LOOKING AT THE TURIN SHROUD AS A TEXTILE*

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History and the Shroud linen

Not long after I became a member of the British Society of the Turin Shroud, I was given a more direct interest in Shroud investigations when David Sox asked me whether I might be interested in looking further at the evidence available about the Shroud as a textile.

My studies soon took me along paths trodden by earlier textile experts, some of whom had concluded that the linen could not be a first-century product. Indeed, statements about the origins of the Shroud as a textile have generally not been satisfactorily substantiated by references to the appropriate literature or by evidence.

I could not, of course, examine the Shroud itself but I was loaned enlarged photographs of the cutting used by Professor Gilbert Raes, the Belgian textile expert, for his textile analysis in the early 1970's (Figs. 1 & 2), and David Sox provided full-length colour photographs and some details of Raes' findings.

Prof. Raes showed that the fibre used in the Shroud was flax. Flax was certainly grown in mediaeval Europe but Pausinius tells us that "the flax of Palestine (first century) is a beautiful yellow colour. Galilee is the centre of production, in a city called 'Arbeel' ".

The occasional cotton fibres spun into the yarns were identified by Raes as *Gossypium Herbaceum*.

I have heard that cotton was grown in southern Spain during the Middle Ages, presumably by the Moors, but as yet I have not traced any historical references to confirm this. Cotton does not appear to have been cultivated elsewhere in Europe, so it seems likely that the Shroud linen is a mid-eastern product. No animal hairs have been found in the Shroud, which would satisfy the Laws of Moses that wool and linen must not be mixed (Deut. 22:11). It could be used by a Jew, so the fibre analysis provides no challenge to the authenticity of the Shroud.

The point has been made that the regularity of the yarns in the Shroud would indicate a later date than the first century for its production. So far as I can judge from photographs, they appear to be quite even and regular, but this could not be regarded as evidence that the Shroud could not be first century. The yarns of many of the Ancient Egyptian textiles in Manchester and Halifax Museums are perhaps even more regular than those of the Shroud. The regularity of

*An expanded version of Mr. Tyrer's article which appeared in *Textile Horizons*, Manchester, U.K., Dec. 1981.

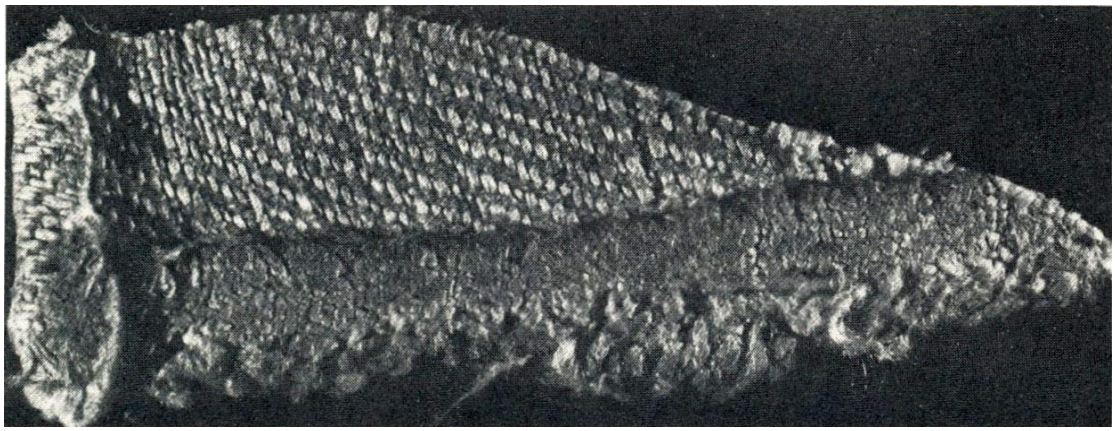


Fig. 1—Raes sample, face of fabric, enlarged approx. 2.5x. Actual size of sample is about 42mm long.

