PATTERNS OF CULTURE

Decorative Weaving Techniques

by M A Hann and B G Thomas
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Patterns of Culture – Decorative Weaving Techniques
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Foreword: D. Holdcroft

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This monograph has been produced as an accompaniment to the exhibition ‘Patterns of Culture – Decorative Weaving Techniques’. The exhibition is composed largely of items from the Bretton Hall collection, a constituent component of the University of Leeds International Textiles Archive (ULITA). Some further exhibits are treasured family heirlooms, on loan from individuals living in Yorkshire. All exhibits are the outcome of hand-weaving techniques, the majority using silk and silver- or gold-metallic yarns.

This monograph explains the basic principles involved in creating a woven cloth. Simple and compound woven structures are described and illustrated. Various forms of weaving apparatus are identified, including the horizontal ground looms and vertical tapestry looms of ancient Egypt, the warp-weighted looms of ancient Greece and northern Europe, the narrow treadle looms of West Africa, the horizontal pit looms of India, the raised horizontal treadle looms of medieval Europe, the figured-silk drawlooms of China and the back-strap looms of Asia and South America. The role played by important innovations such as Kay’s flying shuttle and Jacquard’s selection mechanism in increasing productivity or patterning potential is explained. The emphasis is on craft rather than industrial production and the focus is mainly on decorative silk weaving and its diffusion. The monograph should be of value to teachers concerned with the introductory aspects of weaving, as well as museum professionals, archaeologists and anthropologists keen to gain a basic understanding of woven structures and weaving techniques.

D. Holdcroft
Chairman of the ULITA Committee
1. Introduction

Woven fabric is produced through interlacing, at right angles in the same plane, two sets of threads, longitudinal (or warp) threads and latitudinal (or weft) threads. The warp threads are placed parallel with each other and assembled in a sheet. To facilitate interlacement with weft threads this warp sheet has to be ‘shed’, that is divided and parted to form an upper (or front) sheet and lower (or back) sheet. A trail of weft thread is passed between these two sheets. The two sheets are ‘unshed’ and returned to the one-sheet state, thus allowing the inserted weft to interlace with the threads in the warp sheet. Humankind has been aware of these fundamental principles for the better part of eight thousand years and various types of apparatus have evolved to facilitate shed formation and weft insertion. Variations in weaving apparatus are readily evident from region to region and from period to period.

This monograph explains further the methods involved in creating a woven cloth. Simple and compound woven structures are described and illustrated. The different mechanisms which have evolved to facilitate the interlacement of warp and weft threads are identified. Attention is focused on the means by which highly decorated elements may be incorporated during the weaving process. The emphasis throughout is on craft rather than industrial production.

A further concern is to review a broad range of relevant literature and, from this, to develop the debate on the origin, evolution and diffusion of decorative weaving techniques and their resultant products.

The most highly developed and complex woven textiles of the past three millennia are patterned silk textiles. China appears to be the source from which early silk-weaving techniques diffused, and trade was the main agent of that diffusion. The channel for diffusion was the great trade highway which became known as the Silk Road, linking China with Central Asia, India, Persia, Egypt and Rome. It appears also that silk items may have been transferred westward by a more northerly route; this possibility is explored in one of the later sub-sections. The focus is primarily upon those countries to the west of China which played an important role in the evolution and diffusion of decorative weaving techniques. The principles of weaving are explained first.
As stated in the Introduction, the process of weaving consists of interlacing, at right angles in the same plane, two series of threads. Typically, the warp threads (known also as ends) are assembled side by side and stretched between two rollers. In the simplest case, the weaving process progresses as follows: the odd-numbered warp threads (1, 3, 5, 7, etc) are raised and the even-numbered warp threads are left in position. An opening, or shed, is thus formed within which a weft thread (also known as a pick) is passed. This thread is straightened and beaten into position at right angles to the warp threads. The odd-numbered warp threads are then dropped back to position and the even-numbered threads raised to provide an opening (known as a counter-shed). A weft thread is passed through and beaten into position as before. The cycle is repeated and the most simply constructed woven fabric, with a structure known as plain weave (or tabby), is produced.

Although there are many technological refinements, and numerous structures, the basic operating sequence remains the same: shed formation, weft insertion and beating in. The instrument or machine which facilitates this sequence of operations is known as a loom. Figures 1 (a), (b), (c) and (d) show the stages in weaving a plain-woven structure on a basic, horizontally organised, weaving apparatus [Bühler, 1940, p.1080]. The important component tools which assist in the formation of a shed and a counter-shed (in the example shown) are the lease rod, the heddle rod and the warp sword.

![Figure 1](image-url)
In the preparatory stages of setting up the loom, the lease rod is passed between odd-numbered warp threads (first, third, fifth, etc) and even-numbered warp threads (second, fourth, sixth, etc). Alternate warp threads are thus divided into positions above and below the lease rod. The warp threads positioned below the lease rod are then threaded through loops on the heddle rod. The heddle rod is positioned parallel and to the front of the lease rod. The warp sheet is then stretched between two rollers. During the weaving process the warp sword assists in the formation of the shed as well as beating the weft thread into the fabric. Weaving proceeds as follows:

(a) The warp sword is introduced into the shed created by the lease rod and turned on its edge to enlarge this shed.
(b) The weft is inserted and beaten into place by the flattened warp sword.
(c) The counter-shed is formed by raising the heddle rod. The warp sword is inserted again, but this time into the counter-shed and turned on its edge to enlarge the opening.
(d) The weft thread is inserted and again beaten into place by the flattened warp sword.

In a more technically developed loom a shed may be formed through raising one of a series of heddles consisting of frames holding wires, each wire with an eye (also known as a mail) through which particular warp threads are threaded prior to weaving. Synonymous terms for heddles include shafts, leaves, staves, cambs and headles. After shed formation, a trail of weft thread may be laid by passing a shuttle (a wooden box-like container holding a bobbin of thread) from one side of the shed to the other. Beating the weft into position may be facilitated by using a comb-like device known as a reed which also assists in ensuring an even spacing between the warp threads.

The sett of a woven fabric is an indication of how tightly packed the warp and weft threads are in the woven cloth. This is generally expressed as the numerical ratio of warp to weft threads per inch or centimetre. A fabric with a balanced sett will have an equal number of threads per unit measurement in both warp and weft. The maximum possible sett is the maximum number of threads in both warp and weft that can be woven without difficulty and without the resultant fabric buckling. The sett will
be influenced by the count (or thickness) of the yarn. Oelsner [1952, p.13] stated that the sett should be as near as possible for both sets of threads. But, if the sett of the warp is too close, it will be difficult to beat the weft threads uniformly into position. Ribbed or grooved faults may be generated [Oelsner, 1952, p.13]. On the other hand, ribbed effects may, on occasion, be desirable and may be purposely produced by alternating coarse with fine yarn in warp and weft.

Different sheds may be formed by lifting different combinations of warp threads; these different sheds offer the possibility of producing differently structured cloths with differing technical properties and aesthetic characteristics. Some of the more important woven structures are identified, illustrated and explained in Section 3 below. Further to this the more important loom types are identified and their operating details summarised in Section 4.
The essential component parts of a woven cloth are the warp threads (or ends) which interlace at right angles with the weft threads (or picks). In the vast majority of woven fabrics, the order of interlacement repeats periodically across the fabric in both weft-ways and warp-ways directions. The smallest, individual recurring part is known as a repeat. In the repeat of any weave each thread must have at least two interlacements; otherwise the thread will form a continuous float on one side of the fabric. Numerous sequences of interlacements (known as weaves or woven structures) are possible. The purpose of this section is to identify, describe and illustrate the more important classes of these.

Two broad categories of woven structure are considered in this monograph: simple structures which have only one set of warp and weft threads, and compound structures which include additional warp and weft threads. In the latter category, the additional elements may be in the form of occasional warp or weft threads or may comprise an additional set or sets of warp and/or weft threads. Backed structures involve an extra set of warp or weft threads, double structures two sets of warp and weft threads and triple structures three sets of both warp and weft threads.

In the design or analysis of woven fabrics, it is necessary to plan or determine the sequence of interlacements. Certain systems of notation for recording this sequence have developed over the centuries. The use of marks on squared paper, or point paper as it is known, is probably the most commonly accepted method world wide. The paper is ruled in vertical and horizontal lines thus creating a pattern of small squares. Each square represents a position or point where a warp and a weft thread cross one another. The insertion of a mark on a square may be taken to indicate that one thread passes over the other [Watson, 1954, p.2]. The most widely accepted convention, at least in the British Isles, is that a mark within a square of point paper represents a warp thread over a weft thread. Where a square is left blank this represents a weft thread over a warp thread. Where a vertical column of two or more adjacent squares has been marked, this represents a warp forming a float over two or more weft threads. Likewise, where a horizontal row of two
or more adjacent squares is blank, this represents a weft thread forming a float over two or more warp threads. The squares on point paper are invariably arranged in blocks of eight by eight, separated by thick lines which facilitate the easy counting of threads during the planning of a design on point paper. In the sub-sections which follow, point-paper illustrations are included in the discussion of all simple weaves. Plan views and cross-sectional illustrations are used to assist the explanations of compound structures.

3.1 Plain weave and hopsacks
The most commonly used and simplest structure, where both warp and weft threads follow a sequence of over one and under one, is known as plain weave (or tabby). The relevant point-paper illustration is shown in Figure 2. The maximum possible interlacing is built into the cloth. Plain weave permits the firmest and lightest-weight fabrics to be made from a given yarn type [Moore, 1998a]. More often than not, plain weave is produced using equal amounts of warp and weft. Where this is the case the resultant fabric is considered to have a balanced sett. Plain weave is relatively easy to create and has been produced on the simple looms of ancient times, as well as the most sophisticated, industrial, shuttleless varieties of the early-twenty-first century CE. So although the time gap in technology extends over more than five thousand years, the technique and product remain broadly similar.

Hopsack weaves fall into two classes: regular hopsacks and irregular hopsacks. In regular hopsacks a given number of ends and picks interlace. Assuming a balanced sett, the amounts of warp and weft on the surface will be equal. Regular hopsacks repeat on the same number of ends and picks. The warp and weft blocks produced are uniform. In a regular 2/2 hopsack, two warp threads pass together over two weft threads and then under the next two weft threads. Similarly, with a regular 3/3 hopsack, three warp threads pass together over three weft threads and then under the next three weft threads.
Figures 3 (a), (b) and (c) show regular 2/2, 3/3 and 4/4 hopsacks. Irregular hopsacks may repeat on different numbers of ends and picks, and will exhibit surface blocks (often referred to as spots) of differing size [Moore, 1998b]. Examples of irregular hopsacks are shown in Figures 4 (a) and (b).

A particular category of decorated textiles which relies largely on the use of plain weave is ikat. The process associated with this textile category involves decorating the warp or weft, or both sets of threads, prior to weaving. Technically, ikat is regarded as a resist-dyeing process rather than a decorative weaving process, but it should be noted that it is occasionally used in conjunction with various forms of decorative weaving, especially extra-weft or extra-warp figuring (dealt with in sub-section 3.8 below). Details of the ikat and other resist-dyeing processes have been given elsewhere [Hann, 2005].
3.2 Warp cords and weft cords

In warp cords warp threads interlace, not in groups but singly, over a given number of weft threads. In the simplest case of a 2/2 warp cord a warp thread passes over two weft threads and under two weft threads. Meanwhile the adjacent warp thread passes under two weft threads and over two weft threads. The 2/2 warp cord and other regular warp cords are shown in Figures 5 (a), (b) and (c). A variation, known as an irregular warp-cord weave, is shown in Figure 6.

Weft cords are similar but have weft floats. In a 2/2 weft cord the picks pass over two
ends and under two ends, and adjacent picks pass under two ends and over two ends. This and other regular weft cords are shown in Figures 7 (a), (b) and (c), and an irregular version in Figure 8.

3.3 Twills and related weaves
Moore observed that “...the largest, most significant and most versatile of all the weave families are those known as twills” [Moore, 1998c]. Diagonal twill lines are the principal feature. In a twill weave every single end in the weave will have an identical order of interlacement, but this order will start on a different pick on each successive end of the weave repeat. The starting-points for adjacent ends will therefore differ and could be at two or more subsequent or previous picks depending on the type of twill. This feature can be seen in Figure 9, which shows point-paper representation of 2/2 twill, the most commonly used variety. The notation 2/2 indicates that each warp thread passes over two weft threads and then under the next two weft threads. A twill can be made on any number of threads above two and requires the same number of picks and ends. Twills with orders of interlacement, such as 3/3, 4/4 or higher are also possible. The practicality of large repeats will be governed by the capacity of the shed-forming mechanism associated with the loom being used [Moore, 1998c]. Simple twill weaves repeat on the same number of ends and picks.

The twill lines may run upwards from left to right or upwards from right to left, often described as “Z” and “S” twills respectively (with the central line of each letter indicating the twill direction). Examples of “Z” and “S” twills are shown in Figures 10 and 9.
respectively. Twill lines will be in opposite directions on the face and back of the fabric. Floats of warp and weft on one side of the fabric coincide respectively with floats of weft and warp on the other side. The angle of the twill line is an important consideration and is influenced by the sett of the warp and weft threads. If the number of warp and weft threads per unit length is the same, the angle of the twill will be 45 degrees [Oelsner, 1952, p.17]. Where the density of the warp threads is higher than that of the weft threads, the twill angle will be above 45 degrees, and will be below 45 degrees in cases where the density of weft threads is higher than that for warp threads.

