

THE RADIOCARBON DATE AND HOW THE IMAGE  
WAS FORMED ON THE SHROUD

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When asked by the editor of *Shroud Spectrum International* to write a paper concerning the recent radiocarbon measurement on the Shroud, I was uncertain as to which approach to take. Finally, I decided that a paper dealing with the image formation process in light of the radiocarbon date would be the most appropriate since that is the topic in which I, as a physicist, have been most interested over the past fourteen years.

According to the C14 measurement, the Shroud cloth, and hence the image it bears, most likely dates to the fourteenth century. While I can accept this conclusion in principle, it would be unscientific not to ask if it is consistent with other data concerning the Shroud, or conversely, if other data are consistent with it. Examples of "other data" are historical criticism based on extant documents and paintings, forensic studies, particle analysis (e.g. of pollens and of dirt found on the dorsal foot, etc.), and production mechanisms for the image. Because of the potential importance I have always attached to the Shroud, I would hope that comparative studies in these and other areas would be made by serious scientists and scholars before the C14 date is finally accepted. There must be a basic consistency in our interpretation of all Shroud data which now includes the C14 measurement. In this spirit, then, I would like to comment on the image formation mechanism with respect to the fourteenth century radiocarbon date.

If the Shroud had its origins in the fourteenth century and if we grant that the image bears all the stigmata of Jesus, then it would seem that we are dealing with a deliberate attempt by someone to simulate Jesus' burial cloth. It makes little difference what the motivation was, whether as a raw forgery, sublime piece of Christian art, or ritualistic reenactment of the Passion. For purposes of this paper, what is important is that this "someone" must have employed, either knowingly or unknowingly, a physical process that produced what we now see as the image on the Shroud. This process, operative in the fourteenth century, must be a consequence of the natural laws of physics. Accordingly, we should be able to come up with a plausible image formation mechanism based on standard physical principles which could have been used in the fourteenth century.

Before proceeding with an analysis along these lines, there is one point of logic which should not be overlooked. Scientists are never

really sure that they fully understand the laws of nature; surprises can and do occur. If one were to suggest that perhaps some "paranormal", "supernatural", or "new physics" process was involved in producing the image (whatever term one wishes to use), then I would reply that scientific inquiry into the consistency of the image formation mechanism with respect to the C14 date must cease until this "mechanism" is properly understood. We must be sure that the C14 measurement was not perturbed in some way by the hypothetical image formation process itself. There is nothing wrong with considering such ideas, but serious scientists rightfully should restrict their inquiry first to the natural world with which they are familiar. If, however, someone wants to construct a fourteenth century "new physics" mechanism to explain the Shroud image, fine; but someone else would be just as entitled to propose a first century "new physics" mechanism that altered the C14 measurement as one of its by products. But in this paper, let us proceed along more conventional lines of established empirical science and see where this takes us.

Let us first consider the question as to whether or not the Shroud ever enveloped a human body. This is not a moot point for it is conceivable that someone deliberately laid out the image so as to make it look as though the cloth enveloped a corpse. There are, however, certain subtleties in the image that indicate, to my mind at least, that the Shroud did enfold a human body.

To demonstrate that the Shroud enveloped a crucified body, Lavoie has brilliantly interpreted a certain blood feature which cannot reasonably be attributed to artistic handiwork. The feature in question is the blood flow off the right elbow as it is seen on the positive image (Fig. 1). In a recent paper,<sup>1</sup> Lavoie showed that this feature is consistent with blood flowing down and under the forearm at the elbow where it pooled and dripped off the body. The arm would necessarily had to have been approximately in a crucifixion-like position in order for gravity to migrate the blood along the indicated path. Of course, this presents no problem since the Man of the Shroud appears to be a crucifixion victim. This blood feature is then explained by the wrapping of the Shroud around the arm so as to receive a clot imprint by direct contact.