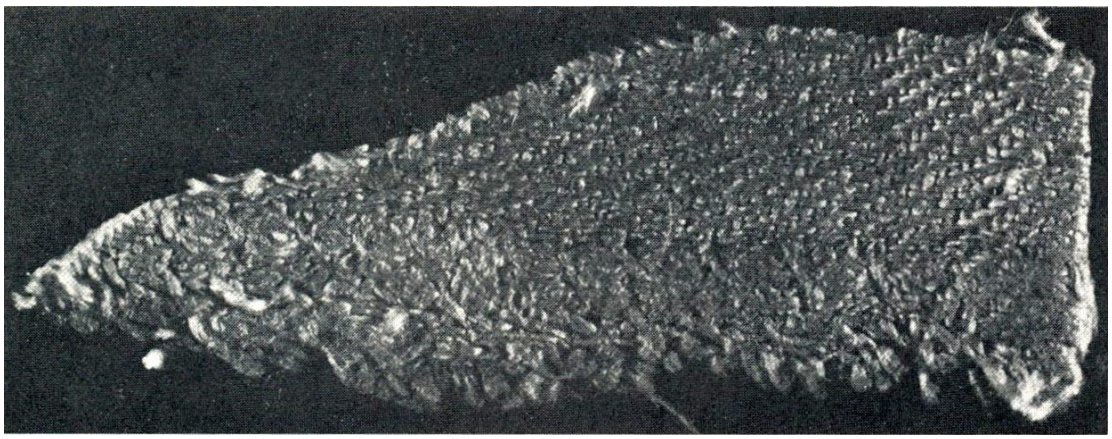
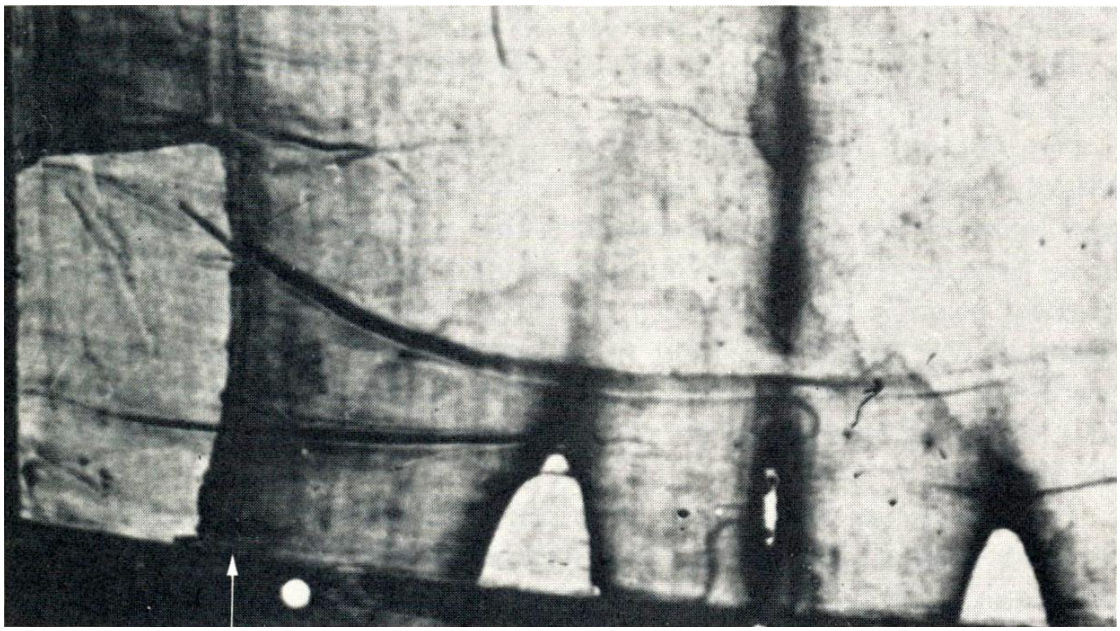
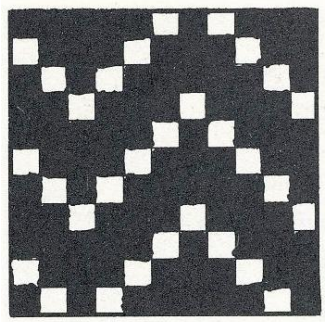


