

# The Development of a Hybrid System for Designing and Pattern Making In-Set Sleeves

A thesis submitted in fulfilment of the requirements for the degree of  
Doctor of Philosophy

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## Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

Signed:

A handwritten signature in blue ink, appearing to read 'M. Campbell', with a stylized flourish at the end.

Morris Campbell

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# Abstract

This research investigates the relationship between the designer, the pattern maker and the elements that constitute a multiplicity of in-set sleeves.

Present sleeve drafting methods represent unpredictable, single-style variations of past methods. They do not vary from the normal non-cohesive practises for any current in-set sleeve styles. Current sleeve drafting methods contain only surface explanations for many of the features contained within the sleeve design. Drafting methods are restricted to surface, point-to-point drafting descriptive - they do not convey the actual detailed mechanisms required of the complete scye and sleeve assembly.

My perspective suggests that designing and pattern making has scarcely advanced since the beginning of the nineteenth century, or earlier. Therefore, the principal research question is: How might the role of the designer, the tasks of the pattern maker, the many in-set sleeve styles and related fabrics, be combined to create a unique inclusive in-set sleeve design system that is advantageous to the apparel industry?

In order to create a unique in-set sleeve design system, this study incorporates a hybrid process derived from a number of design methods. Case studies of a number of sleeve styles and fabrics, representative of a major percentage of the sleeve design range, are developed to confirm the proposition that although each sleeve is a unique entity, they are, contradictory, all one and the same. This is because they are composed of the same limited number of parts and elements.

The study details the parts and elements that compose the scye (armhole) and sleeves. These are united with a compilation of engineering drawing methods which



are explained and analysed prior to incorporation with additional drawing interpretations. The adoption of engineering drawing methods as a base, with further adaptations, to create a new logical sleeve design system, is seen as a complete break from current trial and error practises to a predictable outcomes-focussed process.

Keywords: Apparel, design, pattern making, pattern drafting, sleeve, fabric fullness, engineering drawing



# **Chapter 1 —**

## **Introduction**

### **1.1 Motivation/emphasis**

As a former apparel industry designer and pattern maker, now educator, the motivation for this study is two-fold. Firstly, experience has shown that current/traditional in-set sleeve pattern making methods are labour and knowledge intensive. They produce single style/size/silhouettes from iterative processes before revealing their merits or shortcomings only at three-dimensional fabrications. The second is the investigations of McCartney, Hinds, Seow and Gong (2000a). They stipulate that it may be better to specify the required three-dimensional shape via specialised computer drawing techniques to disclose the two-dimensional silhouette, rather than altering flat patterns to change computerised mannequin representations.

### **1.2 Aim**

This research thesis, therefore, focuses on the design, pattern making and verification of in-set sleeve styles (in a manual capacity). The aim is to explain and develop the methods involved in creating and structuring a unique and flexible design and pattern making system. The system will be capable of confirming the three-dimensional fabric



sleeve at the two-dimensional pattern drafting level. It will incorporate silhouette variations and related fabrics for a decided number of in-set sleeve styles.

### **1.3 Purpose**

In-set sleeves are found typically in garments such as jackets, coats, rain coats, shirts, blouses, overalls and pyjamas et cetera. For each of these garments there are numerous pattern drafting and pattern adaptation methods, and variations, available for a pattern maker to copy or further develop the two-dimensional sleeve patterns. At present there is no single pattern drafting or adaptation method available which is capable of encompassing all or a majority of in-set sleeve styles and their variations.

The purpose of this research, therefore, is to investigate past and present in-set sleeve pattern production methods for a variety of sleeve styles and to examine and test other design disciplines (architecture, engineering et cetera) which may contribute complementary techniques to enhance the development of a new design system.

This thesis is an alternative to the design and in-set sleeve pattern making status quo. It is a search for a new combined design and pattern making system to take the place of the many contemporary, and often-times conflicting, pattern making techniques. It is the development of a new system with computer aided design potential to enable the non-technical designer, in the ready-to-wear (wholesale) apparel sector, the ability to produce sleeve patterns without practical pattern making knowledge.

### **1.4 Context**

Apparel production is an immense worldwide endeavour. Dagliden (2008) valued global apparel exports at US\$310 billion a year, whilst a World Trade Organisation (WTO) report states that world apparel exports totalled US\$362 billion in 2008 (Plunkett



Research, 2010). The United States alone manufactured US\$9.3 billion worth of apparel in 2008 (U. S. Bureau of the Census; Plunkett Research, 2010). By 2010 (at time of writing, 2010), it is estimated that the total value of the apparel industry will reach US\$1,781.7 billion which is estimated to grow rapidly (Fashion Products, 2009).

Clothing manufacturing, therefore, is an extremely important industry requiring considerable strategic planning. Management strategy goals involve the alignment of productive resources and technology (Hill & Westbrook, 1997), the key elements being flexibility, cost, delivery and quality (Ettlie & Penner-Hahn, 1994). Garment design, standing at the forefront of clothing production, plays an important role in their success.

The role of design can be appreciated in the reputation of Italian apparel. Throughout the world Italian design is recognised as being of a very high quality standard. To achieve and maintain this standard, Donatella Ratti explains that '*Research, product and quality has made Italy a big success in the world*' (Lee, 2004). As consumers experience an increased choice of product from global sources, they are becoming progressively more design, cost and quality conscious, leading to a manufacturing and retail focus on product quality and design.

To aid apparel design, control quality and manufacturing production sequences, the use of computerised designing and pattern making is becoming more extensive (see Chapter 4). However, problems arise when the functions of design and manufacturing are divided on a global scale. Two of the largest computer aided design (CAD) manufacturers are Gerber Technology and Lectra. Gerber Technology (Gerber Technology, 2010) has over 1200 customers worldwide using their Accumark® pattern design systems. Lectra (Lectra Systems, 2010) services 20,000 clients for apparel, accessories and footwear, including 660 schools and universities.



Although the use of computers in the clothing industry is widespread, computer aided pattern making processes are still dominated by the traditional two-dimensional manual pattern making methods. The transfer of traditional trial and error pattern making methods into the realms of computer technology for apparel pattern production is in contrast to other modern industries with their high use of computerised technology.

In marine construction, architecture, aeronautical manufacture and other types of engineering undertakings, trial and error methods have been substantially reduced or abandoned. These empirical methods have been replaced with precise drawing methods enhanced by computer aided design (CAD). Engineering drawing methods, unlike garment pattern drafting methods, provide a series of views, or perspectives, of a product for the development phases leading to the final three-dimensional form.

## **1.5 Background to the study**

Subsequent to transferring from an industrial environment to an educational setting, I taught to students the same iterative sleeve design and pattern making methods taught to me. The processes were imbued with the authoritative techniques, views and intellectual rigor of respected authors and practitioners, both past and present. Authors such as Thornton (1894), Poole (1936), Morris (1947) and Kunick (1967) et cetera, were used both as informative text background and practise. After reflection, I questioned whether it was actually necessary to disseminate, to students, either my version or any past or current versions of these manual, 'steeped-in-history', sleeve pattern making methods.

Are these trial and error methods still viable in today's technological environment, or could a more inclusive design and pattern making method be found? Brooks (Schön, 1998) argues that education, among other professions, requires professional flexibility



and must be responsible to meet the constant demand for generating new technology. As an educator, I contend that, currently, for both instructors and practitioners, there is an unnecessary excess of pattern making methods with mutual, though style-disparate origins. As they cannot all be proficient in application they are of limited use for advancement to a technological system that bridges the gap between traditional methods and CAD based outcomes; new explorations must be instigated.

Whilst acknowledging that pattern making methods have served their purpose over some considerable period of time, this research questions the validity of the current disparate, inefficient trial and error methods for designing and pattern making in-set sleeves. Progression to a cohesive, reasoned design and pattern making system, that would sustain product quality, has not eventuated.

After due deliberation and reflective practise, I have concluded that both the historical and current views of designing and pattern making sleeves are out-dated, inconsistent, under-developed and unacceptable. There is no standardised, reduced technical knowledge, efficient and flexible sleeve styling method available. To promote better efficiencies in design and pattern making, a new combined design/pattern making system needs to be created – an approach with the potential for computerisation.

## **1.6 Problem statement**

The present situation regarding 'artistic' design (sketching/illustrating the sleeve style) and technical pattern making (method of constructing the pattern), is for their separation. The designer, creatively using knowledge of design methods, designs clothing (including sleeves) and the pattern maker, utilising a comprehension of the 'mechanics' of cloth manipulations, produces the patterns.



Becoming more mutually exclusive, each subject loses the experience and expertise of the other. The separation of knowledge, within the two disciplines, is continuous, reiterated by constant reuse, remaining two disconnected halves of what should be a united discipline. For this research, the problem lies deeper than just the surface difficulty of artistic and technical separation (acknowledged by McCartney, Hinds, Seow & Gong. 2000a. Their problems (the first and second) are included in the following four parts.

- The accept/reject rates of the style requirements from an 'artistic' designer perspective
- The style interpretation from a pattern maker perspective
- The pattern making method
- The unification of the parts and CAD potential

From the artistic designer's perspective, the first part of the problem involves the sleeve style and quality requirements of the intended design. It is the need to fuse the drawings of the designer with the pattern making expertise of the practitioner - to have them synchronised to affect the required results. How might the non-technical (artistic) designer inform the (non-artistic) pattern maker of the required sleeve style silhouette and associated quality, without a post-production analysis of the results and a probable repeat of the entire practical process from pattern making to fabric sleeve construction? Would it not be easier if the artist could also be the pattern technician?

As seen from the pattern maker's perspective, the second part of the problem entails the interpretation and translation of the designer's sleeve style by the pattern maker. Each type of sleeve has a different, basic silhouette, each silhouette may be changed to create a different affect; the permutations of silhouette and interpretation of the style are almost endless. To achieve the style translation, the pattern maker must make a



decision of how to transform the three-dimensional style sketch/drawing into the technical two-dimensional sleeve pattern and into a three-dimensional fabric sleeve. Would it not be easier if the artistic designer could procure the required patterns for the sleeve design without learning the current techniques of pattern making?

The third part of the problem (a pattern maker's perspective) is concerned with pattern drafting and pattern adaptation methods. In addition to the many sleeve silhouettes, there are many sleeve pattern alteration methods from which to select an appropriate technique for a particular silhouette. The pattern may be constructed from either a personal or non-personal pre-existing sleeve draft, or a new draft may be created; an alternative to this approach is to use an existing base-block (basic pattern shape).

The draft, or block, may be altered by preferred procedures to realise the three-dimensional sleeve style silhouette. However, all the avenues to pattern making use entrenched style-isolated techniques for each sleeve style and its variations. Would it not be easier if the artistic designer could produce the required patterns for the sleeve design without having to decide on which draft to use or adapt. Could this not be an automatic process within the sleeve 'design' process?

Combining the first three parts of the problem (artistic requirements, pattern interpretation and pattern method) it is difficult for the pattern maker to interpret a design sketch exactly – even proficiently – without making a trial garment and having the designer verify the results. The alternative, to the continuous cycle of designer approval/agreement and the reiteration of contemporary style-isolationist pattern making methods to acquire the design, is to challenge the status quo.



The challenge to the status quo is the subject of the fourth part of the problem (The unification of the first three parts and their CAD potential). I believe there is potential to integrate the three problem parts, mentioned above, to combine the artistic and the technical. The technically non-adept designer and the artistically inexperienced practitioner will have access to all of the sequential tasks in the design process (from the sleeve design drawing, interpretation and confirmation of the pattern and fabric sleeve) to provide a successful sleeve product.

This research creates a unique and flexible design and pattern making system to promote the amalgamation of the artistic and the technical aspects of designers and pattern makers of in-set sleeves whilst reducing the insistent reliance on trial and error processes.

## **1.7 Scope**

To explain and validate the design system, this research is confined to manual (non-computer) methods and descriptions. Within the process, from original sleeve design to three-dimensional fabrication, this study will demonstrate how the quality of the final results for a variety of sleeve styles can be identified prior to the actual application of the fabric to the three-dimensional form. The sleeve outcomes are predicted at the two-dimensional pattern stage, not at the end of the entire design process.

The in-set sleeve design system is developed through a sequence of six multiple - case studies and conventional and systematic design processes. Firstly, the design phase of the system enables the designer to delineate the required sleeve silhouettes. Subsequent processes produce the body scye, arm/sleeve elevation angles, crown developments and fabric drape and fullness amounts to the preceding design process. This allows extrapolation of the two-dimensional pattern from the relevant designer-



inspired sleeve silhouette. This system seeks to overcome the many technical problems inherent in the current collection of unpredictable-outcomes sleeve design and drafting methods. The creation of the final predictable three-dimensional fabricated sleeves, from the two-dimensional pattern, is also a consequence of the design phase.

Even so, this research must have the potential to develop, eventually, from manual demonstrations to a CAD situation (a prospective future study). A CAD system organised to allow the student, the uninitiated and the time-constrained pattern maker/technician, automatic access to pattern development. It is anticipated that this will be achieved through a system that takes the pattern making process from both the pattern maker and the designer.

## **1.8 Limits**

The word 'fashion' is of limited use to this study as it is not concerned with past or present fashion styling per se; rather it concerns 'universal' in-set sleeve styling and style adaptations. Since all of the issues that could be incorporated into the development of a new design system would extend this research beyond realistic limits, this project is therefore confined to five sleeve styles case studies for wholesale garment manufacture. It is also limited to a selection of fabric types, and properties that contribute directly to the design system's development. Also, by necessity, this research project is restricted to a manual explanation of the design process.

A size twelve (87cm bust) woman's mannequin provides an unchanging foundation for the design, pattern making and fabrication of the sleeves. Utilised throughout, the mannequin represents a medium sized women's figure. Other ever-changing figure proportions, posture configurations, arms and upper torsos are not reviewed. Neither Objective fabric measurement methods (KES-F and FAST) nor clothing construction



methods (since they vary from maker to maker), are described. These three subjects, in addition to the development of a 3D CAD computer software programme, which would utilise this research as a foundation, are assigned to further research.

## **1.9 Thesis organisation**

To achieve the stated aim of creating a new in-set sleeve design system capable of designer influence and pattern production capabilities, chapter 2 gives a chronological overview of traditional drafting systems up to the present era. This is followed by current sleeve styling, respective pattern drafting and alteration methods. Descriptions of historic and current methods of establishing scye and sleeve elements and their potential to form defects in the fabricated sleeve are analysed in chapter 3. Chapter 4 describes CAD and current research into scye, sleeve and body shapes in addition to modelling and flattening methods.

In chapter 5, case study, conventional and systematic design research methods are combined to test and develop various, distinct elements that will be united in the new in-set sleeve design system. Chapter 6 investigates scye and sleeve elements, orthographic projection and sheet metal development methods. Models are constructed to reveal how various fabric, scye and sleeve elements and sleeve style combinations are organised and operate. Chapter 7 describes the fabric characteristics that have a direct bearing on the development of a new in-set sleeve design system. It also details fabric trials for the sleeve crown section. The actual design and pattern drafting and pattern making results for a number of sleeve styles are documented in chapter 8. These lead directly to the fabric construction of six sleeves (including reusing the tapered shirt sleeve pattern paired with an alternative fabric). The results and contributions are discussed in chapter 9.



## **Chapter 2 —**

# **Drafting Systems and Pattern Adaptation Methods**

### **2.1 Introduction**

The time-honoured method of producing a garment is to model fabric (toile) directly onto the body of a client (Silberberg & Shoben, 1993). However, currently, fabric modelling is regarded as a time-consuming and expensive process for wholesale garment manufacture (Tuit, 1974). Pattern drafting is seen as being a quicker and more efficient means of producing patterns - even though all pattern construction or drafting systems are initially based on modelling (Kunick, 1967). (It could be noted that pattern making techniques have not changed for some considerable time. For example, Bray first published 'More dress pattern designing' in 1964. It was re-issued in 2003; Aldrich's 'Metric pattern cutting' first published in 1976 with a 4<sup>th</sup> edition of 2004 – 39 years and 28 years respectively).

This chapter has two parts. The first part provides examples of historical sleeve style variations. One and two-piece sleeve silhouettes are illustrated with relevant pattern



terminology. To place this research in context, the historical roots of nineteenth century measuring and drafting systems are described and evaluated. Part 2 comprises an array of in-set sleeve pattern drafting and adaptation methods available to contemporary practitioners. The methods, with the aid of a number of significant sleeve style silhouettes, are illustrated and discussed to evaluate their potential for assimilation into a new design and pattern making system.

Before commencing with drafting systems, it may be beneficial to define what is meant, in this study, by the terms designer, pattern maker or pattern cutter. In addition, it will be advantageous to describe the three main sleeve types and identify which of them is the focus of this study.

## **2.2 Designer, pattern maker/pattern cutter**

The term 'designer', as used by Aldrich (2004), describes two types of designers involved in mass production (wholesale or ready-to-wear). The first type of designer is concerned, foremost, with production and an emphasis on repeat designs and fabric economies (technical); and the second is related to design-led manufacturing with a stress on new fabrics and original designs (artistic) – not pattern making. The largest section of fashion design, by far, is *'where firms mass-produce garments following fashion trends set in by fashion forecasters'* (Shiksha, 2008; p.2).

There are various terms used by authors to define the roles of the artistic and technical designer in garment production (Bray, 1997; Richards, 1930; Shoben and Ward, 2000; Morris, 1947). For this study, to suspend confusion, I will refer to those who cut patterns as pattern makers (as in New Zealand) and those who produce fashion styles, as designers.



### 2.3 Sleeve types

There are three basic types of sleeves integrated into garments. Those sleeves that are totally separate from the body sections, are known as in-set or set-in sleeves (Figure 2.1 '1'); those sleeves with part of the body, around the shoulder area, added to the sleeve section, requiring only a partial armhole (scye), termed Raglan sleeves (Figure 2.1 '2'); and those sleeves integrated with the body sections, such as Kimono sleeves (Figure 2.1 '3'). This research is focussed on the development of in-set sleeves (Figure 2.1 '1').

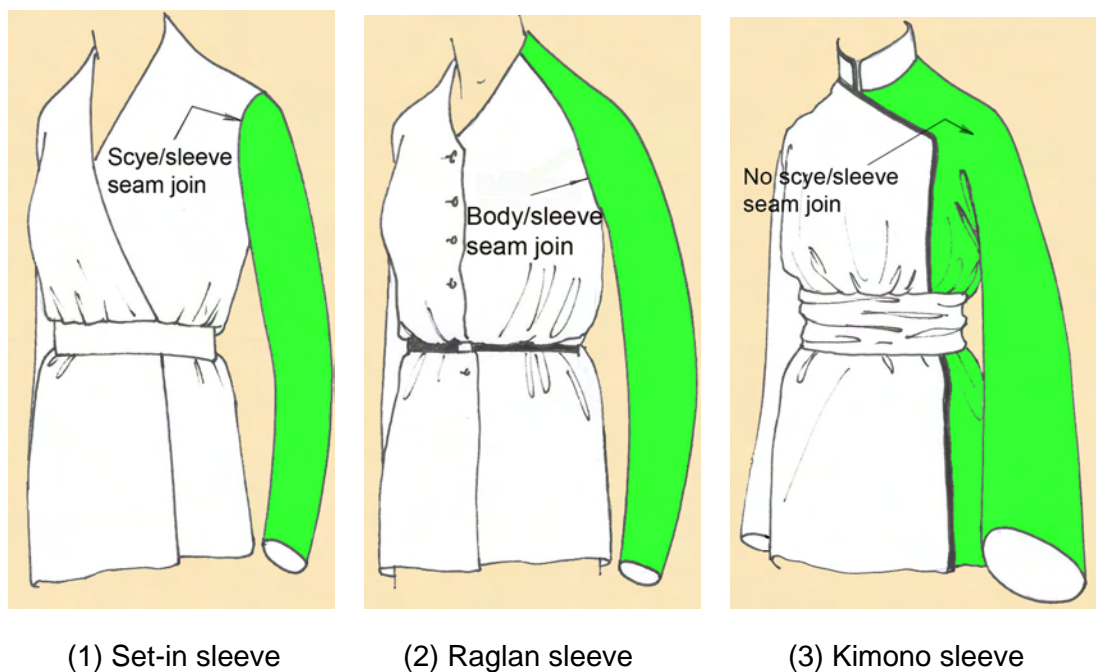


Figure 2.1. Sleeve types



## **2.4 Part 1: Historical in-set sleeve styles; Drafting and measuring systems**

### **2.4.1 Historical in-set sleeve styles**

In-set sleeves, historically, were designed in a multitude of sizes and shapes comprising various widths and lengths for practical and aesthetic purposes (Figure 2.2). Some of these sleeve silhouettes are still in vogue today; they may also be reproduced for historical costume production et cetera. The final form of the sleeve is limited by factors such as the intrinsic performance values of the fabric and the manufacturing methods employed, the creativity of the designer, and the skills and knowledge of pattern drafting systems utilised by the pattern maker.

Figure 2.2. Pictorial outline of English women's costume (sleeve variations)

(c.1660 - 1860)

Source: Adapted from Arnold (1964)



### 2.4.2 In-set sleeves: One-piece and two-piece patterns

In-set sleeve patterns are, primarily, of two types; these are termed the one-piece sleeve and the two-piece sleeve. As the names suggest, the sleeves are either made in one or two sections. Both sleeves may use an in-set sleeve drafting system to establish their silhouettes, or they may be adapted from previously constructed patterns. The green coloured section, for both sleeves (Figure 2.3) represents the top sleeve area and the fawn coloured section is the under sleeve area

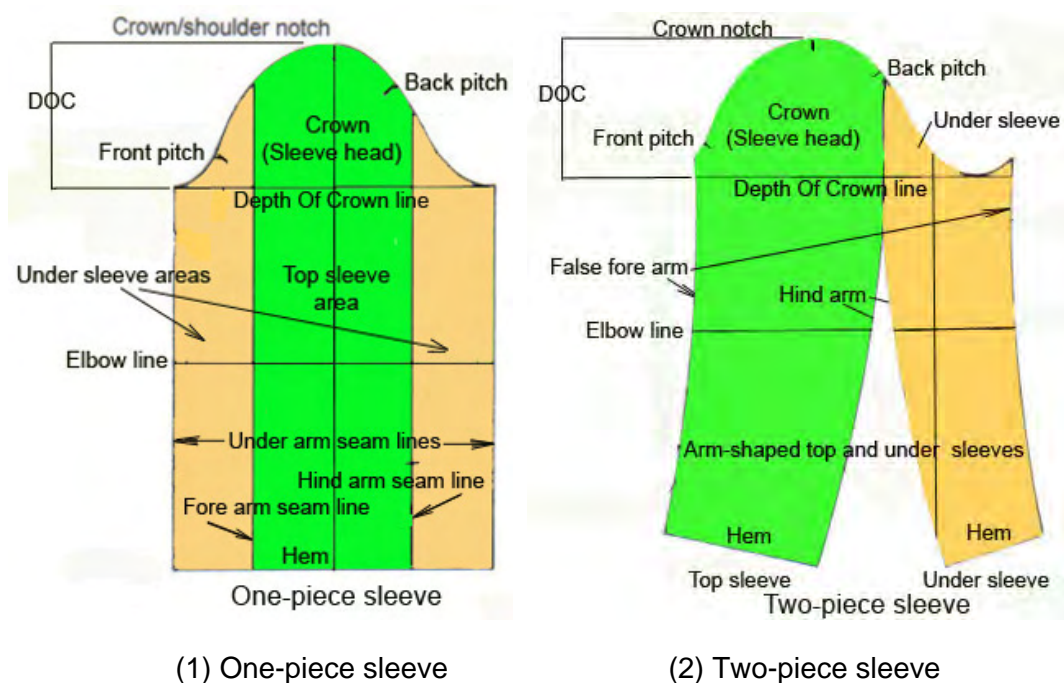


Figure 2.3. Sleeves: One-piece, two-piece and terminology

#### ***In-set sleeves: One-piece patterns***

One-piece sleeves consist of a single complete section, not including the cuff section which may be additional. Depicted in Figure 2.3 '1' is a straight-sided, rectangular, sleeve with under arm seam lines. This type of one-piece sleeve may be used for loose cylindrical, less formal sleeves, or it may be used as a base to adapt into more fitted sleeve styles.



The straight-sided sleeve pattern forms the basis for a variety of sleeves incorporating various arm elevations (movements), arm fittings - from loose to tight, and sleeves which may be gathered, darted or pleated in the crown, elbow or hem. One-piece sleeves may also have allowances introduced to the under arm seam lines to produce tapered or flared sleeves. The sleeve may be styled as either long, medium-long or short in length; they may also be shaped at the under arm seam lines or darted at the hind arm line for ease of elbow movement (see scye and sleeve elements in chapter 6).

### ***In-set sleeves: Two-piece patterns***

In contrast to the one-piece sleeve, the two-piece sleeve is cut in two sections; it therefore has two seams to the sleeve design. The green coloured section (in Figure 2.3 '2') is the top sleeve area and the fawn coloured section is the under sleeve area.

The separation of the sleeve sections means that the seams can be contoured to fit more closely to the shape of the arm (Figure 2.3 '2'). The two-piece sleeves are used mainly for formal sleeve types where aesthetics of shape and appearance are more important than arm manoeuvrability.

There are two types of two-piece sleeve: the false forearm/hind arm and the 50/50 type. It is more usual to see the false forearm/hind arm type of sleeve. This sleeve has the seams placed into the under sleeve area thus creating less width in the under sleeve (fawn colour) whilst the top sleeve compensates by becoming wider (green area), depicted in Figure 2.3 '2'. The 50/50 sleeve, as the name suggests, is divided equally between the top sleeve and the under sleeve; the seams are located at the front (fore) arm and at the hind arm. Both sleeves are formed using drafting systems.



## 2.5 Drafting systems

A drafting system is a form of two-dimensional drawing used to depict three-dimensional clothing items and their constituent parts. Derived from measurements of the figure, mannequin, or directly from a three-dimensional fabric trial (toile), drafting is a grid of body measurements to which curved lines are added to produce fitting capabilities and style shape. From the draft, a set of instructions is produced together with an illustration(s). The draft is used for pattern duplication, as a guide for further development - or style adaptations, or for education purposes. Bray (1985) describes drafting as '*modelling on the flat*'.

As both sides of the body – and both arms, are perceived as being symmetrical (they are not), drafting systems portray patterns from only one side of the body, either left or right; the same pattern is used for both sides. Made-to-measure (Bespoke) patterns are produced in the same manner with each side of the body altered as required.

### ***Drafting systems: Early explorations***

Although a substantial amount of literature has been written on the history of costume comprising thousands of years of clothing styling, the timeframe for drafting systems for clothing pattern making, using documented methods, is perhaps, only some four hundred years old. The origins of cutting by a 'system' (drafting method) have been lost to time Giles (Shep (1987); and, the 'illiterate past' conceals the origins of cutting formulae states Poole (1936).

One of the first recorded journals entitled '*Libro de Geometrica Practica y Traca, &c.*' Madrid, 1589, 'compuesto por Juan de Alcega', recorded cutting by mathematical principles (Shep, 1987). The earliest reference found of diagrams of patterns with instructions, is '*Le Tailleur Sincere*' printed in 1671 (Arnold, 1964), and some of the



earliest known texts from a number of countries include; from France, *'The Sincere Tailor'*. Published by Antoine Raffle, Paris, 1671, *'The Taylor's Complete Guide'* written by Golding and published in England in 1796; and *'The Tailor's Instructor, or a Comprehensive Analysis of the Elements of Cutting Garments of every kind'* written by James Queen and William Lamprey and published in Philadelphia (USA) in 1809.

The most important section of the sleeve, the top section, is the sleeve crown (cap, in the USA). The formation of the sleeve crown was a considerable time in development, the problems only being solved with formalised drafting and cutting systems late in the eighteenth century (Doyle (2005). Prior to this, the sleeve was either a rectangular piece of fabric or was tied to the armhole with laces. As a result of crown formation and drafting systems, the sleeve became a serious subject for study.

## **2.6 Drafting and measuring systems**

Until the end of the eighteenth century there was very little knowledge of patterns and dressmaking (Arnold, 1964). It was not until the first half of the nineteenth century that a plethora of tailor's drafting systems emerged. Doyle (2005) relates that tailors' pattern drafting systems can be traced to Wampen's (1860's) 'Anthropometry, or Geometry of the Human Figure'. Giles (Shep, 1987) describes over forty cutting and drafting systems from France, England and America up to the John Jones's system of 1872.

It is generally acknowledged that there are three types of drafting, or cutting systems (Thornton, 1894; Richards, 1930). Aldrich, (2002, pp. 10 & 12) identifies three systems dominant in the period 1800-1850):

- The divisional (proportional) system
- The direct measurement system
- Combination (sectional) system (being an amalgamation of the former two).



Poole (1936, pp 3-9) also describes three systems: *'the short or direct measures, the shoulder measure principle and the chest measure principle'*. Morris (1947, p. 1) cites two systems: *'divisions of the bust girth in conjunction with the actual height of the figure'* and *'short direct' measurements from one section of the figure to another*.

### ***The sectional principle system***

Otto Madison of New York was the creator of the 'shoulder-measure' principle of drafting patterns (Poole, 1936) with the greatest exponent in England being J. P. Thornton of London.

The sectional principle is founded on divisions of a scale produced from shoulder and over shoulder measurements, supported by the chest/breast measure which is used only to define size of the garment. Thornton asserts that a sectional system (Figure 2.4) working scale allows systematised divisions, a better option for producing sleeve silhouettes. Thornton's sleeve draft is based on  $\frac{2}{3}$  the width of shoulder (WSM), a supplementary measurement.

(Figure 2.4 '1') illustrates, the taking of ordinary and supplementary measurements of the body for the sectional drafting process. Figure 2.4 '2' is the body draft, a derivative of the drafting instructions, and Figure 2.4 '3' is the resultant (50/50) sleeve draft (little different from a modern sleeve).



(2)

(1) Body measurements

(3) Bodice and sleeve drafts

Figure 2.4. Body measurements with Bodice and sleeve drafts (1893)

Source: Adapted from Thornton (1893)

### ***The chest/breast proportional principle system***

The breast principle is based on proportions of the breast or chest circumference measurement (also known as the divisional system (Bray, 1985). The adoption of the proportional drafting system (between 1822 and 1860), says Davis-Meyers (1992), as opposed to the direct drafting method which it displaced, allowed the development of standardised patterns as a means of keeping up with mass production; '*the divisional (proportional) method seeks to produce coats that will give a well-balanced garment for a greater number of wearers*', advised Poole (1936, p. 460).

Hecklinger's, 1881 system (Shep, 2001) requires a division of the armhole to draft the sleeve. Poole (1936, p. 460) also advocated the use of divisions of the scye for sleeves, not the chest measurement. This was upheld by Morris (1947) who thought



that a working scale, for a sleeve system, was not adequate enough to allow for adjustments for changes in arm-hole size. (Since the sleeve fits the scye, whatever size or shape, the scye has to be a more logical approach to sleeve pattern making).

The Morris system (pp. 15 & 67) (Figure 2.5 '1'), indicates the positions and techniques for acquiring the measurements for the proportional drafting system, with Figure 2.5 '2' illustrating the body and (false fore and hind arm seams) sleeve patterns.

(1) Body measurements                      (2) Bodice and sleeve drafts

Figure 2.5. Body measurements with Bodice and sleeve drafts (1947)

Source: Adapted from Morris (1947)

Authors of books relating to pattern systems use a variety of preferred scales and variations on the theme dividing and measuring the chest or armhole (scye or arm-scye), to form the sleeve pattern. Advocates of the proportional system range from



Poole (1936), Pepin (1942), Morris (1947), Cutler (1950), Gebbia (1955), Kunick (1967), Chaudhry (1970), Davies (1986), Shoben and Ward (1990), through to Doyle (2005).

### ***The direct principle system***

After introducing his breast measure system, Hearn introduced a system for short or direct measures in 1818/19 (Poole, 1936, p. 2). These were produced from the direct measurements of various parts of the body. In 1838, G. Walker advocated a direct measuring system for a coat and sleeve which were, in part, taken from the armhole (Shep, 2001, p. 39). Bray (1985, p. 12) advises that there is no substitute for the direct measuring method, although difficulties (of accuracy) will be experienced.

Several illustrations, describing Joseph-Armstrong's (2006, pp. 32-52) method of measuring the mannequin for the direct measuring drafting system, are seen in Figure 2.6, '1' – '5'. The actual drafting method, using a set of displayed measurements, produces the three required pattern sections. Figure 2.6 at '6' depicts the front pattern, '7' is the back pattern and '8' represents the sleeve.

However, the method of producing the shape of the crown of the one-piece sleeve in Figure 2.6 '8' (the two curves measured from the two diagonal lines), must have been derived from a flattened fabric sleeve trial; there is no other certain method; otherwise, the crown would only be an estimate – a guess - of its true contours.



(1) Front      (2) Back      (3) Front      (4) Back      (5) Front/side

(6) Front pattern    (7) Back pattern    (8) Sleeve pattern

Figure 2.6. Body measurements with Bodice and sleeve drafts (2006)

Source: Adapted from Joseph-Armstrong (2006)

### ***Drafting and measuring systems: Are they effective?***

The three pattern and measuring systems (the sectional principle, the chest/breast proportional system and the direct principle system) have been described to ascertain whether they are of value in creating a new in-set sleeve design and pattern making system. However, there are doubts as to whether they can be successfully adopted or adapted as a base from which to construct said new design and pattern making system.



It is important to appreciate that in contrast to those who advocate the use of a particular drafting system, there are those who have opposing views or serious doubts as to their efficacy. Despite two hundred years of drafting history, each of these systems is still open to critical interpretations which are difficult to refute as each has a valid point.

In 1838, George Walker (Shep, 2001, p. vii) expressed an important point concerning the proportional principle system. It was, in his opinion, fallacious to believe that proportions of the breast measurement could establish a system of points for a coat, as human body structures were too diverse. Thornton (1894) maintained that although the chest measurement approach may be advantageous for proportions of width, it may be lacking when it comes to making sleeves, as depth measurements are too difficult and too uncertain. Thornton presents a good example of depth measures; he considers a chest measure (perhaps, 38 inches - 965.2mm). In the proportional system, the scye depth would remain the same in all height instances. This is not correct as a tall person needs a proportionately deeper scye than does a short person.

In 1897, Holding (Shep, 1997) considered another disadvantage of the proportional system; although found to be suitable for the construction of men's drafting it was inappropriate for the disposition of the much more varied contours of the female form (in other words, since the system does not work for the construction of women's patterns, it must also be suspect for men's pattern construction; the contouring of male and female bodies being, in this context, a matter of scale). Richards (1930, pp. 11) is of the same opinion; identifying the breast measurement system as being without a scientific base. The sectional system '*sought to remove the unsound basis of the breast measure system*'. Although of little use to the wholesale trade, Richards (1930,



p. 11) asserts, with some justification, that the sectional system, for men, is, perhaps, '*only suited for Customer Order work*' (made-to-measure or bespoke).

By 1936, Poole was also expressing doubts, describing the limitations of scientific pattern construction with the observation that there is no '*philosopher's stone*' (pp. 1 & 65) to successful garment production. Kunick (1967) also criticised the proportional system because of the lack of body sizing statistics, stating that they are 'hypothetical', relying on an unsound base. Kunick raises a good point concerning statistics comprised of a cross-section of a particular segment of a population which do not equate to any individual – except by coincidence, therefore they cannot fit - except in general terms.

It is rightly asserted by Heisey, Brown and Johnson (1988) that the proportional system assumes too much. Based on the assumption that various body sections are conveniently related to this one measurement (chest, bust, hips et cetera); and therefore, that an entire pattern (it is assumed that this also includes sleeves) can be derived by divisions, or proportions, of this one measurement. They argue persuasively that because drafting methods do not replicate the physical processes of modelling a garment on the dress form, or body, they are ineffectual in producing accurately fitted patterns.

Comparing the three measuring systems, Thornton (1894) judges the direct, point-to-point, system as the most primitive (and least successful). It is too unreliable a method for universal implementation, especially for the uninitiated. This opinion is also shared by Poole (1936, p. 4) who maintained that the direct measure (short measures) principle is '*safe only in the hands of the experienced cutter*'; suggesting that taking



measurements directly from the body is an inexact method of producing patterns as no two persons will obtain the same measuring results (verified personally).

The direct, or short, measurement drafting method is described by Heisey, Brown and Johnson (1988), as assuming that pattern dimensions are a product of the body measurements. They assert that the pattern may not match or be related to the body; *'the shape of the pattern is not entirely a function of the form of the body'*. Even though the direct measure system is prone to practitioner inaccuracies, this method is seen as the most likely to be accepted as a drafting system (Richards, 1930), providing that better methods of measuring are developed (this is raised in chapter 4; body scanning and body measuring).

To emphasise the point that drafting and measuring systems are suspect, Richards (1930, p. 9) records that *'there is not, nor will there ever be, any method of "exactly" fitting the human figure by means of the application of measurements to a flat pattern'*. This is also expressed as; *'there is no such thing as a perfect pattern which has evolved through trial and error processes'* (Doyle, 2005, p. xx).

One reason is the diversity of the human form; although measurements may be the same, the actual contours and postures may differ causing inaccuracies of measurement. Modelling is still the better method of producing a flat pattern (The conversion of modelled body contours to a flattened pattern is pursued in chapter 4)



## **2.7 Part 2: Current in-set sleeve styles; Pattern drafting and adaptation methods**

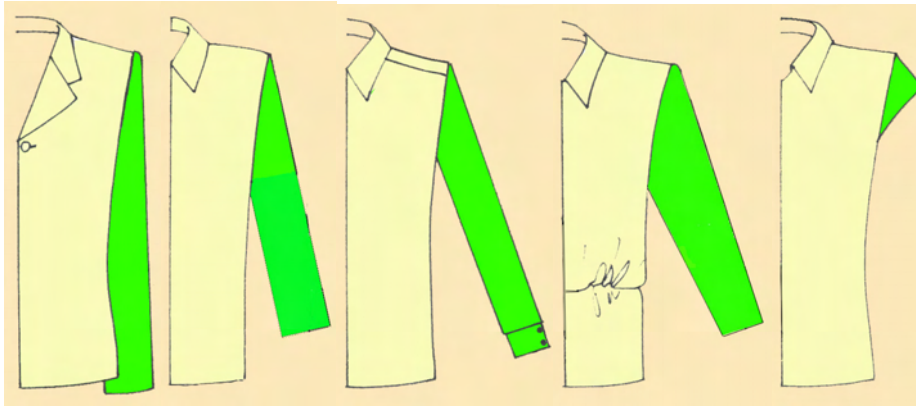
### **2.7.1 Current in-set sleeve styles**

The historical garment styles depicted in Figure 2.2 may differ from their current counterparts; however, in general, the sleeve silhouettes of those eras are not too dissimilar to those depicted in Figure 2.7, which illustrates an array of modern sleeve designs relevant to this project.

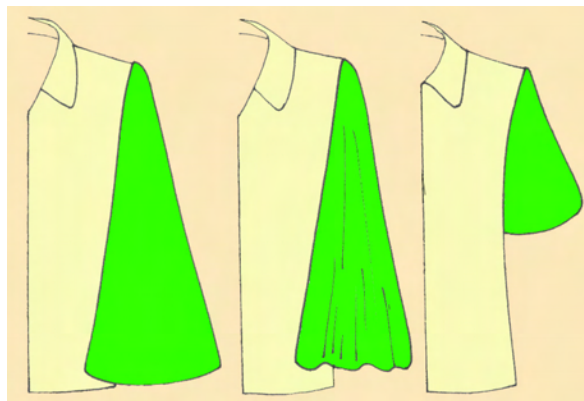
For the designer, there are a substantial number of in-set sleeve styles, or names and sleeve silhouette variations from which to make a selection. The sleeve styles range from a plain straight sleeve to a fully shaped leg-of-mutton style. They include a variety of arm fittings – loose/tight, various crown heights and widths, crown shapes and fullness allowances and a diverse selection of arm elevation/lift allowances.

Sleeves are represented as either straight or tapered styles as seen in '1' – '5' (Figure 2.7); flared sleeve styles as in '6' - '8' and gathered sleeve styles of either flared or tapered silhouettes in '9 – '12'. All of the sleeve styles, represented in Figure 2.7, are of the one-piece sleeve variety except for '1', the tailored sleeve, which is a two-piece sleeve.

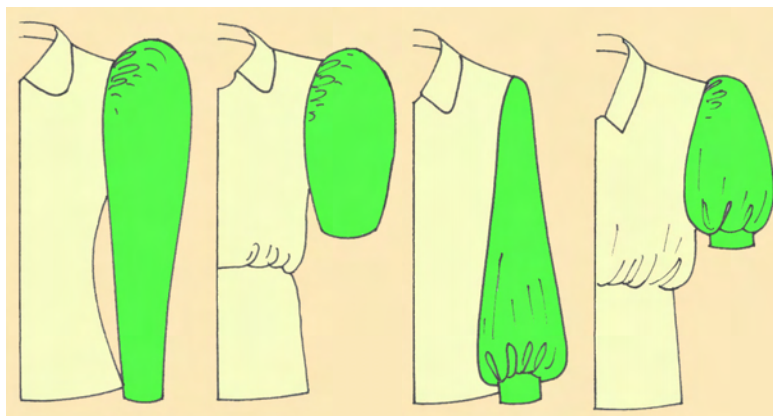




(1) Straight (long)   (2) Straight (angled)   (3) Tapered (with cuff)   (4) Tapered (plain cuff)   (5) Tapered (very short)



(6) Flared (long)   (7) Flared (acute)   (8) Flared (short)



(9) Gathers (long)   (10) Gathers (short)   (11) Gathers (into cuff)   (12) Gathers (short, into cuff)

Figure 2.7. Selection of In-set sleeve styles



## **2.8 Current in-set sleeve drafting and adaptation methods**

In-set sleeve drafting and measuring systems of the 19<sup>th</sup> century link the past to the present; they span the 20<sup>th</sup> century and on into the 21<sup>st</sup> century; the proportional drafting system, for standardising patterns, is the most popular for mass production. A representative compilation of current in-set sleeve pattern drafting and adaptation methods is presented. The objective is to disclose and examine the types of method associated with each current sleeve style to eliminate those that are not suitable for inclusion for further development.

The designers' personal preferences as to sleeve fit, sleeve silhouette and associated aesthetics expand the number and variations of in-set sleeve styles. Style names and drafting and pattern making method permutations are almost as insistent. This chapter consolidates sleeve pattern making methods under a minimum of headings. Although there are many in-set sleeve drafting and pattern making interpretations, observations show that they are all manifestations of three basic approaches, which are:

- **Modelling:**

Modelling is the three-dimensional, dexterous manipulations of fabric directly around the scye of a garment on the mannequin, dress stand or model; it is a time-consuming, expensive and skills-based method.

- **Drafting:**

The sequence to developing a draft is that subsequent to modelling fabric on the mannequin, the modelled fabric is laid flat onto paper and accurately traced around to produce a diagram. To reduce the distortions exposed in the fabric shape, the outer edges of the draft may need to be altered. In addition, the instructions may also require changing to moderate irregular measurements, in order to make the draft easier to use.



Using consequent drafting method involves drawing a two-dimensional sleeve shape, from a set of instructions, onto paper to produce a sleeve pattern. The pattern is placed onto fabric, marked around and cut out. The fabric sleeve is then sewn directly around the scye for deliberation. If the result is unacceptable, iterative fabric modelling may be necessary to improve the product.

- **Pattern adaptations:**

Adaptation methods rely on the use of previously made sleeve patterns produced from modelling via drafting. The patterns are manipulated to create different styles. The resultant pattern is then subjected to the same processes as the drafted pattern.

Basically, there are three pattern making methods. Although they are different in approach they are all produced in planar mode. These are identified as:

- **Drafted around the scye:**

Sleeves that are drafted around the two-dimensional scye shape

- **Drafted as detached from the scye:**

Drafting methods where the sleeve is not constructed around the two-dimensional scye shape

- **Drafted as pattern adaptations:**

Methods that are modified from previously developed patterns.

The number of drafting and adaptation alternatives, utilised to construct all one-piece and two-piece sleeve styles and their variations for men's, women's and children's garments, is considerable. Examples of the three pattern making methods are described; one-piece sleeve methods are described first, followed by two-piece sleeve



styles. (Colour is applied to the original black-and-white illustrations to highlight the various sleeve areas)

### ***One-piece sleeves: Drafted around the scye***

Before commencing with sleeve drafting methods, it has to be assumed that the armhole (scye) is correct in size, shape, position and inclination. Kunick (1967) places the greatest importance on this sleeve construction detail prior to sleeve drafting.

This method of drafting a sleeve, drafting around the two-dimensional scye shape, coordinates the scye with the sleeve pattern (Figure 2.8). The scye and sleeve sections are united and related, revealing how the author (Kunick, in this instance) balances the sleeve with the scye.

Figure 2.8. One-piece sleeve drafted around the scye (1967)

Source: Adapted from Kunick (1967)



Because of their visual relationship, any imbalances or problems in fit and aesthetics between the two (scye and sleeve) will, in theory, be easier to detect and therefore easier to solve. However, as Kunick (1967, p. 109) states, some drafting systems are *'little more than the reproduction of the outline of a sleeve pattern which has been evolved by trial and error'...* which *'cannot give the best results unless constructed in conjunction with the arm-scye for accurate hang and fit'*. (Hang or sleeve balance is described in chapter 3) Even so, the flat scye and sleeve patterns are distortions of the three-dimensional; therefore, they are not true representations.

Shoben and Ward (1990), Kunick (Figure 2.8) (1967), Morris (1947) and Richards (1930) are among the few sleeve drafting authors who illustrate the relationship between the scye and the sleeve, even though they are inexact, flattened perspectives. However, if methods for measuring and producing the body patterns are suspect (see part 1 of this chapter), they may also be doubtful for defining the scye from which the sleeve is structured; thus adding to the problem of constructing two-dimensional sleeve patterns.

### ***Straight sleeves***

A straight sleeve style, depicted in Figure 2.8, traverses the front and back body section patterns (right and left dash line shapes, respectively). The relationship between the scye and the sleeve is, therefore, apparent as both scye and sleeve pitches (labelled as 5 on the front scye and sleeve, and 9 and 9A on the back scye and sleeve - respectively in Figure 2.8) are planar to their respective lines. Also, it is evident, that because the depth of crown line (DOC) has been raised from the depth of scye (DOS) line, a certain amount of arm/sleeve elevation/lift has been instilled into the sleeve pattern. The result is a shallower crown height (DOC to crown notch), and because of this, a wider sleeve pattern to preserve the crown seam length, as seen



between the vertical under arm seam lines. The hem is perpendicular to those two lines.

### ***One-piece sleeves: Drafted as detached from the scye***

The previous drafting method used the scye shape as a means of constructing the sleeve pattern. Sleeve drafting methods that are detached from the scye do not have this visual scye reference as a base from which to proceed. Both Aldrich (2002) and Chaudhry (1964 & 1970), amongst others, use this sleeve method of drafting.

### ***Shirt/tapered sleeves***

The shirt, or tapered, sleeve has reduced elbow and wrist areas, the whole pattern width reducing gradually from the crown to the elbow and down to the wrist. The under arm seam lines may be straight, or slightly curved to provide ease around the elbow circumference. The shirt sleeve illustrated in Figure 2.9 is adapted from a Chaudhry (1970) draft.

Figure 2.9. One-piece shirt sleeve (tapered) (1970)

Source: Adapted from Chaudhry (1970)

The construction technique is a drafting method used for the more unstructured, informal type of sleeve. It is based on a folded-paper method where both the front and



back arm sections are delineated on the same section of paper with the back traced through and unfolded to produce the back arm section. It is easy fitting around the arm, being very loose with an ample amount of ease. The crown is shallow - a short depth of crown (DOC) and therefore, longer under arm length - to give the required arm elevation (see chapter 6C). The front and back crown curves are shaped in a fairly straightforward, usual manner.

### ***One-piece sleeves: Drafted as pattern adaptations***

Rather than producing complicated drafts, the third method, of producing a sleeve pattern, adapts a previously drafted sleeve pattern. Tuit (1974) chose her straight-sided block pattern specifically because straight under arm seams are easier to use for sleeve adaptation purposes than is a shaped sleeve block pattern.

Morris (1947, p. 56) places an emphasis on pattern manipulations rather than drafting when he states: *'we cannot expect a system [drafting] to adapt to all varied and intricate designs that are in vogue without departing from the orthodox principles governing the original draft.'* The non-adaptability of current drafting methods – from one sleeve style, and variations, to another, is one of the main motivations for this in-set sleeve study.

### ***Bell sleeves***

The bell-shaped sleeve is an adaptation of the basic straight sleeve pattern and it does not, as the name suggests, possess an actual bell shape, it is a straight-sided conical shape. This is because the only seam lines are situated at the outside extremities, the two under arm seam lines. This prevents the all-round shaping necessary for a realistic curved bell shape, whether they are short or long.



To adapt a standard straight sleeve shape into the 'Bell' sleeve, the pattern has lengthwise cuts, placed at intervals, into which extra width is introduced into the hem. The number of cuts and the amount of extra width depends on the desired effect and is a matter of designer aesthetic. Illustrated in Figure 2.10 is a gradual introduction of width at the hem openings - designated as 'A0', 'A1' and 'A2' - to produce the 'Bell' pattern shape.

Figure 2.10. One-piece Bell sleeve (flared) (1974)

Source: Adapted from Tuit (1974)

Extra length at the hind arm may also be added to produce a 'blousing' affect, or to alleviate any signs of shortness. This can be seen in the additional length in the region of 'A2', seen in Figure 2.10. There is also additional width in the back between A1 and B4 when compared to the front between A1 and B5. The affect is to have more volume



in the back than in the front hem. It might also be noted that because the top of the under arm seam lines have been raised, the depth of crown (DOC) is more shallow allowing an increase in arm elevation. Arm/sleeve elevation is discussed in chapter 3 and chapter 6.

### ***Leg of Mutton sleeves***

The Leg of Mutton sleeve, so called because of its shape, is voluminous around the crown section, tapering down to the wrist. If the hem is too small to allow entry by the hand, a vertical opening may be constructed at the hem line. The elbow dart may be manipulated into the crown to give further width to the upper sleeve area. If this is insufficient, the pattern may be cut down to, and across, the elbow line to give a larger and more rounded outline. Because the sleeve crown is excessively longer than the scye length it has to be either gathered or pleated to fit the scye, thus giving shape to the style.

The two drafting methods, '1' and '2' depicted in Figure 2.11, applied to produce a Leg of Mutton sleeve, are variations in execution although they both use manipulations from a previously drafted pattern. To produce the crown volume, Joseph-Armstrong (1987) directs the reader to cut down the centre line of the sleeve to a point above the depth of crown line (DOC) (Figure 2.11 '1'). Two diagonal cut lines also radiate, from this point, to two locations on each of the under arm seams, between the bicep and elbow levels. The cut lines are then opened by an appropriate crown gathering amount as per the instructions.



(1) 1987

(2) 2000

Figure 2.11. One-piece Leg of Mutton sleeve (1987 & 2000)

Source: (1) Adapted from Joseph-Armstrong (1987)

(2) Adapted from Shoben and Ward (2000)

In contrast to the pattern manipulation method by Joseph-Armstrong, Shoben and Ward (2000) cut down the centre line, the fore arm line and hind arm line of the pattern to just above the elbow level and horizontally across to the two under arm seam lines. It is also cut horizontally across the elbow from under arm seam line to under arm



seam line (Figure 2.11 '2'). The pattern is then cut and opened to the required gathering amounts, by pivoting from the elbow line. The crown addition is therefore established with considerably more gathering than the sleeve crown of Joseph-Armstrong.

Opening the crown to the desired width, also introduces a certain amount of vertical length at the horizontal elbow line (Figure 2.11 '2'). The amounts of extra crown gathering length introduced into the crown may not be the final solution as there may be a need to cut out a muslin prototype to analyse the results. Whilst the Joseph-Armstrong method retains the dart for elbow shaping, the Shoben and Ward dart is manipulated and absorbed into the crown. The elbow dart of the former method produces ease around the back of the elbow, the latter does not.

### ***Two-piece sleeves: Drafted around the scye***

The two-piece sleeve is used in garments that require shaping to coincide with the arm curvature, such as tailored jackets and coats. To enable the pattern to achieve the curved silhouette there are two vertical seam lines separating the top-sleeve area, the main outer portion of the sleeve, from under-sleeve section, located between the arm and the body.

The two seam lines are located at the hind arm position over the elbow point and one at the forearm line. This distribution gives the sleeve a more natural arm shape curve and better arm-fitting qualities. This type of sleeve, when in the downward hanging position on the body, should be devoid of distortions. When the arm is moved, either forward or upward, creases appear. The tailored two-piece sleeve is the opposite of the non-fitted, movement-oriented, shirt sleeve; therefore, the tailored two-piece sleeves are difficult to perfect without a great deal of care.



Drafting techniques that show the sleeve constructed around the scye shape are depicted in instruction books from authors such as Richards (1930), Poole (1936), Morris (1947), Kunick (1967), and Shoben and Ward (1990). Although their diagrams illustrate how the sleeve relates to the scye, the actual sleeve shapes are different.

The two figures shown in Figures 2.12 '1' and '2' illustrate two different methods of relating the sleeve to the scye. The Richards (1930) top-sleeve extends either side of the scye (red sections at 'A' and 'B' in Figures 2.12 '1'; which will, later, curl under to meet the under sleeve and scye seam. The top-sleeve is in harmony with the scye.

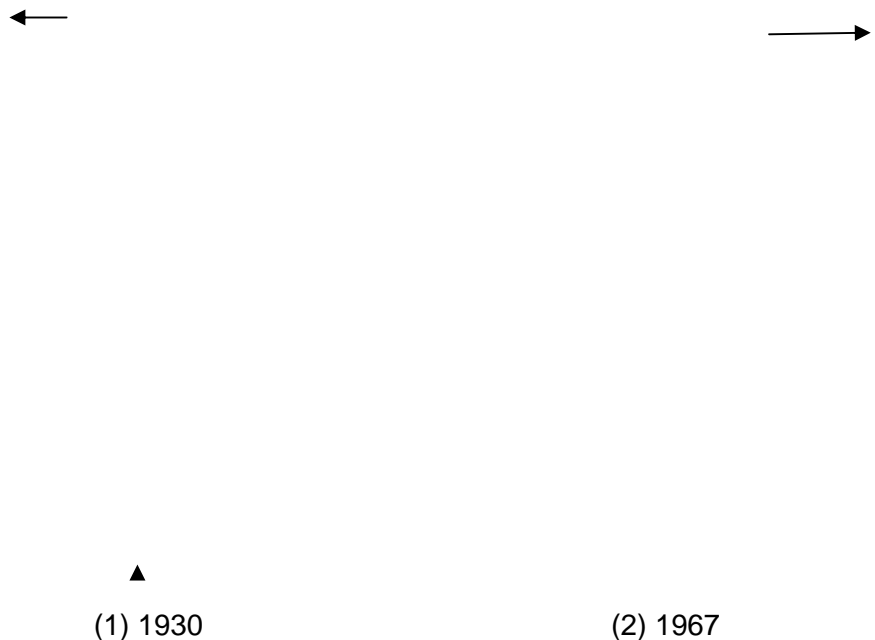


Figure 2.12. Two-piece sleeve drafted around the scye (1930 & 1967)

Source: (1) Adapted from Richards (1930)

(2) Adapted from Kunick (1967)



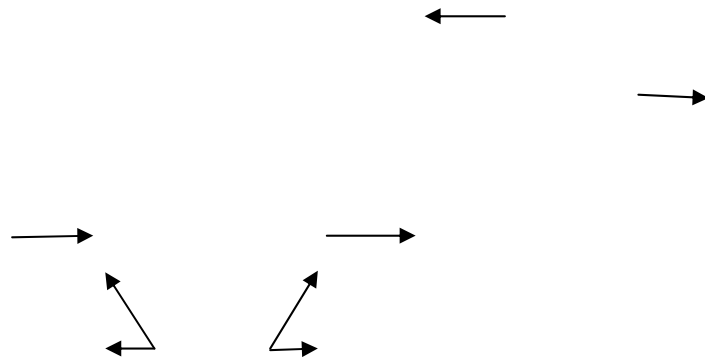
However, the under-sleeve, which balances with the top-sleeve at the hind arm/hem, point 'D', does not balance with the scye. The under sleeve has to move to the left (arrow) to align with its true scye sewing position. This means that the hind arm/hem at 'D' will also move to the left disrupting the top and under-sleeve harmony in that area. The Kunick sleeve (Figure 2.12. '2') shows the opposite effect; it is the top sleeve that has to move to the right (direction of arrow) to align with the scye; in the process disturbing the harmony at the hem (D).

In contrast to the two previous examples shown in Figure 2.12, the Shoben and Ward (1990) sleeve draft (Figure 2.13) is an improved harmonious organisation of the top-sleeve, under-sleeve and scye. The top-sleeve extends both ways from the front and back scye lines (curved lines between the blue scye areas in Figure 2.13 '1' producing the sleeve curvature and blousing around the outer section of the arm.

Figure 2.13 clearly shows the transformation ('1' - '3') of an equally divided sleeve, a 50/50 variety (Figure 2.13 '1', bounded by points 'A' 'B' 'C' 'D' - top and under-sleeve patterns of equal width), into a 'false' (or hidden) fore and hind arm seam sleeve type (Figure 2.13 '3').

As both top and under-sleeve sections, and the scye shape, are in accord with each other, there is no need for either the top or under sleeve to move to the right or to the left. Figure 2.13 '2' shows the new top and under-sleeve separation lines between 'C1' - 'F' - 'E' - 'D1' - 'C1', with the fold lines between 'A' - 'C' and 'B' - 'D'. The blue coloured areas in Figure 2.13 '2' indicate the under-sleeve sections which will be transferred to the top-sleeve.





(1) 50/50 (2) False fore & hind arm (3) Final development

Figure 2.13. Two-piece sleeve drafted around the scye (1990)

Source: Adapted from Shoben and Ward (1990)

Figure 2.13 '3' illustrates the final development of the top-sleeve (green and blue sections) and the under-sleeve (fawn coloured section). The blue sections have pivoted on lines 'B' - 'D' and 'A' - 'C' to their new positions as part of the top sleeve. During the alteration procedure, the inner elbow at 'G' of the top sleeve (Figure 2.13 '3', overlaps, thus shortening the length of the seam line, requiring the seam to be stretched to re-establish the length; whilst the back elbow of the top sleeve, at 'H', opens gaining length; this requires the seam to be shortened by easing-in to the under sleeve seam line.

Drafting the sleeve around the scye shape should serve as a convenient visual reference to determine whether the sleeve and scye actually balance. Even so, as



observed in Figure 2.12, the scye sleeve relationship may not be acceptable. How would the novice or non-technical artistic designer know which method to use without trialling them all?

### ***Two-piece sleeves: Drafted as detached from the scye***

If the sleeve is in correct alignment with the scye, resolved from previously toiled sleeves on the model, the principal or preferred method of visualising the scye/sleeve association; the drafting around the scye method may not be totally necessary.

Some of the two-piece sleeve drafting techniques that show the sleeve constructed without a visual scye reference, are to be found in manuals by Poole (1936, Cutler (1950), Chaudhry (1970), and Davies (1986) all have false-forearm seam lines - seams hidden from view. Of these, only the Davies method (Figure 2.14) contains a measuring system to attain the sleeve crown height ('A' in Figure 2.14) based on the top area of the scye ('B', in Figure 2.14); other methods may use a variation. The measurement is also given as  $1/10^{\text{th}}$  of the scale, the scale being  $\frac{1}{2}$  of the chest measurement.





Figure 2.14. Two-piece sleeve drafted detached from the scye (1986)

Source: Adapted from Davies (1986).

### ***Two-piece sleeves: Drafted as pattern adaptations***

In contrast to the two sleeve drafting methods mentioned above, Bray (1997), Joseph-Armstrong (2006, Figure 2.15), and Gebbia (1955) use one-piece sleeve adaptation techniques to obtain a two-piece sleeve pattern, albeit with differing instructions. Both of the latter authors use a shaped elbow-dart sleeve, whilst Bray uses a straight sleeve pattern. The instructions supplied by Joseph-Armstrong (2006. pp 494-496) (Figure 2.15) give a better appreciation of the alterations required to make the two-piece sleeve pattern.

Figure 2.15 represents a one-piece sleeve which gradually progresses ('1' - '7', a single process) through the adaptation drawings into a two-piece tailored sleeve. Figure 2.15 '1' shows the one-piece sleeve, Figure 2.15 '2' depicts the sleeve folded with points 'A' and 'B' meeting at point 'C'.



The figure is further refined in Figure 2.15 '3'. Figure 2.15 '4' is the top sleeve only, depicted in green. Figure 2.15 '5' is the under sleeve in a fawn colour. The final arm-curved patterns are shown in Figure 2.15 '6' (under sleeve - reversed) and Figure 2.15 '7' (top sleeve), ready for seam and hem allowances.

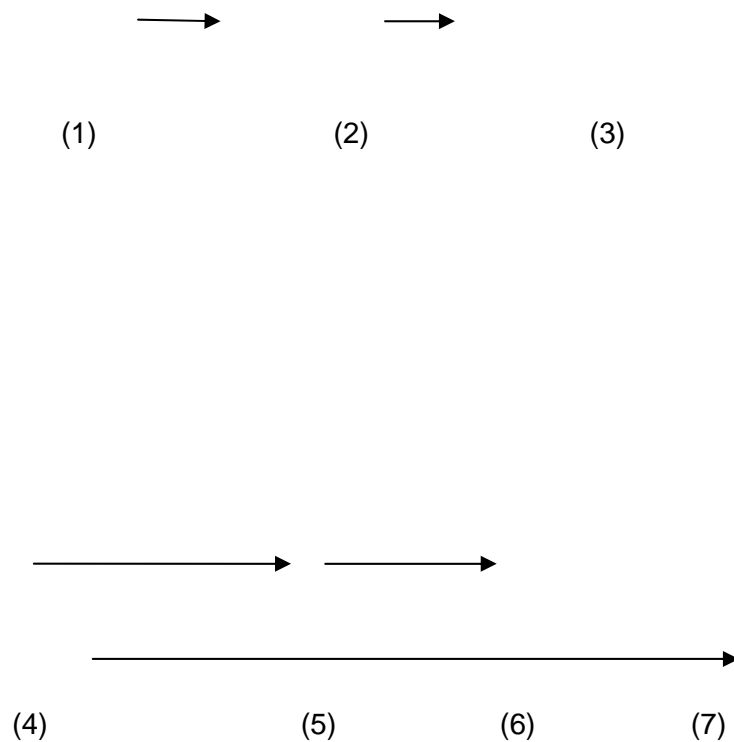


Figure 2.15. Two-piece sleeve drafted as adaptations (2006)

Source: Adapted from Joseph-Armstrong (2006)



### ***Two-piece sleeves: Pattern engineering***

Since this research entails the development of an 'engineered' hybrid system for designing and pattern making in-set sleeves, it is appropriate to provisionally outline a little of what is seen as pattern engineering today. Although it is termed 'pattern engineering', the actual engineering drawing methods are not used in pattern making.

Engineering (verb) is expressed by the Concise Oxford Thesaurus (1997, p.244) as: *to cause, plan, scheme, contrive, manoeuvre, manipulate, control* et cetera. Industrial goods, made from various materials, metals and plastics for example, are planned, controlled and engineered to give an unambiguous result to their final three-dimensional shape. Engineering is an additional perspective to the usual drafting and pattern making methods. To a greater or lesser extent, most mass production garment pattern makers (in my experience) utilise pattern engineering in their work.

Clothing pattern makers, using 'engineering methods', cut the pattern in a manner that attempts to replace the 'artistic' expertise and time consuming practises of the tailor (such as stretching and moulding the fabric), with areas of in-built pattern shaping. Figure-forming darts on the body pattern, for instance, can be repositioned and amalgamated - such as pivoting and moving the bust dart into the front waist dart. Whilst retaining both dart shaping qualities, this has the advantage of easing garment production through the manufacturing processes. The 'flow-on' effect is that in certain situations, less skilled machining-labour can be used. Pattern 'engineering' methods can also be used in sleeve pattern making.

Aldrich (2002, p.49) describes her 'engineered' pattern as '*systemised to maximise and control the production in order to offer good quality at an affordable price*'. This



approach can be seen in clothing manufacturing factories making mass-produced garments, rather than bespoke (traditionally tailored) garment making.

Figure 2.16 '1' depicts the engineered sleeve as envisaged by Aldrich (2002, p. 55); 'A' - 'B' - 'C' - 'D' - 'E' - 'A' represents the top sleeve whilst the under sleeve is 'C' - 'D' - 'F' - 'G' - 'C'.

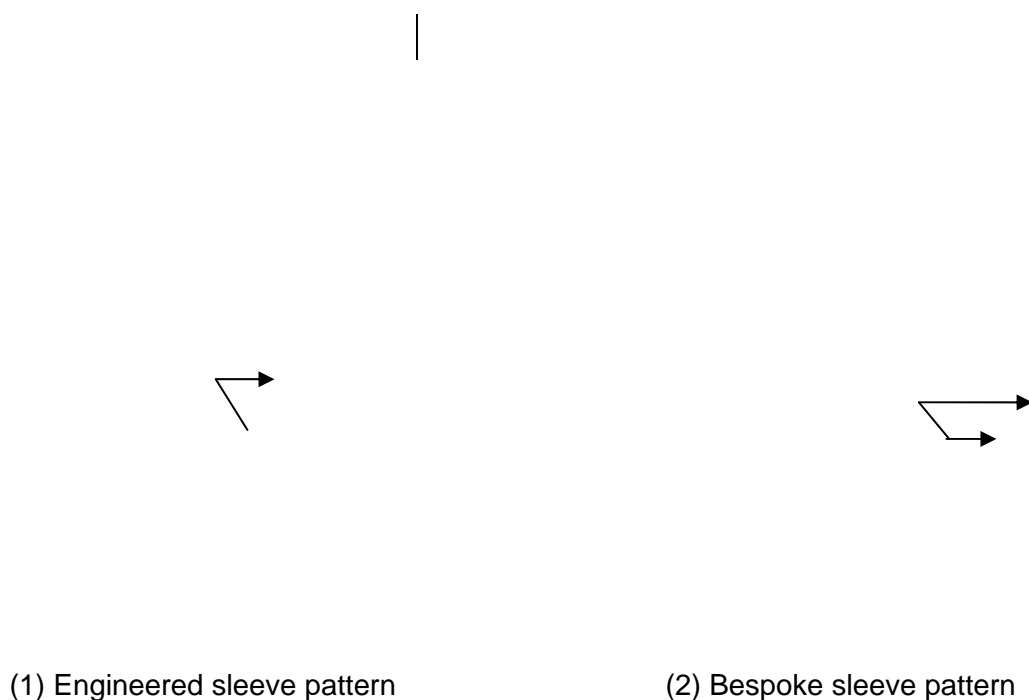


Figure 2.16. Engineered and bespoke two-piece sleeve

drafted detached from the scye (2002)

Source: Adapted from Aldrich (2002)

Although the engineered sleeve crown (illustrated in Figure 2.16 '1' is a different shape (less fullness) to that of the bespoke sleeve ('A' in Figure 2.16 '2'), the two sleeve drafts follow the same current practises of constructing and measuring the scye 'B' and 'C' in Figure 2.16 '2' – except using different measurements. Even the fore arm seams are



the same (although on a different alignment); whereas the top and under sleeve seams of the engineered sleeve have no allowance for inner elbow sleeve shaping (fabric stretch allowance to fit the inner elbow shape), neither has the bespoke sleeve. The top sleeve fore-arm seam should be shorter in order for it to be stretched onto the under sleeve seam length to acquire the correct amount of inner elbow sleeve shaping. The engineered sleeve, even though planned to give control, does not deviate a great deal from the norm. As far as basic sleeve drafting is concerned there is no real 'engineered' method involved.

My personal experiences of pattern engineering include pattern making for John Barran Ltd. (UK), who produced garments for Austin Reed of Regent Street, London. The engineering methods were more extensive than those advocated by Aldrich (2002). For instance, the scye and sleeve had more sections – every 10cm. The number of sections and their related fabric fullness provide a platform from which to grade the remaining sizes in the size range. Each section in each size is measured, using a special grid, to ensure that fabric fullness amounts are proportional to the original scye and sleeve sectors. (p. 47)

There is no evidence in the publications that this approach to pattern engineering takes place. In this regard the 'extensive' use of pattern engineering is seen as being uncommon. The reason for extensive engineering not being part of pattern making is perhaps the same as the division of artistic design and technical pattern making – they are two different disciplines using dissimilar materials – on the surface there is no connection.



## **2.8 Summary**

The first part of chapter 2 determined that the 'in-set' type, or category, of sleeve was the focus of this research. The one and two-piece sleeve outlines and their respective terminology were defined and illustrated. An exploration of early pattern drafting and measuring systems developments was described. It was also stated that these systems were subject to criticism through the years because they are prone to error and only 'safe' if used by experienced cutters (verified by personal observations in practise) or are without a solid scientific foundation. As Heisey, Brown and Johnson (1988) reveal, there is little evidence of any systematic examinations of the theoretical aspects of the tasks involved in pattern drafting methods. (Naturally, these systems were developed using techniques, such as fractions and proportions, which were familiar to both developers and users - they were products of their time, before the introduction of computerisation which tends to separate the developers from the users).

Because of the difficulties encountered in the modelling processes of body and in-set sleeves, drafting became the chief method of pattern production. After two hundred years, or more, of continual technological improvements, Bray (1985), remarks that the 'modern' block, 'sized' patterns, and pattern making methods are still in use in 1985.

The second part of chapter 2 demonstrated that same historical sleeve drafting and adaptation methods are still current in 2010. A small selection of current drafting methods, their pattern adaptation techniques and how they function to produce a decided number of related sleeve style variations was examined.

For the experienced practitioner, those who are curious enough to research and trial unfamiliar drafting methods, the instructions and technical illustrations may be altered



until perfected – they are a starting point (Lange & Pritchard, 2009). The same continuous tedious process occurs with personal drafting techniques.

Choosing a 'how-to' manual is confusing to the uninitiated student as the amount of literature on pattern making and drafting is considerable; What does the inexperienced student look for in the draft and what do they expect from the fabricated sleeve? Students are sometimes surprised to discover that their imagined interpretation of the two-dimensional draft is not what they have actually acquired in three-dimensions.

## **2.9 Conclusions**

This research has drawn attention to the lack of consensus in historical drafting and measuring systems and current drafting methods for a variety of sleeve styles. Since their inception and up to the present, there has been a continuous unbroken line of drafting methods. The underlying processes of pattern making and draft development never change unless a new variation on the existing method theme is trialled. Pattern making methods persist, remaining substantially intact since the nineteenth century - there has been very little evolution in sleeve drafting and adaptation processes. Since there is little prospect of assimilating a wide range of dissimilar pattern making techniques into a new design and pattern making system for the different styles, a breakdown of the scye and sleeve may be beneficial.

Chapter 3 considers the elements that constitute the scye and in-set sleeves. It discusses various defects/disadvantages that arise from continuing to use current drafting and pattern adaptation methods, why a comprehensive knowledge of modelling and pattern making is essential and why this situation has to change.



## Chapter 3 —

### Scye and In-set Sleeve Elements:

### Sleeve Defects and their Remedies

#### 3.1 Introduction

The abundance of in-set sleeve drafting and adaptation methods, discussed in chapter 2, emphasises the wide range of approaches used by authors and practitioners to construct contrasting sleeve styles – no two methods are exactly the same and no two methods would produce the same results. As Lange and Pritchard (2009, p. 49) reveal, *‘Assumptions are made that modern sources (of pattern drafting techniques) are complete and summative authorities of knowledge, but are they?’* This raises the question of whether there is author consensus in the methods for measuring and manipulating the elements that characterise the scye and sleeve. Will the ensuing pattern result in an acceptable level of function and quality in the three-dimensional fabric sleeve and are the results as expected and/or required?

By analysing the current pattern making and adaptation methods and their elements, this chapter continues the theme of suspect pattern making methods and flawed



outcomes. Despite all of the methods and the abundance of practice devoted to these methods, defective sleeve patterns and sleeve fabrications still occur. However, there are far too many types and degrees of defects found in scyes and sleeves to include in this study. Consequently, in order to illustrate only a little of the knowledge required by pattern makers, a number of scye and sleeve elements and their associated defects, some with pattern remedies, are presented in the following text.

### **3.2 Scye and sleeves**

What constitutes good sleeve styling is open to conjecture; different authors cite different combinations of qualities that contribute to good styling. Amongst those recognised as important by various authors are: the scye Richards (1930); and Erwin (1954). The crown: Hecklinger (Shep, 2002), and Pepin (1942). Balance: Erwin (1954). Fabric fullness: Hecklinger (Shep, 2002) and Erwin (1954). Arm movement: Richards (1930).

Even so, at a fundamental level, and no matter what the superficial differences, sleeve drafting techniques exhibit similar procedures and the same sleeve and scye elements. Despite the many sleeve styles and different sleeve drafting methods there is a finite number of basic sections and elements that define the sleeve and its armhole (scye) parts.

#### ***Sections and elements***

The two sections of scye and sleeve contain a number of elements. Each element has its own function within the scye and sleeve structures; therefore, they should be in correct alignment and balance. Without element balance, defects arise that can mar the fit and aesthetics of the two sections. To try to overcome the restrictions inherent in



two-dimensional drafting methods, the different garment sections (scye and sleeve) and their elements are analysed; they are listed as:

- Scye
- Sleeve crown shaping
- Balance and pitch points/marks
- Fabric fullness: a selection of pattern makers' pattern allowances. (Fabric fullness related to sleeve styles is discussed in chapter 7C)
- Fabric fullness measuring
- Depth of crown
- Depth of crown illusion
- Arm elevation/lift

## **Scye**

The scye (arms-eye, arm-scye or armhole) of the body section, is the foundation for the sleeve; it is the opening into which the sleeve directly hinges and is sewn. It is the focal point of sleeve drafting and pattern making. The scye must consist of comfortable proportions for the wearer; therefore it has to be of the correct height and width. This, to a large degree, is reliant on the cutting and joining of the front and back body sections. (It is assumed, for this project that the front and back sections are correctly constructed. It is important to have the scye correct in size, shape and orientation as the sleeve has to fit this section of the garment.

A number of practitioners advocate the use of the scye as a foundation from which the sleeve pattern is drafted (Poole, 1936; Morris, 1947), whilst Richards (1930, p. 53) maintains that the scye shape should be accurate. Erwin (1954, p. 8-12) describes the scye as having to be smoothly curved and not full onto the sleeve.



### ***Distorted scye***

The scye, in its three-dimensional fabric form, should be perfectly constructed to allow for sleeve making. However, in its flat condition, as depicted in drafting manuals – it is deformed. Kunick (1967, p. 88-89) portrays the two-dimensional drafted scye as being distorted when compared to its three-dimensional counterpart (blue oval in Figure 3.1). In this condition, the relationship between the scye and sleeve draft requires allowances to be made to the instructions. All drafting instructions of this type do not illustrate the true association between scye and sleeve, therefore an accurate understanding of their harmony is also missing.

Figure 3.1. Two and three-dimensional scye shapes

Source: Adapted from Kunick (1967)

### ***Sleeve crown shaping***

Containing amounts of fabric fullness, the sleeve crown covers the top section of the sleeve. This lies above the lowest part of the curved scye/sleeve seam line. The shape



of the sleeve crown is related to the scye shape and the sleeve style. Full sleeve crowns, down to the depth of scye line (DOC), are designed in a number of shapes and sizes from a low crown height and silhouette to the considerable expanse of fabric and depth of crown as witnessed in the Leg of mutton sleeve style (Figure 3.2). All sleeve crowns must be harmoniously affiliated to the scye in order to achieve the required sleeve design.

It is the sleeve crown area that causes the most problems related to the elements of sleeve style, fabric fullness (gathers, pleats and darts), sleeve size, ease and sleeve movement (sleeve/arm articulation and elevation).

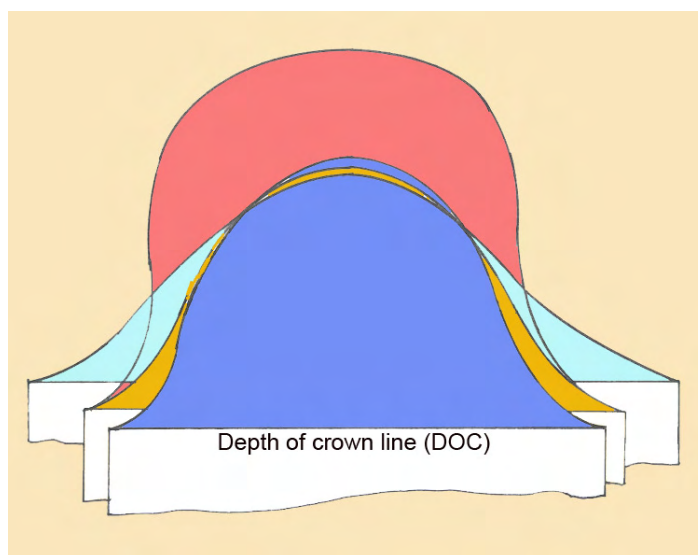


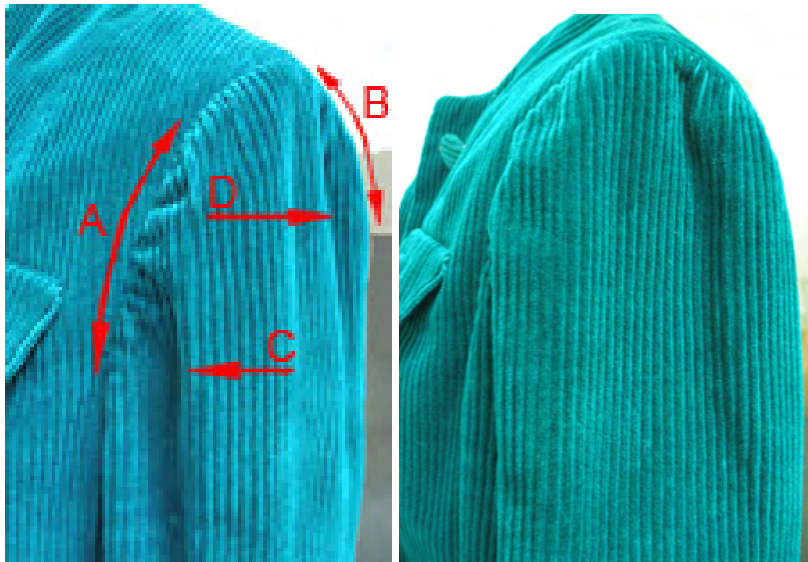
Figure 3.2. Variety of crown shapes

### ***Excessive sleeve crown shaping***

A sleeve, designed for a particular arm, should balance with said arm. The crown and arm-encasing sections (main arm covering section) of the sleeve should harmonise with the scye and arm – be the correct size and shape. When this harmony is broken, problems occur in the fabricated sleeve.

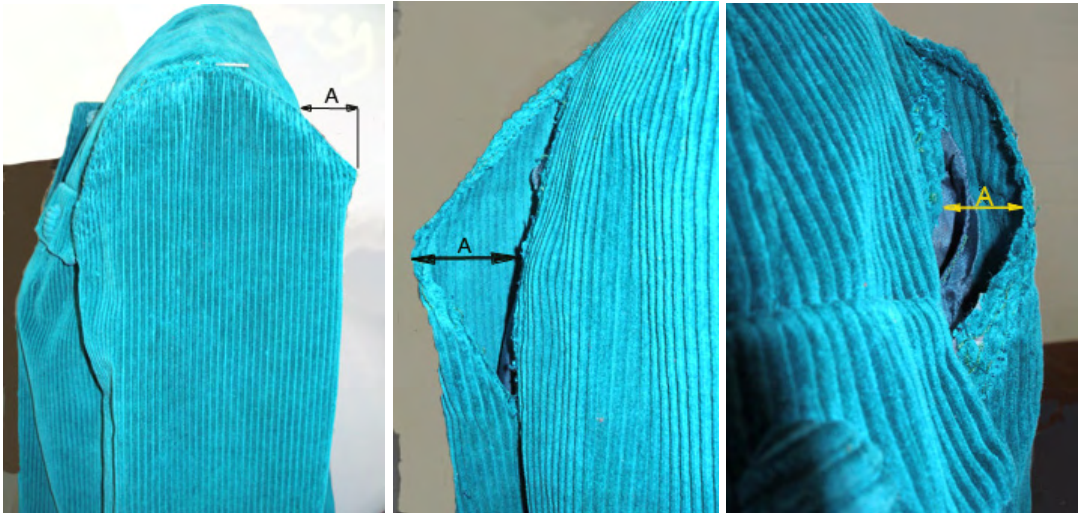


The defective sleeve depicted in Figure 3.3 '1' and '2' is part of a commercially made garment constructed from a corduroy fabric of 100% cotton. It has a crown shape that is too wide in the regions of the lower front 'A' to lower back 'B', resulting in vertical fluting at 'C' and 'D'.



(1) Front/side sleeve

(2) Side sleeve



(3) Side sleeve

(4) Back sleeve

(5) Front sleeve

(back crown opened at A) (back crown opened at A) (front crown opened at A)

Figure 3.3. Excessive crown shaping



In the same figure (at '3'), when the seam is unpicked, the back sleeve overhangs the back scye at 'A'. The overhang and curved length of the sleeve seam is more apparent in Figure 3.3 '4', at position 'A'. The front sleeve (Figure 3.3 '5') also shows the same projection out from the scye. The outcome of this very wide sleeve pattern is an extremely unsightly fabricated sleeve.