Another indication that the Shroud enfolded a human body was recently described to me by Bulst.<sup>2</sup> The features he pointed out are the blood trickle off the dorsal foot and a blood mark of similar size and shape next to the foot region of the frontal image. In our experiments where a volunteer subject was enfolded in a full-scale model of the Shroud with an image drawn upon it, we found, as Bulst indicated, that these features can be aligned directly over one another. This cannot be coincidence nor the result of a super-sophisticated artist who anticipated such a detail. What this congruence shows is that the Shroud was folded lengthwise over the head of a body and that the feet were wrapped so as to bring the

dorsal bloodstain into contact with the frontal end of the cloth where blood residue was transferred.

There are, in addition, other aspects of the Shroud which indicate that the cloth enveloped a real body. This is demonstrated by the numerous bloodstains which correspond to distinctly different directions, consistent with a vertical crucifixion first, followed by a horizontal burial of a real corpse. Several examples that illustrate this are: the wound in the side, trickles along the forearms, puncture wounds on the head and the wrist wound, all corresponding to flows from a body in the vertical position; flows from a body in the horizontal position are the bloodstain across the small of the back and the trickle at the dorsal foot (Fig. 1).

The wrist bloodstain is particularly interesting in that it provides an independent confirmation that the flow-path was in the direction of gravity.<sup>3</sup> Figure 2 shows an ultraviolet fluorescence photograph of the wrist clot pattern in detail. At the tip is a clear halo which can only be explained as a gravitational separation of serum from blood, as described fully by Lavoie.<sup>4</sup> If the two streams of this blood feature are then positioned so as to be parallel with gravity, the accompanying hand and forearm assume a crucifixion position. It is beyond my sense of reasonability to assume that an artist anticipated such details, particularly the subliminal one of the serum separation which is revealed only by ultraviolet fluorescence photography.

We should not overlook the fact that it was only through ultraviolet fluorescence photography that the "scourge" marks were observed to contain many finely spaced lines or scratches, consistent with what would be expected from a flogging of real skin. In addition, on the dorsal foot imprint, the 1978 examination discovered an abundance of microscopic dust or dirt, atypical of the rest of the image. This, of course, is consistent with the concept of dirt being transferred to the Shroud from the feet of a barefoot man. These subliminal details cannot reasonably be ascribed to a hypothetical artist because (1) he himself could not see them and (2) there was no reason to put them there since no one else could see them either. Therefore, these particular details, including the blood features, are consistent with the concept that the Shroud enfolded a wounded and dirty corpse as opposed to a statue or other artistic handiwork. These details are seen in Figures 3 and 4.

The above interpretations of the bloodstains assume, of course, that they are blood as opposed to a reddish pigment, such as has been proposed by McCrone.<sup>5</sup> In this regard, we are fortunate to have the published work of Heller and Adler<sup>6</sup> which conclusively refutes the McCrone interpretation and shows, by a large number of independent microchemical tests on samples taken from the Shroud in 1978, that the bloodstains are in fact blood. We should note that their work was presented before the Canadian Forensic Society in 1981 and subsequently published in the journal of that

Society after appropriate peer review. Heller and Adler's work has also been referenced in other refereed scientific journals.<sup>7,8</sup> Unfortunately, the McCrone studies never were subjected to peer review and appeared only in a periodical published by the McCrone Institute,<sup>5</sup> of which McCrone is the founder and head.

As a final demonstration that the Shroud covered a human body, I would like to refer to my own studies of the body image.<sup>9</sup> These studies show that the intensities of the frontal Shroud image can be calculated using a single mathematical relationship of intensity versus distance between two surfaces. These surfaces correspond geometrically to an anatomically reasonable body shape and a cloth draping naturally over that shape.<sup>9</sup> This is shown best in Figures 5, 6 and 7.