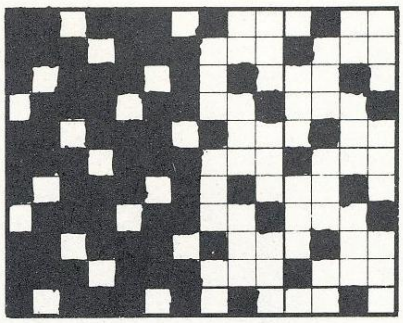
Fig. 2—Underside of Raes sample.



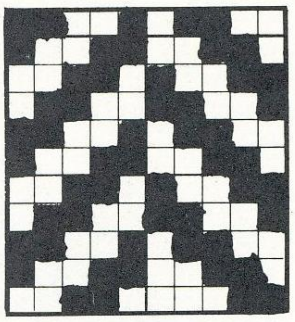
Bottom edge of Shroud, to the left of the feet on frontal image. The lighter area at the corner is the backing-cloth (added by the nuns after the fire of 1532) showing where a rectangular piece was removed some time in the relic's past history. The so-called 'seam' has been left in the fabric where the rectangular piece is missing. The Raes sample was taken from the lower edge of the Shroud immediately coincident with the 'seam'; as indicated by the arrow.



Turin Shroud
3/1 reversing twill
(linen)



Holborough Shroud
3/1 and 1/3 damask
(silk)



Gerumsberg Cloak
2/2 twill broken
to reverse (wool)

a yarn is dependent upon the length of the fibres used to spin it, the effectiveness of the preparatory processes which align the fibres, and the evenness of the drawing and twisting. The knowledge and skill of the spinner is of prime importance. Regular yarns, ancient or modern, cost time and skill, and there is no doubt that the handspinners of flax yarns in the ancient world were more than a match for their mediaeval or modern counterparts.

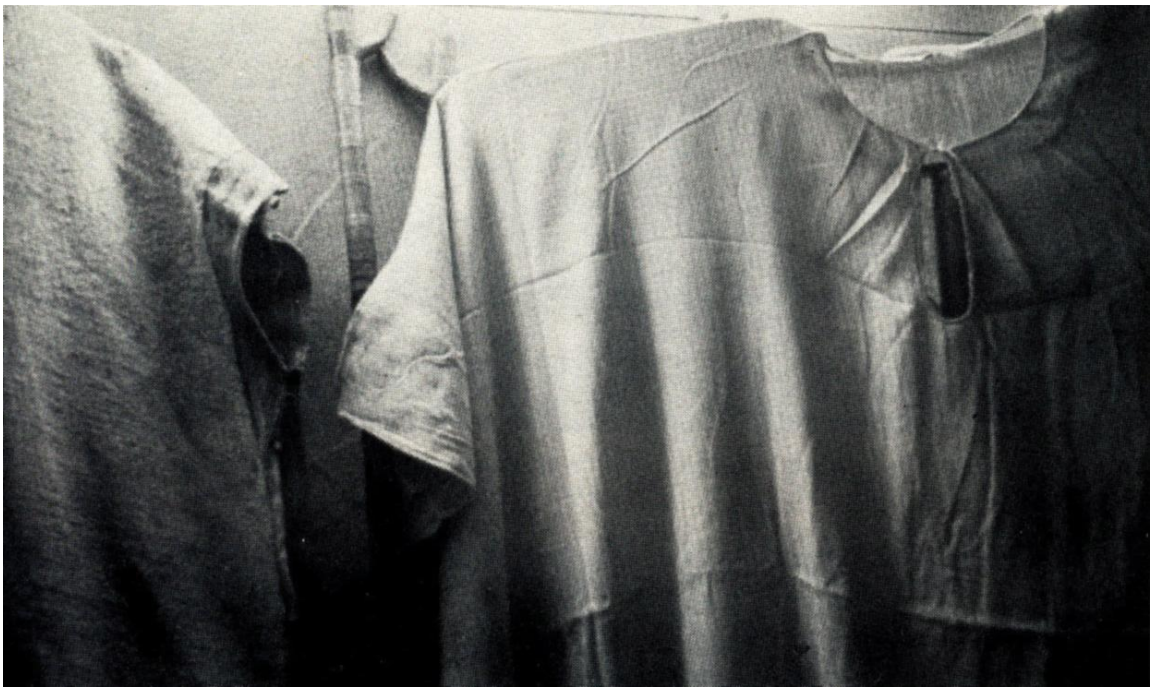
It has been pointed out that the Ancient Egyptians spun their yarns with the spindle running anticlockwise to give 'S' twist, the direction in which the flax fibre turns when wetted. Since the Shroud yarns are 'Z' twist, there has been doubt about placing the linen in the first century.