### ***Balance and pitch points/marks***

There are various instructions from authors regarding the sleeve and scye balance. Balance being the interrelationships, or alignments, between one section of scye and sleeve or line and another; each changing within a particular sleeve design. Sytner (1955, p.27), lists four points that contribute to these qualities: the sleeve heights from the front (1) and back pitches (2), the crown height (3) and the hollow of the under sleeve (4). In any sleeved garment, the sleeve either hangs straight down (Figure 3.4.), unless it is an arm curved sleeve, or may have a slight forward 'swing' (a forward tilt).

Poole (1936) explains how the sleeve head fits into the scye and how the factors are obtained to enable the constructed sleeve to match the scye area. He provides reference to the placement and balance of the sleeve to the armhole; the best method of allowing for the greatest range of hinge movement of the arm. In regard to pitch positions he says: *'Obviously, the answer is, as low as possible in the front, and as high up as possible in the back, so as to give the longest axis between the two points as is compatible with practical results'* (pp. 77-90) (refer to Figure 3.4.). The unification of scye and sleeve, by pitch point placements (which are either marks or cuts in the fabric), also allows for the distribution of different amounts of fabric fullness.



Figure 3.4. Pitch points

Adapted from Bray (1997)

Classic tailored garment sleeve styles are formal at the front, featuring a clean appearance, folds appearing only when the sleeve is raised. Other, more mobile sleeve styles such as shirt sleeves, may position the pitches and fullness differently. The shirt sleeve aesthetics, of clean, smooth fabric devoid of creases, only appear when the sleeve is raised, when in a downward hanging position folds are customary. It is the direct opposite to the tailored sleeve. The amalgamation of these contrasting sleeve styles and element affects is important to this study since incorrect placement is problematical, causing fabric defects.

### ***Incorrect balance and pitch points/marks***

The sleeve has to balance with the garment scye and the wearer's arm, which may 'hang' in a vertical, forward or backward direction – depending on the individual. Thornton (1894, p. 19) stipulates the importance of pitch marks, explaining that the balance of the sleeves is compromised if they are incorrectly positioned, resulting in a creasing of the garment and tightness or looseness around the arm.



However, apart from correct scye/sleeve balance, there are two basic positions when the sleeve may not be in true balance with the scye and arm. The sleeve may be pivoted (usually described as 'pitched') too far forward in the scye, or too far back ('A' and 'B' respectively in Figure 3.5).

As Thomas Mahon (English Cut, May 2006) maintains:

*'You can try your best from start to finish when producing bespoke (garments). The best materials, skilled craftsmen and years of experience. And yet even after all the diligence of checking again and again, things can go wrong. And pitch (scye and sleeve balance) is often where disaster strikes'*

Figure 3.5. Forward and backward-hanging sleeves

Source: Adapted from Bray (1997)

A left sleeve, pitched too far forward, is depicted in Figure 3.6 '1' and '2', where arrows indicate folds of fabric from the high front area to the lower back edge of the sleeve. Folds are also evident at the under sleeve in Figure 3.6 '2'. The solution for a sleeve pitched too far forward is to reposition the pitches; the front pitch moves down from 'A'



to 'B', in Figure 3.6 '3', whilst the back pitch moves up from 'C' to 'D'. In effect, the sleeve swings backwards to align with the arm posture.

(1) Diagonal folds (2) Back sleeve folds (3) Required pattern alteration

Figure 3.6. Forward-hanging sleeve

Source: Adapted from Sytner (1955)

When the sleeve is pitched too far backward the opposite fold faults occur. The key, according to Sytner (1955, p. 26) is to reposition the pitches in an opposing manoeuvre to the previous example depicted in Figure 3.6 '3'. The front pitch moves up from 'A' to 'B' (Figure 3.7 '3'), whilst the back pitch moves down from 'C' to 'D'. The consequences are that, the sleeve swings forwards to align with the arm posture; the reverse of Figure 3.6. Why should these manoeuvres be necessary – even for bespoke garments?

(1) Diagonal folds (2) Back sleeve folds (3) Required pattern alteration

Figure 3.7. Backward-hanging sleeve

Source: Adapted from Sytner (1955)



Although traditional practitioners (Poole, 1936, p. 78; and Morris (1947) place the front pitch, respectively, 'as low as possible' and  $\frac{3}{4}$ " (19mm) above the depth of scye line and place the back pitch (Morris (1947) at half the DOS line, a common allocation method, not all authors agree with this distribution or position of the pitch points.

For the one-piece sleeve, instead of using the usual two pitch marks, one low at the front and one on the half cross-back line, (Richards, 1930, p.20) has four. Shoben and Ward (2000, p. 14) locate the front pitch at a position 60mm above the depth of scye line (DOS), the back pitch is aligned with the across-back line. Aldrich (2002) relates the pitch points of the scye to the pitch points of the sleeve, the back pitch being very low compared to other manuals.

Some authors reverse the scye to sleeve pitch position process. Tuit (1974) arrives at the balance points (pitches) on the armhole by moving and measuring the sleeve head around the armhole (see fullness measuring). Bray (1985) also positions the scye balance marks from the sleeve. For better sleeve positioning, in addition to the pitch positions, a notch on the sleeve opposite the shoulder seam, can also be useful (Pepin, 1942, p. 90). The positions of the pitch points, both on the scye and sleeve, are not standardised, the placement is entirely up to the type of sleeve and the author of the drafting method. Pitches also aid in the distribution of fabric fullness.

### ***Fabric fullness***

This chapter part relates to the views of certain pattern making authors concerning fabric fullness amounts; how actual amounts are calculated is not discussed by the authors (fabric fullness calculations are therefore described in chapter 7C).

Fabric fullness (overfeed or planar compression), is described as the difference between the length of scye and the crown length of the sleeve. The sleeve is always



longer than the scye. Fabric fullness in a jacket sleeve allows for sleeve shaping over the top section of the arm. The reasons for sleeve fullness around the sleeve crown (gathers, pleats and darts) are either purely for a particular style effect, such as tailored or Leg of Mutton sleeve style, or for more aesthetic and practical reasons such as forming curvature. Cabrera and Flaherty Myers (1984, p. 159) state that the reason sleeve fullness is necessary, is '*to allow the sleeve to fall gracefully from the shoulder*'. Still, according to Poole (1936, p. 86) the reason for fullness is because: '*It is impossible to sew a convex sleeve top into a concave scye without minutely pleating or fulling-in the sleeve top...*' (not quite true, see chapter 6 B)

The amount of fullness included in any sleeve is fundamental to the sleeve design as a whole. A jacket, with heavier fabric and less arm articulation has more fullness than a shirt. Each type of sleeve has a range of fullness allowances that can be allocated depending on the fabric. An increase or decrease to any great extent almost guarantees a different sleeve style. Therefore, it is highly pertinent to this research to investigate the amount/s of fullness various authors attribute to standard types of sleeve – whether there is agreement to fullness attributions between the authors.

The text and drafting measurements indicate that Hecklinger's (Shep; 2002 p. 147) top sleeve has no ease allowed whereas the under sleeve has a full 2" (50.8mm) of fullness. Thornton (1894) placed the amount for a man's jacket at 1" (25.4mm). This measurement is insisted, as can be seen from the capitalised, bold lettering used by Thornton in his book of 1894, p. 20. '*The correct amount of fulness [sic] for the sleeve head of a man's coat is one inch (25.4mm)*'

The introduction of only 'a little' fullness in the under sleeve seam is promoted by Poole (1936, p. 53). Still, believing this to be unreasonable, because of the habit of stretching the scye to fit the under sleeve measurement, Poole settles on ½" (12.7mm) of fullness



between these two points. On page 83 he quantifies the top sleeve fullness measurement, between the front and back pitches as 1½" – 2" (38.1mm – 50.8mm).

Pepin (1942, p. 90) measures fullness at an average amount of 1½" (38.1mm) which should be divided equally either side of the shoulder seam (although alterations may be required), also, the under sleeve should be devoid of fullness.

Fullness is introduced by Gebbia (1955, p. 12) into the front and upper back sleeve sections, between the pitches at 2" (50.8mm), ½" (12.7mm) from the back pitch to the under arm point and no fullness from the front pitch to the under arm point (this is similar to Richards's (1930, pp.63-67) fullness amounts). From the one-piece sleeve, ½" (12.7mm) is adopted for the front of the two-piece top sleeve and apart from the curvature of the crown, there is no fullness allowed in the back and under sleeve areas.

Fullness amounts by other authors are even more individual. Tuit (1974, p.96) relates that the amounts of fullness, above and between the pitches on the top sleeve are at least 1" (25.4mm), to as much as 3" (76.2mm) – a considerable range, depending on the choice of fabric its properties. The under sleeve, below the pitch points, is sewn plain, with no fullness.

There is a range of measurements determined by Cabrera and Flaherty Myers (1984, p. 159) as being suitable; 2" to 2-1/4"; 25.4 - 31.7mm, Tighter woven fabrics should have a difference of no more than 2" (25.4mm), measured on the fabric edge. The one piece sleeve draft of Bray (1985) shows no reference to particular measurements of sleeve head fullness allowances, however, the text (page 70) allows for fullness in the upper sleeve crown as an average of 20-25mm. Measuring the sleeve into the Joseph-Armstrong (1987, p. 76) armhole also results in an under sleeve fullness of zero inches. The sleeve crown ease (fullness) is set at between 1¼" and 1¾" (31.75mm and 44.45mm), ideally, 1½" (38.1mm).



A fullness of 6mm to the under sleeve, 3mm to the front section and 3mm to the back section is advocated by Cooklin (1994, p. 18). The top sleeve section fullness amounts are not stated, only that 1/3 of the fullness, above the under arm sections, should be in the front and back lower sections and, therefore 2/3 of the fullness above these two middle sections. Doyle (2005, p.227) states that the crown fullness should be in the region of 1½" (38.1mm), depending on sleeve style, reduced slightly (a subjective term) for a smaller upper arm.

Leg of mutton, and puff style sleeve heads differ considerably from the standard sleeve shape in amounts of volume. The fullness quantity, other than that already infused in the original pattern, (Gebbia, 1955, p. 45) is of approximately 3" (76.2mm) at the shoulder region. This, not inconsiderable, amount of fullness is contrasted with a bell shaped sleeve. When describing the bell shaped sleeve (Shoben & Ward, 1990, pp. 73-74), the principle is: *'...that a flared sleeve needs less crown ease than a straight sleeve, therefore the fullness in the crown can be used as a dart and manipulated into the lower section.'*

It is stated by Aldrich (2002, p. 82) that the amounts of fullness may be reduced by 3mm in the front sleeve area and 2mm in the back sleeve; however, although the actual fullness amounts are not stated there is a note declaring that accurate measuring of the scye is essential.

Fullness (without puckers) is not the only type of overfeed; other sleeve styles may exhibit a high amount of overfeed/fullness (as in the Leg of mutton sleeve). The amounts of fabric fullness that extend beyond the fullness capacity of the fabric produce gathers, pleats or darts. According to Joseph-Armstrong (1987, p.138) gathers, pleats and darts are all equivalents of fullness.



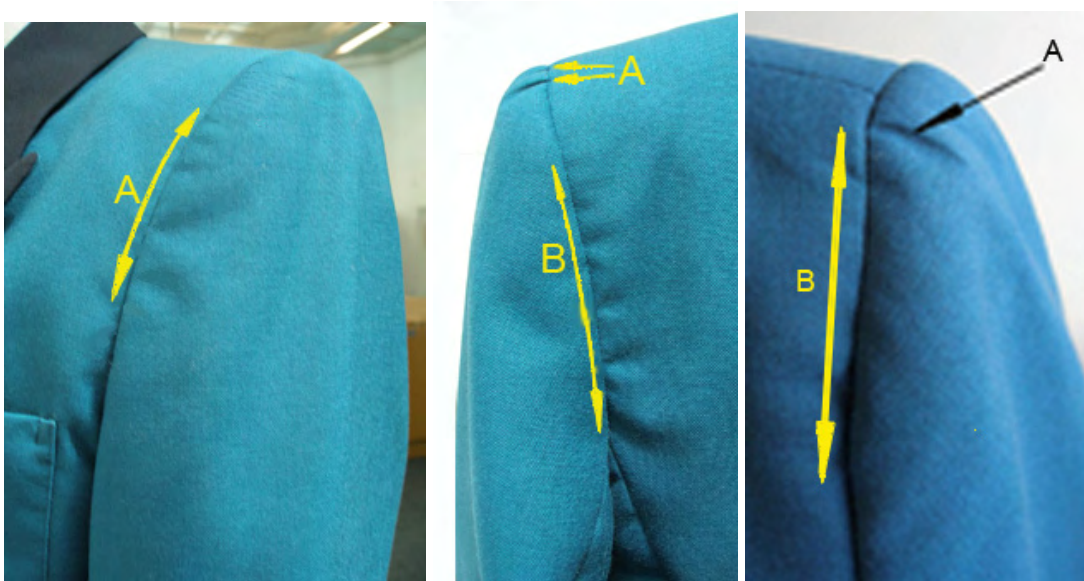
As the amount of fullness increases within a seam, there is a gradual build-up of the extra seam length until the fabric weave can no longer compress any more length, the outcome is gathers. Once the gathered seam has reached its limits there is no alternative but to fold itself into a dart or a pleat. A dart is a pleat with the folded or creased edge line sewn down to a point to form a 'V' shape). Therefore, a pleat is an open dart, fullness and gathers are small pleats, consequently they are all equivalent. *'Gathers are the formation of a style feature in garments or other made-up goods by drawing material together into a succession of small folds and retaining by stitching or other means.'* (McIntyre & Daniels, 1995). And, pleating is *'creasing material into folds'*. (Hard's Year Book, 1972)

### ***Excessive fabric fullness***

Various amounts of fullness, gathers et cetera, produce different sleeve styles and silhouettes, therefore, compressing a longer length of sleeve fullness into a shorter scye seam length does present a problem. There are a number of factors involved in the production of garment sleeves. These relate to the skills of the sewing machinist, the considerable variations in fabric types, weights and thickness, sleeve styling, partially because of the fullness measuring methods involved and partially because the topic is subjective, as seen in the previous comments on fullness amounts.

At times, the amount of fullness can be too generous, unnecessary, or distributed incorrectly around the scye. For aesthetic reasons, 'over-crimping' of fabric in the form of excessive fullness, should be avoided. Figure 3.8 '1', '2' and '3' show a left front, left back and right back of a jacket sleeve, respectively (lightweight fabric type), illustrating this excessive fullness sleeve fault along the seam line at positions 'A'. The front sleeve has too much fullness along the designated area 'A' and little fullness above this area where it is needed.





(1) Front scye and crown (2) Back scye and crown (3) Back scye and crown

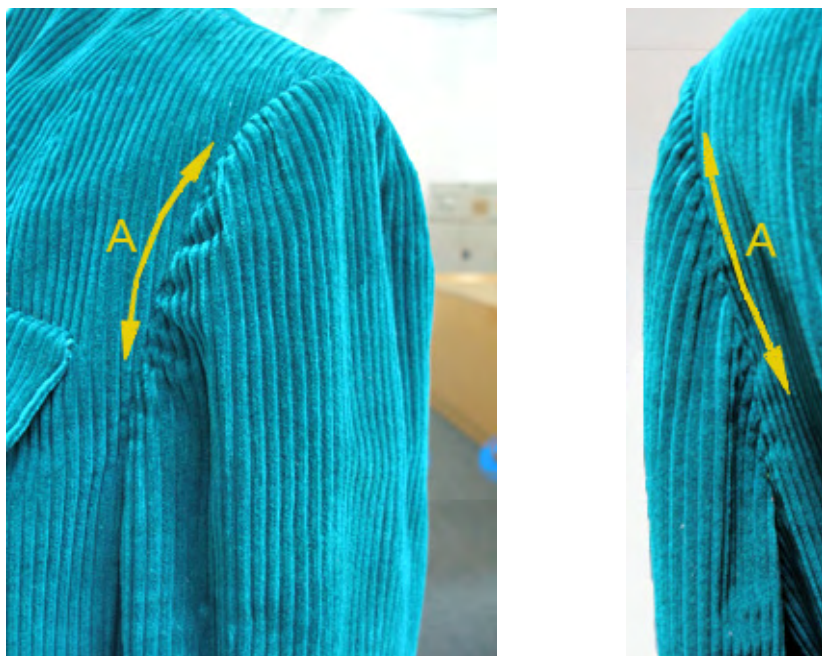
Figure 3.8. Excessive sleeve crown and scye fabric fullness

This is due to a wrong distribution of fullness, indicating that this may be a machining fault. In other words, there is not enough control of the sewing operation. If more placement notches were used, on both the scye and sleeve, the fullness would be better placed. The design system advocated in this project has ten placement notches (including the shoulder seam) instead of the usual two (plus the shoulder seam), delivering greater control of all of the fullness around the sleeve.

In the same figure, the left and right back sleeves have different amounts of fullness (denoted by the two arrows in Figure 3.8 '2' at position 'A' and the single arrow in Figure 3.8 '3' at position 'A'). To give shape in the shoulder blade area, the back scye is, on occasion, eased onto a tape along the back scye. At times, this can be overdone – easing in too much fabric - causing a fullness affect. This fault can be readily seen at positions 'B' in Figures 3.8 '2' and '3'. This is another indication of what can happen when there is not enough control; of the scye, in this case.



A second jacket sleeve, made from a corduroy fabric, is shown in Figure 3.9 '1' and '2'. The same over abundance of fabric is apparent as seen in the former sleeve – except that the amounts of fullness are taken to the extreme; the fullness has been transformed into gathers (this is the same sleeve depicted in the excessive crown width shaping section). All of the sleeves have hollow areas (described by the darker vertical sections). In addition to too much fullness, the hollows under the shoulder represent a shortage of length in the crown this is also seen in the next section dealing with depth of crown.



(1) Front scye and crown

(2) Back scye and crown

Figure 3.9. Excessive sleeve crown fabric fullness

### ***Fabric fullness measuring***

The topic of fabric fullness amounts and their distribution around the sleeve, introduces the question of fullness measuring. Fullness is calculated as the sleeve length minus scye length, giving the total fullness in a sleeve. This however does not answer the question of how practitioners actually measure and check the amounts of fullness.



In his 1880 and 1883 book editions (Shep, 2002, p. 147), Heckler instructs that in order to draft the sleeve there must first be an armhole measurement; this is ascertained by measuring around the scye seam line - not on the seam edge. Thornton (1894) and Cutler (1950) use the same method adding that deducting the scye measurement from the sleeve crown measurement gives the total fullness amount.

In order to draft the women's sleeve, Morris (1947, p. 20 and pp. 56-58) measures round the scye, although he does not indicate whether this should be on the seam line or not, since there are seam allowances added around the scye, shoulder and side seams. Even so, Morris (1947, p. 57) stipulates that '*...measurement of the actual scye circumference is the only practical method of assessing sleeve width in direct association to the needs of the scye*'

When constructing the one-piece sleeve pattern, Richards (1930, pp. 53-54) measures the armhole from the under arm points around to the front and back shoulders. Aldrich (1985) measures the front pitch to shoulder line and shoulder to back pitch around the curved line of the scye. Other measurements are measured along straight lines between two points (as a chord) on the concave scye shape. Aldrich (2002) measures the scye for a bespoke jacket around the curvature of the seam line.

in contrast, Bray's (1985) manner of checking (and measuring) the fullness is by rotating the sleeve seam edge around the seam edge of the scye – there are no seam allowances on these patterns (Figure 3.10). Cooklin's (1994, p. 17) preferred method of checking the sleeve fullness is also by 'walking' the sleeve around the scye circumference - edge to edge.



Figure 3.10. Sleeve to scye measuring

Source: Adapted from Bray (1985)

Tuit's (1974) drafting instructions explain how to obtain balance-points on the armhole, which are also produced by moving and measuring the sleeve head around the armhole, whilst Joseph-Armstrong's (1987) method for measuring the sleeve into the scye is also on the seam edges (pp.76-79).

### ***Imprecise fabric fullness measuring***

Fabric fullness is a considerable problem since the potential for the fabric to form fullness varies according to the characteristics/properties of the material. It is therefore essential that each sleeve be checked to assure that fabric fullness is within those limits, otherwise unsightly puckering of the seam will result. For example, A ½" (12.7mm) amount of fullness is allowed in the front and zero in the back of Richards's (1930, pp. 53-54) sleeve. However, because the measurements are applied in a straight line then curved to form the crown; the amounts of fullness may not be entirely accurate.



It is interesting to find that one hundred years after Hecklinger, ninety years after Thornton (1894) and over thirty years after Cutler (1950), measuring on the seam edge of the scye, not the sewing seam line (Figure 3.11 '1') and the seam edge of the pattern (Figure 3.11 '2') is still being advocated by respected people such as Cabrera (Cabrera & Flaherty Myers, 1984, p. 159). When making made-to-measure garments, however, experience would help considerably in assessing fullness measurement allocations.

(1) Scye measuring

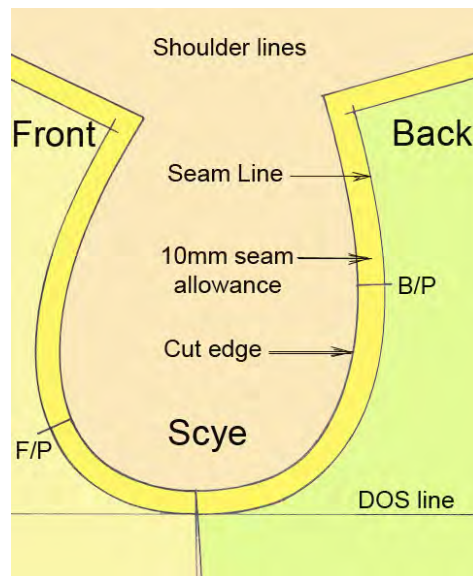
(2) Top sleeve and under sleeve measuring

Figure 3.11. Measuring scye and sleeve pattern

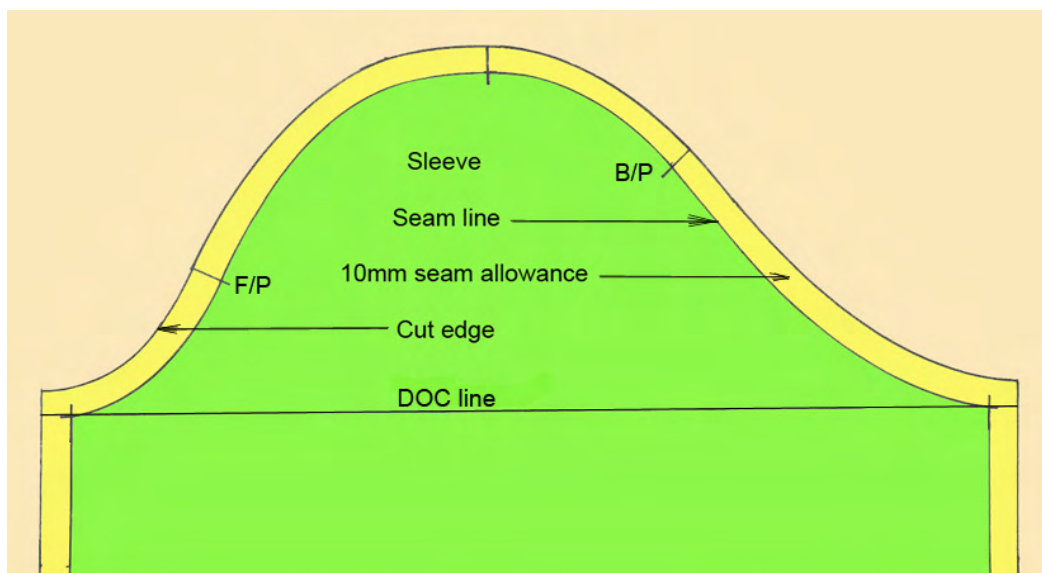
Source: Cabrera and Flaherty Myers (1984)

There is a distinct difference in fullness length when measuring on the seam lines (Figure 3.12 '1') of the scye and sleeve (Figure 3.12 '2') - one seam allowance, 10mm, from the cut edge, and when actually measuring along the cut edge itself. This is because of the concave nature of the scye and the convex shaping of the sleeve. Measuring along the concave cut edge of the armhole gives a shorter length than the actual seam line measurement (10mm inside the cut edge).





(1) Scye measuring



(2) Sleeve measuring

Figure 3.12. Scye and sleeve measuring

The opposite, a longer measurement, is achieved when measuring along the outer, convex edge of the sleeve crown. The result is an 'apparent', or false fullness measurement compared to measuring on the seam line; fullness has to be applied to the seam line, not to the cut edge. During manufacture the scye seam line and the



sleeve seam line are connected, held and controlled by the formation of the stitch; it is therefore, more appropriate that these two lines should be where the pattern fullness is measured, not on the seam allowance edge.

### ***Depth of crown***

The area above the depth of crown line (DOC) is the sleeve crown or sleeve head. The edge of this area includes the fullness and fitting properties which are manipulated to give the sleeve its style and arm/sleeve elevation potential. The crown may contribute to faults in the sleeve if it is too narrow or wide, too shallow or deep, or it may not produce enough arm movement, all depending on the sleeve style.

The depth of crown line indicates the lowest depth of the sleeve crown, which sews to the lowest part of the scye (see Figure 3.12.). The height of the crown and scye may, or may not be the same measurement. It is represented by a right-angled line (DOC line) projected from the outside of the sleeve (an alterable distance) to the bottom of the scye – the under arm point. Shoben and Ward (2000) describe an interesting variable method for measuring the crown height (Figure 3.13).

Figure 3.13. Sleeve crown heights

Source: Adapted from Shoben and Ward (2000)



The depth of crown also influences the amount of ease – tight or loose-fitting properties round an arm (refer to 'A' – tight, comparatively; to 'D' which is loose-fitting in Figure 3.13). A shallow depth of crown is compensated with a wider sleeve, this results in a loose fit around the arm. In contrast to the low depth of crown, a high depth of crown results in a narrow sleeve and a tighter fit around the arm, this has to be counterbalanced with an additional amount of fabric fullness around the sleeve crown, thus expanding the sleeve width and height.

The DOC, theoretically, dictates the amount that the arm can be raised in a lateral direction without restriction. The theory of arm 'lift', related to the depth of crown, is described as: *'The shorter the sleeve crown height is, in relationship to the armhole depth, the more the sleeve will tilt upwards.'* (Shoben & Ward, 2000, p. 21)

The two extremes of sleeve types may be represented by the tailored, restrictive type of sleeve and the more manoeuvrable sleeve type such as the shirt sleeve. The sleeve, 'A', in Figure 3.13 could represent a tailored sleeve with its high crown height (DOC) whilst the more elevated sleeve types are seen, progressively in 'A' - 'D'. The problem of how much crown height should be allowed for a sleeve's intended purpose arises with all sleeve designs.

### ***Deficient depth of crown***

Poole (1936, pp. 79-80) hypothesises on why crown height measurements are difficult to assess accurately. This is because of the bending of the scye (from the two-dimensional) to form the three-dimensional armhole and the bending of the sleeve over the deltoid muscle.



There is no method that logically explains how to calculate the crown heights for sleeve styles that extend above the shoulder end point such as tailored, puffed or Leg-of-mutton. As Bray explains, '*It is not always easy to establish the best depth of crown for average use or even for a particular figure*' (1997, p. 45)

Richards (1930, p. 53) considers that because of the wide variations of breadth and depth of armholes and shoulder lengths, there is no possibility of devising a rule or formula for the DOC in all circumstances, citing experience as the decider (this assertion is addressed in chapter 6). Nonetheless, Cooklin (1994, p. 28) provides a definite measurement, asserting that (in his sleeve pattern) the coat sleeve has a crown height of 16cm; he does not, however, offer any explanation as to why it is this particular measurement that is required.

For a sleeve to hang and have suitable balance, it must have the correct length of crown height at the shoulder and at the two pitch points. Figure 3.14 '1' (side view) shows the deficiency of length in the direction of the arrows and the excess material at positions 'A' and 'B'. The back sleeve (Figure 3.14 '2') illustrates an absence of sufficient length in the vertical direction and a ridge of excess material along the back scye seam line. When the seam is unpicked, the sleeve moves away and down from the scye seam, exposing a shortage of material (seen as 'A', in Figure 3.14 '3').

The solution lies in the pattern manipulation method shown in Figure 3.14 '4'. The whole sleeve is positioned further down on the fabric sleeve by the amount of 'A' - 'B', the deficient crown height and marked around from points 'C' - 'B' - 'D', then reshaped from 'C' - 'A' - 'D' (the ochre coloured areas at the crown are cut off). As the sleeve is now shorter by the distance 'A' - 'B' the length has to be regained at the hem, by reducing the turn-up allowance; as from 'E' - 'F' to 'G' - 'H'



(1) Diagonal folds (2) Back sleeve folds (3) Deficiency A (4) Required alteration

Figure 3.14. Deficiency of sleeve crown height

Source: Adapted from Sytner (1955)

Figure 3.15 (Pepin, 1942, p. 95) illustrates how a blouse sleeve should look in drawing '1'; how it looks with a crown deficiency, in drawing '2'; and, as a contrast, the result of excessive crown height, in drawing '3'. In each example, the depth of crown line (DOC) is the bottom dashed-line on the arm.

(1) Correct crown height (2) Short crown height (3) Long crown height

Figure 3.15. Sleeve crown height

Source: Adapted from Pepin (1942)



It has been shown, in Figure 3.12 and 3.13, that the depth of crown line (DOC) is identified by a straight line. However, this may not apply to all sleeves. A sleeve pattern which has been narrowed at the hem might appear to have a deeper depth of crown at the sleeve's centre, than the straight sleeve when the two under arm points are connected with a straight line. However, this is only an illusion, as the original straight DOC line (10 in Figure 3.16) becomes a curved line between the two under arm points for a tapered sleeve style (10A in Figure 3.16), therefore retaining the original DOC; the hem also curves maintaining over-all length.

Figure 3.16. DOC (height illusion)

Source: Adapted from Kunick (1967)

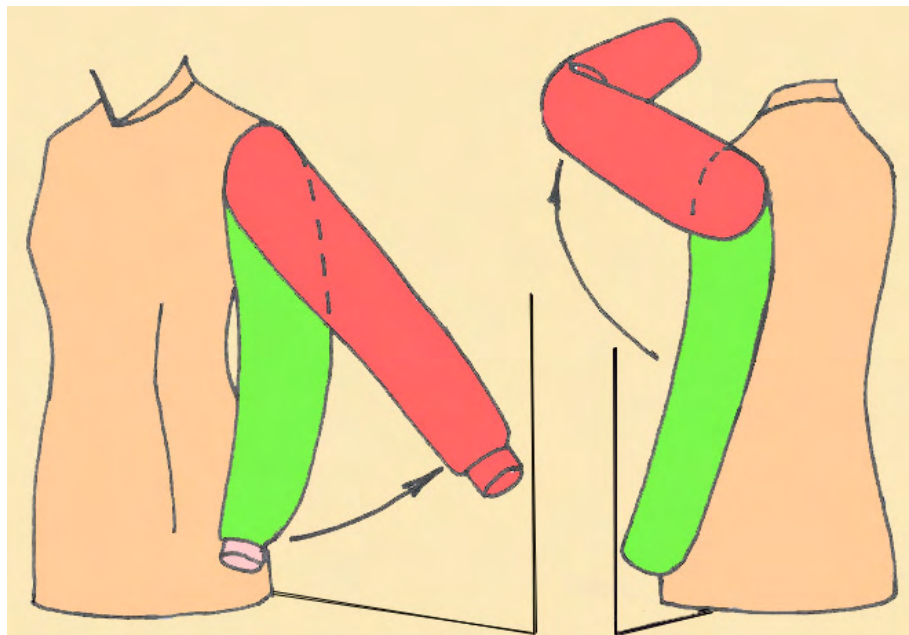
The reverse situation would be seen when the sleeve hem is flared, instead of the DOC line arcing upwards as in the tapered sleeve, it would curve down from the horizontal and across to the vertical centre line, again, maintaining the original DOC



height. (A straight line connecting the under arm points gives an appearance of a shorter depth of crown height).

### ***Arm elevation/lift and articulation***

There are two major directions in which the arm can pivot; lateral arcing (Figure 3.17 '1' and forwards arcing (Figure 3.17 '2'; both require alterations, to a greater or lesser extent, to achieve the correct arm elevation angle. Lateral elevation may involve the entire top and under sleeve crown and under arm sections, whilst an upwards and forwards motion may involve only the under sleeve section.



(1) Lateral arcing

(2) Lateral/forward arcing

Figure 3.17. Arm elevations

Poole (1936, pp. 257-263) describes the rotary hinge action of the sleeve, the forward movement of the arm from its natural vertical alignment to a horizontal aspect. *'...movement, as far as the arms are concerned, is forwards and upwards, and rarely*



*backwards to any degree; so very little allowance is necessary for this backward movement'* (Sytner, 1955)

Arm and sleeve elevation or lift, is the angle at which the arm can be raised before it is restricted by the depth of crown of the sleeve and the garment's body sections. There is a direct association between the amount of arm elevation, the depth of crown and the under arm length of a sleeve; that is, from the depth of crown line to the cuff. This gives a particular scye and sleeve configuration, and establishes the compatibility of the elements for a given affect.

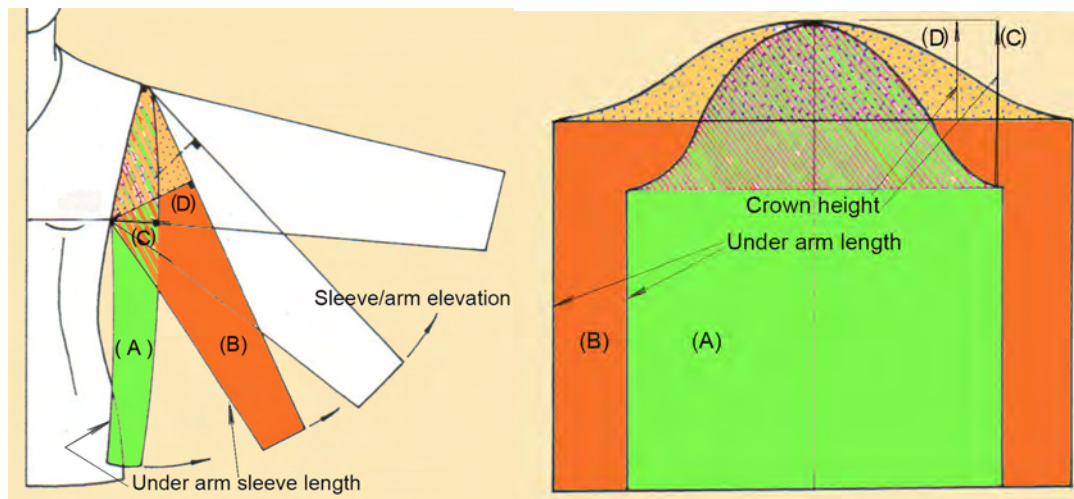
The amount of arm movement (forward and upward or lateral) requires a suitable allowance in the pattern to facilitate mobility. This allowance is usually accomplished by a reduction in the depth of crown, or to be more precise, a lengthening of the under arm seam section which gives the sleeve a more shallow crown height and a wider, flatter appearance. Poole (1936, p. 53) believes that raising the under section of the sleeve (raising the depth of crown line), promotes movement of the arm

The restrictive arm movement and appearance found in a tailored jacket would be inappropriate for manual labour or sporting activities. When appearance is less important (informal sleeve types) than arm movement, it is acceptable to give more arm reach and lifting capabilities to the sleeve pattern by the introduction of increased length to the under arm seam lines. This enables the arm to be raised by a significant amount compared to the original sleeve pattern which may have had restrictive movement capabilities.

Between the vertical and the highest arm elevation there are is a series of arm elevation angles available. Each type of sleeve has its own amount of built-in



elevation/lift, this includes the restricted tailored type of sleeve (which has its elevation allowances on the under sleeve only) to the shirt style with all-round elevation allowances. The tailored sleeve type 'A' depicted in Figure 3.18 '1' and '2', has limited arm elevation, a deep crown height 'C' and a short under arm length. The shirt sleeve type 'B' also seen in Figure 3.18 '1' and '2', has a proportionately greater range of arm elevation, a more shallow crown height 'D' and a longer under arm length than sleeve type 'A'. Kunick (1967, p. 109) raises the depth of crown by  $\frac{1}{2}$ " (12.7mm) to impart an extra amount of fabric to the under sleeve to enable the arm to be elevated slightly.



(1) Arm and sleeve elevation

(2) Crown height and under arm length

Figure 3.18. Arm elevation, crown height and under arm length

### ***Inadequate arm elevation/lift and articulation***

In a number of published materials (Aldrich, Bray, Kunick, Shoben & Ward; et cetera) there is no indication as to the reasons why the underarm points of the sleeve are raised by the prescribed amounts. The subsequent reduction in the crown height required for arm elevation is not fully described and the amount of arm elevation is not defined; why is this? As Kunick (1967) says: *'If a point be fixed, or part located for a*



*sound reason, that reason can and should be given....'* (p. 81) (Cited from 'The practise of garment patternmaking'; W. H. Hume)

As indicated previously, the tailored sleeve has arm elevation allowances restricted to the under sleeve; if the allowance is inadequate an alteration is required to remedy the fault. The problem may not be apparent, at first. When the arm is in a downward direction the sleeve may appear to be an ideal fit. However, when the arm is raised or brought forward, the sleeve feels tight across the bicep inhibiting further arm movement.

One sleeve remedy, if the sleeve fabric has been previously cut out and has inlays (there may be body section faults), is to lower position 'A' (Figure 3.19). Point 'B' is also lowered whilst also moving to the right to maintain under arm length from 'A' to 'B'. To re-establish the two outer vertical seams, the hem is also lowered between 'C' and 'D'.

Figure 3.19. Restricted sleeve/arm elevation

Source: Adapted from Whife (editor, 1950).



The affect is to gain a longer under arm length in the under sleeve (between 'U/A', the under arm, and the hem at 'C' and 'D'). The arm and sleeve are now capable of further movement without restriction. When it is the sleeve pattern that has to be altered, the 'U/A' (under arm) area is raised with point 'B' moving to the right by an appropriate amount', the hem is unaffected.

### 3.4 Summary

This chapter specified the scye and sleeve sections and elements contained within in-set sleeve drafting methods. Whilst a considerable number of authors agree that the scye is the base around which the sleeve should be constructed, the scye and the sleeve are separately represented as two-dimensional flattened images. In their present configuration they may not be in a true balanced harmony, related only superficially it seems, to the three-dimensional sleeve.

Richards, 1930, p. 53) recognised that '*sleeves probably represent one of the Cutter's most difficult problems, since they cover a part of the body which is in an almost constant state of varied movement*'. Because of this, and since there is potential for defects to materialise at any stage of the pattern making and sewing process, historically and currently it was (and is) necessary for the emerging pattern maker to obtain a technical knowledge of sleeve drafting and modelling techniques.

The reason for this is that, primarily, in-set sleeve pattern making methods are too vague in explaining the correct combinations of elements and functions that create scye and sleeve style variations. Compounding these difficulties, confirmation of the success of the pattern, design and fabric relationship is only achieved after the three-dimensional trials stage – the end of the entire design, pattern and sleeve making process.



The depth of crown and its contribution to arm/sleeve elevation was described, as was fabric fullness, its various amounts, distribution around the crown and how fullness is measured. It was determined that the amounts of fabric fullness and its distribution for a range of sleeve styles are not universally held measurements, even though some drafts may display similar total lengths or proportions. Determining which might be the correct amount of fullness, or its correct distribution around the crown of any given sleeve design, is a complicated, subjective and on-going impediment to better sleeves; as is the method of measuring the actual amount of fullness (see chapter 7C).

To illustrate the point that not all drafting methods use reliable or consistent techniques, a small selection of sleeve defects has been presented and examined. Defects were discussed in the areas of scye, crown shaping, excessive or insufficient crown fullness, inconsistent fullness measuring methods, depth of crown and sleeve elevation.

### **3.5 Conclusions**

The profusion of current pattern making methods supports a 'raft' of inherent and associated scye and sleeve element defects. Each defect casts doubts as to the functional value of pattern making methods in general. How can so many pattern making variations deliver good results when they are built around imprecise subjective methods? Pattern making methods demonstrate that none is capable of producing predictable sleeve element results without resorting to fabric trials. Essentially, all sleeves are affected by the same issues and beset by almost the same problems previously described. There are too many questionable methods and results to have faith in using current pattern construction methods

All of the characteristics that contribute to a particular sleeve design can be defined by a certain combination of elements. Each element has a range of possibilities, such as



length, width or amount and as such they are deemed to be transitional – flowing from one extreme through to another; the permutations of elements being almost endless. It is not surprising that mistakes in practical application are made with unexpected, unattractive results and expensive time and fabric remakes.

To achieve the required three-dimensional sleeve results, scye and sleeve elements must be factored into the initial sleeve design silhouette. Unless they are constantly controlled, these individual elements are open to interpretation with a tendency to exhibit almost any result, whether expected, wanted, or not – as seen in the all too obvious sleeve defects.

Chapters 2 and 3 highlighted the divergent pattern making methods available to contemporary practitioners through published materials (not personal, often secretive, and therefore unknown, methods); it is evident that they do not fully recognise or value the functions of the fundamental elements that constitute the scye and sleeve. These chapters also emphasise, the reason for a comprehensive pattern making knowledge.

It is believed by Lange and Pritchard (2009, p. 50) that '*pattern making is an art, not a science*'. However, I believe that it is still treated as an art because the science of pattern making has not evolved at the same rate as has other disciplines. If sleeve drafting methods are created to produce acceptable end results, why is there a need to publish methods to remedy defects?

To contrast manual drafting and pattern making with computerised versions, chapter 4 discusses computer aided design (CAD); current research into sleeve pattern making is also examined.



## **Chapter 4 —**

# **Computer Aided Design and Current Research**

### **4.1 Introduction**

The previous two chapters discussed the almost uninterrupted flow of manual pattern making from the 19<sup>th</sup> century through to the current period. Throughout, the discussion exposed their predisposition to towards defective results if their elements were not controlled - a predilection towards trial-and-error processes. It is important to good sleeve design and accompanying pattern making that the greatest amount of the design and pattern making procedures are regulated if iterative processes are to be reduced to a minimum.

This chapter examines how manual pattern making has progressed into Computer Aided pattern Design (CAD), and body measuring systems. In addition, research into new sleeve pattern development methods, and surface modelling and flattening techniques are discussed.



## 4.2 Computer Aided Design (CAD)

Aldrich explains that In some manufacturing companies, the designer's function may be primarily to create garment styles, as opposed to making patterns for those styles (2008, p. 194). This is, by necessity, a division of labour between the artistic designer and the practical pattern maker. The following text relates only to Computer Aided pattern Design (CAD) pattern making – not artistic design, since the two roles function as separate entities. The problem of unifying the two functions will be discussed in chapters 6 - 8.

The first CAD systems for the clothing and textile industries were set up by the Hughes Apparel Systems in 1968 (Hardaker & Fozzard, 1995). *'In the early days CAD was really a replacement for a traditional drafting board'* (Xu & Hinduja, 2009). Pattern making is amongst many computerised systems embraced by an increasing number of apparel manufacturers (Ashdown, S. & Dunne, L., 2006; Apeagyei & Otieno, 2007). Replacing manual pattern making methods with CAD, Fashion CAD or FCAD, software can have a beneficial advantage in the speed of pattern production because of their ability to store and retrieve considerable amounts of data (K. Anderson, 2005). A further advantage is that CAD software can be adapted to the particular production preferences of the manufacturer.

Developed by international companies such as Gerber, Lectra, Padsystem and Investronica et cetera, CAD work stations with pre-programmed software, give a greater degree of operations flexibility than manual methods. Fang and Ding (2007) relate that traditionally, garment industry design procedures comprise the production of a style drawing and specification of the style, from which the pattern maker decides how to translate it into two-dimensional card patterns.



CAD systems are faster than manual methods of pattern construction using pencil and paper. Compared to manual means, explains Taylor (1997, p. xxvii) computers promote the rapid generation and testing of a greater number of design and/or pattern making ideas prior to manufacture and marketing. They also have the potential to be much more accurate than any available manual techniques.

### ***Pattern Design Systems***

Because of their ability to aid in the control of quality and maintain sizing systems, Aldrich (2008, p. 198) asserts that the main method of producing patterns using Pattern Design Systems (PDS), is to alter existing patterns rather than by other available means such as modelling or direct measurements. Patterns may be drafted using traditional manual pattern drafting methods and 'on-screen' adaptations or on a computer drafting table (Figure 4.1), a 'bridge', or link, between the old and the new.

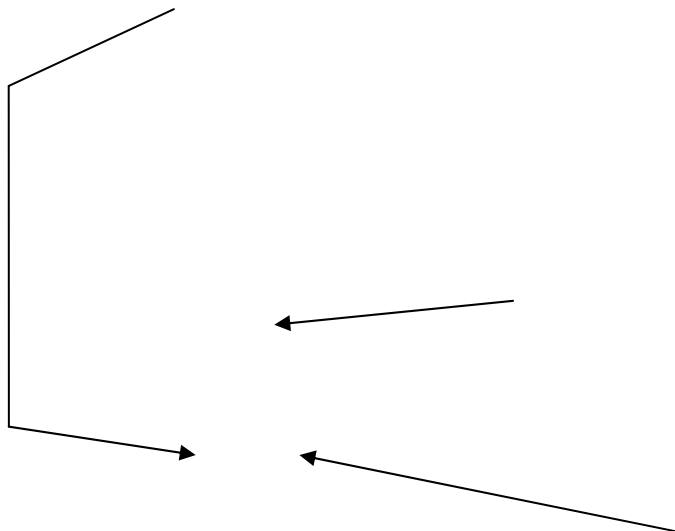


Figure 4.1. CAD: Silhouette Pattern design

Source: Gerbertechnology (Retrieved 29<sup>th</sup> October 2009)

<http://www.gerbertechnology.com>



Patterns may also be placed into the computer by locating their perimeter point positions on the digitising table. By moving a cursor ('mouse') around the pattern, a series of positions gradually builds an image of the pattern piece. PDS systems regard a pattern as a series of unique connected coordinates (positive and negative 'X' and 'Y' directions) or cardinal points - each with separate identification. There may also be other coordinates internal to the pattern.

Another method of creating patterns is by linking a master size pattern to a set of grading rules (a library of alteration directions) to create other sizes within the style. Grading is seen as the most practical method of altering blocks for producing a range of sized patterns. It is relatively easy to apply and most pattern makers are familiar with the concepts involved. Even so, Schofield (Ashdown, 2007); Bye, LaBat, McKinney and Kim (2008); and my personal experience, found that current grading methods, as practised by industry, provide only a 'near' fit throughout a size range.

Since most (Fashion) CAD systems are based on two-dimensions, they do not facilitate three-dimensional visuals (Yang & Zhang, 2007). They still require the operator/pattern maker to be proficient in the skills, knowledge and experience of pattern making as well as accomplished enough to interpret two-dimensional design sketches and resolve them into two-dimensional patterns. Because of their reliance on manual pattern making skills, computerised pattern making is, fundamentally, no different to manual methods

### **4.3 Body Scanning**

The manual tape-measure measuring systems, described in chapter 2, may be unnecessary in the near future as body scanning technology is developed further. Body scanners are non-tactile instruments that produce images of the human body; they



measure the body to generate measurement data (Simmons & Istook, 2003). A subject, or client, steps into a booth to be measured from head to foot by horizontal 'scanning' light rays (white light or lasers) that surround the body, and cameras to capture and produce a computer image.

The collected data are prioritised and selected to then link to pre-made two-dimensional patterns and styles which are automatically altered to suit the client's particular size and shape characteristics; the results are customised garments. Even so, Heisey, Brown and Johnson are of the opinion that the use of three-dimensional data will not automatically increase the accuracy of pattern drafting (1988). The crux of the problem is that the pre-made, computer-inserted patterns are all created by the same manual methods described in chapters 2 and 3; therefore the inadequacies of manual pattern making are perpetuated in the computerised translation.

A further problem is identified; Simmons and Istook (2003) relate that scanning system methods do not allow for current, standard, manual arm measuring techniques. The major measurement, in regards to the sleeve, seems to be only the arm length. This is identified as the distance from the scye, at the shoulder line intersection, down to the wrist. Although other measurements are taken, including across the chest and back from scye to scye, there is no defined scye shape, its size and angle of inclination. In addition, according to Bye, LaBat and DeLong (2006), there is no consistency between body scan system manufacturers on the subject of where measurements should be taken; no landmarks or 'datum points'. Ashdown and Dunne (2006) report that these automated landmarks were problematical, the manual inspection and adjustments of landmarks would be advantageous to improve results.



Using a multiline triangulation technique, Xu, Huang, Yu and Chen (2002) extract surface data from a 3D model. Figure 4.2 shows some of the processes involved. Human Solutions (2010) also provides 3D body scanning. The Tailored Clothing Technology Corporation (TC)<sup>2</sup> maintains that their system can produce a 'true to scale' 3D body model. Simmons and Istook (2003) compared scanning systems and found that some companies were reluctant to divulge too much information, thus continuing the secretive attitudes of their pattern making forebears.

Figure 4.2. CAD: 3D body scanning system

Source: Adapted from Xu, Huang, Yu and Chen. (2002) (Retrieved 30<sup>th</sup> October 2009)

It is reported by Daanen and Hong (2006) that in most cases utilising three-dimensional (3D) full body scan data, only one-dimensional measurements such as the chest or waist girths are used, whilst the remaining 3D data are ignored. The Ashdown and Dunne (2006) study explains that for the information from body scan data to contribute to custom-fit pattern making, there must be a standard graded nest of patterns (range of sizes using the afore-mentioned manual or CAD/manual methods) from which the programme can automatically select the most appropriate size for altering.

It may then be deduced from that the body scanned measurements of a three-dimensional (3D) body are linked to the nearest pattern size (the only measurement mentioned in regards to sleeves, was the sleeve length). The pattern is then altered to



form a new configured shape commensurate with the body. In other words, the computer can only alter existing patterns. There is no mention of the scye, the sleeve silhouette and scye/sleeve balance. Fabric and its selection, in respect to the sleeve crown fullness, although acknowledging fabric properties, may require pattern alterations, were also not disclosed.

The overall conclusions of Ashdown and Dunne (2006) were that although this type of technology would be useful to industry with garments of a looser fit, garments of more complex fitting requirements would be more difficult to address and custom-fitted jackets, with quality intensive in-set sleeves, were not investigated.

In the approach involving the production of a man's jacket, explained by Cugini and Rizzi (2002), there is reference to the programming of two-dimensional patterns via a three-dimensional (3D) CAD system (why use pre-existing patterns with, in all probability, questionable qualities if it is a truly 3D system?). How sleeves are produced within the 3D system is not discussed. Heisey, Brown and Johnson (1988) contend that because computers do not replicate the physical modelling processes, no computer system, either two or three-dimensional can consistently and accurately create two-dimensional patterns. Ashdown (editor, 2007) reports that at this point in the evolution of the technology, traditional pattern development is a necessary part of the CAD process. However, technical achievements continue to show an on-going progression to more effective CAD systems.



#### 4.4 Sleeve patterns: New developments

The garment and restyling system based on mathematical formulas, developed by Fang and Liao (2005a), permits pattern design in three-dimensions via the movement of indicated control vertices on the garment geometric model (mannequin). The design concept can then be previewed and modified in three-dimensions. A convex-hull method (see appendix C) creates the garment section around the bust area and the sleeve girth is generated by the 'armhole girth' which is represented by isometric (Figure 4.3 '1') and plan views (Figure 4.3 '2').

(1) Isometric view

(2) Plan view

Figure 4.3. Sleeve girth generation

Source: Adapted from Fang and Liao (2005a)

In their second paper, Fang and Liao (2005b) continued demonstrating the ability to generate a three-dimensional garment by means of a garment creation and restyling software programme. For the sleeve, the crown (cap) height is given as 5.5cm in Fang and Liao (2005a & b). This seems to be an error, judging by their figures in Part I and in Part II; it should perhaps be a 15.5cm curved length from Cen0 to Cen1 to Cen2, as seen in Fang and Liao (2005a) and Figure 4.4 '1'. Sleeve girth and sleeve orientation



are generated from a front elevation diagram (Figure 4.4 '1'). Figure 4.4 '2' depicts the sleeve pattern with a separate cuff; the length of the crown curve (sleeve cap) is equivalent to the armhole girth.

(1) Front elevation

(2) Sleeve and cuff patterns

Figure 4.4. Sleeve projection and pattern

Source: Adapted from Fang and Liao ('1': 2005a)

('2': 2005a & b)

The results, using the Fang and Liao system (2005b), are of a half-length sleeve (Figure 4.5 '1') with its flat pattern in Figure 4.5 '3'. The dress with the half-length tapered sleeve was modified to create the lantern sleeve Figure 4.5 '2'). However, a seam line appears to be missing from the sleeve. Because of their opposing 'funnel' shapes they represent a non-developable surface (see chapter 6); as such, there needs to be a separating seam line around the widest circumference of the sleeve.



There is no pattern diagram to show how this is achieved; however, I have introduced an approximate pattern depicted in Figure 4.5 '4'.

(1) Tapered sleeve

(2) Lantern sleeve

(3) Tapered sleeve pattern

(4) Lantern sleeve pattern

Figure 4.5. Dress with half length sleeve and Lantern sleeve

Source: Adapted from Fang and Liao (2005b)

A more detailed account (than those of Fang & Liao) of pattern making was conducted by Cho and Miyoshi (2003 and 2005). They provide a rigorous description of the body, scye, arm, sleeve and their relationships. Photographed shadow images, as orthographic projections, of 92 females (age 20) were taken. Measurements of the participants; trunk and arms were also taken. Cho and Miyoshi found a number of



interesting facts. The outer edge of the arm, viewed from the front, does not form an exact vertical, inclining inwards towards the shoulder by an average of  $+3^{\circ}$  (Figure 4.6). This is also emphasised by Cabrera and Flaherty Myers (1984, p. 104), which has a lateral slant of  $7^{\circ}$  (Figure 4.7).

Figure 4.6. Arm/sleeve lateral incline to shoulder point (2003)

Source: Adapted from Cho and Miyoshi (2003)

Figure 4.7. Arm/sleeve lateral incline to shoulder point (1984)

Source: Cabrera and Flaherty Myers (1984)



The amount of arm inclination (Figure 4.8 '1', the distance from the arm's outside hem to the shoulder point and the arm circumference (Figure 4.28 '2' all have an influence on the curvature of the crown area of the sleeve and, therefore, the amount of fullness to be gathered into the scye. The arm inclination and the curvature of the crown into the scye also affect the crown height of the sleeve.

(1) Arm inclination

(2) Crown curvature

Figure 4.8. Arm to shoulder point

Source: Adapted from Cho and Miyoshi (2003)

In a subsequent paper of 2005, Cho and Miyoshi continued with the sleeve theme, using a draping method to obtain patterns. An equation was then developed from the relationship between the body and the pattern. They then give further facts regarding the angle of the shoulder and the back-to-front angle of the arm and scye (Figure 4.9). It can be appreciated that if sleeves are to be constructed from the scye (Yang & Zhang (2007); then the scye could be the base from which a sleeve could be constructed, if it were in three-dimensions. (The scye is analysed in chapter 6A)



Figure 4.9. Back-to-front inclined angle of shoulder and arm

Source: Adapted from Cho and Miyoshi (2005)

#### **4.5 New developments: 3D to 2D**

In addition to the previously described research, investigations also continue into the development of computer software for drawing 'on screen'. Yoram Burg of OptiTex, advises that their objective is to develop software that will grant the ability to create two-dimensional patterns by drawing directly onto an image of a three-dimensional figure (Kim Anderson, 2005).

PAD systems and Lectra are also researching the same 3D to 2D pattern making, Lectra by means of a flattening process (Dr. Anderson 2005). The concepts expounded by Heisey, Brown and Johnson (1988) and McCartney et al. (2000a), and Hsu and Liu (2000) are of a system being capable of designing, drafting and pattern making simultaneously. This is the anticipated result, subsequent to this research. Aono, Breen and Wozny (1994) suggest that there is a great need to create design technologies to assist in the extraction of 2D patterns for determining 3D outlines.



## 4.6 Surfaces

The previous chapter section discussed research into sleeve pattern making and the extrapolation of patterns from the design process. This section explores research into three-dimensional surfaces and the production of two-dimensional patterns. However, the research is undertaken, predominantly, in the torso region, although they might have potential for sleeve pattern making.

Heisey, Brown and Johnson (1988) recognise two individual phases in the process of drafting a pattern: modelling and flattening. Methods for modelling two-dimensional materials to three-dimensional surfaces are described. How those three-dimensional surface fabrics are placed onto a two-dimensional surface (flattened), with the least amount of distortion, is discussed.

### ***Surface modelling***

Breen (1996) recounts that textile modelling can be traced back to research carried out by F. T. Pierce in the 1930's whilst it is reported by Ramgulam (2001) that the first researchers to suggest a method for fitting woven fabrics on complex (non/developable) surfaces were Mack and Taylor (1956).

Modelling the fabric is the creation of the three-dimensional form, or garment, by placing fabric around the mannequin to obtain a fit between the two surfaces. Computer modelling can be classified into three categories according to the main method or theory used (Ng and Grimsdale 1996). The three categories are:

- **Geometric modelling:** This process models material (paper, plastic, sheet metal and fabrics) without considering its mechanical or physical properties.
- **Physical modelling:** The physical modelling method does consider the properties of the materials.



- **Hybrid modelling:** Techniques that combine aspects of the other two modelling methods to implement more complex simulation models (Ji, Li & Qiu 2006).

### ***Surface flattening***

It is reported by McCartney, Hinds, Seow and Gong (2000a) that although attempts have been made to create software programmes for two-dimensional garment patterns, these have been impeded because of a need for a previously existing three-dimensional specification from which to obtain a two-dimensional pattern.

It was proposed by McCartney, Hinds, Seow and Gong (2000a) that to make flattening processes easier, garment specification should be separated into fit and drape areas; Kim and Park (2007) propose the same division with fit and fashion zones. Flattening pattern pieces differs for both fitted and draped areas explain McCartney, Hinds, Seow and Gong (2000a).

Three-dimensional (3D) systems evolve from three-dimensional data (surface modelling) to two-dimensions using a method known as surface flattening. There are two typical methods for flattening surfaces – geometric and physical (Yang & Zhang, 2007, p. 336).

Surface flattening, for complex surfaces, is used in a number of manufacturing industries such as shipbuilding, aeroplane manufacture, shoes construction; the human body is considered to be a complex surface. Most garment computer system programmes are two-dimensional in nature; Fashion CAD does not usually allow for the surface flattening of fabrics. Even so, (Yang & Zhang, 2007, p. 337) relate that



although not considered practical, producing distorted patterns, a number of CAD manufacturers have adopted flattening technology.

Researchers in many disciplines have produced a number of methods to enable materials of various flexibilities, to fit and flatten non-developable surfaces onto the plane. These methods include:

- **Isometric tree:** The hull of a boat can be developed in sections by producing a spine and branches on the 3D surface (geometric flattening). (See appendix C).
- **Wire frame:** A more ambitious project was developed by Yang & Zhang (2007) to reproduce two-dimensional patterns for a women's blouse (using a geometric flattening method). It may be regarded as '*an extension into the third-dimension of the techniques used for 2D drafting.*' (Xu & Hinduja, 2009, p. 2). However, Aldrich (2008; p. 203) relates that the complex shape and fit of many garment types, principally in fashion, negates the implementation of the wire-frame modelling method for the creation of patterns. Even Yang and Zhang (p. 336), acknowledge that this work will not replace current industrial pattern making. Nonetheless, it is an advance into 3D technology. (See appendix D).
- **Facets:** A considerable amount of research has been presented using facets. Facets are small polygons, either quadrilateral or triangular in shape. Meshes of facets are placed together as singles pieces, in strip form, multi-strand or as radial-mesh varieties. Whichever system of facet placement is used, each facet formation requires an algorithm method to reduce the strain developed during the flattening process (a physical flattening method). (See appendix E).

Since there is always some measure of distortion with these methods and because of the implicit construction difficulties of producing garments, facet flattening algorithm systems are seen as being somewhat impracticable at present (Yang, Zhang & Shan,



2007). Another negative aspect of facet developments is that all of the above methods have an underlying structure (the torso) from which to apply their modelling and flattening methods. None of the methods deliberates on the problem of sleeves, possibly because there is no such structure (the arm, needing ease allowances to move freely, is not acceptable) around which to base a modelling method.

#### **4.7 Summary**

There are many Computer Aided Design systems available to clothing manufactures, these assist with the streamlining of production processes, design and pattern making. The emphasis on speed as a main objective of CAD manufacturers is corroborated by Anderson (TC 2), who relates that at Gerber, speed of execution is still the main research focus. The computerisation of manual methods adds very little to aid the development of sleeve pattern making.

Scanning technology is acknowledged as an improvement on the inaccurate use of the tape measure, as characterised in the three major measuring and drafting systems (proportional, direct measurement and sectional); even so, not all of the data is utilised. After some considerable time, it is recognised that the pattern making of sleeves by computerised means, is worthy of investigation. Research into sleeve pattern making is only now beginning to receive its due consideration. Even so, there are few researchers working within the subject of sleeve design and pattern making. However, although in its infancy, there is future potential for the development of 3D information into 2D patterns

#### **4.8 Conclusions**

This investigation into computerisation is primarily a means of illustrating the slender differences between the methods of manually producing sleeve patterns and their



'computerised' counterparts. The lack of accord seen in manual pattern making methods extends into state-of-the-art computer technology. Fashion CAD is performed by the same pattern making personnel using the same manual pattern making knowledge and techniques - except at a faster pace, using a 'mouse' rather than a pencil. However, persisting with these 'manual-computer' methods may not yield any better results than those obtained by the many practitioners that have been and are now involved in the discipline.

Although body scanning technology could be important to future sleeve pattern production, it is not, as yet, capable of producing in-set sleeve patterns, unless adapting existing sleeve shapes. The real contribution to scanning technology still rests in the future. In addition to precisely measuring the body, it will, perhaps, be capable of attaining flat patterns directly from the scanned data.

The Fang and Liao (2005) method of pattern computerisation is a worthy departure from the normal manual sleeve drafting methods. However, sufficient sleeve information, suggesting the roles of various elements relating to other sleeve styles, is not adequately conveyed. Functional elements, such as curved surfaces, fabric characteristics and other variables, are not disclosed. Since the Fang and Liao lantern sleeve is only a 3D depiction and the pattern conversion method is not explained, it is not clear how this sleeve style could be converted into two-dimensional patterns as it is devoid of seams and darts therefore it cannot be flattened.

Diversifying from the Fang and Liao method (2005), the Cho and Miyoshi (2003) research is a conspicuous investigation into the important, (and rarely – if ever specified) features of the scye and sleeve structure. The back-to-front orientation and angle of the (simulated) armhole, the curvature of the sleeve head and the arm's lateral



inclination are documented and worthy of inclusion in a new design and pattern making system.

Although research into drawing 'on screen', and surface modelling and flattening systems are diligently pursued, especially for the torso area, the methods may not be fully-formed, require a pre-formed two-dimensional pattern or need an underlying structure on which to perform. Even so, flattening systems, whether manual or computerised, are of a major interest to design system projects.

Even though the information from the CAD research is valuable, there is no apparent universal manual, or fashion computer aided design, process that will produce a range of in-set sleeve designs and their two-dimensional patterns.

The research into flattening systems suggests using drawing methods which are used to produce basic geometric structures, to create sleeve silhouettes. The basic difference between engineering drawing and garment drafting, for developing flat patterns for 3D objects (for this thesis), is that one produces more precise drawings for static structures such as cylinders and cones, whilst the other is a less exact, more artistic, personal craft drawing process for structures incorporating body and arm movement allowances. They are not, generally, cross-referenced.

In order to formulate the in-set sleeve design system, with pattern making facility, chapter 5 considers research methods and approaches. An iterative design process is developed to aid such a design system.



## **Chapter 5 —**

### **Research Design**

#### **5.1 Introduction**

The literature review of contemporary drafting and pattern making (chapter 2) has shown that there are clear anomalies in the methods used to produce two-dimensional sleeve patterns. Their use (initially at least) of trial and error techniques produce unpredictable defective fabricated outcomes. Chapter 4 discussed computer-aided in-set sleeve drafting and pattern making techniques, establishing that there is no 'state of the art' drafting method.

This chapter describes the design processes involved in the development of an in-set sleeve design system that predicts the three-dimensional – at the flat pattern stage. Although, by necessity, it is manual in nature, it is expected that the results will prove worthy for translation into a parametric fashion-computer-aided-design (FCAD), with an automatic pattern making component derived from the sleeve designs. It is also anticipated that the sleeve design process will be accessible to the artistic as well as the technically adept operator.



I am combining three roles in this study; creator, technician and potential end-user of this manual (and potential digital FCAD) research. My concepts, methods, analyses and evaluations, permeate, straddle and anticipate both the artistic and technical requirements of such a system. The research design methods are therefore considered with these interests in mind.

## **5.2 Development of hypotheses**

Currently, there are a considerable number of authors creating a large quantity of sleeve drafting techniques with a profusion of variations of those methods. These individualised technical drafting and pattern making methods are each devoted to a single example of a single sleeve style, size and shape, which are usually disconnected from artistic (style creative) design. Why are there so many method variations when even a small number of good examples should be sufficient?

After reflecting on the quantity of drafting methods and their related fabricated defects – and the need for remedies, it is considered that current drafting and pattern alteration techniques are deficient, largely. Current in-set sleeve drafting procedures may not be the most efficient methods for the production of patterns, either in terms of sleeve development knowledge or in the act of sleeve design itself. These considerations and the investigations of McCartney, Hinds, Seow and Gong (2000a) form the catalyst for this research - see chapter 1 and 4.

To preserve the skills of accumulated experience and craftsmanship and enhance productivity, Godbold describes (during his tenure with Marks and Spencer) how design was separated from pattern technology in order to concentrate on research and development; it is not stated specifically whether the focus was on design (probably) or pattern technology (White & Griffiths, 2000, p. 109). This is not an isolated case, there



are many such separations; possibly because drawing designs is different when compared to technical pattern making, thus requiring different skills and experiences. *'A designer makes things. Sometimes he makes the final product; more often, he makes a representation – a plan, programme, or image – of an artefact to be constructed by others'* (Schön, 1998, p. 78)

The two types of creation, style creation and pattern creation are currently separated in fashion design. However, if the creative designer, as opposed to the pattern maker, could design the required sleeve, describe the artefact and produce the pattern automatically, that person will have bridged the two creative areas. They will have avoided the communication breakdown inherent in the opposing interpretive mental images of these two practitioners – designer and technician; the two areas will be united.

Drafting and pattern making, using 'how-to-do' manuals as references, treat sleeve styles as single, standard examples; they therefore apply standard methods to create the pattern. However, if each designer could treat the sleeve style (individual cases) as a unique product in its own right (the designer's own distinct silhouette, for example), then each case cannot use current standard pattern drafting theories or techniques. When standard theories and techniques cannot be applied, the question arises; how does the practitioner bring prior knowledge to the formation of new theories and strategies? (Schön, 1998, pp. 129 & 132).

### ***Hypotheses***

The suggestion, by Maramotti (White & Griffiths. 2000; p. 99), is that there is no substitute for the accumulated experience and craftsmanship of pattern cutters and technicians. However, from my perspective, this perception requires reconsideration.



Why should designers have to learn pattern making techniques to obtain their personally envisaged three-dimensional results of the final product? Is the design - pattern separation warranted? Could the development of sleeve patterns function as a direct consequence of sleeve styles/silhouettes and descriptive-drawings? How can these two functions, illustrative design and technical pattern making, be reconciled? Why should this separation of functions be sustained if another method, or system, could be developed to combine both the technical and the artistic - without the need to acquire the technical knowledge?

It is therefore proposed that although each sleeve design is a unique entity, paradoxically, all sleeve styles are one and the same. They are one and the same because they are composed of the same few elements (described in chapter 3). Each sleeve style consists of elements that form 'variation packets'. These packets of elements are organised in a limited number of forms. The forms could be termed sleeve silhouettes therefore there are a limited number of sleeve silhouettes.

Restricting sleeves within the realm of a small number of elements results in style variations of only five sleeve silhouettes: straight, tapered, flared, Leg of Mutton (L. O. M.) and tailored. The differences between these sleeve styles are of elements such as length, shape, size, movement, position, fabric/fabric fullness and angle et cetera, which blend, merge and morph from one design to another. Therefore, variable packets of precisely controlled scye and sleeve elements result in specific 2D and subsequent 3D in-set sleeve structures, and consequently, all style variations.

Because the variable packages of elements, a single design system should be capable of designing and constructing all of the sleeve styles and patterns rather than the



myriad of sleeve drafting methods currently in use. The qualities required of the in-set sleeve design system are presented.

***Brief (self-imposed): Initial sleeve design/pattern making prerequisites***

Current in-set sleeve drafting and pattern making involves individualised methods, with no genuine consistencies, which produce unpredictable results. For this self-imposed (manual) brief, the scye sleeve elements must be compliant enough to be altered by the author (to the author's own biases) and be capable of transition into a number of variations within the sleeve styles under review. The system must also be valid for the subjective demands of other users, individual designers, bearing in mind their personal quality practises. The in-set sleeve design system must be capable of producing:

- The necessary personal aesthetics and functions of the user
- Personally designed sleeve styles using a limited number of techniques
- The sleeve pattern for those individualised sleeve styles and silhouettes
- An array of arm/sleeve elevations/angles and movements
- An incorporation of under sleeve drape, fabric fullness, gathers, pleats and darts for a variety of materials

When achieved, to the satisfaction of the user, the above criteria are deemed successful.

This project is both a means of acquiring knowledge of in-set sleeve design and pattern making, and the development of a design system. It describes the mechanisms, in manual terms, of how various in-set sleeve style silhouettes are developed from the scye by manipulating their elements. Because of their complexity it does not enter into computerised systems. In the longer term however, future developments of in-set sleeve pattern making could be an automatic process, detached from the designer – an automatic designer/pattern making process interface programme (FCAD).



The in-set sleeve design system should provide for in-set sleeve styles inclusivity and be capable of giving the ultimate sleeve silhouette at the designing stage. It should also simultaneously draft the pattern for the sleeve design and produce the two-dimensional sleeve pattern (concurrent engineering). All would occur in a logical, faster, easier, cheaper time-frame whilst being more accurate and three-dimensionally more predictable than is currently possible with manual drafting.

The questions posed at the end of chapter 3 resulted in a search of the literature (chapter 4) to find creative construction methods that might have potential for transference to an in-set sleeve design system; a number of possibilities have been presented. From the review, it was considered that for an in-set sleeve design system, the methods should be as simple as possible to test the proposition, bearing in mind future computer aided fashion design (FCAD) developments. Even so, it is still expected that the 'simple' in-set sleeve design system will be technically complex. The question of how the design system should develop is considered in the following chapter sections.

### **5.3 Design/creativity**

Drawing is fundamental to design. Through the drawing, or sketching process, the designer can quickly convey an artistic interpretation of a product. A series of drawings may aid the creative and reflective processes and be valuable when testing hypotheses. It is a method for problem solving (Do, 2005, p. 383); a method of experimentation and a means of developing solutions to design problems without the need for material interpretations.

Downton (2003, p. 1) identifies design as a way of researching (labelled 'creativity' in some accounts, p. 103), a way of producing knowledge. Design, according to Jonas



(2001, p.66) is a cross-discipline which integrates various expert fields; whilst Sriram, et al. (1989; p. 79) describe design as: *'...the process of specifying a description of an artefact that satisfies constraints arising from a number of sources by using diverse sources of knowledge.'* Sturges, O'Shaughnessy and Reed (1993, p. 93) explain that good conceptual design means innovation.

*'The ability to use knowledge drawn from experience inside or outside the current domain helps produce innovative solution. In particular, a design appears novel if it incorporates knowledge acquired from past experiences in domains different from the current one.'*

(Sriram, et al., 1989; p. 81)

This opinion is echoed by Cunningham (1997, p.410) who states that cognitive complexity is important in reframing experience to give a new comprehension of the problem. He continues to report (p. 413) that a number of new concepts are rearrangements of pre-existing forms which are unique in their new setting. In other words, experience from different 'inside' areas (creative design and dexterous pattern making technology) and 'outside' sources of whatever is original, helpful or convenient, should be integrated in order to widen the propensity for innovative solutions. Tjalve (1979, p. 7) explains that; *'the aim in designing is that the properties present in the finished product should correspond to the properties required.'* On the subject of creativity, Maramotti (White & Griffiths, 2000, pp. 91-92 and 97) believes that it is part of a system or structure - a useful instrument; but also that creativity cannot be strictly planned and must be flexible, ready to change.

Seeking to understand and change a problem, the practitioner cannot know either the solution or indeed whether the problem is solvable. Even so, the parameters imposed by the practitioner, will indicate a method in which they have confidence; and. a successful reframing of the problem leads to a continuing reflection (Schön, 1998, pp. 134, 136 &



141) and, reflection-in-action involves experiment. However, as Lawson (2006, p. 40) advises - you will just have to put it all together yourself.

## **5.4 Summary**

A review of the literature has revealed that contemporary In-set sleeve pattern making methods are too labour and knowledge intensive to continue in their present forms. They are style separatist, individual, non-predictable, iterative and no longer adequate for today's computer-focussed industry. It is suggested that the principles and procedures for designing and pattern making a range of in-set sleeve styles and their variations are not fully developed. Consequently, it would be beneficial to be able to calculate the complete sleeve structure for a range of sleeve silhouettes before undertaking fabric trials.

An amalgamation of reflective practises involving a variety of experiences, such as design sketching and knowledge of cross-discipline environments has lead to informed perceptions for reframing the problem. It is therefore proposed that a new approach to designing and pattern making in-set sleeves be developed and adopted; a system that unites the artist with the artisan.

## **5.5 Fashion design methods**

*'Design (says Jirousek, 2005) is the process of selecting and organising elements or components in order to fulfil a specific purpose'.* Fashion design (according to apparelsearh.com.) is *'the art dedicated to the creation of wearing apparel and lifestyle'.* Design related activities are serial (incremental) in nature (Hsu & Liu (2000), that progress from one activity to the next (as in design concept to pattern to cutting to manufacture). A conventional (traditional) process for garment design, production to



buyer evaluation and acceptance/rejection is presented (modified with iterate steps) in Figure 5.1 (McCartney, Hinds, Seow & Gong, 2000a).

Figure 5.1. Conventional (traditional) design process (Garment design)

Source: Adapted from McCartney, Hinds, Seow and Gong (2000a)

However, subjects considered for this research are centred on design, pattern making and trials/samples. Therefore, iterative routes, from design to pattern production to trials/samples are depicted in Figure 5.2 to illustrate the dissipation of effort, time, and fabric waste during the production process. There may be several iterations before product approval.



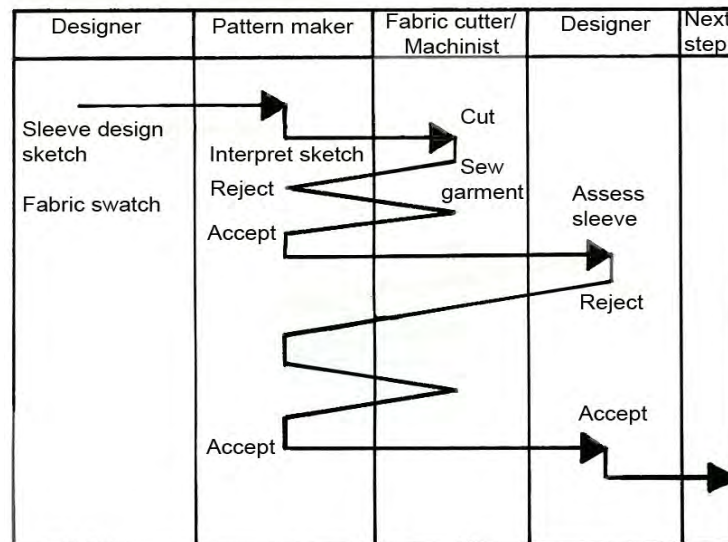


Figure 5.2. Iterative routes in design and pattern making

Design may show a serial progression, however, during the fabric modelling phase (the initial, experimental stages), the fitting and designing are realised concurrently (Heisey, Brown and Johnson (1988). Concurrent engineering is a method where activities are performed simultaneously to reduce the design cycle, also acknowledged by McCartney, Hinds, Seow and Gong (2000a). Significantly for this research, they also report that the engineering design process is more accurate than is the artistic garment design.

Although there is a need to determine methods of data collection, analysis and validation, methodologies may differ in each discipline (Walliman, 2005, p.251). Not all disciplines, however, have dedicated methods. Sources, related to fashion design and pattern making research methods, whether systematic processes or not, are scarce commodities; as Rissanen (2007) points out: *'the kinds of studies on the practise of designing available to other design disciplines (for example, architectural and industrial design) are still lacking in fashion design and patternmaking.'* And, Ian Griffiths adds; *'Amongst the entire body of academic work relating to fashion, there is scarcely a word*



written by a practising designer, or given a designer's perspective'. (White & Griffiths, 2000, p.70).

The analytical design process for fashion, espoused by Au, Taylor and Newton (2004), was based on concepts developed in the architecture and engineering design. As there seems to be few methods for the fashion design field, it is somewhat difficult to decide on a specific forward direction in this regard; especially with the following apparent disagreements. Blaxter, Hughes and Tight (2003, p.63) relate that although '*Research is a systematic investigation to find answers to a problem*', a systematic approach is not always agreed, and as Lawson points out:

*'Many writers have tried to chart a route through the (design) process from beginning to end... Logically it seems that the designer must do a number of things in order to progress from the first stages of getting a problem to the final stages of defining a solution. Unfortunately, ..., these assumptions turn out to be rather rash.'* (Lawson, 2006, p. 33)

Lawson (p. 182) further advises that empirical evidence suggests solution-strategies are more likely to be used by designers (architectural) than are problem-solving strategies; which. Lawson (p.33) relates to the Queen in Lewis Carroll's 'Alice' fairy-tale, who advocates that the sentence should precede the evidence.

*'there is a suspicion, at least within design, that very well planned and orderly research delivering an expected outcome is almost unnecessary as the outcome must be known prior to the research being conducted if the process is to be as orderly as sometimes claimed.'* (Downton, 2009, p.5)



Downton (2003, p. 39) continues, revealing that improved design methods (that may exclude fashion) were being promoted in the 1950s and 1960s. Even so, many theorists have abandoned the use of definitive single approach design methods. Nevertheless, Yin (2009, p.24) explains that a research design is the logic that links the initial study questions to the collected data to the extracted conclusions. A logical route through the entire process of developing a new in-set sleeve design system, therefore, needs method contributions from a variety of methodological sources.

The absence of methods relating specifically to fashion design and pattern making means that methods from other disciplines have to be adopted or adapted. This is especially beneficial since this research draws from drafting and drawing resources from other disciplines. As Caelli, Ray and Mill (2003, p.7) explain; '*no discipline can stand alone, particularly in this age of multidisciplinary research*'. Some apparel design models have their root-source indirectly based on engineering design process theory (Regan, Kincade and Sheldon, 1998, p.39). In addition to this, research methods pertinent to this study were influenced by the mixed method research approach undertaken by S. A. Mayson in his 2006 Doctorial thesis describing the design of a surgical instrument.

## **5.6 Research design methods**

In order to journey from the hypotheses through this research to the results, it is important to define an applicable design process. Research design is the entire process of research from conceptualising the problem to the research questions, data collection, analysis, interpretation and report writing (Creswell (2007, p. 5). This is where the researcher's interpretations cannot be separated from their own background, history, context and prior understanding.



There are many research methods available to the researcher. Walliman (2005, p. 271) lists five major research strategies or methodologies, although he says that this number may be expanded; these are categorised under; experimental, survey, archival, historical and case study. Each has a different way of collecting and analysing empirical knowledge and may be combined to enhance the research. Research methods, according to Blaxter, Hughes and Tight (2003, p.63), have designations such as Case study, User centred, Universal, Experiments, scenario et cetera, with research families designated as either quantitative or qualitative; or a combination of the two.

As a distinct process from that of a quantitative methodology, qualitative design is an emergent process in which the initial plan cannot be tightly prescribed and that all phases of the process may change or shift (Creswell, 2007, p. 39). Patton (1990, p. 44) asserts that qualitative methods are predisposed towards exploration, discovery and inductive (from observations and data) logic. Then again, testing hypotheses by experimentation (Schön, 1998, p. 143), follows a process of deductive elimination; a process which concerns this project.

The design process, according to Sriram, et al. (1989, pp. 79-80) is an iterative six-step process of: Problem identification - Specification generation - Concept generation – Analysis – Evaluation - Detailed design. Kerssens-van Drongelen (2001) states that in order to achieve their objective, researchers should follow three steps of; exploration, explanation and validation. Leedy lists four features that must be present for the research to be tested; these are Universality – Replication – Control - Measurement. Despite this, according to Leedy (1989, p. 81), no matter what the discipline, all research has a basic format - the search for facts to solve a problem.