What is significant about the ability to characterize the Shroud image in this way is that (1) two *complex* surfaces can be related to the *complex* intensity structure of the Shroud image by a *single* and *simple* mathematical equation and (2) that the two surfaces correspond to realistic body and cloth surfaces. This cannot be an accident nor the clever handiwork of an artist; it is further confirmation that the Shroud covered a body shape at the time of image formation. Thus, I believe we are on solid ground to conclude that the Shroud covered a body when the image was formed.

Let us now bring this conclusion together with the fourteenth century radiocarbon date. It would seem, contrary to the famous fourteenth century D'Arcis Memorandum which declares the Shroud image to be "cunningly painted", that the image was somehow the result of the Shroud's covering a body. In order to explain the blood and body image details discussed above, we are almost forced to imagine that someone, in the Middle Ages, was tortured, crucified, and buried in a manner similar to Jesus. I am not prepared, nor do I think it necessary, to spell out the who, where, or why of such a hypothetical event. The salient point is that a cloth-covered body must have been used. The shape information of that body somehow became encoded, with high resolution, into the intensity structure of the body image. It makes no difference whether the image was an unintended accident of a burial simulation or a well-executed and intentional act of craftsmanship. Laws of physics must have operated between the body and cloth in order to produce the image. Can we therefore come up with a consistent and empirically reasonable physical process that could do the job?

To my mind, there are only three main categories of natural physical phenomena that could have been involved: direct contact, diffusion, or radiation. While these mechanisms are reviewed in detail elsewhere,<sup>9</sup> let us consider each one briefly in turn.

Direct contact means that an image is formed only where the cloth touches the body. While the sharp resolution of the image is

