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Scientific investigation of the Shroud of Turin

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This article introduces three research papers discussing various scientific tests run on the Shroud of Turin—an ancient piece of linen that appears to bear faint images of a man's body. It also briefly reviews the chemical, photographic, and x-ray tests not dealt with in the three research papers, which are concerned with optical and IR spectroscopy and thermography.

I. Introduction

In this issue of *Applied Optics* there are three papers dealing with investigations performed in October 1978 on the Turin Shroud.[1-3] The authors of these papers were part of a team of scientists and support technicians known as the Shroud of Turin Research Project (STURP). This team consisted of thirty-two members operating on their own time with their own funds and those of interested contributors. When not on leave the members work at such institutions as Oriel Corp., NUTEK, the Air Force Weapons Laboratory, the Santa Barbara Research Center, Brooks Institute of Photography, the Air Force Academy, IBM, and the Jet Propulsion Laboratory to mention only some. The purpose of this article is to give the reader a short background of this Turin Shroud and to overview the range of tests performed.

II. Background

In the North Italian city of Turin is kept an ancient piece of linen measuring ~4.4 × 1.1 m. Because the cloth has present on it the faint images of a man—front and back—apparently laid out in death and bearing the markings of a violent scourging and crucifixion, many believe it to be the actual burial cloth of Jesus of Nazareth. It is then a relic, an object of faith. Ordinarily science remains detached from such objects, but in this case, the unusual quality of the image intrigues the scientific mind.

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In its known history the Shroud can be traced back only to the 1350s when it is known to have been in the possession of the family of Geoffrey de Charney, a Knight of Lirey, France. This same cloth can be traced forward to its present location in Turin, Italy. How it arrived in Lirey and from whence it came remain a mystery even today, although there is some evidence to suggest that it originated in Palestine at a much earlier time.[4]

Probably the most intriguing quality of the Shroud is the so-called photographic negative characteristic of the Shroud image first discovered by Secundo Pia in 1898. This characteristic is most easily explained by observing Fig. 1, which shows a photograph of the Shroud and the negative that produced it. Notice that in the negative the image of the man appears as a positive.[5] More recently microdensitometer measurements of image density have been correlated with assumed cloth-body distance suggesting that the image also contains distance information.[6,7]

The Shroud was damaged during a fire in 1532, and the results of this heretofore considered unfortunate accident are also visible in Fig. 1 as two parallel lines of char. Ironically, this so-called unfortunate accident with its associated scorches, especially in scorch/body image intersections, has allowed some to speculate as to the chemical origins of the image; certainly, the image does not appear to have been produced by commonly known art techniques.[8]

Analyses of the image by forensic pathologists have led to statements that the image appears to be that of a dead human male—death apparently by crucifixion.[9]

Because the cloth has associated with it the mystery of its chemical origin and intrigue of its unique image, we can say at a very minimum it deserves study. Furthermore and perhaps the most compelling reason is the mystique (whether real or imagined) of the Shroud being associated with the religious and historic figure of Jesus. The question of its authenticity is worth investigating.

