REPORT OF THE PHOTOGRAPHIC EVIDENCE PANEL*

I. INTRODUCTION

(1)** The events in Dealey Plaza, Dallas, Tex., on November 22, 1963, surrounding and including the assassination of President John F. Kennedy, were recorded in a substantial body of photographic evidence. More than 510 photographs that relate directly to the assassination were taken by approximately 75 photographers, in addition to substantial other relevant photographic evidence pertaining to events that did not involve the actual assassination. (*1*)

(2) This photographic evidence provided the Warren Commission with a basis for attempting to resolve important issues such as the number, timing, and source of the shots fired at President Kennedy. The generally poor quality of portions of the materials, however, has resulted in many interpretative questions regarding matters that the Warren Commission purported to resolve. In the years since the Warren Commission, independent researchers have criticized its findings that were based upon photographic evidence as incomplete and unsubstantiated. (*2*)

(3) It is clear that the Warren Commission's investigation was limited for a number of reasons:

(4) 1. It did not have access to all critical photographic materials, such as those from the autopsy;

2. Potentially important photographs were not located;

3. The Commission did not have its own investigators and analysis, but had to rely on other Government agencies, thereby bringing the credibility of its report, if not the quality, into question; and

4. Photographic enhancement technology was not as sophisticated or effective in 1963–64 as it has since become.

(5) In contrast, the House Select Committee on Assassinations, because of the independent status established by its congressional mandate, was able to select its own panel of photographic experts who had access to files and photographic records that, for one reason or another, were not available to the Warren Commission. The committee was also able to secure access, and have its panel review, independent studies that had been conducted in the years since the Warren Commission.

(6) The sciences associated with photography have been advanced significantly in recent years. New processes in chemistry and radio chemistry and new films make possible great sensitivity to changes in the light and dark tones of an image and in the recording of small details. (*3*) Another important development has been the use of com-

*Materials submitted for this report by the photographic panel were compiled by HSCA staff members Michael Goldsmith and Jane Downey.

**Arabic numerals in parentheses at the beginning of paragraphs indicate the paragraph number for purposes of citation and referencing; italic numerals in parentheses in the middle or at the end of sentences indicate references which can be found at the end of this report.

puter technology for the enhancement of photographic picture quality. (4)

(7) Accordingly, the panel was ultimately expected to apply, within the given time and monetary constraints, the most sophisticated photographic technology available to resolve outstanding issues related to the photographic evidence. These issues included the number, timing, and source of the shots, the identification of the murder weapon(s), the identity of the assassin(s) and possible coconspirators, the authentication of both the Kennedy autopsy materials and several incriminating photographs of Oswald with the alleged murder weapon, and the validity of the "second Oswald" theory.

A. *Selection of the Photographic Experts*

(8) Early in 1978, after consulting officers and members of the American Society of Photographic Scientists and Engineers, the committee convened a panel of experts with varied backgrounds in the photographic sciences to study the available photographic evidence related to the assassination and to advise on the newest analytical and scientific procedures which could be effectively applied.* The panel included a broad range of technological expertise, covering such diverse areas as photographic image enhancement, photogrammetry, photointerpretation, and forensic photography.** The photographic evidence panel was composed of the following individuals:

Harry C. Andrews, Ph. D., Image Processing Institute, University of Southern California, Los Angeles, Calif.

Richard J. Blackwell, B.S., M.S., Jet Propulsion Laboratory, Pasadena, Calif.

Thomas N. Canning, B.S., M.S., National Aeronautics and Space Administration, Moffett Field, Calif.

Robert Chiralo, B.S., M.S., the Aerospace Corp., Los Angeles, Calif.

David B. Eisendrath, B.A., consultant in technical and scientific photography, Brooklyn, N.Y.

Ronald Francis, Ph. D., School of Photographic Sciences, Rochester Institute of Technology, Rochester, N.Y.

William K. Hartmann, B.S., M.S., Ph. D., senior scientist, Planetary Science Institute, Tucson, Ariz.