Simple warp-faced twills exhibit one size of warp float and one size of weft float, with the length of the former greater than that of the latter. The most common warp-faced twills are probably 2/1 twill and 3/1 twill, shown in Figures 10 and 11 respectively. Simple weft-faced twills are similar but the weft float is the greater of the two (Figure 12). Balanced twills are where the warp and weft threads come to the surface of the fabric to the same extent.

Double twills are another category. These exhibit two sizes of warp twills and/or two sizes of weft twills within the same structure. An example is shown in Figure 13. The concept can be extended to structures with three or more varieties of twill lines. An example of a triple-twill structure is shown in Figure 14.
A peculiar form of twill, noted by Oelsner, is the steep twill which can be produced by allowing the warp float of each end to rise two or more picks instead of one pick above the float of the preceding thread [Oelsner, 1952, p.65]. A steep twill can be produced by using, in succession, the alternate threads of a conventional twill. For example, by using the interlacements shown for threads 1, 3, 5, 7 and 9, from the twill illustrated in Figure 15, the steep twill illustrated in Figure 16 can be produced. It can be readily seen from the latter point-paper illustration that the twill line has been brought closer to the perpendicular [Oelsner, 1952, p.65, figs 300 and 301]. This would also be apparent in the resultant woven cloth.

Undulating twills are another class identified by Oelsner. These are formed by irregularly offsetting the warp and weft floats; for example by moving the float four threads at one place and three threads at another [Oelsner, 1952, p.77].

Broken or reversed twills are created by reversing the direction of the twill in either the warp or the weft. Certain basic weaves can be combined to create classes of composite weaves. One such class is herringbones, obtained by combining Z and S twills. For example a 2/2 Z twill can be readily combined with a 2/2 S twill, or a 3/3 Z twill can be combined with a 3/3 S twill. Double twills can also be used in the
production of herringbone weaves. Figure 17 shows the point-paper design for a herringbone developed from a 3/2/1/2 twill. Diamond effects are also attainable. Figure 18 shows a point-paper design for a diamond twill, resultant from combinations of a 2/2 twill.

3.4 Satins and sateens
Satin and sateen weaves are warp-faced and weft-faced structures respectively, in which the interlacements produce smooth fabric surfaces [Tubbs, 1991, p.204]. Each class of structure offers numerous possibilities. The aim is to have as much warp or weft on the surface as practicably possible and to ensure that the minimum number of interlacement points do not create any form of twill or optical bar. Both satin and sateen weaves may be further classed as regular or irregular. With regular satins and sateens the points of interlacement are distributed in a regular stepping arrangement. This stepping arrangement is dependent on the step or move number which equals the number of weft threads crossed by the warp floats in satins, or the number of warp threads crossed by the weft floats in sateens. With irregular satins and sateens the stepping arrangement is at random.

Moore outlined standard procedures to create regular satin and sateen structures [Moore, 1999b]. The repeat size must be decided first and, from this, an appropriate move number determined by adhering to two basic rules. First, the move number cannot be either 1 or the number of warp (or weft) threads in the repeat minus 1; both would generate undesirable twill lines. Secondly, the move number must not be a factor
of the number of warp (or weft) threads in the weave, as this would result in certain threads without an interlacing. Assuming a regular satin over eight warp threads and eight weft threads, applying the basic rules will give moves of 3 or 5. Moves of 1 or 7 are eliminated owing to a possible twill effect while 2, 4 and 6 are eliminated as they are factors or multiples of factors [Moore, 1999b]. Figure 19(a) shows a point-paper design for a regular satin weave with a move of 3, and Figure 20(a) the comparable sateen weave. Moore observed that several options are available when using a repeat size which is a prime number. For example, with a repeat size of eleven, a total of eight optional satin moves are available (2, 3, 4, 5, 6, 7, 8 and 9); in practice each of these will have different visual characteristics [Moore, 1999b].

Irregular versions of satins and sateens are also available. A six-end repeat is a good example. Applying the rules outlined above indicates that a regular satin or sateen is not possible over six ends and six picks [Moore, 1999b]. A random distribution of points of interlacement, shown in Figure 21 (a), can be proposed. Four-end satin and sateen versions are shown in Figures 21 (b) and (c). Such weaves are used on their own or in combinations with other weaves to yield figured effects [Moore, 1999b].
3.5 Backed cloths
In chapter 1 of Advanced Textile Design Watson observed that

...backed, double, treble, etc., principles of construction are employed for the purpose of increasing the warmth-retaining qualities of a cloth, and in order to secure greater weight and substance than can be acquired in a single structure which is equally fine on the surface. A heavy single cloth can only be made by using thick yarns, in conjunction with which it is necessary to employ only a comparatively few threads per unit space. A heavy single texture is therefore obliged to be somewhat coarse in appearance. By interweaving extra weft, or extra warp, or both extra weft and extra warp threads on the underside of a cloth, it is possible to obtain any desired weight combined with the fine surface appearance of a light single fabric.

Watson, 1925, p.1

Watson continued by observing that extra threads are introduced frequently for purely ornamental purposes and occasionally for both ornamentation and weight [Watson, 1925, p.1]. When extra yarns are used it is important to ensure that they are bound securely to the face. In addition these stitching or tying threads must be kept out of view on the face of the fabric otherwise marks or indentations are caused. The solution is to ensure that the relevant threads from the underside of the fabric float over the threads of the fabric face, between corresponding floats in the face weave [Watson, 1925, p.2]. Suitable positions for these stitching threads or ties must therefore be selected, and this selection will be determined by the nature of the face weave itself. Watson listed the

---

*Figure 21*
(a) Random distribution of points of interlacement over 6 X 6.
(b) Random 4-end satin. (c) Random 4-end sateen.
convention as follows: twill order of ties used for twill face weaves; sateen order for sateen-based weaves; plain or alternate order where firm binding is required; irregular order for irregular weaves [Watson, 1925, p.3].

Figure 22 illustrates a twill order of stitching for a 2/2 twill-face cloth with backing weft; note that the black areas represent back-weft stitches. Figure 23 illustrates a twill order of stitching using a backing warp; note that the black areas represent back-warp stitches. In both cases the backing-thread stitches are positioned between corresponding floats in the face weave. Each backing-weft stitch depicted in Figure 22 is positioned between face-weft floats and each backing-warp stitch in Figure 23 is positioned between face-warp floats. Figure 24 illustrates a 3/3 twill-face weave on a double fabric stitched by both back-warp and back-weft stitches.

As noted by Watson [1925, p.5], it is important to obtain the right degree of stitching to ensure that the resultant fabric performs to the optimum extent mechanically (in terms of its solidity, strength, elasticity, abrasion resistance, etc). As indicated above, a backing thread generally floats over only one face thread at a stitching point. Occasionally, however, where more secure stitching is required, these floats can extend over two face threads.
Figure 25 shows a weave with both backing-weft and backing-warp stitching on a sateen-derivative face weave on 12 ends and picks. The stitching order is applied following the regularity and order of a 12-end sateen weave. A comprehensive discussion of the characteristics of both weft-backed and warp-backed cloths was presented by Watson [1925, pp.7-24].

3.6 Double cloths

A double cloth is composed of two component cloths, from two sets of warp threads and two sets of weft threads, woven simultaneously as one composite fabric [Moore, 2000h]. Occasionally the two warps may be fed into the loom from separate beams, but more often than not they are combined on one beam. Double-cloth construction permits fabric to be made where the face and back are different, either in terms of surface texture or colour. Double cloths can be categorised into one of three classes, based on how the two components are held together: self-stitched double cloths; interchanging double cloths; centre-stitched double cloths. Self-stitched double cloths rely on selected threads from the back cloth or face cloth interlacing (or stitching) at discreet intervals into the face cloth or back cloth respectively. Interchanging double cloths have two sets of warp and weft threads which swap position at selected intervals, thus allowing each set to create the face of the double fabric on some occasions and the back of the double fabric on other occasions. Centre-stitched double cloths are held together by stitching threads, running warp-ways between the two cloths. These stitching threads interlace alternately (and discreetly) in the face and back cloths. Each of the three classes of double cloths was explained by Moore in his readily understandable review of basic weaves [Moore, 2000i, j & k].
3.6.1 Self-stitched double cloths

When face and back sets of threads are arranged in equal proportions, the backing weave is usually the same as the face weave. Where proportions differ certain combinations have been found to be appropriate. For example where warp and weft threads are in the proportion of 2 face to 1 back, plain weave is suited for backing both 2/2 twill and 2/2 hopsack structures, 2/1 twill for backing 3/3 twill, and 2/2 twill for backing 4/4 twill [Watson, 1925, p.26].

Figure 26 illustrates the structure of a double cloth where the backing stitches (or ties) are positioned between face warp floats, and the face weft (where it enters the back fabric) is concealed on the underside of the cloth by adjacent backing weft.

Figure 27 illustrates the structure of a double cloth where the face and back components are held together by both the backing-warp threads entering the face fabric and the face-warp threads entering the back fabric. On the face of the cloth backing-weft ties are positioned between face-weft floats, and on the back of the cloth face-warp ties are positioned between backing-warp floats.

Figures 28 and 29 illustrate double-fabric structures where the front threads and back threads are in the proportion of 2 face to 1 back. Again each tie on the face or the back of the fabric is positioned between warp or weft floats where appropriate.
3.6.2 Interchanging double cloths
Interchanging double-cloth structures often result in the production of cloths which are reversible. An example of such a structure is illustrated in Figure 30. The sectional view to the right of the illustration shows the interlacing of two adjacent ends, and the sectional view to the bottom of the illustration shows the interlacing of two adjacent picks. Further explanation is given by Watson [1925, pp.63-88].

3.6.3 Centre-stitched double cloths
Occasionally extra threads are added to double fabrics with the objective of increasing the fabric weight; such threads are known as wadding threads and are usually thicker and of lower quality than the face and back sets of threads. In centre-stitched double cloths, the purpose of the centre-stitching threads is to bind the two fabrics together. Centre stitching is often used in cloths where there is a great difference or contrast in the thickness or colouring of the face and back yarns; self-stitching from back to face or face to back may not therefore be appropriate.
Figure 31 illustrates the structure of a double cloth arranged 1 face and 1 back in which centre-warp stitching is employed. Figure 32 shows the structure for a double cloth where a 2/2 hopsack weave is used, and the picks are in the proportion of 4 face and 2 backing to 1 centre-stitching thread. One repeat of the double weave contains 2 centre-stitching threads.

### 3.7 Triple cloths

Triple cloths (referred to by Watson as “treble cloths”) have three sets of warp and weft threads, each set forming one cloth within a layer of three. The general rule governing stitching of double cloths, i.e. that each tie on the face and back should be positioned between floats, is also applicable to triple-cloth construction [Watson, 1925, p.98]. Figure 33, redrawn from Watson’s *Advanced Textile Design* [1925, p.103], shows
the structure for a triple cloth in which threads are arranged 1 face, 1 centre, 1 back, and a 4/4 twill is used for the face fabric and a 2/2 twill is used for both the centre fabric and the back fabric. A wide range of issues of importance in the design of triple fabrics was discussed by Watson [1925, pp.96-106].

3.8 Extra-weft and extra-warp figuring
Decorative effects are often attained through employing extra threads in a warp or weft direction, or occasionally in both directions. An issue of importance in the use of the resultant fabric is the substantial floats which may ensue in sections at the back of the cloth where the decorative threads are not used on the face. Substantial floats will lower the practical usefulness of the cloth. Solving the problem may entail cutting away the excess thread and binding the decorative remainder to the fabric through the use of interlacements positioned at the circumference of the decorated area. Excess weft-ways floats are seemingly easier to deal with. Watson commented:

If extra threads have to be removed from the underside of the cloth, it is more difficult and costly to cut away extra ends than extra picks. The chief advantage of the warp method is in productiveness, but in order that elaborate designs may be designed and woven conveniently and economically, a more complicated Jacquard mount is required than in extra-weft figuring.

Watson, 1925, pp.107-108

An alternative to cutting the excess threads would be to shorten floats through interweaving the thread into the face of the fabric and, if possible, to lower its visual impact by hiding the interlacements between face-warp or -weft floats. A wide range of further features and issues relating to extra-weft and extra-warp figuring was discussed by Watson [1925, pp.108-131 & 131-147].

An important category of fabrics involving the use of extra weft is figured muslins. The characteristic feature of these is the use of opaque figuring on a light semi-transparent foundation texture [Watson, 1925, p.169]. The extra threads float outside the figured areas until weaving has been completed and are cut away subsequently during finishing thus allowing the opaque motif to appear without interruption on the semi-transparent ground. Figure 34 illustrates the structural features of a figured muslin fabric. It is worth noting that the figuring is achieved
through the insertion of extra weft threads in groups of two between the ground wefts of the foundation cloth. Comprehensive details concerning the design and production of such fabrics were given by Watson [1925, pp.169-177].

Depending on the nature of the desired effect, figuring with extra threads may be applied through lappet weaving or through swivel weaving. Brief attention is devoted to each below.