The Egyptians had certainly developed a flax plant with a fibre fineness equivalent to the best grown modernly. This is demonstrated by exhibits at the Halifax Museum. There are some remarkably finely sett linen fabrics in both Manchester and Halifax Museums. One cloth from the Tarkan dynasty (3600 BC) has 140 warp and 50 weft threads per inch. Having examined over a hundred grave cloths in these museums, I have little doubt that the Egyptians favored 'S' twist yarns and plain weaves. Even the famous 'Girdle of Rameses' in Liverpool Museum, with its many colours, its shaping and narrowing by dropping warp ends, has only 'S' twist yarns, and basically a plain lift weave.

However, in *Studies in Ancient Technology*, Vol IV, R J Forbes maintains that the high development of spinning and weaving techniques at the dawn of history points to an origin for the production of linen textiles further north. It is known that Neolithic lake-dwellers in Switzerland had production methods similar to those of the Egyptians. There has also been reference to a knowledge of twill weaves by these people.

In Norwich Castle Museum, there is a working model loom the design of which is based upon archaeological finds that date from the late Bronze Age. It has three healds and has successfully woven twill-based patterns.

Woollen textiles with reversing twill weaves and 'Z' twist yarns have



Ancient Egyptian shirt, of linen, in perfect condition, in the collection of Turin's Egyptian Museum. Photo by Dr. Gilbert Lavoie.

also been found in northern Europe dating back to the late Bronze Age. They are much coarser sett than the Shroud linen, but a cloak found at Gerumsberg is woven 2/2 herringbone twill with a `Z' twist warp. The cloak has been shaped like the Rameses Girdle by dropping warp ends and it was woven without seam. Here is an interesting link with the New Testament (Jn 19:23). This technique of weaving had clearly reached Palestine by the time of Christ.

It is known that looms with four healds, capable of producing complex twill weaves, had been developed in China before 120 BC. At Holborough in Kent, a fragment of a silk shroud with a reversing five-shaft satin weave was discovered in a child's coffin from the Roman period. The silk trade with China would very likely have passed through Syria.

It seems very doubtful, therefore, that the Turin Shroud was a product of ancient Egypt but, mindful of the ferment of ideas that was taking place at the advent of the Christian era, and taking into account the high technology in the surrounding ancient world, it would be reasonable to conclude the linen textiles with `Z' twist yarns and woven 3/1 reversing twill similar to the Turin Shroud could have been produced in first-century Syria or Palestine. They were, after all, at the crossroads of world trade routes where cultural ideas would have been mixing for centuries.

Turning from the ancient world to mediaeval Europe, although it appears that linen textiles similar to the Shroud have not survived in any number from the early fourteenth century, flax was grown and spun, and looms with multiple healds operated by foot pedals were in use. One is shown in a painting by Pintoricchio in London's National Gallery.

Decay effects in the Shroud linen

There would appear to be no reason why the Shroud linen could not have survived from the first century. Much older linen fabrics are extant, for example, Tutankhamun's curtains.

Flax fibres are not attacked by moth grubs, which require keratin to feed on, and other insects tend to avoid flax if they can because of its hardness.