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*Initially, an effort was made to limit membership on the photographic evidence panel to individuals who had never done any work for the U.S. intelligence community. Nevertheless, after spending weeks contacting various photographic specialists, it became apparent that most of the leading photographic scientists in this country have done some intelligence-related work. Accordingly, a previous affiliation with an intelligence agency was not considered to be an automatic basis for precluding someone from membership on the panel.

**Each of these terms has a particular meaning or technical trade usage among photographic scientists. The terms have been defined in the "Dictionary of Contemporary Photography" (L. Stroebel and H. N. Todd, Morgan & Morgan, Inc., publishers, Dobbs Ferry, N.Y. 1974) :

Forensic photography—The specialization of making photographs for law enforcement or related purposes.

Image enhancement—Any process by which a photographic record is improved, as by increase in sharpness or contrast, or by reduction in noise.

Photogrammetry—The technology of using photographic methods to make accurate measurements. The term, initially applied to aerial surveying and cartography, et cetera, has been extended to include other types of mensuration, even to photographic methods of fitting garments to a person. Also see photometrology.

Photointerpretation—The process (usually visual) of obtaining qualitative or quantitative information from a photograph. The term initially had a military connotation but has been extended to other areas, such as geodetic, agricultural, climatic, and population studies.

Bob R. Hunt, B.S., M.S., Ph. D., professor, systems and industrial engineering and optical sciences, University of Arizona, Tucson, Ariz.
Donald H. Janney, Ph. D., Los Alamos Scientific Laboratory, University of California, Los Alamos, N. Mex.
Ellis Kerley, B.S., M.S., Ph. D., chairman, department of anthropology, University of Maryland, College Park, Md.
Sgt. Cecil W. Kirk, Mobile Crime Lab, District of Columbia, Metropolitan Police Department.
Charles J. Leontis, B.S., M.S., the Aerospace Corp., Los Angeles, Calif.
C. S. McCamy, B.C.E., M.S., vice president, science and technology, Macbeth Division, Kollmorgen Corp., Newburgh, N.Y.
Gerald M. McDonnel, M.D., department of radiology, The Hospital of the Good Samaritan, Los Angeles, Calif.
Everett Merritt, retired scientist in analytical photogrammetry, geodesy, and astrophysics, Ridge, Md.
Paul G. Roetling, B.A., Ph. D., principal scientist, image processing area, Xerox Corp., Rochester, N.Y.
Frank Scott, B.S., M.S., the Perkin-Elmer Corp., West Redding, Conn.
Robert H. Selzer, B.S., M.S., M.A., Jet Propulsion Laboratory, Los Angeles, Calif.
Bennett Sherman, B.S., M.S., consultant on optics and allied sciences, Elmhurst, N.Y.
Philip N. Slater, B.S., Ph. D., professor, optical sciences, University of Arizona, Tucson, Ariz.
Clyde C. Snow, B.S., M.S., Ph. D., Chief, Physical Anthropology Division, Civil Aeromedical Institute, Federal Aviation Administration, Oklahoma City, Okla.
George W. Stroke, B.S., Ph. D., former professor of medical biophysics and electrical sciences at Harvard University and State University of New York, Stony Brook, N.Y.

*B. Image Enhancement Technology**

(9) Three types of enhancement technology were available to the panel.

1. PHOTO-OPTICAL/PHOTOCHEMICAL ENHANCEMENT

(10) The recording of a photographic image involves the optical and chemical properties of halide salts of silver. Silver halides, such as silver bromide, silver chloride, or silver iodide, are sensitive to light. Light falling on small grains of these salts makes the silver compounds reactive to other compounds known as developers. During the film development process, a developer separates the silver atoms from the halide atoms (for example, bromine, chlorine, et cetera), which can be washed away by other compounds, leaving an image or picture made up of the remaining grains of silver.(*5*)

(11) Thus, every photographic image is recorded by microscopic silver grains. The presence of these grains is directly a function of light, since light is required to change the silver halide compound so that it may be acted upon by the developer. Where no light falls upon the film, little or no silver will be deposited by the process of development. Where much light falls on the film, much silver will be deposited. The relation between the amount of light and of silver grains results in the creation of a photographic negative or image. The image is referred to as a negative because the regions of the film with little silver appear light, while those with much silver appear dark, even though the regions respectively correspond to dark and bright portions of the object photographed.