3.9 Lappet and swivel figuring
In the production of lappet-woven fabrics, figuring or whip threads are introduced in the form of extra warp on to the surface of a foundation fabric and allowed to transverse in a horizontal or weft-ways direction. Stitching to the ground occurs at each extremity of the figure or motif produced. The structural features of lappet figuring are indicated in Figure 35. Watson observed that any type of ground weave may be used but as the foundation cloth needs to be firm enough to withstand the sideways pull of the whip threads, a plain or gauze weave is usually employed [Watson, 1925, p.296].

Watson observed that the term “swivel” was formerly applied to the type of loom used to weave several narrow-width fabric bands alongside one another [Watson, 1925, p.334]. In more recent times swivel weaving involved the use of a series of swivel shuttles positioned across the loom width and working in conjunction with a conventional shuttle. Weft threads from this conventional shuttle interlace with the warp to produce a foundation cloth upon which the swivel shuttles produce figures in extra weft [Watson, 1925, p.334]. Some swivel looms had two or more decks or banks of swivel shuttles which enabled two- or three-colour combinations to be used.
Figure 36 illustrates a two-colour swivel-woven structure.

### 3.10 Brocades, damasks and tapestries

Where decorative patterning (also known as figuring) occurs in woven fabrics, this is invariably enhanced through the use of more than one colour and may, for example, be achieved through weft- or warp-ways coloured stripes or checks, or through the use of supplementary threads which create coloured weft or warp floats. The use of metallic yarns can add further aesthetic interest. Examples of woven figured-fabric types include brocades, damasks and tapestries.

**Brocade** is a fabric embellishment, conducted during the weaving process, using extra (supplementary) ends or picks. Originally the term was used to denote a class of silk fabrics ornamented with extra wefts of gold or silver. Brocading can be done on a wide variety of structures, including plain, satin or twill weaves. The term “lancé” is applied if the additional weft extends over the entire width of the fabric with only a few interlacements.

**Damask** is a figured fabric, made with a single set of warp threads and a single set of weft threads, generally employing warp-satin and weft-sateen weaves or twills. Often damasks are monochromatic and the pattern is evident through reflections associated with warp-faced weaves such as satin contrasting with weft-faced weaves such as sateen. Weaving was facilitated by a patterning-harness arrangement which controlled supplementary figuring effects and a group of heddles to the front of the loom which gave a ground weave. Every warp thread was controlled by both the harness and the front heddles working harmoniously. The technique is explained further by Schreus (1955, pp.3974-3981).

**Plain weave** is often the basis of tapestry weaving, a technique which is characterised by the insertion of coloured weft threads within small independent areas of the cloth during the weaving process. The weft
does not therefore need to extend across the full width of the conventional shed. In most cases the weft is allowed to dominate and largely keeps the warp from view. Open, warp-ways slits occur in the vertical boundaries where two colours meet. This can be avoided by interlocking adjacent weft threads. Tapestry weaving has been in use across a wide area, including much of Europe, China, India, North Africa, the Near East and the Americas. Kilims, the non-tufted or flat-woven carpets produced in the majority of Asian and North African carpet-producing centres, are woven using a tapestry weave with a plain-weave binding structure. Occasionally a twill weave is used as the binding structure (as is the case in tapestry-woven Kashmiri shawls). Chinese silk tapestry, known as “ke-si”, is finely woven in silk with a plain-weave structure. In the absence of interlinking of adjacent wefts at the interface between two colours, lengthways slits develop; hence the term “ke-si” or cut silk.

An important aspect of tapestry weave is the use of differently coloured wefts. Barber [1991, p.211] proposed that, since wool was available in many natural shades and was also easier to dye than bast fibres, it seems plausible to propose that tapestry weaving was developed by wool weavers rather than linen weavers. This seems appropriate in the context of European and Near Eastern textile production (the primary focus of Barber’s treatise), where vertical weaving techniques, such as warp-weighted and two-beamed vertical looms, were in use. These and other classes of looms are discussed in the next section.
As pointed out by Schaefer the term loom “...comprises every kind of cloth-weaving instrument from the simplest wooden frame to the complicated power-driven apparatus of modern industry” [Schaefer, 1938]. As has been established in previous sections, the key stages in the weaving process are shed formation, weft insertion into the shed, and beating up of each inserted weft thread to form the cloth. Not surprisingly, different means of meeting the requirements of each stage have evolved and developed over the centuries. Certain classes of looms have dominated during particular periods and in different regions. Different cultures were associated with different fibres and different weaving techniques: e.g. ancient Egypt with the weaving of linen on horizontal ground and vertical two-beamed looms, ancient Greece and parts of northern Europe with wool weaving on warp-weighted looms and ancient China with silk weaving on early forms of drawloom. These and other classes of loom are discussed below. Interesting reviews and explanations of numerous loom types were provided by Innes [1977] and Roth [1918, reprinted 1977]. The more important loom classes are described below.

4.1 Horizontal ground loom
Evidence of weaving in Egypt stretches back over five thousand years to pre-dynastic times (before 3150 BCE) in the form of cloth fragments as well as a drawing which has been interpreted as a horizontal ground loom, drawn in cream and red on the inside of a pre-dynastic bowl found in a tomb in Badari (Egypt) [Schaefer, 1938, p.546]. The drawing, reproduced in Figure 37, shows four corner pegs holding two beams at either end with warp threads running between. A small area of woven fabric can be seen and, to the left, three bars across the middle of the warps are shown. Presumably these are the shed or lease rod, the heddle rod and a rod to beat the weft in [Barber, 1991, p.83). In the upper part of the drawing, two human figures are depicted seemingly arranging lengths of weft thread (each of sufficient length to fill the shed and counter-shed of the loom depicted). Barber noted that there had been some

Figure 37
Drawing from pre-dynastic Badari (Egypt) bowl.
dispute among scholars concerning the interpretation of the two drawings on the bowl [Barber, 1991, p.83]. Vandier [1952], for example, maintained that the two figures depicted were involved in building a “palisade” and that the other object was somehow connected to a hunting scene. However the weight of debate seems firmly on the side of the weaving interpretation, particularly when the fringe-like weft located on the left of the fabric is considered. This feature appears to be characteristic of Egyptian horizontal loom weaving only and indeed can be seen on the illustration presented in Figure 38. In this drawing, the fringe can be detected on the right of the completed fabric.

The back beam (or warp beam) and the front beam (or cloth beam) were each attached to two pegs set in the ground. In very early times it was probable that the weft was interlaced over and under the warp threads by hand or possibly using a needle [Horne, 1968]. The process reached a higher level of development when the odd- and even-numbered warp threads were separated to form a shed and a counter-shed through which trails of weft thread could pass. As explained previously in Section 2, in the process of preparing the loom prior to weaving, alternate warp threads were divided into positions above and below the lease rod thus creating a mini-shed. Also, the warp threads positioned below the lease rod were threaded through loops of cord (heavy-duty yarn) attached to the heddle rod which lay on top of the sheet of warp threads. The warp sheet was then stretched between two rollers and weaving proceeded as follows. The warp sword was inserted weft ways into the warp threads, passing through the slight division created by the lease rod. When turned through ninety degrees the edge of the warp sword lifted the series of warp threads (positioned at the top of the lease rod) thus forming a shed. A trail of weft was inserted into this shed, an action which was probably facilitated by the use of a thin stick or long needle. The trail of yarn was then beaten in using the flat warp sword. The warp sword was withdrawn, lowering the series of warp threads. The next shed, known as
the counter-shed (when producing plain weave), was formed by lifting
the heddle rod, and inserting and turning the warp sword again, thus
raising the alternate series of warp threads (positioned at the bottom of
the lease rod). Weft thread was inserted and beaten in as before. The
warp sword was withdrawn and the heddle rod lowered thus levelling the
warp sheet again. The process was repeated and plain-woven fabric was
created [Forbes, 1956, p.194].

Further pictorial representations, dating to twelfth-dynasty (1991-1782
BCE) Egypt, have been discovered, redrawn and published widely in
relevant texts. Some of these loom murals, such as that in the tomb
of Khnemhotep at Beni Hasan (Figure 38), ignore rules of
linear perspective and thus appear vertical; wooden funerary models
found in various tombs dating to the same period give the three-
dimensional reality and confirm the use of the horizontal loom [Hall,
1986, pp.13-14]. The illustration in Figure 39 is more readily interpreted,
at least by twenty-first-century European observers, as a horizontal loom
arrangement. The original murals from which the illustrations in Figures
38 and 39 are sourced are from the same region and the same
approximate period, suggesting further that they are depictions of similar
loom types.

As mentioned previously, weaving on less developed types of horizontal
ground loom may have necessitated needle work. Two possibilities
seem apparent. First, a loom type which offered no division of the warp.
In this case the fabrication process was one of darning rather than
4.2 Vertical two-beamed loom
The two looms depicted in Figure 40 are known as vertical looms, and were in use in Egypt by the eighteenth dynasty (1570-1293 BCE). The warp threads were held taut between an upper and a lower beam fastened to a rectangular frame which, in most cases, was simply propped against a wall or fastened to posts. This type of loom is similar to the tapestry looms still used today in Europe and elsewhere. With this early Egyptian variety, weavers worked singly or in pairs [Schaefer, 1938, p.548]. Considering the apparent height (seemingly up to four metres) of the looms illustrated, it is probable that the lower (cloth) beam of each allowed the resultant fabric to be wound up and that the upper (warp) beam of each could be adjusted to allow the release of warp threads. It has been suggested that the black discs on either side of the frame were appliances for adjusting ropes attached to the warp beam. As with the horizontal ground loom, the sheds were formed by means of a lease rod and heddle rod shown above the heads of the weavers depicted working on the larger of the two looms. Another possibility was that a continuous circular warp was used and the two beams simply served to maintain appropriate tension on the warp. Crowfoot observed that the period of the mural, from which the illustration in Figure 40 has been taken, coincided with the appearance in Egypt of highly decorated textiles seemingly from Syria; these may have had a substantial influence on Egyptian production [Crowfoot, 1954, p.439].
Horn observed that:

On all these looms the first pick was inserted next to the bottom beam, all picks being beaten in with a downward stroke and the fabric being woven in a floor-to-ceiling direction.

Horn, 1968, p.25

This was a different working procedure from that used on the warp-weighted loom, a loom of renowned association with Greek tapestry weaving owing to its frequent mention in classical Greek literature (e.g. Penelope’s use of a warp-weighted loom in Homer’s *Odyssey*).

Figure 41 provides further illustrations of the two loom types described previously as well as an illustration of the warp-weighted loom. Further comments relating to the warp-weighted loom are presented below.

### 4.3 Warp-weighted loom

This loom type is another vertical loom type but it did not employ a lower beam. Rather, bundles of warp threads were attached to an upper beam and kept taut through being attached to weights at their dangling ends. In this case the weft threads were beaten in with upward strokes of a comb-like device. The fabric was thus woven in a ceiling-to-floor direction.
The earliest evidence for this category of loom comes in the form of loom weights and post holes (which would have been used to accommodate the upright posts of the loom) from an archaeological site associated with the Körös culture in Hungary, dated to the sixth millennium BCE (early Neolithic) [Barber, 1991, p.93]. Weights were invariably made from clay or stone and were thus less perishable than fibrous materials, a characteristic which has ensured the survival of vast quantities of loom weights in archaeological excavations throughout much of north-western Europe. Barber commented:

...we can say that the warp-weighted loom seems to have been used in central Europe and perhaps Anatolia from the early (pottery) Neolithic onwards. We see it expanding into southern Greece and northern Italy in the Middle Neolithic, reaching Switzerland in the Late Neolithic and Scandinavia and Britain in the Bronze Age – a generally north-westward movement...

Barber, 1991, p.113

According to Horn [1968, p.25] the upright loom, particularly the warp-weighted variety with its easily manipulated warp threads, was the best for producing the types of patterned fabrics which called for the insertion of coloured weft threads, particularly tapestry-woven fabrics. In tapestry weaving, a full shed from selvedge to selvedge was not required, but rather the warps were manipulated by hand without mechanical assistance. Small lengths of coloured weft were inserted and beaten in as required. Forbes commented:

Among early wool tapestries some classes are found to be beaten compactly, some quite loose. The latter type may point to the use of a warp-weighted loom, as the weft on such looms was beaten up instead of down and gravity should tend to loosen the web rather than tightening it.

Forbes, 1956, p.206

A wide-ranging discussion relating to the operation of the warp-weighted loom was provided by Hoffmann [1964].
4.4 Back-strap loom

The back-strap loom was in widespread use in rural households in India and in South-east Asia, as well as Central and South America, and among the Ainu of Japan [Schneider, 1987]. Such looms were easy to construct from readily available materials. The warp threads were attached to two parallel sticks, one of which was tied to a stake and the other was attached to a belt. The belt was placed around the weaver’s waist. This arrangement allowed the weaver to relax or tighten the warp threads, by a slight movement of the body forwards or backwards, so as to facilitate the opening of the shed and the insertion of weft threads. The two stages in the production of plain weave were as follows:

(a) A heddle consisting of a rod with hanging loops encircling alternate warp threads was raised to form a shed and a weft thread was inserted. The weft was beaten in using a flat stick. The heddle rod was then lowered.