When boiled or bleached, flax has a high resistance to bacteriological attack. Under certain conditions of warmth, dampness and contamination, micro-organisms may attack cellulose, notably cotton, but flax fibres will resist damage well if kept dry. The most important factor in the preservation from decay would seem to be the purity of the fibre and the effectiveness of the bleach. Contaminants remaining from the plant would be likely to be breeding grounds for bacteria.

Flax fibres are obtained from the plant by removing the other vegetable substances by 'retting' in water. This may be done in suitable pits (dams) or by leaving the stalks out in the dew. Dam retting was practised in first-century Palestine.

The bleaching probably involved boiling in alkalis such as wood ash or plants like saponaria, then exposure in the sun. The treatment was probably repeated a number of times, with the sun as the main agency.

It has been conjectured that the Shroud may have been washed since it was first used. The water stains from the Chambéry fire indicate that it has not been washed since 1532. Earlier washing seems unlikely because it would have removed most of the 'blood'. Other contaminants would have been breeding grounds for bacteria but the fire at Chambéry would have sterilized the Shroud and helped with its preservation.

The 'herringbone' weave of the Shroud

From a close study of photographs, it would appear that where the opposing lines of the 3/1 twill meet, the reversal is a true mirror image, whereas in other places the twill drops out of true correspondence to give a herringbone effect. (In a reversing twill the opposing lines of twill are mirror images; in a herringbone weave the two opposing lines of twill drop out of strict correspondence by two or three weft threads.) These changes may be faults in the weave because of incorrect drawing-in through the healds.

No more than four healds would have been needed to weave the Shroud linen. The reversal of the twill lines would be accomplished by drawing-in the warp threads appropriately through the healds: 1 2 3 4 3 2 1 ... The apparently wrong lifting warp threads at some of the twill reversals would seem to be typical of the drawing-in mistakes that could be expected with a comparatively primitive loom.

A 3/1 reversing herringbone or twill fabric would almost certainly have been woven back-up, as a 1/3 lift. In weaving, the back of the

cloth would be uppermost so that only one warp thread in four would need to be lifted for each weft thread inserted. This would lessen strain upon the warp and reduce thread breaks.

An experienced handloom weaver has told me that a 1/3 fabric similar to the Shroud was easier to weave than a plain cloth of the same quality. Moreover, it would probably only be necessary to make 'up' sheds. This could simplify the healds and the means required to operate them may not need to have been very complex.

The Shroud might therefore have been a less formidable task for a first-century handloom weaver than may be thought at first sight.

A problem that can arise with straight twill fabrics is that they may have some tendency to curl from corner to corner following the twill lines, especially when they are wetted. This tendency can sometimes be reduced by having the twist direction of the warp yarns opposing the direction of the twill; that is, 'Z' twist yarns with an 'S' twill weave. The most effective way of dealing with the curling problem is to have a weave with a periodically reversing twill line—a herringbone. The end result can be a cloth that has an attractive striped appearance with a smooth surface that sheds soiling, that does not curl and that drapes well over the human body. Hence the use of these types of cloths for apparel; hence the particular handle and appearance of the Shroud and even perhaps its absorbency properties.

Another interesting feature is the presence of numerous dark (pale in the photographic negative) warp threads that run for some distance through the Shroud and cross from image to non-image areas. A good example runs through one side of the face, across the eye and forehead into the hair. These darker threads indicate that, even though the cloth was piece bleached, the yarns must also have been at least part bleached before weaving, probably in hank form.

Dealt with in hank form, the yarns would not have been similarly and evenly bleached throughout their lengths. Although the cloth would be bleached again after weaving, this treatment evidently failed to even-up the differences in shade between and within the individual yarns.

The image-forming process was superimposed over these variations and the differences in shade between and along adjacent individual yarns appears to be as great as between image and non-image areas as a whole; which must complicate comparative radiation reflectance measurements. Perhaps a closer study of these yarns might help in the investigation of the image-forming process.

The Shroud fabric has been used with the long floats of the warp yarns in contact with the body, for the image appears upon this face of the cloth.