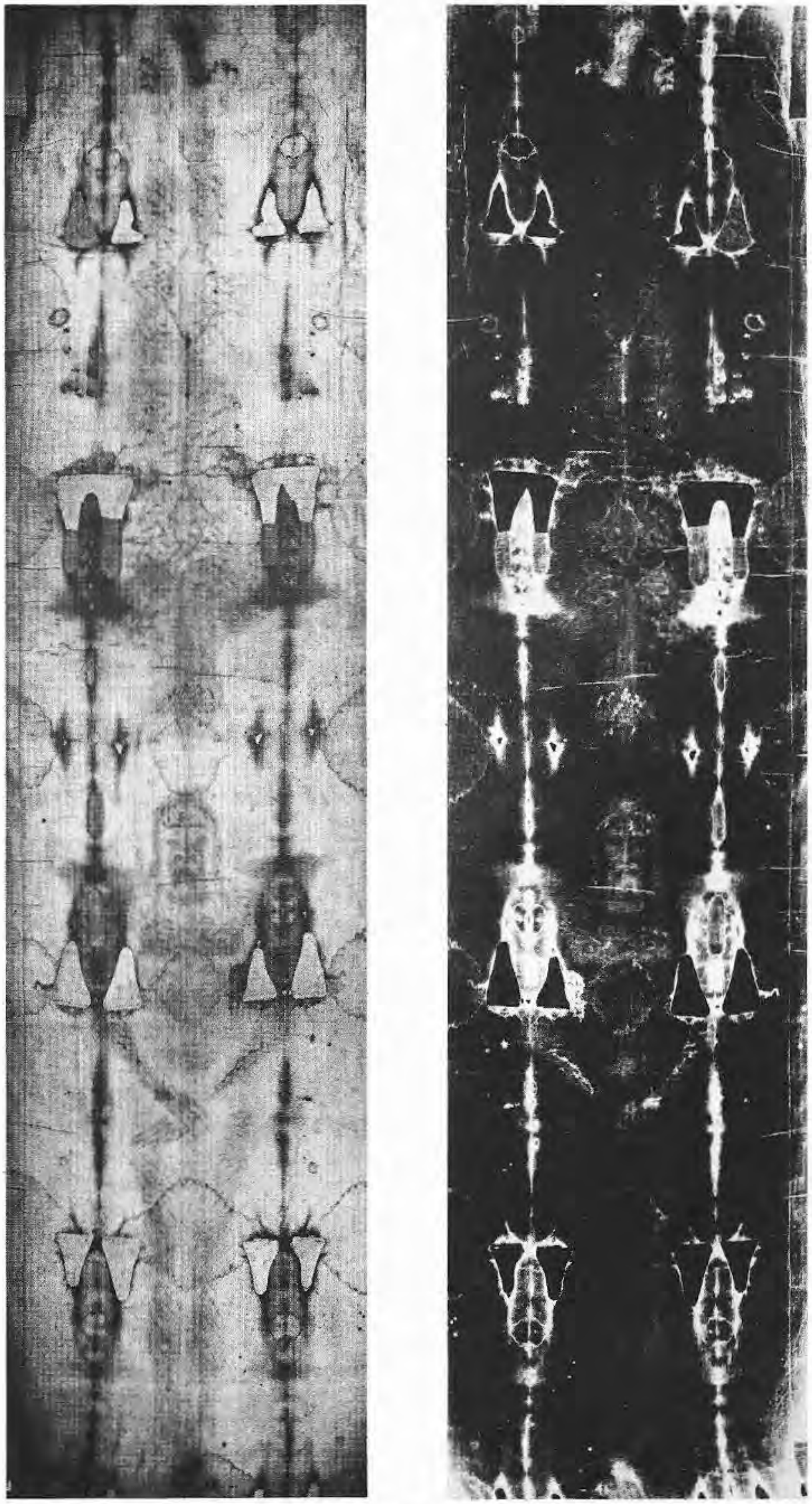

Fig. 1. Black and white photograph of the Shroud of Turin as it appeared at the time of the testing (contrast enhanced, left and associated negative, right). © Vern Miller 1978.

III. Tests Performed

The goals of STURP are to determine through nondestructive testing the chemistry and character of the image(s) on the Shroud. Through the various tests performed on the Shroud we hope to address the question of authenticity (implying, of course, that inauthenticity is a possible outcome) and image formation process(es). To achieve these goals in addition to the optical spectroscopy and IR spectroscopy and thermography reported in this issue of *Applied Optics*, STURP members also performed four other major tests: x-ray fluorescence, x radiography, photography, and chemical analysis. Since these last tests are not well described in this issue, we will briefly review them.

A special test frame was constructed to support the aged fabric of the Shroud and its protective backing cloth. The frame was constructed in such a way that it could be rotated from vertical to horizontal, and magnetic strips were used to attach the Shroud. Panels, 20 cm wide, comprised the middle portion of the frame and were removed singly for some tests such as x radiography and x-ray fluorescence.