(b) A broad counter-shed stick, placed weft ways through the sheet of warp threads, was used to raise the other warp threads and thus form the counter-shed. Another weft thread was inserted and beaten in using the counter-shed stick.

In many instances (e.g. with some Peruvian cloths) the length of the fabrics produced was restricted due to the absence of beams to unwind the warp and wind the woven cloth. The maximum length of fabric was thus governed by the length to which the weaver could stretch in order to insert the weft. In some cases (such as with cloths produced in parts of Indonesia) this restriction was addressed through the use of a continuous circular warp which allowed around twice the length of fabric to be produced. Occasionally (e.g. with some Japanese looms) the back-strap arrangement was used in conjunction with relatively sophisticated shedding arrangements. The addition of cloth and warp beams was another possibility. An example of a Japanese back-strap loom is illustrated in Figure 42.

Figure 42
Japanese back-strap loom, with advanced shedding arrangement.
4.5 Tablet loom

Tablet weaving is a technique for producing narrow-width plain or patterned fabrics (invariably used as belts or attached as decorative borders). The use of the technique has been recorded in Japan, China, Central Asia, India and the Himalayan countries, Persia, Indonesia, the Caucasus, Syria, Palestine, Egypt, North Africa, Turkey, Greece, Macedonia, Bosnia, Russia, Sweden, Norway, Iceland and France [Schuette, 1956, p.9]. The specifics of the technique, the raw materials employed, as well as the patterns and colours used, differed from country to country. Figure 43 shows a typical tablet-weaving arrangement.

A series of square or rectangular tablets, with sides measuring between 4 and 7 centimetres, holds the warp threads and produces the shed unaided by conventional heddle arrangements. Tablets are made from bone, leather, wood, parchment or, in more recent years, plastic or cardboard. Typically, each tablet has a hole in each corner. Triangular tablets are rare, but the use of hexagonal or octagonal tablets for complex elaborate weaves has been reported [Schuette, 1956, p.4]. Warping involves passing warp threads through the holes of the tablet in a pre-determined sequence. Turning selected tablets in their plane by say 90 degrees causes them to twist around each other and form a shed. After insertion and beating in of weft, a further selection of tablets is turned and the process repeated. The resultant structure in the fabric depends on what Schuette referred to as the “turning rhythm” [Schuette, 1956, p.6].

A seemingly infinite series of possibilities unfolds, depending on how many tablets are used, how many holes are in each, the number and order of threads in each, the starting position of each, the turning sequence as well as the direction and angle of each turn. Schuette reported that by varying the turns given to the tablets a wide variety of woven structures was possible, including plain weave, twills, and satins.
The range of end uses for tablet-woven items is restricted by their relatively narrow width. Referring to the Asian context, Schuette listed the following end uses: “...bridles, saddlery, belts, delicate bands for winding round sacred writings and lacquered chests, necklets to be worn by members of high castes in the temples, beggars’ nets (in Burma) for collecting alms etc.” [Schuette, 1956, p.9].

Weaving tablets have been found in a range of archaeological sites. Schuette presented a wide-ranging debate on the origin, development and regional characteristics of the technique and the resultant product [Schuette, 1956]. It is certain that the technique had reached a high degree of development in Scandinavia by the end of the first millennium CE. One of the most fortunate archaeological finds was a weaving set of fifty-two wooden tablets complete with threaded warp discovered at Oseberg, Norway, in the ninth-century CE tomb of Queen Asa [Schuette, 1956, pp.4-5]. This find confirmed the advanced state of knowledge of the process at the time. A number of early examples from ancient Egypt date to the twenty-second dynasty (947-712 BCE). Schuette commented:

Among these there were fine bands measuring 20, 13, and 25 mm. made of linen, the common material in Egypt. The first two pieces are coloured trimming borders, i.e. black and red on white now turned ochre. They were sewn on, as proved by remaining stitches. The third band, one of the most interesting specimens in the collection, is a hollow fabric the regular texture of which argues years of experience in the art of tablet weaving. According to the experts, these three bands date back to [the twenty-second dynasty].

Schuette, 1956, p.18

Older still is the renowned girdle of Rameses III (1182-1151 BCE), tablet woven using alternating decks of four-holed and five-holed tablets [Barber, 1991, pp.118 & 119].

4.6 Raised horizontal or treadle loom
The methods for attaining a shed in a sheet of warp threads underwent radical change when the working of the mechanism was transferred from the weaver’s hands to his/her feet. Previously to this, the shedding (or heddle) rods were moved upward by hand, but with the introduction of the so-called treadle loom foot treadles raised and lowered the sets of warp threads, held in frames called heddles. The heddles were suspended by cords passed over pulleys which, in turn, were attached to treadles.
Treadle weaving is generally associated with the raised horizontal loom where the warp is stretched between two beams (warp and cloth beams) each held in place in a box-like timber frame. Treadle weaving has its origins in Asia, with early examples associated with China. It was (and is) in widespread use in India as well as parts of Africa.

In south Asia, particularly India, treadle looms were in common use by the eighteenth century and, in many cases, involved the building of the horizontally arranged loom above a pit dug in the ground where the treadles were then located. The weaver would thus sit on the edge of the pit with his/her feet in the pit operating the treadles. An illustration of an Indian pit loom from the mid-1800s is reproduced in Figure 44.

A further group of treadle looms is the horizontal narrow-band loom commonly used throughout West Africa in the production of narrow cloth (from 5 to 15 cm. wide). Some narrow looms are held within a wooden frame. Often the heddles are suspended from above the warp. In some cases the warp extends beyond the loom frame and is held taut by a heavy stone which is brought closer to the loom as weaving progresses. A comprehensive explanation of the operation of West African narrow-band looms was given by Picton and Mack [1991]. An interesting review was provided by Lamb and Lamb [1973].
The details of the early introduction of the treadle loom to Europe are not clear. It was certainly the case that from the thirteenth century CE onwards raised horizontal treadle looms were in widespread use throughout much of Europe. A naked weaver working on a medieval raised horizontal treadle loom is shown in the illustration given in Figure 45, reproduced from a thirteenth-century manuscript (held in Trinity College Cambridge). The warp threads are kept taut by the action of a lever attached to one end of the warp beam. The weaver can be seen holding a shuttle at the entrance to the shed. The formation of the shed and counter-shed is facilitated by raising and lowering of the shedding harness which is attached via cords over pulleys to the foot treadles. A further illustration of a treadle-controlled raised horizontal loom, dated to the fourteenth century, is shown in Figure 46. The loom has two pairs of heddles connected to pulleys attached to the ceiling. A well-focused, comprehensive review of the evidence for treadle weaving in Europe during medieval times was provided by Hilts [1990a].

A notable innovation in weaving was the introduction of the batten (or sley) suspended from the upper part of the loom frame [Schaefer, 1938, pp.542-545]. The reed, which was inserted at the lower end of this batten, kept the warp threads evenly spaced and helped prevent their entanglement. Beating up of the inserted weft thread was also greatly facilitated by the weight of the sley.
Over the years there were many attempts further to mechanise the loom. Leonardo da Vinci (1452-1519) had a preoccupation with the mechanisation of weaving but his plans never came to fruition [Schaefer, 1938, p.558]. In 1586 Anton Möller of Danzig is reputed to have invented a mechanised loom for weaving ribbon which required an unskilled attendant to operate a simple lever. Although few details of the mechanism have survived, several edicts against the use of such looms from the early-seventeenth century confirm the existence of such a device [Schaefer, 1938, p.558].

In 1678 a naval officer named de Gennes published a design for a mechanical loom which he claimed could weave without human assistance. Up to a dozen machines were to be driven by means of a shaft operated by waterpower [Schaefer, 1938, p.558]. Despite the benefits claimed, there seems to be no evidence that the machine was adopted at industrial level.

The challenge of mechanising weft insertion was addressed by the reed maker John Kay with the introduction of the so-called flying shuttle in 1733. Prior to this the traditional means of passing the shuttle from one side of the shed to the other was slow and laborious, and required two weavers when particularly wide cloth was being produced. Kay incorporated a simple mechanism which acted like a pair of catapults and projected the shuttle through a warp shed, from one side of the loom to the other. Further details of this and other related mechanisms associated with developments in weaving, using the raised horizontal loom, were given by Schaefer [1938, pp.558-566].

4.7 Drawlooms and Jacquards
Shaft looms (with heddle arrangements) were adequate for most basic woven cloths but fell short in the production of highly figured fabrics. The patterning potential of a loom was governed primarily by its shed-forming potential. The greater the number of sheds which could be created the greater the patterning scope of the loom. Each heddle was used to raise a particular sequence of warp threads, and sheds were formed by raising one or more heddles. There was an obvious physical limitation to the number of heddles which could fit along the length of the loom and could be operated by the weaver. The drawloom addressed this limitation, by attaching warp threads to cords (known as harness
cords) which in turn were gathered into groups as determined by the intended pattern. These groups of cords were pulled and successive sheds were formed. Most drawlooms (e.g. looms for weaving damask) combined two shed-forming arrangements: a set of heddles to create the ground or background weave and a patterning harness (also known as a figure harness) to create figured effects. The most advanced drawlooms had an additional element known as a comber (or cumber) board, a thin wooden sheet containing rows of holes, which evenly spaced the raised cords and prevented entanglements. The drawloom has been associated for much of the second millennium CE, and before, with elaborately figured brocades and damasks in silk and linen [Schneider, 1987].

The operation of the drawloom involved the attention of a weaver to insert the weft thread and to beat it in, as well as an assistant to pull the strings in a predetermined sequence and form the shed. Figure 47 reproduces an illustration of a Chinese drawloom published in 1881.

The introduction of the drawloom may well have influenced the further development of the treadle loom. This view was expressed by Hilts [1990a] when she observed that the advance from treadle looms with only four heddles to those with up to thirty-two heddles was probably
caused through competition from drawlooms. Large multiple-heddle looms may well have presented a challenge to operate, even for a highly skilled weaver, but such looms eliminated the need for the services of the weaving assistant and allowed more rapid production [Hilts, 1990a, pp.25-32]. A comprehensive explanation of the operation of various drawlooms was given by Murphy [1837] and a more recent description of historical developments in drawloom weaving was given by Becker [1987] one hundred and fifty years later.

In 1805 Joseph Marie Jacquard (1752-1834) presented an automatic selection mechanism which could be mounted on a raised horizontal loom and operated by a treadle. This device was to revolutionise pattern weaving. A series of perforated cards, connected in the form of an endless chain, was presented one at a time to the selection mechanism. Depending on the order of the perforations in each card, certain warp threads were raised to form a shed and this shed corresponded to a stage within the predetermined pattern. Schaefer pointed out that by the year 1812 an estimated 18,000 looms were fitted with the mechanism, and by 1834 this had risen to 30,000, data which clearly attest the success of the innovation [Schaefer, 1938, p.564]. A comprehensive explanation of the operation of the Jacquard mechanism was given by Watson [1954, chapters 14 and 15].

4.8 Dobby loom

From the later stages of the Industrial Revolution until the late-twentieth century, dobby (power) looms served in producing the vast bulk of basic woven textiles world wide, in all industrialised countries. Hand-operated dobby looms were popular with hand loom weavers throughout much of the twentieth century. This class of loom had a series of wooden or aluminium frames (known as shafts or heddles), each the width of the warp. Each heddle held a series of vertical wires and each wire had one or more eyelets. Each warp thread was drawn through one of these eyelets on a selected heddle. The order in which the threads were drawn through the eyelets in the series of heddles was known as the draft. The loom was programmed so that prior to each weft insertion a particular selection of heddles and thus a particular selection of warp threads was lifted to form a shed. Typically each shed selection was determined by presenting a row of metal pegs to a selection mechanism located between a metre and a metre and a half above the warp. This selection mechanism
was connected to a series of cords connected in turn to the heddles. Each row of pegs presented to the selection mechanism determined which heddles were raised. The patterning potential of the loom was determined by the maximum number of heddles that could be accommodated by the particular loom. Some looms were only able to accommodate eight heddles while others could operate with around thirty-six heddles. A weaving plan indicated the order in which the heddles were lifted and lowered. This weaving plan was closely related to the woven structure and was based on ensuring that all warp threads with the same interlacement sequence were associated with the same heddle. One or more heddles were raised to give a particular shed. A loom with twenty heddles could therefore weave a fabric with twenty differently working warp threads within the design repeat. As observed by Moore:

In general, dobby woven fabrics tend to be made using simple, basic weaves and their variations. Larger figured effects resulting from combining weaves are also found but these tend to appear geometrical in form. Sometimes designs featuring curved lines are attempted on dobby looms, but the potential for this is somewhat restrictive.

Moore, 2000f

5. The Evolution and Diffusion of Decorative Weaving

As indicated in the Introduction, one of the concerns of this monograph is to review the source, development and spread of decorative weaving techniques. This is the principal objective of this section. Theoretical perspectives associated with invention and diffusion are reviewed. Attention is focused on technical aspects of particular types of woven textiles, and relevant evidence relating to decorative weaving in a range of national or cultural contexts is presented.