All research is based on theory, whether it is theory building or theory verification (Flynn, Sakakibara, Schroeder, Bates & Flynn, 1990, p.250). The gaps between the application and theory of design and pattern making have been noted in previous discussions. The gap is still evident. This research is based on verifying the proposition that all sleeves are composed of the same number of elements therefore they are variations of a single morphing sleeve, by testing smaller theories within the proposition which include element structure and function.

The research project described, involves a number of fundamental components and practises that are also nebulous in nature. It was identified in the research that there are a limited number of elements which are described in the proposition as packets of variables. Just as there are few structural variable elements, there are only a few sleeve styles that account for the many (see chapter 6). Therefore, the number of styles is limited to a focus group of five. (As a further test of the design system, there is a sixth sleeve of an alternative fabric - using the same sleeve pattern - see chapter 8). However, none of these underlying essentials are said to be fully resolved, explained, researched or validated. It is, therefore, important that the design process considers the propositions' reliability and validity for later generalisation. This is accomplished through a series of case studies encompassing conceptual, empirical observations and experiment, creative, evolutionary and iterative approaches.

### ***Case studies***

The most important step in research is to define the research questions and, generally, case studies are the preferred methods to use when 'why' and 'how' questions are being asked Yin (p. 10, 2009). Although all methods overlap with indistinct boundaries, case studies are often needed when creativity and innovation are present (Colorado State University, 2009).



Case study research involves the study of an issue explored through one or more cases within a bounded system (Creswell, 2007, p. 73). There are three variations of case studies; single, multiple and intrinsic case studies. A case study is also known as a triangulated research strategy – in this case it is a methodological triangulation – when one approach is followed by another (Tellis, 1997, p. 1). The case study approach is a way of building theory (Evans & Gruba, 2009, p. 92), within a conceptual framework, with no focus on specific instances or authors. Yin explains that the research design in the case study methodology is somewhat difficult to determine (2009, p. 25); unlike other research methods, there is no completed inventory of research designs.

Experiments, although confirming the worth of a procedure, are lacking in their ability to describe ‘how’ and ‘why’ some phenomenon works (Yin, 2009, p. 4). Exploratory, descriptive and explanatory, case studies (how or why questions), therefore, are of value to this research. This is more so, as case studies allow generalisations as the results can lead to some form of replication (Noor, 2008). To Yin’s three case types, Stake (1995, pp. 3-4) adds three more: intrinsic – a specific interest in the case, instrumental – in accomplishing a particular task and collective – studying more than one. Yin (2009, p. 2) advises that the advantages and disadvantages of a method rely on three conditions:

- The type of research question
- The control an investigator has over events
- The focus of contemporary phenomena rather than the historical

Soy (1997), and Creswell (2007, p.76), propose six steps that should be used to conduct case studies:

- Determine and define the research questions
- Select the cases and determine data gathering and analysis techniques



- Prepare to collect the data
- Collect data
- Evaluate and analyse the data
- Prepare the report

*‘A key strength of the case study method involves using multiple sources and techniques in the data gathering process’.* (Soy, 1997)

Eisenhardt (1989, p. 548) states that theory-building from case studies does not rely on previous literature, empirical evidence or when extant theory seems inadequate. This is consistent with the notation in the introduction to this chapter, which argues that the literature review of drafting has shown that explanations are rarely insightful and that there are many anomalies in the drafting methods.

Case studies focus and underpin this thesis. This includes using a standard, average size (87cm bust) mannequin as a case study (for other endlessly variable figure proportions, postures and configurations), on which to develop sleeve styles. This model, unlike a movement-prone human subject, is always available, has a non-changing stance, and does not include an arm that would hinder sleeve elevation angles, accurate measurements nor obscure the development of the scye and under sleeve.

Each of the five in-set sleeve styles (plus the sixth fabric alternative) is presented as separate case studies. The straight, tapered, flared, Leg of mutton and tailored sleeve styles contain the sleeve elements that comprise all sleeve styles. Therefore, they will represent all other sleeve styles involved in all in-set sleeve designs. This empirical investigation uses relevant data collection methods – sources of evidence, such as



documentation, participatory observations and physical artefact; a triangulation of evidence for reliability (Tellis, 1997, p. 9).

### ***Conventional design process***

In a conventional design approach, there are no clear defined steps or clear starting point of how to achieve the brief. The process is rather like a mass of bubbles with no defined route from start to end (Sivaloganathan, et. al, 2000 p. 72) (Figure 5.3).

Figure 5.3. Conventional Design process bubbles

Source: Ashby and Johnson (2002, p.34)

In the conventional process, a technical specification is written in order to comprehend a given design brief. As much pertinent information is then collected to develop insights in an iterative manner from which exploratory solutions to the brief are considered (Sivaloganathan, Shahin, Cross & Lawrence 2000, p. 60). Concept models are developed and evaluation criteria are advanced to establish a single solution for further consideration. Prototypes are produced, tested and problems resolved ('1' Figure 5.4), an equivalent apparel method might be as shown in '2', Figure 5.4. The conventional design approach relies heavily on building models and testing them, whereby a special effort has to be taken to capture design knowledge (p. 72).



(1)

(2)

Figure 5.4. Conventional approach

Source: (1) Sivaloganathan et. al (2000)

(2) Adapted from Sivaloganathan et. al (2000)

### ***Systematic design process***

The systematic process begins with the needs of a patron or patrons (and other stakeholders such as end-users, transport and manufacturers et. cetera), from which a specification, including functions, restrictions and materials, is created. The systematic process breaks the design process into a series of clear actions supported by other additional design methods (for design problems which have been previously specified in form or structure – existing product) such as a morphological analysis of various concepts, a parts function and a function analysis (Sivaloganatham, et. al; 2000) ('1' in Figure 5.5). An equivalent apparel method could be '2' (Figure 5.5).



(1)

(2)

Figure 5.5. Systematic approach

Source: (1) Sivaloganathan et. al (2000)

(2) Adapted from Sivaloganathan et. al (2000)

The conceptual phase concerns the problem of creating new ideas or solutions to older problems - aiding synthesis and evaluation in the early design phases (Sturges, O'Shaughnessy and Reed, 1993). They relate (1993, p. 93) that well established research tools should be used to solve problems which have been specified previously in form or structure (a systematic approach). Any design representation must include design description, function, behaviour and structure, and have entry by elements within those mechanisms Gero (1990, p. 30).

*'Function, structure, behaviour and relationships form the foundation of the knowledge that must be represented for specific design processes to be able to operate on them.'* (Gero, John S. 1990, p. 31)



And Sriram, et al. (1989) *'The decomposition of the problem is known, but the alternatives for each of its subparts do not exist and must be synthesised. The designer uses some fundamental principles of the domain to develop alternatives; these alternatives might be a novel combination of existing components. One must note that a certain amount of creativity comes into play in the innovative process. Further, a system considered as innovative in one culture might not seem innovative in another culture.'* (pp. 80-81)

### **5.7 Thesis hybrid research design process**

Patton (1990, p. 187) explains that more than one method is required to fulfil the objectives. I believe that in order to better advance and support this thesis, this research follows Patton's premise, exploring two approaches. When there is enough known data, the systematic approach is used, whereas when there is insufficient data the conventional process is preferable (Sivaloganathan, Shahin, Cross & Lawrence 2000, p. 73). Therefore, a hybrid method approach is considered to be appropriate for this study; the application of a number of discipline methods to form the complete design method process. This is described by Caelli, Ray and Mill (2003, pp. 3-4) as a generic methodology; although their full definition (p.4) is defined as research *'which is not guided by an explicit or established set of philosophic assumptions in the form of one of the known qualitative methods.'*

With the hybrid method there is a combination of at least two methods to achieve abilities that could not be achieved using individual approaches (Nishioka, Kurio and Nakabyashi, 2000. P. 170). The Hybrid Design Process (Figure 5.6) is a combination of incremental and iterative development. Cockburn (2008) defines incremental and iterative as:



*Incremental development is a staging and scheduling strategy in which various parts of the system are developed at different times or rates and integrated as they are completed; (whilst) Iterative development is a rework scheduling strategy in which time is set aside to revise and improve parts of the system. (p. 27)*



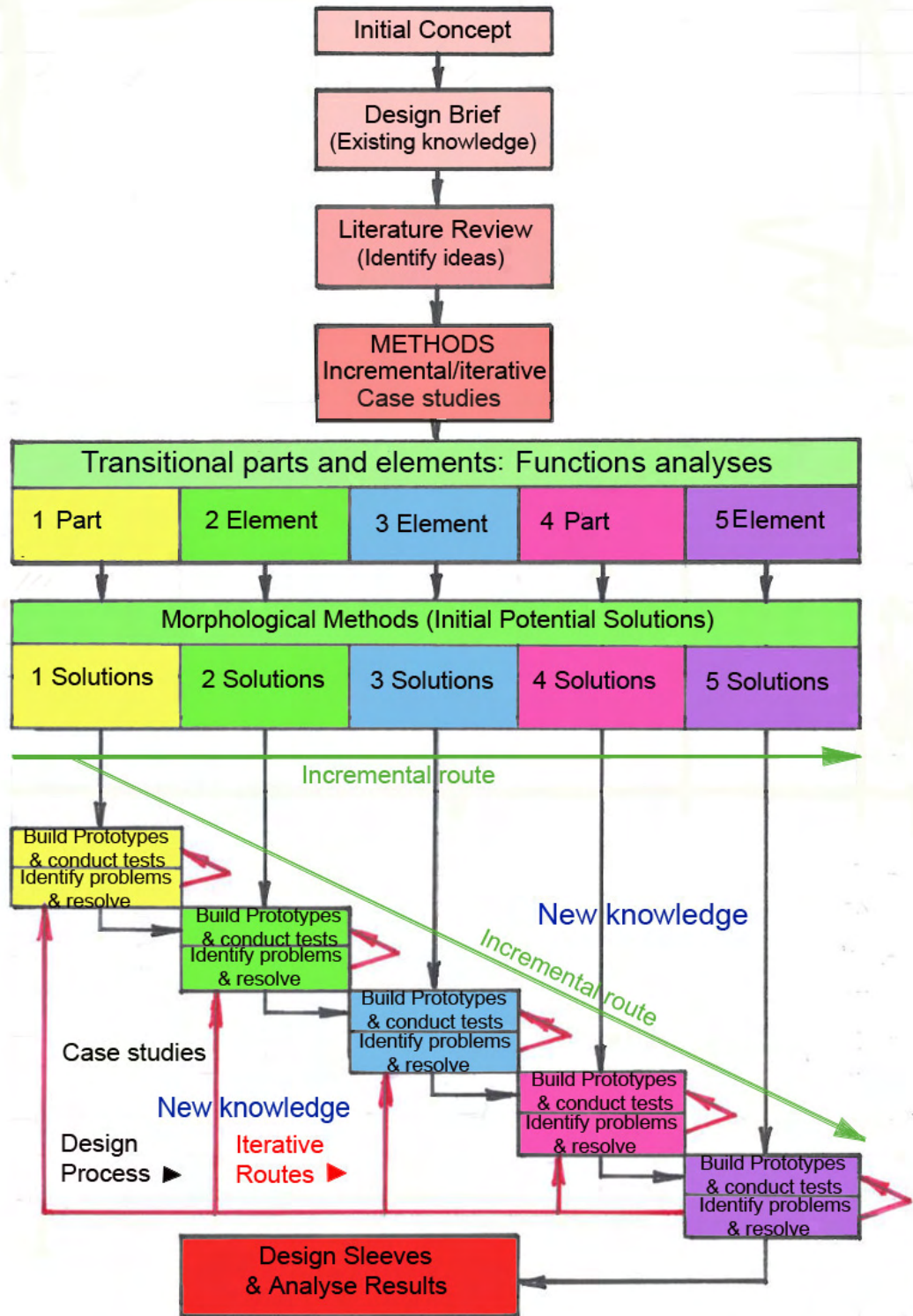


Figure 5.6. Hybrid Design Process



## **5.8 Hybrid application: Development process**

The instigation of this design project was an initial concept which stated that there are innumerable sleeve drafting methods. Each method produces a single variation of a single sleeve style/design/name or silhouette. They appear to assign definite-measurements drafting instructions to produce a diagram of the sleeve style. This, almost, implies a 'rule', or 'set of rules' that must be adhered to, to enable the user to generate a sleeve style.

These strict methods are inconsistent, having the potential to produce defective results. None are capable of generating patterns that predict the fabricated products. These assertions were verified by the literature review which also confirmed that contemporary drafting methods were knowledge based and trial and error intensive. However, this rigidity of style/design and pattern making does not have to be perpetuated. An incremental development process is utilised to reduce the number of methods, style names, silhouettes, basic structures, parts and elements of the scye and in-set sleeve, to be later combined within a distinct design and pattern making system.

## **5.9 Scye and in-set sleeves**

At a primary level, the sleeve is a section of fabric shaped, firstly, to cover and move with the arm, or part of the arm, and to fit into the armhole, and secondly to create a distinct style silhouette. Designers and future designers have their own preconceived ideals of silhouette, fit and aesthetics, nevertheless, the primary sleeve style silhouettes have not changed significantly over the last eighty four years (between 1926 and 2010). Even so, there are many designated and non-designated interpretations of these sleeve silhouette styles. Preliminary enquiries of the research into sleeve designations, style names, and silhouettes proposed that they should be either deleted (designations of loose-fitting or semi-fitted for example) or style names



such as Bishop or Puff;- or kept only as reference, shirt or Bell for instance. Sleeve shapes could be or grouped / reduced to a manageable few which can be further subdivided into primary silhouettes.

### ***In-set sleeves: Style names reduction***

In general, sleeve style names, such as Bell and Bishop et cetera, impede a clear focus of the underlying parts and functions of in-set sleeves. Because of the blending affect of the many variations (small transitions) in sleeve style names, it is seen as permissible to reduce the number represented for this study.

This reasoning is in accord with Tuit (1974, p. 107) who explains that the Bell and Bishop sleeve styles may be constructed by '*any of the four methods used to construct a bishop sleeve pattern may be used for a bell sleeve...*'; meaning that, apart from length, these two sleeves – the bell and the bishop sleeves - are almost identical. Bray (1997, p. 1), expands this viewpoint, emphasising that adaptation methods in tailoring (and other style areas), use basic block patterns which reveal that every type of pattern is connected to other patterns – even though the silhouette and fit may vary. Reducing the importance of sleeve style names places a focus on sleeve silhouettes; what are these shapes and how could they be reduced to provide a basic few?

### ***In-set sleeves: Style silhouettes reclassification***

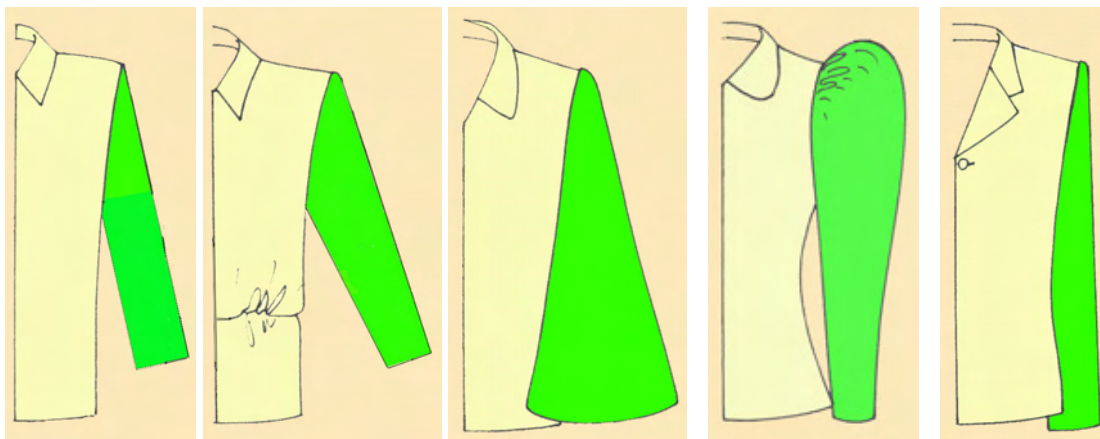
Among the oversupply of sleeve style variations are those styles depicted in Table 5.1, column '1'. Whilst there are variations of sleeve styles with names, other variations are recognised only by their relative shape. It was determined that because of their basic characteristics five sleeves would form individual case studies from which other sleeve styles could be generalised. The five basic sleeve silhouettes (which were analysed in



chapter 2), as depicted in Table 5.1 column '2', and Figure 5.7 are the straight '1', tapered '2', flared '3', Leg of Mutton '4' and tailored sleeve '5'.

Table 5.1. Sleeve styles

1 Sleeve styles	2 Sleeve styles (reduced to five styles)
<ul style="list-style-type: none"> <li>• Basic straight sleeve</li> <li>• Basic straight sleeve (gathered into cuff)</li> </ul>	1 Straight sleeves
<ul style="list-style-type: none"> <li>• Loose fitting sleeve (tapered).</li> <li>• Semi fitting sleeve (tapered).</li> <li>• Tight fitting sleeve (tapered).</li> <li>• Semi fitted at hem (tapered).</li> <li>• Fitted at hem (tapered).</li> </ul>	2 Tapered (Shirt) sleeve
<ul style="list-style-type: none"> <li>• Bell sleeve (flared)</li> <li>• Bishop sleeve. (flared) (flared)</li> <li>• Slightly flared sleeve.</li> <li>• Very flared sleeve.</li> <li>• Short sleeve.</li> <li>• Short sleeve–fitted.</li> </ul>	3 Flared (Bell) sleeve
<ul style="list-style-type: none"> <li>• Leg o' mutton</li> <li>• Puff sleeve.</li> <li>• Gathered sleeve head.</li> <li>• Darted sleeve head.</li> <li>• Pleated sleeve head.</li> </ul>	4 Leg o' mutton (flared /gathered crown)
<ul style="list-style-type: none"> <li>• Tailored - jacket/ overcoat (with shoulder pads).</li> </ul>	5 Tailored - jacket/ overcoat (straight and tapered)



(1) Straight (2) Tapered (3) Flared (4) Leg of mutton (5) Tailored

Figure 5.7. Basic sleeve silhouettes



### ***In-set sleeves: Basic style silhouettes***

Firstly, what are the basic sleeve silhouettes? Hecklinger, (Shep, 2002, p. 57) is of the opinion that the crown should have enough fullness and should be cylindrical in shape and be based on geometric principles. Although not giving the number of sleeve sections, Pepin (1942, p. 89) also explains that the arm is a cylindrical shape (possibly meaning down to the elbow), bent at the elbow and tapering towards the wrist, (therefore, the area below the elbow may, perhaps, be better described as an inverted conical shape). The bell shaped sleeve is geometrically opposite in shape to the tapered effect described above, it being conical – its base (hem) being wider than its top area.

Explaining the duplication of patterns for body sections, Kunick (1967. pp.83-84) identifies the square or rectangle as being the foundation for all symmetrical objects and reveals that suppression, or reduction of one edge produces a conical shape. He develops his ideas further by placing an inverted frustum of a cone on top of a cylinder to represent those sections of the body above and below the waist line. The same reflections may be relevant to sleeve sections. To further illustrate the geometric rather than the artistic, Richards (1930, p.13) suggests that a block pattern should disregard fabric distortions and as a result the pattern should fit even if made from tin (see: Engineering drawing: Sheet metal developments chapter 6B).

### ***In-set sleeves: Basic geometric structures***

From the opinions of the seminal authors cited above, in addition to personal observations, it is apparent that the three basic geometric structures – cylinder, cone or inverted cone (or a combination) constitute in-set sleeve silhouettes. These are illustrated in Figure 5.8 '1' as the cylinder, the cone (Figure 5.8 '2') and the inverted cone (Figure 5.8 '3'); the circle in Figure 5.8 represents the plan view of the three structures.



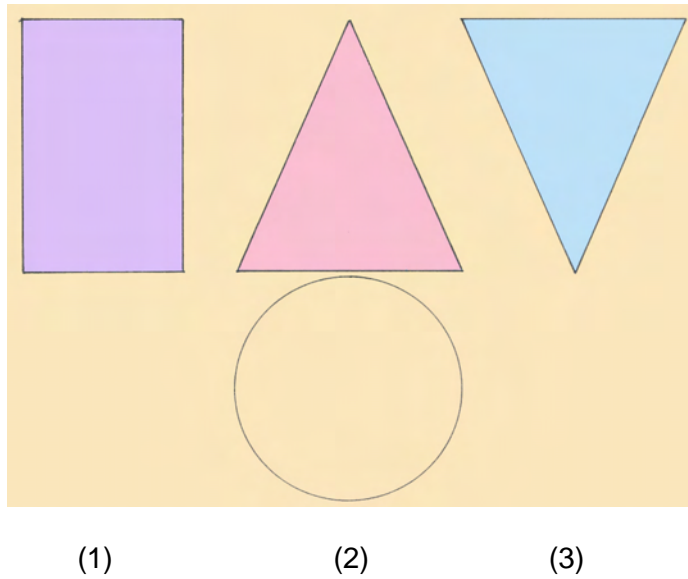
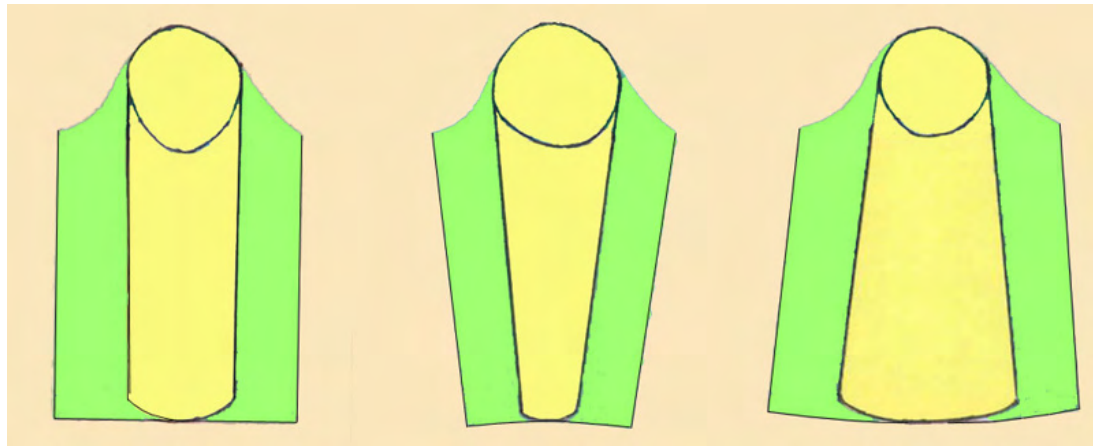


Figure 5.8. Basic geometric structures: Cylinder – Cone – Inverted cone

***In-set sleeves: Basic geometric truncated structures  
and sleeve patterns***

Advancing from the three basic geometric shapes, further empirical observations (what Kuhn describes as ‘thinking from exemplars’ (Schön, 1998, p. 183), confirm that there is a direct similarity between a straight sleeve style pattern and a developed (flattened) ‘engineered’ pattern for a truncated cylinder; the flattened cone also portrays a resemblance of tapered or flared sleeve style patterns. Figure 5.9 ‘1’, ‘2’, ‘3’ respectively, illustrates how the three basic geometric truncated structures; cylinder, inverted cone and cone, align with their superimposed two-dimensional sleeve pattern counterparts which are the straight, tapered and flared variety.





(1) Straight

(2) Tapered

(3) Flared

Figure 5.9. Basic geometric truncated structures and sleeve patterns

***In-set sleeves: Basic combined geometric structures  
and sleeve patterns***

Additions to the single structures of cylinder and cone can be obtained to produce style variations. The seven basic forms (depicted in Figure 5.10) are dual combinations, with a horizontal joining line, of the three shapes illustrated in Figure 5.8. More shapes could be added to produce further more complicated variations.

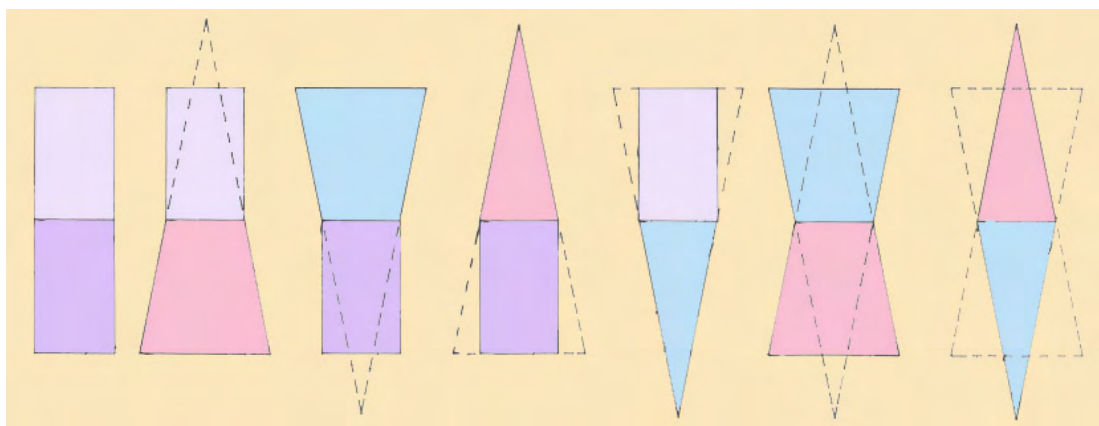


Figure 5.10. Basic structure combinations



All other variations are still duplications of the three basic shapes. Nevertheless, one other sleeve shape needs to be accounted for, a sleeve which is more aligned to the curvature of the arm – the tailored sleeve. In this portrayal of the combined basic structures (Figure 5.11), a wedge of material has been inserted into the centre line, producing an angled affect similar to the curve of the arm at the elbow, on a tailored sleeve from the selection in Figure 5.11, only the tailored sleeve will be developed, either from the drawing to the extreme left at '1', with a cylindrical lower section, or the drawing third from right at '5' with its tapered lower section.

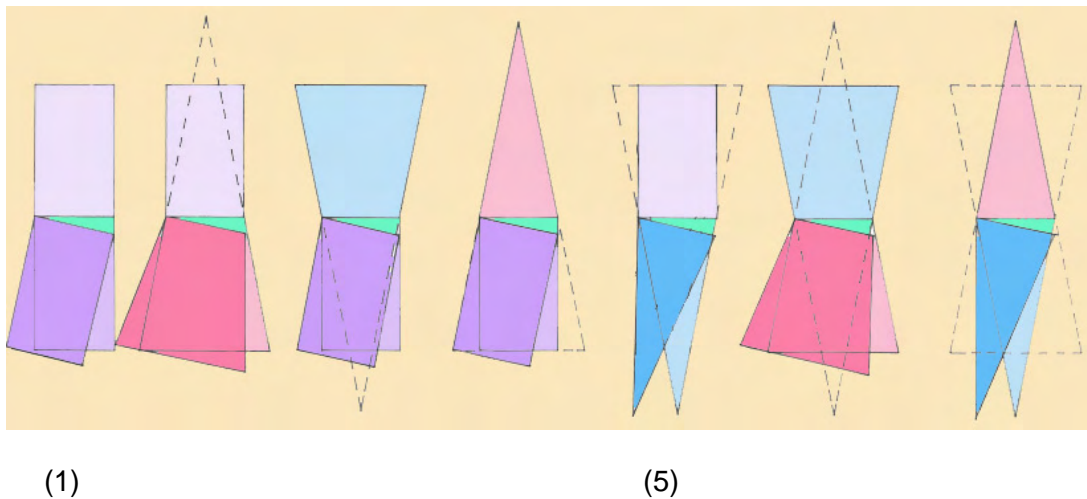


Figure 5.11. Basic structure combinations with angled lower regions

### ***In-set sleeves: Basic geometric structures***

#### ***and sleeve style amalgamation***

To complete the unification of sleeve silhouettes and names for this research, all of the sleeve shapes must be compressed into a restricted number of styles. Table 5.2) restates the five in-set sleeve styles and pairs them with basic geometric shapes; other sleeve styles are combinations of these five sleeve styles.



Table 5.2. Sleeves and their equivalent geometric shapes

	Sleeve style	Basic geometric shape	
		3D geometric shape	2D pattern shape
1	Straight sleeve	Cylinder	Rectangle
2	Tapered (Shirt) sleeve.	Inverted cone	Tapered
3	Flared (Bell) sleeve.	Cone	Flared
4	Leg of mutton	Inverted cone	Tapered
5	Tailored sleeve	Cylinder or inverted cone	Rectangular or tapered

### ***Scye and In-set sleeves: Parts/sections***

All in-set sleeve styles fit into a scye (armhole); the scye and sleeve are represented by a number of parts or sections that relate to the body and arm in a variety of ways. They alter in shape and size depending on the sleeve style (see Transitional parts and elements).

The body and arm views (Figure 5.12 '1') illustrate the arm landmarks. The widest (red band), intermediate (green band) and narrowest (yellow band) arm circumferences of the biceps, elbow and wrist positions noted. The sleeve is depicted in Figure 5.12 '2' and '3'. There are four distinct sections:

1. Body section including the scye shape (blue band)
2. Sleeve section between the scye (blue band) and above the depth of scye (DOS) (red band in Figure 5.12 '1') which is the crown area or depth of crown (DOC) of the sleeve, represented as 'A' in Figure 5.12 '2' and '3')
3. Sleeve section (upper arm-encasing) between the DOS line /DOC line and the elbow level (green band (Figure 5.12 '1') and 'B' in Figure 5.12 '2' and '3')
4. Sleeve section (lower arm-encasing) between the elbow level and the wrist level (yellow band in Figure 5.12 '1' and 'C' in Figure 5.12 '2' and '3')



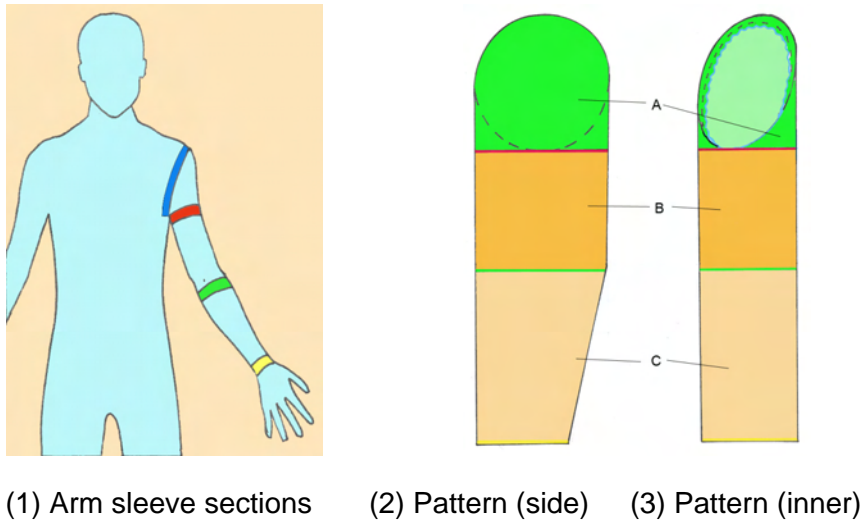


Figure 5.12. Body scan landmarks

### ***Scye and In-set sleeves: Parts and elements***

All sleeve styles have a basic structure consisting of parts/sections which are primarily the cylinder, cone or inverted cone, plus combinations, are composed of elements. Each sleeve style, or silhouette, contains the same parts and the same elements. The parts are the body sections (front and back) that form the scye, the sleeve sections of crown, upper-arm encasing and lower arm-encasing. The parts are composed of elements. The elements are: silhouette (size, shape, length, position, fit et cetera), arm/sleeve elevation and fabric fullness and drape.

The parts and elements combine in various structural relationships or 'packets'. Each 'part and element packet' is unique to the formation of a particular sleeve style. Each variation of the sleeve style or design has a variation of the parts and element packet (of silhouette, arm/sleeve elevation and fabric fullness). When all the parts and elements are combined in their unique relationship 'packets' the sleeve style is achieved. It is achieved when all of the parts and their elements are in harmony for the style variation or design – they all balance.



The scye and sleeve parts and elements contribute to the over-all properties of the sleeve. The most important properties of a product (sleeve) are its functions (Tjalve, 1979, p. 7). These are to cover the designated arm area, to fit the scye, have the necessary movement/elevation capabilities, fabric fullness allowances, the decided aesthetics, dimensions and arm fit. All of the properties- composed of parts and elements - vary depending on the type of garment to which the sleeve is attached.

### ***Scye and In-set sleeves: Transitional parts and elements***

It has been explained that different sleeve styles have unique arrangements of traditionally named elements that structure the scye and sleeve parts; these can all be manipulated to produce sleeve 'styling/design' variations. Different designers have their own preferences as to how the elements should be combined to achieve the silhouette, fit and movement et cetera - the methods are almost endless.

However, as with sleeve style names, giving labels to elements that are essentially the same, adds to the confusion of how to simplify the sleeve structure in order to create a new in-set sleeve design and pattern making system. For example, darts are a variation of sewn pleats – pleats are essentially large gathers, gathers are lengths of fullness, and fullness is compressed flat fabric. They are therefore all transitional in nature, transforming from one extreme of form (darts to fullness), material, dimension and surface (Tjalve, 1979, p. 7) to another – within their limits. As such, they all contribute to a greater or lesser extent to the over-all structure of the sleeve.

As the names for elements are condensed to reduce the design/pattern making process, each element appears to merge within its own restraints, simplifying the sleeve composition. Transitions may be listed as:

- Scyes: Although ovoid in shape, scyes vary in dimensions and orientation



- Silhouettes: Sleeves are composed of cylinders or cones, simple geometric shapes producing variations of fit and length. Within the basic shapes are hems. Hems are transitional elements of diameter - they are different only in circumference
- Sleeve/arm elevation: Sleeve elevations are differences in angles and movements
- Sleeve crowns: Crowns are transitional, having variations in volume – width and height
- Fabric fullness: Previously explained as gathers, pleats and darts - manifestations of a longer seam line length being pushed into another shorter seam line. Fabric drape is valued for its aesthetic contributions.

Since the parts and elements are all variables, they can change in size, silhouette, movement, fullness et cetera, to produce a seamless, fluid transitional progression or development from one sleeve style to another. It is this transitional fluidity of parts and elements – as opposed to rigid contemporary drafting methods - that enables a new inset- sleeve design and drafting system to be created. The introduction of transitional elements simplifies the under-lying combinations of elements that constitute the sleeve style parts. Sleeve design and pattern making may now be explored from different perspectives than is currently performed.

### ***Scye and In-set sleeves: Transitional parts and elements;***

#### ***Functions analyses***

It was determined that each of the sleeve styles and their design variations can be understood as variations of functional 'packets' of parts and element information which change with the sleeve style - in all in-set sleeve styles. Understanding that scyes and sleeves consist of only five major transitional parts/elements means that the number of



sleeve styles for consideration can be reduced to five case studies. This simplifies the research process.

Further analyses must be performed in order to establish the underlying functions of each element. As this project can be described as an existent product variation, a systematic approach was considered appropriate at this stage of development to produce a parts and element - function analysis. The functions were documented in the lower half of Table 5.3, the function section.

- The scye, the armhole to which the sleeve is attached, is one of the most important elements in this research. It must have its own orientation to the body and arm, and it must be controlled for sleeve development purposes.
- Sleeve silhouettes, the main arm-encasing section, vary greatly in their dimensions within the five sleeve style groupings.
- Sleeve elevation, is the angle to which the arm may lifted from the body without being restricted by either by the sleeve or the garment. Each sleeve style has its own range of angles. (Drape, because of its extra vertical length, could be classed as elevation; however for this study drape is discussed in chapter 7D)
- Crown section, is: the sleeve section that fits directly into the scye; each style has its own unique scye fitting abilities.
- The scye fitting capacities of the sleeve is influenced by the type of fabric and its related linear compression (fullness) abilities which form the crown curvature.

It is essential to consider the processes and organisations that influence the function of each element.



Table 5.3. Transitional parts and elements - Functions analyses

Transitional parts and elements: Functions analyses					
Part ► Element	1 Body and scye	2 Sleeve: Style/silhouettes	3 Sleeve: Elevation	4 Sleeve: Crown	5 Fabrics
	Body sections Body/scye	Straight Tapered (Shirt) Flared (Bell) Leg of mutton Tailored	Depth of crown (DOC)	Depth of crown (DOC)	Fibre family Woven construction Fabric selection
F U N C T I O N	Inclination: Lat. C/L Alignment Sectionalisation Shape/size/fit Width/height Sleeve/arm to fit association Fabric selection Control	Shape Size/fit Width Height Fabric/style Associations/selection	Lateral/vertical movement  Vertical/forward movement  Various angles	Fabric/style curvatures  Fit to scye	Drape Stripes/checks Dimensional stability Fullness/gathers pleats/darts potentials and therefore style

### ***Scye and In-set sleeves: Morphological methods/solutions potentials***

The two systems of drawing, garment drafting and engineering drawing, are distinct to their own disciplines and skills base which are not usually perceived as being transferable. Nevertheless, there is no reason to believe it is an unbreakable rule. It is seen as possible to use engineering drawing methods for sleeve design and pattern making if they are adapted to accommodate transitional scye and sleeve parts/elements developments.

Research into computerised surface modelling and flattening (chapter 4) has revealed how a number of disciplined methods manage transformations from three-dimensional data to two-dimensional patterns (surface flattening). These techniques suggest solutions to the problems inherent in today's pattern making methods. However, it is apparent, according to Popper (Schön, 1998, p. 143), that any pre-formed hypothesised solutions must be regarded as tentative, as there may be more



satisfactory resolutions available (it may be appropriate to investigate manual modelling and flattening methods as opposed to the computerised methods).

Although part/element - functions can be listed and analysed, the theory and processes that lie behind some functions is not so obvious. Even when a morphological (the study of form - structure) analysis is produced from the literature, it is still not apparent which, if any, of the available processes could be adopted. Since there is no defined style/element - design/pattern making method available, conceptual solutions were required.

Various solutions to this problem are presented. The surface solutions range from a developable surface technique (able to be flattened) to a variety of non-developable surface methods that cannot be flattened without cutting or overlapping. Devising, making and testing these novel practises or developmental systems are therefore necessary. If there are no immediate surface flattening solutions available exploratory experiments may have to be performed to assess those solutions that are available (Schön, 1998, p. 145). A conventional design approach is therefore found to be essential in this regard.

An analysis of the surface flattening methods documented in the literature review in chapter 4, found that some methods, for various reasons (a lack of computer software, for example), may be regarded as speculative or unacceptable, and others (topographic mapping) marginally acceptable or suitable for further investigation. The methods that were deemed to have potential for further investigation are identified in Table 5.4.



Key: The red coloured sections in the morphological methods (Table 5.4) represent potential design/pattern making solutions for the development of the five scye and sleeve element - functions. Each method is described with the sleeve style concerned.

Table 5.4. Morphological methods (Initial solution potentials)

Morphological methods (Initial solutions potentials)						
Method ▼		1. Body: Scye	2. Sleeve: Style/silhouette	3. Sleeve: Elevation	4. Sleeve: Crown	5. Fabric: Drape Fullness
C O N V E N T I O N A L	▼ Developable surfaces ▼					
	Parallel line development					
	Radial line development					
	Triangulation					
	▼ Non-developable surfaces ▼					
	Geometric modelling/flattening					
	Physical modelling/flattening					
	Hybrid modelling/flattening					
	Isometric tree					
	Wireframe					
	Facets: Quadrilateral or Triangular:					
	Lobster back					
Key:		Potential Methods ►				

## 5.10 Summary

As a way to create theory, a number of case studies of sleeve styles were proposed.

The type of case studies (multiple) that will be performed in this project might be classified under ‘explanatory’ case studies, which are concerned with providing actual events and explanations as in an experiment that provide only evidence that supports a ‘proof’ (Cunningham, 1997, p. 404).

The case studies ultimately concern the dynamics of a small group of elements, a range of fluctuating geometric arrangements that dominate the scye/sleeve relationship; how they develop and fit together to form the various sleeve styles. For this research, it was



considered necessary to use case studies of five in-set sleeve styles, plus the alternative-fabric sleeve, from which to generalise expectations for other styles.

Within the research method, a hybrid approach, a combination of conventional and systematic, was deemed necessary. Using an incremental development method sleeve style names were systematically reduced in number and importance. Sleeve silhouettes were also reduced to basic geometric forms. The 'packets' of elements from which the scyes and sleeves are assembled are seen as transitional in nature, and therefore controllable.

A part/element - function analysis was prepared for the five major elements that compose scyes and sleeves. To aid the selection of methods, to determine how the function methods would be resolved, a morphological study was compiled from the possible solutions examined in the literature review. This showed a number of potential approaches that could be investigated.

in chapters 6 and 7 each of the five elements, scye, silhouette, elevation, crown and fabric (fullness and drape) will be tested, incrementally, for validation through empirical observations, use of models and trials within a hybrid (mixed/triangulation) method. As Yin (2009, p. 113) points out, artefacts, tools or models, can be important components in a case study. (The only seam allowances are those on the body toile around the scye and to join the front section to the back (chapter 6A); and, additionally, around the sleeve crowns in chapter 8.)

It is anticipated, because of the intricate nature of the study, that each subsequent element and stage of development, will expand in complexity, each incrementally underpinning the next in a series of representation models, trials, analyses, iterations and evaluations to ascertain their merits.



## **Chapter 6 —**

### **Scye and Sleeve Development**

#### **6.1 Introduction**

The previous chapter recognised five sleeve parts/elements which are combined to construct all in-set sleeves - each sleeve style represents a unique combination of these parts and elements. The five sleeve style/design case studies: straight, tapered – a second fabric described in chapter 8, flared, Leg of Mutton and tailored, are therefore all represented in portions of each of the subsequent five parts/elements descriptions.

In order to function at an optimum level, each part and element requires a suitable and unique design/pattern construction method. All of the construction methods need to operate individually and brought together into a united design system. This thesis chapter describes, incrementally, the scye, sleeve silhouette, elevation and crown parts/elements (fabric fullness and drape are discussed in chapter 7) which form the design and pattern making processes.

Since it is expected that the design and pattern making system in its entirety will be complex, it is deemed necessary to separate, consider and describe each part or



element incrementally; each is therefore assigned its personal chapter 6 part and letter (6A, 6B, 6C and 6D). Fabric characteristics, explained in chapter 7, are introduced periodically as they relate to the investigated area.

Because the sleeve fits directly to the scye (arm-scye or armhole) it is the first of the parts or elements which needs to be defined, discussed and constructed. The remaining parts or elements are investigated in the order previously applied as: sleeve silhouette, sleeve elevation, sleeve crown and fabrics. Chapter organisation:

- Chapter 6A. The scye is the line to which the sleeve is attached to the garment body. The formation of the ten-sectioned scye circumference is a fundamental part of a unique construction process. None of the sleeves can be described or constructed prior to the formation of the scye.
- Chapter 6B. Sleeve styles are contained within two basic silhouettes and an inversion. Trials confirmed that the method of sleeve construction was compatible with the scye to which it was meant to fit. The adoption and adaptation of engineering drawing methods to produce in-set sleeve silhouettes is not previously documented in any sleeve drafting manual.
- Chapter 6C. In order for the arm to articulate with the sleeve style, the sleeve must comprise a decided amount of elevation and/or drape. A number of exclusive (to this thesis) solutions are discussed.
- Chapter 6D. The sleeve crown fits into the scye with various shapes of crown, producing the style silhouette. This part of the chapter explains, using a newly-created process, the formation of the crown shape using a multi-view drafting technique. Current drafting methods do not explain how the crown curvature – a non-developable surface, is formed or how it is adaptable to other sleeve designs.



## **Chapter 6A —**

### **Scye and Sleeve Development: Scye**

#### **6.2 Introduction**

Five parts/elements were identified in chapter 5. The scye, arm-scye or armhole is the first to be defined and discussed. The scye has a certain shape, is aligned at an angle to the body centre line, has a lateral inclination towards the arm and has to be controlled to allow the sleeve to fit. The scye is fundamental to the construction of the sleeve; therefore, this chapter part describes the processes involved in scye formation.

#### **6.3 Body toile preparation**

For this research, the distorted two-dimensional scyes depicted in current sleeve drafting methods (for example; the Bell sleeve depicted in Figure 2.10, p. 39) are inappropriate for developing sleeves. The scye has to be an accurate size and shape and have the correct orientations. A scye template, taken from the modelled toile (trial garment), is the only shape suitable for sleeve development. To achieve the scye template a hybrid fabric modelling and pattern flattening method (see Figure 6.5) is utilised.



For ready-made garments, it is assumed that the right and left sides of the body are symmetrical. It is therefore necessary to use only one side of the mannequin; in this instance it is the left side. The vertical centre front and centre back lines for the left section of the mannequin are established; these are placement lines for the toile, to confirm correct balance of the garment and sleeve. It is also essential that a preferred horizontal line be selected. As this garment terminates at the waist, the bust line is seen as the ideal horizontal. All three lines, centre front (CF), centre back (CB) and bust line were created using a height measuring gauge (Figure 6.1). An instrument not usually associated with garment design (more usually, for engineering, a Vernier height gauge or an anthropometry set of gauges for figure measuring) therefore it may not be familiar to some designers or pattern makers.



Figure 6.1. Height measuring gauge for toile and pattern balance

(Part of an R. Martin set of gauges, TSUTSUMI Co. Ltd)



To ensure fabric stability, fused calico is used for the body/scye section. It is measured for approximate size and prepared with the vertical centre front, centre back lines and a bust line perpendicular to the two verticals. The toile is then modelled on the mannequin, matching the lines on the fabric with the lines on the mannequin – front and back (Figure 6.2 '1' and '2' respectively).



(1) Front toile

(2) Side/back toile

Figure 6.2. Modelled toile

### ***Scye: Measuring and sector points***

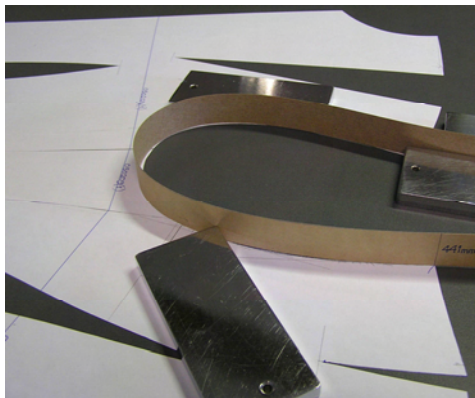
A 25mm card-strip (scye measuring band) is cut (Figure 6.3) to measure the scye length. The individual prototype scye and related card-strip is assigned day, month and year (DMY) numbers for identity purposes.



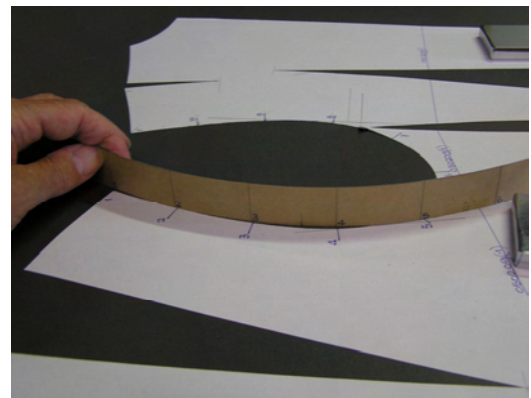


Figure 6.3. Scye measuring band 050209(1)

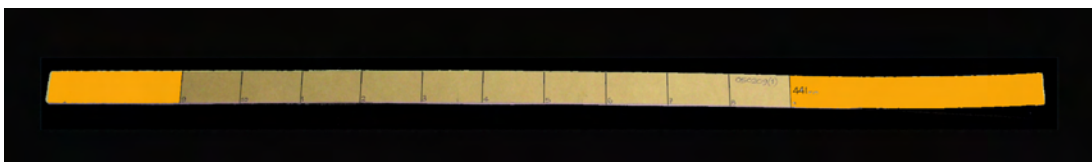
The toile is taken from the mannequin, laid flat and a front and back pattern produced from the flat toile (Figure 6.4 '1'). The total scye circumference of the flat pattern is then measured onto the card strip and divided into ten equal sectors for scye/sleeve alignment (Figure 6.4 '3'). The card strip is then re-placed to the flat body pattern. Each of the section points is transferred from the card-strip to the body pattern scye seam line (Figure 6.4 '2'). The sector points are positioned (and numbered) from the front shoulder seam line, around the front scye, under arm and up the back scye to finish at the back shoulder seam line.



(1) Front and back patterns/scye measuring



(2) Scye sector positioning

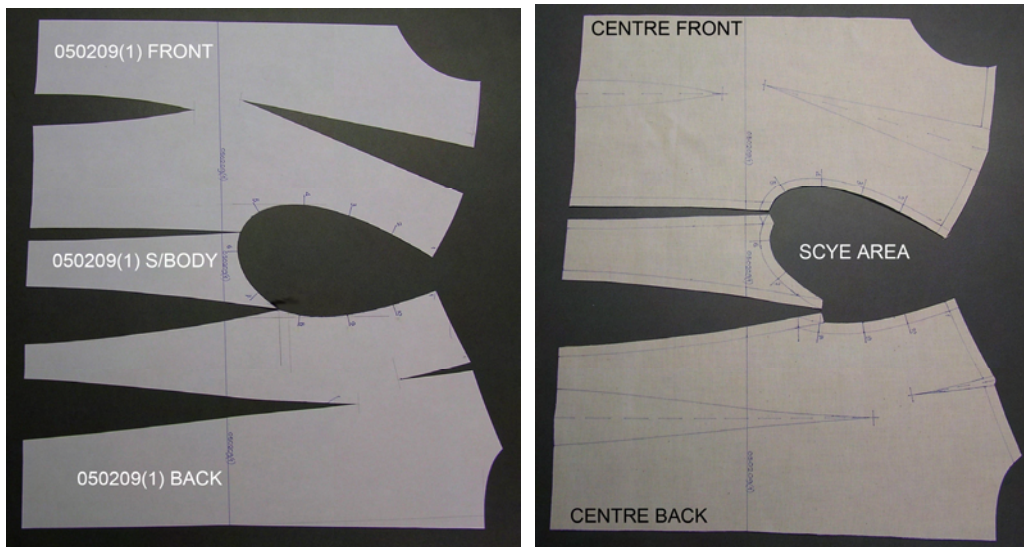


(3)

Figure 6.4. Block pattern: 050209(1) and card strip



The flat body patterns (taken from the toile) with scye sectors marked and without seam allowances is depicted in Figure 6.5 '1'. The final fused fabric toile is then created from the pattern with the scye sections marked and a 10mm seam allowances added; the darts are not cut at this stage (Figure 6.5 '2').

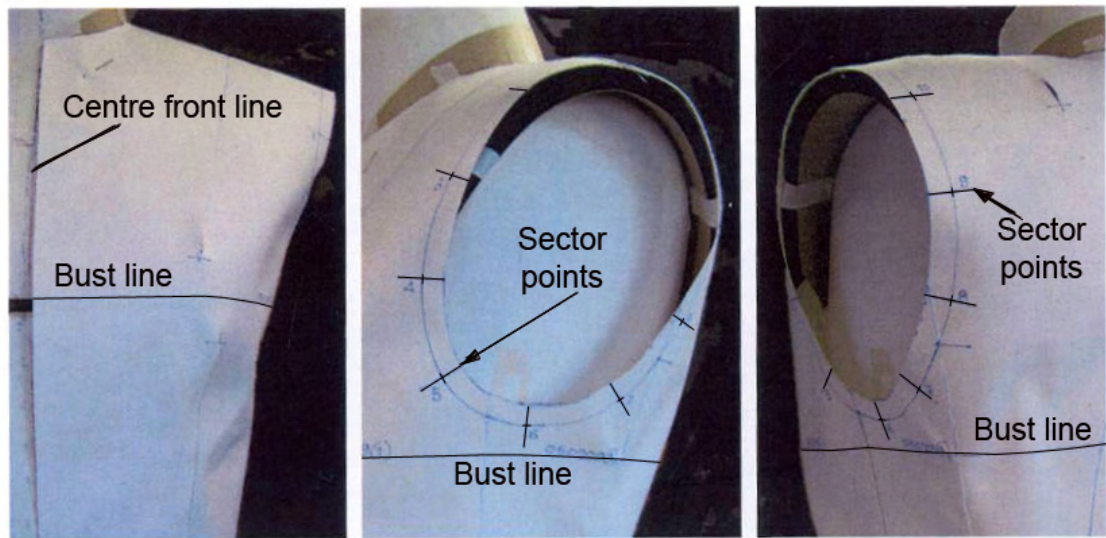


(1) Patterns (no seam allowances)      (2) Patterns (with seam allowances)

Figure 6.5. Block pattern: Number (DMY No.) 050209(1)

The toile (from Figure 6.5 '2') is then re-placed on the mannequin and aligned with the matching marks (centre front, centre back and bust line), ready for scye inclination measurements and scye template formation (Figure 6.6). Figure 6.6 '1' is the front view of scye; '2' is the side view of scye and '3' is the back view of scye - showing the sector points. To ensure a correct upper scye shape, a shoulder pad is positioned beneath the fabric (Figure 6.6 '2' and '3').





(1) Front toile and scye      (2) Side toile and scye      (3) Back toile and scye

Figure 6.6. Prepared toile placed on the mannequin

### ***Scye: Front to back orientation preparation***

For design purposes, the inclined orientation of the scye is determined to enable the sleeve to fit to the scye correctly. The forward incline of the scye (front-to-back) is established from the centre line of the body, seen as 'A' in Figure 6.7 '1'. The gauge is aligned perpendicular to line 'A' (set-square 'B' in Figure 6.7 '1'), touching the front scye at a pre-determined height.

The gauge is then moved along line 'C' (parallel with line 'A'), at the same height (Figure 6.7 '2'), to measure the distance to the back scye. The difference between the two measurements produces the front-to-back angle. The front-to-back orientation of the scye to the centre line of the body was determined to be 5° (arrow projection line on table in Figure 6.7 '2'). It is one of the most important alignment elements when designing sleeves using the new in-set sleeve design system. (This feature is not discussed in other drafting methods until Cho and Miyoshi (2005), (see Figure 6. 7 '3').





(1) Forward incline (front scye)



(2) Forward incline (back scye)

(3) Forward scye incline (plan view)

Figure 6.7. Scye: Front-to-back orientation preparation (Back view)

Source: (3) Adapted from Cho and Miyoshi (2005)

During the design and pattern development process, the drawings are aligned at a perpendicular angle to the inclined ( $5^\circ$ ) scye line; corresponding to the angle as seen in the Cho and Miyoshi (2005) plan view reproduced in Figure 6.7 '3' (inclined arrow and green shaded section at the left of figure).



### ***Scye: Lateral inclination preparation***

The lateral inclination of the scye, from the high point at the shoulder to the lower point or depth of scye line (DOS), requires confirmation as sleeve and sleeve-crown development factors. This produces the correct alignment of the sleeve with the scye and the arm (The scye inclination is not discussed in manual drafting methods).

From a static position (Figure 6.8), the height gauge is used to measure, firstly, the horizontal distance to the topmost point of the scye, at the shoulder seam line (Figure 6.8 '1'); then the distance to the base of the scye (Figure 6.8 '2') is measured from the same height-gauge position. The difference in the two measurements (41.5mm) furnishes the lateral inclination of the scye (Figure 6.8 '3') and the scye angle of 74° to the vertical.

The front-to-back orientation and lateral inclination of the scye are vital as starting points for the production of a scye template. However, in its present form, the scye is too unstable to be of use in the creation of sleeve patterns; a more rigid interpretation is required. The template, in turn, initiates the pattern generation process.





(1) Lateral inclination (top of scye)



(2) Lateral inclination (base of scye)



(3) Scye angle (74°)

Figure 6.8. Scye: Lateral inclination preparation (Back view)



### ***Scye: Shape preparation***

In order to duplicate the scye shape as a flat template, the original card-strip (Block pattern: 050209(1)) is placed to the toile scye (Figure 6.9 '1' and '2'). The card-strip, with sector points, is curved around and placed to the toiled body scye. Each of the card sector points are located at their corresponding positions on the body toile and fixed into position.



(1) Scye shape (front view)      (2) Scye shape (front/side view)

Figure 6.9. Scye: Card-strip placement (Front and side views)

To preserve the scye shape, retaining bands are constructed around the card-strip. The supported scye shape is given vertical orientation points for pattern development (Figure 6.10). The supported scye shape is then taken from the body toile and transported onto the flat for the scye template development.



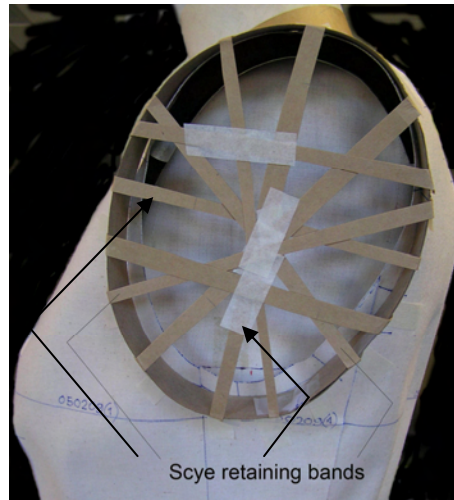
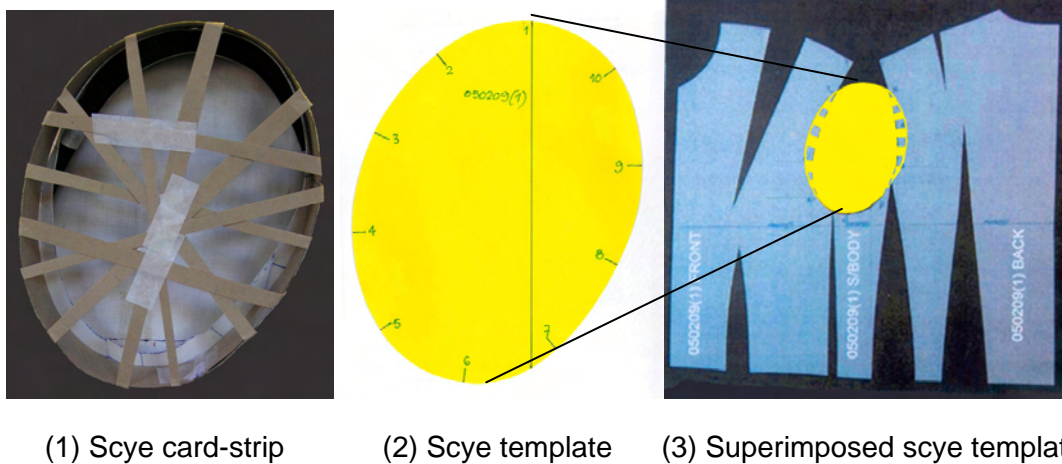


Figure 6.10. Controlled scye shape

### ***Scye: Template shape development***

The retaining-band supported card-strip form is separated from the three-dimensional toile and laid flat (Figure 6.11 '1'). The scye-shaped card-strip is then delineated on paper and given numbered sector points and a vertical alignment line. Figure 6.11 '2' depicts the scye template copied from the retained-band scye shape. The front of scye is to the right and the ten numbered sector points begin at number 1 at the top, proceeding anti-clock-wise as sector points 2, 3, 4, 5, 6, 7, 8, 9, 10 and 1. The scye template is utilised for sleeve design and pattern making purposes.



(1) Scye card-strip

(2) Scye template

(3) Superimposed scye template

Figure 6.11. Scye template shape



When the toile (front and back body sections) is laid flat, the shape of the toile scye is seen to be distorted when compared to the superimposed scye template (depicted in yellow in Figure 6.11 '3'). This is the usual, unavoidable, distorted view of the two-dimensional scye as represented in all pattern making manuals (see Kunick, 1967, p. 89). This is clear evidence that the flat scye shape is inappropriate for producing sleeve patterns unless special compensatory allowances (after trialling) are made – an imprecise method requiring additional enhancements to be effective.

## **6.4 Summary**

The mannequin and fabricated body sections were aligned using vertical and horizontal lines directly from a height gauge. The complete development of the body sections and corresponding scye were accomplished in a precise manner. Measuring and sectioning the scye was achieved using a card-strip. The angles of the scye were established for later sleeve designing. The card-strip was attached to the toile scye whilst on the mannequin and reinforced to retain the integrity of the scye shape. The supported card-strip form was then released from the toile and copied onto paper to produce a scye template – with numbered sector points.



## **Chapter 6B —**

### **Scye and Sleeve Development:**

### **Sleeve Silhouettes and Sleeve Trials**

#### **6.5 Introduction**

Chapter 5 described sleeve styles as conforming to only two basic geometric structures, these being the cylinder and cone. Chapter 6A explained the formation of the body sections, the scye area and the scye template. This chapter part explores engineering drawing methods that reflect the basic sleeve silhouettes which, for this account, are connected directly to the scye, without the benefit of crown curve and fabric fullness, which are explained in chapter 6D and 7C respectively.

All of the various contemporary scye and sleeve drafting methods rely on two-dimensional drawing methods. They represent single views, or perspectives that do not depict or reveal their processes of development from the three-dimensional sleeve silhouette to the two-dimensional draft. They are not sufficiently adaptable to contribute to a novel sleeve design and drafting system – neither are they appropriate techniques from which to construct sleeve patterns for a selection of sleeve styles.



Prior to explaining the actual engineering drawing processes, it is necessary to describe the types of two-dimensional surfaces involved in shaping sleeve silhouettes. The methods for attaining sleeve style silhouettes were depicted in developable surfaces in Table 5.4 - Morphological methods (page 137). The three basic geometric shapes, described in chapter 5, are surface forms.

## **6.6 Surfaces**

Surface forms are made from two-dimensional materials of limited thickness. Materials such as fabric, plastic, paper, cardboard and sheet metals et cetera. Surfaces have to be described in order to clarify how they will be developed. Two-dimensional templates/patterns are placed on flat materials and traced around. The outline is then cut out and formed into the required three-dimensional shape by bending, rolling or folding. Technically, when sheet metal is folded and is compressed, it stretches, becoming thinner. However, for this research it is assumed that, for the most part, fabrics are non-extensible. The curved forearm seam line of the tailored top sleeve, is an exception, it requires stretching to regain lost length.

Due to the vast array of fabrics produced for garment manufacture, only a select few participate in this investigation. They have qualities such as weight, compression and stretch et cetera that contribute significantly to the in-set sleeve design and pattern development progression. These will be discussed periodically as they relate to the particular scye and sleeve elements. However, no matter how many fabric types there are, there are only two types of surface: the developable surface and the non-developable surface. Developable surfaces are surfaces such as cylinders and cones that can be flattened onto a plane material without distorting. Non-developable surfaces are described in sleeve crown – chapter 6D.



### ***Surfaces: Developable***

Surfaces with a Gaussian measurement of zero (Hinds, McCartney & Woods, 1991) at every point are described as developable. This means that they can be constructed by bending a plane sheet material onto a three-dimensional surface. A developable three-dimensional surface (also known briefly as a 'developable') is described by Manning (1980) as able to be unrolled onto a plane without stretching or tearing, they need neither darts nor compression to attain the correct shape. Developable surfaces can be described by two equivalent ways: A ruled surface in which consecutive generators (straight lines) intersect or are parallel; or, a surface enveloped by a one-parameter family of planes. Two examples of ruled surfaces are straight sleeves and tapered and flared sleeves (cylinders and cones).

## **6.7 Engineering drawing: Orthographic projections**

One of the most important differences between pattern drafting methods and engineering methods is their (engineering methods) use of orthographic projections (multi-views, perspectives or elevations) to give an over-all impression of the three-dimensional object to be manufactured; they 'invite' a vision by the observer of the three-dimensional outcome. Whilst still depicted in two-dimensions, engineering drawings, whether first or third angle projections (See appendix B), provide a series of viewpoints of objects, each viewpoint contributing and exposing a different face of the subject. As more views are presented, a more logical approach to the whole scye/sleeve assembly is possible.

Introducing engineering drawing methods results in a divergence from the current and historical single-view perspective drafting methods that are transitional-element resistant – they do not allow for part and element variations. Since the scye and sleeve can be viewed from different directions, front, side and top simultaneously, it almost



(but not quite) resembles designing (or modelling fabric) in three-dimensions. The sleeve therefore, is substantially designed as it will appear in three-dimensions. The sleeve created at the design stage follows through to the drafting stage, the pattern stage and on to the three-dimensional fabricated end product.

### ***Engineering drawing: Sheet metal developments***

When thin metals or plastics are to be made into surface forms, development drawing methods are utilised. These methods are formulated for developing sheet materials for various types of cylinders and cones, some of which exhibit resemblances to the three basic sleeve shapes; straight, tapered and flared. It is because of these similarities between truncated cylinders, cones and sleeve silhouettes that sheet material developments relevant to this study are now described.

The drawing method, for sheet metal development, uses a system of engineering drawing which provides sheet metal craftsmen with a means of making two-dimensional (developed or flattened) template patterns. These are later manipulated from the flat to three-dimensional products. The products can be cylindrical, box-like, pyramidal shaped, conical or any such combination.

Combinations of segmented areas are used to form 'curved' pipes. Since curved pipes represent a non-developable surface they require small sections (segmented or 'lobster' bends. See appendix F) in order to be flattened onto the sheet metal; Figure 6.12 'A' depicts three views of such a pipe. Figure 6.12 'B' and 'C' illustrate two similar pipes each with a developed section 'B1' and 'C1'; the vertical ends of each pipe resembling vertical scye shapes - as does the metal pipe at 'D'. Note how shape 'B1', and especially template 'E5', resemble patterns for short sleeves. The segments of the pipe all fit together in harmony – as should a scye and sleeve.



Figure 6.12. Segmented or lobster bends

Source: Adapted from <http://www.tyharness.co.uk/taperedbend/taperedbend.htm>  
(2008)

As the sheet-metal pattern template development processes 'mirror' garment sleeve construction - from two-dimensional drawings to three-dimensional object, these drawing methods are utilised, initially, as a new sleeve designing blueprint. Currently, different types of sleeve design have a different drafting, or adaptation method. Engineering drawing methods, to produce the two sheet metal shapes, are no exception, although using fewer and more precise methods to achieve the appropriate shape.

There are three commonly used methods of sheet metal drawing that are considered for inclusion in the new in-set sleeve designing system. The three methods to develop the shape are:

- Parallel line development: used for cylinders (and for prisms)
- Radial line development: used for cones (and for pyramids)
- Triangulation: used to join different shapes (transition pieces); as an approximation method (See sleeve/arm elevation).



The final shape of the three-dimensional object (sleeve) dictates which method will be used to produce the two-dimensional pattern. Depending on silhouette, sleeves may be categorised under the appropriate basic shape. As mentioned, each style of sleeve or sleeve type, has an equivalent, basic geometric shape which must allow for the variations in sleeve silhouette, these variations are shown in Table 6.1. It is realised that sleeves are more complex than truncated cylinders or cones; sleeves do not have regular crown shapes, they are asymmetrical, the front being a different shape to the back; sleeve crowns are described in chapter 6D.

Table 6.1. Basic shape silhouettes for sleeves

Cylinders	Cones
Truncated cylinders	Truncated 'Right' cones
	Inverted and truncated 'Right' cones (truncated at one end)
	Inverted and truncated 'Right' cones (truncated at both ends)
	'Oblique' cones (See sleeve/arm elevation)
	Truncated 'Oblique' cones (See sleeve/arm elevation)

### ***Development of a truncated cylinder: Parallel line development method***

The information given by the two views of the truncated cylindrical object, front elevation and plan view produces a clear picture of the object to be made (Figure.6.13). It is circular, of a certain height and has a chamfered top edge of any particular length and angle.

To develop the truncated cylinder (blue shape on the right in Figure.6.13), the plan view has its circumference divided into equal parts. These circumference points are projected vertically onto the front elevation until they connect to the truncation line. They are transmitted horizontally onto the development diagram (to the right), which has previously been measured and divided longitudinally by the same circumference section lengths (numbered) as the plan.



Figure 6.13. Truncated cylinder (Parallel line development)

Source: Adapted from Rhodes and Cook (1975)

The junction of each of the vertical and horizontal lines on the development diagram, are joined to connect the curve of the (light blue) developed truncation. The development is a basic cylindrical sleeve pattern. The isometric view of the object (green shape to the lower right in Figure.6.13) also depicts a development from a truncated cylinder. Although the cylindrical, truncated figure has its uses, a more refined multipurpose figure is required for the majority of sleeve outlines.

#### ***Development of a truncated Right Cone: Radial line development method***

The truncated right cone (apex directly above the centre of the base), with its slanting sides, may also be an adaptable sleeve drafting proposition. The truncated cone diagram (frustum) (Figure 6.14) shows the cone shape with an angled, truncated top edge.



Figure 6.14. Truncated cone (Radial line development - stepping-off method)

Source: Adapted from Rhodes and Cook (1975)

The numbered divisions on the plan are projected on to the base of the cone and extended up to the apex through the truncation line. The apex is used as a pivot point to mark the curved base line from point 1, on the cone's base line. The divided and numbered sectors, measured from the base circumference, are then stepped off to find the curved base line length. The stepped and numbered marks on the curved base line are then drawn to meet the apex (radial lines).

At each point, where the projected lines to the apex meet the truncation line, a line is drawn across the cone parallel to the base line. Each of these truncated lines is then arced through the development area. The cross points (where these lines bisect their numbered counterparts from the curved base line) are then joined to form the truncation



line of the development. Note how the straight truncation line of the front elevation has been transformed in to a 'crown-shaped' curve on the development (light blue) pattern.

Both the truncated cylinder (Figure. 6.13) and the truncated cone (Figure. 6.14) give developed template shapes that are analogous to the drafted shapes of in-set sleeves - the straight sleeve and the flared sleeve. However, not all sleeves are straight or flared at the hem (base line); they may be tapered towards the bottom edge, when this shape is required, the cone is inverted.

### ***Development of an inverted and truncated (at one end) Right cone:***

#### ***Radial line development method***

Figure 6.15 shows how a basic, inverted and truncated cone shape may appear before adaptation into a more practical profile. The inverted, truncated cone is developed in a similar manner to the previous truncated cone, except inverted, with its section lines projected down to the pivot point rather than up. The straight truncation line, level with the base line in this instance, is now in the lower edge, with the plan view above the cone base. Using the 'apex' as a pivot point, an arc is expressed on the developed diagram to describe the base line and length. The process is then repeated (as illustrated in Figure 6.14) to procure the radial lines and the truncation curve, which in this instance is a regular arc.



Figure 6.15. Inverted truncated (at one end) cone (Radial line development)

Source: Adapted from Rhodes and Cook (1975)

***Development of an inverted and truncated (at both ends) Right cone:***

***Radial line development method***

Truncating the cone at both ends produces an enhanced functional silhouette. The lower truncation is a line parallel to the upper 'base' line. The higher truncation is on an angle (Figure 6.16). The two truncations are dealt with in a similar manner to the other two demonstrations. All of the aforementioned elevations play their own distinct roles in making the complete vision of the cone. Figure 6.16 could be interpreted as a tapered sleeve with a very full crown line (Leg of Mutton sleeve). Right cones, with the apex directly above the centre of the base, can be contrasted with cones that have the point located outside of the centre of the base. They are identified as 'oblique' cones.



Figure 6.16. Inverted truncated (at both ends) cone (Radial line development)

Source: Adapted from Rhodes and Cook (1975)

## **6.8 Scye and sleeve: Preliminary simulated unification**

Truncated cylinders and cones were identified as simplified outlines of in-set sleeves. Preliminary drawings representing the three basic sleeve silhouettes are executed to illustrate initial scye and sleeve unifications. All were treated as developable surfaces formed from a circular base, without fabric fullness allowances.

### ***Straight sleeve silhouette: Short (truncated) sleeve***

The straight sleeve in Figure 6.17, is developed by the parallel line development method from a simplified truncated cylinder (the truncation line represents the scye). The drawing to the left (coloured light blue) represents the front elevation of a coat with adjoining sleeve (coloured light red). Beneath the sleeve is the plan view of the sleeve, divided into ten equal parts around the circumference. The construction technique used



for this sleeve duplicates the truncated cylinder (Figure 6.13) process. The developed in-set sleeve pattern (mid-tone red) is on the right.

Figure 6.17. In-set sleeve pattern development: Straight sleeve

Source: Adapted from Rhodes and Cook (1975)

***Flared sleeve silhouette: Short (truncated) sleeve***

Figure 6.18 illustrates a flared sleeve using the radial line development method; it has the addition of a front elevation coat and a scye line (truncation line). The development process replicates that in Figure 6.14. The mid-tone red pattern to the right is the developed flared in-set sleeve pattern.



Figure 6.18. In-set sleeve pattern development: Flared sleeve

Source: Adapted from Rhodes and Cook (1975)

***Tapered sleeve silhouette: Short (truncated) sleeve***

The tapered sleeve (Figure 6.19) is a reverse projection of the previous flared sleeve, similar to the truncated cone in Figure 6.15, as is the development process. The junctions which form the crown curve of the in-set sleeve development pattern (mid-tone red). All three preliminary unification-development simulations represent the basic foundations from which the various in-set sleeve styles will progress.



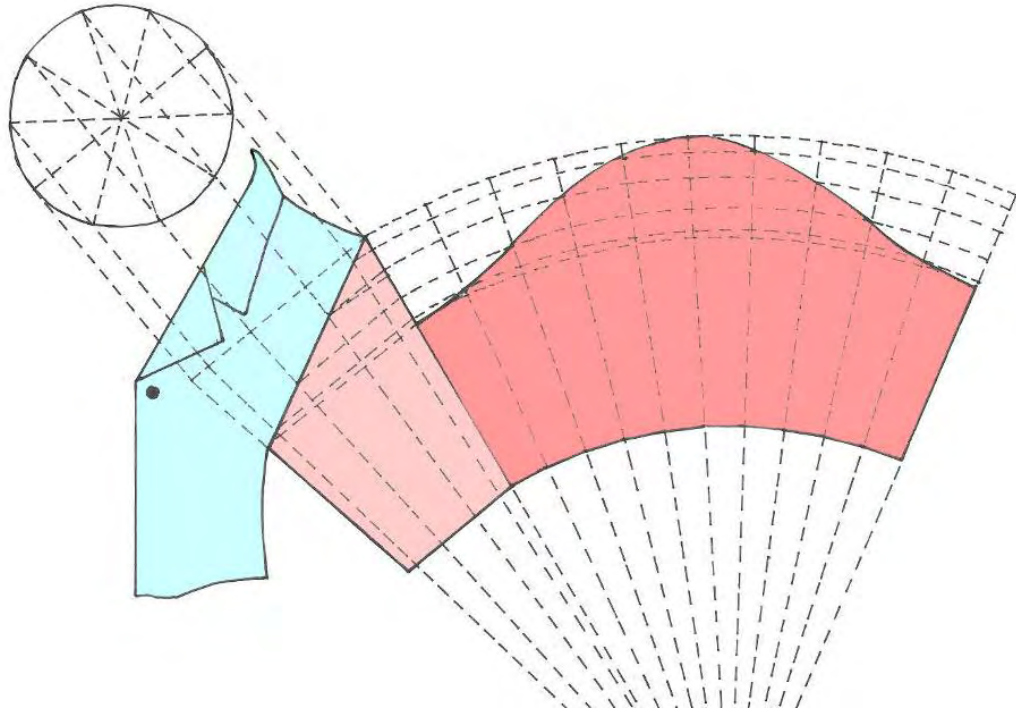
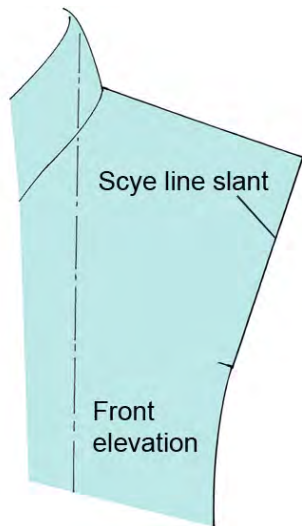


Figure 6.19. In-set sleeve pattern development: Tapered sleeve

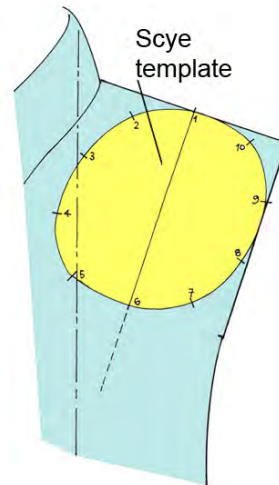
## 6.9 Scye and sleeve: Cylindrical/straight sleeve development

The forthcoming figures represent the development method for a cylindrical sleeve with an arbitrary lateral arm slant. Quantified arm slants for tapered and flared sleeves (sleeve elevations) will be discussed in chapter 6C. The scye depicted in Figure 6.20 '1' (slanted line on the blue front) is seen directly from the front (front elevation), in perspective; the true scye height is measured as a vertical. The first objective is to place the scye template (yellow shape from the body toile; as depicted in Figure 6.11 '2') onto the front elevation, with its vertical balance line aligned with the scye inclination. This is a side elevation view, as seen from a perpendicular angle to the scye slant line (Figure 6.20 '2').

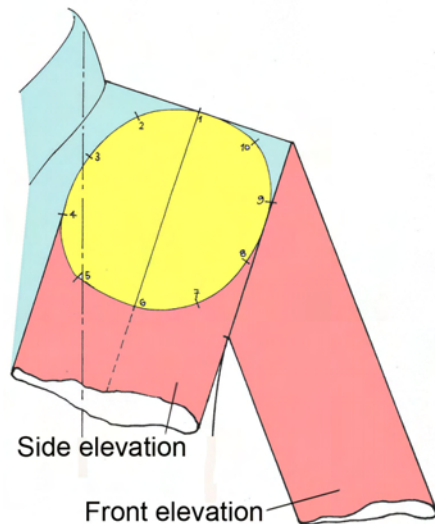




(1) Front elevation (body)



(2) Front elevation (body and scye)



(3) Front elevation (body, scye and sleeve)

Figure 6.20. Cylindrical/straight sleeve development

The sleeve (mid-tone red) is allocated its position, elevated out from the body to the right of the diagram (Figure 6.20 '3'). (The sleeve is also shown as a diagonal side elevation view, on the blue body, from the yellow scye shape). There is no sleeve crown fullness in this exercise therefore both sleeve drawings are aligned directly from the shoulder and through to the bottom of the scye. The depth of scye (DOS) is not calculated, it is merely a by-product of the pattern development process.



All of the sector points are projected across from the scye shape (yellow) to the scye line slant; their true front elevation positions (Figure 6.21 '1'). The sector points are then projected down the slanted sleeve (front elevation view). All of the sector points are also projected down the side elevation view sleeve for ease of measuring. The sector points are also projected across the side elevation view of the sleeve, perpendicular to the outer edge of the sleeve, producing a grid (Figure 6.21 '2').

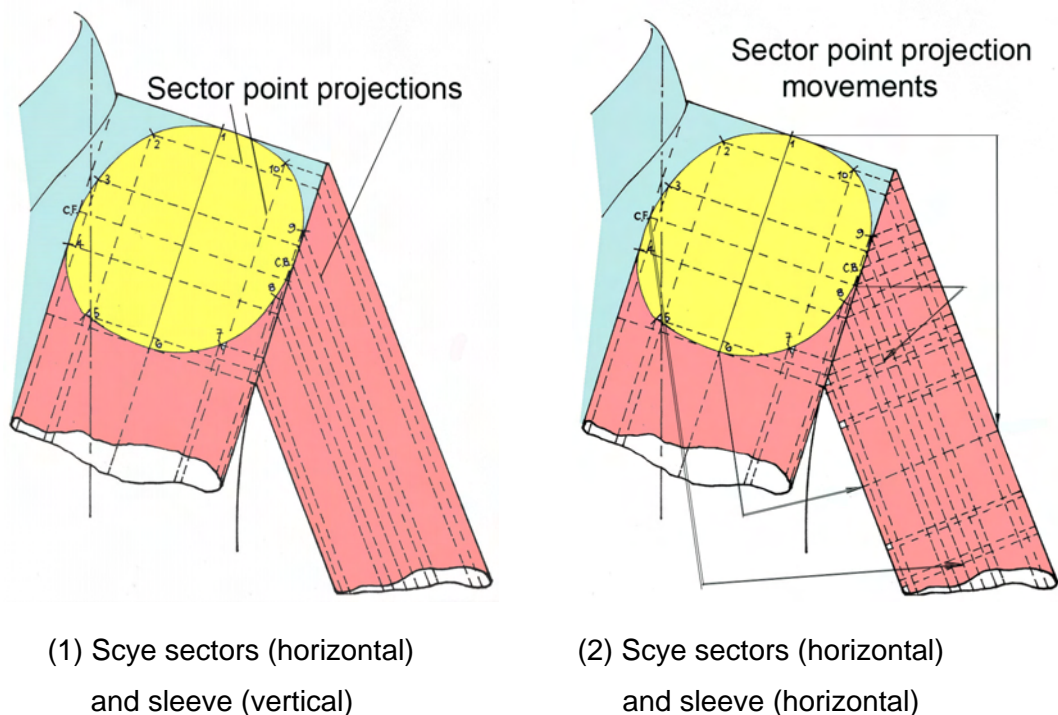


Figure 6.21. Sleeve development: Projected scye sector points

The plan view shape of the sleeve (white oval) are extrapolations of each sector width (as measured on the yellow scye template), measured length-wise down the sleeve (from the same nominated height), along the previously projected lines down the sleeve from the scye slant. Joining the intersecting points produces a grid from which the white oval plan view of the sleeve is defined (Figure 6.22). The circumference and sector measurements of the white plan view of the sleeve, provides sector widths and total in-set sleeve pattern width of the pattern development.