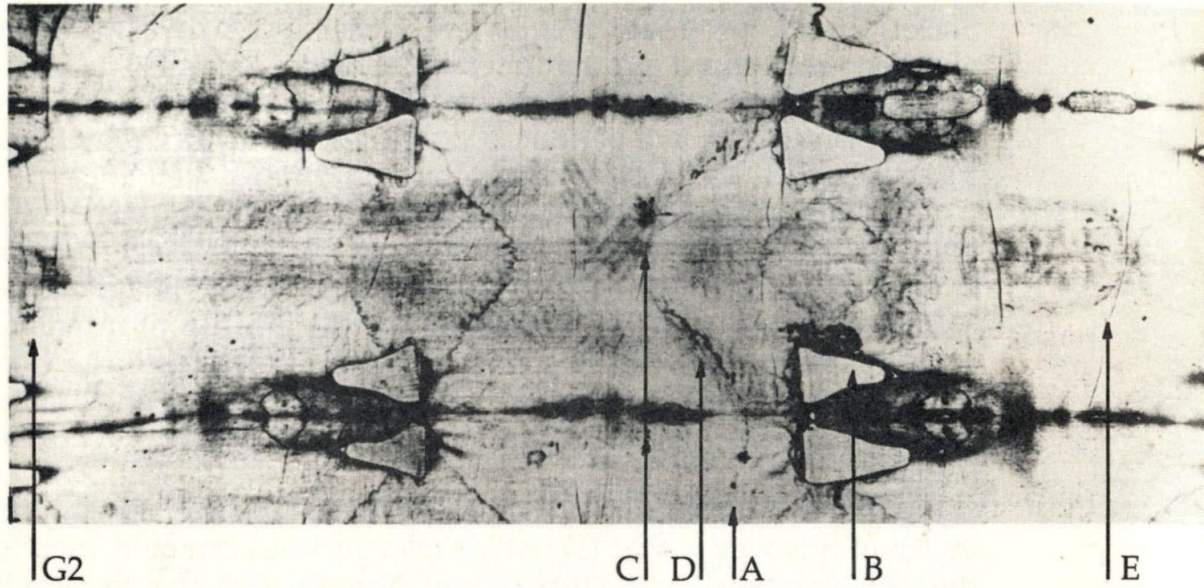


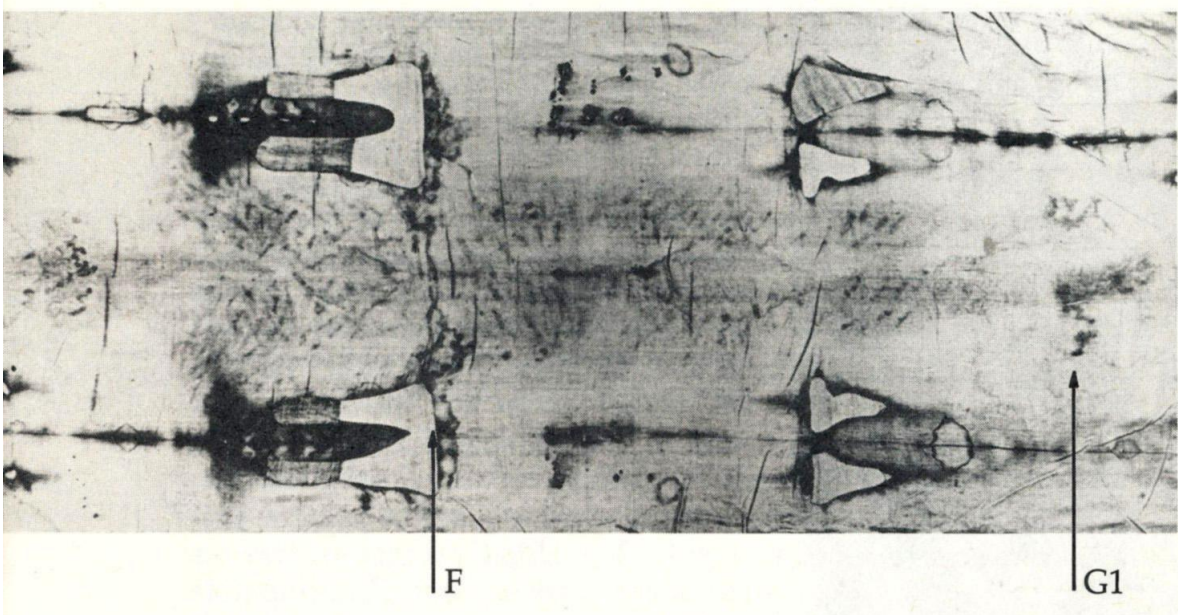
Fig. 1: Positive reproduction of the Shroud. Arrows indicate features discussed in text. A— Bloodstain corresponding to cloth molded around elbow. B— Wound in the side (vertical flow). C— Wrist wound (vertical flow). D—Trickles along forearms (quasi-vertical flow). E— Puncture wounds on head (See page 7) →



Fig. 2: Ultraviolet fluorescence photograph of wrist clot pattern. Note serum separation at tip of flow.

readily accounted for by this mechanism, the discontinuous on/off nature of a direct contact image is clearly inconsistent with the continuous three-dimensional structure of the Shroud image<sup>9</sup>. In addition, severe lateral distortions occur unavoidably in the image (Fig. 9).





(vertical flow). F—Bloodstain across small of back (horizontal flow). G—Trickle at foot (horizontal flow). G1 & G2— Bloodstains that match when cloth envelops a full 3-dimensional body.



Fig. 3: Ultraviolet fluorescence photograph of scourge wounds. Note microstructure separations into thin, parallel lines.



Fig. 4: Microscopic dirt found on dorsal foot imprint.