5.1 Theoretical considerations

Anthropologists have addressed the question of how similar cultural traits or the use of certain technologies, techniques of production or forms of decoration, can occur among different peoples in different geographical locations. Competing schools of anthropology consider two principal possibilities: independent invention with parallel development or else a process of diffusion. Up to the nineteenth century it was believed by certain scholars that human progress was governed by sets of universal laws. This belief culminated in the so-called evolutionist (or inventionist) school of anthropology, a label given to scholars who believed in autonomous local cultural development. In the late 1800s, there was a reaction to this perspective from scholars such as Boas [1891, republished in 1948], Ratzel [1896] and Frobenius [1898], who took the so-called diffusionist perspective on development. They stressed that changes in culture were almost totally as a result of diffusion of ideas, artefacts or cultural traits from other geographical areas. The two schools of thought were largely incompatible. Strict adherence to evolutionist views meant that independent invention and development were seen as inevitable and that all societies were destined to discover fire, the use of the wheel, spinning, weaving, agricultural practices, etc. Meanwhile, diffusionists maintained that all cultural development relied on the spread of ideas from one or two super cultures [Silver, 1979]. An interesting review of the debate was presented by Wescott [1998].

In order to examine the origin, development and spread of decorative weaving, it appears that a more integrated approach rather than strict adherence to either an evolutionist or a diffusionist view is required.
It is the contention in this monograph that decorated woven textiles diffused from several locations and these products stimulated the evolution of weaving processes elsewhere. A process encompassing diffusion and subsequent evolution is apparent. Where objects or ideas are adopted from another culture, probably based in another geographical area, a process of change and selection occurs. That is, borrowed elements usually undergo change or adaptation. This was recognised by Wescott [1998] when he maintained that inventions, when adopted, needed to be reinvented in the minds of the receivers: “...to the degree that an invention is a theme, most inventions permit – perhaps even invite – variations”. He continued: “...when a theme is diffused, most of its variations are invented by those receptive to the invention” [Wescott, 1998]. These views, which can also be found in the literature associated with invention and innovation research, are of value when considering the spread of decorative weaving techniques. For this reason, perspectives of invention and innovation are considered below.

The evolution of decorative weaving techniques was dependent on invention (defined here simply as a new combination of knowledge) and innovation (defined as the application of new combinations of knowledge). Terminology and definitions relating to these and related terms were reviewed previously by Hann and Jackson [1982, pp.2-8]. In 1954, Usher in the revised edition of A History of Mechanical Inventions proposed three general approaches to explain the emergence of inventions [Usher, 1954, chapter 4]. These were: the transcendentalist approach, the mechanistic-process theory and the cumulative-synthesis approach. Further explanation of each is provided below.

The transcendentalist approach attributed invention to the exercise of intuition by the rare genius who, occasionally, achieved great flashes of inspiration. The implication is that invention could not be planned, predicted or forecast. [Usher, 1954, chapter 4]. The second perspective on the emergence of invention, the mechanistic-process theory, has its origins with a group of scholars known as the Chicago sociologists. This group rejected the transcendentalists’ view and proposed that the process of invention was typically represented by an original combination of individual elements or answers, accumulated in the past. For example, according to Gilfillan [1935, p.10] “...a device can no longer remain unfound when the time for it is ripe”. The process of invention was
therefore seen to proceed as an instrument of history. Empirical evidence associated with this perspective was presented by Ogburn [1922, 1938], Gilfillan [1935] and Ogburn and Nimkoff [1940]. As a reaction to the other two perspectives, Usher [1954, chapter 4] proposed the cumulative-synthesis approach. In so doing he relied heavily on the insights into mental and social processes provided by Gestalt psychology. Within this third approach, major or radical inventions were visualised as emerging from the cumulative additions of relatively minor or incremental inventions, each of which required an act of insight. Usher suggested four consecutive stages towards the creation of a minor invention. First it was necessary to identify the problem; generally this involved the realisation of an incomplete or unsatisfactory procedure or approach to addressing a need. Secondly, it was necessary to set the stage, by assembling the elements of data necessary to solve the problem. Usher stressed that in order to arrive at a solution there needed to be an individual who possessed sufficient skill to understand and manipulate the data. The third stage necessitated an act of insight, and this involved “new organisations of prior knowledge and experience”. Usher stressed that a high degree of uncertainty made it impossible to predict the timing or the precise configuration of a solution in advance. The fourth stage, that of critical revision, involved applying newly perceived solutions and adjusting these, where appropriate, to resolve fully the problems. Further acts of insight were required at this stage. The results of the four stages represented building blocks for what Usher termed major or strategic invention. A major invention was seen as an accumulation of many minor inventions. These minor inventions were therefore seen to be of importance in setting the stage for major inventions, which in turn required the same four steps outlined above. He commented:

The gestalt analysis presents the achievements of great men [and women] as a special class of acts of insight, which involves synthesis of many items derived from other acts of insight. In its entirety, the social process of innovation thus consists of acts of insight of different degrees of importance and at many levels of perception and thought. These acts converge, in the course of time, towards massive synthesis. Insight is not a rare, unusual phenomenon as presumed by the transcendentalists; nor is it a relatively simple response to need that can be assumed to occur without resistance and delay.

Usher, 1954, p.61
Usher’s cumulative-synthesis approach is appealing, in the context of examining the evolution and diffusion of decorative weaving techniques. One weakness appears to be his failure to differentiate between invention and innovation. While it seems reasonable to assume continuity between the two, in the context of technological developments of the type being considered here it is appropriate to use the term “invention” to refer to the act of insight and the term “innovation” to refer to the application of that insight in production. This usage is adopted in this study. So, as stated above (in the third paragraph to this sub-section), an invention can be defined as a new combination of knowledge and an innovation can be defined as the application of new combinations of knowledge. In the context of this monograph, it is of importance to stress that the newness of the combination of knowledge is not of importance in the absolute geographical and historical sense, for it is argued that inventive activity in weaving, although focused on similar problems, was practised independently in different locations and periods. It is the view of the authors, therefore, that the first-past-the-post view of invention, predominant in the bulk of relevant literature, is of little value in developing the debate concerning the evolution and diffusion of weaving techniques.

5.2 From plain to twill
The first step beyond weaving plain weave and its derivatives (including various hopsacks and warp and weft cords) was probably the weaving of twill weave, an innovation which Barber maintained may have occurred among wool weavers [Barber, 1991, p.211]. In order to produce a 2/1 twill three sheds are required. A plain-weave structure by comparison requires two distinct sheds. It is doubtful that the discovery of twill weaves and their derivatives occurred in one single location and diffused from there. Independent invention, at different times in different locations, seems to be the realistic possibility.

A simple twill structure such as 2/2 twill (which can also be written 2 X 2 twill) involves each warp thread being lifted over two weft threads and then under two weft threads. Compared to the adjacent warp thread, each interlacement is offset by one weft thread, so that a diagonal of short warp floats appears in the finished weave. Once this diagonal effect has been discovered, reversing of the diagonal at intervals to produce wavy or zigzag effects and further reversal to create diamond effects seem
logical further steps. Furthermore, as observed by Barber [1991, p.187], these 2/2 twill derivations are based on weaving using only four distinct sheds, attainable, for example, through the use of four heddles on a horizontal loom.

In published studies dealing with the origins of weaving the consensus is that weaving is indebted for its origins to basketry and mat making. Early mat making was produced by over-and-under interlacements by hand and, initially, did not involve the use of an apparatus to form a shed. Horizontal ground mat looms were used in antiquity, but mural evidence of mat weaving in Egypt (e.g. Figure 39) does not predate early evidence of textile weaving using a loom or early textile fragments. Reference to basketry and mat making can however be valuable, for such crafts may well have stimulated early intentions to assemble lengthways threads and to darn a weft in a plain-weave structure. The next step in inventive activity was true weaving, which involved the creation of a series of two different sheds or divisions in a sheet of warp threads and the insertion of a trail of weft across this division.

There is much early evidence for the use of twills and derivative structures in mat making. These predate the earliest evidence for twill structures in textiles but, as indicated previously, do not predate early plain-woven textiles. An example of a 2X2 twill structure in mat making comes in the form of impressions on pot bases, found in late Neolithic sites in the Hungarian Republic, dating to the fifth millennium BCE [Crowfoot, 1954, p.421]. A 3X3 herringbone twill basket design, dating to the fourth millennium BCE, was discovered at Tarkhan near Cairo [Crowfoot, 1954, p.420]. In these and similar cases weavers may have been stimulated to create similar structures. Early imitations of a twill effect may well have involved darning on a warp sheet or embroidering on a plain-woven structure.

As observed by Forbes, the transition from plain weave to twills, satins and ultimately all forms of figured weaving demanded increasing control of the warp threads [Forbes, 1956, p.214]. This was achieved initially through the invention of the means for creating a third shed. A three-shed facility meant that warp threads could behave in one of three ways and interlace in one of three sequences, thus allowing for the production of a 2/1 twill. There is a likelihood that such inventive results were arrived at
independently at different periods and in different locations and, in some instances, may have been stimulated by the examination of twill structures on basketry or matting. The second stage of development was the addition of further shed-forming arrangements to allow for the production of higher-order twills and satin and sateen weaves. This was facilitated through the addition of heddle rods or heddles. Again, there is a likelihood of independent discovery. It is not clear from the evidence available where the first twills were produced; it may have been in northern Europe, the Near East (including Egypt), the Pakistan/India sub-continent or China. It is also not clear whether or not the earliest dated fragments were produced by darning or by real weaving (involving shed formation).

Inventive activity relating to weaving can be readily seen within the framework of Usher’s cumulative-synthesis approach (sub-section 5.1 above). Each major stage of development (such as the production of 2/1 twill) was the outcome of cumulative additions of inventive activity, each requiring acts of insight. The following four stages are proposed:

(a) The identification of the problem or question is the first stage. In this context, the problem is how to produce a woven textile in 2/1 twill. This may have been inspired by reference to basketry, matting or to twill-woven textiles from elsewhere.

(b) The next stage requires that all elements necessary to solve the problem are assembled, and an individual with the necessary experience and skill to address the problem is at hand. The requirement is an experienced weaver with a questioning mind able to focus on the problem at hand. A loom, ancillary equipment and a ready supply of yarn must be available.

(c) The third stage requires acts of insight. Prior knowledge and experience are required and also the capability of reorganising this knowledge. There needs to be the realisation that warp threads must behave in one of three ways and that three sheds are required. The lease rod is of little value; it will simply act to keep the threads in order and will not assist with shed formation. A repeating structure over three ends needs to be produced (shown in Figure 10). Three heddle rods are required and the warp
threads must be drafted through these rods with thread 1 in heddle rod 1, thread 2 in heddle rod 2 and thread 3 in heddle rod 3. The lifting plan for three successive picks should be as follows: (i) lift heddle rods 1 and 3; (ii) lift heddle rods 1 and 2; (iii) lift heddle rods 2 and 3. A solution to the problem set at (a) is thus proposed. (d) At the fourth stage, that of critical revision, the solution proposed at (c) needs to be tested, appraised, adjusted and improved for the particular circumstances of its application. The effects of the innovation on other aspects of production must be carefully considered. For example, different yarns may be required and the ideal sett of the cloth will need to be determined (as the range of possibilities with a 2/1 twill will be different from that for plain weave).

After the discovery of further twills, satins, sateens and their derivatives (each requiring acts of insight), it seems that a major leap was the development of decorative-weaving techniques. This involved the inclusion of a patterning facility (generally referred to as a patterning or figuring harness) which would work in conjunction with a series of heddles. A patterning harness exercises control over large numbers of threads, and this was the key characteristic of drawlooms as well as Jacquards. This added patterning facility was the basis on which brocades and damasks were produced.

The debate concerning the development and diffusion of decorative weaving is largely one concerned with silk weaving, although aspects of both linen and wool weaving are also of importance. The most highly developed and complex woven textiles of the past three millennia were patterned silk textiles. It is evident that China was an important source from which early silk-weaving techniques diffused, and trade was the main agent of that diffusion. Silk weaving is therefore an important focus of the discussion presented in this section.

5.3 The channel of diffusion
The overland routes between east and west were opened up at least a few centuries prior to the beginning of the Common Era. This brought China, Central Asia, Afghanistan, Persia, India, Alexandria, Antioch, Palmyra and Rome into contact. The so-called Silk Road was in reality an
extensive network of trading routes through the deserts and mountains of Asia. Tradition claims that trade along the route began in the Han dynasty (206 BCE-220 CE). However, as noted later in this sub-section, there is evidence to confirm that silk textiles were transported outside China before that time.

It is plausible that the network of trade routes was built up over many centuries or even over the duration of the first millennium BCE. Initially, relatively local exchange of goods over a few hundred kilometres may have taken place. Routes may have developed in response to geographical obstacles and political circumstances. Chang’an (modern Xi’an, in Shaanxi province in northern China) is considered to be the starting point for the international trade in silk. It is doubtful if any caravans or merchants travelled the full distance from Chang’an to the Mediterranean. Rather, trade may have taken place at many points along the way. Kashgar, Sarmarqand, Peshawar, Bactra, Bukhara, Tabriz, Shiraz, Esfahan and Constantinople were all, at some time, important destinations for traders.