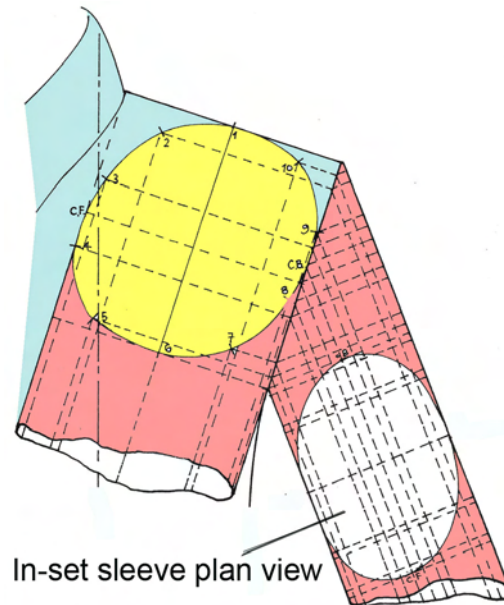
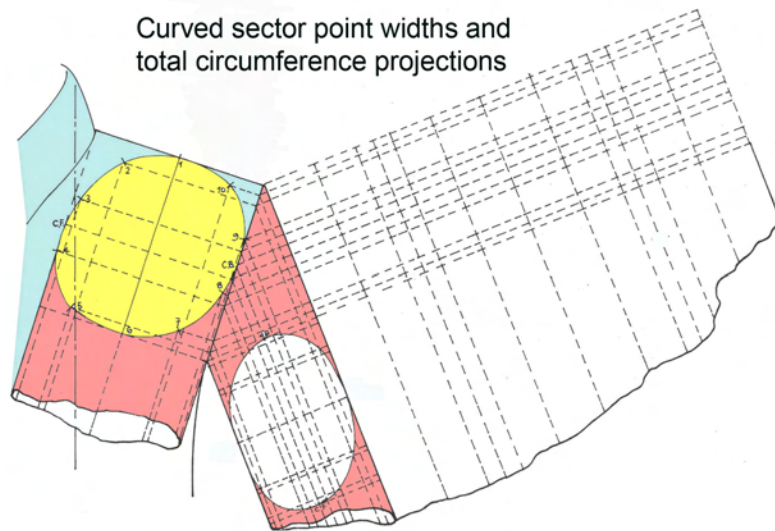


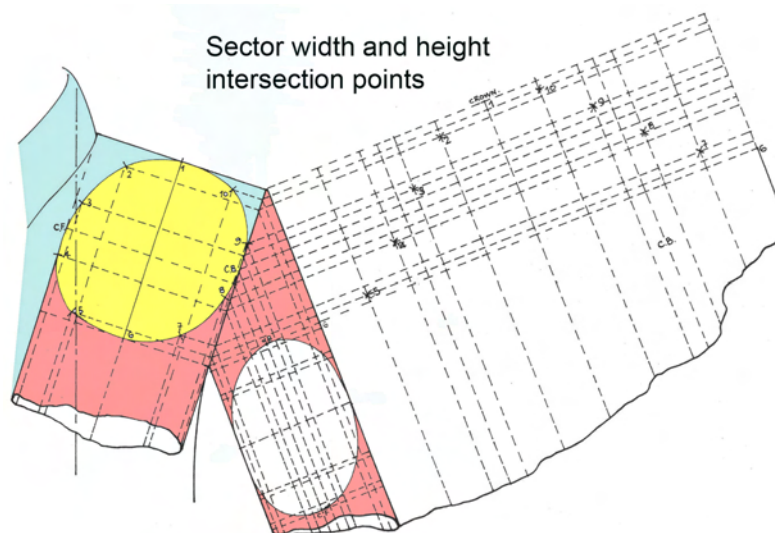
Figure 6.22. Sleeve development: Sleeve and scye (Plan views)

There are two sets of measurements required to develop the sleeve pattern. The first set of measurements comprises the sector point heights, which are projected from the scye slant, to the right of the front elevation sleeve (perpendicular to the outer edge). This automatically determines the crown height (no fullness allowances) and all the sector heights (Figure 6.23 '1'). The second set of measurements involves the curved lengths between each of the sector points depicted in the white oval plan-view of the sleeve. Each of these sectors is measured along the appropriate, numbered and projected sector line – out to the right of the sleeve. These points are then angled upwards to form a grid (Figure 6.23 '1'). The intersection points establish the sleeve crown curvature (Figure 6.23 '1').





(1) Sleeve pattern grid

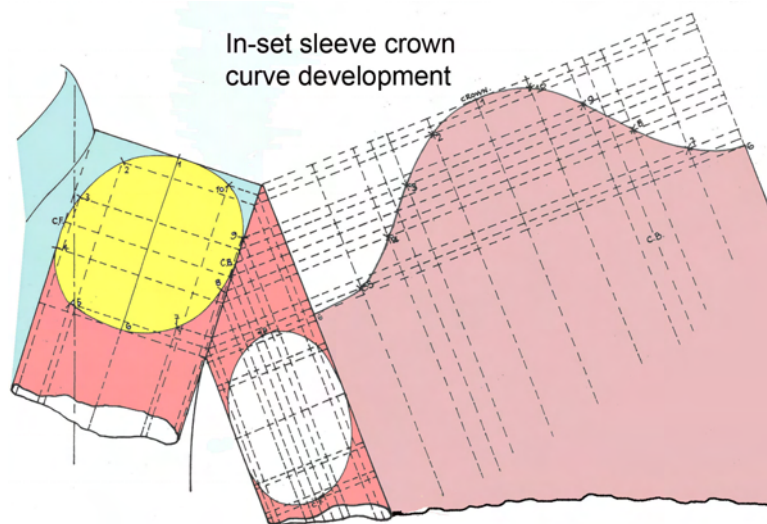


(2) Sleeve pattern grid with crown curve sector points

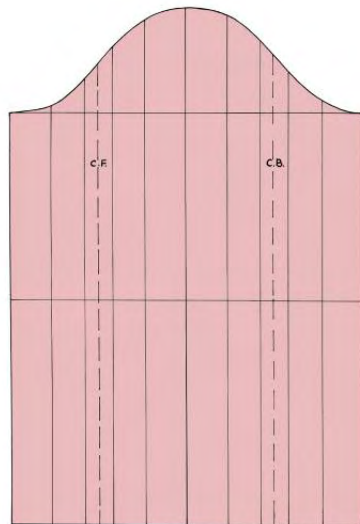
Figure 6.23. Sleeve pattern: Sector development

The intersected points are joined with a curved line to form the developed sleeve crown shape, including sector points, as illustrated in Figure 6.24 '1'. The fully developed sleeve pattern is revealed in Figure 6.24 '2', ready for attachment to the three-dimensional scye. The sector points arranged around the sleeve crown will match the scye sector points during fabrication to assure correct alignment of both scye and sleeve.





(1) Crown curve of sleeve pattern



(2) Sleeve pattern (no seam allowances)

Figure 6.24. In-set sleeve pattern development and sleeve pattern

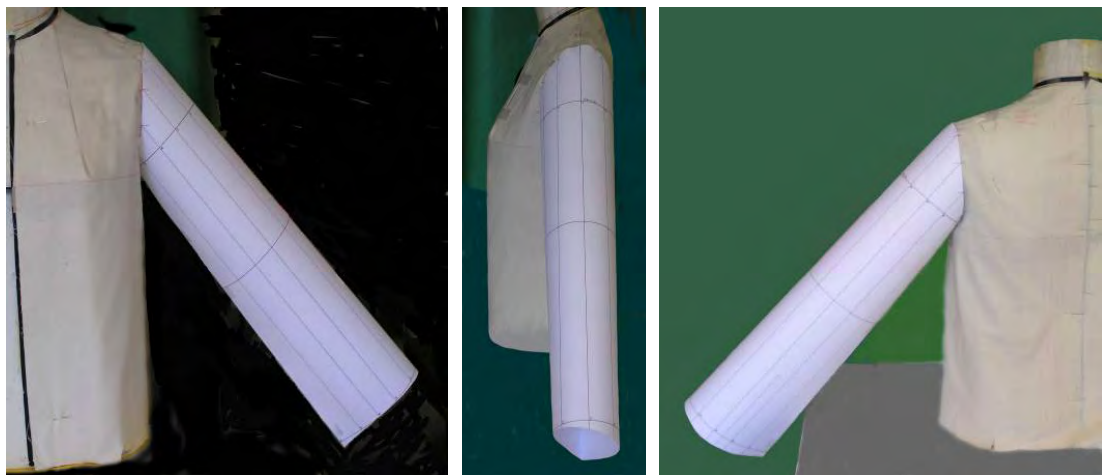
### ***Scye and sleeve: Cylindrical/straight sleeve development trial***

The body and sleeve patterns from the cylindrical/straight sleeve development process are used to produce a trial (toile). As a means of eliminating any distortions that would be apparent if fabric were used, the truncated cylindrical/straight sleeve development with sector points, was copied onto paper. The paper sleeve was then cut out and



attached to the original body toile. Each sector point of the sleeve matches its corresponding sector point on the scye.

The results, shown in Figure 6.25 '1' (front elevation), '2' (side elevation) and '3' (back view), identify the scye and sleeve as being compatible and correctly balanced. The total scye circumference and the sleeve crown circumference being equal.



(1) Sleeve (front elevation)

(2) Side view

(3) Sleeve (back view)

Figure 6.25. Fabricated cylindrical/straight in-set sleeve (one-piece)

## 6.10 Summary

It has been observed that certain three-dimensional objects represented in two-dimensional drawings such as truncated cylinders and cones, reflect the basic shapes of sleeve designs. The two-dimensional drawings resonate with comparisons to straight, flared and tapered sleeve silhouettes (devoid of crown fullness). The premise of this exploration was that the methods of producing three-dimensional sheet metal objects from two-dimensional images could be adapted to the designing and pattern-making of in-set sleeve designs. They are unlike contemporary sleeve drafting methods expressed in pattern making handbooks which change with each and every author and each sleeve style.



The process of creating a method for the unification of scye and sleeve, to form basic sleeve silhouettes was investigated. The retention of the scye shape, from a trial garment on the mannequin, was realised with a scye-shaped band supported by a reinforced banded structure. Scye sector division points were translated onto the scye band for greater accuracy. Removal of the scye band enabled a flat scye shape, with sector points, to be produced.

The inclination of the trial garment scye was calculated for inclusion in the orthographic projections of the sleeve pattern developments. Trials were undertaken to confirm that the developable methods would work without regarding the problems related crown curvature and fabric fullness.

Preceding crown curvature and fabric fullness, there is one other topic to consider; the problem of sleeve/arm elevation. This is necessary as it has a direct influence on the sleeve crown shape; arm and sleeve elevation is discussed in the next chapter part.



## **Chapter 6C —**

# **Scye and Sleeve Development: Sleeve Elevation**

### **6.11 Introduction**

The fabricated (paper) cylindrical/straight sleeve trial (Figure 6.25 in chapter 6B) is seen to be in complete accord with the scye (no crown styling or fabric fullness). It also has a certain amount of arm elevation as characterised by the lateral sleeve angle. This chapter continues by discussing arm/sleeve elevation. This variable sleeve element is explored to determine how it functions and how it is introduced into the patterns.

As with the development of the straight or parallel sleeve in Chapter 6B, the following examples of tapered and flared sleeves are constructed from paper to reduce distortions. They also have no fabric fullness allowances - as had the previous straight sleeve in Figure 6.25.

Arm elevation in a garment is either an unrestricted or limited function of the sleeve. There are many sleeves (and patterns) which have numerous unrestricted arm



articulation/angle possibilities for informal sleeve styles (shirt types, for example). There are fewer possibilities for the more restricted formal/tailored sleeve variations. Interleaved between these two types of sleeve are various degrees of sleeve function and fit. The arm, and sleeve, can be raised in two distinct directions; either laterally or laterally/forwards.

## **6.12 Sleeve elevation**

The following description is an account of how contemporary sleeve drafting may explain the problem of sleeve elevation:

After fabrication, the seam around the scye and sleeve is firstly unpicked, leaving a 'hinge' at the top. The sleeve is then raised to the required angle (elevation angles are rarely, if ever, discussed in contemporary drafting). The green coloured sleeve in Figure 6.26, has been raised from its original position – which was joined to the under arm point at the depth of scye (DOS) line. This allows the fabric sleeve to pull away from the body by various degrees as the arm and sleeve are raised. The result is the formation of a gap (depicted as the red section in Figure 6.26) between the scye and the sleeve, from the shoulder down to the under arm points and tapering to the sleeve hem.

In the process of elevating the arm, the under arm length 'A' on the green sleeve, is no longer adequate to join to the DOS line. The sleeve requires lengthening from the sleeve hem to the under arm point at the DOS line, to form the under arm length 'B' on the filled-in reddish coloured sleeve (the crown area, from the shoulder to the DOS line, also has to be filled-in). This in turn raises the depth of crown (DOC) line, measured at a right angle from top edge of the sleeve, to align with the under arm point. (It may be noted that in this cutting manoeuvre, the over arm length, from shoulder to the hem line, does not shorten).



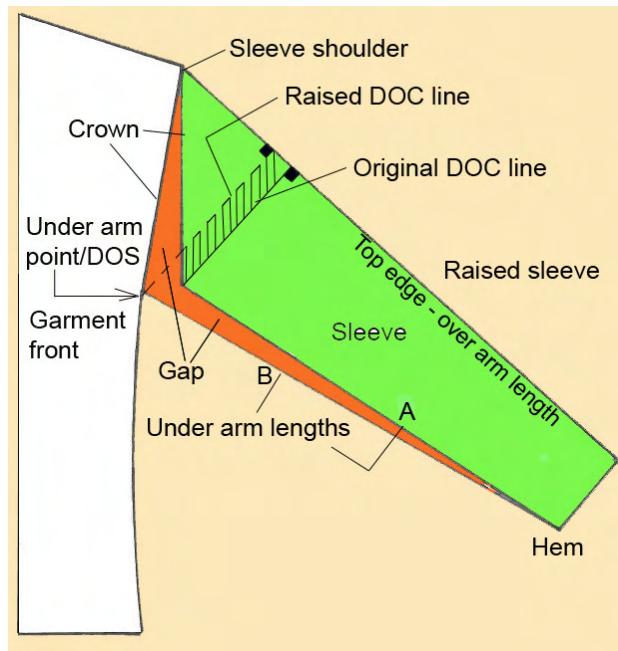


Figure 6.26. Required sleeve elevation increase

In addition to raising the DOC line, extra sleeve width is created, this maintains the original crown length to fit into the scye seam line. However, the only length that has been measured is the under arm length from the hem to the DOS, from which the crown is shaped up to the sleeve shoulder. There are few, if any, registered intermediate sleeve points between the shoulder and the DOC, therefore the actual crown shape is only an estimate. The non-existence of intermediate points has to be rectified. In the new in-set sleeve design system, intermediate points are positioned every few centimetres – ten points in all - to accurately produce the actual crown shape; more points may be added for greater accuracy.

### ***Sleeve elevation: Lateral arcing***

When sleeves demonstrate lateral elevation they usually involve the whole circumference of the sleeve. This means that the entire depth of crown (DOC) line is raised, lengthening the whole sleeve area below this line and shortening the area above it. Sleeves may be elevated laterally to any practical angle consistent with the sleeve



style and the wearer. The straight (cylindrical) sleeve style elevation angle (Figure 6.24; chapter 6 B), generates a certain depth of crown (DOC) height and a crown shape to match and fit the scye. Each variation in elevation angle creates a different DOC and crown shape.

Each variation in sleeve style and elevation angle generates a new combination of elements and, a new problem of sleeve pattern construction. However, in the conclusions to chapter 6B, it was determined that the depth of crown is an unnecessary element within this research into an in-set sleeve design system. Therefore, to allow a greater arm and sleeve elevation in a lateral direction only (Figure 6.27), it is necessary to determine the lengths of the ten sleeve section points from the scye to the sleeve hem (as depicted in the paper sleeve in Figure 6.25).

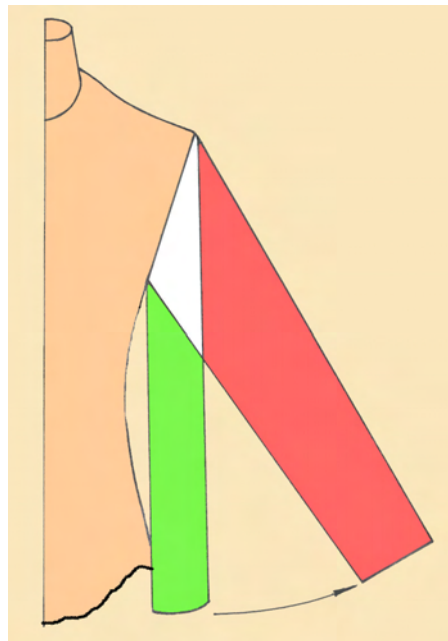


Figure 6.27. Arm elevation: Lateral arcing

The straight sleeve is constructed using the parallel line development method. This method produces a consistent sleeve sector length of DOC line to hem, around its circumference (although the hem may be shaped for style). The flared and tapered



sleeves are constructed using either the radial line or triangulation method. This is not really problematical, unless the pivot point lies outside the base circumference of the sleeve hem. When this is the situation, each sleeve sector length (scye line to hem line) has to be calculated. This necessitates constructing the sleeve by another method – an oblique cone method.

### ***Sleeve elevation: Triangulation development method***

Sleeves may not consist of convenient symmetrical shapes - they may be asymmetrical, therefore an alternate drawing method may be required from those of the parallel and radial line development methods. To define the triangulation method, an oblique cone is firstly described. A cone that does not have its apex directly under the centre of the base is called an oblique cone (Figure 6.28).

Boundy (1992) defines an oblique cone as: *‘a surface which has a circular base and a curved sloping side which radiates from a point not situated vertically above the centre of the base’*. (p. 266)

Since this type of cone has varying slant heights it is more complicated to construct than the right cone (apex in centre of base). The triangulation development method takes into account the inconsistent lengths of the radial division lines, which are important for the correct developed shape of the object (sleeve). The ‘true’ length of each radial line is not apparent when viewed either from the top or at an angle, unless the angle is 90°. (Also see warped-surface cone in appendix B)



Figure 6.28. Inverted truncated oblique cone (Triangulation development)

Source: Adapted from Boundy (1992)

The method to develop the pattern for the oblique cone is as follows:

The height of the cone is Apex to 0 on the front view and Apex-2 on the true length diagram (diagrams B). Apex-1's (radial lines) on the plan view (diagram A) are 2-4 on the true length diagram, along line 2-3. The true lengths of the cone's radial lines are Apex-4 (the hypotenuse of a triangle) on the true length diagram.

The first line of the developed pattern A-0 (diagram C) is the same as on the front view. Apex-4 on the developed pattern is the next true length, with 0-4 being a section of the plan view base circumference. Apex-0, 0-4 and Apex-4 are the sides of a triangle. The



process is repeated for the other sections. The same process is used for the truncation lines which are projected onto the true length diagram from the front view.

### ***Sleeve elevation: Tapered sleeve, lateral arcing***

#### ***Triangulation development method***

The tapered sleeve follows the same principles laid down in the Inverted truncated oblique cone, radiating from an apex and using a true length diagram. The example, Figure 6.29 '1' is the planning stage of the sleeve which has a circular scye and hem (for continuity purposes) and a given elevation angle of  $45^\circ$  to the top edge of the sleeve.

The true length diagram (Figure 6.29 '2') produces the required lengths of the sector lines for the whole height from the apex and also the sector heights for the sleeve pattern. The sleeve pattern is depicted in Figure 6.29 '3' – (not to scale). Note how the hem line is curved; this is a result of the hem being set at a right angle to the outside edge of the sleeve, therefore the sectors are not the same distance from the apex. The sleeve depicted in Figure 6.29 '4', '5' and '6' is constructed from paper to reduce deformation.







## ***Sleeve elevation: Flared sleeve, lateral arcing***

### ***Triangulation development method***

The reverse of the tapered sleeve is the flared sleeve, the same, although reversed, triangulation method is still valid. The previous tapered sleeve diagram has a circular scye and hem; however, sleeves may have more of an ovoid description. The flared sleeve in Figure 6.30 has an elevation of  $45^\circ$  to the top edge of the sleeve and ovoid scye and hem shapes. This necessitates a scye template (yellow shape) which has the sector points projected onto the scye line. The outer edges of the sleeve converge at an apex. From the apex, each of the sector points on the scye line is extended through the sleeve length to the hem line.

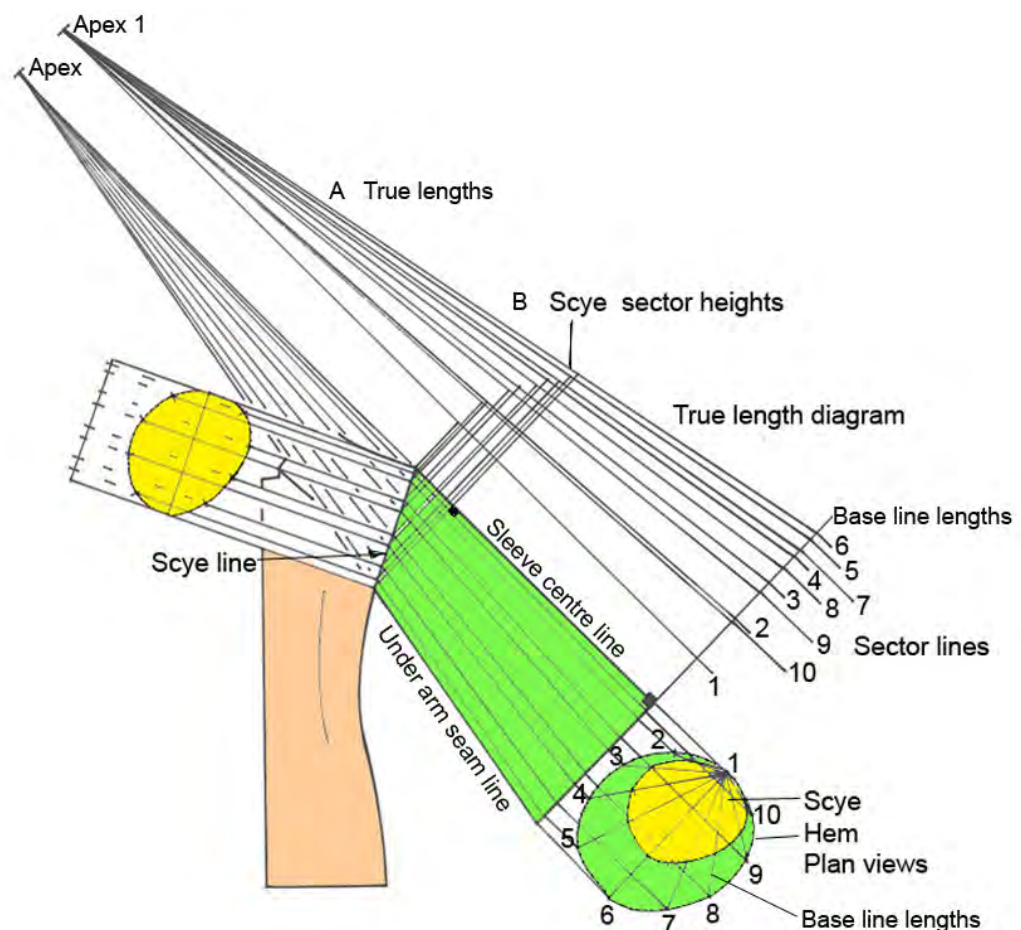


Figure 6.30. Flared in-set sleeve (one-piece) (Triangulation development)



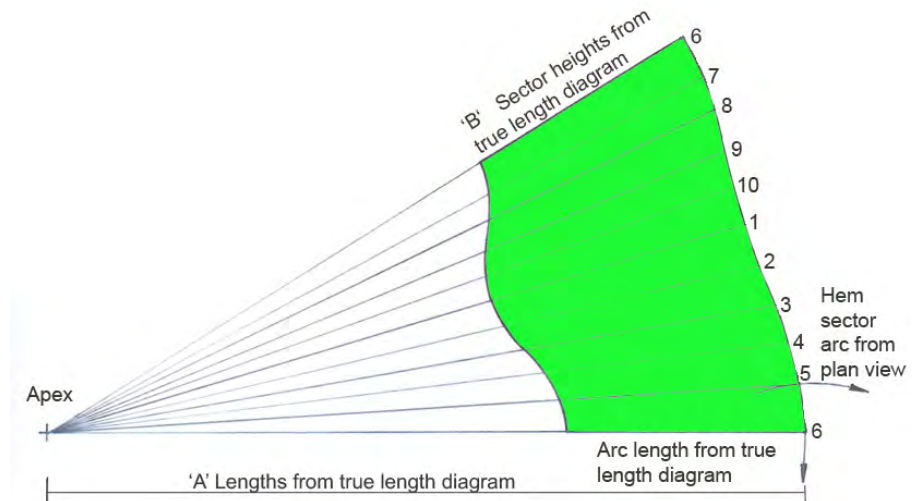
The shape of the plan view scye is a combination of sector widths measured from the sleeve centre line to the scye line edge and the sector widths on the scye (original yellow shape on the front elevation). The lines from the apex, reaching down to the sleeve hem line are projected downwards, perpendicular to the hem line.

To produce the scye plan view (lower yellow shape at the hem), the scye widths and heights are measured from the side elevation shape (yellow shape in top left). Lines radiate from sector point 1 (of the scye plan) through each sector point on its circumference. The junction of these lines and the lines from the hem line produce points for the circumference curve of the hem in the plan view.

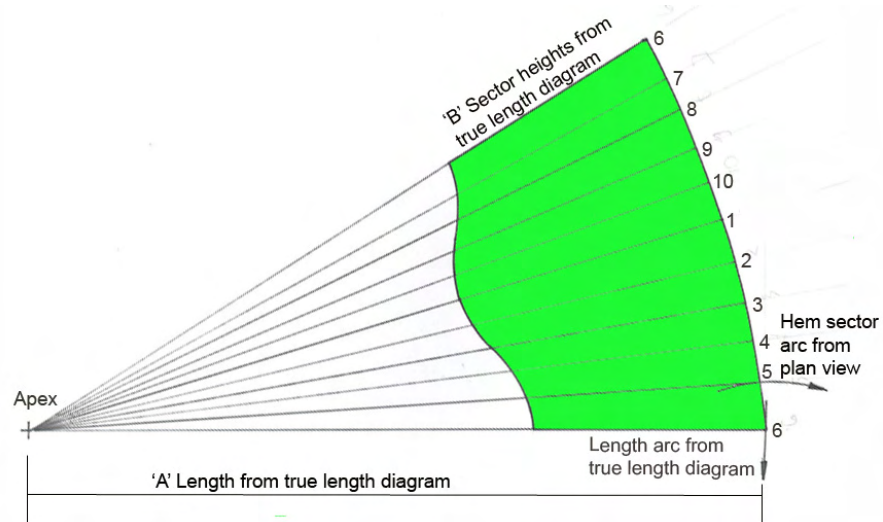
The true length diagram height (Apex 1 - 1) is a right angle from the sleeve hem line. Each of the radiated lines on the plan view, from point 1 through the scye sector points to the hem sector points, form the base line lengths for the true length diagram. The lines from Apex1 to the base line are true lengths. Projecting each sector point on the scye line across to the true length diagram produces the lengths of the sectors for the sleeve pattern from base line to B.

The sleeve pattern (Figure 6.31 '1', '2') starts with length Apex - 6. The width of the sector 6 - 5, on the plan view hem, is arced from 6. The true length of 5 is measured and arced from the apex to give a triangle for that sector. The process is repeated for each sector. To form the crown shape, the true length of each sleeve sector, from base lines 'B' are measured along its respective line to establish a series of crown points. These are joined to conclude the complete sleeve pattern. The sector points around the crown join the sector points of the scye during unification (Figure 6.31 '3', '4', '5').





(1) Sleeve pattern (hem 90° angled hem from the top edge)



(2) Sleeve pattern (hem sectors are same distance from the apex)



(3) Sleeve (front view)

(4) Sleeve (side)

(5) Sleeve (back view)

Figure 6.31. Truncated oblique sleeve pattern (Triangulation development)



Note that the curve of the hem (Figure 6.31 '1') is a result of the 90° angled hem from the top edge (as the tapered sleeve). When a regular curved hem is required (Figure 6.31 '2'), the hem sector points must be at the same distance from the apex, thus changing the hem angle and subsequent construction details. The flared sleeve shown in Figure 6.31 '3', '4' and '5' is a paper representation to illustrate the scye and sleeve unification shape. Since there is no underlying arm support against gravity, the sleeve has dropped from the original angle of 45°.

The triangulation method can be used for four of the five sleeve styles. These are the tapered (shirt), Flared (Bell), Leg of Mutton and straight. The straight sleeve may use either the triangulation or the parallel line development method. The remaining sleeve, the tailored sleeve has a more complicated elevation movement; the triangulation method, however, is still utilised.

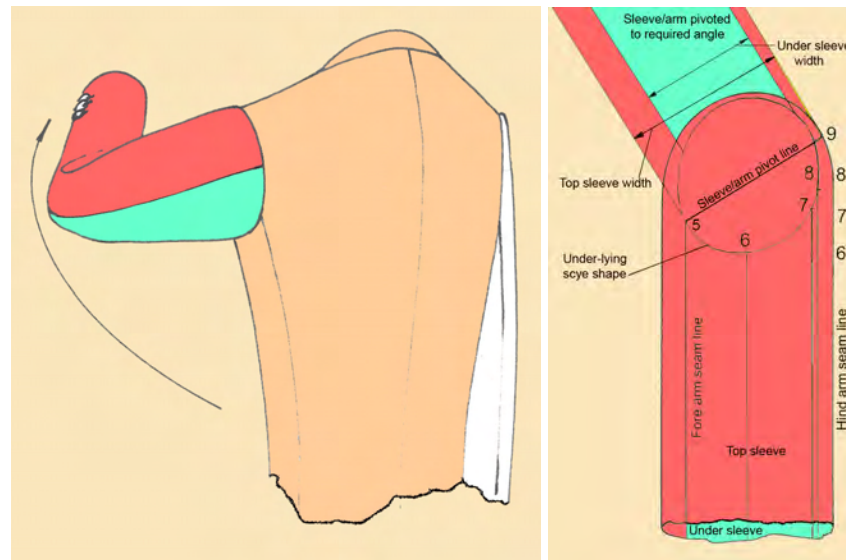
### ***Sleeve elevation: Tailored under sleeve analysis***

As the name suggests, tailored sleeves are parts of formal garments such as jackets and overcoats. They are cut as two individual patterns - the top sleeve pattern and the under sleeve pattern. Since the top sleeve pattern, being a formal entity (no elevation), has to remain aesthetically pleasing, the crown height cannot be shortened. Therefore, it is the under sleeve that accommodates sleeve elevation (Figure 6.32). Nevertheless, there are still restrictions because of the aesthetics associated with this particular sleeve style.

The top sleeve section (red zone in Figure 6.32; '1' back view and '2' side graphic) is defined as the area between the sector 5 scye and sleeve point, at the low front of sleeve, over the crown and round to sector point number 9 at the higher back scye and sleeve point (As recommended by Poole, 1936; pp. 77-90. See page 56). The area encloses the red zone of sector points 5, 4, 3, 2, 1, 10 and 9. The two points (5 and 9)



provide for as much hinged movement and top sleeve drape aesthetics as possible around the front top sleeve crown and down through the front arm. The remaining sectors (green zone) constitute the under sleeve.



(1) Sleeve arcing

(2) Sleeve hinging

Figure 6.32. Arm elevation: Lateral and forward arcing

Since the under sleeve has to be joined (sewn) to the top sleeve, at the top of the fore and hind arm seam lines, sector points 5 and 9 of the top sleeve are also the same sector points of the under sleeve. The low front sector point 5 and the high back sector point 9 allow for the necessary arm elevation length at the back under sleeve area. The under sleeve is formed of sector points 5, 6, 7, 8 and 9.

Normally, for less formal type of sleeves, all of the sectors, from 1 to 10, are involved in the process. With the tailored sleeve, the usual method of arm elevation (parallel, tapered and flared sleeves) is suspended. The prime consideration of the tailored sleeve is aesthetics in both the top and under sleeve, rather than a good deal of arm movement. The top sleeve does not have arm elevation capacity, therefore consideration is only given to the arm movement of the under sleeve.



The concept for this method is to determine each of the true lengths of the under sleeve sector lines, from the scye to the hem, for a given arm elevation angle (which is different for each elevation angle). Extra length is required in each of the sleeve sector lines 6, 7 and 8, from the hem to the scye, of the under sleeve, to facilitate arm elevation and to produce the correct under sleeve pattern. The hem to scye sector under sleeve lengths for points 5 and 9 do not change.

Figures 6.33 '1', illustrates the side view of a vertically hanging sleeve (blue-coloured card) without elevation. The sector points of the sleeve 5, 6, 7 and 8, all correspond and align with their respective scye sector points. In this situation, the sleeve cannot be raised. When the sleeve is elevated, angle-hinged at sector points 5 and 9, pivoting occurs in an upward and forward motion. During this process a gap develops between the scye and the sleeve at sectors 6, 7 and 8; illustrated in Figure 6.33 '2' and '3'.

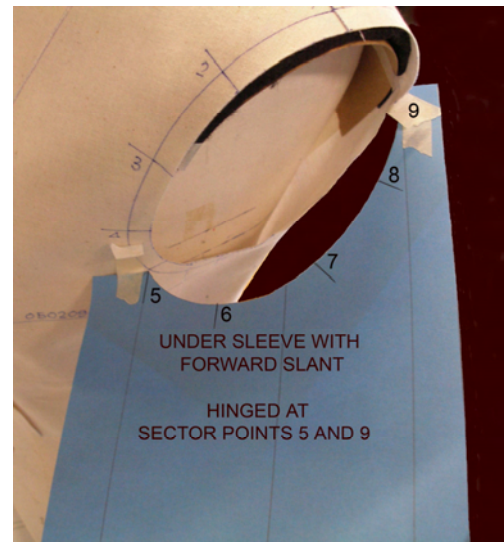
The hem to scye sector distance for point 6 has to be measured, as have sector points 7 and 8 to determine its true length ('A' in Figure 6.33 '4'). The addition of length allows the sleeve to span the gap to its corresponding position on the scye. Although not referred to in the text or figures, it is envisaged that supplementary points between the normal ten numbered sector points, could be added for further sleeve shaping refinement and accuracy. As a step in that direction, the grain line for the under arm sleeve has been included as a supplementary sector. The process is described below.

The gap has to be filled with an additional portion of sleeve, from the hem to the scye sectors 6, 7 and 8. The additions of under sleeve sector lengths, although more complicated, is the same as encountered in other arm elevated one-piece sleeves except at a lateral and forward angled motion rather than in a direct lateral direction.

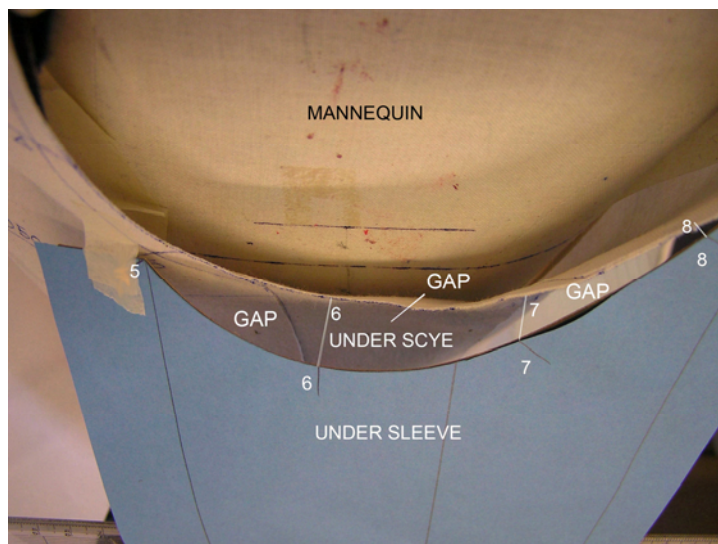




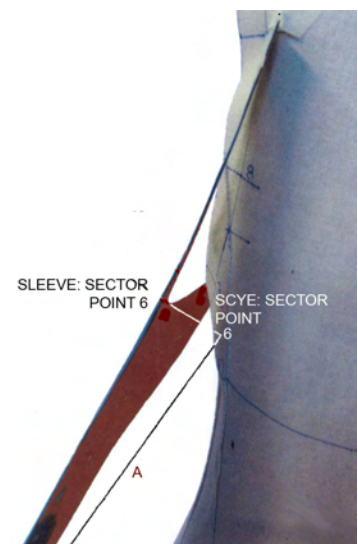
(1) Under sleeve pattern (no elevation)



(2) Under sleeve pattern (elevated)



(3) Under sleeve pattern (elevated with scye/sleeve gap)



(4) True length hem to scye

Figure 6.33. Under sleeve design development

### ***Sleeve elevation: Tailored under sleeve, lateral and forward arcing***

#### ***Triangulation development method***

The preceding sleeves, tapered and flared, utilised triangulation construction methods. However, because tailored sleeves pivot in an upward- lateral and forward direction – an arc, rather than a lateral pivot, the figures and descriptions appear to have altered. The method explained below however, is a variation of the same method. The



triangulation process comprises an arm elevation angle, vertical heights to the sleeve hem curve, two lateral lengths and diagonal lengths from elevated hems to scyes - which are the true lengths objectives. The under sleeve pattern is then lengthened appropriately. For ease of calculating the true lengths of the under arm sectors, it is decided that the sleeve will, initially, be flat with hem curvature widths added further through the process.

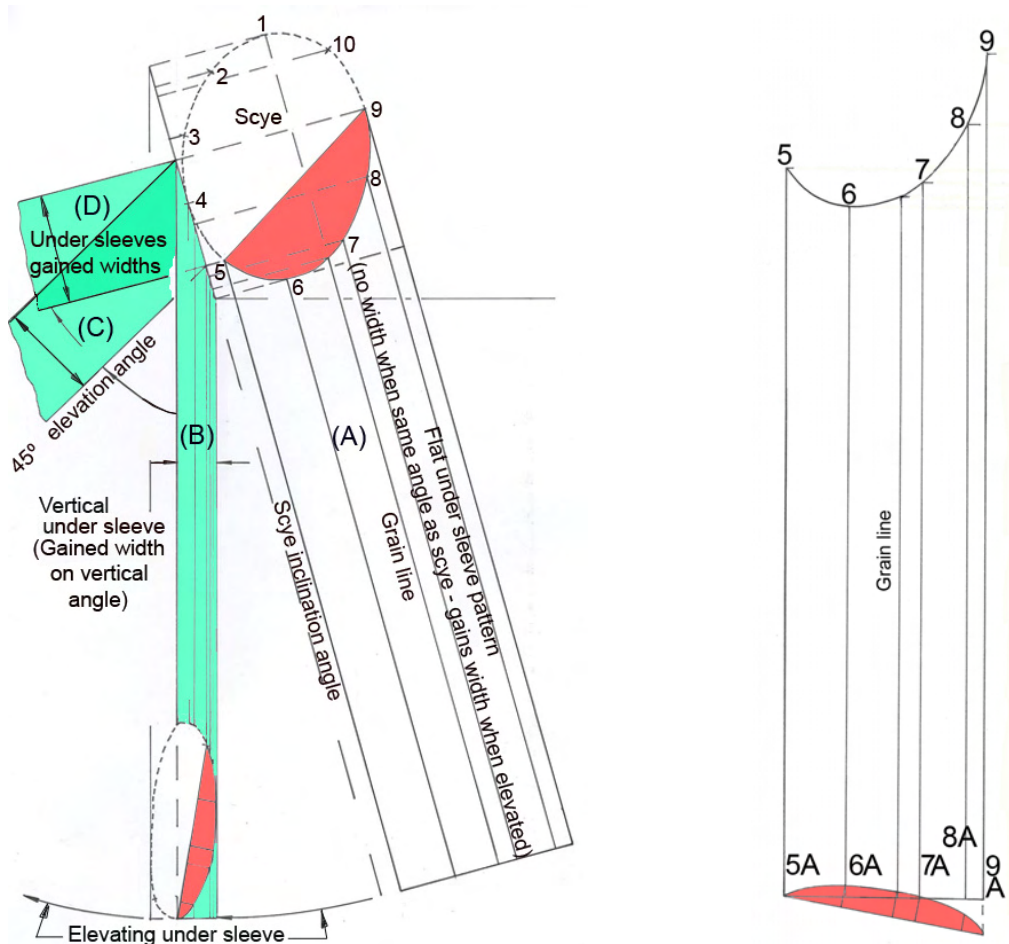
To begin with, the sleeve is aligned with the scye therefore, as with the scye it has no width – it is flat. During elevation, the sleeve gradually gains width with the elevation angle (from 'A', with zero width, - 'B', - 'C' - 'D' Figure 6.34 '1'). However, the width of the under sleeve length, initially for any elevated angle, is to remain the same - that of the under sleeve whilst in a vertical situation. As the sleeve is elevated, the same hem width is retained.

Since the top sleeve remains unaltered (sectors 5, 4, 3, 2, 1, 10 and 9), only the under sleeve is described in this chapter part; the top sleeve is discussed in Chapter 6D. Figure 6.34 '1' represents the back view of the under sleeve/pattern as it would appear without any provision for elevation. The red-coloured section of the scye indicates the extent of the required area reviewed, from the front of scye/sleeve at section 5, around the under arm to the back scye/sleeve at section 9. The green striped area is the under sleeve lengths down to the hem. The red coloured hem section is a plan view.

The area bounded by sectors 5, 6, grain line, 7, 8 and 9 at the scye, and 5A, 6A, grain line A (alignment of pattern warp of fabric), 7A, 8A and 9A at the hem (Figure 6.34 '2') is a true flat rendering of the under sleeve (between sector points 5 and 9). This is seen from a perpendicular angle to the scye slant line in Figure 6.34 '1'. The angle of arm



elevation for this particular under sleeve is set at  $45^\circ$  from the scye slant angle and perpendicular to the pivot line.



(1) Under sleeve/pattern (no provision for elevation)

(2) Under sleeve pattern

Figure 6.34. Tailored under sleeve

Figure 6.35 (isometric perspective – not in proportion) illustrates the development of the true length required for one sector line (for clarity purposes). The true length of the required sector line is  $6 - 6D$  (green line).



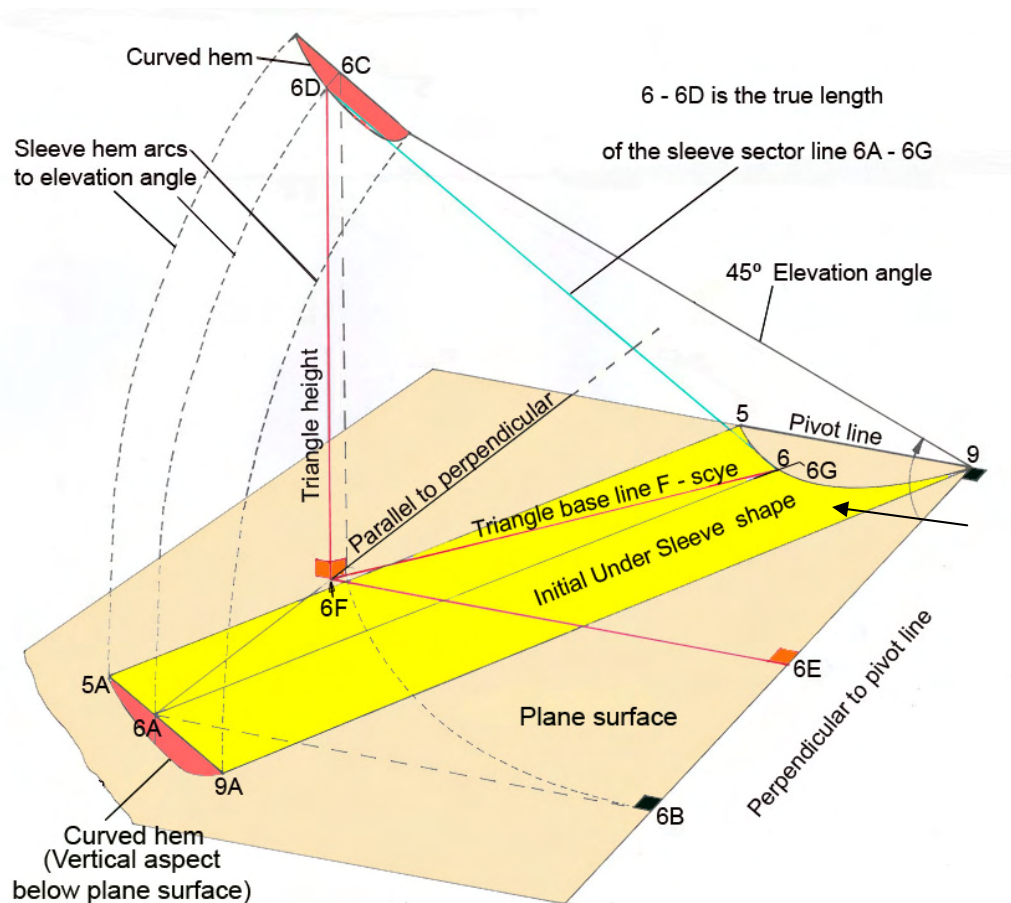


Figure 6.35. Tailored under sleeve: Elevation schematic

The initial under sleeve is laid on the plane surface, to align with the scye shape and its vertical orientation line (the grain line). Sector points and sector line 6 – 6A are established. The arm pivot line (a hinge) is extended between points 5 and 9. A line, perpendicular to the pivot line, is placed from point 9. A right angled line from the perpendicular line to point 6A; is point 6B.

The sleeve (and its sector points) is pivoted to its required angle (45°) to locate point 6C. The width of the curved hem, at sector point 6A, is added to point 6C to produce 6D the actual position of the hem. (Point E is explained in subsequent figures). Point 6F is the junction of a line descended from point 6D to the plane surface and a parallel to the perpendicular extended from point 6A.



The base line of a triangle, to produce the true length (the hypotenuse), is  $6F - 6$ . The height, to produce the true length is  $6D - 6F$ ; the true length and  $6D - 6$ . The true length is applied from sector point 6A, on the hem, to sector point 6G beyond the scye at point 6. All of the true lengths (6, grain line, 7 and 8 "A's – G's") allows the arm and sleeve to elevate. Without the extra (true) lengths, sleeve elevation would not be possible without opening the seam. (In pattern making, an approximate method of determining the true lengths is to cut into the scye/sleeve seam line of a toile, elevate the sleeve to its required angle, measure the resultant gap between sleeve and scye, then add the results to the pattern – which means another fabric sleeve trial).

The following figures (Figures 6.36 - 6.41) are all seen from the direction of the arrow as depicted in Figure 6.35. The figures (turned to a horizontal position, a perspective usual for pattern makers) may be envisaged as two combined views; the under sleeve as a plan view, whilst the construction, elevation angle and perpendicular lines are side elevations.

The under sleeve pivots from the pivot line, which itself extends from sector point 5 to sector point 9. The  $45^\circ$  sleeve elevation angle (extending from sector point 9 towards the upper left) is set from the perpendicular line, which is on the same plane as the flat scye (Figure 6.36). Since the scye is set at an angle of  $15^\circ$  from the vertical, the effective sleeve elevation is  $30^\circ$  from the vertical.

Although pivoting between sector points 5 and 9, these two lengths to 5A and 9A do not alter, they remain as fixed lengths no matter the elevation angle. The remaining sector 'true' lengths have to be calculated.



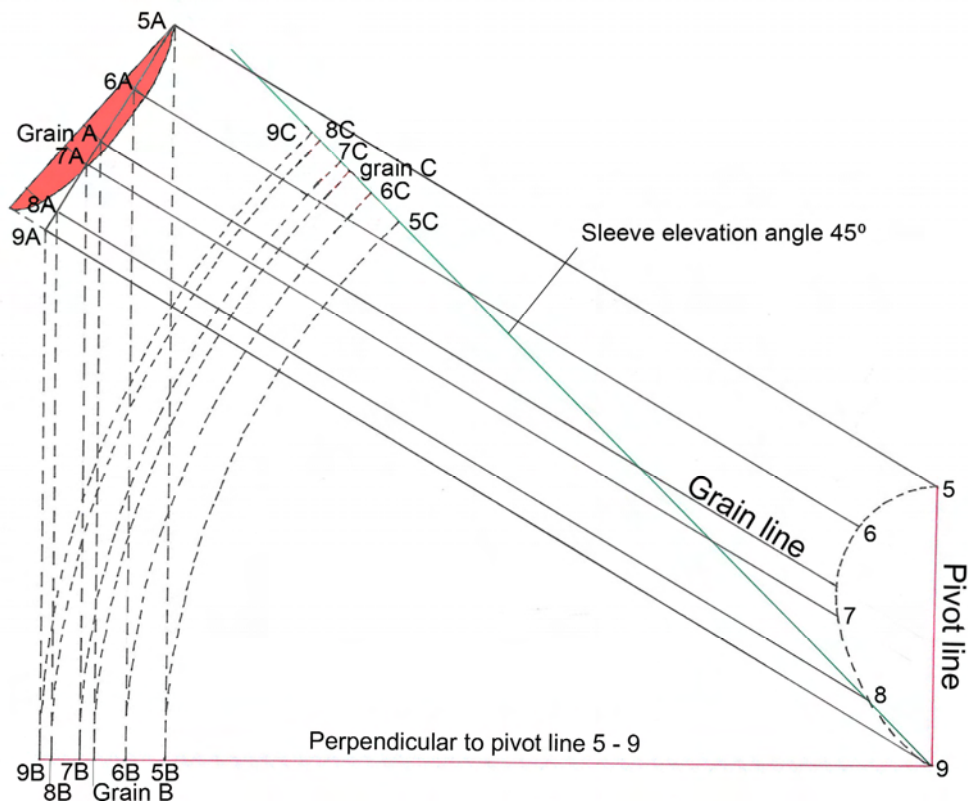


Figure 6.36. Tailored under sleeve: Hem pivoting

The sector points 5B, 6B, grain B, 7B, 8B and 9B are produced as extended lines from the scye sectors 5, 6, grain, 7, 8 and 9. A line, perpendicular to the pivot line, is projected from point 9. All points 'A' on the sleeve hem are projected onto the perpendicular line to produce all points 'B'. The points 'B' are then arced (pivoting from sector point 9, which represents the entire 5 to 9 pivot line) to intersect the sleeve elevation angle line ( $45^\circ$ ) to produce points 5C, 6C, grain C, 7C, 8C and 9C. These are the heights of the flat hem sector points prior to the curved hem measurements. Since the under sleeve hem is curved throughout its width, the curved widths reduce the elevated hem sector heights.

The method to account for the hem sector height reductions is to measure each of the heights of the curved under sleeve hem (red curved section located at the hem, perpendicular to line 5A to 9A in Figure 6.36) and apply those measurements from



points 'C', at a right angle to the 45° elevation line, to produce sector points 'D'. The distances between points 'D' and points 'E' are the correct hem heights (Figure 6.37). The heights ('D'-'E') form the first lines of the triangles (see Figure 6.35) which find the true length hypotenuse.

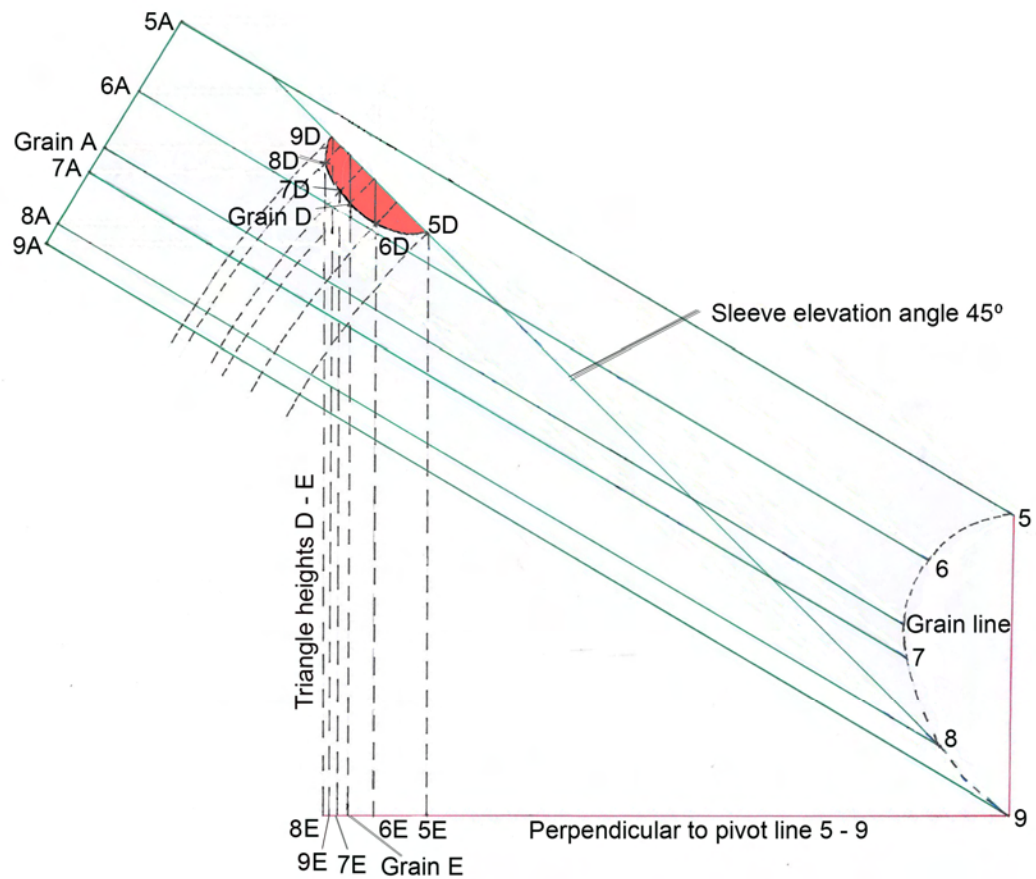


Figure 6.37. Tailored under sleeve: Curved hem sector height location

The shape of the under sleeve, from a back view perspective, is the green shaded section (Figure 6.38); the sector lengths are not, as yet, true lengths.



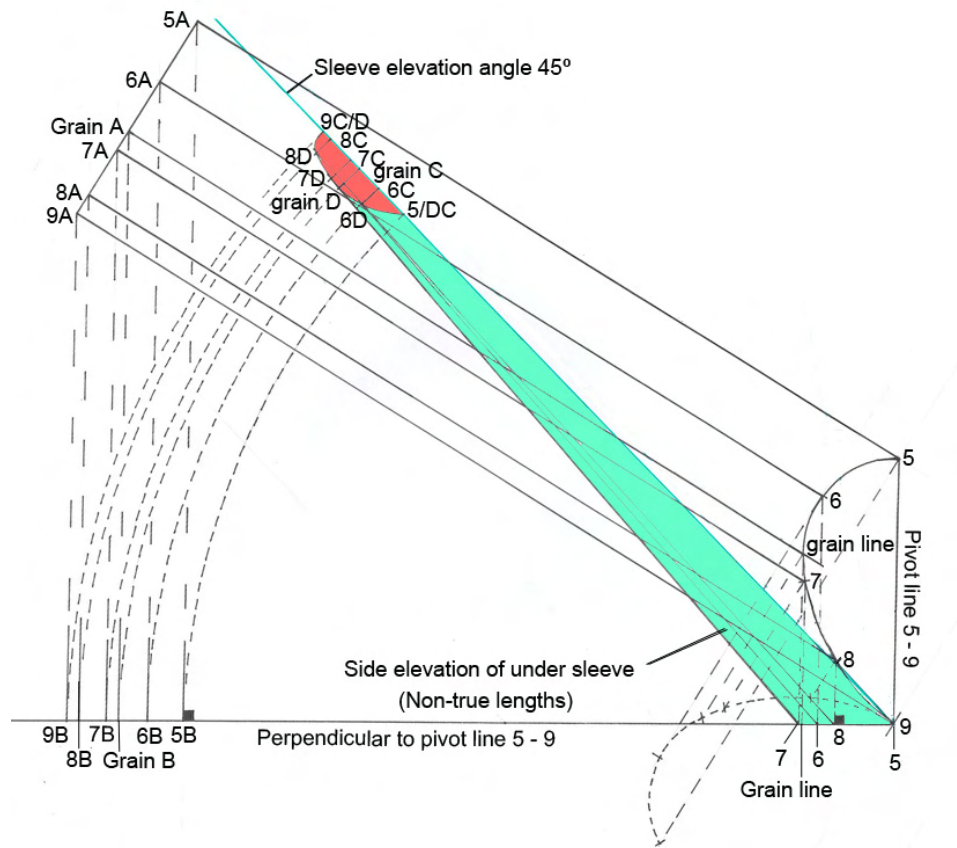


Figure 6.38. Tailored under sleeve (Back view)

To locate the planar position of each of the curved hem sector points, in relation to the scye sector points 5 – 9, two projected lines are required to intersect. The first projected line extends from points 'E' through points 'D' ('2' in Figure 6.39, enlarged view in '1') to intersect a second projected line which extends from point 'A' at the hem, parallel to the perpendicular line. Each intersection confirms points 'F'. (Points 'F' are plan views directly below points 'D'; as in Figure 6.35).







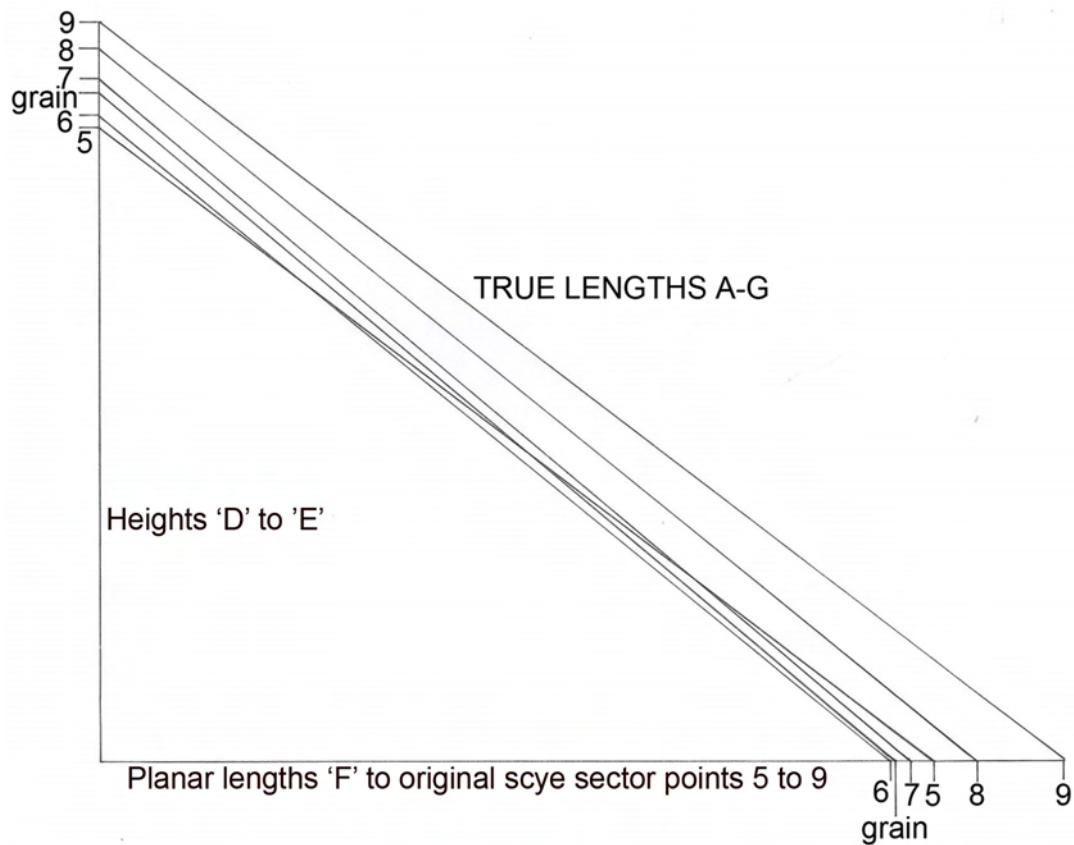


Figure 6.40. Tailored under sleeve: True-lengths

The true lengths of each sleeve sector, to allow arm elevation to the required angle, are projected along the appropriate sector line on the flat sleeve pattern, from the hem (points 'A') to locate points 'G' above the scye shape, sector points 5G and 9G do not change in length (Figure 6.41). Joining points 'G', results in a shorter distance between these points when compared to the original scye sectors.



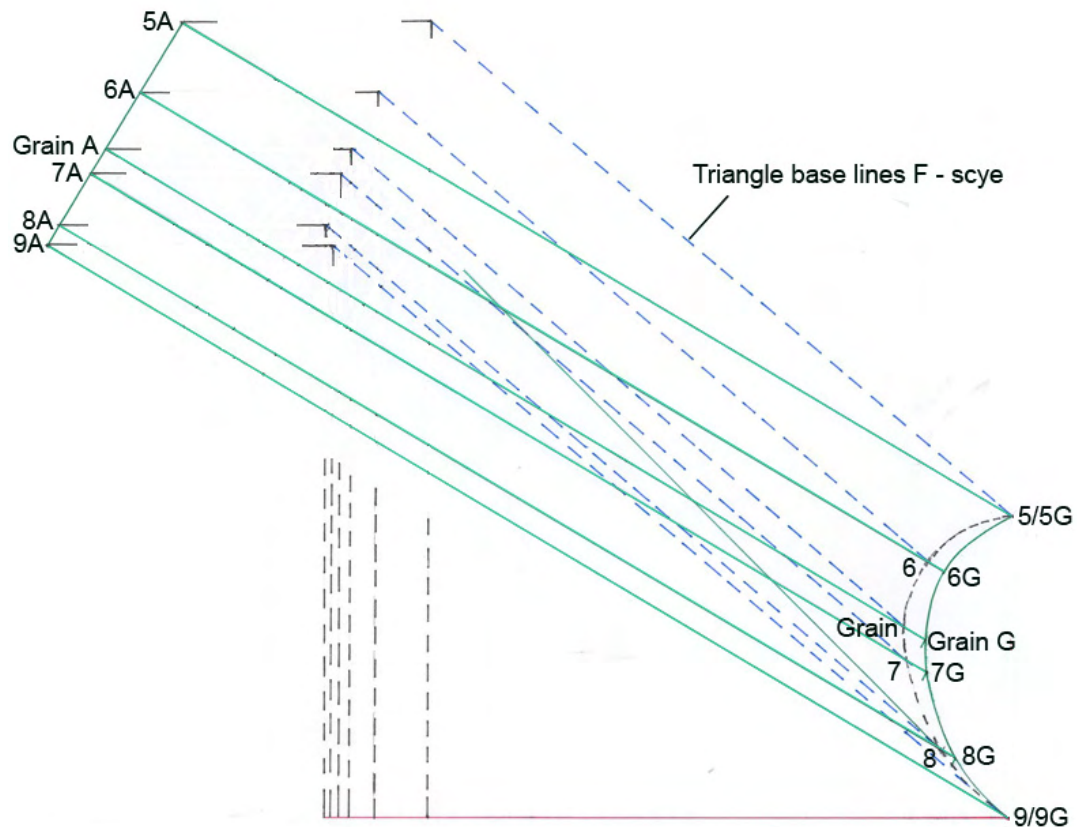


Figure 6.41. Tailored under sleeve: True-length of sector lines

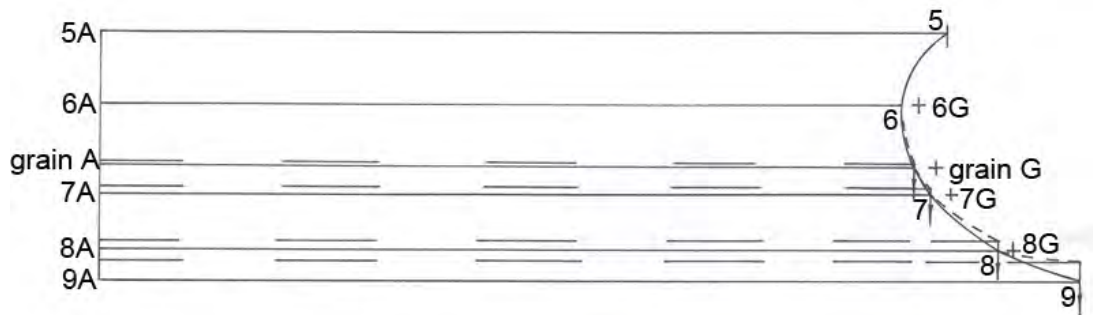
There are two manipulations required to finalise the pattern - without seam allowances. These are the parallel line development method and the triangulation development method. The first is to measure the lengths of the sectors at the hem to determine the sleeve width, and the second is to re-establish the scye sector lengths.

The total width of sleeve is determined by measuring each of the sectors on the curved hem plan view (red section in Figure 6.34) and moving the pattern by these increments (Figure 6.42 '1'). This manipulation also confirms the scye sector lengths for the original sector heights.

The second manipulation is to reinstate the scye sector lengths for the raised sectors ('G'). The method to establish the under sleeve sector widths to match the scye (Figure



6.42 '2') is the same method used to produce the oblique cone; the triangulation development method. The triangles are 'A' – 'G' and the widths of the original scye sectors from 5-6, 6-7, 7-8 and 8 –9. Note the slightly curved hem line due to pivoting.



(1) Under sleeve (hem width and hem to scye lengths at 'G')



(2) Under sleeve (scye sector widths for sleeve)

Figure 6.42. Under sleeve construction: Parallel line and triangulation methods

The completed manipulations produces the developed under sleeve pattern, without seam allowances (Figure 6.43).



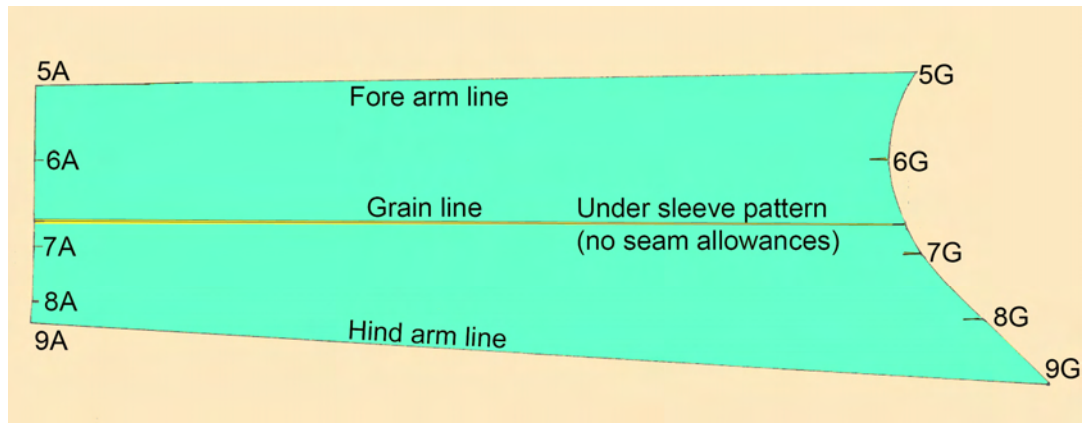
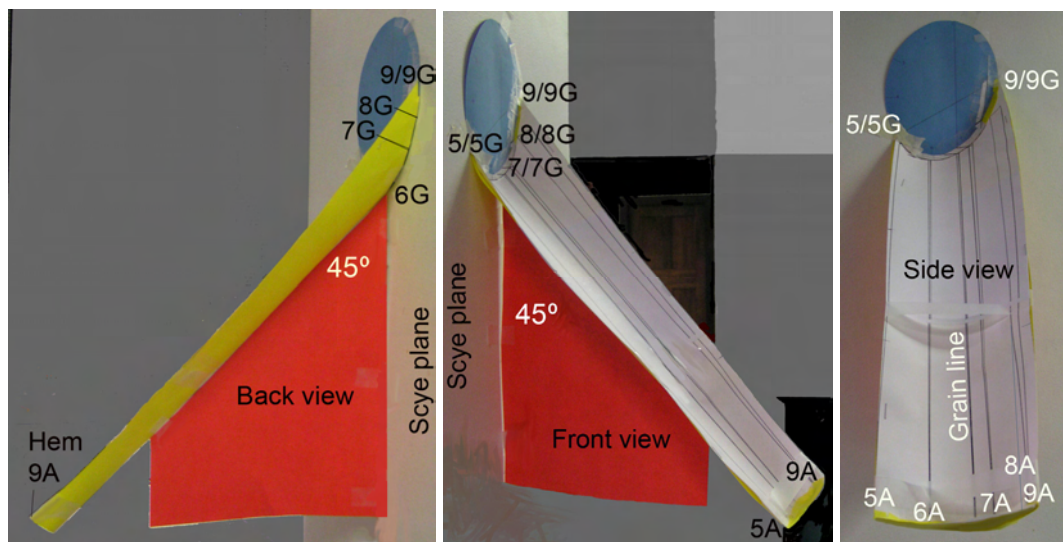


Figure 6.43. Tailored under sleeve

The under sleeve pattern (created in paper to reduce distortions) is placed to the scye with the under sleeve sector points matching the scye sector points. The result is as observed in Figure 6.44 '1' is back view, '2' is the front view and '3' is the side view.



(1) Under sleeve (back view) (2) Under sleeve (front view) (3) Side view

Figure 6.44. Tailored under sleeve: Scye and sleeve unification

The unification of the under sleeve and scye demonstrates the required sleeve angle of  $45^\circ$  measured from the scye slant with an effective  $30^\circ$  arm elevation from the vertical. This angle can only be increased if the body of the garment moves in the same



direction as the sleeve and arm, or if the scye/sleeve seam is placed under tension, splitting from the scye.

The descriptions to find the true lengths of the under sleeve sector lines; 6A-6G, grain line A - grain line G, 7A - 7G and 8A – 8G, are for an effective sleeve elevation of 30° (45° angle from the scye plane). All other sleeve elevation angles would result in different sets of measurements and therefore different sleeve silhouettes.

Figure 6.45 ('1' is the back view, '2' is the front view and '3' is the elevation) is a sleeve with an elevation of 45° from the scye plane (slant angle on mannequin) with an effective elevation angle of 30° from the vertical. A 100% wool fabric with a weight of 277g/m<sup>2</sup> was used for the under sleeve whilst the top sleeve, cut from calico fabric, was used purely as a support for the under sleeve. To have the least amount of influence on the under sleeve, the top sleeve is taped to the under sleeve at various points, rather than sewn. The crown area is not attached to the scye – although it is taped at the shoulder as an additional weight-support.

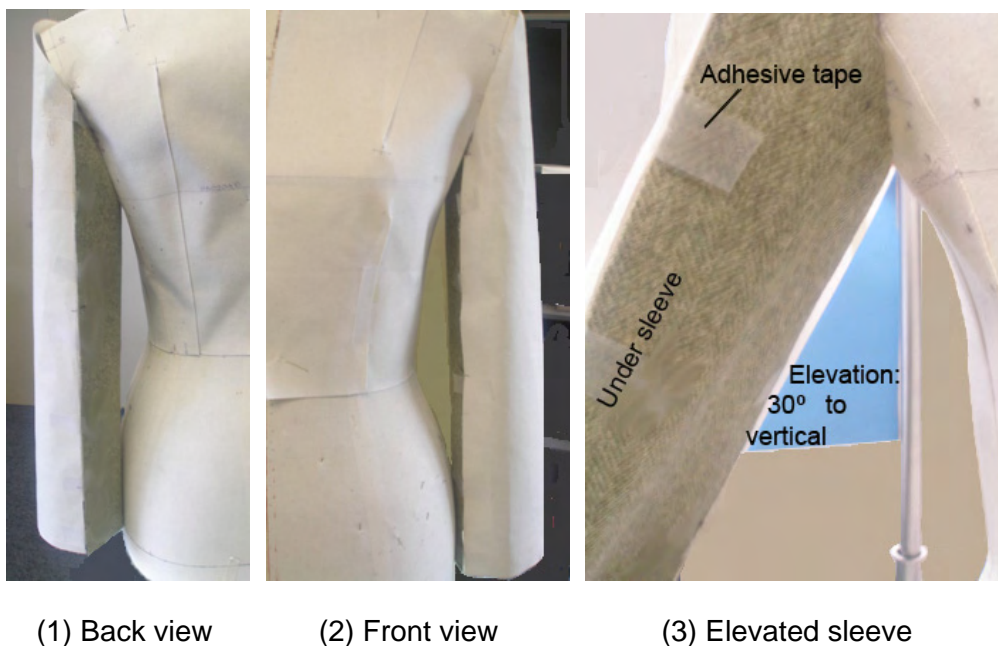
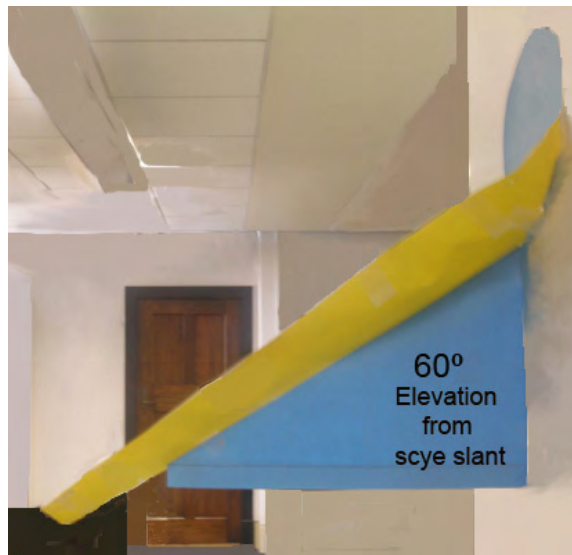


Figure 6.45. Tailored under sleeve: Elevation of 45° from scye slant



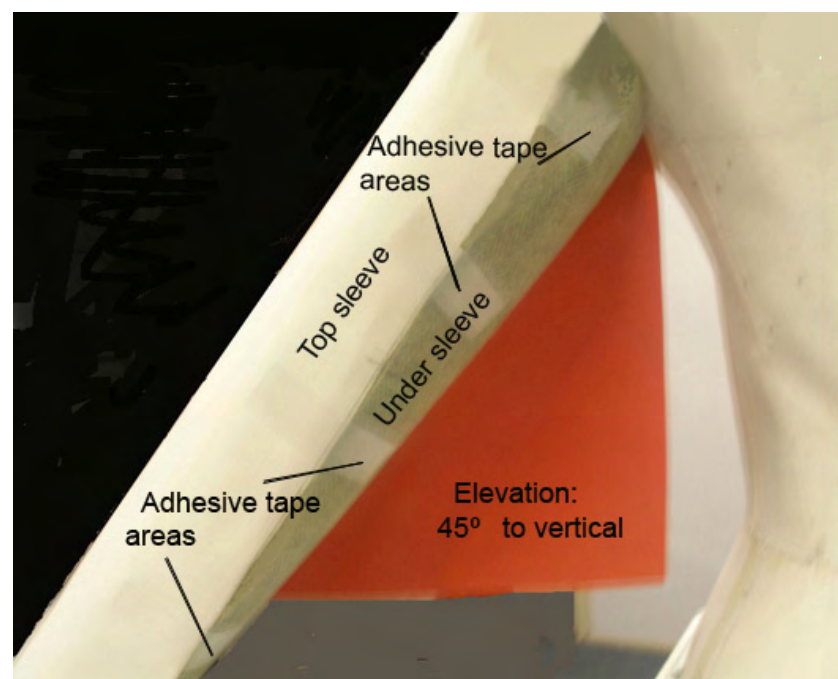
Figure 6.46 ('1' is the elevation angle, '2' is the back view and '3' is the sleeve elevation) represents an under sleeve with an elevation of  $60^\circ$  from the scye plane (slant angle on mannequin) with an effective elevation angle of  $45^\circ$  from the vertical.



(1) Elevated under sleeve pattern



(2) Fabric under sleeve



(3) Elevated sleeve

Figure 6.46. Tailored under sleeve: Elevation of  $60^\circ$  from scye slant



### **6.13 Summary**

The methods described to develop straight, tapered, flared sleeves and tailored under sleeve patterns provide answers to the problem of sleeve elevation. Each sleeve design utilises a number of perspective views. All sleeve elevations, whether informal or formal, are constructed with the triangulation method. This method necessitates calculating the true lengths of the involved sector lines from scye to sleeve hem.

Whether for informal sleeves – tapered and flared (entire sleeve elevation), or for formal sleeve types – tailored (under sleeve elevation only), each sleeve elevation angle requires a different set of sector line lengths. Since the method raises the sleeve sectors above the scye, each sleeve sector length (5-6, 6-7, 7-8 and 8-9) becomes shorter (held between the non-changing sector points 5 and 9). These need to be lengthened to re-establish their original sector lengths. This can be achieved using either the parallel line or triangulation method of construction depending on whether the sleeve is straight from scye to hem, or tapered in either direction.



## **Chapter 6D —**

### **Scye and Sleeve Development: Sleeve Arm-Encasing area and Crown Curvature**

#### **6.16 Introduction**

Chapter 6B introduced sleeve silhouettes and their initial pattern development. Developments were restricted to developable surfaces; without crown curvature. Chapter 6C discussed and described sleeve elevation and development for tapered and flared sleeves; this was also without recourse to matters of crown curvature. The formations of sleeve elevation for tailored sleeves were examined and determined.

Chapter 6D expands on the previous two chapter parts, discussing the main section of the sleeve - referred to as the arm-encasing area that covers the arm below the crown section. The arm-encasing area of the sleeve represents the developable surface of the sleeve; the top sleeve crown curvature section is a non-developable surface – it cannot be flattened without adding (in this instance) fabric.



To simplify explanations of the full sleeve it is deemed necessary to separate the arm-encasing area from the crown area with a sleeve truncation line (STL) line. This is a line parallel to the top edge of the crown curve. The second part of Chapter 6D relates to the crown area that curves from the sleeve truncation line into the scye. Methods for resolving the individual curvatures of the sleeve en-casing area and the crown are determined.

Sleeve crowns are the most difficult areas of the sleeve to construct as they must balance with the arm and scye and deliver the correct three-dimensional silhouette from the two-dimensional pattern. Unfortunately, current drafting techniques dictate that each sleeve style has a different, and often-times, unpredictable approach to achieve the required style silhouette. Unpredictability must be reduced to a minimum to lessen the incidence of trial and error processes in both pattern and garment sleeve generation.

Since the new in-set sleeve designing system is a progression from a three-dimensional (orthographic) sleeve design to a two-dimensional pattern, the problem of sleeve pattern development, or flattening, is addressed. The question of fullness (gathers and pleats) is tentatively explored. The difficulties involved in calculating the amounts of fabric fullness, gathers, pleats and darts are discussed in more detail in Chapter 7C.



## 6.17 Sleeve arm-encasing curvature

The curvature of the sleeve, above and below the sleeve truncation line (STL), must be related in order to maintain the integrity of the whole outer surface of the sleeve. Lines of curvature leading into the crown area and ultimately into the scye, actually begin in the body of the sleeve below the STL, the arm-encasing area. The sleeve develops from the arm-encasing area, through the truncation line, over the crown and into the scye, with a non-undulating consistent curvature. It is the method to establish these curvatures in the sleeve body that is the subject of the first part of this chapter.

The sleeve arm-encasing is depicted as the green area in Figure 6.47. The sleeve body is segregated from the crown by the sleeve truncation line STL, which is parallel to the top of the crown curve. The area of sleeve body in the front elevation of Figure 6.47 relates to the full circumference of the sleeve – top and under sections of a one-piece sleeve.

