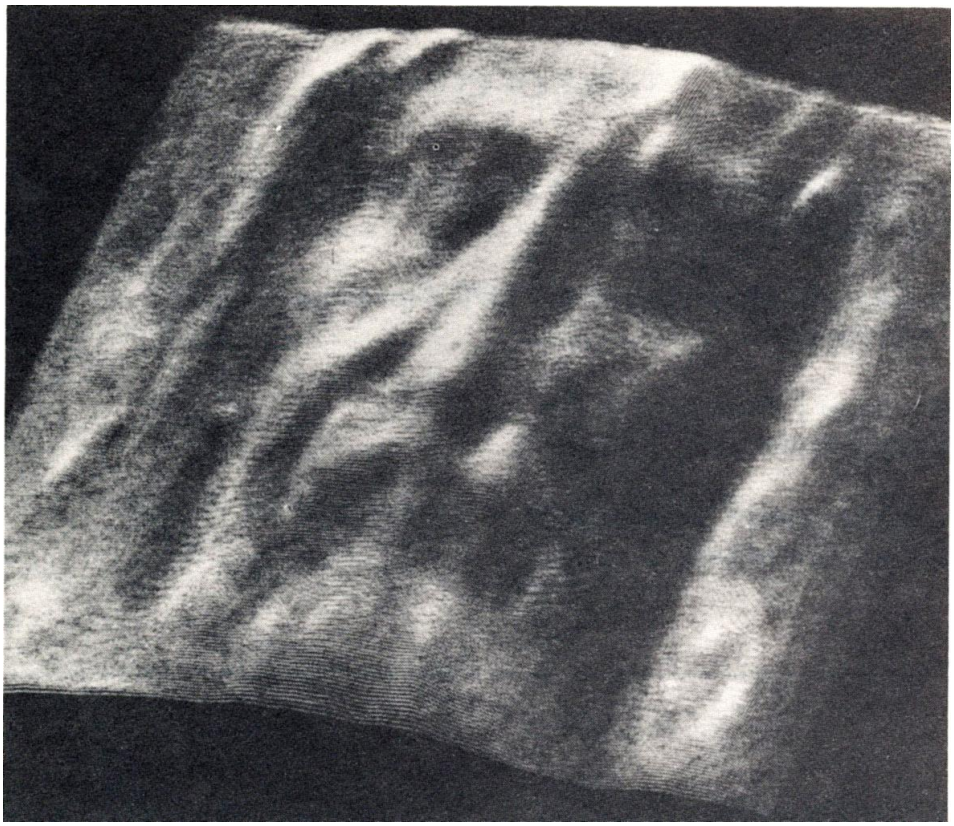

Fig. 1: Three-dimension face, with signs of martyrdom reduced.