Trade was not just in silks but also in numerous other goods. An assumption, evident in much of the literature, is that only certain items were transported in an eastward direction and certain other items in a westward direction, and that all traded items were transported the full length of the Silk Road from one end to the other. It is doubtful if this was the case. Rather, it is better to consider that the Silk Road was a continually evolving entity, with each of the hundreds of trade centres along the way dealing and trading in the types of goods demanded, at a particular point in time, by traders travelling east or west (or north or south or in any other direction). It appears that woven and embroidered silks were in great demand and formed a major component of the goods traded. It is highly probable that some of the silk items from China did not reach as far as the Mediterranean, at least in the early centuries of the first millennium CE, but instead found destinations in countries in between. This is an important consideration when examining the possible evolution and geographical diffusion of patterned silk weaving, for many technical developments may have been based on knowledge gleaned from such Chinese silks and may have occurred at centres located in between the two geographical extremities of the Silk Road.
Trade along the Silk Road flourished during the Tang dynasty (618-907 CE), and continued until around the fourteenth century CE. Probably the most significant commodity to be carried along parts of the Silk Road was religion, initially Buddhism and then Islam. There have been many important finds at archaeological sites along the Silk Road, both in and outside China, some with Buddhist or Islamic associations. Some of the archaeological evidence is reviewed briefly in sub-section 5.5 below. There is also, as mentioned above, evidence which predates the Han dynasty from beyond the Silk Road. A number of important archaeological discoveries confirm that Chinese silk was in circulation in Europe at least as early as the fifth century BCE. Vicari commented:

Fragments of woven silk or silken threads from bombyx mori, and therefore certainly of Chinese origin, have been found in an Athenian tomb in the cemetery of Keramikos, datable to the fifth century [BCE] and in two Celtic tombs in Germany, one at Hihmichele in Württemberg, and one at Rheingönheim, datable to the end of the fifth century [BCE].

Vicari, n.d., p.1

It is difficult to ascertain with any degree of certainty the exact route by which these Chinese silks reached so far west as to arrive in Athens or to be in the possession of Celtic aristocracy. The routes across the Iranian plateau to the Mediterranean are a possibility. A further possibility is that they were transported westwards along some northern route by Scythians and were traded, exchanged or gifted ultimately with Greek merchants or Celtic warriors. The Scythians were a loose association of nomadic tribes whose sphere of influence extended from around the Black Sea area to Mongolia, as far to the east as the northern borders of the Chinese Empire. As observed by Vicari, it is known from Chinese sources that Chinese emperors were “...in the habit of pacifying the warlike northern tribes [the so-called Scytho-Siberians] with lavish gifts of silk” [Vicari, n.d., p.1]. Such provenance does not seem to be impossible for the Athenian or Celtic finds.

It is generally accepted that the Silk Road (with its numerous tributaries) was the primary network, from east to west, for trade in silk and other goods (and also the potential channel for the diffusion of decorative weaving techniques) from the Han dynasty onward. The interaction between the Chinese and the Scytho-Siberians should not however be ignored. As stated above, around two to three centuries before the
beginning of the Han dynasty quantities of decorated textiles were obtained by the Scytho-Siberians. It is hypothesised that some of these items were kept and the remainder transported westward, possibly as exchange goods or gifts between neighbouring Scytho-Siberian tribes. At some final stage, towards the north-western, western and south-western extremities of Scytho-Siberian influence, the goods were exchanged or gifted with Celts, Greeks or Persians. This hypothesis is debated further in the final sub-section below.

The sub-sections which follow deal with the nature of patterned weaving in different cultural contexts, during different periods. In view of the important role played by China up to the end of the first millennium CE, attention is focused first on aspects of Chinese production.

5.4 Decorative weaving in China
China was an early starter in the production of decorated woven textiles. Many of the earliest examples were obtained from excavations in sites along the Silk Road, both within and outside the geographical boundaries of China. These excavations followed in the wake of Sir Marc Aurel Stein’s momentous discovery in 1913 of quantities of plain and figured silk fabrics at the site of Loulan in the Tarim Basin of Central Asia [Andrews, 1920; Stein, 1921, 1928; Ribold, 1977; Vollmer, 1986]. As these excavations were supported largely by western governments, the resultant finds were removed from China and lodged in western museums. Documentation was scant and the precise archaeological context of discovery rarely recorded. Dating of many items was therefore difficult and, at best, relied on stylistic comparisons based on a limited number of reliably dated examples. Since the mid-twentieth century, with the exception of the period of the Cultural Revolution of the 1960s and early 1970s, there have been many archaeological expeditions organised from within China. Archaeological records have become more comprehensive and post-excavation conservation has become more sophisticated. Vollmer commented:

Since 1950, field archaeology within China, under the direction of the Ministry of Antiquities, has flourished. Surveys, mostly of a salvage nature, have been carried out in the northern centres of Chinese cultural development, south central China, Mongolia and Central Asia. To date, well over 100 sites in which fabrics have been found have been excavated.

Vollmer, 1986
Technically and aesthetically some of the fabrics found are without parallel. By way of demonstrating the scope and range of items found, Vollmer listed part of an inventory of an early-Han-dynasty (206 BCE-220 CE) tomb (located at Mawangdui, outside Changsha in Hunan province) excavated in the early 1970s:

...seventy-seven items of intact clothing, including twelve robes, two skirts, three pairs of mittens, two pairs of socks and four pairs of shoes. There were forty-six rolls of uncut lengths of silk, numerous wrappers, bags and pouches. Fabric types included monochrome silk tabbies (twenty-two examples, four with embroidery), mock leno silks (seven examples, three with painted or printed and painted décor), monochrome patterned silks (three examples), patterned silk gauze (ten examples, two with embroidery), polychrome warp-faced compound silk tabby (four examples), polychrome pile warp silks [Vollmer comments that this was described as warp-faced compound twill with velvet pile in the Chinese literature] (fifteen examples), as well as three fragments of hemp tabby and seventeen fragments of ramie tabby.

Vollmer, 1986

Although the quantity of archaeologically authenticated ancient textiles increased dramatically in China during the twentieth century, information relating to these items remained outside the mainstream of textile history until recently. As a result, many textbooks begin their chronology of Chinese textiles with only fleeting reference to textile manufacture prior to the Han dynasty [206 BCE-220 CE]. It is however the case that the foundation of Chinese expertise in the processing of silk, wool and certain bast fibres was laid many years earlier [Hann, 2004, p.6].

The earliest-known Chinese woven textiles are three pieces of ge (kudzu vine) fabric [Nanjing Museum, 1980, p.4]. These rib-woven fabrics, with lozenge-type patterns, which exist as pseudomorphs (where metal corrosion has replaced the organic fibrous material) were found at Chaoxieshan, Jiangsu province, in 1972, and were dated to 3,400 (± 100 years) BCE [Nanjing Museum, 1980, p.4]. Further details were given by Hann [2004, p.8].

Silk fragments have been found, together with some ramie cords, at the site of Qianshangyang in Wuxing, Zhejiang province [Wang and Mou, 1980; Rawson, 1992, p.170]. A carbon-14 dating, equivalent to 2,750 (± 100 years) BCE, based on rice husks excavated with the fragments, has been published [Wang and Mou, 1980]. The bulk of textile finds
from Neolithic times (up to around 2000 BCE) until the Xia dynasty (c. twenty-first century to sixteenth century BCE) appear to be plain-woven. A few, however, have woven geometric patterns such as rhombs and zigzags, both bearing a striking similarity to the stamped pottery patterns from the same period [Su Bingqi, 1984, pp.199-201]. Although still restricted, in the main, to small-scale geometric patterns, the woven fabrics from the Shang dynasty (c. sixteenth century to eleventh century BCE) and Western Zhou dynasty (c. eleventh century to 771 BCE) are rich in a variety of motifs. Twill weave was used extensively, either in the form of twill patterns against a plain ground or in the form of fancy twills. Hui (revolving) motifs, cloud motifs and thunder motifs were in widespread use and echo the decorative style of bronzes, jade items and ceramics of the time [Hann, 2004, p.10].

Warp-patterned silks, known as jin, were the most common patterned woven fabrics in the Chu textile finds (from the Warring States period, 475-221 BCE) and they indicate the wide application of technically advanced drawlooms. A total of twenty-three pieces of brocade, together with a quantity of plain-woven silks, was unearthed from Tomb 44 at Zhojatang, Changsha, Hunan province [Xong, 1975, p.49]. These brocades were patterned through the use of warp threads of three different colours. Construction densities ranged from 80 ends per centimetre by 44 picks per centimetre to 138 ends per centimetre by 40 picks per centimetre. Further details have been given elsewhere [Hann, 2004, p.14].

It is worth remarking that weft-patterned silks (although in the minority) were also found dating to the Warring States period. Previously to the publication of details of such finds, it was assumed [e.g. Jenyns, 1981, pp.16-18] that weft-patterned silks were not produced in China until the Tang dynasty (618-907 CE) when, so it was claimed, appropriate technology was introduced from the west. It should be noted also that silk gauzes were found in Chu tombs from the Warring States period; these are commonly believed to be product innovations of the Han dynasty (206 BCE-220 CE) [Wilson, 1979, p.185].

Technological innovation during the Warring States period (475-221 BCE) therefore provided the impetus for the development of various silk weaves (especially in the state of Chu) as well as the potential for
producing larger and more sophisticated patterns on the warp brocade of the period. One example [cited by Zhong and Hann, 1989] is a lined quilt, measuring 333 centimetres by 233 centimetres and composed of five pieces of fabric. On each piece, a complex pattern depicting dancers and various animals is arranged across each fabric. In one case a complete design repeat measures 5.5 centimetres by 49.1 centimetres, and uses around 286 weft threads and about 7,600 warp threads [Peng, 1982, p.5]. Owing to the high labour intensity and skill levels required in brocade weaving, it is not surprising that such fabrics were apparently employed only sparingly in end uses such as decorative borders on costumes [Shen, 1981, p.27].

The weft-patterned silk brocades found in the Chu tomb in Jianling were produced by one of two fundamentally distinct techniques. In some cases the extra-patterning weft threads were carried the full width of the fabric, from selvedge to selvedge. Other cases relied on discontinuous brocading by a method similar to swivel weaving (see sub-section 3.9 above), in which the patterning wefts were inserted by small shuttles within small areas across the shed [see Zhong and Hann, 1989]. With this latter technique, the extra-patterning wefts were of higher linear density than the basic warps and wefts so that the finished fabric showed a slightly raised effect [Editorial Board for Textiles, 1984, p.128]. This technique may well have been the precursor to the ke-si (silk tapestry) technique, reputedly developed in the Tang dynasty (618-907 CE) around a millennium later [Zhong and Hann, 1989; Chen, 1984, pp.291-292]. Motifs on both weft- and warp-patterned brocades from the Warring States period were similar, and ranged from simple geometric motifs to more complicated figured scenes [Huang, 1985, pp.7-8].

It can thus be seen that archaeological finds from the last few decades of the twentieth century have yielded evidence of advanced weaving in China during ancient times. The complexity of woven silks available in Han-dynasty China suggests a pattern-weaving technology centuries ahead of elsewhere. Patterned woven silk is closely associated with the use of some sort of drawloom. There is a long-standing argument on the origination of the drawloom, with views varying between China and the Near East (Persia or Syria). The essence of the argument against Chinese origin is based on the belief that patterning in ancient Chinese woven textiles was totally through warp figuring, and that weft-figured
fabrics were first produced in the Near East. In the production of weft-figured fabrics a more sophisticated selection mechanism needs to be employed. It was therefore assumed that, since weft-figured textiles were produced earlier in the Near East, more advanced weaving mechanisms (including a form of drawloom) were employed there first. However, as outlined above, certain archaeological finds, from excavations conducted in China during the latter half of the twentieth century, have confirmed that weft-patterned brocaded silks were being produced in China in the third century BCE. Sophisticated looms were therefore in use in China at this earlier time. These looms would have been of little value without teams of highly skilled weavers, the outcome of a tradition which, it could be argued, stretched back several hundred years. It is therefore the view of the authors that China held dominance in the production of patterned-textile production, both weft-patterned and warp-patterned, using sophisticated drawloom-weaving technology, from the middle of the first millennium BCE up to and including the Tang dynasty (618-907 CE).

5.5 Decorative weaving in Egypt
Archaeological excavations of Egyptian sites dating to the pre-dynastic and early-dynastic periods have yielded immense quantities of textiles, the bulk used as mummy wrappings. Although all plain-woven, variations in texture, sett and yarn count are evident. Crowfoot, commenting on early-Egyptian (third-millennium BCE) woven linens, observed that:

Remarkable variety was obtained in plain weave by varying the size and quality of the yarn; for example, a striped effect was given by a thick soft warp used with an almost invisible weft, and a spotted one by the snarls in over-spun yarn on a muslin-weight cloth.