The absorbency and draping properties of the Shroud

It is a fact of textile technology that the performance properties of a fabric are associated with the quality particulars of the cloth structure. These will include the areal mass of the cloth, its fibrous composition,

the presence and type of any added matter of finish, the number of threads per inch, and the type of weave and the number of turns per inch in the component yarns and the count (linear density). In the case of natural fibres, such as cotton or flax, whether the cloth has been bleached or is in the natural state will be important.

So far as the Shroud is concerned, the comparatively closely sett structure of the linen may not be immediately absorbent of water, let alone the more viscous liquids draining from a corpse. The water stains from the Chambery fire do not suggest a high rate of absorbency for they do not seem to have penetrated far and there are tidemarks where absorbency ceased. Similarly, flax is not as easy to dye as other cellulosic fibres and this would have complicated the problems of a forger, and would suggest the use of pigments rather than dyes. An interesting question that cannot be answered by the study of photographs is whether the image varies at all as it passes around crease marks like the one under the chin of the image. The answer may be relevant to the image-forming process.

In considering the possibility that the Shroud image is a contact print, either from a corpse or a sculpted form, the draping properties of the fabric would be important. Because of the fabric structure, the linen may be stiffer warpway than weftway, and therefore drape more easily across the figure. The Shroud photographs appear to suggest that the material has supported itself stiffly across the hollows between chin, chest, abdomen, hands and knees, but that there was more tendency for it to hang widthway into hollows. It would be a remarkable achievement for a painter to anticipate such draping in a negative image.

Best-Gordon has investigated the development of contact images as defects in textiles that may not be evident when first formed, where uneven distribution of urea-formaldehyde resins and variations in effective polymerization were involved; and he has drawn attention to the Shroud image from that point of view.

The arguments against the Shroud image being a contact print are: that the the image would suffer lateral distortion due to the fabric's draping around the sides, and that the imprint would be in only two tones, like a brass rubbing. There is no lateral distortion in the Shroud image and it shows remarkable gradations and subtleties in shading. It must be remembered that in 1350, it would be at least another generation before printing, woodcuts and engravings would be introduced into Europe.

The textile analysis of the Shroud linen and edging strip

Photographs of the Shroud and descriptions in the literature indicate that along the edge of one of the long sides, there is a narrow strip of material divided from the main area by a seam-like thickening. Unlike other patches on the Shroud, this edging strip is similar in tone and hue to the main area. Just what is involved is a matter of much conjecture.

Prof. Raes has given different textile constructional particulars for what he describes as 'Piece I', the main Shroud, and 'Piece II'. He also gives some details of the sewing thread that he found joining these pieces together. It has been assumed that 'Piece II' is part of an edging strip which was stitched to the main body. It has been conjectured that the addition was made to centre the image better.

Raes' results
(as published by Ian Wilson in *The Turin Shroud*)

		Piece I	*Piece II*
Threads cm	Warp	38.6	—
	Weft	25.7	25.7
Linear density (count) of the yarn (tex)	Warp	16.3	18.0
	Weft	53.6	73.1
Direction of twist	Warp	Z	Z
	Weft	Z	Z

Raes also describes the sample he obtained as carrying a selvedge. The photograph of Raes' triangular sample (Fig. 1) does show a narrow warpway band of different structure on the longest side. The ends of the weft yarns protrude at this edge and appear to have been cut through.

However, several persons who directly observed the Shroud were of the opinion that the weft threads in the main area of the Shroud were continuous across the so-called 'seam' into the edging strip. I have the concurrence of this opinion from Vernon D Miller of the Shroud of Turin Research Project (STURP).

If one examines large photographs of the Shroud taken by transmitted light, variations in the density of the weft carry through the 'seam', even if one takes into account that one is looking at the effect of light transmission through backing cloth as well as Shroud. Moreover, if the edging strip is joined by a seam to the main Shroud and differs throughout its length in cloth quality particulars, one would expect to see evidence of cockling along the line of the 'seam', particularly if the Shroud has been wetted or washed. There does not appear to be obvious evidence of such cockling.

