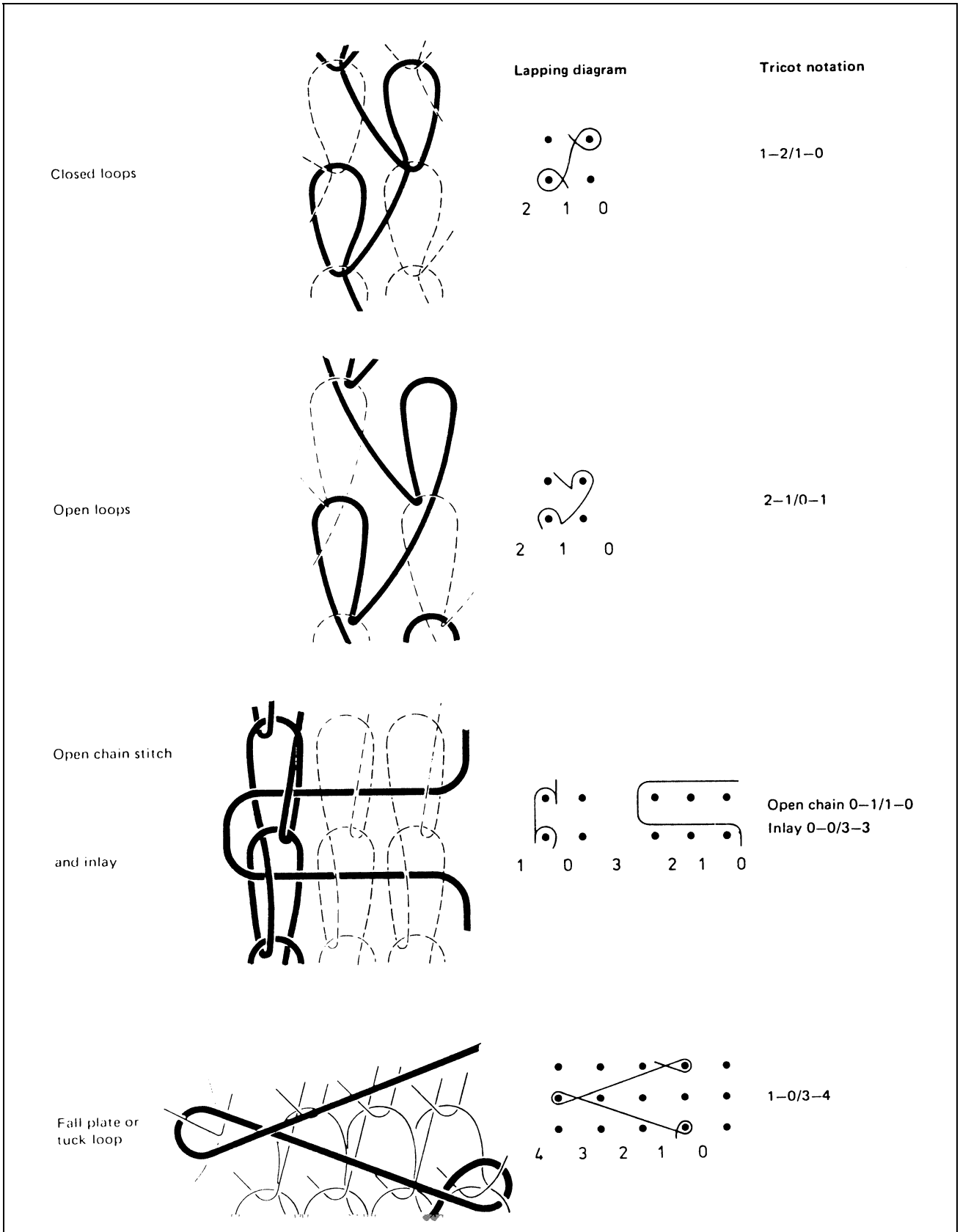

Figure 10 — Symbols for thread path diagrams in warp knitted fabrics

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Publications referred to

BS 950, *Artificial daylight for the assessment of colour.*

BS 950-1, *Illuminant for colour matching and colour appraisal.*

BS 1006, *Methods of test for colour fastness of textiles and leather.*

BS 1051, *Glossary of terms relating to the conditioning, testing and mass determination of textiles.*

BS 1930, *Methods for the determination of width of woven or knitted fabrics when relaxed at zero tension.*

BS 1931, *Method for the determination of length of woven or knitted fabrics when relaxed at zero tension.*

BS 1955, *Method for the determination of dimensional changes of wool-containing knitted fabrics during washing.*

BS 2471, *Methods of test for the mass per unit length and per unit area of woven or knitted fabrics.*

BS 2544, *Methods for determination of thickness of textile materials.*

BS 2861, *Methods for presentation of a weave diagram and plans for drafting, denting and lifting.*

BS 2862, *Methods for determination of number of threads per unit length.*

BS 2863, *Method for determination of crimp of yarn in fabric.*

BS 2864, *Method for determination of twist in yarn removed from fabric.*

BS 2865, *Method for determination of linear density of yarn removed from fabric.*

BS 2866, *Method for determination of the mass of warp and weft per unit area of fabric.*

BS 4294, *Methods of test for the stretch and recovery properties of fabrics.*

BS 4407, *Methods for quantitative analysis of fibre mixtures.*

BS 4768, *Method for the determination of the bursting strength and bursting distension of fabrics.*

BS 4784, *Methods for determination of commercial mass of consignments of textiles.*

BS 4784-1, *Mass determination and calculations.*

BS 5497, *Precision of test methods.*

BS 5497-1, *Guide for the determination of repeatability and reproducibility for a standard test method.*

BS 5811, *Method for determination of resistance to pilling and change of appearance of fabrics.*

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