Crowfoot, 1954, p.434

From the viewpoint of patterned weaving, the most important items have come from three New Kingdom (1570-1070 BCE) tombs. The patterned items associated with each are identified below. Four fabrics from the tomb of Tuthmosis IV (1419-1386 BCE), excavated by Howard Carter in 1903, constitute the earliest surviving examples of Egyptian tapestry weaving. They were woven using dyed weft threads including blue, red, yellow, green and dark brown. [Crowfoot, 1954, pp.439-440, and
The tomb of Tutankhamun (1334-1325 BCE), discovered in 1922 by Carter, yielded a vast quantity of textiles and garments, including shirts, loincloths, kilts, shawls, gloves, belts, scarves, caps and headdresses [Hall, 1986, p.40]. Most notable from the viewpoint of early patterned weaving was a sleeved tunic with applied pattern-woven and embroidered bands, known as King Tutankhamun’s tunic. Hall commented that the woven bands forming the borders were “...of a warp-face weave with weft concealed” and that this created a pattern of squares, checks, zigzags, chevrons and diamonds [Hall, 1986, p.43]. There is a distinct possibility that these woven bands were tablet woven. Commenting on the decorative content of the woven and embroidered bands, Hall observed:

The designs are distinctly Syrian in derivation, although displaying marked Egyptian influence. The winged female sphinxes and griffins with interspersed palmettes are typical Mesopotamian and Syrian motif.

Hall, 1986, pp.43-44

Further decorated linens from the tomb of Tutankhamun included a quiver, a bag and gloves, all with tapestry-woven decoration [Hall, 1986, p.44].

A common question presented in the literature is whether the tapestry-woven textiles from the tombs of both Thutmosis IV and Tutankhamun were of Egyptian manufacture or whether they were manufactured elsewhere. Syria is mentioned as the most probable source. This appears to be a distinct possibility, supported by information provided by various texts such as the Annals of Thutmosis III (1504-1450 BCE) which, according to Hall, reported that Syrian captives on the estate of Amun at Karnak were clothmakers [Hall, 1986, p.18]. Hall hypothesises that these captives may have been instructing the Egyptians in the craft of tapestry weaving [Hall, 1986, p.18]. This supports the view that tapestry weaving diffused to Egypt via Syria, probably at the same time as the vertical two-beam loom was introduced. The agents of diffusion may well have been the captive Syrian weavers.

Possibly the best-known decorated textile from ancient Egypt is the so-called girdle of Rameses III (1182-1151 BCE). The item has a pair of longitudinal strips (showing repeating patterns) separated by a central
plain-woven linen band. The patterned strips show zigzags, dots and rows of ankhs, in linen using four dyed colours and white. The method of production was debated for many years [e.g. Crowfoot, 1954, p.441, and Schuette, 1956, p.18]. It has been confirmed in recent years that the item was tablet woven with alternating decks of four-holed and five-holed tablets [Barber, 1991, p.120].

The burial field of Akhmin, near the ancient city of Panopolis on the banks of the Nile in Upper Egypt, yielded vast quantities of textiles, many of which have found their way to museums and textile collections in Europe and North America. The vast bulk of these textiles, date within the period from the fourth century to late-twelfth century CE and are known as Coptic textiles. The word Copt is associated with Egyptian Christians. In 1959 Beckwith noted that although a very considerable quantity of material has survived it was difficult to establish a totally satisfactory stylistic chronology of surviving items [Beckwith, 1959, p.2]. This was due primarily to the lack of supporting documentation and to the unsystematic excavation procedures of the late-nineteenth and early-twentieth centuries. None the less it is readily apparent that tapestry weaving had reached an advanced state during the first millennium CE in Egypt.

Coptic tapestries generally used undyed linen warps and dyed wool for weft, although some silk was in evidence during the latter half of the first millennium CE. Occasionally the weft was woven as loops [Beckwith, 1959, p.5]. Compositions showed a strong Hellenistic influence in terms of both style and content; scenes from classical mythology (e.g. Dionysus, Ariadne, Eros, and Hermes) were common. Often compositions were enclosed in roundels. Religious themes (e.g. the story of Joseph) were also used, as well as saints, hunters or heroes on horseback, birds, fish and animals. A proportion of Coptic tapestries showed purely geometric compositions, including key patterns and diamonds, as well as symbols such as the ankh. From the late-first millennium CE there was a strong tendency to divide human and other figures into segments of colour outlined by means of dark thread; the result was similar to figures depicted in Celtic manuscripts of the same period.
5.6 Decorative weaving in Persia, Byzantium and Europe

In ancient times, Persia was a commercial crossroads between the Hellenistic-Roman world of the Mediterranean to the west and the Han Chinese to the east. Iranian textile production is recorded from the Achaemenid dynasty (c. 557-330 BCE). Both the Parthians (c. 211 BCE-224 CE) and the Sassanians (224-642 CE) took advantage of Iran’s strategic geographic location and exercised as much influence as possible over the lucrative silk trade between east and west, thus threatening Roman and Byzantine control.

By the mid-sixth century, the Sassanian empire stretched from Central Asia in the east to the western part of Iraq. The Persians probably knew the secret of sericulture (rearing silkworms in order to harvest their silk) by the third or fourth centuries CE, and probably used Chinese yarn prior to that. It is also highly likely that the Iranians used some form of sophisticated drawloom in the early centuries of the first millennium CE and subsequently. It is reasonable to suppose that the development of decorative weaving in Persia made close reference to Chinese silk-weaving techniques and products.

Only a few Parthian and Sassanian textile fragments remain, and the bulk of these were recovered from outside Iran. What does emerge however is a golden age of textile manufacture, especially in the production of decorated silk brocades, and knotted carpets; there had been a long tradition in the production of the latter, as attested by the so-called Pazyryk carpet of the fifth century BCE, almost certainly of Persian origin. The iconography of kingship, wars and battles, hunting scenes and heraldic-type imagery, as well as compositions including birds and animals (the senmurv, the winged horse, the rooster, the ram and the eagle), developed within Persia itself. Forbes noted that:

Literary sources inform us that the Sassanian authorities took weavers from their western provinces (for at that time they dominated Syria) and moved them to their weaving centres and factories in the east to weave silk. These must have been wool weavers, for the Near Eastern silks which appear in quantity in the fifth century [CE] are woven in the peculiar drawloom technique developed by the Syrian wool weavers and later also adopted by the Byzantines to weave silk.

Forbes, 1956, p.211
The influence on woven-silk production and design elsewhere was immense; Byzantine, early Islamic, and Japanese woven silks of the last few hundred years of the first millennium CE relied heavily on the compositional aspects of Sassanian design (especially the use of roundels) [Ackerman, 1953, p.3521]. During the Islamic period (642-c. 1194 CE) there was initially a decline but, owing to the patronage of various local dynasties, figured-silk weaving was revived and much innovation in design and composition (particularly the use of roundels and ovoids) was introduced [Ackerman, 1953, pp.3521-3526]. A particularly strong Chinese influence is evident in the design of Persian woven silks after the Mongol invasion in the early-thirteenth century CE. During the Safavid period (c. 1499-1722 CE) there was much use of metallic yarns in woven silk production. Silk double cloths were produced and triple cloths evolved. The interlocking-twill tapestry weave (found in Kashmir shawls) was also used in seventeenth-century Persia [Ackerman, 1953, pp.3529-3535].

Byzantine silk textiles gained a reputation for exquisite decoration. Byzantium was the eastern part of the Roman Empire, with its capital located at Constantinople (present-day Istanbul). Founded in 324 CE, Constantinople grew steadily in importance. Between the fourth and seventh centuries CE state-controlled workshops were established in Constantinople and in provincial centres in Egypt and Syria. In the early years these depended largely on the import of Chinese silk yarns through Persia, but conflict between the Byzantine and Persian empires jeopardised the dependability of this supply source. An internal source of supply was therefore demanded and sericulture was introduced. According to Muthesius [2002, p.150] early documentation suggests that Byzantine Syria was an early location for sericulture. Realistically, the introduction of sericulture would have involved plantations of mulberry trees, a vital food source for *Bombyx mori* (the Chinese variety of silk-worm). Muthesius suggests five stages of raw-silk acquisition up to the twelfth century CE:

(1) an initial phase centred in Syria before the fall to the Arabs (5th-7th centuries); (2) a subsequent stage of sericultural activity within Asia Minor (8th-9th centuries); (3) a third period of activity concentrated in western Asia Minor and the Balkans (9th-10th centuries); (4) a further initiative that saw the importation of Syrian silks to boost domestic supplies (10th century); (5) finally, a decentralization of raw silk supply (11th-12th centuries).

Muthesius, 2002, p.152
Muthesius remarked further that these five major shifts of raw-material supply indicated that the Byzantine weavers must have been highly skilled, for the quality and nature of the yarn provided would have influenced the weaving technique selected and the ease or difficulty encountered in producing certain designs [Muthesius, 2002, p.152]. Adaptability was required, and weavers would have had to envisage how techniques and designs could be adjusted to accommodate changes in the physical characteristics of the raw material supplied.

The majority of surviving Byzantine silks from the first millennium are to be found in ecclesiastical treasuries. Probably the most famous Byzantine silk is the early-eleventh-century elephant silk at Aachen Cathedral Treasury. The composition depicts single elephants held in foliated roundels measuring 91 cm. in diameter. The loom that produced the silk would have been around two metres wide, thus involving perhaps up to four weavers. The design required 1,440 manipulations for the production of one repeat [Muthesius, 1993, p.78].

In the last few centuries of the first millennium CE Islam spread from its initial base in Arabia to gain influence or control over many of the lands to the east as far as India and, to the west, all of North Africa as well as parts of the Iberian peninsula and the island of Sicily. This was to have a dramatic influence on the diffusion of silk weaving. Knowledge and skills sourced and developed in China, Egypt, India, Persia and Syria, centuries previously, were introduced into countries under Islamic control. Fine silk weaving was widespread across much of the Islamic world until the thirteenth century. Important producing locations were Alexandria, Antioch, Baghdad, Cairo, Palermo and Cordoba. The silk industries of Italy and Spain, during the late Middle Ages, owed their origin to the processing knowledge acquired in centres previously under Islamic influence or control. The spread of Islam was a crucial agent first in the distillation of wide-ranging knowledge relating to textile manufacture, and secondly in the diffusion of this knowledge across a vast geographic area.

In Turkey, weaving focused traditionally on making tufted carpets and tapestry-woven kilims. Quantities of decorated woven textiles were also produced. In 1338 CE the Byzantine city of Bursa (an important silk-producing centre) was captured by the Ottomans. Fifteen years later, in
1453 CE, Constantinople also came under Ottoman control and was renamed Istanbul [McDowell, 1993, p.86]. The Ottoman empire at its peak extended from Anatolia to include much of Arabia, Mamluk Egypt, North Africa as far as Morocco, Iraq, part of north-west Iran (for a short time) and the Balkans [McDowell, 1993, p.86]. Trade and production in silk flourished. By 1502, over 1,000 looms were operating in Bursa. Examples of fabrics woven in Bursa, many for the Ottoman court, are held today in Topkapi Sarayi Museum in Istanbul. The political centre of the Ottoman Empire was located in Anatolia, a bridge between Asia and Europe. Traders from Iran passed through Anatolia as far as Bursa, where business was conducted with various European traders, many being Italians.

By the twelfth century CE, Italian weavers in Lucca, Florence and Venice had developed advanced skills in silk weaving and were producing damask designs which mirrored developments in Gothic art, including the use of naturalistically represented animals and plants [Braun-Ronsdorf, 1955]. By the fourteenth century there was much influence from Chinese silks (shown in the use of phoenix motifs), and by the fifteenth century an impressive variety of designs was produced; designs on damask and brocades showed a bewildering variety of motifs including animals “... shown running, leaping, giving chase or locked in combat, and separated by tendrils and flowers” [Braun-Ronsdorf, 1955]. Italian woven silks enjoyed great demand from both the Church and the aristocracy. In the sixteenth century CE, elements of design adapted and modified by Venetian and Florentine silk weavers from Persian, Byzantine and Turkish examples influenced greatly developments in both Spanish and French weaving styles [Braun-Ronsdorf, 1955]. France imported large quantities of Italian woven silks from the Middle Ages to the mid-seventeenth century. By the end of the seventeenth century, with encouragement from the state, a distinctive French style developed and the reliance on imported Italian silks was on the wane. The eighteenth century saw the French silk-weaving industry go from strength to strength and by the first half of the nineteenth century, after the introduction of the Jacquard selection mechanism, Lyon emerged as the foremost silk-weaving centre in Europe [Braun-Ronsdorf, 1955].
5.7 Decorative weaving in India and Pakistan

Early evidence of textile processing in the India/Pakistan subcontinent is in the form of textile fragments from excavations associated with the Indus Valley civilisations of Harappa and Mohen-jo-Dara (c. 3000 BCE). Literary reference to a variety of textiles can be found in the *Rigveda*, the *Ramayana* and the *Mahabharat*. Further evidence is provided by religious sculpture as well as ancient Buddhist scripts and murals (e.g. the Adjanta caves). Indian textiles were traded in the ancient world, e.g. with Rome in the early years of the Common Era. Substantial trade with Egypt during the fifth century CE is confirmed by significant textile finds at Fostat (Egypt).

Over the past two millennia the subcontinent has offered a bewildering variety of decorative textile techniques and products, including painted, printed and resist-dyed cottons, embroideries, appliqué work, carpets, shawls, ikats and batiks. Among the most renowned of woven textiles were Kashmir shawls and Banaras woven silks. The former had an immense influence on European weaving during the latter half of the eighteenth century and first half of the nineteenth century, and have been dealt with comprehensively by scholars over the past thirty years. By comparison, Banaras silks have had much less scholarly attention. In view of this (and also because several Banaras silks are included in the exhibition to which this monograph is an accompaniment), brief further comment is provided below.