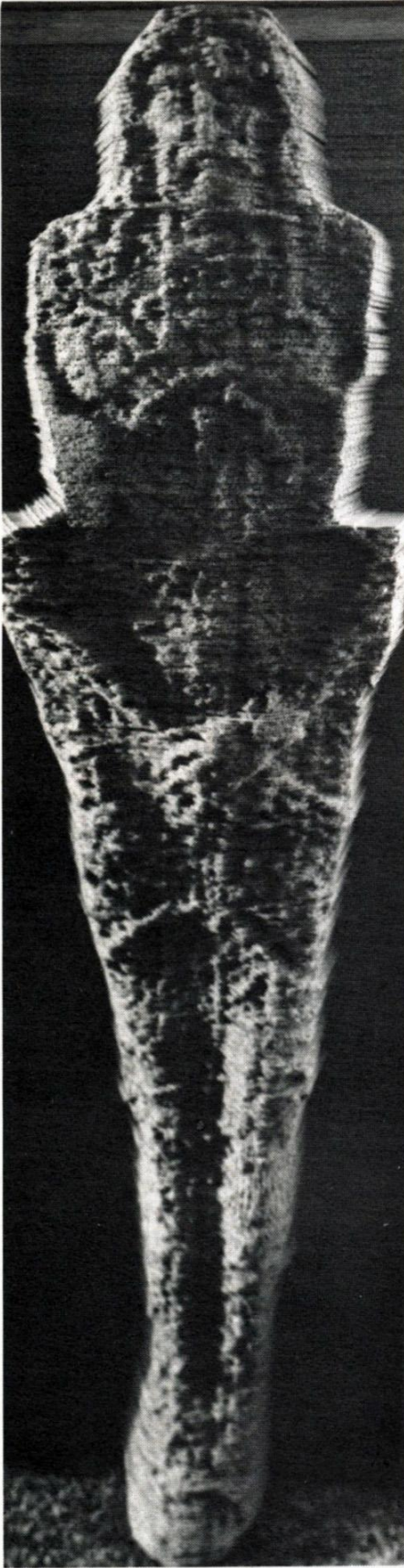


Fig. 5: Anatomically reasonable body surface used in Shroud image intensity calculation. The vertical distance,  $D$ , between this surface and the one representing cloth drape in Figure 6 can be converted with precision into the corresponding image intensity value,  $I$ , measured on the frontal Shroud image by a single mathematical relationship,  $I(D)$ . This relationship,  $I(D)$ , is valid rigorously over the entire frontal image at all points. Shoulder information is missing due to the 1532 fire.

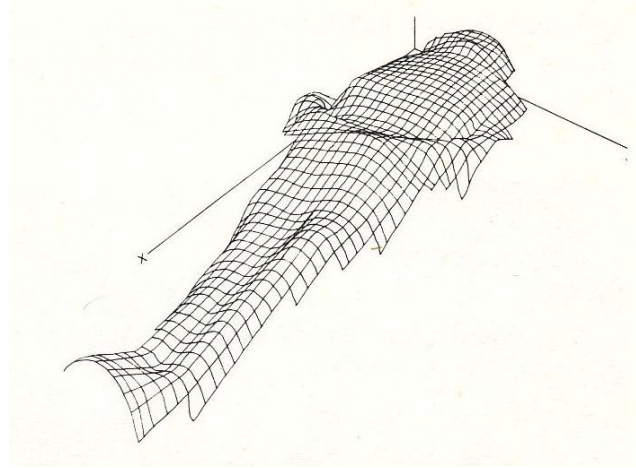


Fig. 6: Mathematical representation of cloth draping over the body surface of Figure 5. Note the close correspondence of this representation with that of an actual cloth draping over the Figure 5 body surface.



Fig. 7: Linen cloth model of the Shroud, woven in a 3:1 herringbone twill of thickness approximate to that of the Shroud cloth, draping over the Figure 5 body surface.

Diffusion and radiation mechanisms can give, under suitable conditions, a continuous falloff of intensity with cloth/body distance, but cannot simultaneously account for the sharpness of the Shroud image. Figures 10 and 11 show experimental diffusion and radiation images. The lack of resolution is obvious, and in both cases, unacceptable lateral distortions are also present.