These observations are important since they would appear to indicate that the 'seam' is some kind of anomaly in the fabric structure and not a join. Nevertheless, Raes was clearly dealing with a seam and its sewing thread. The place where the triangular Raes sample was removed (Fig. 3) can be seen close to the foot on the frontal image, between the main area of the Shroud and the edge of a missing rectangular area.

It is not easy to determine what is involved here from photographs

alone, but doubt remains as to what Raes' Piece II' may have been. Was it wholly edging strip or was it partly a sewn-on mediaeval patch? This should be resolved if it is intended to use the Raes sample in the eventual carbon-dating tests.

But why such an anomaly in the cloth? It can hardly be a defect in the weave, for that would have been corrected at its onset. Is the 'seam' really a 'cord' of warp threads deliberately woven into the fabric? Perhaps a weaver's aid to finding the shed in the warp when using a primitive shuttle? Or such a cord of warp threads may have been of help to a handloom weaver in inserting a beater stick into the shed of warp threads. Beaters are illustrated in tomb paintings of Egyptian looms; they are used to press the weft thread into the fabric as it is formed. Combs, similar to those on display at the British Museum, may have been used to supplement the beater, especially with finely sett cloths, before the loom reed was developed.

The cord may also have been of help in forming the 1/3 division of the warp sheet if comparatively primitive healds were being used.

Although the cord could have assisted in some ways in the weaving of the Shroud, it could also have caused difficulties when the cloth was being wound into a roller at the front of the loom. As the woven cloth was wound, the thicker cord might be expected to cause uneven take-up unless the effect was compensated in some way in the loom design.

The 'cord' might also mark a border to a material that was intended to be worn as a toga-like garment over light underclothing, a method of dress in Roman Palestine. In this connection, one is reminded of the *sindon* that was discarded in haste by the young man (Mark?) who ran from the Garden of Gethsemane (Mk 14:51). If so, then the Shroud may have been an apparel cloth hastily pressed into service for funerary purposes (Lk 23:53).

It has been suggested that the 'cord' may be a strengthening band by which to hang the cloth for displaying the image. Still another suggestion is that the 'cord' is a lengthwise 'tuck' in the cloth. If this is so, why should it have been made? If a 'tuck' is involved it appears to have been most accurately and neatly done, for it is coincident with the line of the warp threads down the full length of the Shroud.

Textile analysis of the Shroud is of major importance in several aspects. Definite identification of the manufacture would be an aid in dating the relic, and a study of the spinning and weaving defects might throw light on the method of production. We may be looking at evidence about the type of loom that was used and this may be historically important. The presence of the edging strip certainly holds some unsuspected information.

Whatever future research may reveal, this particular textile technologist has to acknowledge that the Shroud is probably the most remarkable 'Standard Sample' for the interpretation of the history of textiles that has come down to us. No Christian would expect it to be otherwise.

REFERENCES

I Wilson. The *Turin Shroud*. Penguin Books, 1979.

J Walsh. *The Shroud*. Allen, London, 1964.

Rev H David Sox. *File on the Shroud*. Coronet Books, 1978. The Image on the Shroud. Unwin, London, 1981.

A Cameron. *The Sceptic and the Shroud*. Inaugural lecture. Kings College, London, April 1980.

R Hoare. *The Testimony of the Shroud*. Quartet Books, 1978. P Vignon. The Shroud of Christ. London, 1902.

G Crowfoot. *Methods of Hand-Spinning in Egypt and the Sudan*. Bankfield Museum, Halifax. Reprinted 1974.

H Ling Roth. *Ancient Egyptian and Greek Looms*. Bankfield Museum. R J Forbes. Studies in Ancient Technology. Brill, Lieden, 1964.

Singer, Holmyard, Hall and Williams. *A History of Technology*. Oxford, Clarendon Press, 1954.

J P Wild. *Arch. Cant. ixxx*, 1965. National Geographic. June 1980.

H W Best-Gordon. *The Turin Shroud*. JSDC, 97, June 1981.