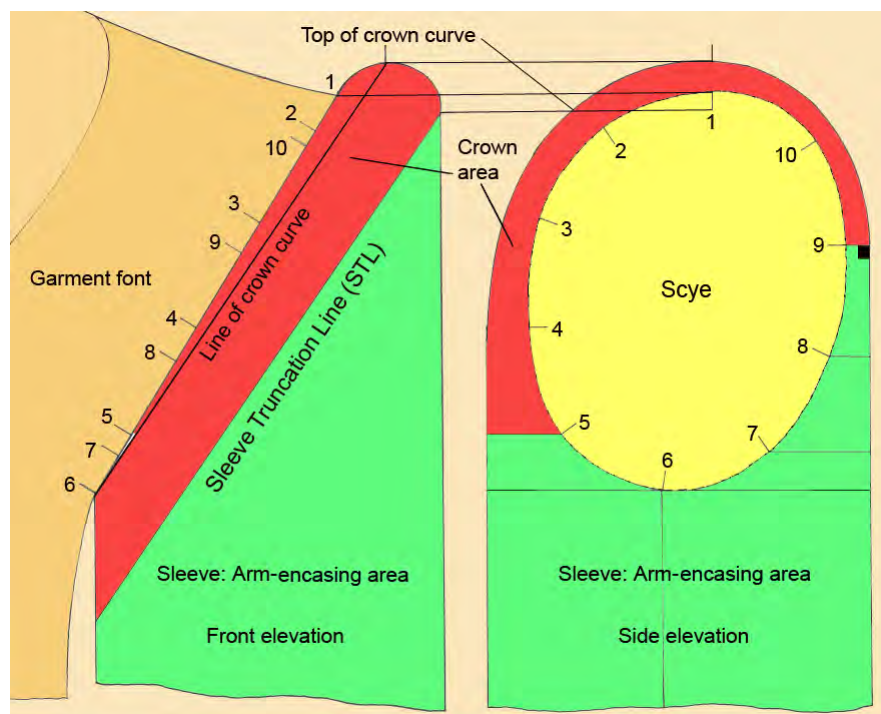


Figure 6.47. Sleeve truncation line



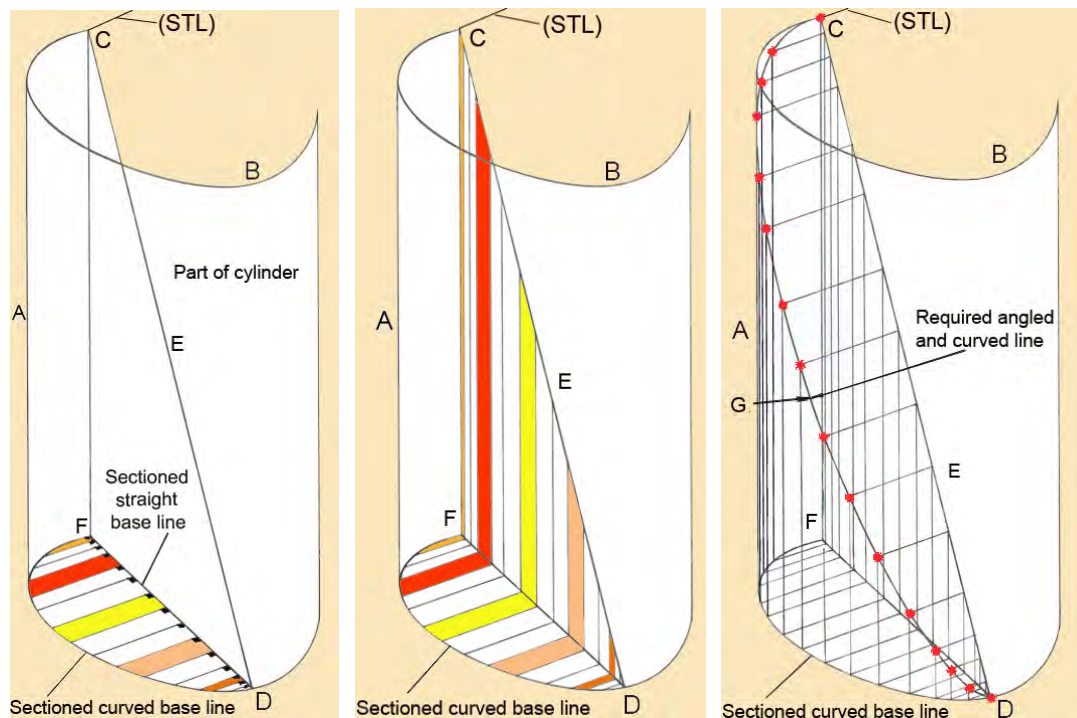
The side elevation represents the body area of a tailored sleeve style - below sectors 5 to 9. As with the front elevation, all of these sectors are represented by the shape of the plan view circumference. Sleeve sectors; 5, 6, 7, 8 and 9 of the tailored under sleeve is described in Chapter 6C.

Figure 6.48 depicts a series of isometric drawings describing the method to determine the curvature of an angled line ('G' in Figure 6.48 '3') on a part cylinder surface which represents a part sleeve). This is achieved by means of its angled straight line counterpart 'E'. The part cylinder of height 'A' and width 'B' (Figure 6.48 '1') has an angled line from 'C' to 'D' (designated as 'E'), that joins the truncation line at 'C' at a right angle.

The straight base line from 'F' to 'D' (directly beneath line 'E'), is sectioned and projected horizontally onto the curved base line 'D' to 'F'. The section lines are also projected in a vertical manner to join the line 'E', in Figure 6.48 '2'. The individual horizontals between the straight and curved base lines are measured. These are projected, perpendicular to C to D, from their respective vertical positions on line 'E'.

Joining the points (red points) produces the required angled curved line of 'G' (Figure 6.48 '3'). Whilst the views represent how a curve is determined, they are perspective views; they do not correspond to the actual curve. The actual curvatures of several sector lines have to be tested for validity.





(1) Angled line 'E'      (2) Horizontals and verticals      (3) Established curve

Figure 6.48. Curved line on cylinder

The objective of the next step is to create effective functional true-curves below the sector points arranged around the sleeve truncation line (STL) on a cylindrical structured model. Since each has to be independently determined, the process is abbreviated. To achieve the abbreviation, the front and back sections are assumed to have the same shape. For the same reason, the circular plan view is reduced to a semi-circle. Therefore, the ten sectors of the circle are paired, initially, as 1/1, 2/10, 3/9, 4/8, 5/7 and 6/6; the pairings change with each sector viewpoint. The front elevation with a truncation line is depicted in Figure 6.49. The viewpoint is between sectors 4/8 and 3/9

The methods for attaining surface curves on hollow structures are not part of the normal processes encountered in garment design. Traditionally, garment drafting does



not approach pattern making with any degree of geometric finesse, therefore because of this lack of practise, it is deemed necessary to test the method with models.

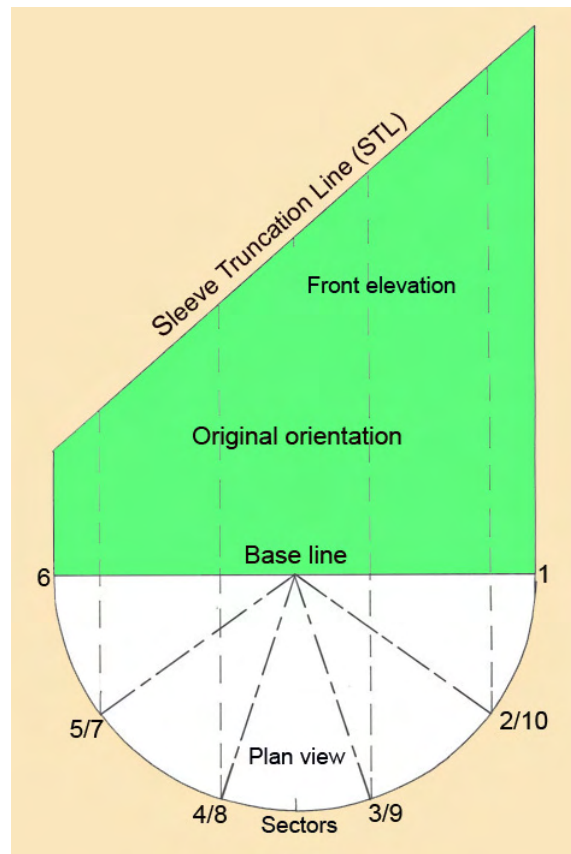


Figure 6.49. Cylindrical sleeve structure

A developed pattern of the truncated cylinder (half the entire cylinder shape) depicts the curved edge of the sleeve truncation line (STL). The curves of the sector lines below the STL are unknown quantities (as are the sector crown curves and lengths above the truncation line). To determine the actual three-dimensional shape of the sleeve body sector line curves in the arm-encasing area up into the sleeve truncation line (STL), the process is described.



The sector point angles are all  $90^\circ$  to the sleeve truncation line. The angles for the sectors, from the vertical are: sectors 1/1,  $90^\circ$ ; 2/10,  $27^\circ$ ; 3/9,  $40^\circ$ ; 4/8,  $40^\circ$ ; 5/7,  $27^\circ$ ; 6/6,  $90^\circ$  (Figure 6.50), these are shown as straight lines. However, since the truncation is on a three-dimensional cylinder, these lines will also be contoured in the same manner. Neither the flat-pattern straight lines nor the flat-pattern curved lines are the required shapes. The required surface curves emanating from the arm-encasing area into the truncation line sector points are created in a similar manner to the curved surface line created in Figure 6.48.

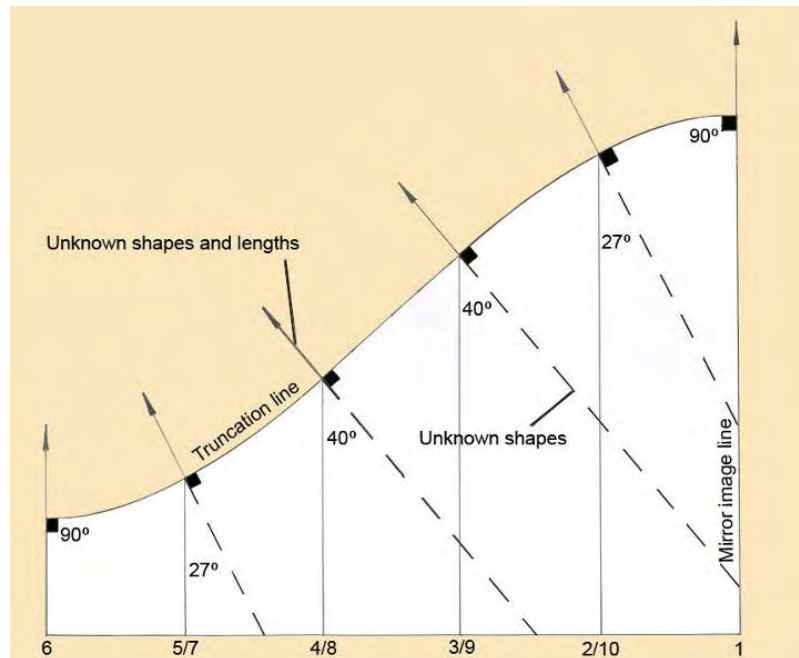
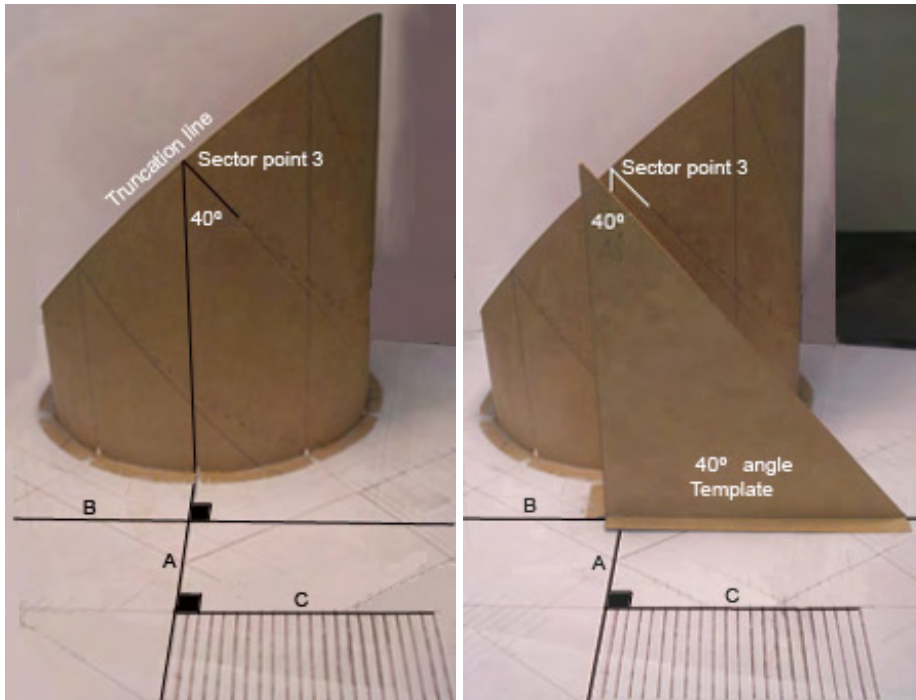


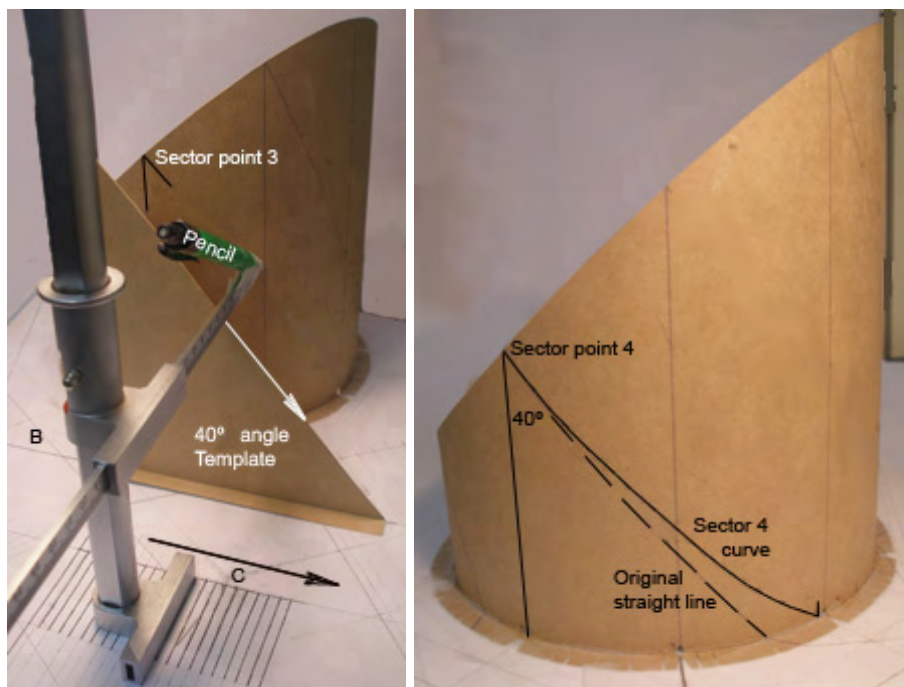
Figure 6.50. Cylindrical sleeve structure: Sector point angles

A model of the sleeve structure represented in Figure 6.51 '1' is constructed to test the sector curves below the sleeve truncation line (STL). To determine the projected angle and curvature of each of the sectors requires a perpendicular view to that sector. A single sector curve (sector point 4) is seen from a perpendicular view to the sector (line 'A' in Figure 6.51). Line 'B' is parallel to the sector, as is line 'C'; line 'C' is the front position of the height gauge.





(1) Perpendicular view to sector (2) Template (as angle in Figure 6.50)



(3) Drawing the sector curve (4) Sector point 4 curve on sleeve

Figure 6.51. Cylindrical sleeve structure: Sector point 4



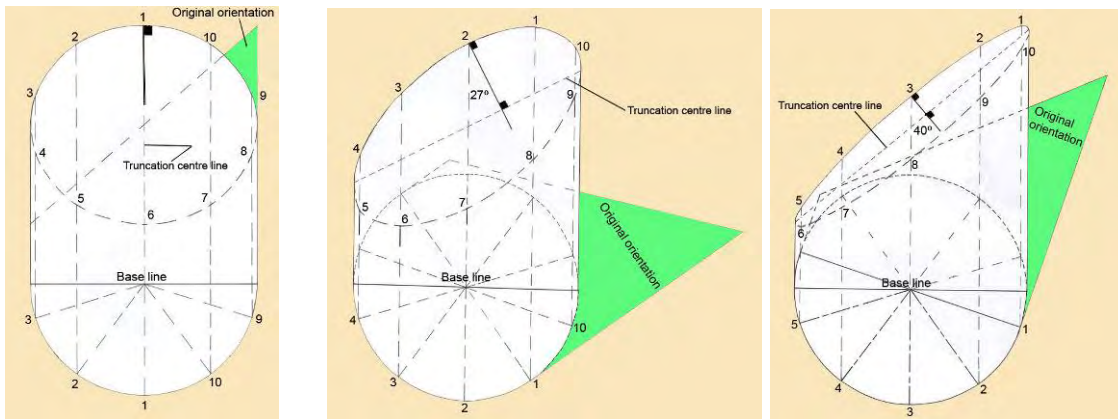
A 40° angled template (angle seen in Figure 6.50) is positioned along line 'B' to correspond with sector point 4 on the sleeve truncation line (Figure 6.51 '2'). A height gauge, with pencil attached, is positioned on line 'C' (Figure 6.51 '3'). The gauge is moved progressively to the right with the pencil moving forward and lower, touching the template, with each new position. Each position is marked on the sleeve structure. Gradually, a series of positions produces a curved line on the arm-casing sleeve structure, rather than the original straight line (Figure 6.51 '4'). This is the required curve for sector point 4. Geometric construction of all of the sector curves (/1, 2/10, 3/9, 4/8, 5/7 and 6/6) is required.

### ***Sleeve arm-encasing curvature: Geometric cylinder curvatures***

The entire sleeve structure rotates to acquire the front elevation viewpoint for each of the sectors. The amount of rotation is identified in the six sector-point views depicted in Figure 6.52 by the position of the original orientation. The six views (Figure 6.52) are: '1', sector point 1; '2', sector point 2; '3', sector point 3; '4', sector point 4; '5', sector point 5 and '6', sector point 6.

Since the new viewpoint requires the sector heights of the sleeve structure to be re-positioned, the result is a transformation in the shape of the truncation line to an oval and a new truncation centre line. A right angle from the sector point on the truncation line and the truncated oval centre line provides the angle for the required sector line curvature below the sleeve truncation line (STL).

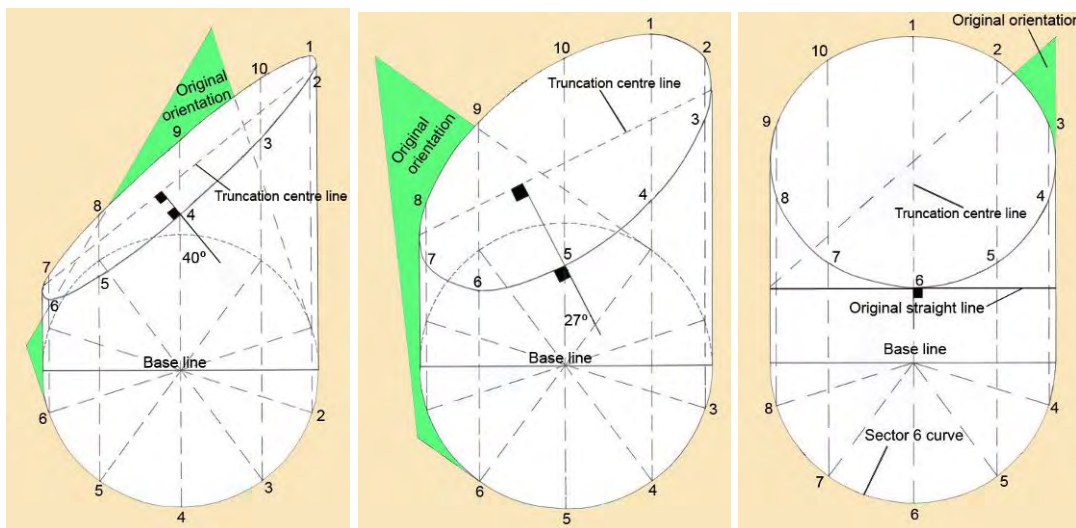




(1) View of sector point 1

(2) View of sector point 2

(3) View of sector point 3



(4) View of sector point 4

(5) View of sector point 5

(6) View of sector point 6

Figure 6.52. Cylindrical sleeve structure: Sector points

Sector point 4, in Figure 6.52, is reproduced in Figure 6.53 to create the actual curvature of the sector line 4 to 'A'. The perpendicular is lengthened to reach the base line at point 'A' on the front elevation (sectors 2 and 3 do not reach the base line). A series of lines, from the base line, is extended down to reach the curve 'B' to 'C' on the plan view and up the front elevation to reach the truncation angle 4 to 'A'. Each length of 'base line' to plan view curve ('B' to 'C') is projected from the truncation line (4 to 'A'), to produce the points (red) for the required sleeve sector 4 curve.



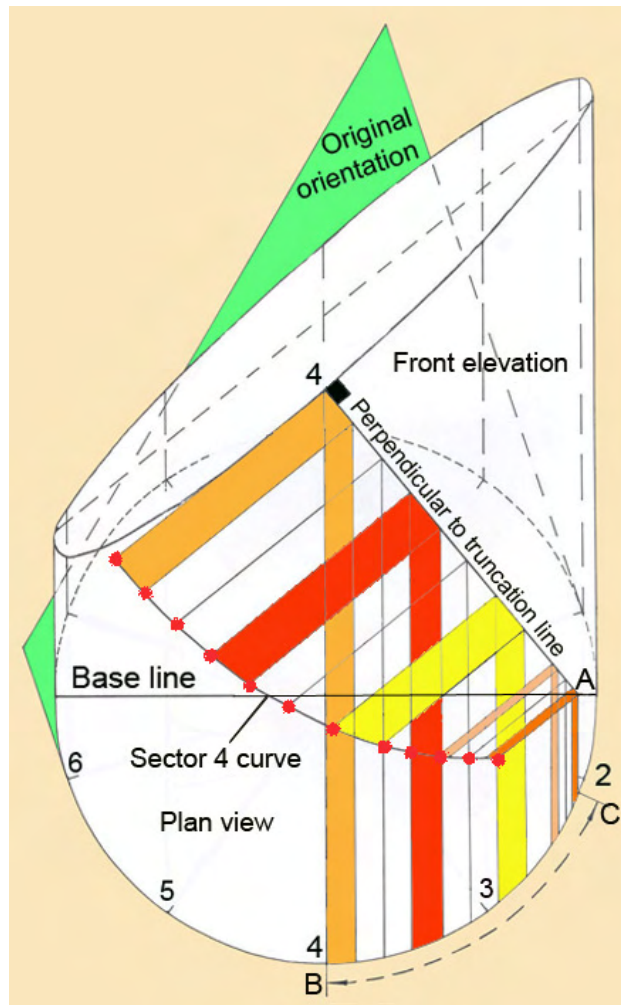
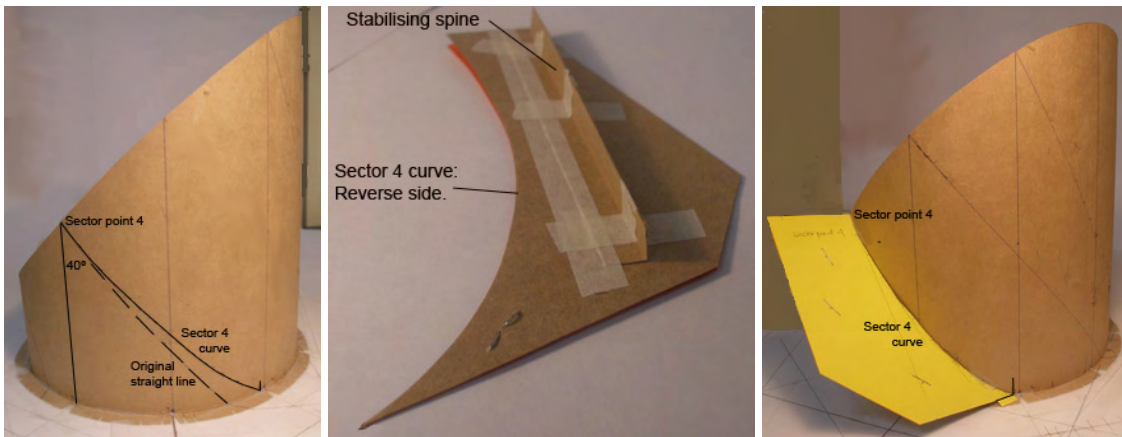


Figure 6.53. Cylindrical sleeve structure: Sector point 4 curvature

To confirm the sector 4 curve in Figures 6.53 and 6.54 '1', a template of the resultant sector curve is created (produced from Figure 6.53) with a stabilising spine (Figure 6.54 '2'). It is then placed to the sector 4 curve line on the sleeve structure (Figure 6.54 '3'). Curve templates for sectors 2, 3 and 5 are also created. Sector 1 and 6 are straight vertical lines.





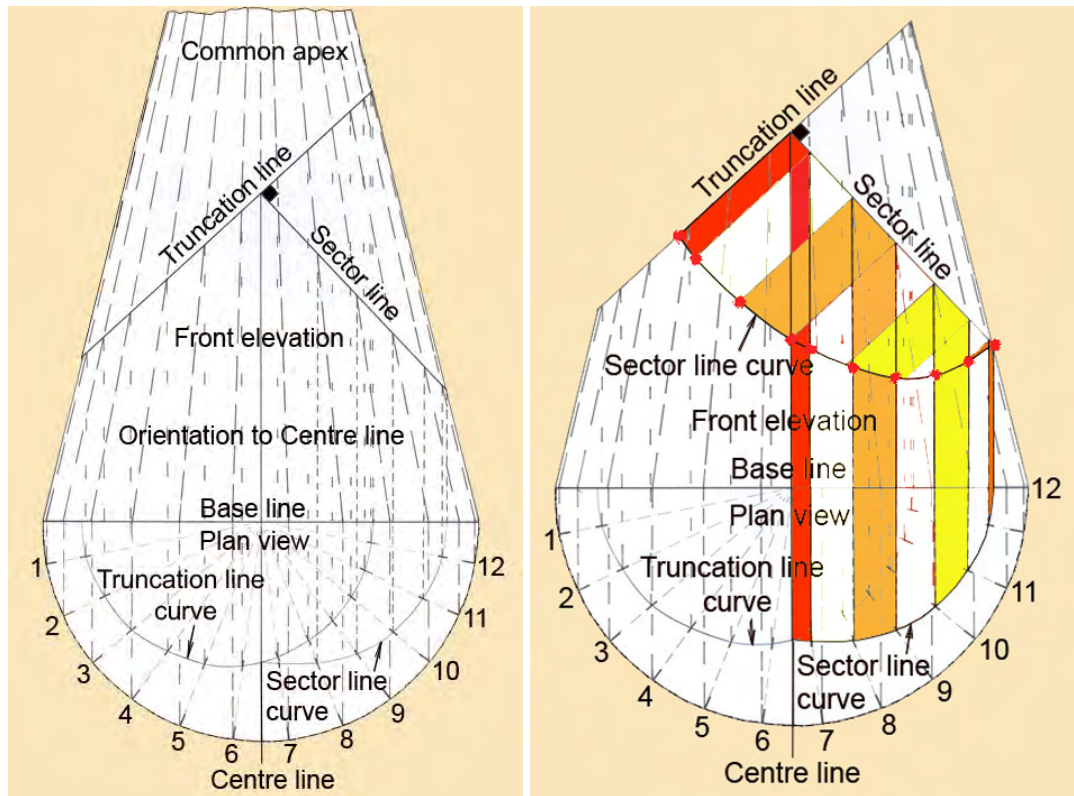
(1) Sector point 4 curve    (2) Reinforced sector 4 curve    (3) Confirmed curve

Figure 6.54. Cylindrical sleeve structure: Sector point 4 curvature confirmation

### ***Sleeve arm-encasing curvature: Geometric conical curvatures***

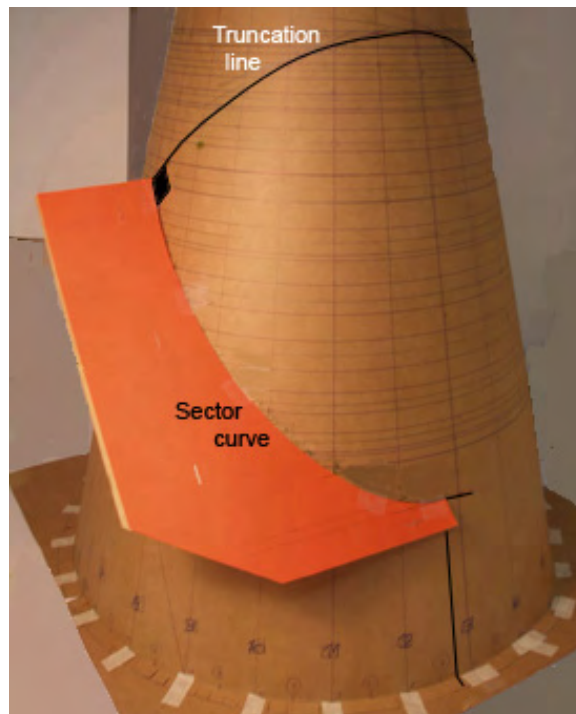
Conical arm-encasing sleeve surface curves are created using the same approach as seen in the cylinder. The difference being to determine the position of the sector line curve on the plan view which has different – tapered – top and base circumference. The front elevation and plan views of a right cone are depicted in Figure 6.55 '1'. The means of constructing the required surface sector curvature is observed in Figure 6.55 '2'. Verification of the sector curve (Figure 6.55 '3') is confirmed by means of a sector surface curve template.





(1) Right cone (front elevation/ plan view)

(2) Surface sector curve



(3) Confirmed curve

Figure 6.55. Conical sleeve structure: Sector point curvature confirmation



## 6.18 Summary

A method of determining the curvatures of angled lines across surface forms (hollow structures) such as sleeve arm-encasing areas was described. These lines are regarded as being perpendicular to the sleeve truncation line (STL), important to ensure the integrity of the crown curve. All of the arm-encasing curved lines are contained within the sleeve plan view.

## 6.19 Sleeve crown curvature

Heisey, Brown and Johnson (1988) explain that close fitting areas of the body (in this instance the curvature of the sleeve crown) need specifying in greater detail than areas that do not follow the body closely - the sleeve arm-encasing area.

The second part of this chapter explores sleeve crown curvature. This is the association between the crown curve and the amount of crown curvature (style, or silhouette), from the arm-encasing area into the scye – a *'double curvature region'* (Geršak, 2002, p. 170).

### ***Sleeve crown curvature: Style silhouettes***

Figure 6.56 illustrates a few of the many sleeve silhouettes, or style variations, available to the designer; '1' is the tapered, straight and flared ; '2' the tailored and straight sleeve and '3' the leg-of-mutton sleeve. Each sleeve has its own fullness or gathering measurements; each has its own crown height and each has, in current pattern making, a different drafting procedure.

Each crown curve silhouette leads naturally to the question of sleeve how much crown height and crown curvature. Current drafting methods usually provide a single crown height – at, or near, the centre line of the sleeve width; the remainder of the crown



curve is then described as containing certain convex and concave curvatures below this crown height point.

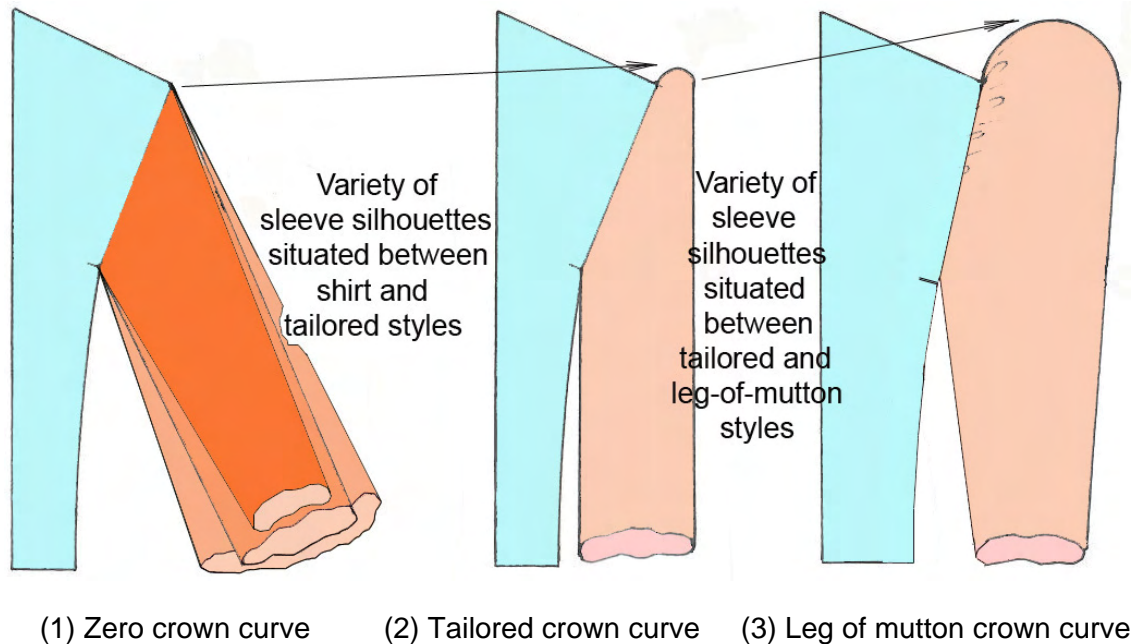


Figure 6.56. Sleeve crown styling

### ***Sleeve crown curvature: Crown heights***

Since sleeves cover a part of the body which is in an almost constant state of varied movement and articulation, sleeves represent one of the most difficult of pattern problems. The characteristics of a well-cut sleeve are, according to Richards (1930), is that:

*'it (the sleeve) must hang well with the arm at rest. Secondly, it must drape gracefully when the arm is bent. Thirdly, it must allow reasonable freedom of movement in every direction. Now, providing that the size and shape of the armhole are correct, all these points will be governed by the shape of the sleeve head'. (p. 53)*



Related to the shape of the sleeve head is the depth of crown, crown height or DOC. Richards (1930) asserts that one of the main aspects in sleeve pattern construction is the height of crown, which is governed by the depth and width of the armhole and by the length of the shoulder. Because each individual scye and sleeve element is capable of wide variations, Richards declares that a controlled, determined procedure or formula to govern crown heights in all situations is unfeasible. He further suggests that the calculations for assessing crown heights are based on judgements through experience.

However, that supposition only applies to traditional drafting methods. The new sleeve design and drafting system is a distinctive departure from the normal drafting processes; each sleeve style and crown height evolves from this new process. Figure 6.57 depicts three sleeves with variations of crown styling, all result in contrasting sleeve pattern crown heights. The variations are understood with the aid of four position points which are:

- 'A' is the under arm point
- 'B' is the shoulder point
- 'C' is the depth of crown-point, located from a perpendicular line projected from the outer edge of the sleeve into the under arm point at 'A'. 'A' to 'C' is also the sleeve width.
- 'D' is the top of the sleeve pattern crown.



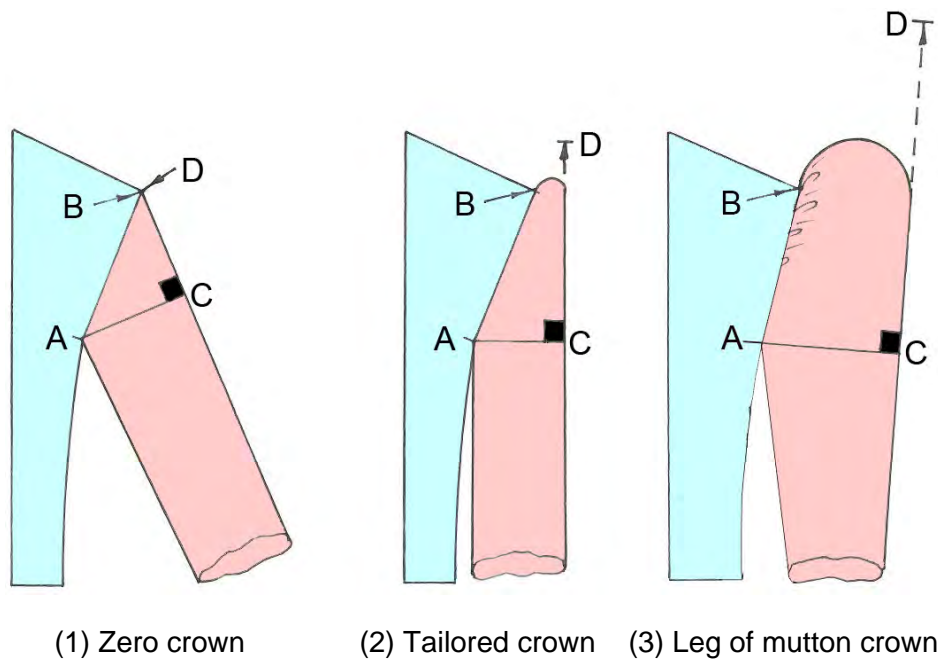


Figure 6.57. Crown heights

The sleeve pattern crown height is reliant on the position of the shoulder end, the curvature of the crown, (measured on the outer edge of the sleeve from point 'C' around to point 'B' (In Figure 6.57), the sleeve width (from point 'A' to point 'C') and the arm elevation angle. To calculate the sleeve pattern crown height necessitates measuring from 'C', around the crown curve to 'B'. This measurement is projected from 'C', along the outer edge of the sleeve to 'D' to give the correct sleeve pattern crown height. The sleeve pattern crown height for all sleeve styles is calculated in this manner.

Figure 6.57 indicates the correct crown heights ('C' to 'D') for three types of sleeve. Since there is no crown curvature into the scye, the crown height for sleeve '1' is the same measurement as C' to 'B'. Figure 6.57 '2' has a moderate amount of crown curvature therefore 'D' is projected slightly above the shoulder point at 'B'. The Leg of mutton sleeve ('3') shows a marked increase in sleeve pattern crown height, 'D' being considerably higher than the shoulder point level at 'B'. Still, to produce the correct



sleeve crown curve and its development for all styles, there must be intermediary heights around the crown curve to create the required three-dimensional fabric sleeve.

### ***Sleeve crown curvature: Hypothesis***

A method has not been determined, in present or past drafting approaches, for establishing the precise position of each sector point (and pitch points) on the sleeve to correspond with its scye counterpoint. There is also no pattern drafting method that explains how the crown develops onto the plane. Additionally, there is no method to determine the amounts of fabric fullness in each of the sleeve sectors, between the ten sector points. These are important aspects of crown formation which require clarification (fabric fullness is discussed in chapter 7).

The premise for the development of the sleeve crown area, is that any line projected from the main body of the sleeve (the arm-encasing), curves over to meet the scye line in a perpendicular manner to the sleeve crown curvature.

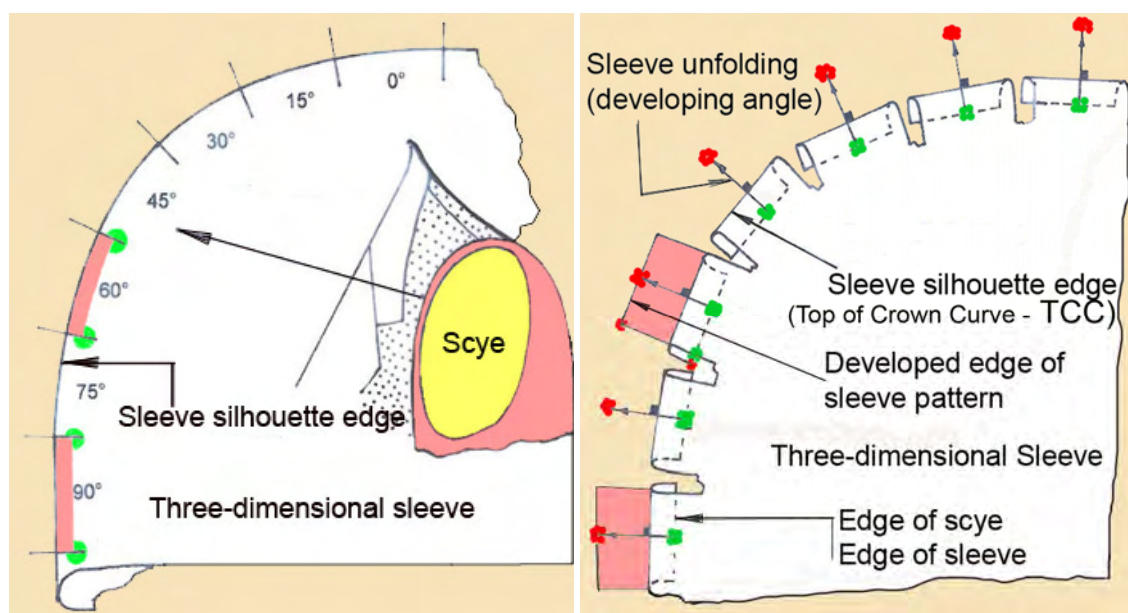
Since no evidence has been found in the literature regarding the mechanics of the sleeve crown for a number of sleeve styles, analyses of these are regarded as essential prerequisites to clarify the actual sleeve design system. This part of the chapter therefore, describes the method used to produce the sleeve crown area (the area above the sleeve truncation line - STL), for all the sleeve styles featured in the inset sleeve design system. This is achieved by matching sector points on the sleeve (positions as yet unknown) with the sector points arranged previously around the scye (known). Consideration is given to the underlying formations of the distinctive three-dimensional sleeves and how they develop/flatten from the scye sector points (in three-dimensions), into two-dimensions to form the sleeve pattern.



### ***Sleeve crown curvature: Simplified development***

A diagram of a front section of a sleeve crown is divided into angled sections (Figure 6.58 '1') to illustrate the hypothesis procedure. To sectionalise and simplify the process, the sections' angles are measured between the horizontal weft ( $0^\circ$  degrees) to the vertical warp ( $90^\circ$  degrees) with angles of  $90^\circ$ ,  $75^\circ$ ,  $60^\circ$ ,  $45^\circ$ ,  $30^\circ$ ,  $15^\circ$  and  $0^\circ$  (see chapter 7). The angles may not be regular in actual sleeve design and development. Since the curves over to match the scye in three-dimensions, these sections might represent the sleeve fitting into the scye sector points (green points for scye and sleeve in Figure 6.58 '2').

The unfolding (development from 3D to 2D) process of the sleeve sections, onto the plane, is noted in Figure 6.58 '2' where the sections  $90^\circ$  and  $60^\circ$  have been unfolded perpendicular to the edge. The green sector points of the sleeve (which match the scye sector points) unfold to become a flat pattern; the red points are the resultant sector points around the sleeve crown curve.



(1) Angled crown sections

(2) Unfolding (from 3D to 2D)

Figure 6.58. Formation of the sleeve crown



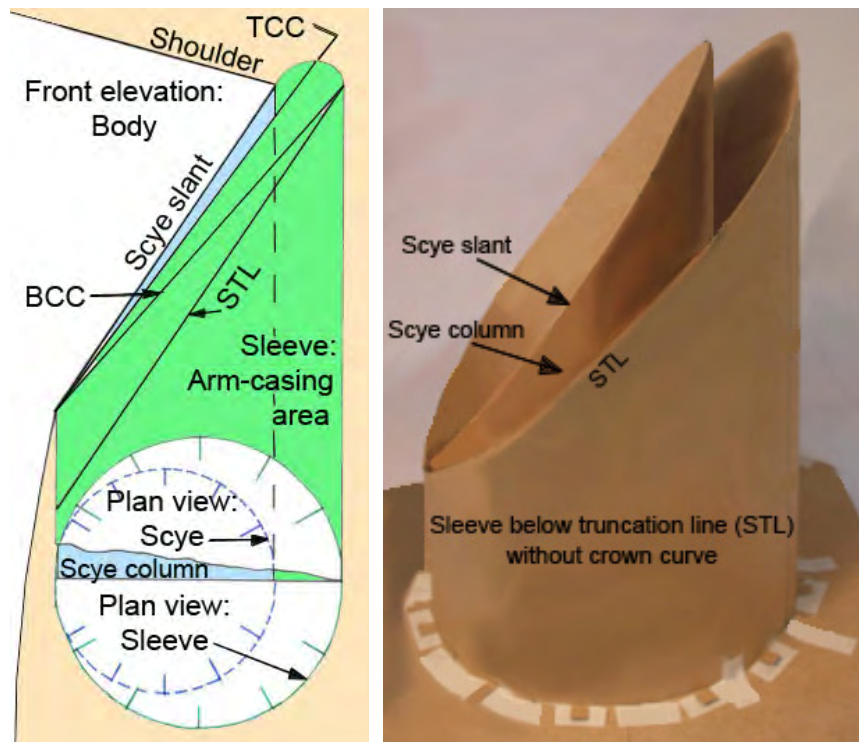
### ***Sleeve crown curvature: Development terminology***

Previously (and for the results chapter), the scye has ten equal sectors and points, as has the sleeve. However, as may be observed from Figure 6.58, precision is enhanced with the addition of more sectors. For the following explanation of the sleeve crown curve, two extra points are added for a total of twelve sector points.

The crown curve development hypothesis, discussed above, is a simplified version of the actual crown curve development process. Further explanation is necessary to clarify terminology and view-points (front elevation in Figure 6.59 '1') prior to explaining the scye and sleeve sectors. The crown requires a number of lines from which the three and two-dimensional structures can be determined. The lines are: the scye line, the top of crown curve (TCC) line, the base of crown curve (BCC) line and the sleeve truncation line (STL) - which is parallel to the TCC line. This line also separates the crown area from the sleeve arm-encasing area previously described.

A simple cylindrical scye and sleeve card structure (Figure 6.59 '2') is used to explain the most intricate sections of the crown construction. The scye slant (angle) and sleeve shape are shown in front elevation in Figure 6.59 '1' and '2' (card model). To 'suspend' the scye circumference and therefore its slant (angle) in space, a column is constructed (Figure 6.59 '1'). This is shown as blue section in Figure 6.59 '1'; the green section which surrounds it represents the sleeve. The area lying between the scye line and the sleeve truncation line (STL) is the crown curve section. This section accommodates the lines that represent the top of crown curve (TCC) and the base of crown curve (BCC) lines. Since the crown curve is a non-developable surface, it is developed separately from the main part of the sleeve – the arm-casing area.

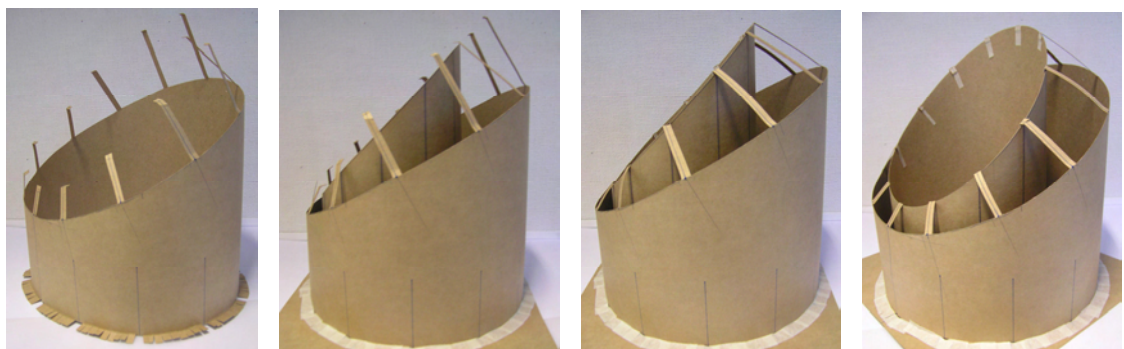




(1) Front/plan (scye/sleeve) (2) Scye and sleeve card structure

Figure 6.59. Scye and sleeve construction

A sequence of photographs of a scye and sleeve card model (Figure 6.60 '1' '2' '3') shows the gradual formation of straight (simplified crown curves) sleeve-to-scye sector point 'bridges'.



(1) Sleeve 'bridges' (2) Sleeve and scye (3) Sleeve/scye bridged (4) Unification

Figure 6.60. Three-dimensional scye and sleeve structure with uniting bridges



The position of the crown bridges, are calculated positions on the sleeve truncation line (STL). From these sleeve points the 'bridges are lowered onto the scye line'. Success of the sleeve crown development hypothesis is when the end of each sleeve crown bridge is aligned with its corresponding sector point on the scye (Figure 6.60 '4').

### ***Sleeve crown curvature: Defining the scye and sleeve sectors/points***

To facilitate a more detailed explanation of the sleeve crown development processes, both the scye and the sleeve continue to have circular bases. These are divided into twelve equal sections around the circumferences (for clarity reasons the circle is reduced to a semi-circle in subsequent figures).

In the new design and pattern making system, it is the scye which is firstly divided into equal sector lengths (see chapter 6 A). However, for these demonstrations, it is easier to divide the plan view into equal sections then to establish the scye sector points. The sector points, around the semi-circular base – plan view, are then projected up to find their place on the (front elevation) scye line. (At this point, the explanations are the actual sleeve crown development processes). In order for the sleeve to balance with the scye, the sector points of both the scye and the sleeve are required to match. The purpose, therefore, is to calculate the positions of each sleeve sector point on the sleeve truncation line (STL) that will match their corresponding sector point on the scye.

The sleeve surrounds the scye (and its column). Sector points 7 of the scye and sleeve are in vertical alignment – no drape allowances. The crown curve is higher and wider than the scye at sector point 1, gradually reducing to zero at sector point 7. Scye line, top of crown curve (TCC) line, base of crown curve (BCC) line and sleeve



truncation line (STL) are all positioned on the front elevation (Figure 6.61); the scye sector heights are also established.

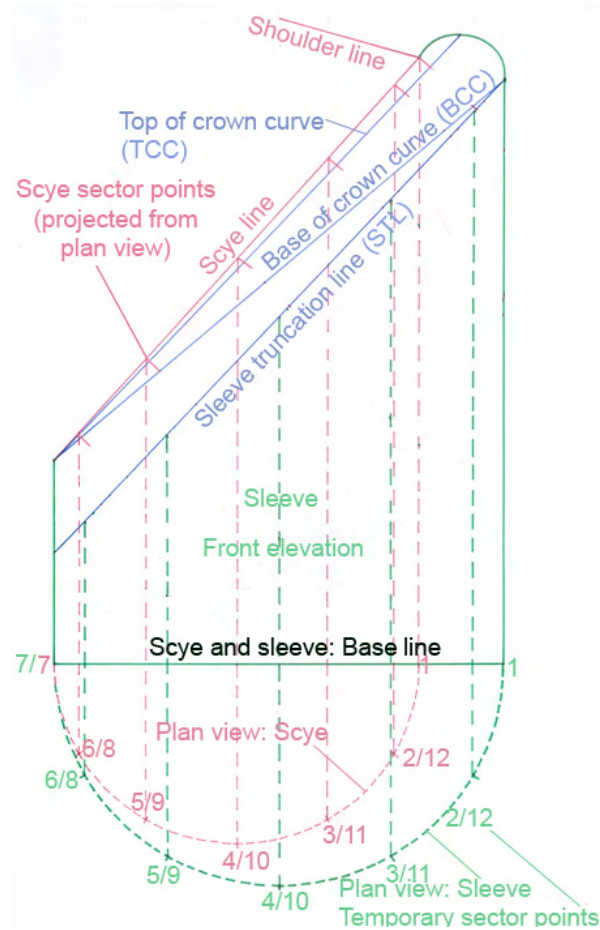


Figure 6.61. Scye and Sleeve before sector point matching

The (semi) circular plan of the scye is divided into six equal sectors, with scye sector points numbered 1 – 12 to represent the full base circle. The scye sector points are projected up to the angled scye line in the front elevation. The circular (semi-circular in this view, with paired sector points) sleeve plan shape is also divided into twelve equal sectors (these are temporary only - for establishing the STL plan view curve). The sleeve sector points are projected up to the STL.



It is required that a scye semi-curve be produced, as seen from the sleeve truncation line (STL) perspective. This is a precursor to harmonising with the sleeve.

The numbered scye sector points on the angled scye line are projected across the diagram perpendicular to the STL (Figure 6.62). The widths of each of the scye sectors, taken from the plan view (base line to semi-circle curve), were measured from the STL to produce the curved scye line (red, dashed line).

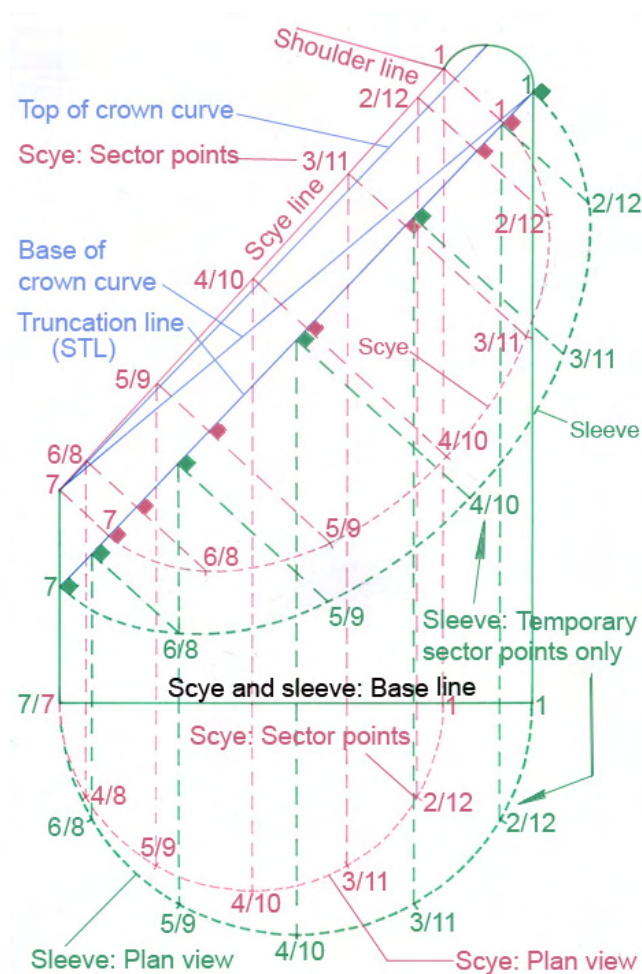


Figure 6.62. Scye and Sleeve truncation line shapes

The temporary sleeve sector points are projected up to the sleeve truncation line and across in the same manner as the scye. The sleeve is also measured on the plan



view, from base line to circumference line. These measurements are also projected to produce the sleeve curve (green, dashed line). This produces the (half) shapes of the sleeve and scye as observed from the STL.

The temporary sleeve sector points and lines are then abandoned in order to locate the true positions of the sleeve sector points that harmonise with the scye sector points. Figure 6.63 shows lines projected (at a right angle) from the sleeve shape (green, dashed line) to each scye sector point on the scye shape – these are the true positions of the sleeve sector points. The scye and sleeve are now joined and matched at the correct sector points.

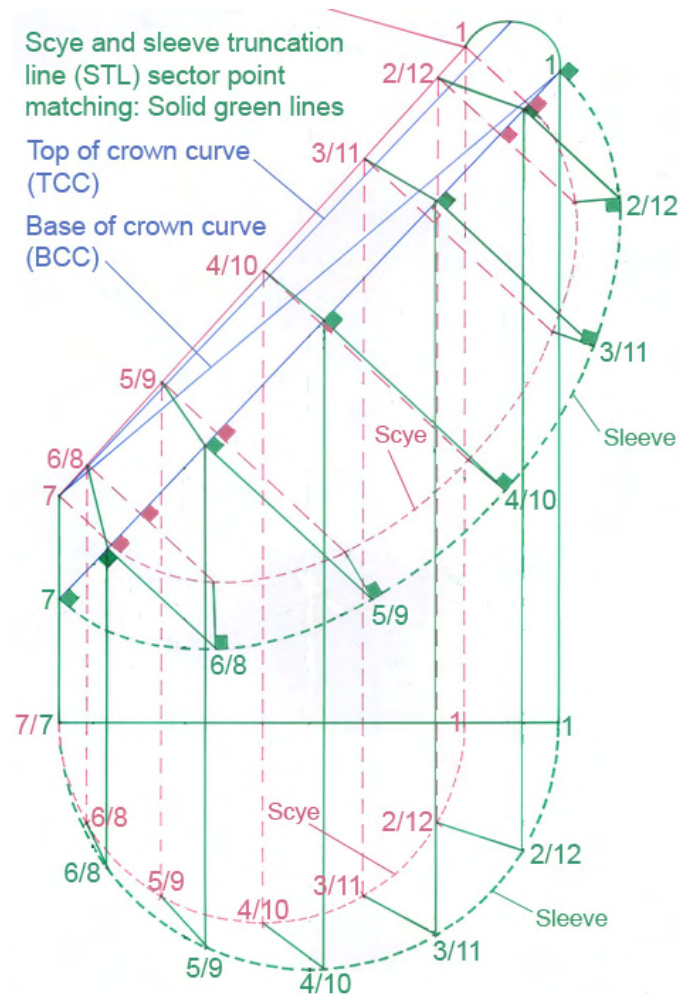


Figure 6.63. Scye and Sleeve sector points matching



The true sector points on the front elevation sleeve curve (Figure 6.63) are projected onto the sleeve truncation line (STL) and on to the scye line; in the process they intersect the base crown curve (BCC) line. From the STL, they descend to the sleeve plan semi-circle where they are joined to the scye sector points in that view. (The true sleeve sector points also establish the sleeve sector heights, from base line to the sleeve truncation line (STL) of the sleeve sectors).

Since the angles between the sleeve and scye sectors (the lengths of the joining lines, in the plan view) are not the correct lengths from sleeve to scye; the correct lengths are from the sleeve to the BCC line – line 'A' (Figure 6.64). The intersections at the BCC of the scye/sleeve joining lines (green) are projected down to the plan view and onto the scye to produce lengths of 'A', the required lengths.

The true sector points on the front elevation sleeve curve are projected onto the sleeve truncation line (STL) and on to the scye line; in the process they intersect the base crown curve (BCC) line. From the STL, they descend to the sleeve plan semi-circle where they are joined to the scye sector points in that view. (The true sleeve sector points also establish the sleeve sector heights, from base line to the sleeve truncation line (STL) of the sleeve sectors).



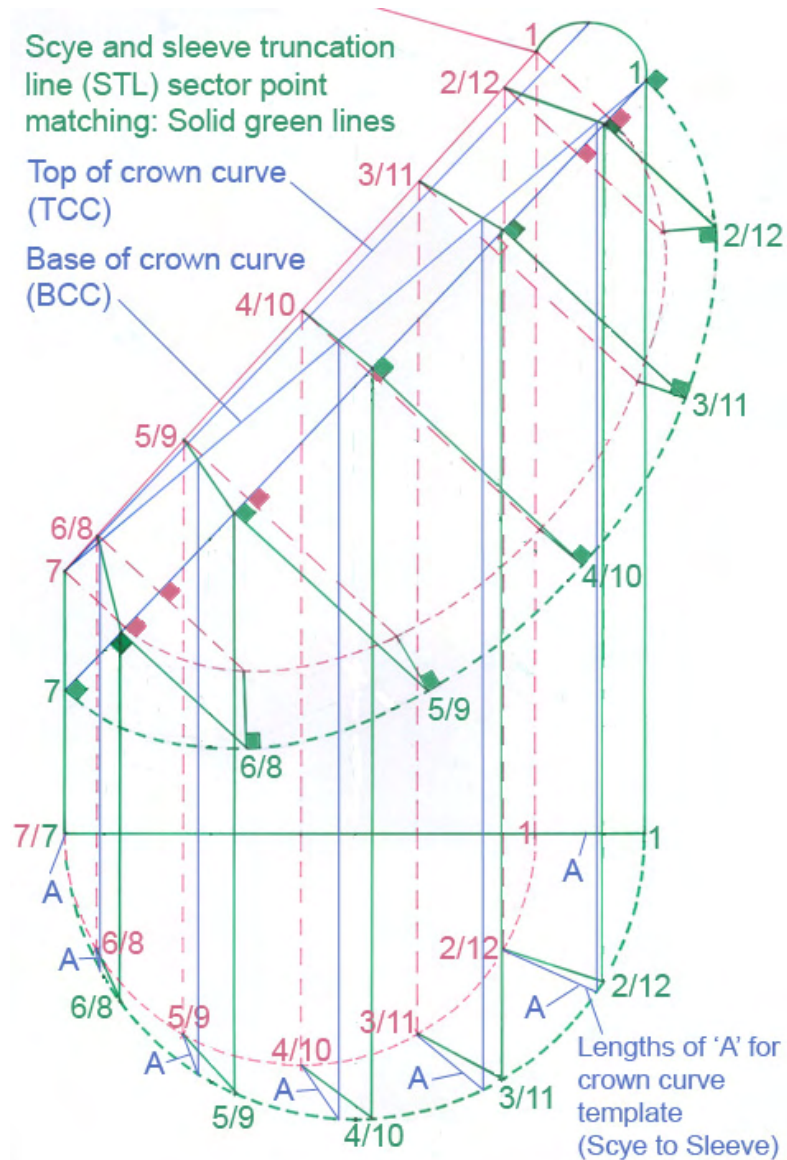


Figure 6.64. Scye and Sleeve lengths 'A'

### ***Sleeve crown curvature: Pattern development***

The sleeve truncation line (STL) sector heights – from the front elevation and the sleeve sector base lengths – from the plan view curve - produce the curve for the preliminary pattern in Figure 6.65. Since the plan-view is semi-circular, there is only a requirement for half a pattern – the other half being a mirrored image. The crown curve development angles are generated, at the top of each sleeve sector line, perpendicular to the truncation line curve.



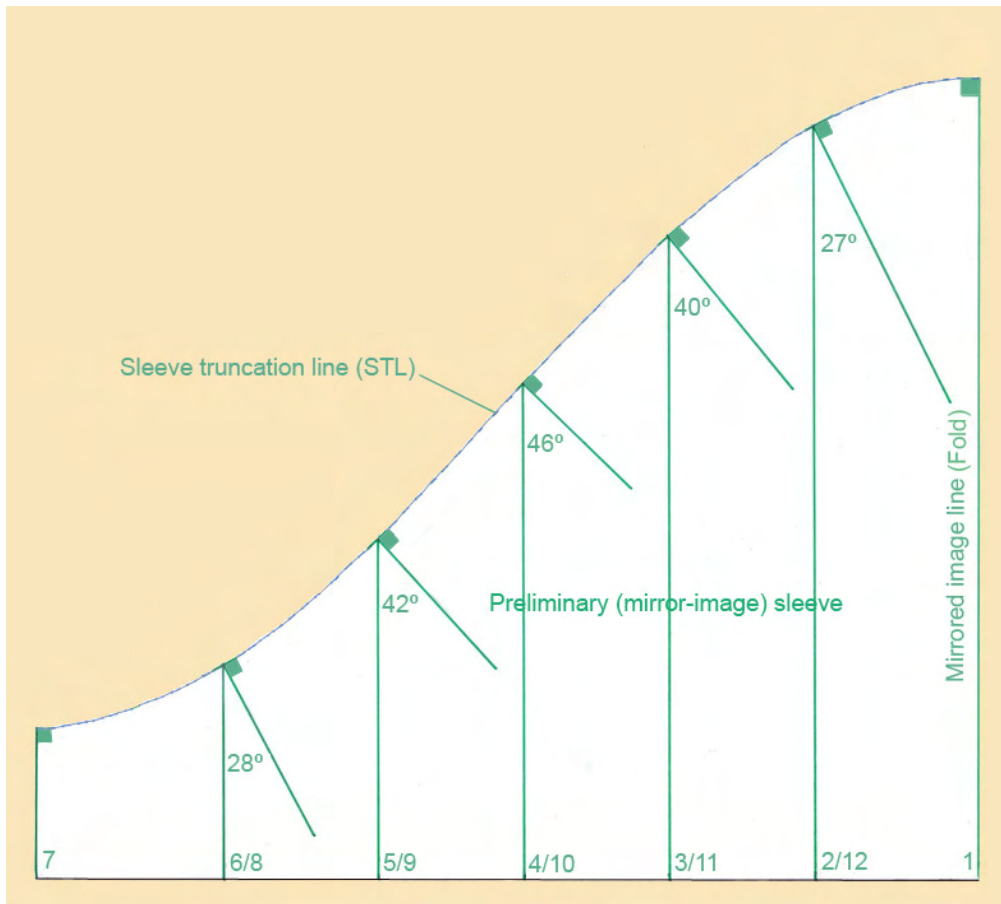


Figure 6.65. Sleeve truncation line

The crown development angles are the precursors of the two additional measurements ('B' and 'C') necessary to construct the sleeve crown curve. Measurement 'B' requires the formation of the base of crown curve (BCC) line and the top of the crown curve (TCC) line - of the outer sleeve (Figure 6.66). The curves are extracted as was the sleeve truncation curve.



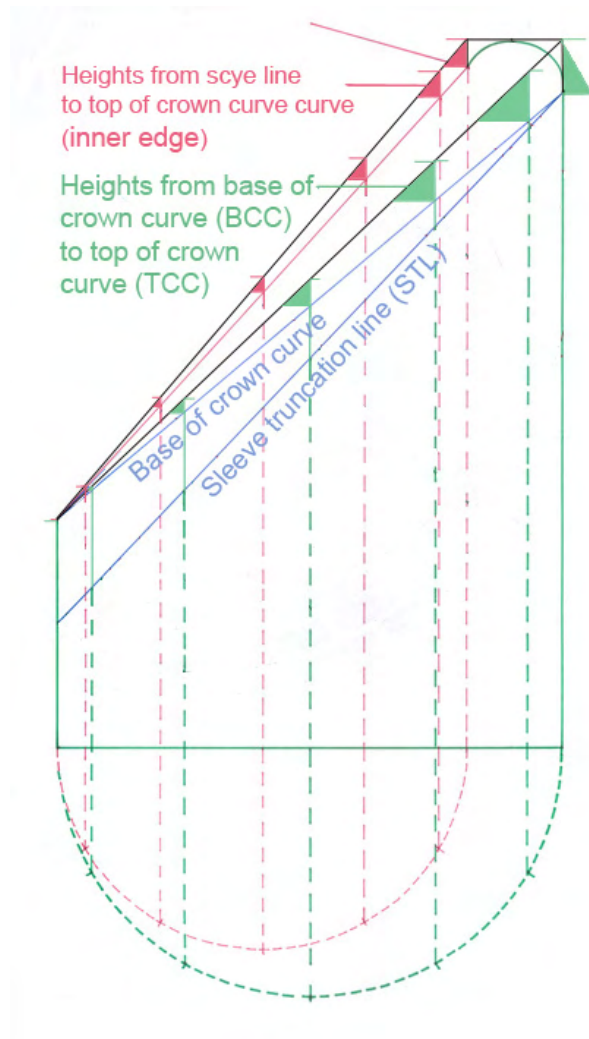


Figure 6.66. Inner and outer edge heights

The results are reproduced in Figure 6.67. The required lengths of 'B' are measured along the sector angles between these two lines.



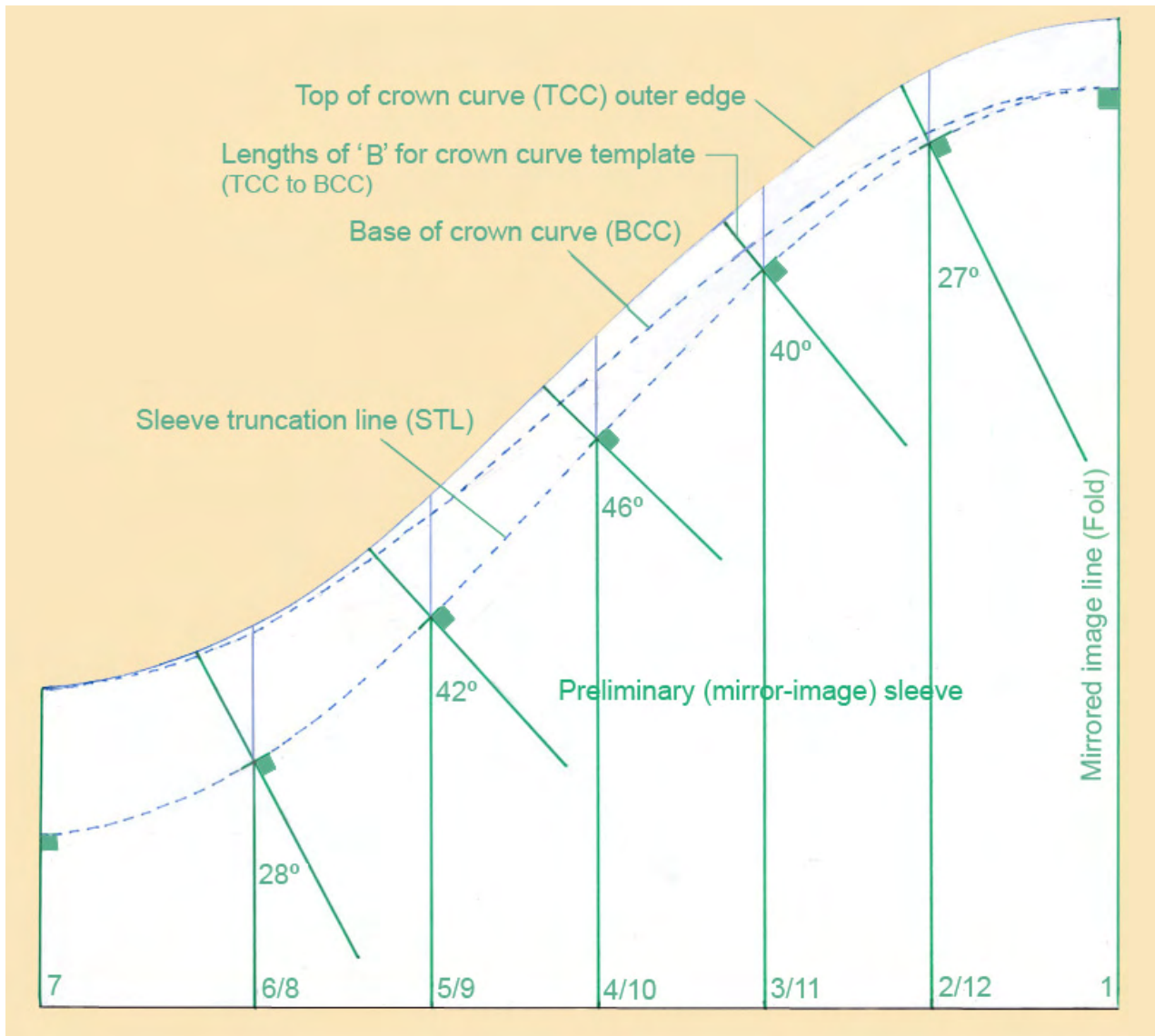


Figure 6.67. Scye and Sleeve lengths 'B'

The remaining set of lengths 'C' is based on the scye. Front elevation scye sector heights and curved base line sector lengths form the scye (half) pattern. The sector angles (from Figure 6.67) are applied to the top of each vertical sector line. The sector heights for the inner top of crown curve (TCC) line (from Figure 6.66) is described. The required lengths of 'C' are measured along the angled lines between the two curves (Figure 6.68).



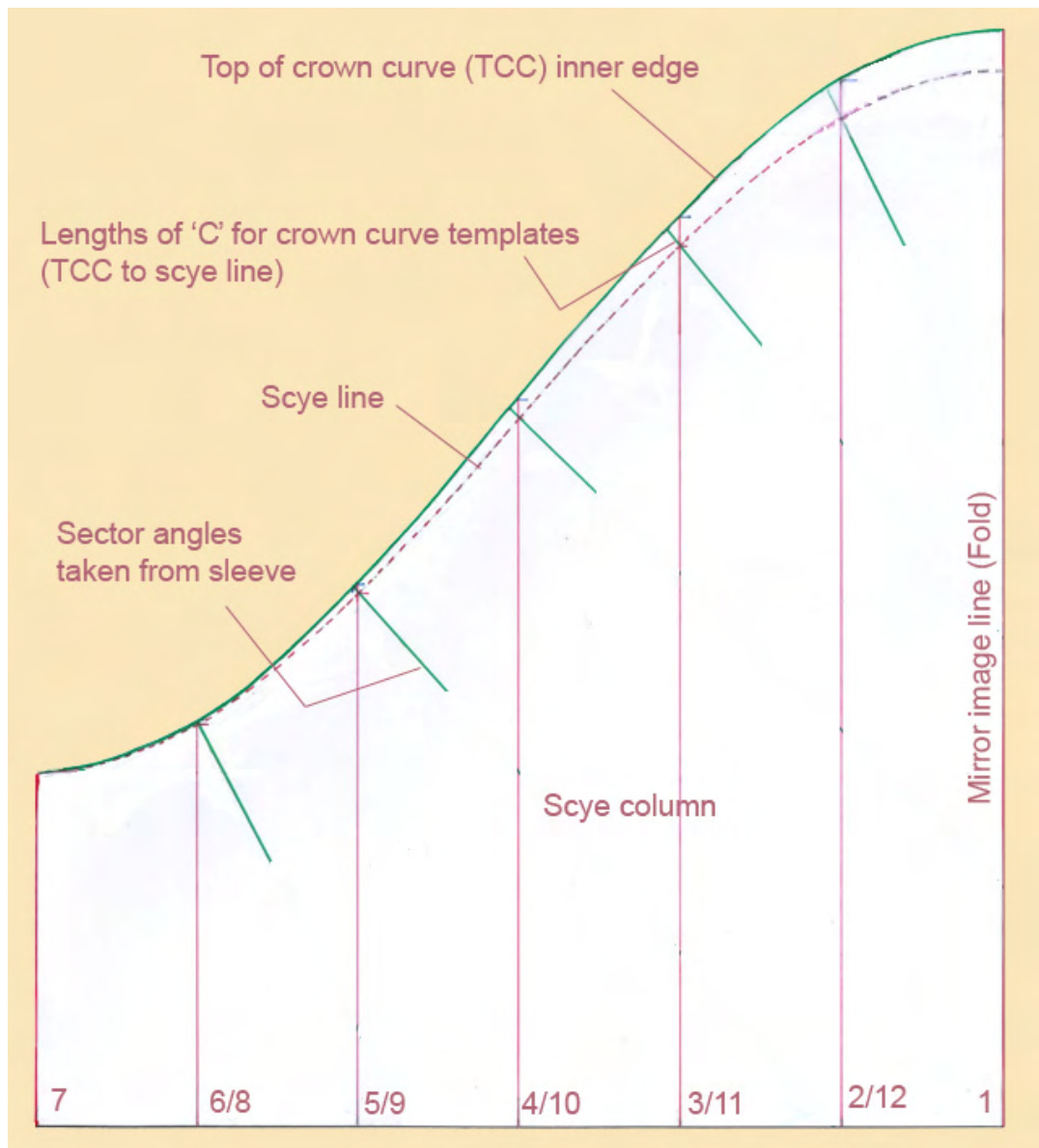


Figure 6.68. Scye and Sleeve lengths 'C'



Lengths of 'A', 'B' and 'C' form irregular polygons of size relative to their respective sector positions around the sleeve, diminishing in size from sector 1 to sector 7 where there is no curve. The irregular polygons (Figure 6.69) contain the crown sector curve – and therefore its length, between the base of crown curve (BCC) – lower point of 'B' and the top of crown curve (TCC) at 'A'. The base of line 'C' represents the scye edge line. (See appendix G for further crown curve explanations)

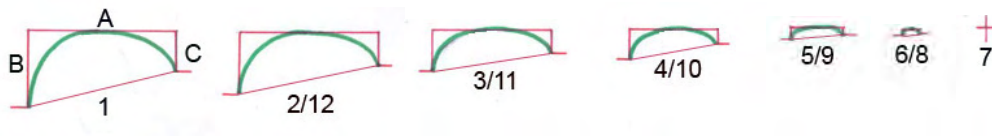
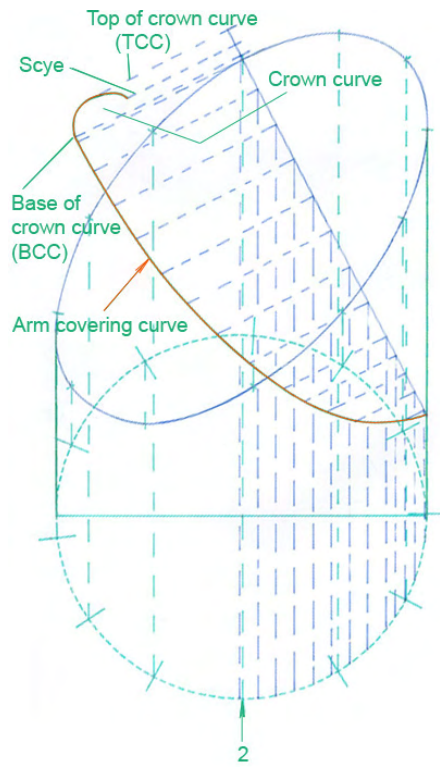


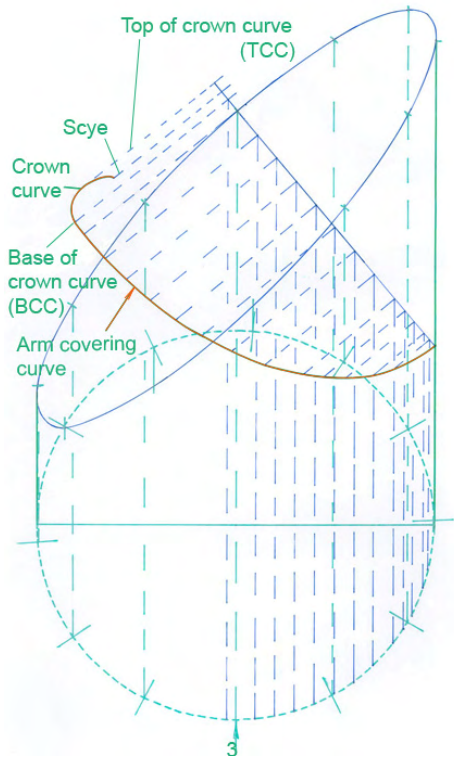
Figure 6.69. Sector crown curve formations: Sectors 1, 2/12, 3/11, 4/10, 5/9, 6/8 and 7

To confirm that the arm-encasing sector curve forms a continuous flow into the base of crown curve (BCC), through the crown curve and into the scye (B-A-C), the arm-casing curve must be added to the section between the sleeve truncation line (STL) and the BCC, between the BCC to the top of crown curve (TCC) and on to the scye line. The results of the total sector curves (curves 2, 3, 4, 5 and 6 respectively) - from the arm-encasing section to the scye are illustrated in Figure 6.70. The method for attaining the arm-encasing curve is described previously in this chapter.

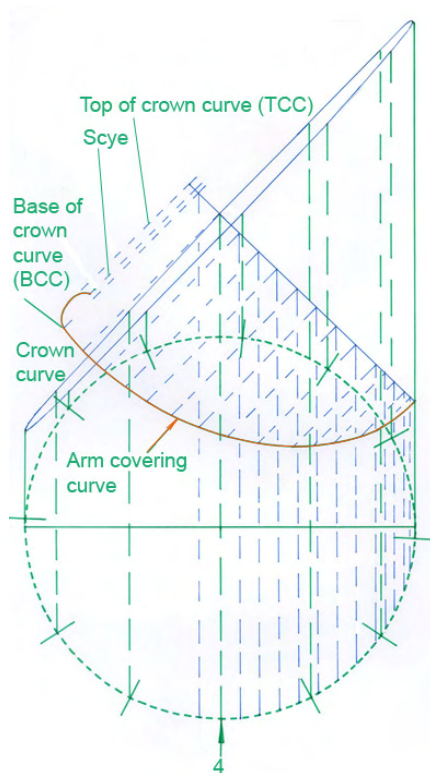




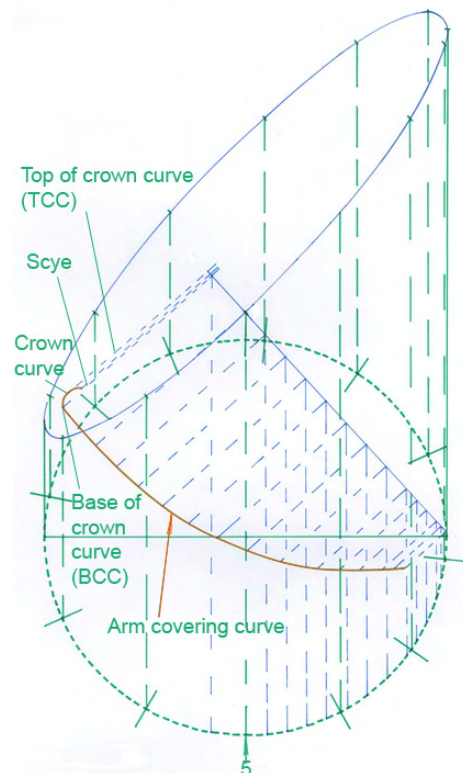
(1) Arm covering curve 2



(2) Arm covering curve 3

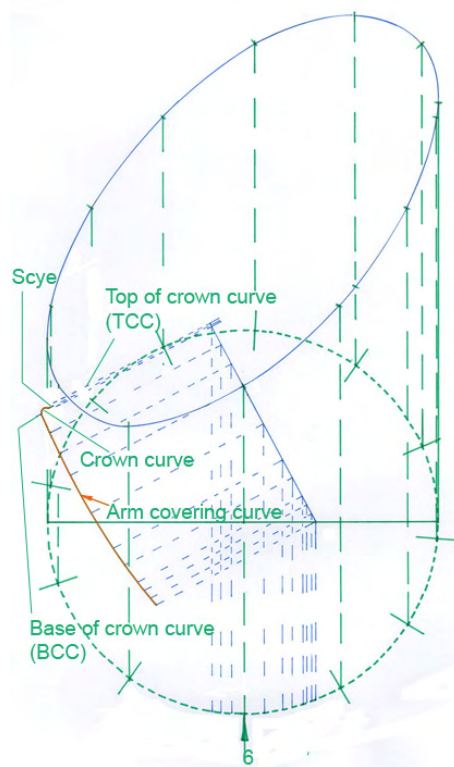


(3) Arm covering curve 4



(4) Arm covering curve 5





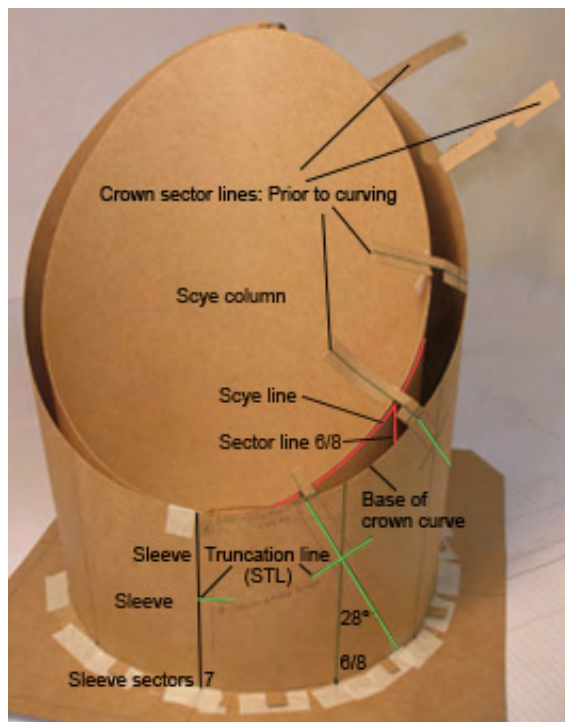
(5) Arm covering curve 6

Figure 6.70. Combined arm-encasing and crown sector curves

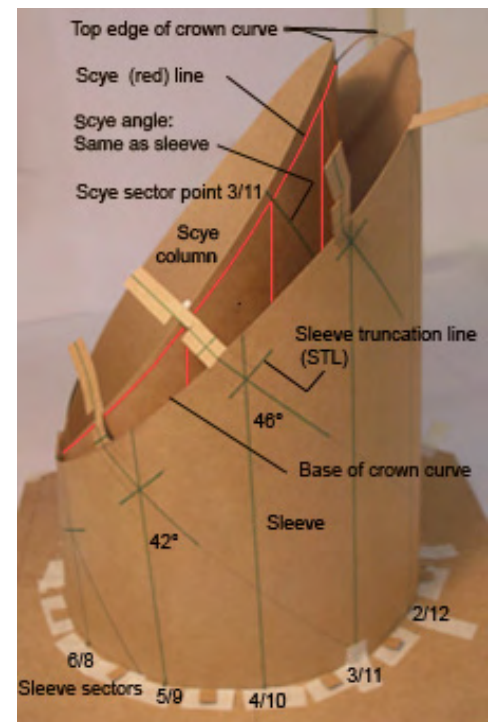
### ***Sleeve crown curvature: Confirmation of the hypothesis***

The next consideration, after combining the arm-encasing area with the crown sector curves, is the confirmation of the hypothesis. Card models of the scye and sleeve with crown curve bridges are constructed. The bridges are formed, perpendicular to the sleeve truncation line (STL), between the sleeve sector points and the corresponding scye sector points. The bridges, in line with the arm-encasing sector curves, determine whether all of the scye and sleeve sector points are aligned. The 'initial' un-joined bridges are illustrated in Figure 6.71 '1', '2', '3'.