Banaras (or Varanasi as it is now known) holds a reputation for textile manufacture and has a long tradition of silk brocade production, in particular zari brocades which relied on the use of extra-weft figuring threads of silver or gold. During the first millennium CE there was much reference in contemporary literature to textile manufacture and, in particular, to the use of metallic yarns [reviewed by Mookerjee, 1966, chapter 1]. Dhamija observed that an important factor in the continuation and further development of the brocade-weaving industry in India was the introduction of the Tiraz factory system from Syria, during the Sultanate period. This was an Islamic tradition of weaving ateliers, sponsored by the Caliphate [Dhamija, 1999]. Traditionally a treadle pit loom was used in the production of Banaras brocade, but the Jacquard mechanism was introduced during the latter half of the twentieth century.
Banaras brocades were woven in a workshop known as the kārkhanā. The zari thread, known as ‘kalābattūn’, had a core of silk with a thin film of metal wound spirally round it. Mookerjee commented:

To prepare silver *kalābattūn*, a thin bar of silver, which can scarcely yet be called a wire, is drawn out. It is beaten and drawn through a succession of holes in an iron plate, each hole being smaller than the preceding one, till a wire of about one-twelfth of an inch fine is obtained. It is further pulled out to the required fineness by means of a wheel and axle apparatus. ...Strong white thread is then taken and the silver wire, after being slightly flattened, is twisted spirally round it to entirely cover the thread. This is *rupa kalābattūn*.

Mookerjee, 1966, pp.67-68

Further procedures were necessary in the production of gold kalābattūn. Mookerjee explained:

In the case of gold *kalābattūn* the basis is the silver wire. Gold not being sufficiently ductile and hard to yield, a fine pure gold wire is unsuitable for *kalābattūn*. Therefore, gold is added at the perforated plate in the final stages of wire drawing. As the silver, touching the gold piece, passes briskly through the hole, it is heated by the friction and thus acquires a coating of gold. This is...twisted round yellow silk thread to make the gold thread, the *sonā kalābattūn*.

Mookerjee, 1966, p.68

Probably the most common end uses for Banaras brocades were as wedding textiles, particularly saris [Dhamija, 1999]. The market for sari fabrics and brocaded textiles for the use of the indigenous aristocracy was extremely large and silk weaving developed all over India. It was however demand from the Mughal court that ensured the production of some of the finest silk brocades ever produced. These became coveted items sent to powerful rulers in neighbouring countries and far-off lands [Dhamija, 1999]. Besides Banaras, other important silk-sari-weaving areas/centres were Murshidabad in Bengal (pictorial Baluchari saris), Gujarat (brocaded Ashavali saris), and Paithan (for Paithani saris). Baluchari textiles, originally woven in the village of Baluchar, were produced with an elaborate pallu (the broad patterned borders woven at the start and end of a length of sari fabric). Pictorial representations in the pallu were in the form of simple outlines and invariably included human figures. Ashavali saris, named after the former name of Ahmedabad in Gujarat, were brocaded using gold thread and numerous colours and, according to Dhamija, imitated enamel work prepared on
jewellery [Dhamija, 1999]. Paithani saris used silk and metallic yarns and were finely woven in tapestry weave.

In the early years of the first millennium CE sea trade routes had developed, linking Egyptian ports on the Red Sea coast with ports located on the west coast of India around the mouth of the river Indus. It was along this route that Roman and Alexandrian seafaring merchants sought spices, pearls and Chinese silks [Vicari, n.d., no.2, p.1]. India was the source of knowledge relating to cotton manufacture. Accomplishments in dyeing and printing were far in advance of those elsewhere in ancient times. Available evidence suggests India as the source of both invention and innovation as well as diffusion of patterning techniques, both to the east and to the west. The introduction of brocade weaving throughout much of South-east Asia can be readily traced to Indian traders or missionaries. Remarkable similarities to Indian methods of production and design are evident in Indonesia for example, where songket (extra-weft figuring) often includes the use of silk with gold or silver metallic yarns [Hauser-Schäublin et al., 1991, p.34; Warming and Gaworski, 1978, p.129; Kartiwa, 1986].

By the early-twenty-first century India still maintained a traditional handloom-weaving sector. While skilled silk weavers were not as numerous as a century previously, large quantities of woven silks, including patterned brocades, were still produced.

5.8 Evidence from the tombs of Scytho-Siberian warriors

In the Greco-Roman world and its fringes, in the latter half of the first millennium BCE, there was widespread awareness and familiarity with exquisitely decorated silk textiles from China. There are numerous literary allusions to such textiles, mediated by poets, historians, and geographers. Archaeological evidence (from Athenian and Celtic-German tombs, mentioned in sub-section 5.4 above) confirms the use of such textiles in Europe during the fifth century BCE. The circumstances of how these items may have been transported to Europe are not clear. A possible provenance is suggested below.

As mentioned previously, in the latter half of the first millennium BCE the Chinese authorities attempted to pacify their north-westerly neighbours through gifts of woven and embroidered silk textiles and
other items. A series of archaeological digs close to the north-west frontier of China offers evidence of the acquisition of such textiles by the Scytho-Siberian tribes associated with the Pazyryk Valley. The Pazyryk Valley is located in the Altai Mountains, in southern Siberia, close to Outer Mongolia and China’s north-west border. A brief commentary on the nature of the Scytho-Siberians as well as the outcome of these archaeological digs is presented below.

During the first millennium BCE various southern-steppe pastoral nomadic people, with common interests and customs, formed a loose association. Their sphere of influence extended from the Black Sea to the north-western border with China, a 3,000-mile-long corridor of grasses and other vegetation necessary to meet the grazing requirements of large numbers of horses, cattle, goats and sheep. To the west were the Scythians (800-100 BCE), a semi-nomadic group that eventually turned to agriculture. In the mid-plains were various small groups including the Sarmatians (600 BCE-450 CE). In the east, located around the Altai Mountains, were the so-called Pazyryk people, named by the archaeologist Sergei Ivanovich Rudenko from the local word for mound. The collective term Scytho-Siberian has here been used to refer to all of these groups. They adhered to common forms of decoration which were stylistically different from Chinese or Persian decoration of the time. They were however familiar with both Persian and Chinese decorated items.

Horses were highly valued, as a source of transport as well as a source of food. The Scytho-Siberians were unrivalled as archers, and were skilled at using the powerful composite bow from horseback. They challenged the greatest invading army of the day, that of Darius the Persian. Although each tribe within the larger Scytho-Siberian group probably roamed distances of several hundred miles, the tribes to the far east probably never came into contact with those to the far west.

In the late 1940s, a range of interesting items, including many textiles, dating to the fifth century BCE, was discovered during a series of archaeological digs led by Sergei Ivanovich Rudenko in the Pazyryk Valley. The excavated items are currently held by the Hermitage Museum in St Petersburg. Further details were provided by Rudenko [1970]. Probably the most publicised item found by Rudenko was the
so-called Pazyryk carpet, assumed by most carpet experts to be of Persian manufacture. The Pazyryk carpet exhibits such advanced technical skill and complexity of decoration (incorporating human and animal figures as well as geometrical elements) that its production would have been part of a long-standing textile manufacturing tradition with skills honed over several (or more) generations. The Persians of that time were highly accomplished weavers. The technically advanced construction of the carpet suggests a tradition of carpet weaving stretching back several centuries previous to its manufacture. Other textiles were also found, including decorated felts (believed to have been produced locally by the Pazyryk people) and quantities of woollen cloth (the bulk plain-woven and some in 2/2 twill). An ornamental horse cloth with a felt base and cut-up pieces of woollen weft-faced tapestry-woven cloth believed to be Persian is of importance [Barber, 1991, p.200].

Also found in the Pazyryk digs were various Chinese silk textiles, some decorated during weaving and some afterwards in the form of embroidery. One particular silk is worth attention in the context of this monograph. It is a “double-faced 3/1 twill with a complex geometric pattern” [Barber, 1991, p.203]. Barber (citing Rudenko) comments:

...one face was formed with a grey weft, the other with a green weft; and each colour of weft was bound into the shed at every fourth warp (a base weave that must have given a rather satiny look) in such a way that the second colour did not normally show on a given face. The pattern was then formed by bringing each colour to the opposite face – patterning with complementary weft.

Barber, 1991, p.203

It is suggested that some of these Chinese textiles were kept as prized possessions (and thus included as grave goods buried with tribal chiefs and other high-ranking individuals) and the remainder transported westward through exchange or as gifts between successive Scytho-Siberian tribes. At some final stage, at locations close to the north-western, western and south-western extremities of Scytho-Siberian influence, the goods were exchanged with Celts, Greeks or Persians.
6. In Conclusion

In this monograph the term diffusion has been used to refer to the spread of decorative weaving techniques as well as their products. A strict diffusionist perspective has not been taken. The emphasis has been on assembling evidence relating to the possible evolution and diffusion of weaving techniques and their resultant products. In studies such as this authors tend to provide and readers expect the presentation of a clear, unambiguous chronology. Invention is perceived in the popular imagination as a unique event, always occurring at a point in time and location. This is not the case with the inventions examined here. A precise chronology of inventions and their development is not possible owing to lack of clear, unambiguous evidence. Also, independent inventive activity and development across a vast distance and over many centuries took place.

Traders and others involved in obtaining textiles from centres along the so-called Silk Road may have brought back to their home base exquisitely patterned textiles, patterned in a way which was perhaps not possible with the technology available in their home country. These textiles will have presented a puzzle. The solution to the puzzle was the details of manufacture. How were these threads interlaced in this way? Imported textiles may therefore have provided the stimulus for inventive activity. They defined the problem (the first stage in inventive activity) and they called for a solution to a problem. In order to develop this discussion further it is worth considering the possible early stages in the development of weaving itself.

Basketry and mat making may have stimulated the invention of thread interlacement. Warp threads were stretched into a sheet between two parallel rods. Interlacement of these threads with others involved the darning of a weft thread over and under successive warp threads, thus producing a structure known as plain weave. Increased control of warp threads was facilitated through the addition of a means to lift them in two separate groups (of odd- and even-numbered threads) to form sheds; this marks the point where true weaving was invented.
In the absence of substantive evidence to the contrary, there is no reason to suppose that the invention of true weaving occurred in one location only at one point in time. Rather it was perhaps invented independently at many locations over a wide geographical area and over a time-span which, world wide, may have extended over a millennium or even two. Thousands of different types of apparatus or loom were developed to facilitate the first stages in the mechanisation of the weaving process. It should be noted that only a few broad classes of loom have been dealt with in this monograph. Each class of loom had hundreds of different types or sub-categories, and each of these was different in some aspect of its operation. Often within a small geographical area the use of several different types of loom can be identified, indicating different approaches to the weaving process.

The transition from plain weave to twills, satins and ultimately all forms of figured weaving demanded progressively increased control of the warp threads. After the invention of weaving itself, involving the facility to produce two sheds, the next challenge was the invention of the means for creating a third shed. A three-shed facility meant that warp threads could behave in one of three ways and interlace in one of three sequences, thus allowing for the production of a 2/1 twill.

Again there is no reason to suppose that the discovery of a three-shed facility could have occurred only at one place at one point in time. There is a likelihood that such inventive results were arrived at independently at different periods and in different locations and, in some instances, may have been stimulated by the examination of twill structures on basketry or matting. It is not clear from the evidence available where the first twills were produced; it may have been in northern Europe, the Near East (including Egypt, Syria and Persia), the Pakistan/India sub-continent or China. Also it is worth commenting that it is not clear whether or not the earliest dated fragments were produced by darning or by real weaving (involving shed formation).

A further stage of development beyond the three-shed arrangement for 2/1 twills was the addition of shed-forming arrangements to allow for the production of higher-order twills as well as satin and sateen weaves. This was facilitated through the addition of further heddle rods or heddles. Again, there is a likelihood of independent invention and development.
The next stage in the development of decorative weaving techniques was the inclusion of a patterning facility (generally referred to as a patterning or figuring harness) which would work in conjunction with a series of heddles. A patterning harness exercises control over large numbers of threads, and was the key characteristic of drawlooms, operational in China, Syria, Persia and probably also India in the early-first millennium CE. This added patterning facility was the basis on which brocades and damasks were produced.

It is highly improbable that a full drawloom apparatus was transferred substantial distances, from one location to another, east or west, along the Silk Road. Rather, diffusion of weaving techniques probably relied on the consideration of the products of these techniques, the decorated woven textiles themselves. From the Han dynasty onward, when trade along the Silk Road was building up and, subsequently, when silk industries were being established outside China, stylistic details of designs were copied from centre to centre. Close technical examination by weavers of imported woven products would have helped the inventive process and would have stimulated developments in weaving centres.

An important aspect of the discussion relating to the diffusion of decorated woven textiles is the proposal that, while the Silk Road (with its numerous tributaries) was the primary network for trade in woven silks and other goods from the Han dynasty onward, a northern channel of communication had developed before this time, and it was this channel which introduced decorated woven silks to Europe (and probably also to Persia and Syria). The subsequent two millennia saw a process of independent invention, evolution and diffusion of decorative weaving techniques. A crucial aspect of this evolution and diffusion was the ability of societies to adopt, adapt and develop elements from other cultures and to incorporate them into their own.
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**Sources of illustrations**