McCrone and Skirius. *Light Microscope Study of the Turin Shroud*. I, II, and III, The Microscope. 28, 1980; 29, 1981.

Jumper and Mottern. *Scientific Investigation of the Turin Shroud*. Applied Optics 19, #12.

F Pellicori. *Spectral Properties of the Shroud of Turin*. Applied Optics 19, #12.

Accetta and Baumgart. *Infra-red Reflectance Spectroscopy and Thermographic Investigations of the Shroud of Turin*. Applied Optics 19, #12.

Gilbert and Gilbert. Ultraviolet, Visible *Reflectance and Fluorescence Spectra of the Shroud of Turin*. Applied Optics 19, #12.

Morris, Schwalbe and London. *X-ray Investigation of the Shroud of Turin*. X-ray Spectroscopy. 9, #2, 1980.

A A Mills. *A Corona-Discharge Hypothesis for the Mechanism of Image Formation on the Turin Shroud*. Proc. British Soc. for the Turin Shroud. Autumn 1979— Summer 1981.

J Thorsen *Modification of the Cuticle and Primary Wall of Cotton by Corona Treatment*. Text. Res. J. 44, p. 422-29, 1974.

J Volckringer. *Le probleme des empreintes devant le science*. Carmel de]'Action des Graces. Paris 1942.

J H Heller and A D Adler. *A chemical investigation of the Turin Shroud*. Can. Soc. Forens. J. Vol 14 #3, 1981.

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ADDITIONAL READING

Virginio Timossi; "Analysis del tessuto della S. Sindone"; *La Santa Sindone nelle Ricerche Moderne*, Acts of Congress, Turin 1939, ed. by Mons. Pietro Scotti, SDB. Timossi's research on the Shroud fabric presented to the National Convention of Textile Experts, Rome, Jan. 1938, gained for him a gold medal.

The museum of Turin's Centro Internazionale di Sindonologia possesses a facsimile of the Shroud, specially made for Virginio Timossi.

Vittorio Marchis: "Interrogativi e risposte sul tessuto della Sindone"; *Sindon*, Dec. 1960. The author mentions a piece of cloth woven diagonally, found in the excavations of Pompei.

Pietro Savio, SDB: Ricerche sul tessuto della Santa Sindone: Grottaferrata, 1973. A compilation of ancient texts. There is an illustration of a cloth woven in herringbone pattern, dated 130 AD, which had been discovered by Gayet in the excavations of the necropolis of Antinoe.

Gazzetta del Popolo, Turin, Sept. 1978, pg 47. Some textile details in an article by Silvio Curto, superintendent of Egyptian Antiquities, Egyptian Museum, Turin.

Riccardo Gervasio: "Bruciature, macchie ed aloni the si riscontrano sul tessuto della Sindone"; *Sindon*, Oct. 1976. Prof. Gervasio's minute observations include a description of the two sections of cloth at the ends of the edging strip (also called lateral strip) outside the 'seam'. These rectangular pieces, Gervasio writes, were added before 1532; the reason for their addition being that the ends had become worn and raveled from handling; for it was the custom (as we see in numerous illustrations) for ecclesiastics to hold up the Shroud at the ends and along the length, when displaying it to the public. The added pieces are of plain white cloth, 35cm x 8cm and 15cm x 8cm, sewn on by "non-linear" stitches. The larger section was re-enforced later with brown thread irregularly stitched.

L A Schwalbe & R N Rogers: "Physics and Chemistry of the Shroud of Turin"; *Analytica Chimica Acta*, 135, (1982) pg 42. Concerning the edging strip, the authors say: "The distinct weft structure is continuous across the seam joining the two panels and strongly suggests that the side strip and the main section were of a single manufacture."

V D Miller & S F Pellicori: "Ultraviolet fluorescence photography of the Shroud of Turin", *Journal of Biological Photography*, Vol 49 #3, (1981). On page 85, the authors are of the same opinion as above: "The 8cm side strip ...shows weft bands that are continuous with the main body of the Shroud. The suggestion is that this strip was not separated from the main body over its entire length."