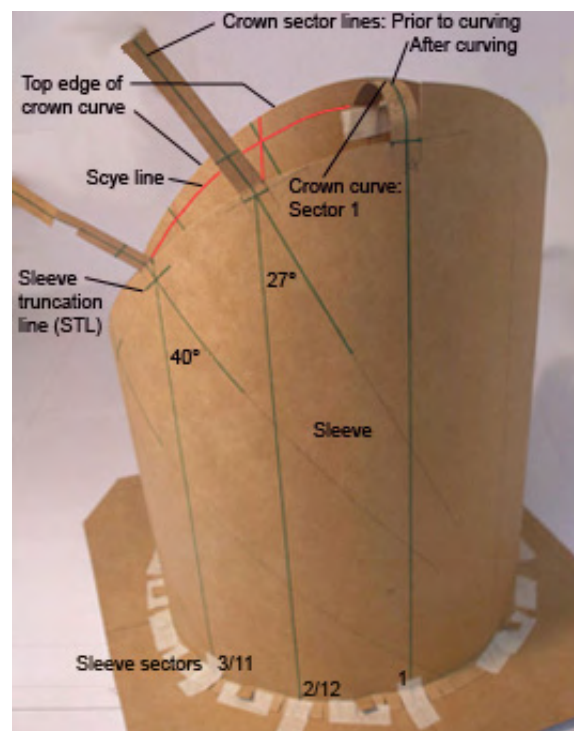




(1) Crown curve bridges (inner side view)



(2) Crown curve bridges (front view)

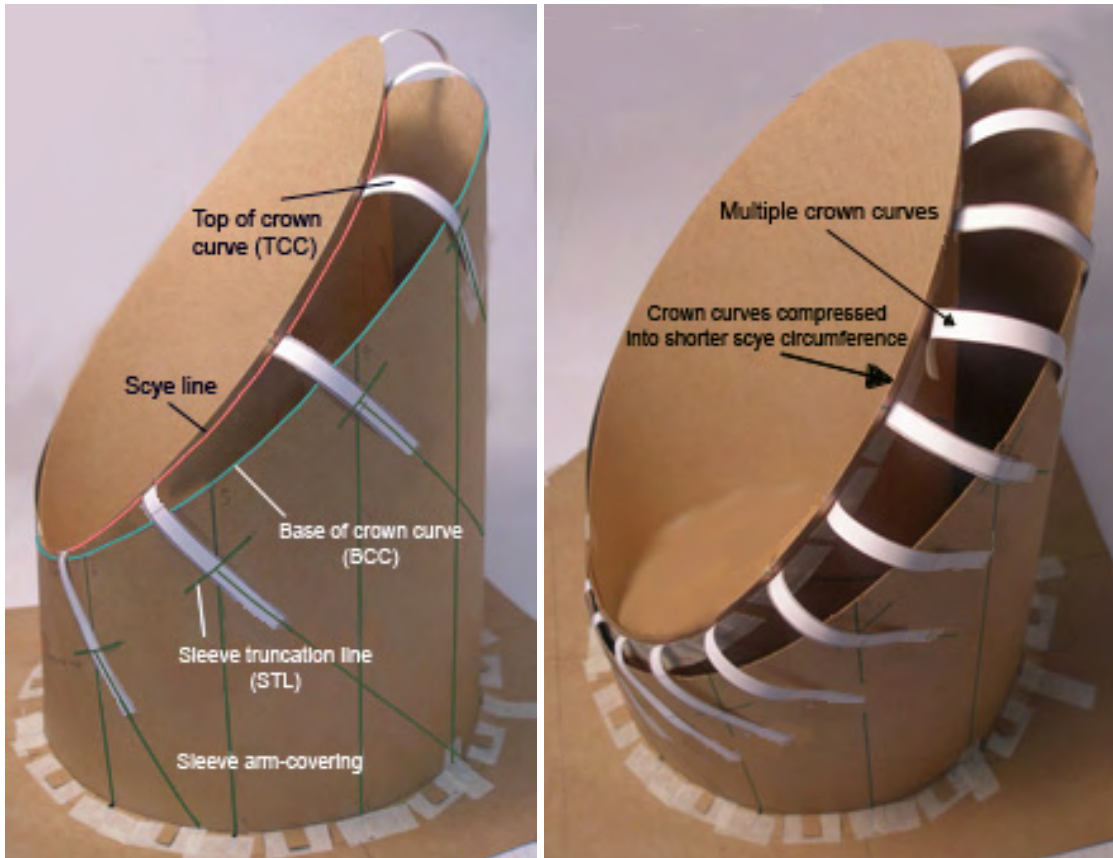


(3) Crown curve bridges (outer side view)

Figure 6.71. Three-dimensional scye and sleeve structure with bridges



The lengths of each of the crown curves has been calculated previously, adding the crown curve lengths to the sleeve sector points on the sleeve truncation line (STL) and arm-encasing sleeve area, forms the actual crown curves as depicted in Figure 6.72 '1', with seven curves and Figure 6.72 '2' with additional curves.



(1) Crown curve bridges (front view)

(2) Multiple crown curve bridges (front view)

Figure 6.72. Sleeve crown curvature

The depiction of the crown curves in Figure 6.72 illustrates how the longer circumference of the sleeve, obliges the crown to compress into the shorter circumference of the scye. The compression of a longer length (of fabric) into a shorter length is known as fullness. The problem of fullness, surface decoration, in the form of stripes and checks, and drape are discussed in chapter 7C.



## **6.20 Summary**

The construction of the sleeve arm-encasing areas led to the variable formations of sleeve crowns and a method for realising different crown heights. Techniques for the assembly of the three-dimensional non-developable sleeve crown area were achieved. This was accomplished by sub-dividing the crown into bands. The bands use border lines of sleeve truncation (STL), base of crown curve (BCC), top of crown curve (TCC), top of crown curve (inner edge) and the scye line.

To deal with the problem of crown curvature into the scye, card templates of small crown curve angle sections, equivalent to rectangular strip and multi-strand mesh facets (see appendix E), were constructed and examined. These revealed the natural curvature of sections of the sleeve crown into the scye and also the development (flattening) process.

## **6.21 Conclusions**

Chapter 6A reported that in contrast to contemporary two-dimensional scye shapes, the scye template is not distorted. It provides a positive base from which to proceed to sleeve design and pattern making. The scye shape is a fundamental element in the new design system. Each in-set sleeve design has its own scye template similar to the scye template shown in Figure 6.11 '2'. The scye template, sectioned around its perimeter, offers greater accuracy and control whilst providing a better integration with the sleeve design. The completion of the three-dimensional toiled scye and the controlled two-dimensional scye template, with its appropriate ten-sector measurements, allows in-set sleeve designing, drafting and pattern making to proceed to initial trials.

Chapter 6B explained that replacing traditional sleeve drafting methods with engineering drawing techniques imparts a standardisation to the design and drafting



process. In geometric terms, it has been identified that there are only two basic regular profiles that may be associated with initial sleeve silhouettes; the truncated cylinder and the truncated cone. The truncated cone could be readily adapted to different interpretations of the basic conically shaped sleeve outlines and is easy to visualise and draw in various perspectives, giving a holistic interpretation of the three-dimensional object.

The three methods of developing (flattening) a three-dimensional surface have been acknowledged as having the potential for the creation and development of a novel inset sleeve design method. Using these drawing techniques allows for a more systemised design approach and a better standard of quality as well as more predictable sleeve pattern making results at the design stage – not at the end of the trialling cycle.

Chapter 6C discussed sleeve elevation. Sleeve development incorporated a range of arm/sleeve elevation angles for both formal and informal types of garments. The elevation methods were documented and explained.

It has been shown that sleeve elevation for an array of angles need not be subjective. Methods of elevation for lateral and lateral/forward movements were created to include various sleeve styles of both a formal and informal nature.

In chapter 6D, for simplification reasons, the sleeve crown area (the 'banded' section linked directly to the scye) is partitioned from the sleeve section – the arm-encasing area - immediately below. A system of sleeve crown curvature development has been created and detailed. Using large-scale card models of the scye and sleeve arrangements, the hypothesis that the sleeve develops onto the scye (and reversing



the process, onto the plane) in a perpendicular direction to the sleeve silhouette, is physically confirmed. The problem of assessing the amounts of fabric compression/fullness and their distributions for each of the sleeve sectors is recognised.

The sleeve crown area is simultaneously associated with fabric fullness and its transitional qualities of gathers, pleats and darts. However, the separate amounts of sector fabric fullness in any sleeve style have to be confirmed as fit for purpose. Since the actual amounts of sleeve crown fullness, for a selection of fabrics and individually designed sleeve styles have still to be calculated, a method of calculation has to be created. Fabric fullness has a major influence on the final form of the three-dimensional sleeve crown and the two-dimensional sleeve pattern. Fullness and other relevant fabric characteristics are discussed in Chapter 7.



# Chapter 7 —

## Fabrics

### 7.1 Introduction

The previous chapter discussed the geometric structures of the in-set sleeve, ranging from the scye, sleeve silhouettes, elevation, crown curvature and the development of the pattern onto the plane. Geometric structures are continued, in regard to fabric surface decoration and drape, however, since geometric structures do not consider the mechanical or physical properties of the materials, physical modelling (which does) in the form of fabric fullness, is addressed.

Sleeves are constructed from a variety of fabrics manufactured with an assortment of properties, finishes, applied coating applications and different patterned effects. Chapter 7 therefore, explores fibres, fabrics (plain or decorated), fabric properties such as drape and fabric fullness (overfeed or planar compression) - its equivalents - gathers, pleats and darts and their distribution. This chapter also introduces a method for calculating fabric fullness amounts for the various crown sectors and sewing angles arranged around the sleeve crown of the flat pattern.



Usually, in-set sleeve drafting methods do not stipulate which fabrics have been used to create the sleeve pattern. Other areas of neglect are how fabric fullness is determined and how fullness is distributed around the crown to achieve the resultant three-dimensional sleeve. This has an impact on the teaching of manual pattern making where students are often isolated from the associations and interactions of fabric and pattern making. As Aldrich (1996) observes, there is a tendency for institutions of learning to separate fabric technology and pattern making. Broadly speaking, literature on the two subjects, fabrics and pattern making, tends to focus on their separate subject matter and as a result the connections between the two fields are not always apparent. This weak point, of not considering fabric characteristics and behaviour with pattern making, is commonly not carried through to two-dimensional pattern CAD systems.

The diversities of fabric characteristics are, to some degree, accommodated in two-dimensional CAD systems. However, the success of this is reliant on the pattern technician who has a thorough comprehension of fibre and fabric properties. Krzywinski, Röedel and Schenk (2001) rationalise that it is essential that the integration of fabric parameters with pattern making should be further developed and included in future manual and CAD drafting and pattern making systems. I would add that the not-too-clearly defined subject of fabric fullness and their distributions around the sleeve crown need further investigation for the computer environment. These clear oversights of fabric characteristic inclusion, into pattern making, bring uncertainty to the problem of sleeve drafting as a whole. These are important points that should not be overlooked.

The ensuing discussion is concerned with redressing that anomaly and to strengthen the association between sleeve design, drafting and pattern development. The purpose



is to predict the final sleeve pattern size and shape in the design and pattern making function prior to production. Chapter organisation:

- Chapter 7A. Fabrics, their construction (weave), fibre content, properties and their selection are described. Fabric/fibre and sleeve silhouette combinations are also discussed.
- Chapter 7B. Details surface decorations in the form of stripes, either horizontal stripes, vertical stripes, or a combination of both are analysed to determine their construction and their affect on fabric fullness.
- Chapter 7C. Fabric fullness, introduced in chapter 7B, is explored in relation to sleeve crown curvature. Fullness amounts, their calculations and distribution around the sleeve head, for the selected fabrics are analysed.
- Chapter 7D. Geometric drape, or blousing, whilst not considering fabric properties, is tentatively (because of its complex nature) introduced into the under sleeve of a tailored garment.



## **Chapter 7A —**

# **Fabrics: Fibre Selection, Properties and Sleeve Silhouettes**

### **7.2 Introduction**

To verify a new design and pattern making system, control of results is very important. The organisation and performance of fabrics, therefore influences results significantly. Fabric properties, their fibre content (important to this study), their selection and relationship to sleeve silhouettes are discussed.

### **7.3 Fabrics: Selection**

To assist dimensional stability during the testing of this new in-set sleeve design system, trials are confined to woven fabrics. The reasons are best defined by Heisey, Brown and Johnson (1988) who discuss the differences in drape between knitted and woven fabrics, identifying that depending on the looped structure of knitted fabrics (long and narrow or short and wide), there may be significant changes in length along the horizontal and vertical axes. Conversely, the grid structure of a woven fabric is better able to resist changes in length in the warp and weft directions although it may alter in the bias direction.



There are many types of weave, from the simple plain weave (Figure 7.1) to the more complex weaves. The various characteristics/properties shown by fabrics are governed by such factors as weave (close or open), weight, the ratio of ends to picks per centimetre and the type of yarn, fibre content and finish.

Figure 7.1. Plain fabric weave structure

Source Miller (1976)

### ***Fabrics: Fibre selection and sleeve silhouettes***

This thesis is centred on a finite number of sleeve silhouettes. In total, five styles (tailored has both straight and curved variations) are examined with each style traditionally linked to specific fabric types. Each of the selected fabrics are analysed for fibre content, then weighed. Table 7.1 illustrates the combination of in-set sleeve style with a particular fabric selected from the four fibre groups list: cellulose, natural protein, man-made and regenerated fibres. A distinct in-set sleeve style/silhouette is made from each fabric group. The chosen fabrics are cotton; a mixture of acetate and viscose; polyester and wool.



Table 7.1. Sleeve style and fabric type

Sleeve silhouette	Fibre type	Fabric content	Fabric weight
Tapered (Shirt)	Cellulose fibres	100% Cotton	129.26g/m <sup>2</sup>
Tapered (shirt)	Regenerated fibres	50% Acetate 50% Viscose	119.13g/m <sup>2</sup>
Flared (Bell)	Man-made fibres	100% Polyester	72.66g/m <sup>2</sup>
Straight (Tailored)	Natural protein fibres (Harris-Tweed)	100% Wool	347g/m <sup>2</sup>
Shaped (Tailored)	Natural protein fibres (Hounds-Tooth)	100% Wool	173g/m <sup>2</sup>
Leg-of-mutton	Cellulose fibres	100% Cotton	124.24g/m <sup>2</sup>

### ***Fabrics: Properties***

Taylor (1997) describes two classes of fabrics; fabrics that are essential to the user of a garment (and sales) and fabrics that impinge on the ease and efficiency of clothing production. Fabric properties important to manufacturing include freedom from visible defects, skewing, sewability, tailorability, dimensional stability, and drape (McCartney et al. (2000). Designers and pattern makers are situated between sales and manufacturing; they have to be aware of both classes of fabric properties and have to consider both sales and manufacturing.

Heisey, Brown and Johnson (1988) state that there are:

*'No parameters for the physical and mechanical characteristics of the fabric from which a garment will be made are used in any popular drafting system', and, 'inaccuracies in fit are likely to occur if...the final pattern is made from a different fabric than the one used to drape the pattern'. (p. 5)*

Nevertheless, the focus of the subject of fabrics must be limited to the fabric properties that directly impact in-sleeve designing and pattern drafting. By necessity, other



remaining properties such as weight, thickness and tailorability are described in appendix H

Aldrich (1996) suggests that because the enormous range of fabrics and combinations of fibres within the fabrics available to manufacturers today, the amount of accessible, technical information may not be constructive, informative or understood by the designer/pattern maker. In addition, the various properties of fibre, weave, finish and fabric ensures that the characteristics of cloth are in-built, inaccessible and not easily alterable by the designer or pattern maker. Poole (1936, p.54) relates that fabrics have changeable, irregular flexibilities. Suggesting that adaptable drafting and pattern making methods are required, Richards (1930) asserts that different fabrics cut from the same pattern will not, necessarily, be alike when made into a garment; identifying that a degree of fitting will always be required.

Aldrich (1996) identifies five properties of fabrics that should be taken into consideration when undertaking garment trials. These are: weight, thickness, shear, drape and stretch. To Aldrich's list of important fabric properties, Taylor (1997) adds tailorability and dimensional stability.

However, of the selected woven fabrics utilised for trialling purposes in this study, only a few fabric properties are deemed to be important. The selected properties are those that influence the design and pattern cutting of sleeves and therefore should be incorporated into any new design and pattern making system. Integrating fabric properties within the design system removes the need for the artistic designer to learn such characteristics.



There are three properties that should be incorporated into any new design and pattern making system. Integrating fabric properties within the design system removes the need for the artistic designer to learn such characteristics. These are:

- Fabric surface decoration, in the form of stripes and checks for aesthetic value
- Fabric fullness, for sleeve crown styling, aesthetics and manufacturing purposes
- Fabric drape/blousing, in the tailored under arm sleeve, for aesthetics/elevation

## **7.4 Summary**

It was identified that fabrics and pattern making are two separated practises during the learning experience; that fabric characteristics are not evident in drafting methods. The re-unification of these two disciplines was acknowledged as essential to the development of the sleeve crown – in both sleeve pattern making and sleeve fabrication.

The original five sleeve silhouettes, plus a duplication of the tapered sleeve, were paired with six woven fabrics chosen from the four main fabric groups of fibres. The main fabric properties focal to this investigation were accepted as: weight, drape and linear compression (fabric fullness).



## **Chapter 7B —**

### **Fabrics: Surface Decoration**

#### **7.5 Introduction**

Chapter 6D described the development of the crown curve area at a perpendicular angle to the upper curve edge; this is suitable for all fabrics, however, the inclusion of surface decoration complicates the aesthetics and construction of the end results.

Surface decoration, in this context, is regarded as striped fabric, horizontal in a weft direction or vertical in a warp direction; or their varied combinations which form checked fabrics. With the aid of card models or templates, the question of how straight-line stripes and checks form around, at, and over the sleeve edge curve to match the scye seam edge line and how this affects fabric fullness is now considered.

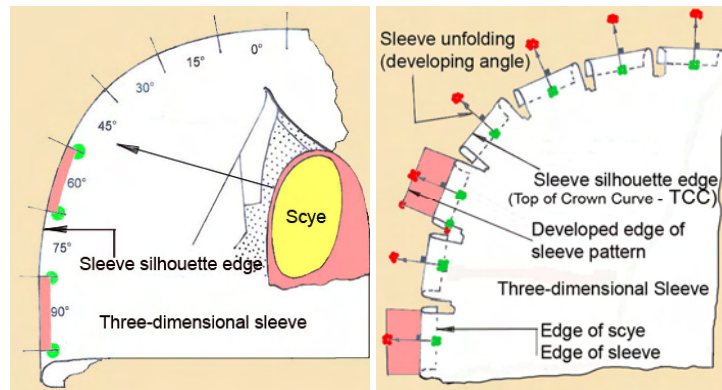
#### **7.6 Stripe fabrics: Sleeve crown curvature**

The curves of the sleeve around the crown are regarded as a series of small straight lines (Figure 6.58 is referenced in Figure 7.2 '1'). These small crown subdivisions are reproduced as large templates (Figure 7.2 '2') for ease of observation. To reduce the number of cardboard templates, the angles are paired in combinations of 90°/0°,

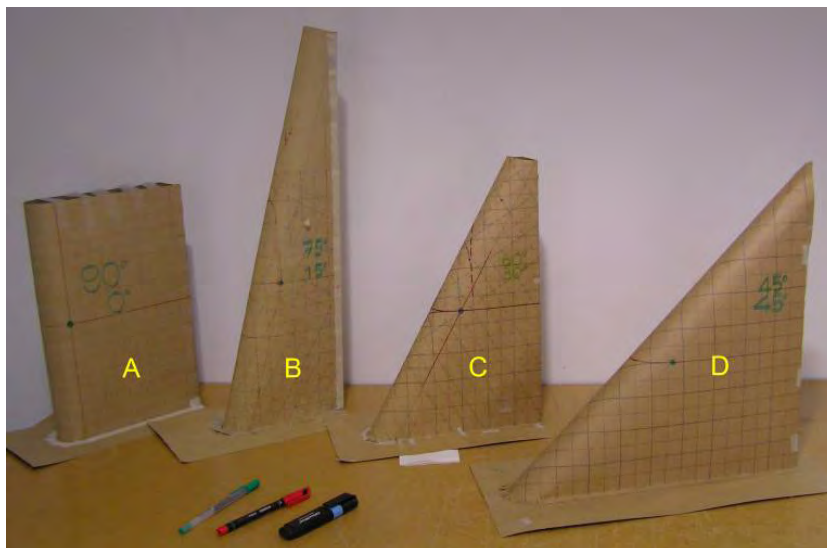


75°/15°, 60°/30° and 45°/45°, needing a total of only four templates. The templates are constructed with a curve diameter of 60mm and a curve length of 94.248mm to represent the crown curvature into the scye line.

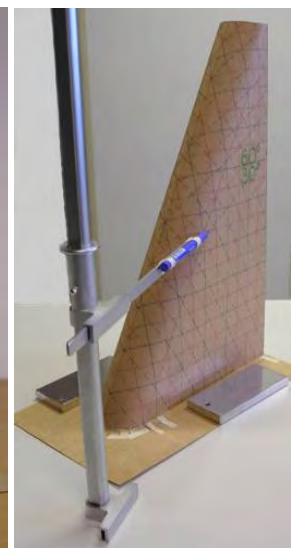
Each template is given a square mesh arrangement of lines to represent a fabric surface with stripes and checks. The mesh acts as a guide for the developments. Figure 7.2 '3 shows the manner in which a horizontal stripe curves around each of the templates; for vertical stripes the templates are inverted.



(1) Angled crown sections/unfolding (from 3D to 2D)



(2) Variety of crown section angle templates



(3) Stripe marking

Figure 7.2. Sleeve crown angled-sections, templates and horizontal stripe marking



To illustrate how fabrics curve over the sleeve crown silhouette, a coloured point (dot) system is devised. The coloured points aid the confirmation of the crown curve-over affect that links the sleeve with the scye in the sleeve development process. The development of the three-dimensional crown onto the plane requires that a point on one side of the sleeve should have a corresponding point at the same horizontal or vertical, on the other side of the sleeve.

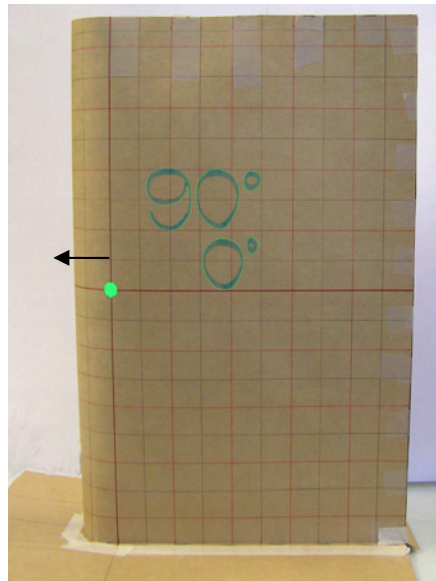
All sector points on the outer sleeve (green points) have their counter-points on the scye/sleeve edge (red points). The concept of green and red points is to observe the behaviour of the red point in relation to the original green point. This reveals any changes in direction striped or checked fabric, and, more importantly for this study, the distortions that would manifest in fullness allowances for the sleeve patterns.

### ***Stripe fabrics: Formation of horizontal stripe***

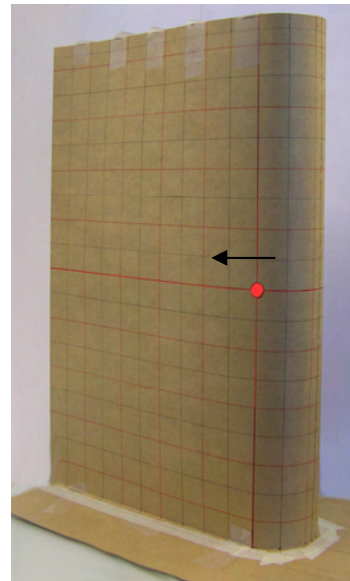
#### ***(90° crown curve section)***

A horizontal red stripe, 'moving' from the right side of the three-dimensional template, encounters the crown curve at the green point on the vertical template – perpendicular to the front of scye (Figure 7.3 '1'). The line progresses, without deviating from the horizontal, from the outer sleeve at the green point, around the vertical crown curve section (at 90°) and onto its equivalent point - the red point on the scye/sleeve edge (Figure 7.3 '2').

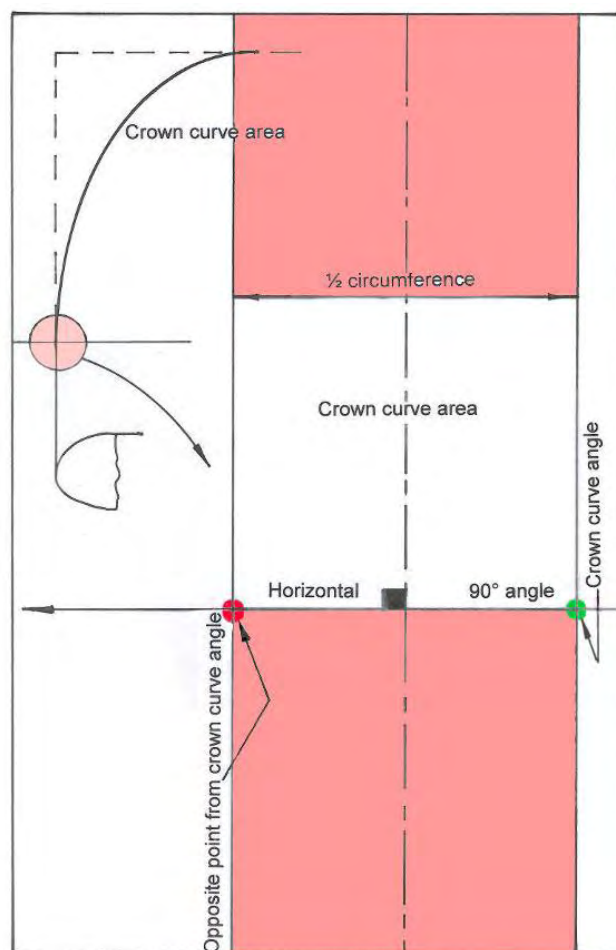




(1) Red stripe meeting crown curve



(2) Progress around curve



(3) Unfolded (developed) crown curve

Figure 7.3. Horizontal stripe fabric (90°crown curve angle)



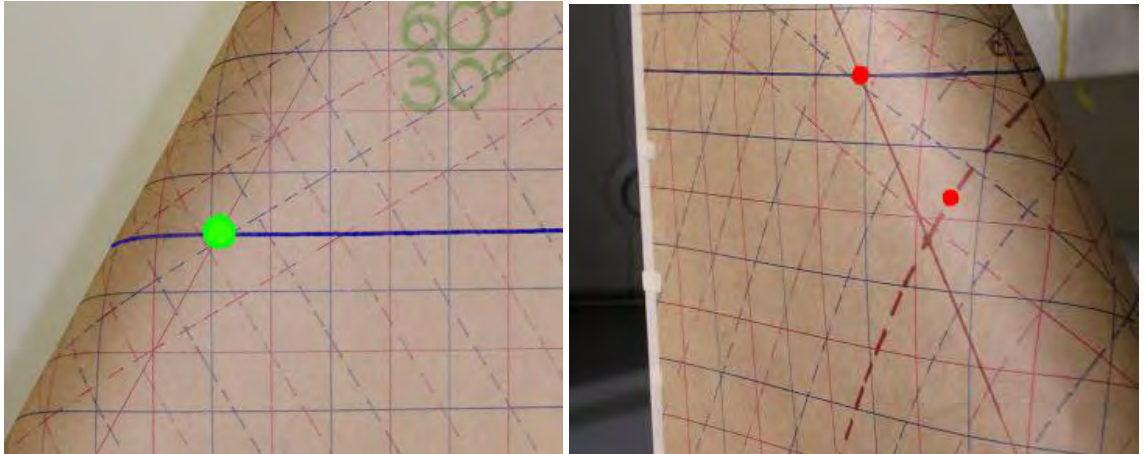
An unfolded, or developed, graphic of the 90° sleeve crown section (Figure 7.3 '3') demonstrates how a green point on the outer edge of the curved section has its red counterpoint on the direct opposite edge of the three-dimensional curve on the same horizontal plane, at a 90° angle to the sleeve edge angle. Inverting the template (not shown) simulates a vertical stripe, progressing in a similar manner across a horizontal crown curve section at 0°. Check fabrics, consisting of both horizontal and vertical stripes, develop in the same manner.

***Stripe fabrics: Formation of horizontal stripe***  
***(60° crown curve section)***

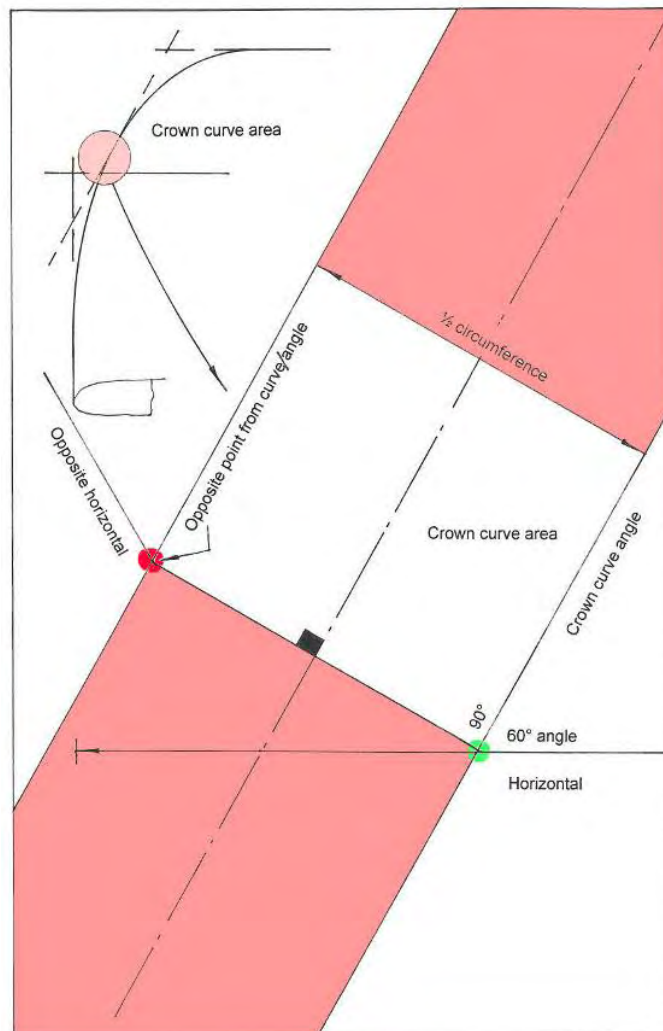
The same process as seen in Figure 7.3, using the green and red points on a three-dimensional card template, is applied to the 60° angled sleeve section (30° angle when inverted). Figure 7.4 '1' and '2' illustrate the horizontal stripe (blue line) and the aligned green and red (upper) coloured points. However, the actual direction of the stripe follows a downward trajectory after it encounters and curves through the crown section (red dashed-line in Figure 7.4 '2'). It is apparent that the actual resting place of the red point is out of horizontal alignment, lower than its intended position along the blue line when compared to the green point.

When the stripe is observed on the plane, it does not deviate from its horizontal direction (arrow in Figure 7.4 '3'). However, since the fabric stripe has to fit to the scye, without appearing to deviate, it must be compelled to change direction at the sleeve silhouette curve - the green point position, and over the silhouette edge to the higher, required, red point. The deviation angle is always 90° to the curve therefore the green point's equivalent, the red point (which matches the scye), is located along the angled line. This is the principle applied to all section angles and all fabrics – plain or stripe; this produces a balanced scye and sleeve.





(1) Blue stripe meeting angled crown curve    (2) Progress around and down curve



(3) Unfolded (developed) crown curve

Figure 7.4. Horizontal stripe fabric (60° crown curve angle)



### ***Stripe fabrics: Horizontal stripe deviation***

#### ***(60° crown curve section)***

It has been shown that a stripe deviates from its horizontal path when it encounters an angled curve. It is evident that the horizontal stripe (the blue line in Figure 7.4 (1) and (2), upon entering and passing through the curved crown surface area, deviated in a downward trajectory at the same angle as the angle of the curved sleeve silhouette edge (in this instance 60°, therefore a 60° deviation). The stripe, and plain fabric, and all of the fabric in this area, is still travelling along its original horizontal line, as would be observed if the template were flattened.

A plan view graphic of the horizontal stripe and its deviated course is presented in Figure 7.5. To establish where the deviated line would terminate, and the amount of deviation, the horizontal stripe (blue line) is measured from green point to upper red point. This measurement is transferred from the green point along the continued horizontal line to finish at the lower red point. An opposite horizontal, from the left, was extended into the curved area. The perpendicular distance from this line to the lower red point is the measure of vertical deviation in three-dimensions.



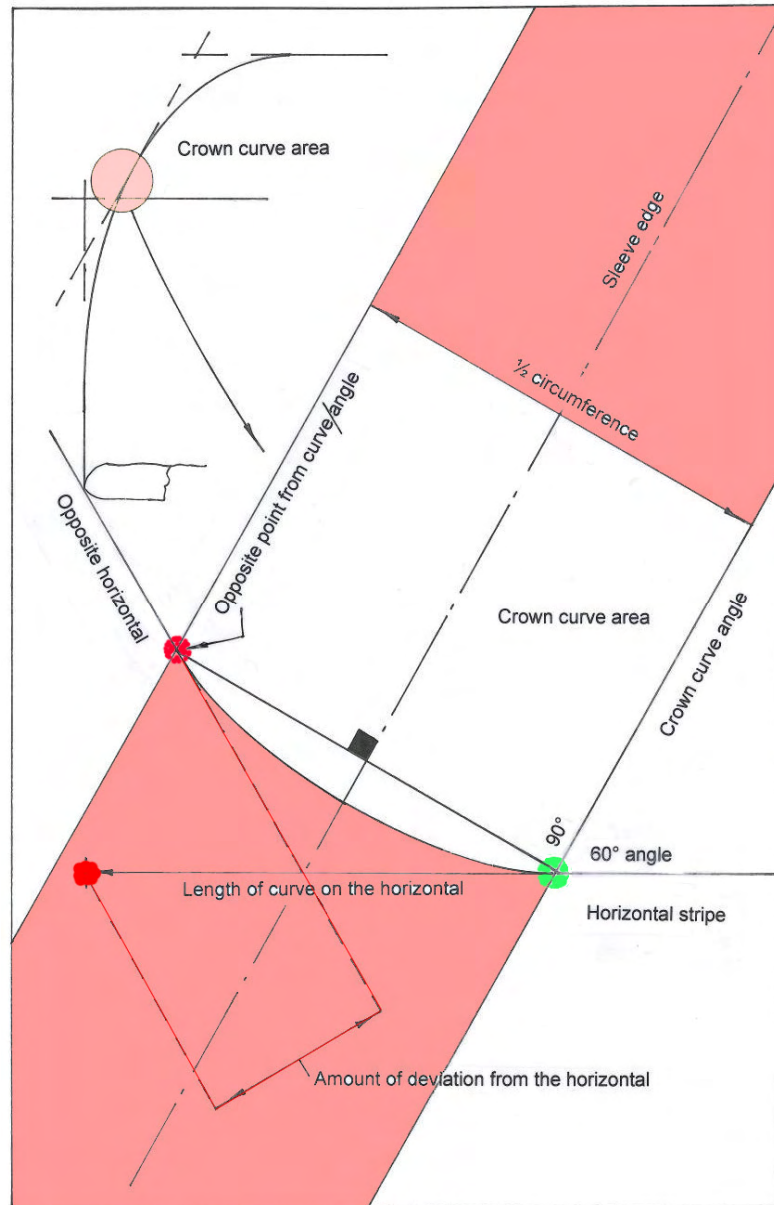


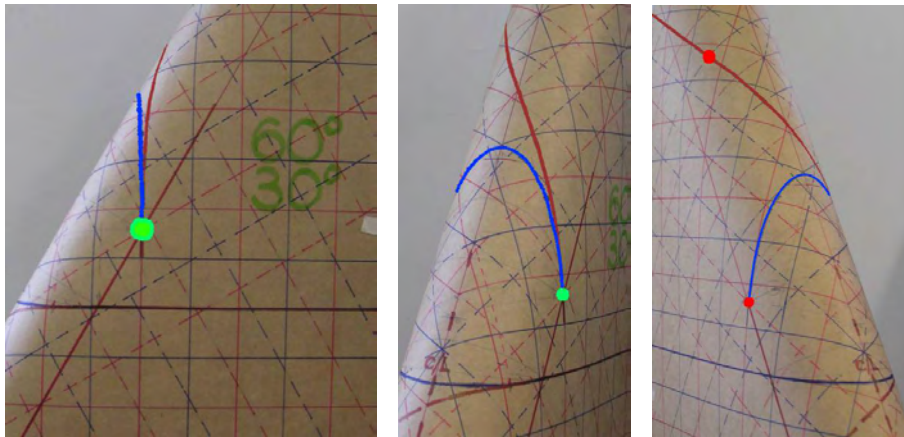
Figure 7.5. Horizontal stripe fabric deviation (60° crown curve angle)

### ***Stripe fabrics: Formation of vertical stripe***

#### ***(60° crown curve section)***

As with horizontal stripes meeting a slanting curved edge, vertical stripes also deviate – except in the opposite, upward direction and therefore at a different angle. Although the same 60° template, utilised in the previous example, is used, the angle at which the vertical stripe encounters the sleeve silhouette edge is 30° (Figure 7.6).

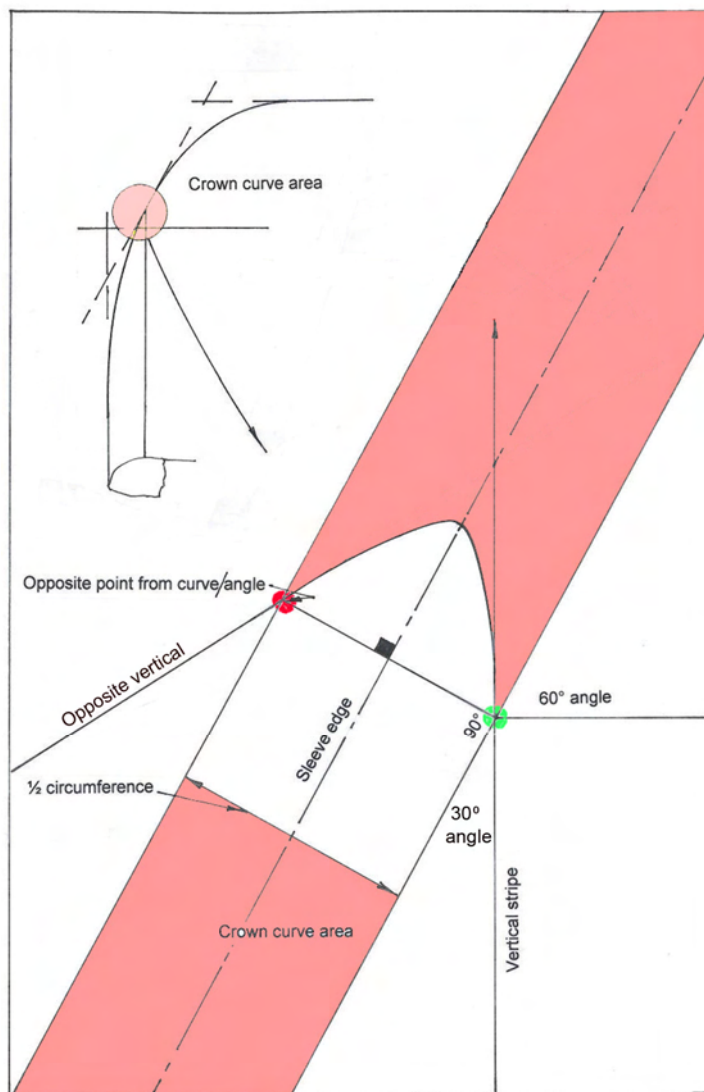




(1) Red stripe meeting angled crown curve

(2) Red stripe upward spiral

(3) Red stripe spiral progression



(4) Unfolded (developed) crown curve

Figure 7.6. Vertical stripe fabric deviation (60° crown curve angle)



The vertical stripe (red line) begins at the base of the template. It encounters the crown curve edge at the green point (Figure 7.6 '1') and proceeds to spiral around the curve (Figure 7.6 '2', and '3'). The blue line is the required vertical that tracks around from the green point to encounter the lower red counter-point (Figure 6.102 '3'). The finished length of the blue line (Figure 7.6 '1' - '3') forms a natural spiralled route from the green point to re-locate at the upper red point (Figure 7.6 '3'). When seen on the plane, as with the horizontal stripe, the vertical stripe remains on its straight line course (Figure 7.6 '4').

### ***Stripe fabrics: Vertical stripe deviation***

#### ***(60° crown curve section)***

A graphic of the vertical stripe and its deviation can be seen in Figure 7.7. The vertical stripe enters from the lower right base line, unites with the green point, angles (90°) through to the lower red point and continues on its vertical path (shown as a 30° slant line to the lower left). Continuing the 30° slant line in the reverse direction, towards the upper right, and forming a right angle into the upper red point gives the vertical deviation length.

All of the other angled sections of sleeve silhouette crown curve follow the same distorted procedures; except for a 90° angle to the edge. Only a 90° angle will fix a point on the sleeve to its rightful corresponding position on the scye – all other angles produce distortions of the sleeve.



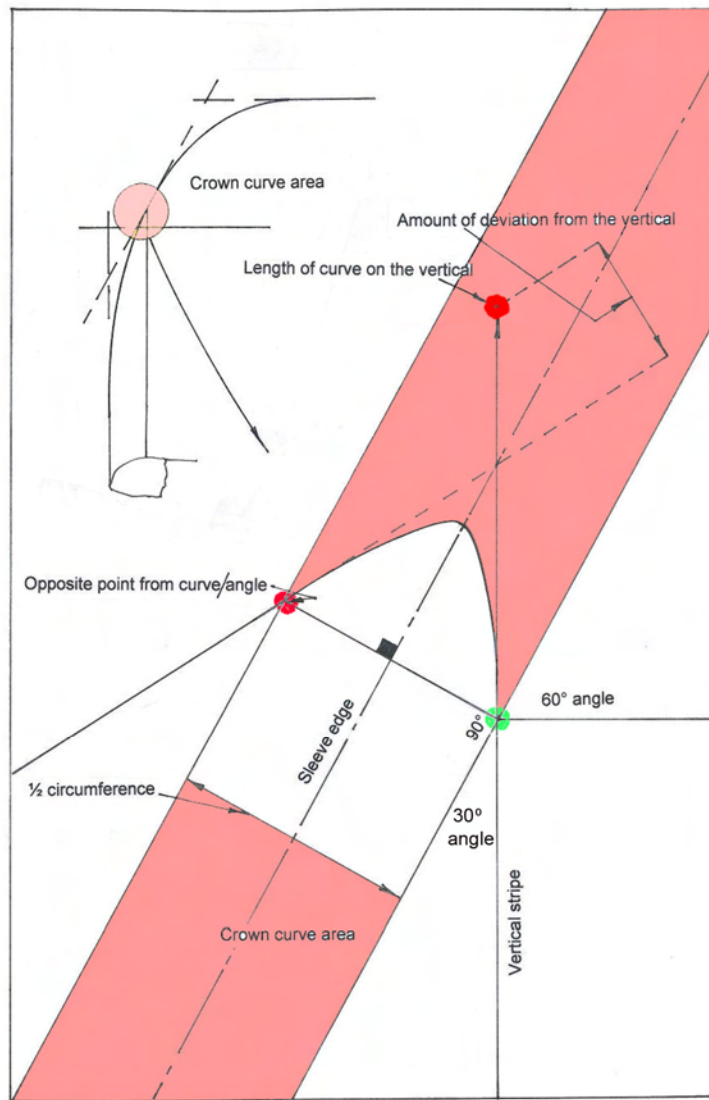


Figure 7.7. Vertical stripe fabric deviation (60° crown curve angle)

### ***Stripe fabrics: Horizontal and vertical stripe fabric fullness***

Stripe and check fabric deviations pose problems wherever curved crown sections are involved. The problems are to maintain the horizontal or vertical directions of the stripes, matching sleeve stripes to scye stripes, and fabric fullness. To counteract the deviations inherent in horizontal and vertical stripes as they cross the crown area necessitates straightening the horizontal (weft) stripe in an upwards direction (blue shaded section in Figure 7.7) and the vertical stripe (warp) in a lateral direction, towards the left (green shaded section in Figure 7.8). Length-wise stripe fabrics require



only the vertical stripe alteration whilst check fabrics, vertical and horizontal stripes, require both alterations.

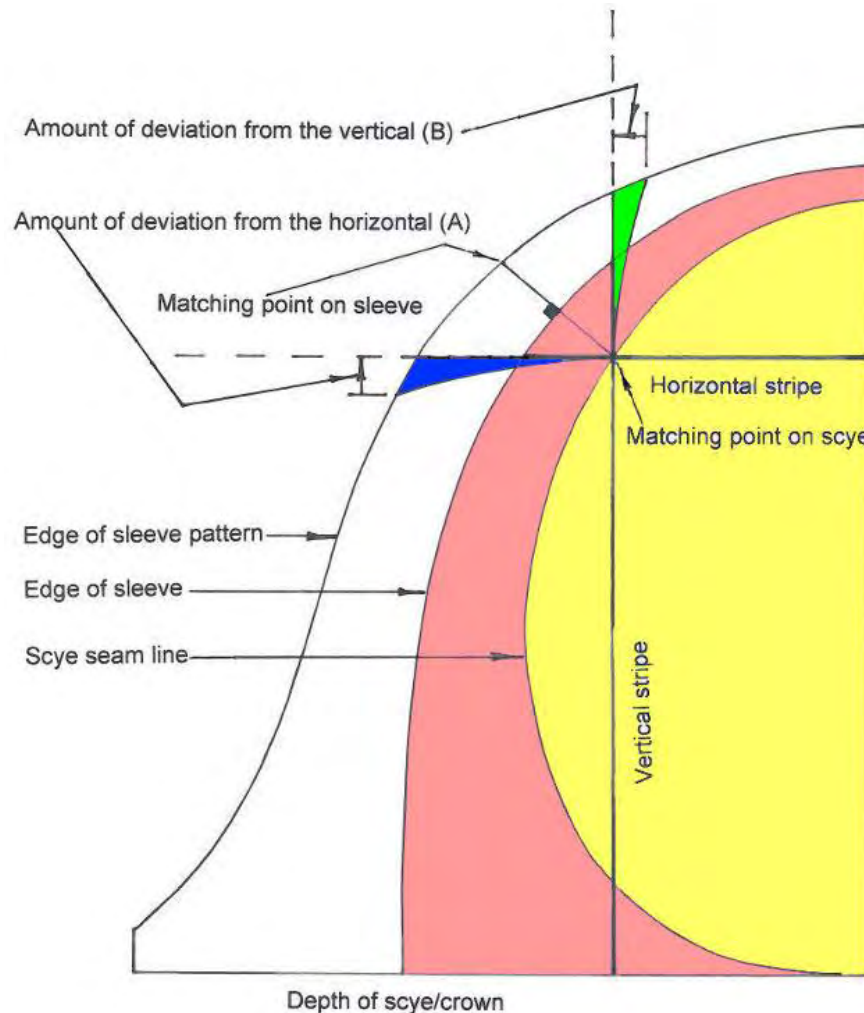


Figure 7.8. Check fabric: Deviation of horizontal and vertical stripes

The alterations to align the stripes to either horizontal or vertical requires compressing the fabric into the sleeve sector seam line; this action produces fullness. Whether this fabric length is extra to requirements, or can be absorbed within the sector, depends on the fabric, the distance that the crown edge is located from the scye seam line and the sleeve curvature. There may be a necessity to misalign one or both of the stripes if the total fullness to be compressed into the scye sector length is excessive. The stripe



misalignment may also be ignored and treated as a plain fabric. To appreciate an enhanced comprehension of problem of fabric fullness, an amplification of the topic is required.

## **7.7 Summary**

An exploration of card model simulated sleeve crown curves in regard, primarily, to striped and checked materials, was undertaken. The simulations uncovered the manner in which stripes deform when encountering an angled edge; the angle of encounter having a greater or lesser affect and its affect on fabric fullness. Fabric fullness is investigated in chapter 7C.



## **Chapter 7C —**

### **Fabrics: Sleeve crown Fullness**

#### **7.8 Introduction**

The crown curve imparts to the sleeve its distinct style in the upper area. The amount of crown curvature ranges considerably from almost zero to a large volume. To form the crown curve, a longer sleeve circumference has to be reduced to fit into the shorter scye circumference. The scope of fabric reductions around sleeve crowns is also extensive. In order to accomplish the task of reduction, the fabric has to compress in a linear direction – producing fabric fullness. This chapter part is concerned with how this is accomplished.

#### **7.9 Sleeve crown fullness (overfeed or planar compression)**

Fabric fullness (linear compression or overfeed) is the most important property of fabrics to be assessed for this research project. Since it has to be manipulated and moulded into distinct sleeve crown silhouettes. It contributes significantly to designing, pattern drafting and final three-dimensional fabrication. Fabric fullness develops as a consequence of the double-curved nature of the sleeve.



Fullness (overfeed) is the potential or capacity of a fabric to be reduced in its length in any direction whilst being sewn. It is the ability of a longer seam length to be compressed into a shorter seam length.

*‘An extension to the length on one of two sections of a garment joined by a seam, used to create volume or shape in the garment, e.g. in the sleeve head’ (McIntyre & Daniels, 1995).*

When inserting sleeves into an armhole, the majority of sleeve styles incorporate an ‘overfeed’ of sleeve length to scye length; the fabric must be capable of being compressed without appearing excessive, without distortions or buckling appearing. There should be no outward appearance of deformation of the sleeve in a garment with fullness, especially in the more formal garment types such as a fully tailored garment. O’Brien and Webster (1991) define the limit of overfeed in a seam as *‘the maximum degree to which a seam can be overfed before unacceptable surface undulations appear’*.

The sleeve crown silhouette is a product of the fabric, if the crown of the sleeve pattern is too long to fit the scye, there will be an excess of fabric fullness – the pattern will have to be reduced. Therefore the sleeve design (and its pattern) is subservient to the type of fabric.

It is reported by De Boos and Rozniok, (1996) that in the manufacture of men’s and women’s jackets, one of the most difficult and skilled operations is the insertion of sleeves into armholes. This procedure requires a considerable amount of overfeed (fullness) to form the sleeve head silhouette, the amount of overfeed depending on the style of sleeve, the type of fabric as well as the garment manufacturing techniques. As



a consequence of this difficult operation, the rectification of faults in sleeve insertion is a costly endeavour requiring a considerable amount of time and effort.

Although there are drafts that give the fullness relationship for each of the usual four sections of scye/sleeve, none calculate fullness for particular fabrics and none sectionalise the scye sleeve a series of smaller controllable sectors. In order for the sleeves to be constructed in fabric, each fabric has to be tested for its potential to form fullness and gathers. Whilst Aldrich does attempt to combine fabrics with general garment pattern cutting, there appears to be no in-depth integration of fabrics and two-dimensional drafting and pattern construction in respect to sleeves; this is endorsed by Heisey, Brown and Johnson (1988, p. 5).

Cabrera and Meyers (1984) cautions that tighter woven fabrics should have less fullness and the various fullness properties of different fabrics have to be measured in each instance. Postle (1986) stipulates that light-weight or relatively light-weight fabrics are less flexible and difficult to manipulate because of the deficiencies in their formability and extensibility attributes; which limit longitudinal compressibility (fullness).

There are various amounts of overfeed, or fullness, depending on the type and design of sleeve, the arrangements of overfeed range from a minimum of overfeed to the maximum allowed by the fabric. Amounts of fullness (overfeed; see O'Brien and Webster [1991] range from only a few millimetres of extra sleeve length, spread over the entire armhole length, to 3cm or more, arranged in various amounts and combinations around the armhole. A shirt and its related tight weave fabric will accommodate lower levels of fullness around the sleeve to fit the armhole, whilst a tailored garment cut from a loose weave fabric will emphasise fullness at the upper level, or maximum fullness.



The ability of a fabric to bend, to give a 'blousing' affect around the upper arm and the fullness compression (overfeed) potentials of a given fabric effectively dictate the maximum size of a sleeve crown, unless gathers or pleats form acceptable aesthetics of the three-dimensional silhouette. In general terms, the greater the fullness or compression potential observed within a fabric, the greater is its tailoring potential. Even so, low fullness potential fabrics can still achieve volume in a design by increasing the fullness amounts to form gathers or pleats.

### ***Sleeve crown fullness: Crown formation***

Although fabric fullness has been described by a number of practitioners, it has not been determined in drafting methods, in an exact manner, for specific fabrics.

Three-dimensional objects, such as sleeve crowns with double curvature cannot be fully developed onto the plane without an expansion of length and width taking place. To expand onto the plane, the three-dimensional sleeve must firstly be designed as a compressed silhouette – with fullness. The compression of a longer piece of fabric (sleeve), onto a shorter section of fabric (scye), provides a means to create distinct three-dimensional sleeve styles in the crown area surrounding the armhole. The amount of fullness depends on the circumference and height of the sleeve. Since the sleeve is wider than the scye, the sleeve has to bend from its outer edge and onto the scye.

The compressed sleeve illustrated in Figure 7.9, is comparable to the shape of a hemisphere. As Heisey, Brown and Johnson (1988) explain, the flattening of a three-dimensional garment to produce a two-dimensional pattern is analogous to cartographic map making (isometric tree).



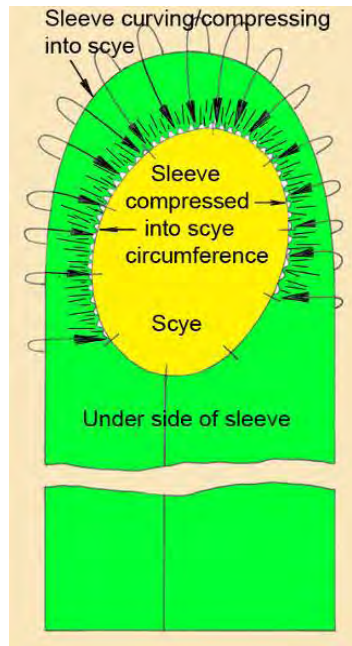


Figure 7.9. Sleeve crown compression onto the scye circumference

Figure 7.10 '1' depicts a hemisphere showing the approximate development onto the plane (also see Heisey, Brown & Johnson, 1990a). When flattened, after cutting down the lines of longitude, (Figure 7.10 '2'), the sectioned material spreads apart along the cut lines producing gaps. The upper edge of each section ends in a point therefore there is zero length at the points.

(1) Hemisphere

(2) Flattened hemisphere

Figure 7.10. Non-developable hemisphere

Source: Adapted from Hinds, McCartney and Woods (1991)



Truncating the hemisphere produces a simplified representation of a scye and sleeve (Figure 7.11 '1'). The truncation line depicts both a scye line (body) and a crown line (sleeve). The flattened sleeve sections representation is portrayed in Figure 7.11 '2'

(1) Truncated hemisphere

(2) Flattened truncated hemisphere

Figure 7.11. Non-developable truncated hemisphere/sleeve representation

Source: Adapted from Hinds, McCartney and Woods (1991)

Usually, darting is unacceptable in most garment sleeve styles therefore the gaps (darts) have to be filled-in with fabric to form a continuous crown edge. The filled-in gaps (Figure 7.12 '1') have to be compressed to gain the original top edge length (scye/crown length) thus producing fullness (Figure 7.12 '2').

The reverse process is presented in Figure 7.12 as '3' - the pattern; '4' - the fabric construction trial (and iterative pattern) and '5' – the final three-dimensional scye and sleeve construction. This process is the familiar procedure of garment design and production – flat fabric and pattern to three-dimensional- double curvature - garment sleeve.



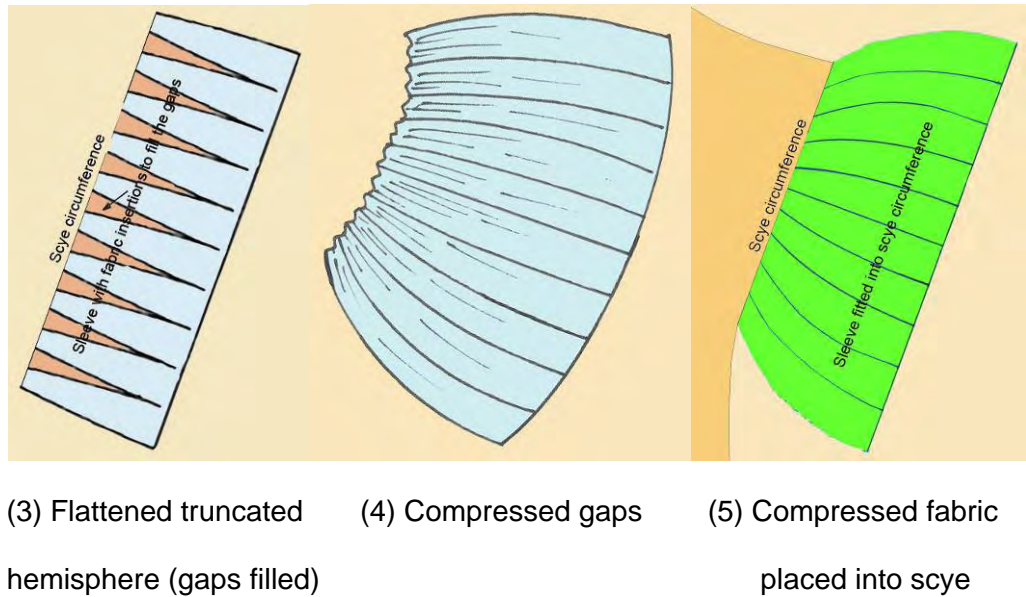
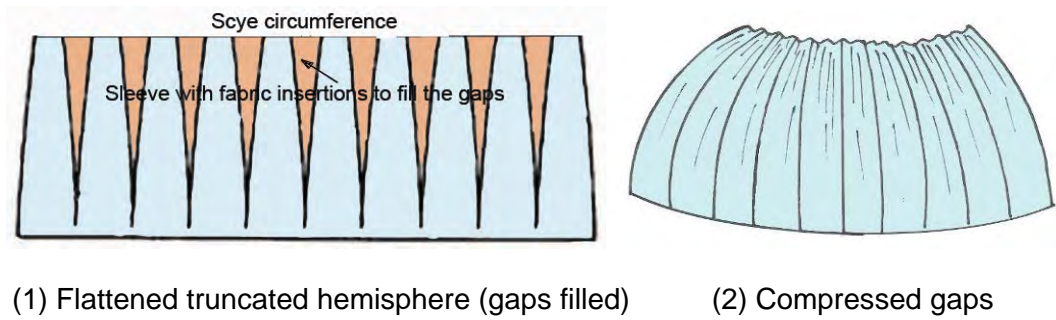


Figure 7.12. Representation of a non-developable sleeve process

### ***Sleeve crown fullness: Distribution***

Figure 7.13 shows the varying lengths of each of sleeve sectors (between the sector points 1, 2/12, 3/11, 4/10, 5/9, 6/8 and 7 – as shown in chapter 6 D). It is measured as the scye sector length into which the sleeve sector has to fit (red arrows) and the fabric fullness which must be compressed (chevron sections at the end of each sleeve sector) to fit the scye sector. Each amount of sleeve sector compression differs from its neighbour – each has to be assessed in relation to the fabric fullness (compression potential). However, fabric fullness does not accumulate at the end (or both ends) of a sector; it is distributed throughout the sleeve sector.



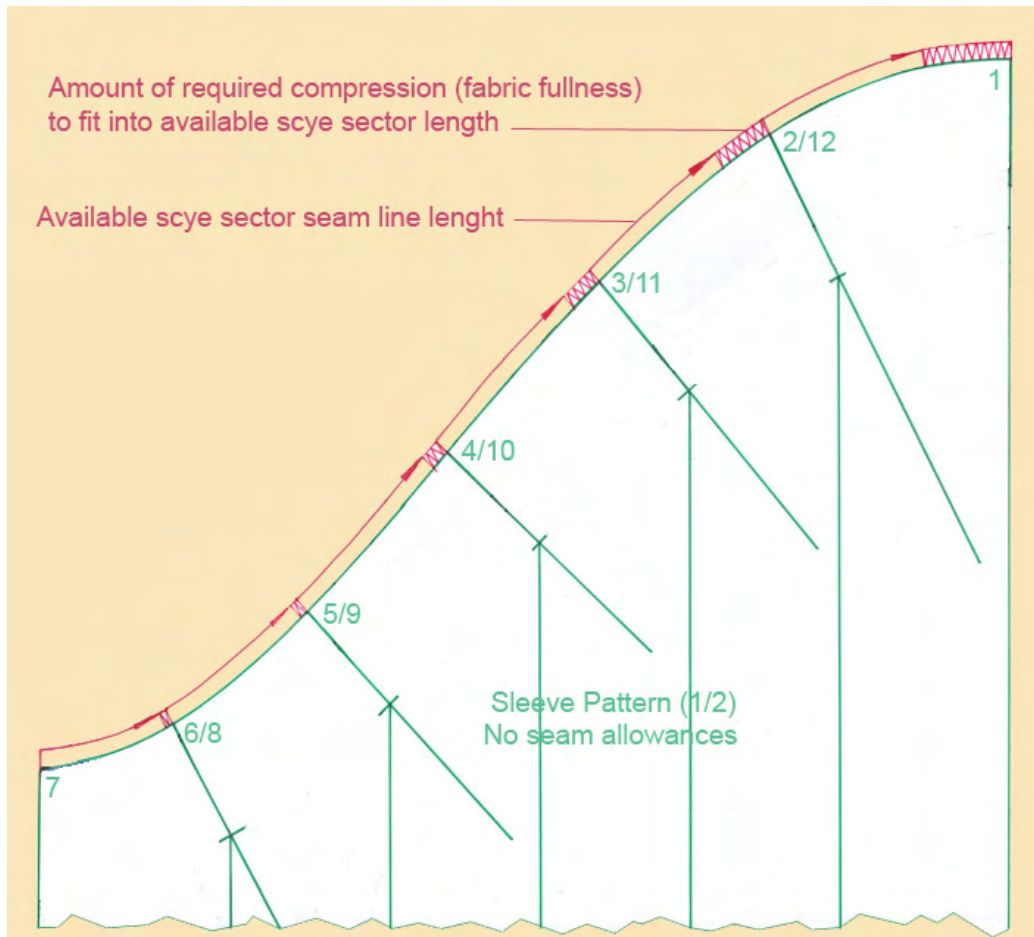


Figure 7.13. Compression/fullness distribution

Figure 7.14 depicts a scye, a three-dimensional sleeve crown attached (sewn) to the scye and a developed, onto the flat pattern (The development stage is akin to the hemisphere, rectangular facets and torus). The sector division marks on the scye are represented by green points, the sector lengths between the green points are characterised by the letter 'A'. As the sleeve sector (green) points and sector lengths unfold, they develop perpendicular to the three-dimensional sleeve crown edge, onto the flat. The green sleeve sector points are relocated and denoted by the red points on the sleeve crown edge.



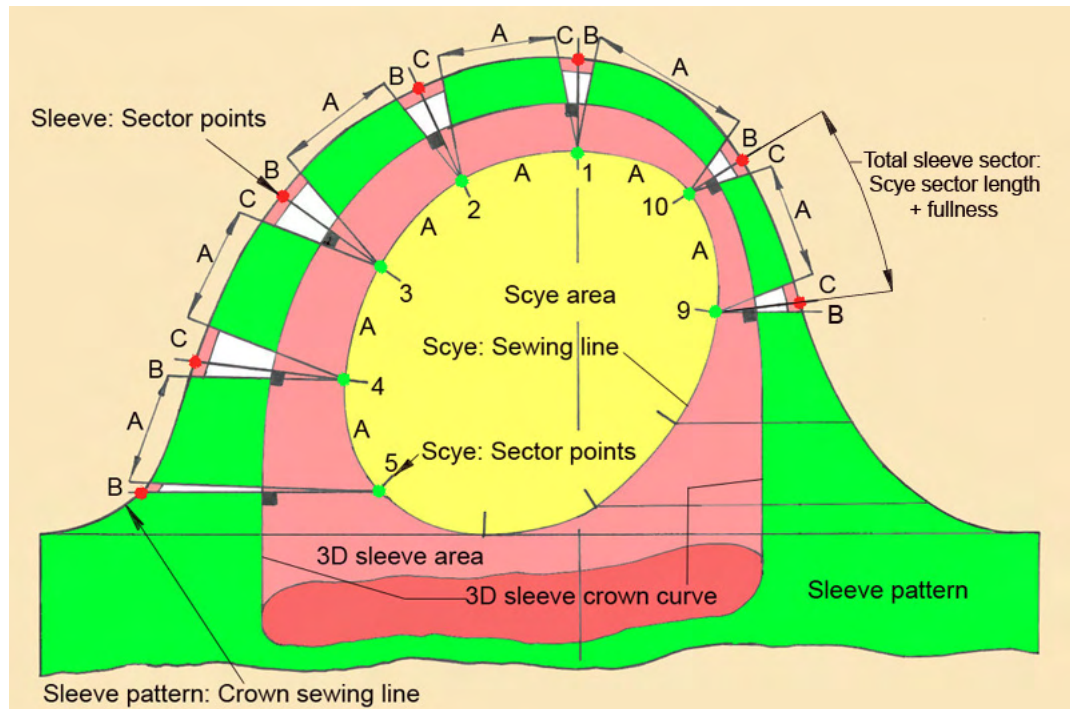


Figure 7.14. Plain fabric: Fullness distribution

The developing process produces small 'packets' (lengths) of sleeve crown fullness between each of the red points. (For easier explanation, the fullness has been localised either side of the red sector points; they are explained further in Fabric: Sewing angles). The scye sector lengths 'A' also develop onto the flat to become sleeve sector lengths 'A'. (Between the green and red sector points are numerous, smaller, divisions of sectors each with its own amount of fullness – not shown for clarity)

Each sleeve sector length 'A' has its own personal amounts of fullness portrayed at each end as either 'B' or 'C'. The total length of each sleeve sector is therefore either 'B'+ 'A'+ 'B' or 'C'+ 'A'+ 'C' (scye sector length plus fullness). Total lengths differ in each sector depending on the curvature of the three-dimensional sleeve crown edge. Each measurement, of 'B' and 'C', needs to be reduced (compressed) to the original 'A' lengths during sleeve crown insertion into the scye.



The above description is standard for all in-set sleeve styles, only the size and shape of the sleeve crown and the amounts of fullness change with each circumstance. However, the amount of fabric fullness (and therefore the sleeve silhouette) is not completely resolved until it has been calculated as being within the allowed maximum. The fullness therefore remains only a potential amount.

### ***Sleeve crown fullness: Potentials***

Although the underlying functions of the engineering drawings of the design and drafting processes assume non-deformation of materials (due to weight distortions or shear) to provide stable underlying foundations, these foundations must allow for the moulding capabilities, around the sleeve crown, of a variety of fabrics.

In this investigation, overfeed or fullness, remains a 'potential' for the reason that each sleeve style, a change in crown silhouette, requires a precise amount of fabric fullness to acquire its distinct shape. All sleeves have crowns of various proportions of fabric fullness arranged around their edge, exceeding the maximum fullness levels results in a gathering affect, further expansion causes pleating to appear. When not required, these become problems of aesthetics and manufacture. When using wool fabrics, pressing-away (or reducing) fullness is more easily achieved than when using fabrics made from man-made fibres as these cannot be readily pressed-away and shrunk, thus causing puckers. It is therefore necessary to be able to calculate fullness accurately. However problems are encountered, these are listed as:

- The actual fullness for any of the selected fabrics is an unknown quantity; there is no fullness detail specification included with the fabric.
- What are the precise fullness (gathers, pleats or darts) amounts and are there maximum and minimum amounts for each sector to produce a variety of sleeve styles and associated fabrics?



- Not only must the maximum amounts of fullness be calculated for the warp, weft and bias sewing directions (angles), it must also be calculated for other contributing angles.
- Having definitive amounts of fullness for each fabric type, each fabric sewing angle and each sleeve sector, means that the size and shape of the sleeve is dependent on fabric fullness. Therefore, does fabric fullness dictate the final shape of the flat pattern and three-dimensional sleeve? Is the designer limited in their choice of sleeve size and shape? For example; if seam pucker is to be avoided in a tailored sleeve type, the sleeve must be designed within the fabric's maximum fullness boundaries.
- The fabric fullness amounts should be localised to particular sectors of the sleeve crown for correct development of the two-dimensional sleeve pattern and the three-dimensional sleeve.
- Currently, for any given fabric and sleeve silhouette, there is no identifiable method for determining fabric fullness potentials (Neither does the problem appear to be answered in the Fang and Liao (2005) method (Figure 4.3 - 4.5).

O'Brien and Webster (1991) found that, depending on the seam direction, the limits of overfeed were difficult to assess, they advise that a method be developed to establish the overfeed limits for all fabrics. However, fabric fullness potentials, or overfeed, still does not have (in 2010) an adoptable formula for calculating these measurements.

### ***Sleeve crown fullness: Calculations***

Fabrics have different abilities to produce fullness, gathers, pleats and darts which contribute to sleeve style silhouette. Fullness requires calculating to enhance sleeve style aesthetics and control sleeve manufacture. Since fabric characteristics are not prominent in today's drafting methods, and subsequent to fabric selection results, a



unique method is realised for measuring the maximum fabric fullness for each of the chosen fabrics.

In addition to the intrinsic properties of the fabric fullness, the sewing angle of a seam line relies on the grain line of the sleeve pattern and its alignment on the fabric. The fabric grain is the relationship of its structural elements to vertical (warp) and horizontal (weft) lines (Miller, 1976) - and the bias direction, a 45° angle to these two directions. Geršak (2002) quotes Bona (1994), and Lindberg, Waessterberg and Svenson. (1960):

*'as well as by fabric properties, the maximum level of overfeed is also conditioned by the direction (angle) of sewing: warp to warp, weft to weft, on the bias'. (pp. 170-171)*

Geršak (2002) also expands this with:

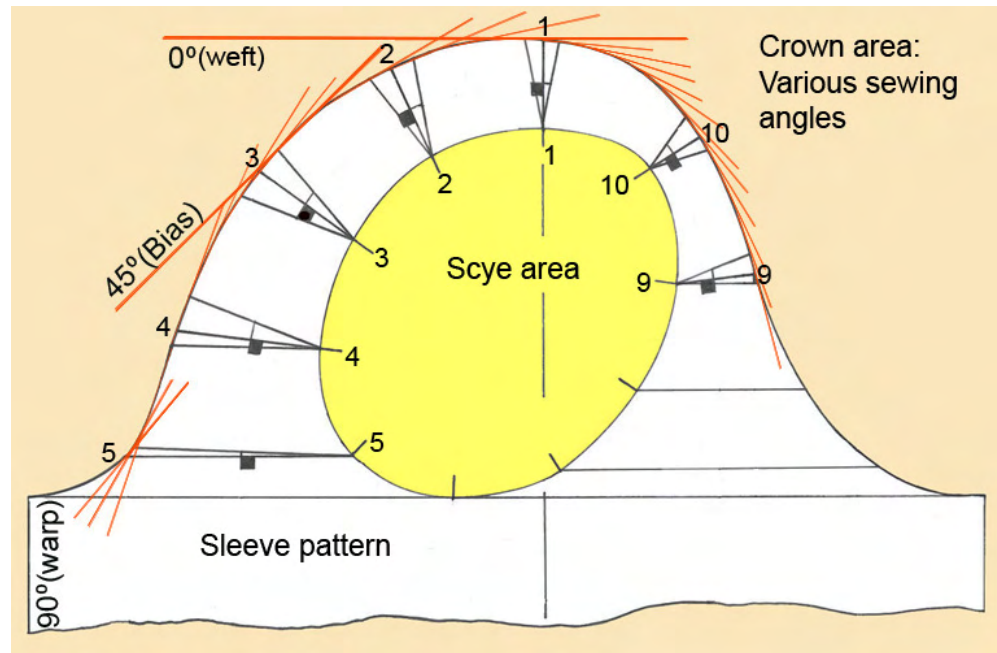
*'all these studies clearly indicate the possibility to adapt the making-up technique to the properties of the fabrics; or else, inversely, to establish limits of acceptability for the later' (sic), (p. 171)*

The amounts of fullness (overfeed), of various fabrics, and its equivalents, gathers, pleats and darts are integral to the three-dimensional sleeve formation. All contribute to the volume and shape of the three-dimensional sleeve style. Because of the fullness differences and restrictions, compressions (sewing) of maximum fullness in warp, weft and bias directions have to be calculated in each of the selected fabrics.

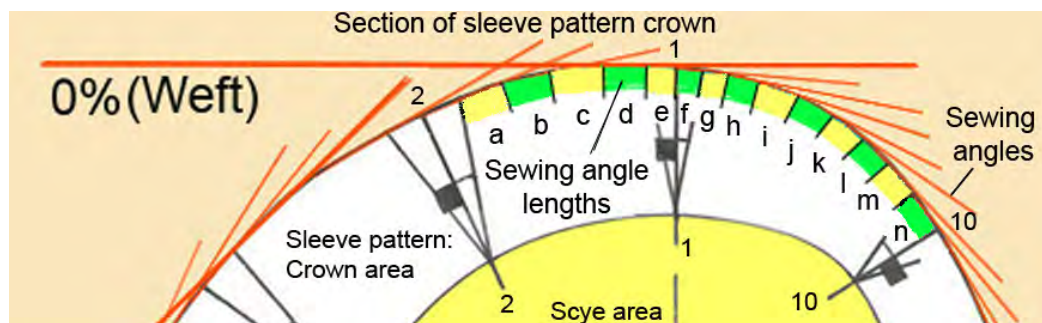
To be more accurate when measuring fabric fullness, the curve of the sleeve crown may be sectioned into shorter lengths (Figure 7.15) each producing a different angle to



the three standard angles of warp, weft and bias when measured from the grain line. Each sectionalised sewing-angle of the fabric around the sleeve crown produces its own amount of sleeve shaping (Figure 7.15 '1'). The higher the crown section and the more it is curved, the more sewing-angles (and shorter curved crown sections) are involved.



(1) Various sewing angles



(2) Detail of upper crown sewing angles

Figure 7.15. Crown sections: Sewing-angles



The compression angles, measured at 5° intervals - as convenient spacing's, have to be extrapolated from the results of fullness trials in the warp, weft and bias directions. This is to find their maximum fullness for sleeve designing. More accurate results would ensue if the angles were measured at 1° intervals (Figure 7.15 '2'). Whilst the maximum fullness allowed within a particular fabric has been calculated, it may not be necessary to use the maximum to fulfil the required style or crown silhouette, less fullness may meet the requirements.

### **7.10 Trials process**

To reduce the amount of fabric shrinkage during manufacturing of the sleeve trials, all fabrics were pre-shrunk, that is heated and pressed, prior to manufacture. To assess the fullness capabilities of the fabric itself, rather than any supporting materials, there was no underlying canvas or fusible structures utilised on the fabric strip (sleeve) representations. However, the fabric to which the 'sleeve' section is applied, the 'body scye' fabric, is fused with an appropriate fusible material. The 'body scye' fabric is used as a control from which to assess the fabric fullness capabilities. It is understood that thread type, needle size, stitching tensions and frequency, sewing machine foot pressure and pressing times, pressure, moisture and temperatures are all as required.

#### ***Trials process: Determining maximum fullness***

The following are descriptions of fabric fullness trials; how they were controlled and how the maximum fabric fullness in warp, weft and bias directions was calculated. Sewing angles between these three orientations were extrapolated subsequently.

Lengths of fabric representing a section of the body scye were fused only as a means of retaining the fabric's original length during manufacture. The edge of the body (scye seam line) fabric was marked and notched every 50mm for a length of 400mm. The



length between the notches was set at 50mm, rather than the preferred 100mm, for easier control since it is nearer to a sample-machinist's method of 'finger-pushing' fabric fullness towards the sewing needle; a smaller length than 50mm would have been ineffective. To subjectively assess the fullness distributions, eight section lengths was deemed sufficient.

The rectangular fabric band representing the sleeve was notched at every 50mm plus a trial amount of fullness for eight sections (Figure 7.16 'A'). The first notch at the right side of the 'sleeve' was aligned with the right end notch of the body fabric. Each section notch of sleeve was then progressively matched and pinned to each section notch of scye, until the far end at the left is reached (Figure 7.16 'B'). Next, all eight sections were hand-basted (sewn) into position with fullness equally distributed between the notches. The two sections were sewn with a sewing machine and pressed with a hand iron.

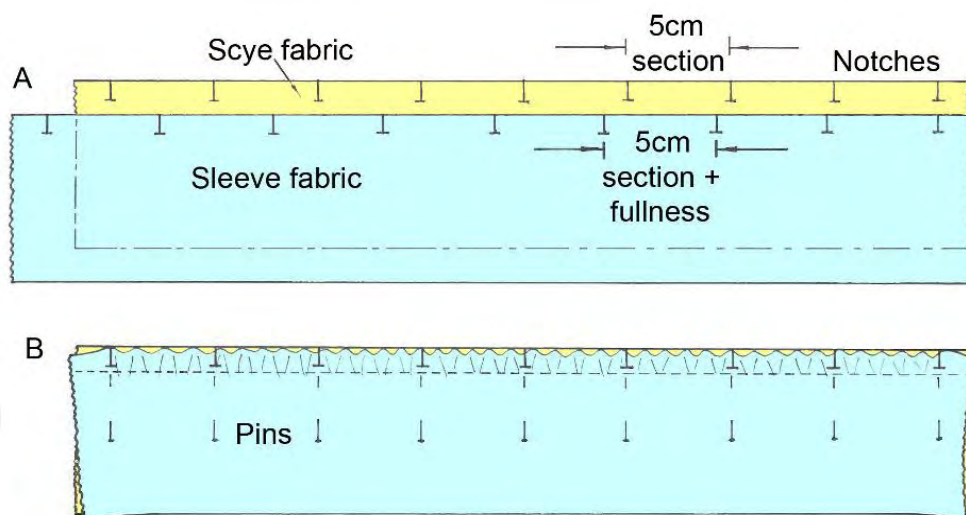


Figure 7.16. Fabric fullness trials

To establish the maximum fullness amounts for each fabric, a number of trials were undertaken exploring weave directions; warp to warp, warp to weft and warp to bias. It may seem that in some of the trials (numbered), the first trial was selected as having



the maximum amount of fullness without puckering. However, depending on its sewing direction (warp, weft or bias), a number of iterations was necessary. Although more trials are made subsequently, these were found to have excessive amounts of fullness). Depending on the fabric and its sewing direction (warp, weft or bias), various iterations may be necessary. Only those trials that resulted in the maximum fullness have been fully documented. Trials with less or more fullness are only partially described to show the process. The trial was then draped on the mannequin for evaluation.

***Trials process: Cellulose fibres - 100% Cotton (weight 129.26g/m<sup>2</sup>)***

In the cotton shirting trials the two directions of warp and weft, using a 1.5mm fullness limit, distorted slightly leading to a reduction to 1mm per 50mm (0.2mm per 10mm, 2%) of scye which was found to be permissible (Figure 7.17 '1' and '2'). In the bias direction, fullness began with 53.75mm of sleeve per 50mm of scye length (0.75mm per 10mm), the amount was gradually reduced until 1.5mm (0.3mm per 10mm, 3%) was decided as the limiting fullness allowed by this fabric, with a minimum of subjective distortions appearing in this direction (Figure 7.17 '3'). The same process of pinning, basting and machine sewing, seen in Figure 7.17, was observed throughout the shirting trials.