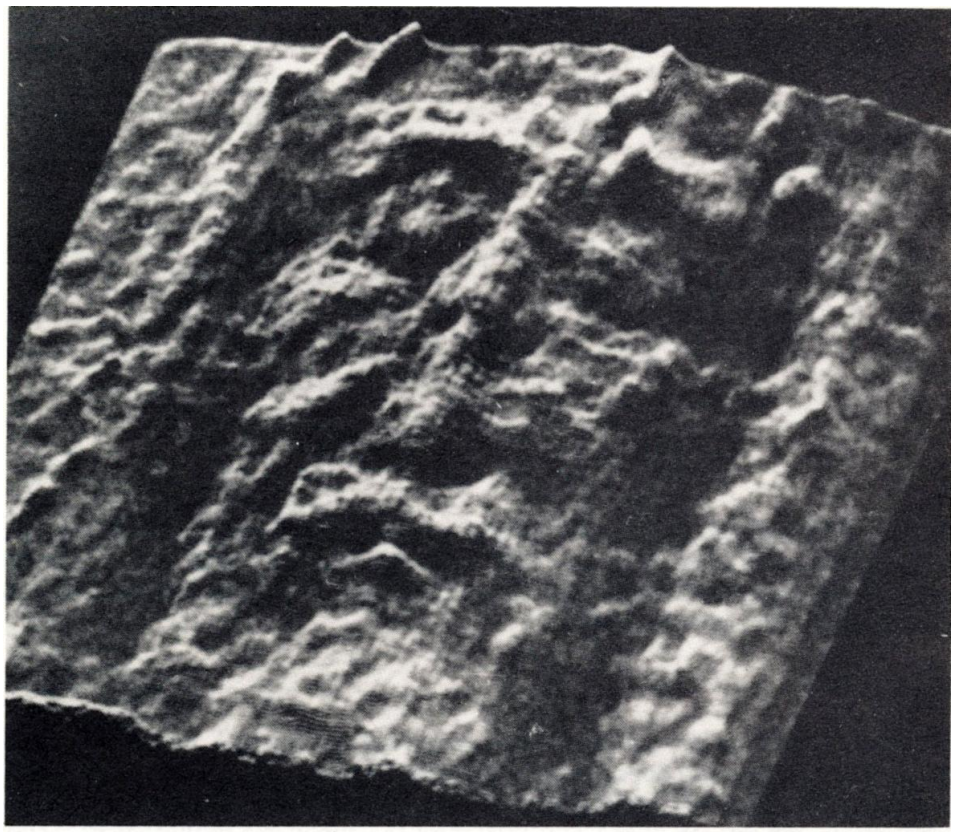

Fig. 2: Three-dimension face.

AN IMAGE RESURRECTION OF THE MAN OF THE SHROUD

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Introduction

Among the various disciplines applied to the study of the Holy Shroud of Turin, computer science has supplied the most surprising and unexpected results. Significant among these results are the three-dimensional image of the Holy Shroud[1,2] and the three-dimensional woundless face image obtained from it through numerical filtering.[1,2]

The first of these images demonstrated that the Shroud had indeed covered the body of a man, and has revealed twenty-odd details not visible to the naked eye in the original two-dimensional image.[3] Some of these details correspond to events mentioned in the Gospels. The second image gives us our first view of the face of the Man of the Shroud, who is probably Jesus Christ.

Through the centuries, the figurative arts have given us many images of Jesus Christ, including the Christ of the catacombs and the Christ of Daphne, cited in the transactions of the Albuquerque Conference. The face of Christ in Leonardo's "Last Supper" is also widely known. Unlike these images, the woundless face reproduced by the computer is a mathematical reconstruction of the real face on the Shroud, and is thus more likely to be a close approximation of the real face of Jesus Christ.

The natural face[1] shown in Figure 1, however, had not yet been perfected. It should be noted that this image was produced by exploiting the fact that the facial features and the wound images have differing two-dimensional spectral contents. In fact, the wound images show much more rapid intensity variations than the facial features. Consequently, the wound images can be considerably reduced with practically no effect on the facial features by using a low-pass two-dimensional numerical filter.

Obviously, when this method is used, the large wounds are less attenuated than smaller ones. Thus, in the face shown in Fig. 1, traces are still visible of the large wound on the right cheek, the trickle of blood shaped like an inverted number 3 on the forehead, the extensive wounds below the left eye, and the two large clots of blood on the upper lip.

Nevertheless, the face is not excessively disfigured by these marks, as the remains of the large wound on the right cheek resembles a wrinkle, while the other traces do not detract from the beauty of the face.

They are even less noticeable in the face published in (1), (3) and (4),* where the areas indicated by the computer as corresponding to the eyebrows and beard have been darkened to represent hair.

Despite the fact that the woundless images thus produced are of relatively high quality, there are a number of ways in which they could be improved. The first of these would be to eliminate all traces of wounds on the face without affecting the facial features. This cannot be done with the method used to produce Fig. 1. Indeed, subjecting Fig. 1 to a further filtering operation would be equivalent to an overall filtering with a narrower band, and would alter the facial features.

One possible method consists of subtracting the signs of martyrdom from the three-dimensional face with wounds shown in Fig. 2 and presented for the first time in (1). Basically, this method would replace the torn, bruised or bloodstained skin with the hypothetical appearance of undamaged skin. The problem with such a process, however, is that while the computer can supply a good indication of the position of clots and bloodstains, as in Fig. 3, it does not seem to be capable of indicating the position of wounds and bruises with sufficient accuracy.