A. X-Ray Fluorescence

The x-ray source used for radiography was used to excite a foil of tin. A lead collimator was installed over the end of the x-ray tube. The tube was located so that a 50-kVp x-ray beam would impinge upon the tin. The 25.5-keV K-alpha was filtered by a silver foil at the exit end of the collimator. A Si(Li) detector was mounted coaxially above the x-ray source. A lead shield with a 4-mm collimation hole was fitted over the detector. This arrangement defined a one square centimeter sample area on the cloth.

The combination of x-ray source and detector was mounted on a heavy-duty camera tripod. It could, thus, be raised and lowered across the width of the cloth. Also, the arrangement could be rotated for background and calibration measurements.

Pulses from the detector were fed to a linear amplifier and stored in a 512-channel pulse height analyzer. After a 2000-sec counting interval, the accumulated spectrum was stored on a digital tape cassette for subsequent analysis.

Titanium and copper foils were used for calibration. From the measured positions of the K-fluorescence lines of these standards and their tabulated energy values, a calibration curve was determined. Calibration data were collected before and after each test data run.[10]

B. X Radiography

Low energy radiography was performed at 15 kVp. The x-ray source with a 1.5-mm square focal spot was positioned on a heavy-duty tripod 1 m from the linen cloth. A 20-cm wide panel was removed from the frame on the side opposite the source. A 36- × 43-cm film pack containing a type DR and type M film was taped over the opening. Following the exposure and removal of the film pack the source was moved vertically one-quarter of the width of the cloth (~27.5 cm). Another two-film pack was taped over the opening in line with the source and exposed. After the third relocation of the x-ray source and exposure the panel was reinstalled, and an adjacent panel was removed. The tripod with the x-ray source was aligned with the new opening, and three more exposures were made. In this manner the entire subject was radiographed.

An aluminum frame, ~1.25 m × 1.5 m, was suspended on the source side of the cloth. The frame was strung with horizontal and vertical wires spaced 20 cm apart. Each intersection of wires was identified with a unique letter-number pair. Thus, each radiograph was identified by shadows of wires and their intersection identifiers.

A darkroom was set up in a nearby room. All films were manually processed shortly after exposure. In another room film viewers were located, and the processed films were given a preliminary examination. Any needed correction in exposure was relayed to the test room.

C. Photography

Mosaics at 5.6:1 and 22:1 reduction were made of the entire surface of the cloth. For each section a successive series of exposures were made with red, green, and blue filters for color separation. In another series UV transmission filters were used for contrast enhancement. To detect fluorescence in a different series, UV transmission filters were used over the light sources, while UV blocking filters were used over the camera lens. For another series the visible spectrum was partitioned into 100-Å intervals by a series of filters.

D. Chemical Analysis

Trace samples of surface materials were obtained by means of adhesive tape. The tape and the adhesive were compounded of pure hydrocarbon. A specially designed roller was used to apply the adhesive to selected areas of the linen cloth. After being carefully removed the tapes were attached, with the adhesive side up, to microscope slides and identified. All slides were stored in a plastic box that was tightly sealed.

The tapes are being examined by microscope and analyzed by the micro-Raman method. Additional analysis will be performed by electron spin resonance, electron spectroscopy, ion microprobe, and scanning electron microscope.

E. Additional Tests

Additional tests not noted here were performed on an opportunity basis that included transmission photographs, side lit photographs, and glancing photographs.

IV. Conclusion

We plan to continue to publish the results from these tests and further analyses as the work is completed. The consensus conclusions on authenticity and image formation will be drawn from a synthesis of these results. In the end the definitive conclusion may require further testing.

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Blood on the Shroud of Turin

By spectroscopic and chemical tests (conversion of heme to a porphyrin) **John H. Heller** and **Alan D. Adler** of the New England Institute have identified the presence of blood in the alleged blood areas on the Shroud of Turin. This paper will appear in a later issue, probably 15 August.

Ultraviolet–visible spectrometry of selected areas; see the paper by Gilbert and Gilbert on page 1930. Photo: © 1978 Mark S. Evans.