(1) Fullness in warp

(2) Fullness in weft

(3) Fullness in bias

Figure 7.17. Cellulose fibres: 100% Cotton (weight 129.26g/m<sup>2</sup>) (Colour distorted '1')



***Trials process: Man-made fibres - 100% Polyester (weight 72.66g/m<sup>2</sup>)***

The trials for this fabric demonstrate that the most fullness to be expected in the warp direction was 0.2mm per 10mm, or 2% of scye length (Figure 7.18 '1'), twice that amount (0.4mm, 4%) in the weft (Figure 6.114 '2') and 0.8mm per 100mm, or 8% in the bias direction (Figure 7.18 '3').



(1) Fullness in warp

(2) Fullness in weft

(3) Fullness in bias

Figure 7.18. Man-made fibres: 100% Polyester (weight 72.66g/m<sup>2</sup>)

***Trials process: Regenerated fibres - 50% Acetate 50% Viscose  
(weight 19.13g/m<sup>2</sup>)***

All three sewing directions needed to be trialled three times because of the minuscule amounts of permissible fullness. Both warp and weft attained only 0.2mm (2%) of fullness per 10mm of scye length (Figure 7.19 '1' and '2') whilst the bias direction attained a maximum fullness of 1.0mm per 10mm, 10% (Figure 7.19 '3').



(1) Fullness in warp

(2) Fullness in weft

(3) Fullness in bias

Figure 7.19. Regenerated fibres: 50% Acetate 50% Viscose (weight 119.13g/m<sup>2</sup>)



***Trials process: Natural protein fibres - 100% Wool (347g/m<sup>2</sup>)***

The first warp fullness trial (not shown for conciseness) proved to be in excess of capacity for this fabric and direction. A second trial, although on the border of suitability, was acceptable. The front view in a vertical orientation, after pressing, appears to be subjectively acceptable with a fullness ratio of 1.0mm of sleeve for every 10mm of scye, or 10% average (Figure 7.20 '1').

There were no problems in the weft sewing directions (Figure 7.20 '2'), the first trials being acceptable (1.0mm per 10mm, or 10% average). The bias direction produced 1.75mm per 10mm, or 17.5% average (Figure 7.20 '3'). Figure 7.20 '4' - '7' illustrates four views of the draped fabric trials.



(1) Fullness in warp

(2) Fullness in weft

(3) Fullness in bias



(4) Bias drape (side) (5) Bias drape (back) (6) Weft drape (side) (7) Bias drape (front)

Figure 7.20. Natural protein fibres: 100% Wool - Harris Tweed (weight 347g/m<sup>2</sup>)



***Trials process: Natural protein fibres - 100% Wool (173g/m<sup>2</sup>)***

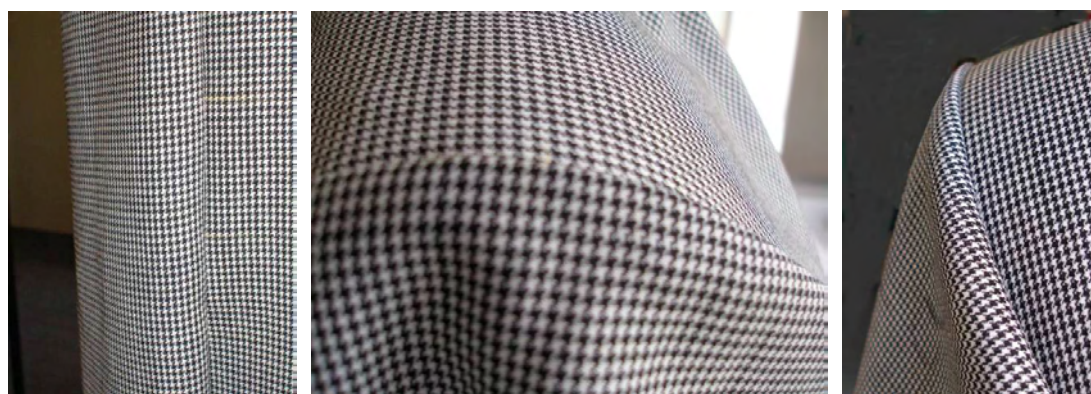
The third fullness trial (first and second not shown for brevity) (Figure 7.21 '1') in the warp direction was eased onto the fabric at a rate of 0.6mm per 10mm (53mm of sleeve for every 50mm of scye, 6% average, or 424mm of sleeve for the trial scye length of 400mm). The sleeve sectors of 53mm, were marked, notched and pinned into position before being sewn to the body scye representation fabric. The third weft trial was determined to be the most appropriate fullness with a maximum of 53mm of sleeve for every 50mm of scye, 6% average, or 424mm of sleeve for the trial scye length of 400mm (Figure 7.21 '2') .



(1) Fullness in warp

(2) Fullness in weft

(3) Fullness in bias



(4) Warp drape (front)

(5) Weft drape (side)

(6) Bias drape (front)

Figure 7.21. Natural protein fibres: 100% Wool - Hounds-tooth (weight 173g/m<sup>2</sup>)

After deliberation on the first trial, it was apparent that more fullness might be expected from the fabric in a bias direction. A second trial, with an increase to 1.75mm per centimetre (17.5% average), was initiated to test this assumption. Compared to the first trial, the second trial (Figure 7.21 '3') displayed a great deal more fullness, probably



very close to the maximum. Subsequent to sewing, the fabric was pressed and draped on a mannequin in an aspect corresponding to its position on the sleeve (Figure 7.21 '4', '5' and '6').

***Trials process: Cellulose fibres - 100% Cotton (weight 124.24g/m<sup>2</sup>)***

Since this fabric is designated for the Leg of Mutton sleeve style, fullness potentials are not required. The sleeve design is composed from a series of pleats around the crown therefore pleating is a necessity. A tremendous amount of pleating can be compressed into all three sewing directions (warp, weft and bias); a maximum, of 40mm per 10mm is experienced - (400% average). Figure 7.22 illustrates the results in the warp direction ('1'), the weft direction ('2') and on the bias ('3'); '4' represents the draped view.



(1) Fullness in warp



(2) Fullness in weft



(3) Fullness in bias



(4) Drape (front)

Figure 7.22. Cellulose fibres: 100% Cotton (weight 124.24g/m<sup>2</sup>)



### **7.11 Fabric fullness potentials: Extrapolations**

Not all fabric sewing/crown curve angles were trialled to determine their fullness potentials. Instead, the maximum fullness in the warp, weft and bias angles were resolved; the results were utilised to extrapolate the fullness potentials for the remaining angles. The process is as follows:

Evans (1995) illustrates the method adopted to extract the maximum potential fullness amounts for each of the remaining sewing angles for each fabric type. This is achieved by dividing, equally, the vertical and horizontal outer edges (see 'A' and 'B' in Figure 7.23) and joining each of the paired points to accomplish the fullness potential curve.

Figure 7.23. Ruled surfaces of sound in Metastasis (1954)

Source: Evans, R. (1995)

Standardised sewing line section lengths from the rectangular fabric trials are embodied in the warp direction (horizontal line), the weft direction (vertical line) and the

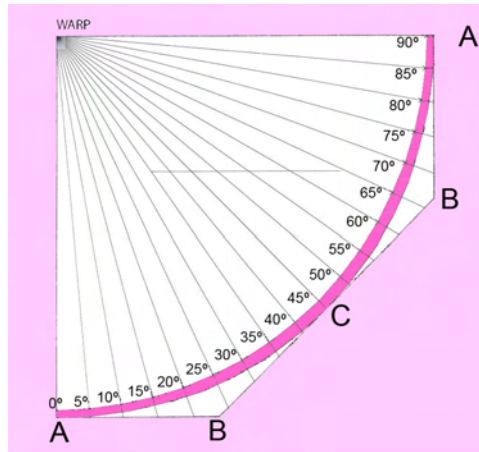


bias line (diagonal centre line); each representing crown curve section lengths (Figure 7.24). The remaining radiating lines representing the un-trialled angles (those between 0° and 90°), are spaced at intervals of 5° between the three directions. The fabrics represented in Figure 7.24 are; '1' is 100% cotton; '2' consists of 50% acetate - 50% viscose; '3' represents 100% polyester; '4' is 100% wool; '5' is a heavier weight 100% wool and '6' is a 100% cotton.

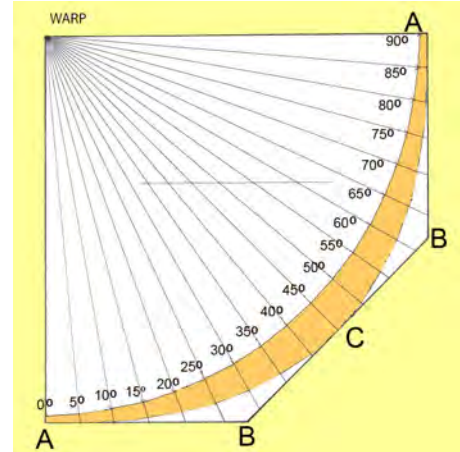
Radiating lines, sectioned between the horizontal to vertical lines, are all the same length, representing the required crown curve section length. Each line radiates from the source at the upper left corner and down to the first curved arc line. The measured lengths that extend to the outer perimeter of the coloured band, correspond to the maximum amounts of fullness (overfeed) that can be expected for the fabric type represented in each fabric trial.

The method for calculating fullness around the crown curve is firstly to physically trial and measure drawings of the radiating lines. These are then replicated in Gerber's pattern design system (PDS) software to test and compare the accuracy of hand-drawn results. This confirmed the findings and generated the images and measurements depicted in Figure 7.24 (Original drawings; M. Campbell; PDS confirmation: L. Mutsaers) and the resultant Table 7.2.

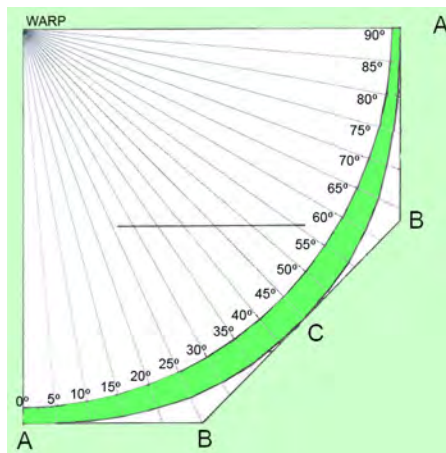




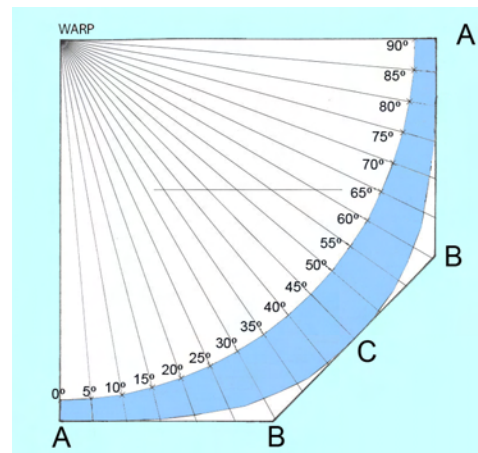
(1) 100% Cotton



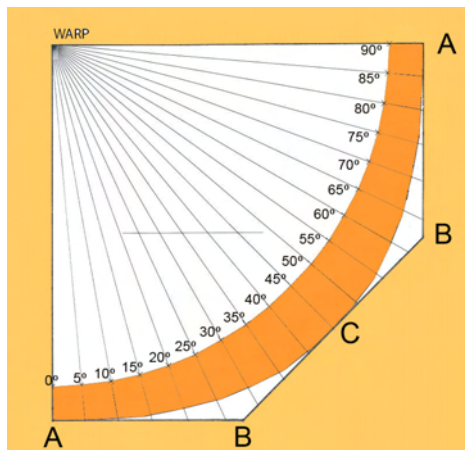
(2) 50% acetate - 50% viscose



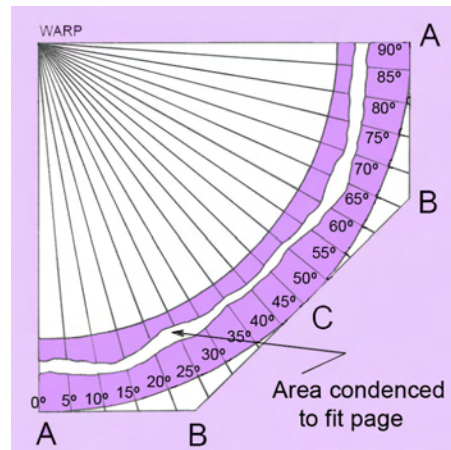
(3) 100% polyester



(4) 100% wool



(5) 100% wool (heavier weight)



(6) 100% cotton

Figure 7.24. Extrapolated fabric fullness potentials



Table 7.2. Extrapolated fabric fullness/gathers (warp to bias to weft)

Sleeve Type ►	1. Shirt: Cellulose fibres Fabric: 100% Cotton Weight: 129.26g/m <sup>2</sup> Fullness/compression per 10mm and %	2. Shirt: Regenerated fibres Fabric: 50% Acetate 50% Viscose Weight: 119.13g/m <sup>2</sup> Fullness/compression per 10mm and %	3. Bell: Man-made fibres Fabric: 100% Polyester Weight: 72.66g/m <sup>2</sup> Fullness/compression per 10mm and %
Sleeve crown sewing angle: ▼			
0° Weft	0.200mm 2.00%	0.200mm 2.00%	0.400mm 4.00%
5°	0.205mm 2.05%	0.232mm 2.32%	0.415mm 4.1%
10°	0.210mm 2.10%	0.311mm 3.11%	0.465mm 4.65%
15°	0.220mm 2.20%	0.416mm 4.16%	0.520mm 5.20%
20°	0.249mm 2.49%	0.537mm 5.37%	0.580mm 5.80%
25°	0.277mm 2.77%	0.691mm 6.91%	0.650mm 6.50%
30°	0.282mm 2.82%	0.808mm 8.08%	0.710mm 7.10%
35°	0.288mm 2.88%	0.895mm 8.95%	0.760mm 7.60%
40°	0.294mm 2.94%	0.989mm 9.89%	0.790mm 7.90%
45° Bias	0.300mm 3.00%	1.000mm 10.0%	0.800mm 8.00%
50°	0.294mm 2.94%	0.989mm 9.89%	0.780mm 7.80%
55°	0.288mm 2.88%	0.895mm 8.95%	0.730mm 7.30%
60°	0.282mm 2.82%	0.808mm 8.08%	0.650mm 6.50%
65°	0.277mm 2.77%	0.691mm 6.91%	0.550mm 5.50%
70°	0.249mm 2.49%	0.537mm 5.37%	0.440mm 4.40%
75°	0.220mm 2.20%	0.416mm 4.16%	0.350mm 3.50%
80°	0.210mm 2.10%	0.311mm 3.11%	0.285mm 2.85%
85°	0.205mm 2.05%	0.232mm 2.32%	0.230mm 2.30%
90° Warp	0.200mm 2.00%	0.200mm 2.00%	0.200mm 2.00%
Sleeve Type ►	4. Tailored Two-piece: Natural protein fibres Fabric: 100% Wool 173g/m <sup>2</sup> Hounds-tooth Fullness/compression per 10mm and % =	5. Tailored & straight: Natural protein fibres. Fabric: 100% Wool 347g/m <sup>2</sup> Harris Tweed Fullness/compression per 10mm and % =	6. Leg of Mutton: Cellulose fibres Fabric: 100% Cotton Weight: 124.4g/m <sup>2</sup> Gathers/pleats per 10mm and % =
Sleeve crown sewing angle: ▼			
0° Weft	0.600mm 6.00%	1.000mm 10.00%	40mm 400%
5°	0.631mm 6.31%	1.016mm 10.16%	40mm 400%
10°	0.730mm 7.30%	1.090mm 10.90%	40mm 400%
15°	0.905mm 9.05%	1.215mm 12.16%	40mm 400%
20°	1.076mm 10.76%	1.331mm 13.31%	40mm 400%
25°	1.306mm 13.06%	1.487mm 14.87%	40mm 400%
30°	1.497mm 14.97%	1.586mm 15.86%	40mm 400%
35°	1.646mm 16.46%	1.711mm 17.11%	40mm 400%
40°	1.716mm 17.16%	1.740mm 17.40%	40mm 400%
45° Bias	1.750mm 17.50%	1.750mm 17.50%	40mm 400%
50°	1.716mm 17.16%	1.740mm 17.40%	40mm 400%
55°	1.646mm 16.46%	1.711mm 17.11%	40mm 400%
60°	1.497mm 14.97%	1.586mm 15.86%	40mm 400%
65°	1.306mm 13.06%	1.487mm 14.87%	40mm 400%
70°	1.076mm 10.7%	1.331mm 13.31%	40mm 400%
75°	0.905mm 9.05%	1.214mm 12.1%	40mm 400%
80°	0.730mm 7.30%	1.089mm 10.89%	40mm 400%
85°	0.631mm 6.31%	1.015mm 10.15%	40mm 400%
90° Warp	0.600mm 6.00%	1.000mm 10.00%	40mm 400%



Out of the six fabric types, the two natural protein fibre types (Figure 7.24 '5' and '6') show a greater range of fabric fullness and are delineated only by weight and weave (Figure 7.24 '6' is compressed to fit the page). The distinctive amounts of fullness for each of the four remaining fabric types can be readily seen by comparing the coloured curved bands.

On this scale, the 100% cotton fabric (100% cellulose fibres) has the least amount of fullness followed by the 50% Acetate/50%Viscose fabric (regenerated fibres) and the 100% Polyester (man-made fibres). The Hounds-tooth fabric of 100% Wool (natural protein fibre), and another natural protein fabric (in this instance a Harris-Tweed, 100% Wool) have proportionately more fullness than the others. A 100% cotton fabric (cellulose fibres) will have pleats rather than fullness because of the sleeve style.

The outcomes of the fabric fullness trials prove that sleeve styling (size/crown volume) for each fabric is restricted because of the fullness potentials. A cotton fabric for example (shirt style fabric), does not have the same fullness potential as a Harris-Tweed (jacket style fabric). Consequently, a cotton shirting could not successfully be made into a tailored sleeve as the sleeve circumference would be restrictive and crown curvature almost non-existent to achieve a suitable tailored sleeve silhouette.

As discussed previously, there are various amounts of fabric fullness flowing through into gathers, pleats and darts. In any designed sleeve, the amount of fullness in each of the sleeve sectors has to be evaluated and verified as within the proscribed fullness limits. When the upper limits of each fabric's fullness and gathers in all of the 5° angle sections have been resolved, each sleeve style's pattern crown section length and amount of fullness can be ascertained and verified as fit for purpose - before committing to fabric trials.



### ***Fabric fullness potentials: Verification and sleeve design***

Since there is more than one sewing-angle in each of the ten sleeve crown sectors, the fullness in each sewing-angle contributing to the sleeve sector must be added to find the over-all fullness for the total sleeve sector and sector length. Adjacent sewing angles and amounts of fullness may differ only slightly, however they all contribute to the complete sleeve crown section and sleeve design. Each of the sewing-angles has a length of scye plus a length of fullness compression. For example: in sector 1 – 2, sewing-angles/lengths a, b, c, d, e are added to assess fullness and sector 1 - 10 sewing-angles/lengths f, g, h, i, j, k, l, m, n are added (Figure 7.25).

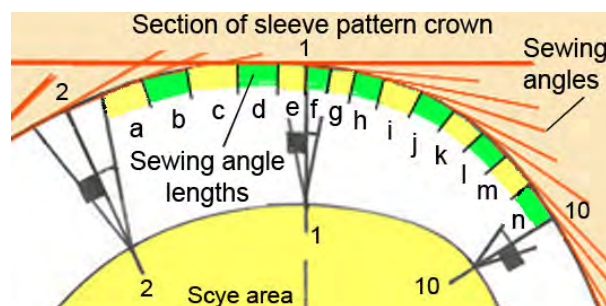


Figure 7.25. Sleeve crown section: Sewing-angle sub-divisions

The maximum percentages of compression in each of the sewing-angle lengths, that comprise a sleeve sector, are added to produce 'B' in Figure 7.26. The percentages are calculated from the quantities in Figure 7.26 and Table 7.2. The lengths of sleeve crown sewing-angles (mm), minus their respective percentages of compression = the remaining useful length of sleeve sector ('C' in Figure 7.26) which must fit scye sector 'A'.

When the total sleeve crown sector length ('C' in Figure 7.26 excluding the calculated sleeve sector fullness) is the same length or less than the scye sector length into which it will be sewn, the sleeve pattern is acceptable; it is within the fullness parameters. A



shorter length of 'C' indicates that, for the particular sleeve style, the maximum of allowable fabric fullness is not required to fit into the scye sector. However, when this length is exceeded, it means that there is too much fullness and therefore, the pattern must be re-considered.

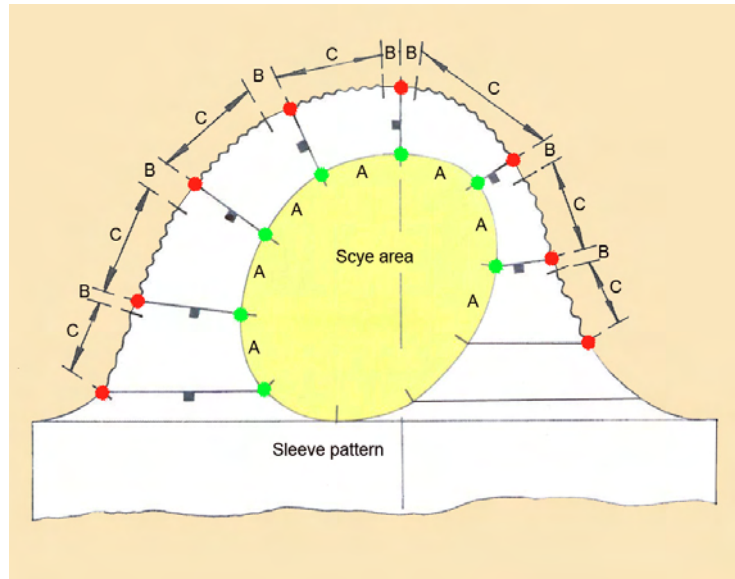
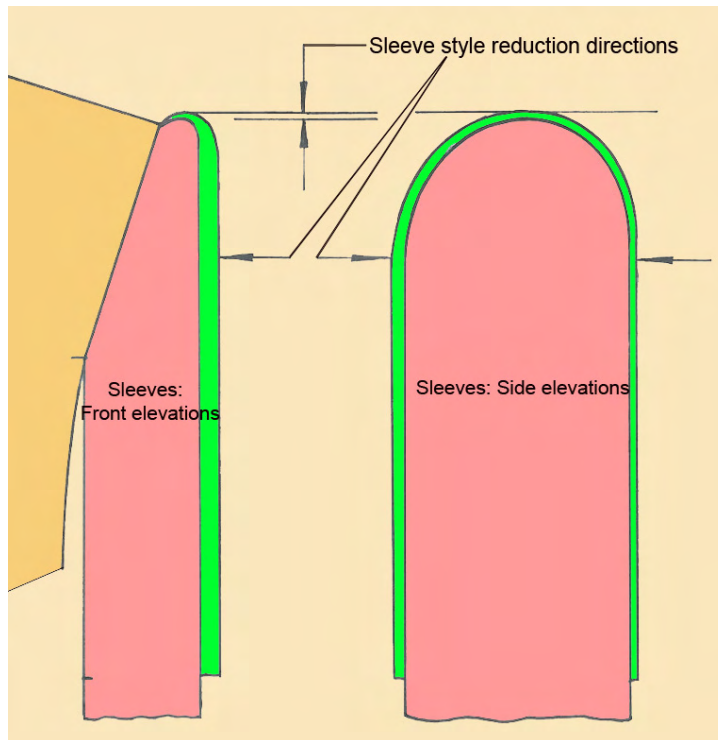


Figure 7.26. Sleeve fullness: Compression verification

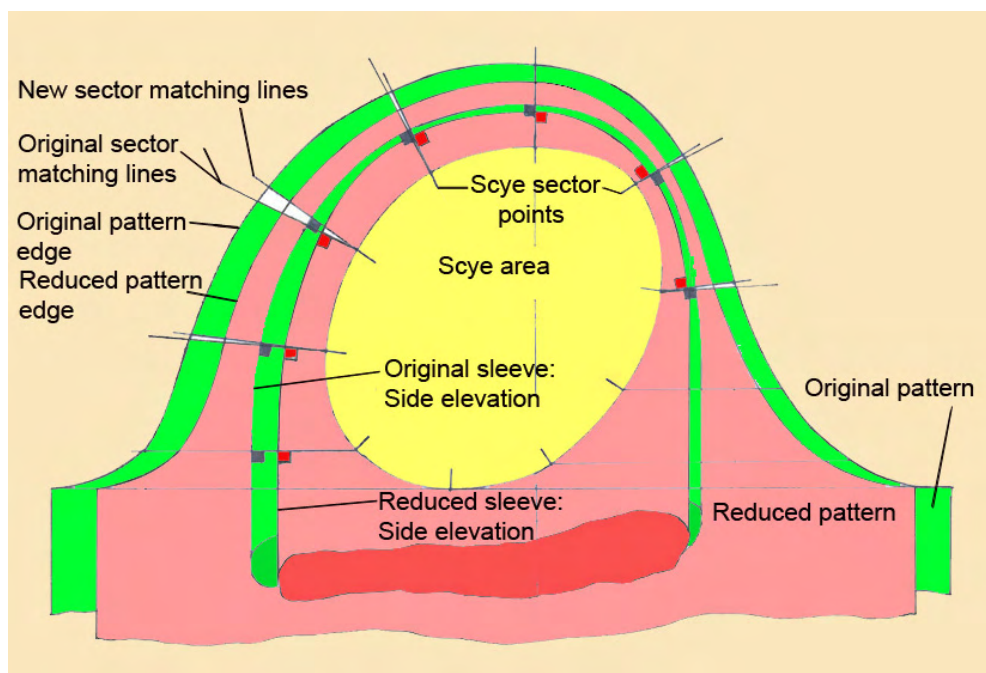
To find out whether the design of the sleeve (size and shape) is acceptable, each of the ten sleeve sector fullness allowances has to be checked for functional performance, considering that each sleeve sector is comprised of sewing-angles that have different sleeve fullness-to-scye ratios.

When the sleeve sector/s length is/are too long for the equivalent scye sector/s, the sleeve must be re-thought. Figure 7.27 '1' represents two views of the three-dimensional sleeve. The front and side elevations, the outer lines, represent the compromised sleeve, the inner lines are the re-considered, reduced-size sleeve.





(1) Sleeve and re-considered, reduced-size sleeve



(2) Sleeve and re-considered, reduced-size sleeve patterns

Figure 7.27 Sleeve style reduction directions



Figure 7.27 '2' indicates the too-large and re-appraised sleeve pattern. When all of the sectors, with corresponding fullness, are found to be acceptable, the pattern is a success. A sleeve found to have a longer sector length than its corresponding, permissible scye sector length, might signify a negative response. However, it is only a negative response for the fabric matched to the sleeve pattern - it does not mean, necessarily, that the pattern is rejected. The fullness may be found to be quite adequate for a fabric with a greater fullness potential. Perfecting the sleeve design and its corresponding pattern, in this manner, has all been achieved without recourse to costly fabric trials.

## **7.12 Summary**

The difficulties of maximum fabric compressions, encountered during crown insertion into the scye, were recognised. The problem of fabric fullness indicated the need for the creation of a system for determining the maximum potential fullness for a selection of fabrics. Fabric trials were implemented to ascertain the maximum allowable fullness in warp, weft and bias directions. A distinctive method to extrapolate the remaining sewing and crown curve angles (every 5° between 0° and 90°) was produced to conclude the fullness data.

The completed fullness compression trials information and extrapolated results are tabulated for reference during the sleeve design stage. A novel method for verifying the design of the sleeve, in regard to size and shape was explained as a series of separate sewing-angle sections and fullness problems related to each of the ten sleeve crown sectors.



## Chapter 7D —

### Fabrics: Sleeve Drape

#### 7.13 Introduction

The focus of this chapter part is the under sleeve of the tailored sleeve style, expressed as a geometric modelling exercise. As stated in chapter 5, this process models material without considering its mechanical or physical properties. Drape for sleeve styles other than the tailored sleeve are not required since they do not require this type of formal aesthetics. Various methods of achieving drape are tested and described.

#### 7.14 Sleeve drape

In addition to elevation, the tailored under sleeve, for aesthetic purposes, may include some form of drape, a blousing affect at the hind arm. As a result of extra under arm length in the sleeve, drape may be said to be related to arm/sleeve elevation allowances. Kenkare and May-Plumtree (2005) quote British Standards (5058 1973 (1974, still current at 2010) for the definition of drape as: *'the extent to which a fabric will deform when it is allowed to hang under its own weight'*; Shyr, Wang and Cheng (2007) also cite weight as a factor. Collier (1991) asserts that draping qualities correlate to



shear and bending properties (and designers' subjective appraisal) rather than weight and thickness.

Sharma, Behera, Roedel and Schenk (2005) define drape as a fabric's ability to hang freely in graceful folds when some area of it is supported over a surface and the rest is unsupported. Drape is the manner in which a fabric falls or hangs on a three dimensional object, the ability of a fabric to hang in soft folds without distorting or creasing (Kadolph and Langford, 2002). Orzada, Moore and Collier (1997) give these two explanations of drape (1) Drape is the arrangement of a fabric in graceful folds as a result of gravity. (2) (Drape is)... dependent on a fabric's structural and mechanical properties. Kadolph and Langford (2002) are of the opinion that yarns and fabric structure may be more important in determining drape. Other factors which may affect drape quality are seams, stitch type, sewing thread, fabrics (woven/knitted), whether the outer fabric shell is fused or not and the alignment of the garment piece on the fabric and also .

The grain lines, angle of placement (alignments), of the body and sleeve sections on fabric are usually aligned in the direction of the warp, although it may also be aligned with the weft, or on the true bias at a 45° angle. The angle on which the garment part is cut is a critical element in apparel construction which also contributes to draping qualities (Orzada, Moore & Collier 1997).

The preceding information quantifies a considerable number of opinions regarding fabric drape. Although drape is a complex subject with results difficult to predict (Aldrich, 1996), it is of interest to this research to investigate the subject even though it is only tentatively included - there are some practitioners who favour under sleeve drape, or a 'blousing affect', to some extent.



Under arm drape, in this context, is an excess of fabric, in horizontal, vertical or both directions, it is the ability to form extra curvature to partially fill the gap between the under section of a tailored sleeve and the body of the garment. This is in order to produce a pleasing outward appearance in the back under sleeve area. Three basic methods could be used to calculate the size and shape of the under sleeve to accommodate sleeve drape for aesthetic purposes. These are the parallel line development method, the triangulation development method or the isometric tree method; they may also be used in combination.

### ***Sleeve drape: Tailored under sleeve***

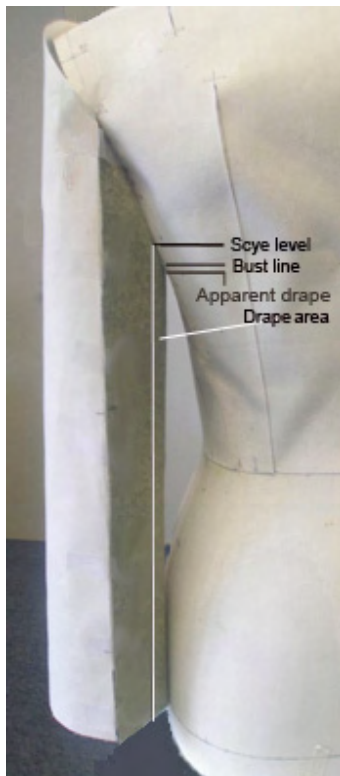
#### ***Elevation pattern and Triangulation development method***

Figure 7.28 illustrates the different drape affects between three under sleeves using the sleeve elevation method and resultant pattern as a base. The under sleeves of '1' and '2' are developed from the same tailored under sleeves described in sleeve elevation (Figures 6.36 - 6.42).

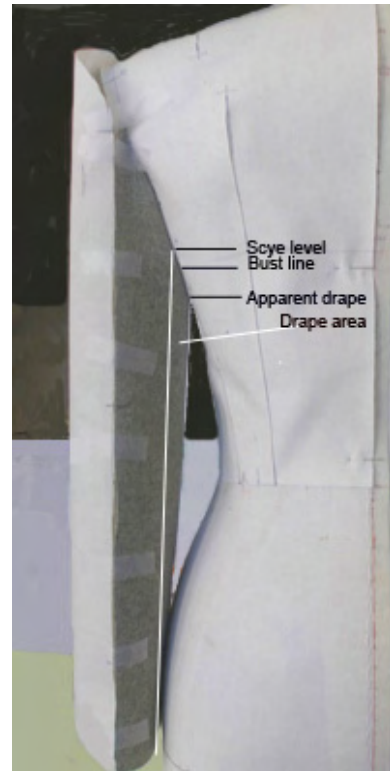
A 100% wool fabric with a weight of 277g/m<sup>2</sup> was utilised for the under sleeves whilst a calico top sleeve is used to control and support the under sleeves. Since the drape is for the under sleeve only, the crown has not been assembled. The under sleeve is held in place by the pitch points and the front and back seam lines.

The initial patterns are tapered towards the hem with the required sleeve elevation. The angle of elevation produces extra length in the under sleeve between the hem and the scye-joining, line pattern automatically providing a draping affect – an apparent or discovered drape.

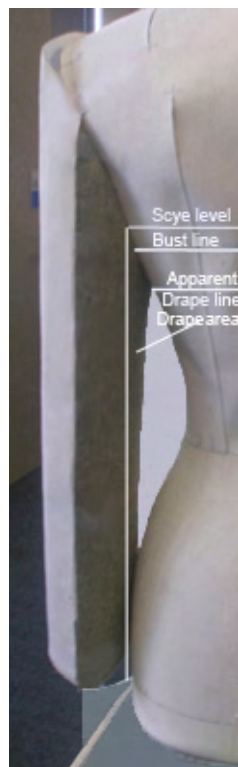




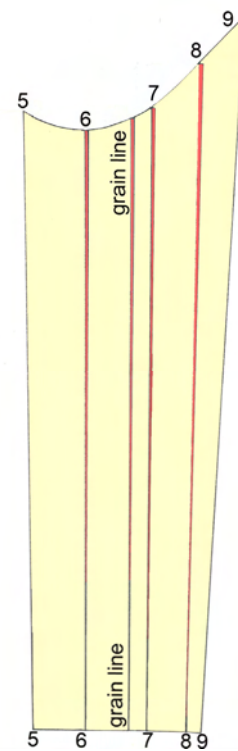
(1) Under sleeve with 30° elevation



(2) Under sleeve with 45° elevation



(3) Under sleeve with 30° elevation plus drape



(4) Under sleeve pattern (from '3')

Figure 7.28. Three under sleeve drape affects



Figure 7.28 '1' is an under sleeve with an effective 30° elevation from the vertical; Figure 7.28 '2' is an under sleeve with an effective 45° elevation, therefore, more drape. Figure 7.28 '3' is an under sleeve with an effective 30° elevation plus a drape allowance in the form of extra fabric fullness length eased into the scye.

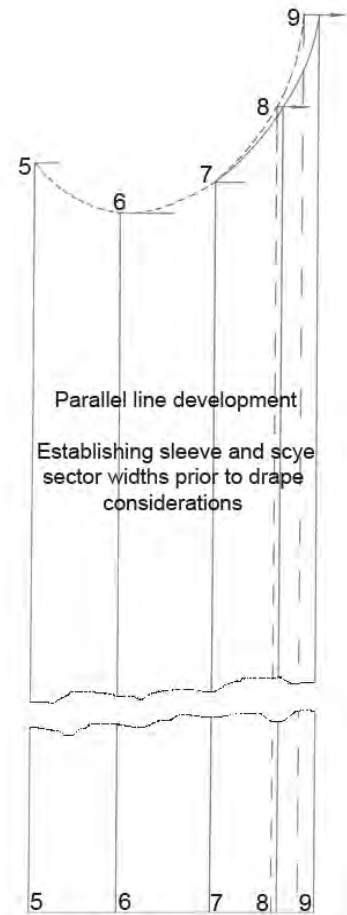
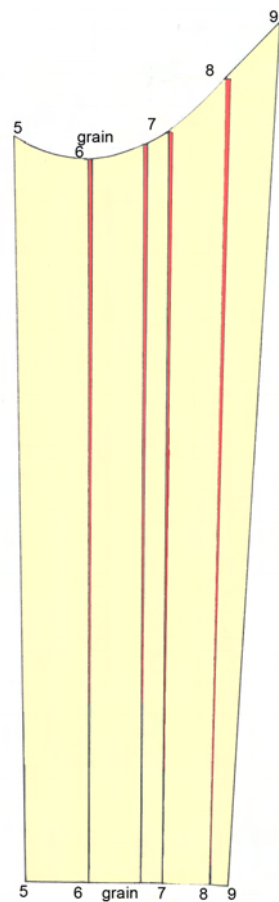
The looser weave of the fabric in '3', (Figure 7.28) allows the additional sleeve seam length (fullness) to be compressed into the scye. The amount of fabric fullness (extra length pivoted from the hem) is 3mm between each under sleeve sector between sector points 9-8, 8-7 and 7-6 (pattern in Figure 7.28 '4'). The amount of drape increases slightly through the three under sleeve examples. The 45° elevation, Figure 7.28 '2', results in a drape allowance almost comparable to the 30° elevated sleeve + a horizontal drape allowance of Figure 7.28 '3'.

### ***Sleeve drape: Tailored under sleeve***

#### ***Elevation pattern and Triangulation/parallel line development methods***

Figure 7.29 '1' is the same under sleeve pattern as used for Figure 7.28 '3'. The tapered sleeve however, since it is pivoted from the hem, it is narrower below the upper sleeve sector points. The next sleeve (Figure 7.29 '2') has the previous deficiency of width restored. The under sleeve in Figure 7.29 '2' has a consistent under sleeve width from the top, down to the hem. The development method is equivalent to a parallel line development. Regaining the sleeve sector widths/lengths moves the sleeve sections (from scye to hem) in a parallel motion to the right, from sector 6, for points 7, 8 and 9.



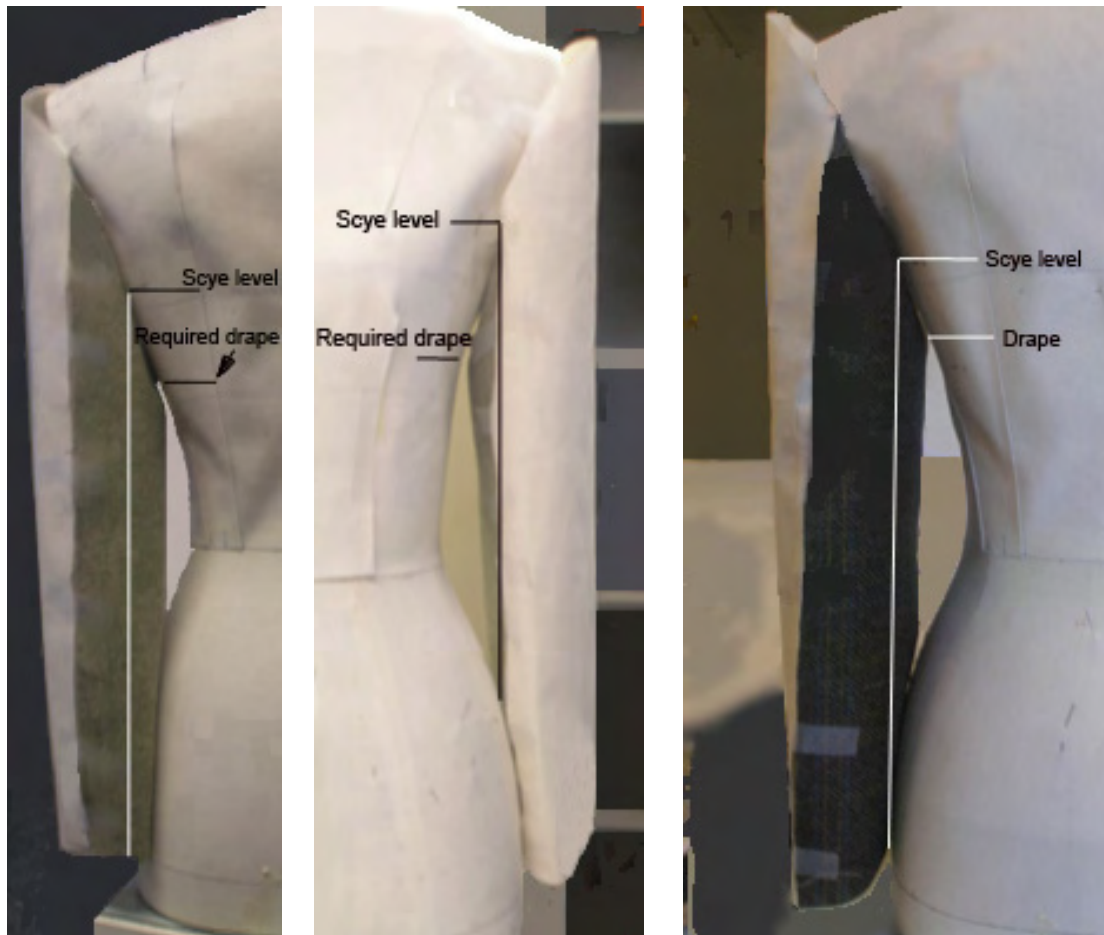


(1) Under sleeve pattern (from Figure 7.28 '3') (2) Under sleeve pattern plus width

Figure 7.29. Tapered and straight under sleeve

The extra width, below the scye level produces a slightly better draping affect ('1' back view and '2' front view in Figure 7.30). Since the sleeve is angled towards the body's centre line the drape will appear to be narrower at the front than at the back. Sleeve '3', back view, is made from a heavier yet more pliable 347g/m<sup>2</sup> weight fabric. Although more under sleeve fabric fullness can be compressed into the scye, there is very little increase in drape; however, the under sleeve produces a more rounded silhouette in the horizontal plane than the previous examples.





(1) Drape affect (back) (2) Drape affect (front) (3) Drape heavier weight fabric (back)

Figure 7.30. Straight under sleeve

### ***Sleeve drape: Tailored under sleeve***

#### ***Body contour length and Triangulation/parallel line development methods***

This method involves an arced scye sector length and parallel line development method to determine the under sleeve pattern. The under sleeve length is determined from the amount of drape curvature necessary to partially fill the space between the body and the arm at sector point 6 (Figure 7.31). To enable the measurement of the drape, curved lengths of the body in the under sleeve area are investigated.



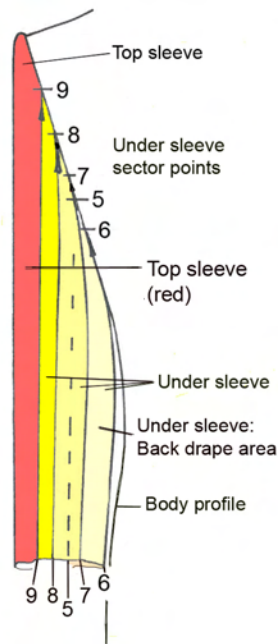
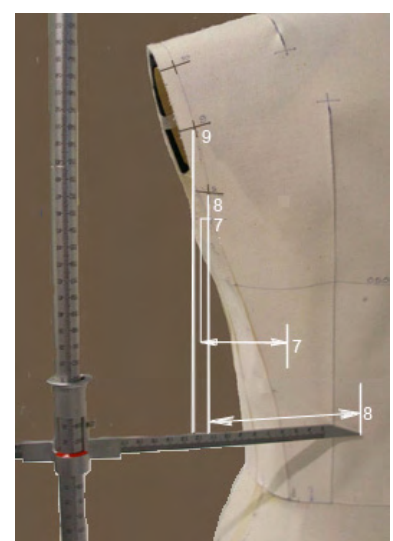
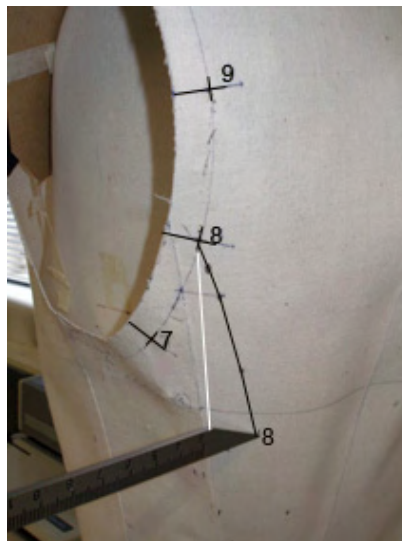
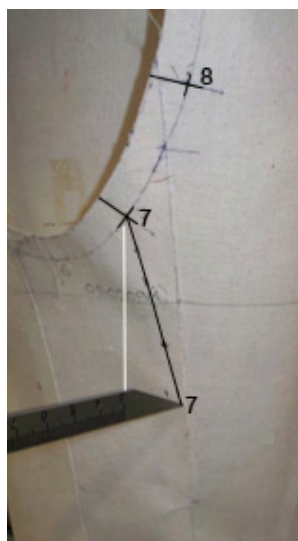


Figure 7.31. Back under sleeve drape area

Initially, the body profiles below the sector points 6, 7 and 8 were described from a perpendicular line to the scye alignment. Whilst this is ideal for sector point 6, points 7 and 8 (and 9) projected too far towards the centre of the back body. Figure 7.32 '3' is at waist height.

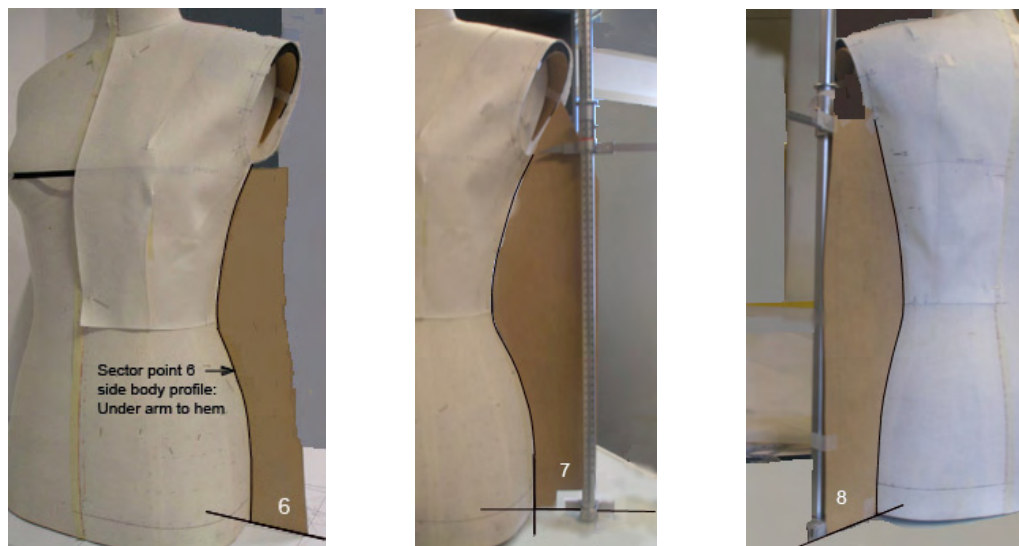


(1) Sector 7 body profile    (2) Sector 8 body profile    (3) Sector 6, 7, 8, 9 body profiles

Figure 7.32. Initial trial body sector profiles



The body profiles actually develop perpendicular to the body below the scye sector point for sector points 6, 7 and 8 (Figure 7.33). Since sector points 5 and 9 are the two points from which the under sleeve is initially suspended, these will not require body contouring.



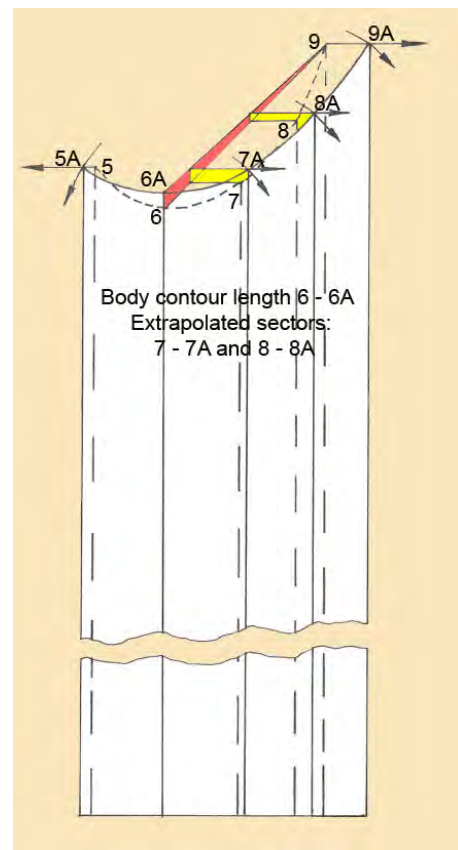
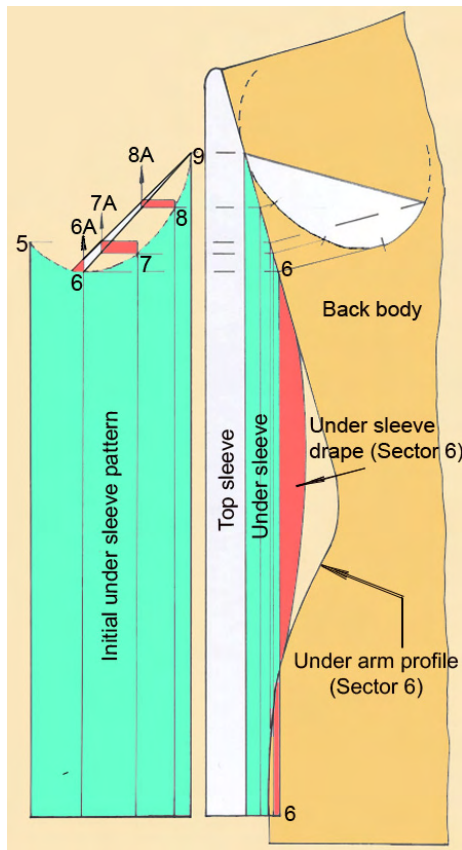
(1) Body sector profile 6    (2) Body sector profile 7    (3) Body sector profile 8

Figure 7.33. Body sector profiles 6, 7 and 8

The primary calculation for the drape shape is the curved length of the under sleeve drape at the lowest scye sector position – sector point 6, extending from the scye to the hem; without considering elevation. The profile of the body gives an indication as to the curvature of the under sleeve (below point 6). The difference between the vertical height of sector 6 (on the body) and the curved height of the drape is projected above sector point 6 to find 6A (horizontal red zone above sector point 6 in Figure 7.34 ‘1’).

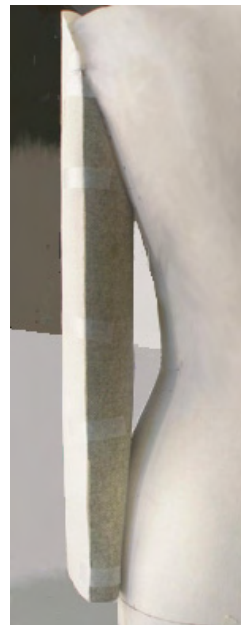
The remaining two sleeve sector height positions 7A and 8A (horizontal red zones in Figure 7.34 ‘1’) are the product of the raised under sleeve at sector 6A. By connecting point 6 and 6A to point 9, and projection 7 and 8 across to the lower line, the heights for sector points 7A and 8A are attained proportional to the height from 6 to 6A.





(1) Primary calculation drape shape

(2) Pattern with drape shape allowance



(3) Under sleeve (back view)

(4) Plus top sleeve support (back)

(5) Front view

Figure 7.34. Tailored under sleeve drape



Horizontal lines are extended to the left for sector point 5 and to the right for sector points 7A, 8A and 9A (Figure 7.34 '2'). Beginning with sector point 6A, the scye sector lengths are arced in sequence, to find the horizontal positions of points 5A, 7A, 8A and 9A. These positions are projected down to the hem to complete the under sleeve pattern width and heights. Due to the weight of the fabric and the position of the sleeve hem in relation to the hip curve, the full drape potential did not materialise. The constructed results are illustrated in Figure 7.34; '3' back view (under sleeve only), '4' (under sleeve supported by the top sleeve) and '5' the front view.

### ***Sleeve drape: Tailored under sleeve***

#### ***Isometric tree development method***

One of the quandaries relating to the development of a pattern for a doubly-curved surface is whether the fabric is extensible enough to conform to the required shape or whether sectionalising the assembly, into smaller sections to make up the whole, is a better option. The latter can be achieved using a class of mapping based on the idea of an isometric tree (isometric, in differential geometry, meaning length retaining), as considered by Manning (1980). The spine (vertical) and branches (horizontal) (Figure 7.35 '1'), are developed in sequence, working from spine outwards, to build the final flat pattern of the three-dimensional shape on the plane sheet (Figure 7.35 '2') (See appendix C).

(1) Spine and branches

(2) Spine and branches flattened

Figure 7.35. Isometric tree

Source: Hinds, McCartney and Woods (1991)



The objective of using this method is to produce a draping affect in the back under sleeve area to hide the scye seam between sector points 5 and 9 (yellow sections in Figure 7.36). The isometric tree method involves measuring the horizontal curved lengths of the sleeve at the level of each sector point at 5, 6, 7, 8 and 9. All are measured from the hind arm sleeve seam line, around the back section of the under sleeve to the scye.

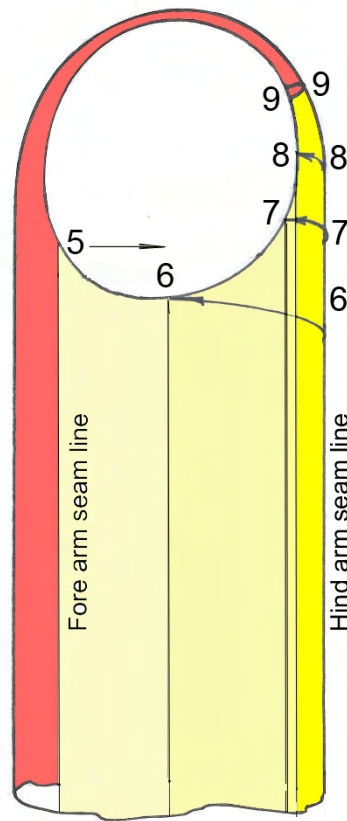


Figure 7.36. Tailored under sleeve drape

To aid the horizontal back sleeve drape curvature at each sector height, it is necessary to determine the curvature of the back garment body at those heights. The curvature of the body at each sector height is accomplished with the aid of a profile former (Figure 7.37 '1') and a height gauge (Figure 7.37 '2'). To facilitate plan view drawings, templates are prepared from the profiles (Figure 7.37 '3' and '4').

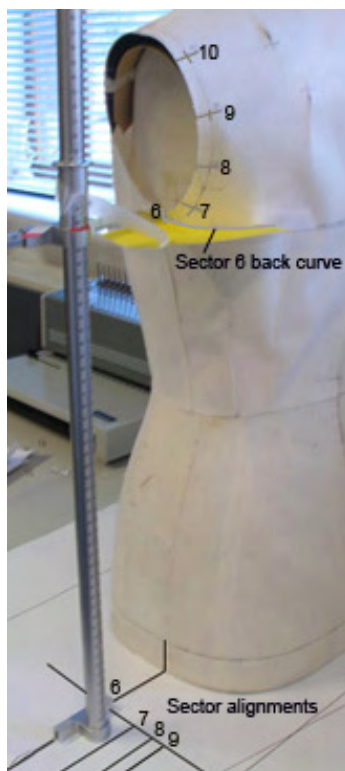




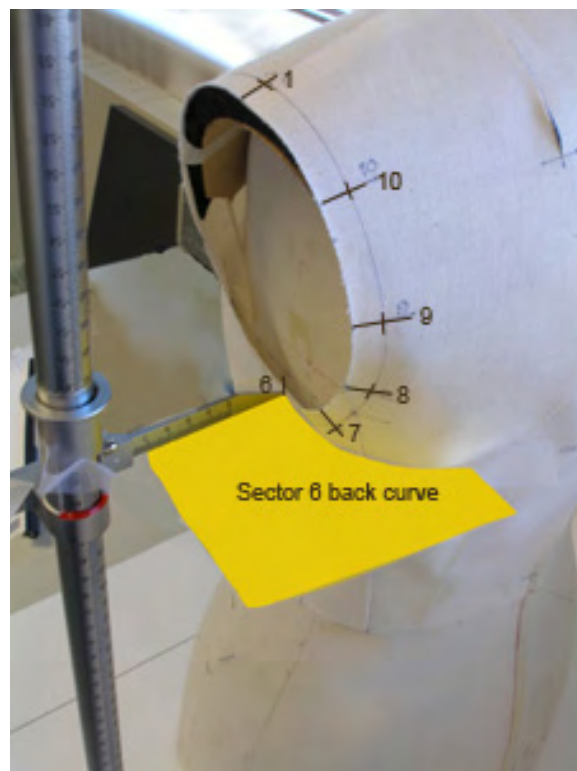
(1) Sector 6 profile template



(2) Sector 6 profile (front view)



(3) Sector 6 profile (back view)



(4) Sector 6 profile (back view detail)

Figure 7.37. Horizontal curves from scye sector point



The curved templates assist in establishing the direction and shape of the sleeve drape from the scye towards the centre back line. The sleeve follows the body curve for a short distance at the required sector point height, before curving in the opposite direction towards and into the under sleeve hind arm vertical.

The scye template (yellow area) is aligned with the scye slant (back view in Figure 7.38). Each of the sector lines is projected onto the scye slant and across to the left to establish their true height. Top sleeve, under sleeve and under sleeve drape are delineated on the back view. Progressively, each of the scye sector widths is transported from the back view scye template (yellow area) to produce a side elevation view of the scye and under sleeve. The sector points, from the side elevation scye are then drawn in a downwards direction ready for the plan view of the under sleeve. The scye and sleeve sector widths, in the plan view, are those of the back view sleeve sector widths.

The back (garment) sector templates are placed to the plan view scye to depict their curved outlines ready for the drape curves. The individual sector widths, from the back view, are set down on the plan view. The blue section of the plan view is the normal under sleeve area; the red areas of the back and plan views in Figure 7.38 represent the amount of drape for the sector.



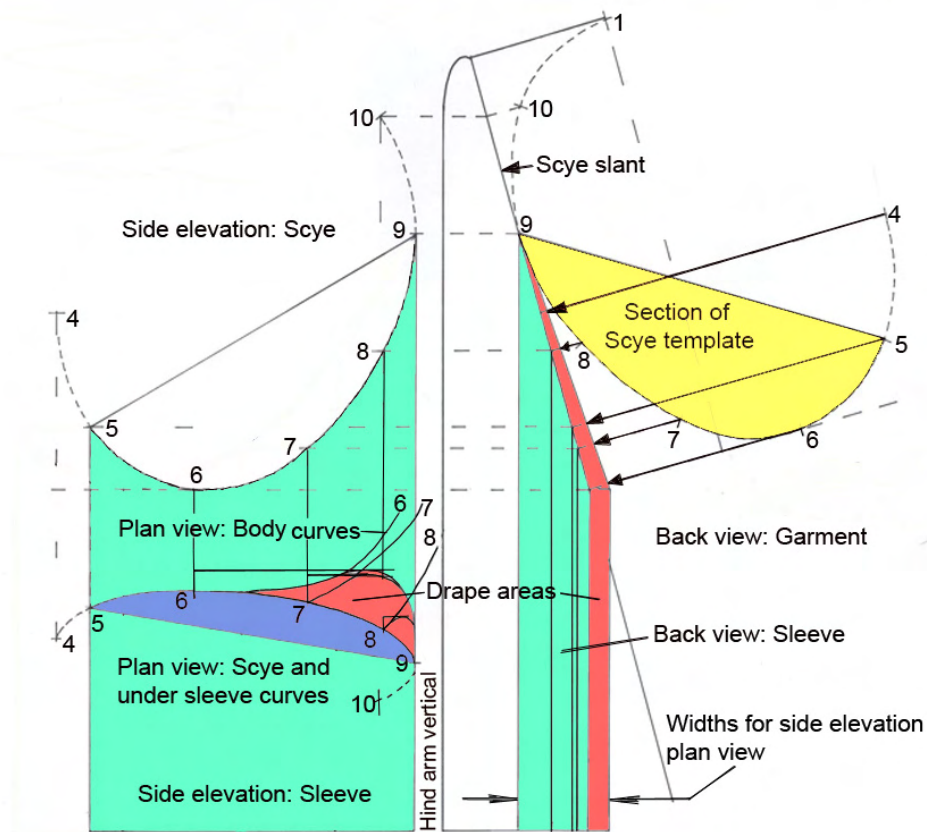


Figure 7.38. Under sleeve/drape planning

Figure 7.39 illustrates the method for plotting the sleeve drape curvature, for each of the sector heights, from a simulated fabric drape affect.

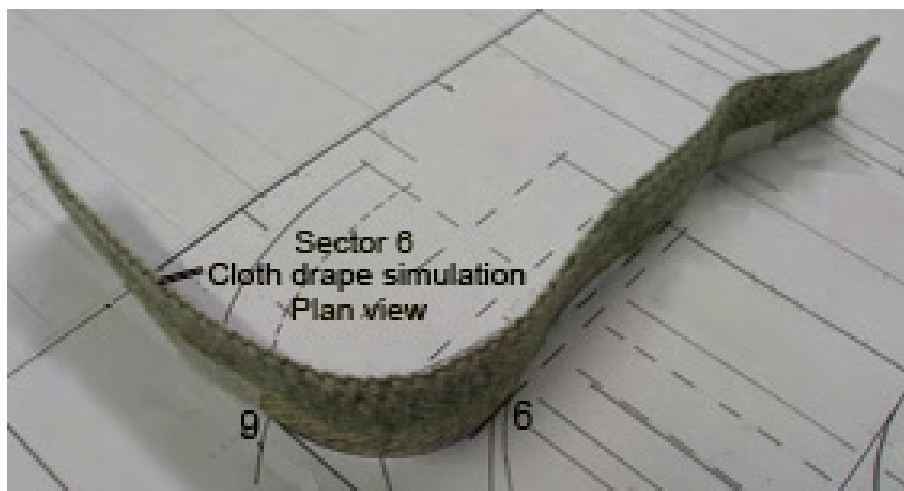


Figure 7.39. Fabric drape curve simulation



Each of the horizontal drape curve lengths 5, 6, 7 and 8, on the plan view, is measured from hind arm vertical in line with sector point 9/9A. These measurements are progressively applied, in a horizontal direction (arrows), to the side elevation scye, from sector point 9/9A to their respective scye sector heights of 5A, 6A, 7A and 8A (Figure 7.40). The sector heights are calculated in the same manner as those depicted in Figure 7.34 '1' and '2').

The combination of scye sector height and drape curve length produces slightly longer sleeve sectors compared to the original scye sectors (introduced fabric fullness). The amount of fullness between the sector lengths ranges from 5mm (9A - 8A), 3mm (8A - 7A), 2mm (7A - 6A) and zero mm between 6A - 5A, since there is no drape curve between these last two points.

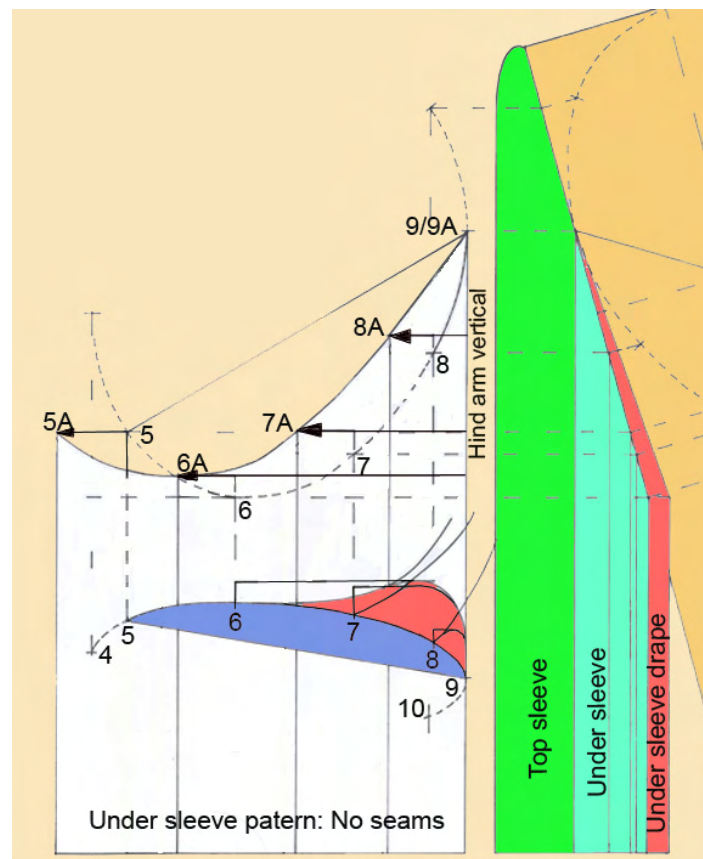


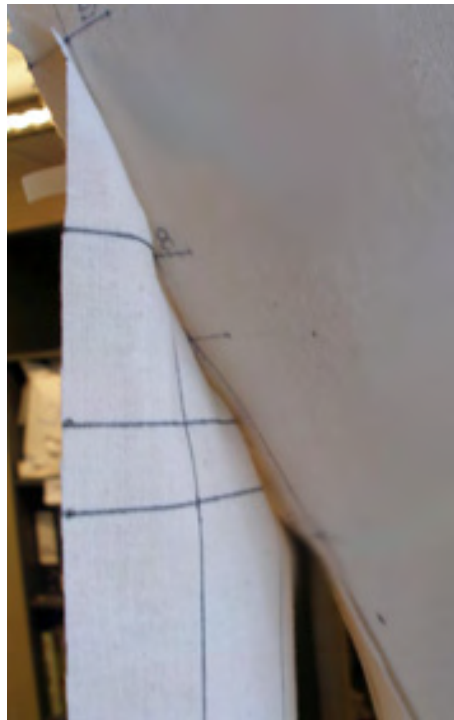
Figure 7.40. Under sleeve pattern development



A copy of the sleeve pattern was then tested twice. The first test was cut from an inexpensive calico (Figure 7.41 '1', '2' and '3'). This trial proved to have a slight amount of excessive fabric fullness for this type of material (Figure 7.41 '3'), producing defects in the form of puckers.



(1) Calico test (back view)



(2) Calico test (back view detail)

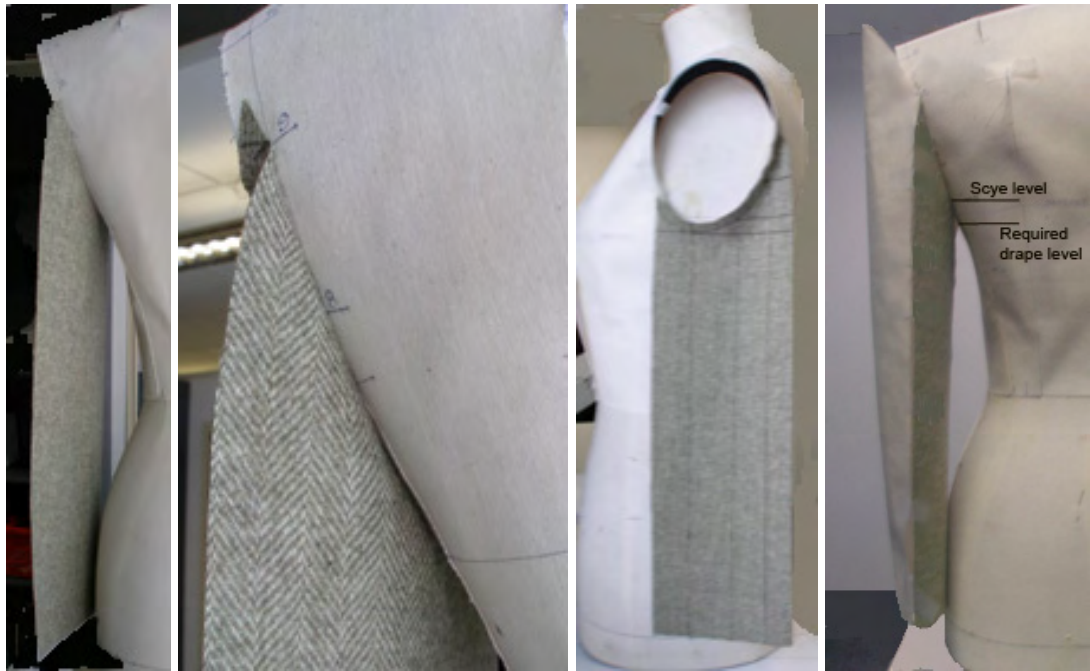


(3) Calico test  
(excessive fullness)

Figure 7.41. Back scye drape: Calico fabric

The second trial, using a wool fabric (277g/m<sup>2</sup>), produced a better union between scye and sleeve – with no puckering (Figure 7.42 '1', '2' and '3') and an enhanced back drape which hides the scye seam line. Figure 7.42 '4' has a top sleeve added for better stability.





(1) Back view (2) Back view (detail) (3) Inner side view (4) Under/top sleeve

Figure 7.42. Back scye drape: Wool fabric

### 7.15 Summary

The tailored under arm drape allowances were chronicled and discussed. Drape and its problems of formation, in the under sleeve of tailored sleeves, were acknowledged and described.

The application of both horizontal and vertical drape, may, depending on the amounts, result in a retention of the original non-fullness sleeve sector lengths or each sleeve sector may lengthen - include variations of fabric fullness. Therefore, each sector needs to be calculated individually and as a whole.

The raising of the under sleeve scye area by an excessive amount to produce drape, leads to fabric distortions (approximately 12mm appears to be the limit, depending on fabric) as does too much fabric fullness; there are therefore, limits to both. The type of fabric and its weight have a bearing on the draping qualities of the under sleeve.



## **7.16 Conclusions**

Chapter 7A acknowledged that for simplicity reasons during design and pattern development, dimensional stability, non-extensibility of fibres, has been assumed in the majority of scye and sleeve areas. The materials assume the qualities of metal or plastic sheeting with no deformation abilities (except in the non-developable crown area). Non-deformation of materials was emphasised by Yeung, Tang and Wang (2004).

It is reasonable to assume that once a fabric (along with its fullness and surface pattern properties) has been selected for a particular garment design/purpose, all of the other fabric properties including weight, thickness and drape, through acquiescence, have also been embraced and that those properties cannot be assessed until the sleeve design and pattern have been completed.

Chapter 7B discussed stripe and check fabrics with reference to fullness distribution and fabric pattern alignment. Stripes and checks have a propensity for distorting when deviating from horizontal or vertical directions. The problem of fullness distribution and its quantities, altered depending on whether the fabric was plain or whether the fabric consisted of stripes or checks patterns.

Chapter 7C; this chapter part discussed the advantages of having a method for calculating a fabric's fullness properties for a variety of sleeve crown styles. Measuring each of the ten crown scye sector sewing-angles and associated fullness produces an enhanced synchronisation between the sleeve design, the fabric and its corresponding sleeve pattern development. The fullness potential in each sleeve crown section dictates the curvature of the pattern in that section, which, in turn, culminates in a



unique self-imposed unity of crown curve section combinations leading to the total sleeve pattern shape and hence the three-dimensional fabricated sleeve.

Fabric fullness amounts are intrinsic to the fabric; therefore, the fabric dictates the maximum fullness ratios around the sleeve crown. Consequently maximum fullness compression potentials are decided when the designer chooses the fabric for the sleeve style. Subsequently when designing sleeves, a designer is restricted to the fabric's maximum and minimum fullness compression allocation range. Accordingly, to achieve a particular sleeve style, sleeve designs must be restricted to a certain range of fabrics.

Consequently to obtain a particular three-dimensional sleeve design silhouette, using a particular fabric, there can be only one combination of fullness/gathering/pleating allocations; each combination of fullness produces a different sleeve shape. Furthermore, it is only a small step to conclude that for any specific three-dimensional sleeve silhouette there can only be a single, two-dimensional sleeve pattern. All other sleeve pattern shapes will produce different sleeve silhouettes.

Chapter 7D determined that there is disagreement as to the defining properties of drape. The quality of fabric deformation, due to weight/gravity and other considerations does not, at the moment, allow for better predictions of drape. The complexities experienced in the production of under sleeve drape prohibit the use of a more precise method of producing fabric curvature. This research therefore, is a tentative step into under sleeve drape for tailored sleeves. The characteristics and formation of under sleeve drape require a good deal more research before more predictable sleeve pattern outcomes can be developed.



## **Chapter 8 —**

# **Sleeve Designs and the Development of their Two-Dimensional Patterns**

### **8.1 Introduction**

This chapter unifies all of those transitional scye and sleeve elements, described in chapters 6 and 7, into a flexible in-set sleeve design system. The scye shape was established as being crucial to the initiation of the design and pattern making process (chapter 6 A). The three methods of developing sheet materials onto the plane (parallel, radial and triangulation (chapter 6B) have indicated that they have the potential to develop the arm-encasing areas of in-set sleeves. Elevation, for one and two-piece curved sleeves, was described in chapter 6C. Sleeve crowns, as double-curved surfaces, were discussed in chapter 6D. All of these parts and elements are contained within the following sleeve representatives.

In addition to the crown developments, the two-piece tailored sleeve requires further adaptation in the arm-encasing area using an isometric-tree/wire-frame/radial line method. This is because it consists of two sections, a cylinder (above the elbow) and an inverted and truncated cone (below the elbow) – a non-developable structure.



The initial solutions, listed in Table 5.4 (Morphological methods), is restructured (Table 8.1) to depict the methods utilised or merged to produce parts of each of the sleeve designs, their patterns and their fabricated sleeves within the hybrid design system. These are depicted in the red boxes (Table 8.1) whilst future potential methods are noted in the yellow boxes.

Table 8.1. Morphological methods (Sleeve type solution potentials)

Morphological methods (Sleeve type solutions potentials)						
Method ▼		1. Tapered (Shirt)	2. Flared (Bell)	3. Straight (Tailored)	4. Two-piece (Tailored)	5. Leg of Mutton
C O N V E N T I O N A L	Parallel line development			Arm- encasing	Arm- encasing	
	Radial line development	Arm- encasing	Arm- encasing		Arm- encasing	Arm- encasing
	Triangulation (Appendix B. Warped-surface cone)					Arm- encasing
	Hybrid modelling/flattening (All sleeves)					
	Isometric tree (Appendix C)	Crown	Crown	Crown	Crown	Crown
	Wireframe (Appendix D)			Arm- encasing	Arm- encasing	
	Facets: Quadrilateral or Triangular :(Appendix E)					Crown
	Lobster back (Appendix F)					Crown
Key:		Methods utilised or merged ►		Potential methods ►		

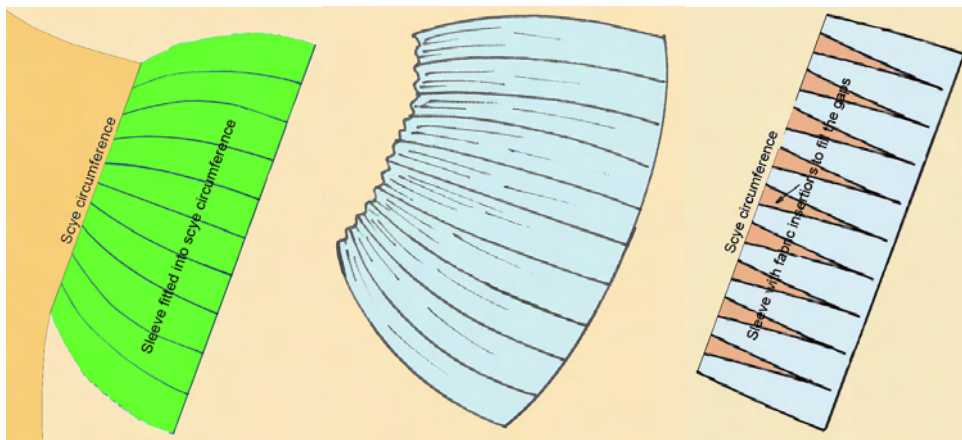
## 8.2 In-set sleeve design process

Current drafting methods reveal the true nature of the fabricated sleeve at the end of the designing, drafting, pattern making and sleeve fabric trial process. This is where it is declared a success – or not.

This study into the development of a distinct design and pattern making system begins with the required design of the crown shape (including the arm-encasing area) as



represented by Figure 8.1 '1'. Three-dimensional sleeve information is extracted from sleeve designed around the scye (Figure 8.1 '2') and flattened (developed) onto a plane to form the pattern (Figure 8.1 '3'). The flattening process expands the top crown edge, producing an amount of fullness. The fullness amount is checked against a fabric fullness chart for confirmation. This is where it is declared a success or not - not at fabrication.



(1) Sleeve crown shape (2) Sleeve (detached from scye) (3) Sleeve (developed)

Figure 8.1. Non-developable sleeve flattening process

The design system achieves the five designs of tapered (Shirt), flared (Bell), Leg of Mutton and tailored sleeves (one straight, and one arm-curved; using two different fabrics). In addition to the five sleeve styles of tapered (shirt), flared, straight tailored, curved tailored and leg of mutton; a second shirt sleeve is included for a total of six designs. The inclusion of a second tapered shirt sleeve is to demonstrate that a range of fabrics can be allocated to a single sleeve pattern – providing that the fabric fullness allowances of the second shirt fabric are within the pattern allowances of the first shirt sleeve allowances - thus saving on the design and construction phases.



The tailored two-piece curved sleeve involves a contrast from the one-piece straight sleeve. This sleeve also involves a change in fabric from a heavy-weight type (Harris-Tweed) to a lighter-weight. Unlike the additional tapered shirt sleeve, which did not require changes to the fabric fullness and pattern, this tailored sleeve example does need a change in pattern (around the sleeve crown) as the requisite lighter-weight fabric fullness amounts differ from that of the heavier-weight fabric.

All of the sleeve styles, as a prerequisite to the design and production of the individual sleeve patterns, require fullness allocations to be calculated to determine their potentials). The fullness (Table 7.2), initially calculated in 5° steps, is refined to agree with those angles that lie between the 5° steps.

The design and pattern making development methods are those detailed throughout chapter 6. The six sleeve designs are verified through a series of individual design drawings and development progressions through to the two-dimensional pattern and the three-dimensional fabricated sleeve.

Since the individual crown curvatures (see Figure 6.69) involved in the tapered and flared sleeves are small and difficult to determine in reduced-size drawings, the crown curve illustrations are confined to the more significant tailored crown curves. The Leg of Mutton sleeve has the same all-round crown curvatures in its front-to-back crown region, therefore, the same front elevation crown curve is utilised throughout.

Currently, the tailored sleeve, because of the aesthetics involved, has to be constructed in a more precise manner than non-tailored sleeve styles. However, the new in-set sleeve design and pattern making system does not differentiate between sleeve styles.



All sleeve styles are regarded as being equal, and therefore, they are accomplished with the same precision.

It must be emphasised that the visual and artistic aesthetics for all of the following sleeve styles are those of the author and as such may not reflect those of other users. It is the individual user that dictates the required intrinsic merits of their fabricated sleeves, all within the confines of the in-set sleeve design system. (See chapter 5: Brief (self-imposed)).

### ***Tapered (Shirt) sleeve 1***

The amount of sleeve crown curvature, outward expansion from the scye, is very small, measured as 1mm extra width to the front and back sleeve, 3mm to the height of the top of the sleeve crown and zero at the base of scye. The wrist, measured at a distance of 59cm from the crown, has a circumference of 19cm. Additions for hem pleats would be made at this stage which produces a 'blousing' similar to crown curvature (see adaptation from flare to Bishop sleeve Flared (Bell) sleeve on page 329). The sleeve elevation angle, measured from the vertical, is 40°. The tapered (Shirt) design, drafting and pattern making progression is illustrated in Figure 8.2.