The Image Resurrection

Consequently, we decided to adopt a differential filtering process, i.e., a two-dimensional low-pass filtering whose *cut-off* frequency is different for each of the various areas of the face and is selected in accordance with the structure of said areas. This procedure was suggested by the differing structure of the facial features. In fact, the cheeks and forehead are considerably smoother than the other features, which makes it possible to use a low-pass filter with much narrower band width than is feasible in other areas of the face. It will be seen from Fig. 1 that it is here on the cheeks and forehead that the largest wounds are located. The large wound on the right cheek, as shown in the three-dimensional image reproduced in Fig. 2, was presumably caused by a blow from a cudgel,[3] while the largest of the marks left by torture is the now-famous trickle of blood resembling an inverted number 3 on the forehead. The lesions over the left cheekbone, which are clearly visible for the first time in Fig. 2, were probably sustained in a fall on stony ground. Figure 1, however, shows traces of the two large bloodclots on the upper lip, which were also revealed for the first time by Fig. 2. In addition, Fig. 2 shows three marks which may make nose filtering difficult: a) the clearly defined cut on the left side of the nose, presumably caused by the tip of the reed or hyssop branch on which the sponge soaked with sour wine was offered[1,3] and b) the two holes alongside the nose, which are of unknown origin and could be an important factor in determining the authenticity of the Shroud.

As these three marks are almost completely filtered in Fig. 1, it might be thought possible to use this same image in eliminating the

* See *Spectrum* #2, "Reading the Holy Shroud ... with the Aid of the Computer", by Dr. Tamburelli. [Ed.]

Fig. 3: Bloodstains and clots identified by the computer.

remaining traces of martyrdom through suitable filtering. However, this type of processing is not advisable in view of the total filtering to which Fig. 2 was subjected in order to produce Fig. 1, filtering which was carried to the point of achieving an heuristic compromise between reducing the traces of martyrdom sufficiently on the one hand, and of keeping the alteration to the facial features within acceptable limits on the other. In this context, it should be noted that a two-dimensional low-pass filter widens and flattens the facial features, and hence the features shown in Fig. 1 appear somewhat wider than those in Fig. 2. Even so, they are thinner than the features shown in the original photograph of the Shroud image, where the wounds and blood make the features appear larger.

In Fig. 2, the facial features can be distinguished from the traces of martyrdom, and are thus much thinner.

For this reason, it was decided to use the image of Fig. 2 as the starting point for producing a picture of the face without wounds and blood. It will be remembered that the image in Fig. 2 was processed[1] in such a way as to make the details stand out as clearly as possible, and that it is precisely the appearance in Fig. 2 of new, well-defined details (viz., the stereoscopic appearance of the drop of blood on the right side of the upper lip) which provides a guarantee that the image is a close approximation. It should also be noted that Fig. 2 was derived from an official photograph by Enrie.

The first step in processing the image in Fig. 2 was an overall low-

pass filtering. Filter *cut-off* frequency was sufficiently high to eliminate some of the wound traces (i.e., those with higher frequency spectral contents) without significantly changing the features. This first step completely removed all traces of blood from the eyelids. The image was passed through two filters in succession.

This was followed by intensive local filtering of several areas: the right cheek, to eliminate the deep wound which was presumably caused by a blow from a cudgel; the left cheek, to reduce the wounds and bruises; and the forehead, to eliminate the bloodstains.

These local filtering operations were followed by another global filtering of the entire image, which served to remove the last traces of martyrdom and make the image uniform. A *zero order prediction* filter was used in three places where the wounds were particularly deep, *viz.*, the top of the right cheek and the holes at each side of the nose.

The resulting image is shown on the cover of this issue of *Spectrum*. Comparison with Fig. 2 will show that the facial features remain essentially unchanged, while the wounds and traces of blood have almost entirely disappeared.

The high definition of the image shown in Fig. 2 makes it likely to be a good representation of the actual wounded face; likewise, the image shown on the cover can be considered to be very close to the real appearance of the Man of the Shroud prior to torture. The remaining differences are probably due to a general bruising of the face, which clearly cannot be eliminated, and to rigor mortis.

Though a medical expert could perhaps be of assistance in quantifying these differences, we believe the face shown on the cover to be so lifelike as to make further improvement a matter of secondary importance. Indeed, as the unmartyred face appeared for the first time on the video screen, we were pervaded with emotion at seeing what can be thought of as a "resurrection" of the Man of the Shroud.[5]

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