A further problem with direct contact, diffusion and radiation mechanisms can be demonstrated by referring again to the blood feature off the elbow. As Lavoie rightly concluded, this blood feature must have been formed by direct contact of the cloth molded around the elbow region. And the important point to be made here, as Lavoie notes,<sup>1</sup> is that there is no body image recorded in the immediate vicinity of the elbow blood clot. He therefore concluded that the body image could not have been formed by a direct contact mechanism. To this, I would further add that diffusion and radiation mechanisms are also inconsistent with this observation because they too should have caused image discoloration to occur. Note that we readily observe image intensity in locations on the frontal image where cloth-body distances are much greater (centimeters) than what could possibly have been involved in the elbow blood clot contact region.

Thus, I do not see how the Shroud image could have been generated by any of the above three mechanisms or hybrid combinations thereof. Yet, an enveloped body shape must have been involved. So it is not clear how a hypothetical "someone" in the fourteenth century could, on the one hand, envelop a body shape in the Shroud cloth and, on the other, utilize a physical process to encode, either intentionally or unintentionally, body shape information with high resolution into the Shroud image. The only alternative, it would seem, would be to invoke a mechanism that does not belong to the broad categories of direct contact transfer, diffusion, or radiation, and it is not at all clear what this mechanism would be.

To further complicate matters, I would like to call attention to a preliminary study which indicated that image features on a cloth draping over a body align vertically above their corresponding body parts.<sup>10</sup> Since that work was published, I have concluded a major study of this phenomenon which I believe conclusively demonstrates this characteristic. The study, still to be published, was accomplished by full computer reconstruction of body surfaces from the Shroud image according to various body-to-cloth mapping hypotheses. The point to be made is that the vertical alignment of image and body features is inconsistent with the diffusion and radiation mechanisms. I do not know of any natural mechanism that acts in a vertical direction so as to produce an image of high resolution and diminishing intensity with cloth/body distance. Yet, the adoption of the radiocarbon date carries with it the corollary that such a mechanism was utilized by "someone" in the fourteenth century.





Fig. 8: Model used in producing the experimental images of Figures 9-11, using a draping cloth simulation.



Fig. 9: Experimental direct contact image.

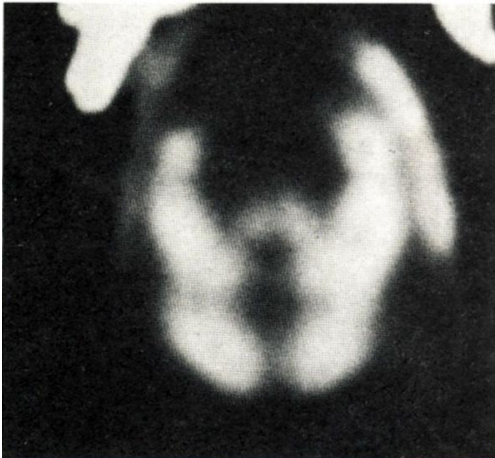
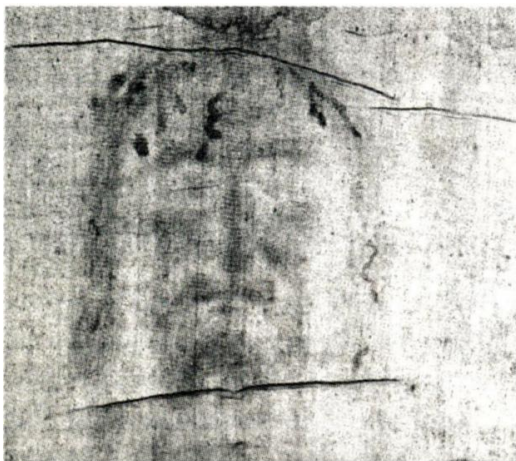


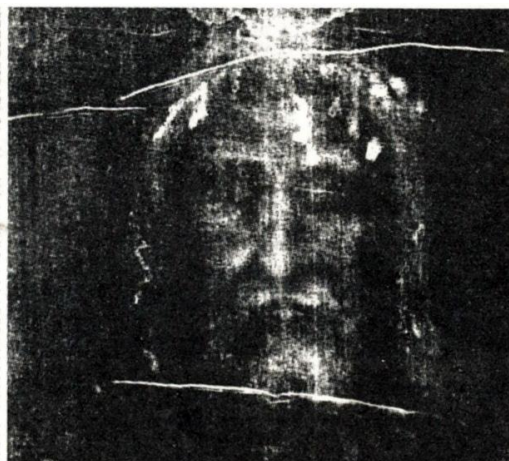
Fig. 10: Experimental diffusion image.