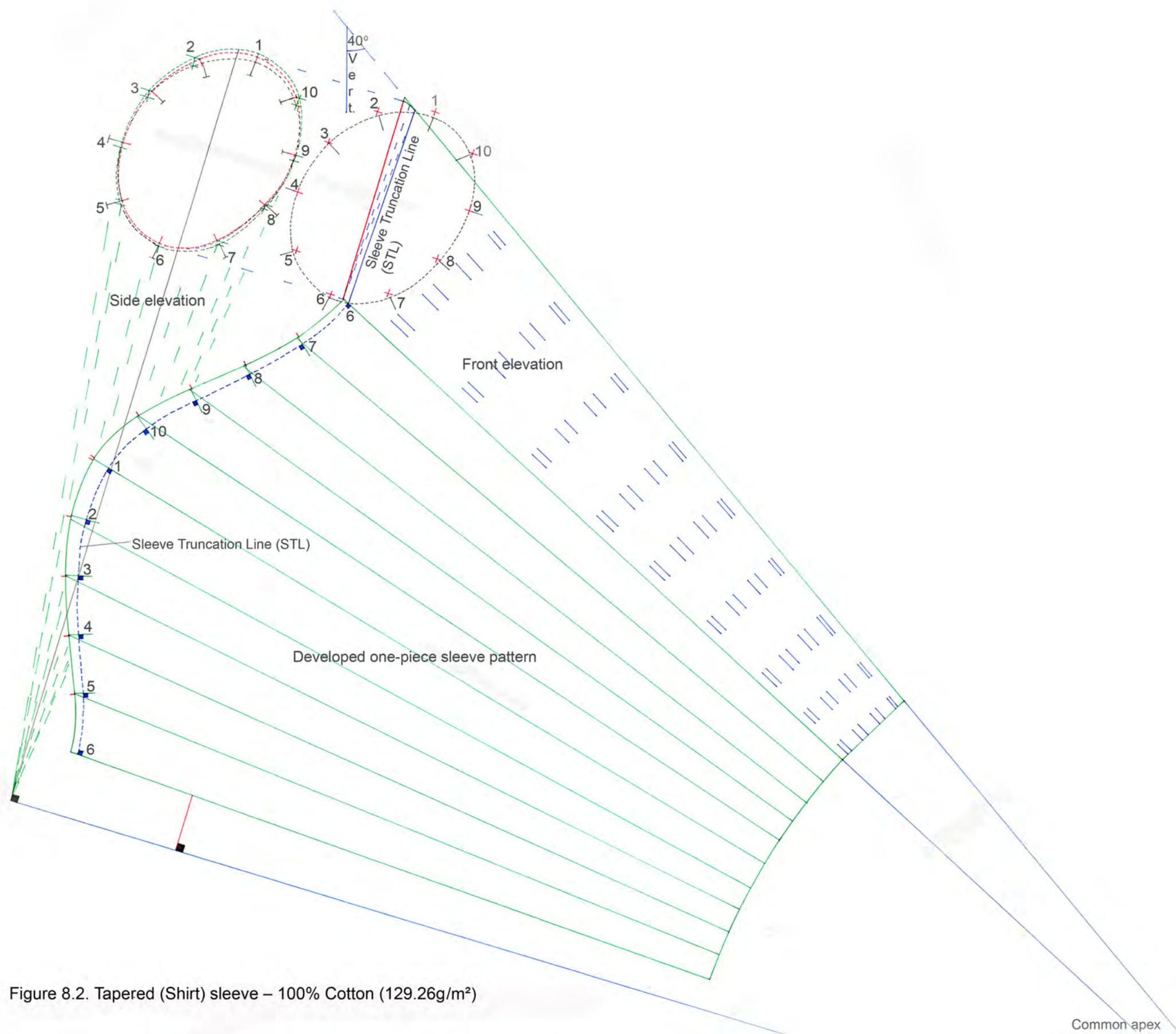


Figure 8.2. Tapered (Shirt) sleeve – 100% Cotton (129.26g/m<sup>2</sup>)







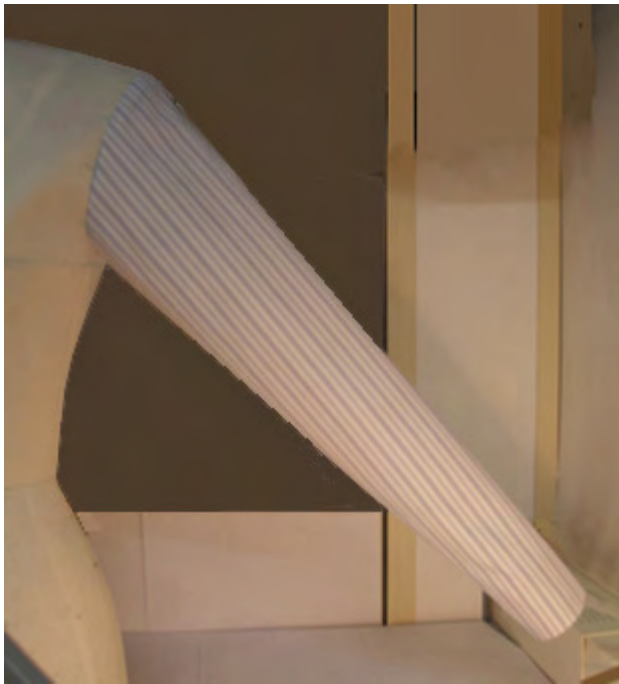
Each of the sleeve crown sectors of the pattern is measured to assess whether they are within the maximum fullness allowances for the sector length and the sewing angle (taken from Table 7.2 and restructured for additional angles). The fabric fullness allowances – all within tolerances – are tabulated in Table 8.2.

Table 8.2 Tapered (Shirt) sleeve fullness

<b>Shirt sleeve. Fabric: Cellulose fibres. 100% Cotton. Weight: 129.26g/m<sup>2</sup></b>					
Sector	Angle	Fullness	Sector length	Maximum allowable fullness per sector:	Within fullness allowances
1-2	10°	0.21mm	4.45cm	0.935mm	✓
2-3	25°	0.277mm	4.45cm	1.233mm	✓
3-4	35°	0.288mm	4.45cm	1.282mm	✓
4-5	36°	0.289mm	4.45cm	1.286mm	✓
5-6	28°	0.280mm	4.45cm	1.246mm	✓
1-10	15°	0.220mm	4.45cm	0.980mm	✓
10-9	33°	0.286mm	4.45cm	1.273mm	✓
9-8	35°	0.288mm	4.45cm	1.282mm	✓
8-7	30°	0.282mm	4.45cm	1.255mm	✓
7-6	20°	0.249mm	4.45cm	1.110mm	✓

The fabricated results are verified in the front view '1'; side view '2'; side view (close-up) '3'; and back view '4' in Figure 8.3.





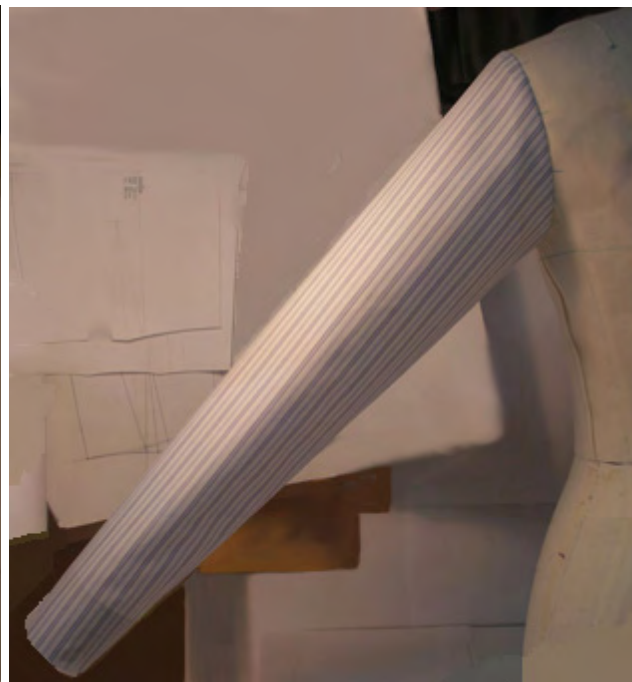
(1) Shirt sleeve (front view)



(2) Shirt (side view)



(3) Shirt (detail side view)



(4) Shirt (back view)

Figure 8.3. Tapered (shirt) sleeve - 100% Cotton (129.26g/m<sup>2</sup>)



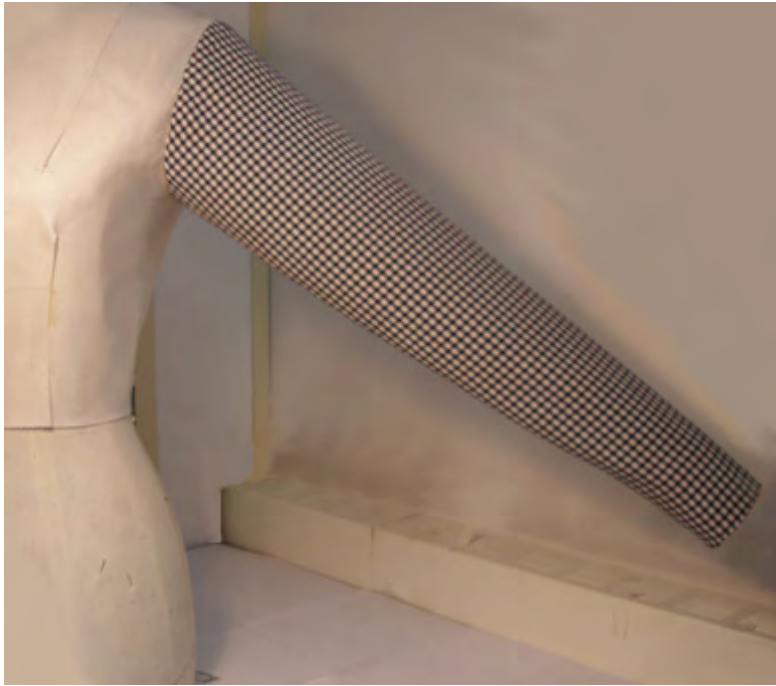
### ***Tapered (Shirt) sleeve 2***

The following, additional, tapered sleeve provides an alternative to producing individual sleeve patterns for each fabric. A previously constructed sleeve pattern (depicted in Figure 8.2.) for a fabric with a restricted range of fullness, can be utilised for other fabrics - providing the amount of fabric fullness in each sleeve crown sector is the same or less than the tolerances of the previous pattern. This particular fabric is an acetate (50%) viscose (50%) mix with a greater fullness capacity than the original fabric therefore it is compatible with the sleeve pattern. The actual allowable fullness amounts are those tabulated in Table 8.3. The front, side and back views of the fabricated sleeve are shown in Figure 8.4.

Table 8.3 Tapered (Shirt) sleeve fullness

<b>Shirt. Fabric: Regenerated fibres. 50% Acetate 50% Viscose. Weight: 119.13g/m<sup>2</sup></b>					
Sector	Angle	Fullness	Sector length	Maximum allowable fullness per sector:	Within fullness allowances
1-2	10°	0.311mm	4.45cm	1.384mm	✓
2-3	25°	0.691mm	4.45cm	3.075mm	✓
3-4	35°	0.895mm	4.45cm	3.982mm	✓
4-5	36°	0.914mm	4.45cm	4.067mm	✓
5-6	28°	0.761mm	4.45cm	3.386mm	✓
1-10	15°	0.416mm	4.45cm	1.851mm	✓
10-9	33°	0.860mm	4.45cm	3.827mm	✓
9-8	35°	0.895mm	4.45cm	3.982mm	✓
8-7	30°	0.808mm	4.45cm	3.595mm	✓
7-6	20°	0.537mm	4.45cm	2.389mm	✓





(1) Shirt sleeve (front view)



(2) Shirt (side view)



(3) Shirt (back view)

Figure 8.4. Tapered (Shirt) sleeve - 50% Acetate 50% Viscose ( $119.13\text{g/m}^2$ )



### ***Flared (Bell) sleeve***

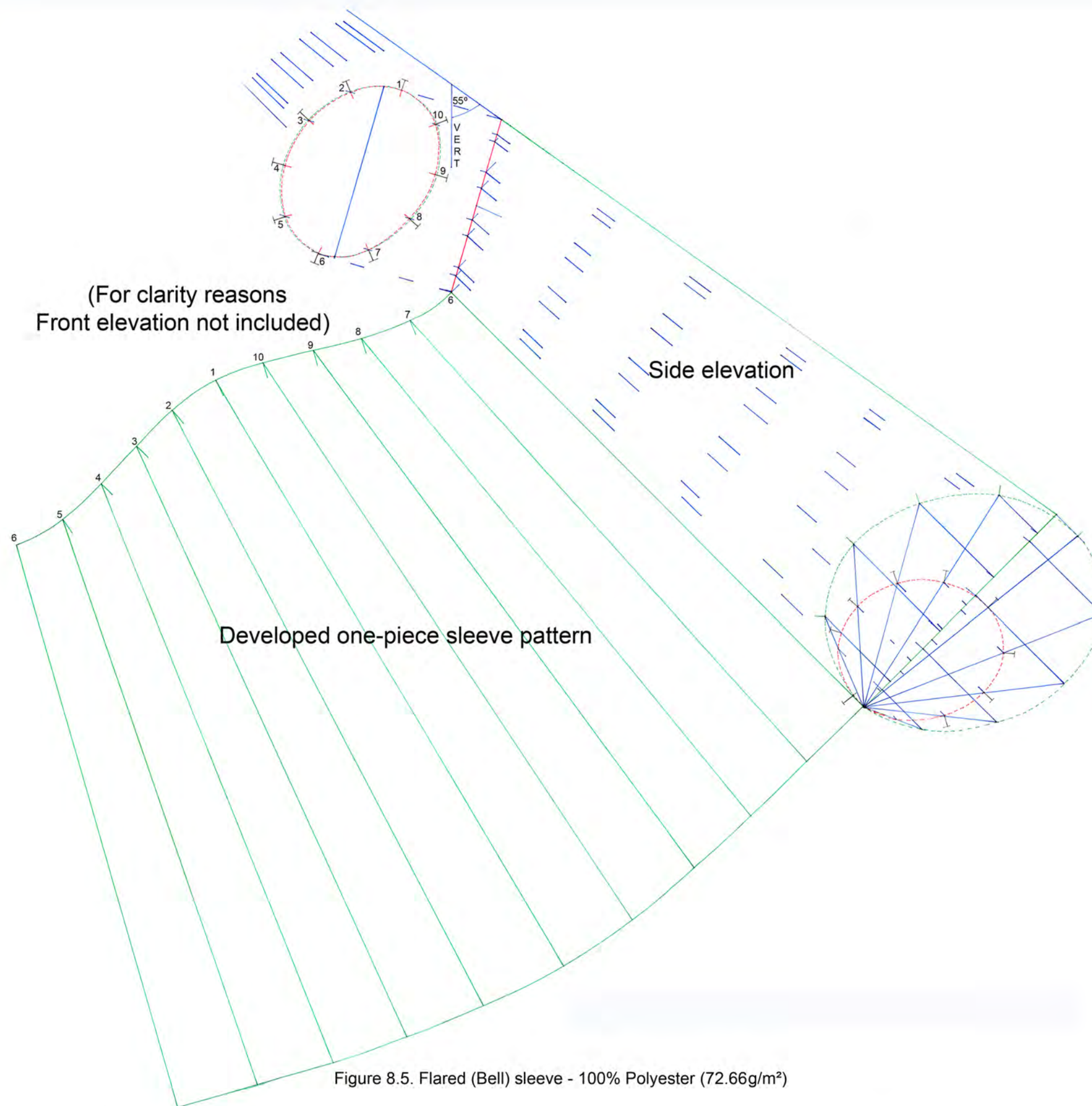
Since this sleeve has an elevation angle of  $55^{\circ}$  to the vertical, is flared through its length and has adequate width at the bicep area, there is sufficient arm ease allowances, it does not require a good deal of fabric fullness around the crown, therefore, the fullness around the scye is reduced to a minimum.

The sleeve, out from the scye, is wider by 1mm at the front and back with no allowance at the top of crown and base of scye; the flared hem circumference is 56cm (Figure 8.5.). The size, shape and positional relationships between the scye and hem are observed in the plan view seen at the hem level. To reduce shape distortions during photographic recording, a card band is inserted into the hem.















The allowable fullness for each sector is recorded in Table 8.4 as being within the allowable range. The fabricated sleeve is represented in (Figure 8.6).

Table 8.4 Flared (Bell) sleeve fullness

<b>Bell sleeve. Fabric: Man-made fibres. 100% Polyester . Weight:72.66g/m<sup>2</sup></b>					
Sector	Angle	Fullness	Sector length	Maximum allowable fullness per sector	Within fullness allowances
1-2	5°	0.415mm	4.45cm	1.847mm	✓
2-3	16°	0.532mm	4.45cm	2.367mm	✓
3-4	17°	0.544mm	4.45cm	2.42mm	✓
4-5	12°	0.487mm	4.45cm	2.167mm	✓
5-6	0°	0.4mm	4.45cm	1.78mm	✓
1-10	13°	0.498mm	4.45cm	2.216mm	✓
10-9	16°	0.532mm	4.45cm	2.367mm	✓
9-8	15°	0.52mm	4.45cm	2.314mm	✓
8-7	10°	0.465mm	4.45cm	2.07mm	✓
7-6	5°	0.415mm	4.45cm	1.847mm	✓

Although the flared sleeve in Figure 8.6 corresponds to the side elevation observed in Figure 8.5, it may be noted that the sleeve fabric is distorted on its lower edge due to gravity (Figure 8.6. '3'). This type of distortion is one of the reasons why the arm-encasing area is treated as a geometric modelling exercise - it models material without considering its mechanical or physical properties.

(A design related to the flared sleeve is the Bishop sleeve - see Figure 2.7, '7' (flared) and '11' (Bishop). Since it is created in a like manner to the flared sleeve, with a previously explained crown section, the Bishop sleeve is not fully described in the text. The hem of the Bishop sleeve is flared, whilst also being contained, within a narrower circumference of cuff, to produce a gathered effect. The design of the flared/curved silhouette into the cuff is analogous, and achieved by the same (inverted) means as the crown of a Leg of Mutton sleeve portrayed in Figure 6.57 '3' on page 221).





(1) Bell (front view)



(2) Bell (side view)



(3) Bell (back view)

Figure 8.6. Flared (Bell) sleeve - 100% Polyester (72.66g/m<sup>2</sup>)



### ***Tailored (Straight) sleeve 1***

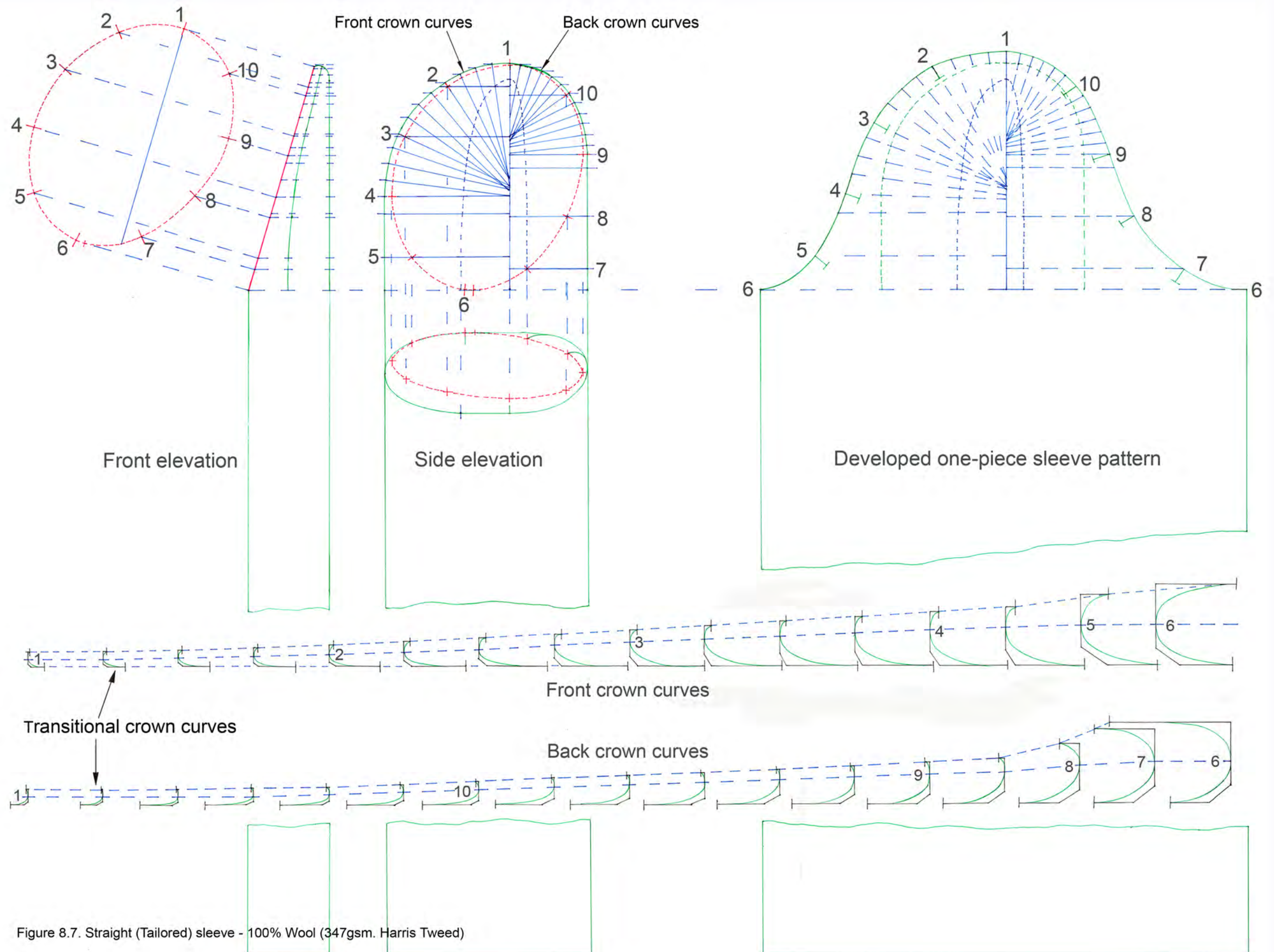
This sleeve representation is of a one-piece straight tailored sleeve type, constructed with vertical edges as illustrated in the front elevation in Figure 8.7. The crown curves, at each front and back sector point, are transitional, expanding through the curves from sector point 1 to the front and back pitches; and contracting from sector point 6 to the front and back pitches. The crown would have regular curvature throughout if the sectors at the crown curve were set at regular intervals. However, because the scye and sleeve crown are irregular in shape, the crown curves are not regular. This is more apparent in the front, between sectors 4 – 6, and in the back between sectors 6 – 9 (see plan and side elevation views). The measurements of these curves were projected outwards along the appropriate sector angle during pattern development. Joining the end points produced the total crown curve and scye matching sector points/notches.

The sector sleeve points, with scye and fullness allowances, match the scye sector points during fabrication. Since the sleeve is a straight sleeve style suspended from sector points 4, at the front and 9 at the back, the arm-encasing area is formed in a perpendicular manner between and below these two points.















Note how the fullness allowances between sector points 1 – 2 and sector points 1 – 10 (coloured red in Table 8.5) are not compatible with the scye sector lengths; they are 1mm too long. However, the extra minute amounts of fabric fullness in the two sectors are not enough to reject the sleeve pattern outright; they are deemed to be within a subjective tolerance – the fabricated outcomes, seen in Figure 8.8 are not affected.

Table 8.5 Tailored (Straight) sleeve fullness

<b>Tailored (Straight) sleeve. Fabric: Natural protein fibres. 100% Wool. 347g/m². Harris Tweed</b>					
Sector	Angle	Fullness	Sector length	Maximum allowable fullness per sector	Within fullness allowances
1-2	12°	1.1864mm	4.45cm	5.28mm	✓
2-3	44°	1.748mm	4.45cm	7.78mm	(+1mm)
3-4	68°	1.3934mm	4.45cm	6.2mm	✓
4-5	64°	1.5068mm	4.45cm	6.7mm	✓
5-6	31°	1.611mm	4.45cm	7.169mm	✓
1-10	25°	1.487mm	4.45cm	6.617mm	(+1mm)
10-9	65°	1.487mm	4.45cm	6.617mm	✓
9-8	63°	1,5266mm	4.45cm	6.8mm	✓
8-7	46°	1.748mm	4.45cm	7.778mm	✓
7-6	18°	1.2846mm	4.45cm	5.716mm	✓





(1) Tailored (front view)    (2) Tailored (side view)    (3) Tailored (back view)

Figure 8.8. Tailored (Straight) sleeve - 100% Wool (347g/m<sup>2</sup>. Harris Tweed)



### ***Tailored (Two-piece, curved) sleeve 2***

The tailored two-piece sleeve is parallel from crown to elbow line. From the elbow line it is tapered into a narrower wrist hem – in the hind arm area (Figure 8.9.). The outside arm angle in the front elevation view is 5°, which is between the angles of 3° and 7° as explained by Cho and Miyoshi (2003) and Cabrera and Flaherty Myers (1984) (see Figure 4.6 and Figure 4.7.). Since the fabric weight for this sleeve is lighter (173g/m<sup>2</sup>) than the straight tailored sleeve, (347g/m<sup>2</sup>) and the silhouette is curved and tapered in the arm-encasing area, a separate design and development process is undertaken. The same irregular crown curvature, seen in the previous straight tailored sleeve is apparent in the curved tailored sleeve in Figure 8.9.







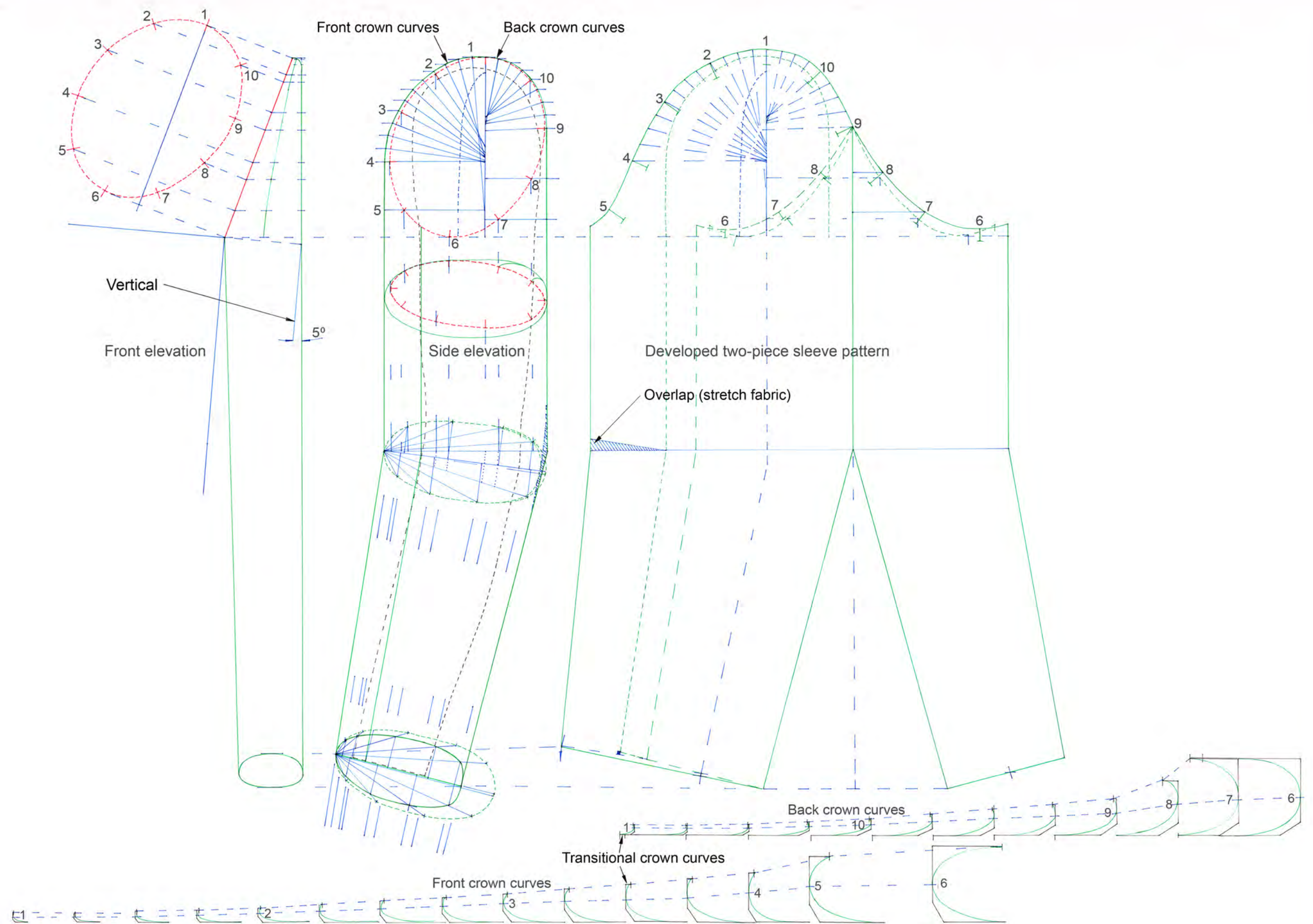


Figure 8.9. Tailored (Two-piece) sleeve - 100% Wool (173g/m² Hounds-tooth)





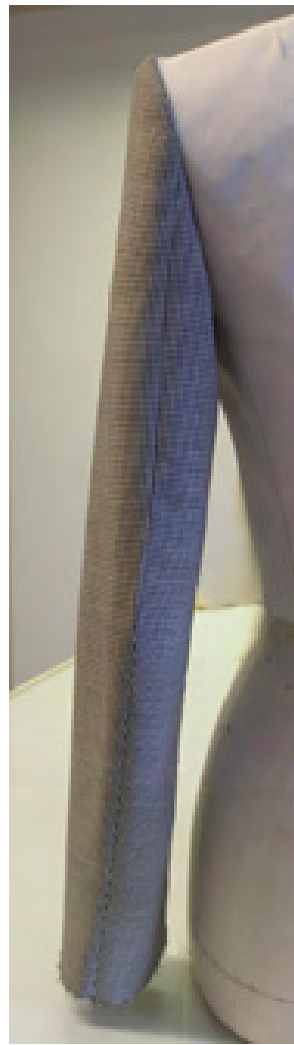


As is the normal practise in the design and pattern making system, each of the sectors arranged around the sleeve crown, is measured for fabric fullness. All are found to be within the allowable range (Table 8.6). The resultant sleeve is seen to be free of defects around the crown and down the arm-encasing area (Figure 8.10.).

Table 8.6 Tailored (Two-piece) sleeve

<b>Tailored (Two-piece) sleeve. Fabric: Natural protein. 100% Wool. 173g/m<sup>2</sup>. Hounds-tooth</b>					
Sector	Angle	Fullness	Sector length	Maximum allowable fullness per sector	Within fullness allowances
1-2	13°	0.835mm	4.45cm	3.716mm	✓
2-3	38°	1.688mm	4.45cm	7.636mm	✓
3-4	60°	1.497mm	4.45cm	6.66mm	✓
4-5	64°	1.344mm	4.45cm	5.981mm	✓
5-6	31°	1.528mm	4.45cm	6.8mm	✓
1-10	22°	1.168mm	4.45cm	5.198mm	✓
10-9	59°	1.528mm	4.45cm	6.8mm	✓
9-8	55°	1,646mm	4.45cm	7.324mm	✓
8-7	43°	1.736mm	4.45cm	7.725mm	✓
7-6	16°	0.939mm	4.45cm	4.178mm	✓





(1) Tailored (front view)

(2) Tailored (side view)

(3) Tailored (back view)

Figure 8.10. Tailored (Two-piece) sleeve - 100% Wool (173g/m<sup>2</sup>. Hounds-tooth)



### ***Leg of Mutton sleeve***

Of all the sleeve styles, the Leg of Mutton has the largest expanse of crown curvature (Figure 8.11.). Although the method to determine the crown curvatures of the previous sleeve examples, the isometric-tree method, could be utilised, it is suspended to enable an alternative development method to be trialled – the ‘lobster back bend’ technique. This method involves segmented polygonal shapes, pieces, facets or strips (see chapter 6B, Figure 6.12 and appendices E and F). The ‘lobster back bend’ method illustrates that the ‘lobster back bend’ technique is a viable option for the creation of the crown curve area of the Leg of Mutton sleeve; and the other sleeve styles reviewed.

The gathers around the top crown section of the sleeve between sectors 4-3, 3-2, 2-1, 1-10 and 10-9 are considerable, even though they are all within the allowances (Table 8.7). There is no fabric fullness in the under scye section of the sleeve between sector points 4-5, 5-6, 8-7 and 7-6. Since the arm-encasing area is composed of a type of oblique truncated cone, a triangulation method of determining the sections is utilised.







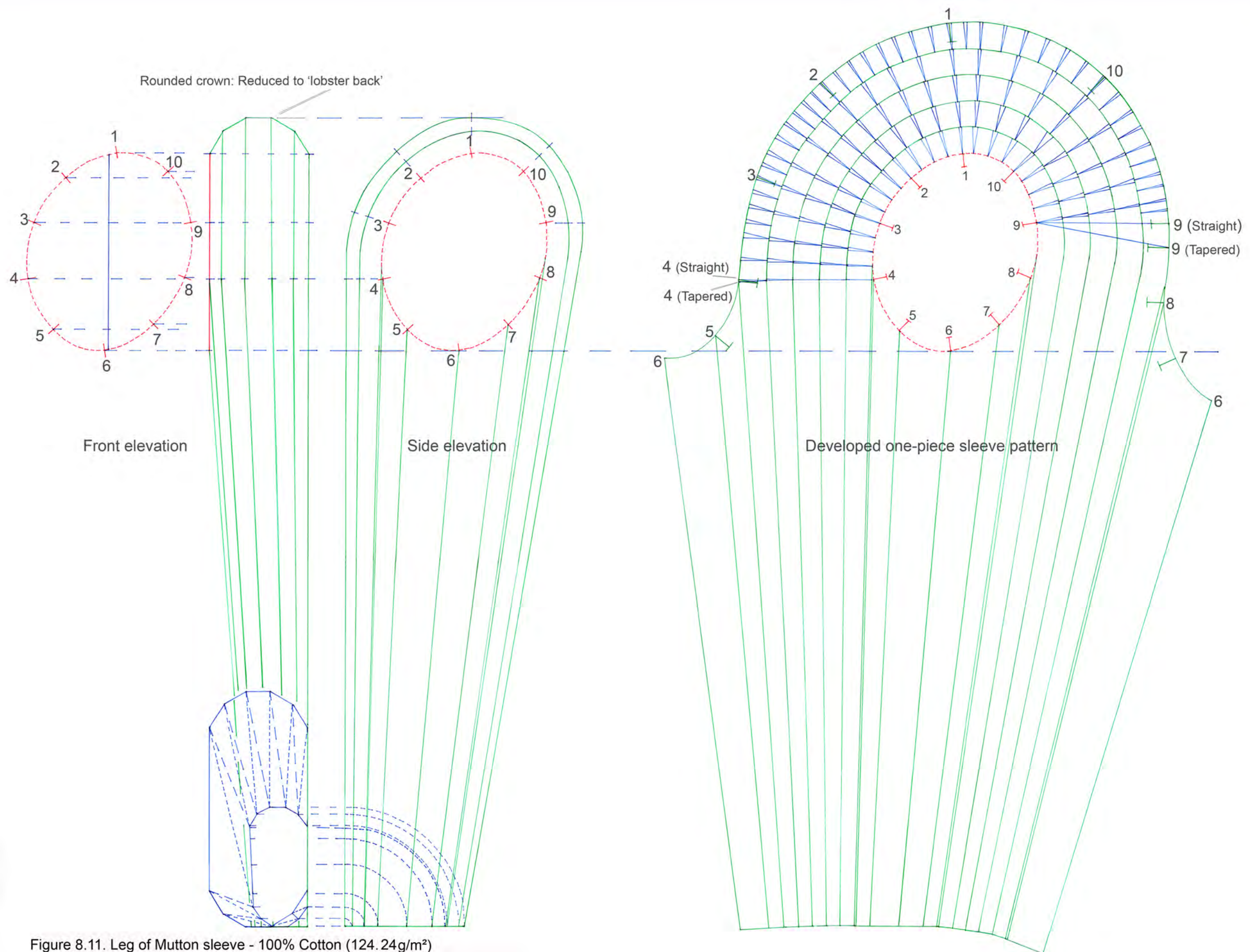


Figure 8.11. Leg of Mutton sleeve - 100% Cotton (124.24g/m<sup>2</sup>)





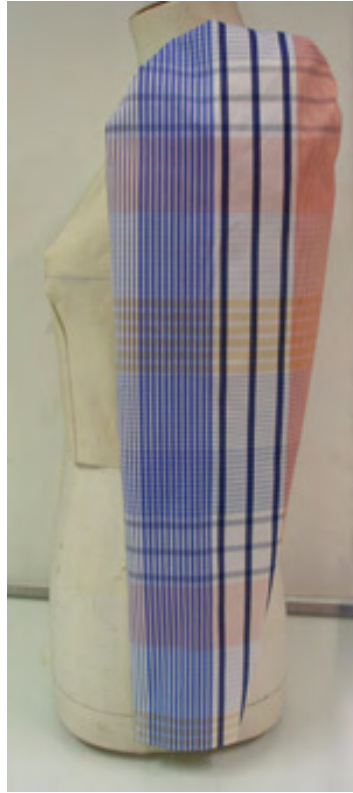


Table 8.7 Leg of Mutton sleeve

Leg of Mutton sleeve. <b>Fabric: Cellulose fibres. 100% Cotton. Weight: 124.24g/m<sup>2</sup>.</b>					
Sector	Angle	Fullness	Sector length	Maximum allowable fullness per sector	Within fullness allowances
1-2	28°	40mm	4.3cm	172mm	✓
2-3	55°	40mm	4.3cm	172mm	✓
3-4	80°	40mm	4.3cm	172mm	✓
4-5	75°	40mm	4.3cm	172mm	✓
5-6	20°	40mm	4.3cm	172mm	✓
1-10	18°	40mm	4.3cm	172mm	✓
10-9	66°	40mm	4.3cm	172mm	✓
9-8	87°	40mm	4.3cm	172mm	✓
8-7	77°	40mm	4.3cm	172mm	✓
7-6	49°	40mm	4.3cm	172mm	✓

Figure 8.12 illustrates the fabricated sleeve with its excessive crown curvature and narrow hem. Since the front of sleeve has been designed as a vertical, the stripes are in alignment with horizontal and vertical planes (Figure 8.12. '1' and '2'), whereas the back stripes appear to be skewed because of the inward tapered design, (Figure 8.12. '3').





(1) L. of Mutton (front view) (2) L. of Mutton (side view) (3) L. of M. (back view)

Figure 8.12. Leg of mutton sleeve - 100% Cotton (124.24g/m<sup>2</sup>)

### 8.3 Summary

The previous two chapters, 6 and 7 described the various combinations of the scye and sleeve parts and elements. These combinations form the structure and functions of individual, sleeve styles. This chapter has combined the individual parts and elements into 'packets' which represent the six individual in-set sleeve design case studies. A variety of development methods were utilised to achieve the patterns and fabric sleeves. There were no patterns or fabricated trial sleeves constructed prior to the final fabrications, shown in the figures.



## **Chapter 9 —**

# **Conclusions, Findings, Contributions, and Recommendations for Further Research**

### **9.1 Introduction**

Unlike disciplines such as engineering and architecture, the design and pattern making of garments are not scientific undertakings. Therefore this research is a response to the confusion seen in the plethora of personalised sleeve pattern making methods and their reliance on costly, knowledge-intensive, trial and error techniques.

The separation of design and pattern making represents a serious flaw in the design/pattern making process (McCartney, Hinds, Seow & Gong. 2000a). This is because interpretations of requirements, from both perspectives, may represent a significant range of possibilities. Through a series of incremental methods, the two disciplines were united into a new unique design system. The design system, harmonising an array of in-set sleeve styles and fabric characteristics with multi-view engineering drawings (orthographic projections) leads to a better appreciation of design and pattern making processes. Predicting the three-dimensional fabricated sleeve,



prior to sampling and production therefore, is potentially much easier to accomplish than in any current iterative methods.

## **9.2 Current design and pattern making**

In spite of the fact that drafts are a simple copying processes, a 'join the dots' form of drawing, they are difficult to interpret as three-dimensional objects in their present planar form. All pattern making methods have a flat pattern focus, therefore it is necessary to interpret a flat pattern shape (and the designer's needs) into a reasoned or virtual three-dimensional sleeve. In reality it is an informed guess; in other words they are unscientific. In addition, there is no agreement between authors and experienced practitioners as to what should constitute the ideal configuration of scye and sleeve pattern for any given sleeve design. As such, for the uninitiated, the final three-dimensional sleeve will always be in doubt until the final three-dimensional sleeve is constructed.

In order to create a unique in-set sleeve design system, it was determined that a methodical description be performed of the scye and sleeve. As a consequence, it is believed that in-set sleeves are complex structures not readily appreciated within the two-dimensional framework of present drafting methods, which are devoid of holistic design interpretations. In their current form, none of the drafting methods are information-rich to be efficient in execution. They are technologically inadequate, no longer serving their purpose. As a consequence, it is difficult to successfully unite the required scye and sleeve elements to achieve a single in-set sleeve design and pattern making system.

The total focus of effort expended to perfect personal variations of prevailing drafting and adaptation methods might be misplaced, in the author's opinion, as it tends to



inhibit the practitioner from thinking of alternative approaches outside the discipline. As a consequence, it is not generally recognised that there is a need to reassess these unpredictable, inefficient, trial and error methods; the status quo is perpetuated. Hence, the need for the creation of a new combined design and pattern making system.

### **9.3 Conclusions, research findings and contributions**

The design and pattern making system described in this thesis has not been previously documented. This system negates confirmation of results on the mannequin, the last operation prior to full verification, preferring to validate the sleeve at the pattern design stage, much nearer to the initial design concept. This earlier confirmation enhances product quality and aesthetics whilst promoting an increased confidence, both in the design system and in its results, reducing iterative three-dimensional constructions.

Through a hybrid conventional and systematic design process including case studies as a base, the new design system explains, incrementally, the inclined, sectionalised scye. It details arm elevations (which automatically account for variations of sleeve crown heights), the angled curvatures of the sleeve arm-encasing sections up to the sleeve truncation line (STL) and the flattening onto the plane, of the non-developable surfaces of the crown. These elements are not analysed to this depth in any previous drafting method.

Currently, fabric fullness and its incorporation into sleeve patterns are discussed only in general terms. There are no analyses in the literature of the amounts of fabric fullness inherent in a variety of fabric types and weights. The factors involved in the distribution of fullness around the crown and why fabric fullness measuring practises are inconsistent are explained, for the first time, in detail. Additionally, it is established that there is no documentation concerning crown sewing angles (see 9.5 recommendations for future research for a description of body/sleeve crown sewing angles).



The design system documents the creation of a unique method for calculating fabric fullness for all crown sewing angles and explains crown fullness and its sector distributions, thus amalgamating styles that contain zero fullness, tailored sleeve fullness amounts, to the gathers of a full Leg of Mutton sleeve style – never previously acknowledged in the literature (Included in the following contributions).

Monitoring fullness compression potentials for sleeve production will limit the sleeve rejection rate. This will also reduce the need to re-work sleeve pattern shapes because of incorrect fullness allowances. Allowing the designer to both design and pattern make sleeve styles, without the required technical knowledge, could represent considerable advantages in the reduction of organisational duties, fabric cost, time management and manufacturing whilst increasing garment quality.

Utilising the new in-set sleeve design system described in this thesis, the sleeves designed at the beginning of the development process are reflected in the last stage of the design process - the three-dimensional fabricated sleeves. Since the sleeve designs did not deviate from the initial concepts there was no need for design development iterations. Within the new design system developed in this thesis, the following contributions are identified and documented:

- The new in-set sleeve design system fully integrating design, drafting and pattern making into a single unit which automatically balances the arm, sleeve and scye (Chapter 8: 8.2)
- Non-distorted scye shapes are the base for in-set sleeve designing (Chapter 6A: 6.3)
- The same finite number of elements (not previously acknowledged) are contained in all in-set sleeve styles (Chapters 3: 3.2; 5: 5.9 and throughout chapters 6 and 7)



- In-set sleeves styles are composed of only two geometric shapes – the cylinder and cone; these integrate a succession of variable sleeve silhouettes (Chapters 5: 5.9; 6B: 6.7; 6.8; 6.9 and 8: 8.2)
- The question of how to ascertain the correct flat pattern crown height of the entire three-dimensional crown curve for all the sleeve styles is established (Chapters 6D: 6.19 and 8: 8.2)
- A method is determined to illustrate how the three-dimensional sleeve/fabric folds over the crown curve to align with the scye and its sector points (Chapters 6D: 6.17, 6.19 and 8: 8.2)
- A method to ascertain how the three-dimensional sleeve develops to form the flat pattern (Chapters 6B: 6.8, 6.9; 6C: 6.12 and 8: 8.2)
- A method to determine fabric fullness for a variety of fabrics and sewing angles is developed (Chapters 7A: 7.3; 7C: 7.9, 7.10, 7.11)
- The question of how to determine the correct, precise sector-length fabric fullness and its automatic distribution for each change in sleeve size, style silhouette and surface decoration (stripes/checks) is answered (Chapters 6D: 6.17, 6.19; 7B, 7.6 and 8, 8.2)
- A distinct method for sleeve elevation and a provisional introduction to under arm drape is presented (Chapters 6C: 6.12; 7D; 7.14 and 8; 8.2).

All of the above features for a single, or a combined array of in-set sleeve designs are not evident in the literature, either as single identities or as a whole system.

#### **9.4 Limitations of the research**

The complex nature of the design and pattern making system limited the number of sleeve styles and fabrics investigated. However, as the sleeve style silhouettes (straight, tapered and flared) form all sleeve styles; and since the fullness and gathers are at their extremes (minimal fullness to maximum gathers), the six case studies



described encompass a considerable number of alternative silhouettes available to the designer. This is noted with a partial description of the Bishop sleeve, on page 329.

The complexities involved in the development and execution of the in-set sleeve design system also negated the inclusion of fabric shear and drape properties - under sleeve drape was introduced provisionally in chapter 7D. Since these two aspects do not obstruct the development of the design system, investigations into these aspects must be deferred for future developments.

## **9.5 Recommendations for future research**

The creation of the scye template is difficult to construct from the toile, as the toile has to be precisely formed allowing for a plane scye surface (see Figures 6.6 – 6.10). The plane scye surface may not always be possible to produce under manually dexterous conditions. However, it is anticipated that future body scan technology, or facet development, may allow for scye development - when proficiency in these CAD technologies has advanced further.

To enhance crown curvatures, the angles of the body sections, from which they emanate, have been calculated for a future study. The prospective incorporation of the body curves would be an advantage to the precision of crown curves from the scye seam line (see appendix G).

It is apparent that the number of sleeve pattern development methods, performed in the new design system, after designing, could be reduced. The two arm/sleeve elevations lateral and side/forward would be better served as a single unit. The drafting and pattern development methods changed with the sleeve silhouette (parallel, radial, triangulation). Even so, these three could be condensed to the triangulation method for all of the styles, as could the crown development methods - Isometric tree, lobster



back-bend, facets et cetera. There would be no change in the fullness assessment process as all sleeves follow the same progressions.

Subsequent to the realisation of the designing and drafting system, it might be possible for existing, or future, drape algorithms to be amalgamated to give a more comprehensive and inclusive nature to the system.

Since garment construction methods are not addressed in this research, they also require consideration, as does the development of a table of divergent fabric fullness qualities. This would include a complete record of sleeve crown sewing angles to reduce the reliance on fabric trials. A mathematical equation could be generated (perhaps, if willing, by fabric manufacturers?) to include fabric fullness capabilities. There may also be potential for a future investigation into the possible inclusion of an array of Raglan and Kimono sleeves into this study.

### ***Computer Aided Sleeve Design***

Because of their diversity and flat characteristics, present manual in-set sleeve drafting methods do not readily adapt themselves to computerisation. Current computers programmes for pattern making still rely on traditional, knowledge intensive methods and the skills of the operator; therefore, there is little likelihood of these methods being developed any further than their current status.

Consequent to the documentation of the above features, it is anticipated that a new in-set sleeve design system CAD programme will be created to permit the designer to perform the duties involved in both the designing and pattern making of in-set sleeves. This would be equivalent to the suggestion by McCartney, Hinds, Seow & Gong (2000a), which is that it may be better, through sophisticated drawing techniques, to specify the required three-dimensional (sleeve) shape, rather than altering two-



dimensional patterns to change illustrations on a computerised mannequin. The three-dimensional garment sections would reveal the two-dimensional shape and constructional detail required to achieve the final form.

Instilling the system within a computer programme would considerably reduce the need for a reliance on the human knowledge aspect of the application. In reality, it would not be necessary to teach or learn in-set sleeve pattern making at all. It is envisaged that the experience of the pattern maker and iterative trialling of sleeve design and pattern making will be eliminated – replaced with software that enables the designer to perform those duties ‘on screen’.

## **9.6 Summary**

It is stated in chapter 1 that the aim of this research project was the creation of a unique and flexible design and pattern making system for a decided number of in-set sleeve styles, their silhouette variations and related fabrics. It is further declared that there are barriers to the realisation of a new design system in the form of the current divide between design and pattern making methods, and the deficiencies of said methods; this study may have the potential to reverse these barriers and deficiencies

The division of design and pattern making and the profusion of sleeve styles and their variations combined with the almost limitless supply of entrenched style-isolated drafting methods produces a bewildering and conflicting situation. This situation has endured for some considerable time; it is inefficient and no longer sustainable in modern garment manufacturing. In this research project, the division of ‘artistic’ design and technical pattern making has been reversed.

Since design preferences produce an array of dimensional changes within any given sleeve style, the names of sleeves are used only as references for the case studies,



they are no longer paramount. The styles themselves are reduced to simple geometric structures with both developable and non-developable surfaces. Each part and element of the scye and sleeve is documented. The trialling approaches, currently in vogue for pattern making are no longer required, reduced to verifying fabric fullness. Equipped with a table of fabric fullness compression measurements, it is easier to gauge the final pattern silhouette, and its quality, prior to manufacture.

The sleeve style requirements of the designer (sleeve style interpretation), the pattern development method and the intended fabric – with its fullness potentials – have all been united into a single designing and pattern making. This is an all inclusive process or system, accomplished by the same person – the designer.

This study demonstrates that a considerable number of sleeve designs and patterns can be created within the new, united, in-set sleeve design and pattern making system. The original five in-set sleeve style case studies, plus a second tapered (shirt) sleeve for a total of six, are depicted and resolved. The new design and pattern making method illustrates that where variations of style, scye, size, silhouette, elevation, crown - shape and fabric fullness are concerned they are no barrier to predicting the resultant three-dimensional fabricated sleeves. The final fabric sleeve is predicted without resorting to a host of iterative processes.

This study is only the inauguration of a new design and pattern making system representing a manual design and pattern making process. Since disciplines unrelated to apparel, such as architecture and engineering, are continuously reliant on CAD to function more effectively, it is apparent that clothing design and manufacture must also follow this efficiency route. A progression to computerisation is the next stage in in-set sleeve designing.



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# Appendix A

## Glossary

### A

Adaptation	The use of previously made sleeve pattern to create different styles/shapes
Angle of elevation	Pivotal movement of the arm/sleeve in a lateral direction

### B

Back pitch. (B/P)	Back balance point of the scye and sleeve
Balance	Correct alignment of pattern or garment parts
Base pattern (master)	Median/master size, a base from which other sizes in the range are produced
Bespoke	Made to measure garments (MTM)
Bias	Diagonal (45°) direction to warp and weft of fabric
Block pattern	Basic pattern shape to which designs can be added

### C

C.A.D.	Computer Aided Design
C.A.M.	Computer Aided Manufacturing
Centre line. (c/l)	Line down the centre of the sleeve
Chord	Straight line joining an arc
Cross-section	Cut-away section view of an object
Crown	Top section of the sleeve that fits into the armhole, (above the scye line)
Cuff	Separate section of sleeve at the wrist or hem

### D

Darts	Sewn tapered area that creates shape in one area whilst reducing width in another
Development	'Flattened' pattern from orthographic projection drawings; and 2D materials developed into 3D products
Distribution of fullness	Placement of ease, gathers, darts or pleats



	around the sleeve crown
Depth Of Crown (DOC)	Area from top of crown to the scye line
Depth Of Scye (DOS)	Line delineating the lowest point of the armhole
Draft /drafting	Blueprint or diagram of a pattern
Dropped scye	Lower than normal depth of scye
<b>E</b>	
Ease	Excess of material that surrounds the arm
Elbow position	Horizontal line measured at the elbow level
Elements	Individual parts of a scye or sleeve
Elevation (arm/sleeve)	Lateral and lateral/forward movement of sleeve (and arm)
Elevations (drawing)	Front or side views of an object
Engineering drawing	Formal method of conveying technical information
<b>F</b>	
Fabric fullness (overfeed)	Lateral compression of fabric to reduce sleeve crown length to fit the armhole
Forearm line (f/a)	Line down the front of the sleeve
Forearm (false)	Forearm seam is moved into the under sleeve to hide the seam line from view
Front pitch. (f/p)	Front balance point of scye and sleeve
Fusible	Inner fabric shell fused by glue to the inner side of the outer body fabric to give shape and structure
<b>G</b>	
Gathers	Excess of fabric that is suppressed along the seam to create fullness in another area
Grading	Method of producing a pattern size range from a master block or pattern
<b>H</b>	
Hem	Lowest edge of the sleeve (not including the cuff area)
Hind arm line	Line down the back of the sleeve
Hind arm (false)	Hind arm seam is moved into the under sleeve to hide the seam line from view



## **I**

Inlay	Additional fabric for alteration use
Isometric drawing	All three views have measurable lines parallel to major axes

## **L**

Lower arm	Section of sleeve from the elbow to the hem
Lift	See elevation (arm/sleeve)

## **M**

Manipulations	Movements of elements
Mannequin	Representation (usually plastic) of the human body
Master pattern	See base pattern
M.T.M.	Made to measure (bespoke)

## **O**

Oblique drawing	Drawing with a true-shape front view or elevation. Other views at either 30°, 45°, 60°
Orthographic Projection	Principle method of drawing objects; showing at least two views of a component. Either 1 <sup>st</sup> angle (UK/Europe) or 3rd angle (North American)
Overfeed	See fabric fullness

## **P**

Plan	Technically detailed drawing
Planar	A flat surface
Plan view	View of object seen from above
Pattern	Various shaped apparel templates for marking around on fabric
Pitches	Marks on scye and sleeve for orientation purposes
Pitch of sleeve	Marks on scye and sleeve for orientation purposes
Perspective	A particular view of an object
Plaquet (placket) line	Sleeve opening at the hind arm from the hem
Pleat	A fold of material sewn across one end that gradually releases fullness from that point



## **Q**

Quality Level of acceptable types/number of errors

## **S**

Scale A drawing proportionally reduced or enlarged

Scye Arm- scye or armhole

Scye inclination (Vertical) Angle of the scye from base to crown

Scye inclination (Horizontal) Angle of the scye from front to back

Scye line Lowest level of the scye

Seam Method of joining pieces of fabric

Sector Section of the sleeve

Shrink Use of heat and moisture to reduce the length or width of fabric

Slashing/overlapping Cutting into a pattern to reduce width or length

Slashing/spreading Cutting in to a pattern to increase width or length

Sleeve hang See balance

Sleeve style Design of a sleeve, usually its silhouette

Sleeve type Category within which there are a number of sleeve styles

Sleeve (50/50) Two-piece sleeve divided vertically into two equal parts

Stretch Lengthening of fabric using heat and/or force

## **T**

Toile Three-dimensional fabric trial of a whole, or part of a garment

Top sleeve (t/s) Vertical sleeve section of the outside arm

Transitional Elements Changeable elements: fullness into gathers, gathers into pleats, et cetera

Truncation line Line that separates sleeve crown from arm-casing (frustum)

## **U**

Underarm points (u/p) Seam placement at top of side seam or underarm seam

Underarm seam Joining sleeve seam at base of scye

Under sleeve (u/s) Vertical sleeve section of the inside arm

Upper arm Sleeve section from depth of scye to elbow line



**W**

Warp	Lengthwise threads of fabric
Weft	Crosswise threads of fabric
Width	Circumference of scye, bicep, elbow and hem
Working scale	A proportion of, usually, the $\frac{1}{2}$ or $\frac{1}{3}$ of chest or bust: ( $\frac{1}{2}$ , $\frac{1}{3}$ , $\frac{1}{4}$ , $\frac{3}{4}$ etc.)

**X**



# Appendix B

## *Orthographic projection*

The German artist Albrecht Dürer (1471-1528) (Figure B 1) is seen as the first person with the basic knowledge of orthographic projection ([www.tech.purdue.edu/](http://www.tech.purdue.edu/)). However, it was not formalised until Gaspard Monge (1746 - 1818) (CETA).

There are two methods of orthographic projection, differing in the manner in which the two-dimensional views are set out on the page to represent a three-dimensional object. These are termed: First-angle projection and Third-angle projection.

The first-angle manner of projection is the main method of drawing used in the U. K. and Europe; the third-angle orthographic projection is used in North America). Figure B 2 gives an indication of how each viewpoint of the object is projected onto paper. The diagrams to the left in Figure B 1 show the resultant set of views arranged for the first angle projection drawing method. The front and side elevations (views) are presented in the top of the figure. The right side view is drawn directly at the left, as it is 'projected' from the right side of the front elevation; the left side view (not shown) would be at the right side. The plan view is projected directly below the front view.

The diagrams to the right in Figure B 1 show a set of views laid out in their familiar locations for third angle projection. The front and side elevations (views) are arranged on the same horizontal line. The right side view is drawn directly at the right side of the front elevation; the left side view (not shown) would be at the left. The plan view is projected directly above the front view.



Figure B 1 Engineering drawing: Orthographic projection

(First and Third angle projection)

Source: Adapted from CETA (California Engineering & Technology Alliance)

***Warped surface:***

***Development of a truncated, parallel and angled to the base, warped-surface Cone: Triangulation development method***

Three-dimensional sleeves may be described as warped surfaces since the crown differs in plan shape from the hem. A warped surface (non-developable) is in this instance a surface that is a transition from a truncated circular shaped base area, to an oval opening at the top. Brown (1974, p. 295) informs us that although not accurate, by use of the triangulation method, a warped (ruled) surface may be approximated on the plane.



The method of realising the development for a warped surface shape is much more involved than the cylinder or cone. The method is by means of the triangulation development method and is illustrated in Figure B2 with the aid of plan, side and true length diagrams. There are, however, differences to the triangulation method described for the oblique cone. The warped cone shape and the elliptical top opening of the piece are divided into the same number of divisions (top view in Figure B 2). These points are joined to form triangle shapes which are used as the base lines to produce the true length diagrams. Following the attainment of the true length lines, the triangular sections may then be 'stepped off' (a series of arced lengths equal to the sides of the true side lengths and the top and base section widths) to form the developed shape of the piece. The developed half-pattern is seen in the diagram to the right in Figure B 2, for the full shape one of the edges will have to be a folded edge.

Figure B 2 Non-developable surface: Development of a truncated warped cone

Source: Brown (1974)

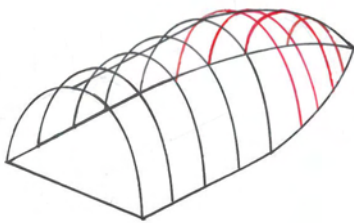


# Appendix C

## *Isometric tree*

Straight sleeves are cylindrical in shape; the top (crown) being elliptical. As such, the following method is of interest to crowns.

A ship's convex hull (Figure C '1') has double-curvature, lateral and length, making construction difficult as the sheet metal plating is capable of being bent in one direction only. It is a non-developable surface - more so in the red curved lines in the bow (Figure C '1'). By sectionalising the plates, producing a spine and branches on the 3D surface (Figure C '2'), a double curvature of the whole hull can be achieved one section at a time. The smaller the sections the better is the ability to conform to the required three-dimensional double-curvature shape. This is achieved using a class of mapping based on the idea of an isometric tree (isometric, in differential geometry, meaning length retaining), as considered by Manning (1980). The spine (vertical) and branches (horizontal) are then developed in sequence, working from spine outwards, to build the final pattern of the three-dimensional shape on the plane sheet (Figure C '3').



(1) Ship's hull

(2) Spine and branches

(3) Spine and branches flattened

Figure C Isometric tree

Source: (2 and 3) Hinds, McCartney and Woods (1991)



However, although the spine and branch lengths are preserved (on a cylindrical body), when considering an elliptical surface, the previously equally-spaced branches will spread out and widen, thus demanding shrinkage of some description (darting perhaps). In contrast, hyperbolic regions will converge or cross over requiring stretching or gusseting.



# Appendix D

## *Wire-frame*

The wire-frame method appears to be a method situated somewhere between the isometric and strip facets (See appendix E) methods. All three methods may be of use, in the future, for modelling (designing) and flattening (pattern making) sleeves, even though there is no underlying structure for modelling.

Using a virtual 3D mannequin and three pre-processed methods symmetrising, re-sampling (repeated sampling) and convex hull, Yang and Zhang (2007) have developed two-dimensional patterns from three-dimensional body-scan data.

A prototype flat pattern (front and back, from Japanese Bunka Women's University) is constructed as a confirmation model (Figure D 1 '1') and a 3D curve network mannequin generated (Figure D 1 '2'). One side of the mannequin is divided into ten zones to generate a wireframe of the garment with feature points and structure curves (left side only, front and back; Figure D 1 '3').

The final wireframe of the mannequin is represented in Figure D 1 '4'. The ten zones differ in size and shape depending on the topography of the mannequin's surface. Part of the wireframe is flattened (zone D) (left side, front in Figure D 1 '5'). Figure D '6' is a final, flattened prototype pattern (front and back). It is actually a reversed, flattened, image of the mannequin seen in Figure D 1 '4'.



(1) Pattern (front and back)

(2) Mannequin generation

(3) Ten zones

(4) Wire frame

(5) Wireframe is flattened (zone D)

(6) Flattened pattern (front and back)

Figure D 1

Source: Yang and Zhang (2007)



# Appendix E

## ***Facets (platelets)***

An alternative method for producing sleeve patterns, to those previously described, for surface modelling and flattening is a method using either rectangular or triangular facets or platelets. Since the sleeve has no structure, such as a mannequin, on which to model the facets, perhaps orthographic projection designs could be utilised – as a type of wire-framed sleeve.

In order to produce a plane pattern from a three-dimensional surface, small plane elements (facets) are utilised. The facets are either quadrilateral or triangular in shape and when assembled they ‘fairly accurately’ substantiate the original structure (attributed to Calladine by Hinds, McCartney and Woods, 1991), there being distortions during the flattening process.

In garment manufacturing it is inevitable that a two-dimensional fabric will have to distort to conform to a non-developable surface such as a human body or its equivalent – the mannequin. The distortions can be quantified in terms of the energy that must be accorded to the two-dimensional flattening process in order to duplicate the three-dimensional surface. Authors have proposed a variety of algorithms to accommodate the flattening of three-dimensional surfaces.

Wang, Tang and Yeung (2005) define the problem of free-form surface flattening as finding a two-dimensional pattern of a three-dimensional free-form surface (and its material properties) by mapping the relationship between the two so that when the two-dimensional pattern is folded onto the three-dimensional surface the amount of



distortion is minimised. The surface flattening algorithm is based on the fitting of a woven mesh on to a free-form surface.

### ***Quadrilateral facets: Section of a Spherical surface***

A sphere is a symmetrical three-dimensional geometric object, having the same perfect curvature in any direction on its surface. It is possible, by using quadrilateral facets on the surface of a sphere, to delineate a section of that sphere onto the plane (Hinds, McCartney and Woods; 1991. Figure E 1 '1' is a section of a sphere with one quadrilateral facet highlighted. Ramgulam (2001) explains that, in this case, each facet is a rhomboidal tile (Figure E 1 '2'; 2D mapping), the angular defects are inserted by adjusting the internal angles of the rhombuses. The corners of the quadrilaterals, defining the section, fall on the surface of the sphere (the lines connecting the corners fall within the curved surface of the sphere), producing angular defects that appear when the quadrilateral is flattened; Figure E 1 '3' represents four facets and their combined deviation.

Extending the number of facets (tiles) and aligning each onto the next, produces an expanded deviation effect, illustrated in Figure E 1 '4'. An extrapolation of the facets coupled with an increasing density gives a closer approximation of the complete sphere' the angular defect is aligned vertically and horizontally on the lower left corner (Figure E 1 '5'). As Ramgulam (2001) relates, the angular defect of the facets increases as the distance lengthens from the starting point.



Figure E 1 Quadrilateral facets: A section of a Spherical surface.

Source: Adapted from Hinds, McCartney and Woods (1991)

### ***Quadrilateral facets: Section of a Torus surface***

The surface of a torus has both elliptic and hyperbolic curvature regions (Figure E 2 '1'). As with the previous example, the lines of constant of the elliptic regions (outer surface) of the torus lie interior to the surface corners, whilst the lines of constant in the hyperbolic regions (inner surface) lie exterior to the surface corners. Figure E 2 '2' illustrates a facet on the elliptic surface. Figure E 2 '3' depicts the developed pattern centred on the (inner surface) central quadrilateral facet of the torus section. This results in an overlapping of segments of the facets in the hyperbolic regions and a spreading apart in the elliptic regions. In this format the surface cannot be cut from a sheet fabric unless the former areas are imbued with gussets and the latter with darts; two operations in the manufacturing process.

However, if the quadrilateral facets originate and are centred round the outer elliptic curves, a different pattern emerges (Figure E 2 '4'). In this configuration the pattern can



be cut from a single sheet material as there are no overlaps; there is only a necessity to remove material (with darts), making the manufacturing process somewhat easier. The same manner of two-dimensional joined-section construction is exploited by Cho et al. (2006) for the development of a skirt pattern formulated from 3D body scanning data. The Lin et al. (2006) approach was to reduce the computational time to create a 'fast flattening algorithm as seen in the distorted flattened view of a sectioned torus.

Figure E 2 Quadrilateral facets: A section of a Torus surface.

Source: Adapted from Hinds, McCartney and Woods (1991)

It is noted that surface sections of a torus, are similar to the inside forearm elbow 'C' and at the hind-arm elbow 'D'. 'D' is also analogous to crown fullness.

### ***Triangular facets***

For general three-dimensional surfaces it is necessary to consider triangular facets, because any four local points, as used in quadrilateral facets, are unlikely to be planar (within the same surface/plane). When producing a flat pattern from the three-dimensional body, using triangular facets, the facets, because they are non-developable, have to deform (Yang, Zhang & Shan, 2007). Flattening algorithms



calculate the strain of fabric as it is transformed (deformed) from the three-dimensional body to the two-dimensional plane and try to minimise the amounts of distortion.

McCartney, Hinds and Chong (2005) explain that three-dimensional triangular meshes are linked with tensile deformation of individual edges, whereas actual fabric distortions are connected with the energy related to stretch and shear of the weave. Ramgulam (2001) explains how a high point (vertex) of triangles on a 3D surface (Figure E 3 '1') acquires an angular deflection of the triangles as it is flattened (Figure E 3 '2').

(1) Vertex of triangles

(2) Flattened triangles

Figure E 3 Triangular facets.

Source: Ramgulam (2001)

A spring-mass (sic) based deformable model was used by Fan, J. et al. (1998). They proposed a general method of transforming (deforming) established 2D patterns to produce a virtual 3D garment on a mannequin. The results were then transformed back to 2D. A disadvantage of the system is the reliance on pre-made two-dimensional patterns. Zhong and Xu (2006) also used pre-digitised (existing) two-dimensional patterns and a mass-spring system of flattening the triangulated surface to wrap around a mannequin.



### ***Triangular facets: Strip facet development***

The Azariadis and Aspragathos (1997) method of plane development progresses in three stages, which are to define the proper triangle and/or strip guide geometrically, develop the three-dimensional surface onto the plane and refine the initial plane development to eliminate gaps and overlaps.

The concept is to describe a starting strip and a chosen direction, along which triangles are unfolded onto a plane; the major negative aspect is the presence of gaps and overlaps. Gaps and overlaps are also mentioned by Hinds, McCartney and Woods (1991) in their development of a torus and McCartney,

To reduce distortions during flattening, Li, Zhang, Lu, Peng, Wen and Sakaguti (2005) used a mass-spring model, with crossed springs and using strips of triangles, extending from a central triangle (automatically chosen) of a mesh, to accelerate the flattening process; fabric was not a consideration in this method, which, they identify, would change the flattening results. Cross springs (Figure E 4 '1') are used to prevent the flattened mesh from distorting too much, thus decreasing the possibility of overlapping or gaping sections. The flattening process is accelerated by the use of triangular strips rather than individual triangles.

A triangle strip is a series or set of connected triangles, which are flattened, from a central triangle, without deformation (Figure E 4 '2'). By using triangle strips the computational time is reduced and efficiency is raised, compared to adding a single triangle at each step. Energy relaxation occurs on the triangle strip before connecting to the previously flattened section and so on (Figure E 4 '3' adjacent triangle strips, and '4', further strip connections), after which 'global' energy relaxation is accomplished. The algorithm automatically selects a central triangle of the



three-dimensional mesh with the problem of overlapping solved by a constraining iteration and local correction method which can cope with complex surfaces. Li, et al, 2005) point out that if the fabric is changed, the two-dimensional result would also be modified.

(1) Cross springs            (2) Triangle strip    (3) Adjacent strips    (4) Further connections

Figure E4 Triangular strips

Source: Li et al. (2005)

### ***Triangular facets: Multi-strand mesh development***

An extrapolation of triangular facets is seen when a three-dimensional front garment piece, with both elliptic and hyperbolic regions, is firstly given a grid structure (an equal sided mesh) and primary and secondary spines from a central vertical axis. From the grid a multi-strand effect is developed on the flat, one section being joined to the next. Although giving satisfactory, but unequal-sided results, and is straight forward in execution, Hinds, McCartney and Woods (1991) (Figure E 5) acknowledge the laborious process involved (including trimming the mesh edges) and the need for the multi-strands to be simplified to make a pattern acceptable to the clothing industry. By grouping the small darts, a single large dart may be constructed and to eliminate overlaps, the strands may be rotated. Figure E5 '1' represents the mesh taken from the mannequin with both overlapped and spread sections. '2' has the overlaps eliminated, '3' is the simplified pattern which is then placed on the mannequin '4'.



(1) Mannequin mesh (overlaps and spreads)

Figure E 5 Multi strand mesh

Source: Hinds, McCartney and Woods (1991)



McCartney et al. (2000) accept that the final shape taken by a garment is often achieved through the assimilation of darts, seams, localised stretch and other separate agents such as fusibles, pads and fillings. In addition, to be credible, CAD systems should be able to function at a level of complexity normally found in garment construction.

Hinds, McCartney and Woods (1991) stress that a comprehensive interior mapping description through 3D triangulations, rather than solely an outline of the pattern piece, is necessary to achieve two-dimensional flattening of drape effects). Also, triangulations and duplicated nodes allow flattening and the formation of darts to develop.



# Appendix F

## ***Lobster back***

Instead of the angled scye of the previous sleeve styles (tapered, flared, straight and tailored), the leg of mutton sleeve, in this example, incorporates a vertical scye (F1). This enables the large sleeve crown to be placed further onto the shoulder where it has more support. Construction of this type of sleeve, because of its large crown surface and less precision than the tailored sleeve, may be simplified by means of a 'Lobster back' drawing method.

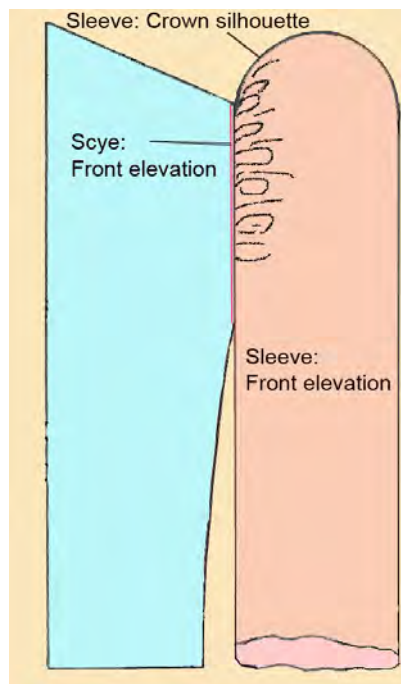
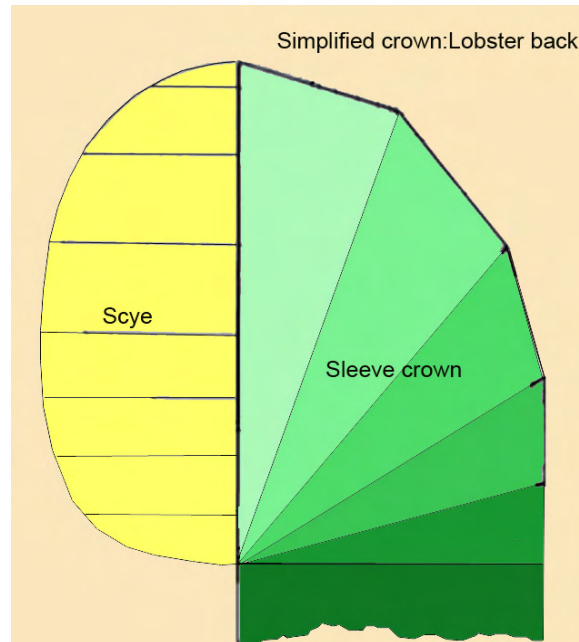


Figure F1. Sleeve crown curvature (Leg of Mutton): Simplified construction

The lobster back is a series of part right cones (F 2 '1') utilising the radial line development method. The lobster back method simulates by simplification, the development of the sleeve crown. The sleeve in this view is lying in a horizontal position. F 2 '2' is an altered representation of F 2 '1' rotated 90° to the right – vertical, it depicts a Leg of Mutton sleeve crown without a crown height, demonstrating the



potential for its use as a sleeve crown pattern producing tool. The flat pattern is then developed section by section.



(1) Lobster back

(2) Lobster back (sleeve crown)

Figure F 2 Development of a lobster back sleeve crown

Source: (1) Adapted from Yarwood (1983)



# Appendix G

## **Sleeve crown curvature: Experimental scye sector body angles**

The crown curvatures, between the scye and sleeve, are formed at a right angle to the truncation line. However, the actual curve of the crown from the scye seam line differs depending on the angle of the front and back at each scye/sleeve sector point. Figure G1 is the crown sector and crown curve. In order for the crown to curve from the scye, all of the sector point angles (attaching the sleeve to the scye) must be calculated. The calculation, used to form the curvature of the sleeve from the scye seam in this experiment, is taken from the outside edge of the sleeve and represented in Table G1.

Table G1 demonstrates the type of curve that might be expected from each of the sector seam sewing angles, ranging from an almost flat curve on sleeve curve sector 6, on the under arm section, through a tight crown sleeve curve on sector 1, to a wide sleeve curve sector 5 at the front (and 7 on the back). Since both the manner in which the body angles are calculated and the crown curves themselves are difficult to duplicate by manual drawing means; both of these areas require further experimentation and development.

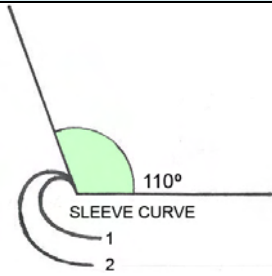
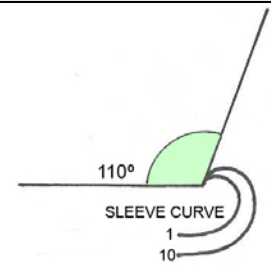
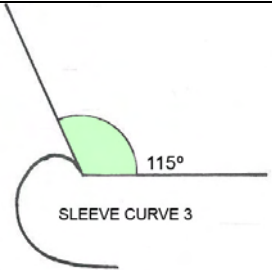
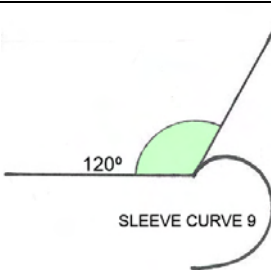
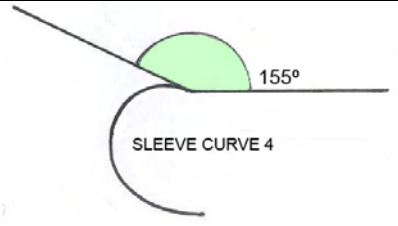
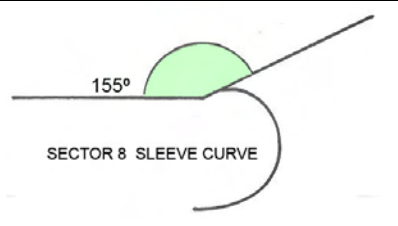
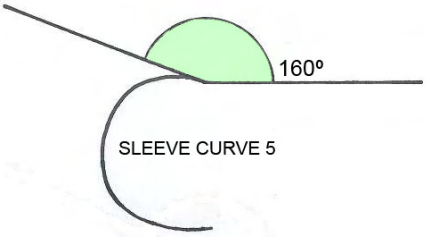
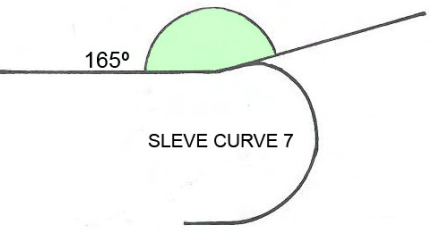

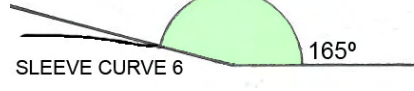




Figure G1 Angle of body seam and 'forced' crown curvature



Table: G1 Scye sector body angles, sleeve projections and sleeve curves

SCYE SECTOR BODY ANGLES and SLEEVE PROJECTIONS/SLEEVE CURVES			
FRONT SECTOR ANGLES and SLEEVE CURVES (Horizontal line = outside sleeve) (Angled line = Body/seam line)		BACK SECTOR ANGLES and SLEEVE CURVES (Horizontal line = outside sleeve) (Angled line = Body/seam line)	
SECTORS		SECTORS	
1 & 2		1 & 10	
3		9	
4		8	
5		7	
6		6	



# Appendix H

## ***Fabrics***

Wingate (1976) describes fibre as 'the basic unit of which a fabric is made. To make a yarn, several fibres may be grouped (often twisted) into a strand'. Taylor (1997) justifiably states that there are no fibre types with all properties required by all end users, and of course, deficiencies can be partially or fully overcome by blending fibres or applying special processes. Not having fibres with all properties has a bearing on the design of garments and their components such as sleeves.

Kadolph and Langford (2002) divide fibres into four groups classified as: vegetable, animal, synthetic and regenerated, they also reveal that fibres are classified into groups by their chemical composition. Fibres with similar chemical compositions are placed in the same generic group. A typical grouping of fabrics is identified in Table: H.1.

Table H.1: Fibre types

<b>Cellulose fibres</b>	<b>Regenerated fibres</b>	<b>Man-made fibres</b>	<b>Natural protein fibres</b>
Cotton	Rayon	Polyamide-Nylon	Merino wool
Kapok	Lyocell	Polyester	Angora wool
Coir	Acetate	Olefin	Camel hair
Flax	Polyactide (PLA)	Acrylic	Cashmere wool
Ramie	Polysaccharides (Alginate)	Modacrylic (modified acrylic)	Llama
Hemp	Diacetate	Elastane	Alpaca
Jute	Triacetate	Terylene	Vicuna
Sisal	Viscose/Rayon		Yak
Linen			Silk

## ***Fabrics: Weight***

Fabrics and their properties are usually considered for the garment at the design stage. In this investigation they are matched to in-set sleeve designs. This means that for any given sleeve design there is a range of fabrics with inherent weight and thickness, from which to select the most appropriate for the task.



There is a considerable range of fabric weights that spread from the lightest, as little as 16.95g/m<sup>2</sup> to the heaviest at approximately 678g/m<sup>2</sup>, density being the weight of a fibre expressed as grams per cubic centimetre (Kadolph and Langford, 2002; Joseph, 1986). Aldrich (1996) offers the following fabric weight distribution index (Table H.2). Due to their inherent properties and weight, each fabric is paired with an appropriate sleeve style, for example; cotton is an appropriate fabric for a tapered (shirt) style whilst wool, using two weights, is selected for its association with jacket styles

Table H.2. Fabric weight index, (Aldrich, 1996)

### ***Fabrics: Thickness***

Thickness is a property that influences the ability of the fabric to be compressed and sewn without extending. Compression resiliency is the ability of fibres to recoil to their original height after being compacted. Applying pressure decreases a cloth's thickness whilst 'raising' and 'brushing' increase thickness. In general terms, the effect of pressing is to decrease seam thickness, depending on the degree of overfeed (fullness) and the direction in which it is sewn.

Fabric thickness decreases the ability to be 'fed' through the sewing machine, thus reducing the amount of fullness potential (overfeed) for the sleeve crown. However, the experiments carried out by O'Brien and Webster (1991) do not support the 1982 findings of Mahar, Dhingra and Postle, that overfeed, or fullness in all three directions (warp, weft and bias) should increase after pressing. Due to thickness variability and



the difficulty in establishing a precise measurement, each fabric has to be judged on an individual basis, each fabric has to be assessed for its 'fitness for purpose'.

### ***Fabrics: Tailorability (moulding)***

Tailorability is the ability to be moulded (shrunk and stretched) with pressure and heat, it is required to simulate body curvature, incorporating bending and flexibility, especially useful in tailored garments. 'Tailorability of fabric relates to its capacity to produce a smooth fit and well-defined silhouette, together with freedom and comfort of movement for the wearer' (Taylor, 1997). Webster and O'Brien (1991) relate that Shishoo (1990) describes tailorability as 'the ability and ease with which fabric components can be qualitatively and quantitatively sewn together to form a garment'. A well tailored garment, such as a jacket, requires a "sculptured" look, well pressed with unwrinkled contours of fabric and seams, particularly in the areas around the sleeve head where fullness has created curvature.

Postle (1986) explains that wool and wool-rich fabrics are more easily tailored than polyester-rich fabrics because of their levels of formability and extensibility. The garment is expected to hang well and smoothly from the shoulders and over the hips (Taylor, 1997). This is achieved by careful planning and pattern drafting as well as controlled methods of inter-lining insertion and pressing, to achieve the required silhouette.