Fig. 11: Experimental radiation image with moderate attenuation between face and simulated cloth surface.



The Face on the Shroud:



positive and negative.

I am uncomfortable accepting any date for the Shroud, in particular the current radiocarbon date, until I can see (or be shown) how the image could have been produced in that time period. If we are dealing with a natural physical process which must therefore be repeatable, then it should be possible to replicate empirically all the characteristics of the Shroud image using technology available in the fourteenth century. That this is nontrivial is underscored by the fact that in this present century, no one, including the present author,<sup>9</sup> has been able to reproduce satisfactorily the Shroud image. In fact, replicating the Shroud image with its high resolution, 3-dimensionality, positive/negativity, superficial alteration of threads, vertical mapping, and cellulose dehydration chemistry should be insisted upon by the scientific community if a "natural" process was involved.

From my point of view, if I accept the C14 date outright then I tacitly must accept the existence of a process that produced the image in the fourteenth century, and I do not like accepting something that I do not understand. More directly, I do not feel that this is scientifically proper, given the legitimate uncertainties which still exist concerning the Shroud image. Accordingly, I believe another examination of the Shroud is in order, specifically the one proposed by STURP in 1984.<sup>11</sup> Perhaps this would fill in needed pieces of the puzzle.

While we struggle with trying to understand the image formation mechanism to see whether or not it is consistent with the radiocarbon date, it is equally important to critique the C14 measurement as well. For no measurement or piece of data in science is beyond reproach. I am confident that, in time, science will resolve the issue of image formation. But clearly more work is needed and we must be patient until science, with respect to the Shroud, runs its course.

#### REFERENCES

1. LAVOIE, G., and others, "Blood on the Shroud of Turin: Part I", *Shroud Spectrum International*, June 1983.
2. BULST, W., private communication, 1987.
3. JACKSON, J., "Blood and Possible Images of Blood on the Shroud", *Shroud Spectrum International*, Sept. 1987.
4. LAVOIE, G., "Blood on the Shroud of Turin: Part II", *Shroud Spectrum International*, Sept. 1983.
5. McCRONE, W., "Microscopical Study of the Turin Shroud"; I, II, & III, *Microscope* 1980-81.
6. HELLER, J. H., and ADLER, A. D., "A Chemical Investigation of the Shroud of Turin", *Can. Soc. Foren. Sci. J.*, Vol. 14, No. 3, 1981.

7. SCHWALBE, L. A. and ROGERS, R. N., "Physics and Chemistry of the Shroud of Turin", *Analytica Chimica Acta*, 135, 1982.
8. JUMPER, E., and others, "A Comprehensive Examination of the Various Stains and Images on the Shroud of Turin", ACS in Chemistry, No. 205, *Archaeological Chemistry III*, Joseph B. Lambert, Ed., 1984.
9. JACKSON, J. P., and others, "Correlation of Image Intensity of the Turin Shroud with the 3-D Structure of a Human Body Shape" *Applied Optics*, Vol. 23, July 15, 1984.
10. ERCOLINE, W., and others, "Examination of the Turin Shroud for Image Distortions", in *Proceedings*, 1983 IEEE Conference on Cybernetics and Society (IEEE New York, 1982).
11. D'MUHALA, T., and others, "A Scientific Proposal for Studying the Shroud of Turin", *Shroud Spectrum International*, Dec. 1984.

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