(12) Color photography is a simple extension of the process involved in black and white photography. A color photograph has three separate layers of silver grain. Each is sensitive to only one particular

*This section prepared under the direction of Bob R. Hunt.

primary color of light, a property achieved by color filtering compounds intermixed with the layers of grain. One layer might respond only to red, a second to green, a third to blue. Since all secondary colors can be composed from a proper mixture of these three primary colors, the film can record any color of light. In the color development process, the silver grains are replaced by color dyes, and the primary colors of the layers combine to form the true image colors.

(13) The visual qualities of a photographic image are governed by the physical and chemical properties of the constituents in the photographic process, for example, the actual silver halide compound used, the size of the silver halide grains and the distribution (from smallest to largest) of the sizes of the grains, the chemicals used for development, and the time and temperature at which development is carried out. Once a developed photographic image has been produced, the image carried by the silver grains is fixed within the developed piece of film.

(14) Other photographic processes can be used to amplify differences in deposited silver that are faint in the original film. The extent to which an image feature can be visually detected is associated with contrast, which is related to the difference between the brightest and darkest portions of an image. (*6*) Features with low contrast, that is, with small differences between the maximum and minimum deposition of silver grains, are difficult (or impossible) to detect visually. However, if differences do exist, it is possible to use photographic materials and processes to enhance them.

(15) Photo-optical and photochemical enhancement may be used to improve image contrast. This type of enhancement employs high contrast photographic materials and processes, that is, materials and processes which amplify low-contrast details, making greater the differences between bright and dark portions of the image so that they become visible. The experienced photographer often refers to these techniques as "darkroom exercises," because an enhanced copy of the original image is produced in the darkroom by selection of photographic materials, exposure time, and development chemistry.

2. DIGITAL IMAGE PROCESSING

(16) Digital image processing is the use of a digital computer to manipulate an image. When successful, this process may be used to clarify images by removing blur and altering contrast. The actual type of computer manipulation chosen depends on what is to be achieved. For example, computer enhancement of image detail requires a different computer process than that for measuring object dimensions.

(17) There are three important phases in computer image processing: (1) Image sampling and quantization; (2) computer processing of the image samples; and (3) re-creation of an image from the computer's output. (*7*)

(18) Sampling and quantization is the process of converting an image into computer numbers. An image is a representation of visible light, whereas a computer works with numbers. The visible light representation of an image must be converted into numbers of the kind used by the computer. This is done by a device generically referred to as a sampler/quantizer; as applied in this process, it is known as a scanning microdensitometer.

Simple Diagram of Computer Scan of Image

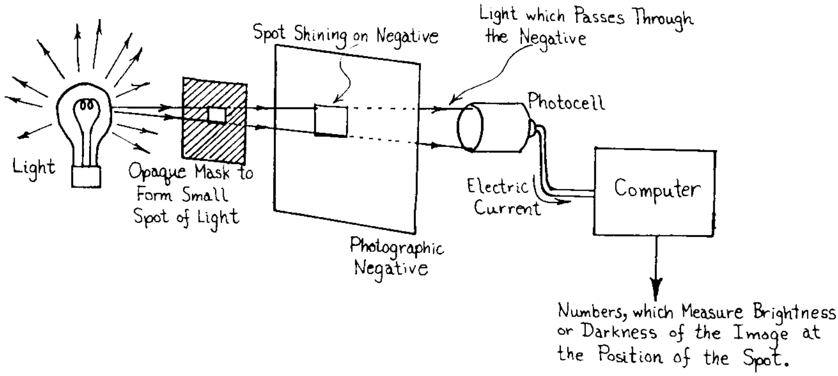

FIGURE I–1

(19) Figure I–1 (JFK exhibit F–149) is a schematic diagram of the sampling/quantization process. A small spot of light is projected onto a photographic transparency image. Light passes through the image at the position of the spot and is collected by a photocell. The amount of light collected is directly proportional to how dark or light the transparency is at that position. The collected light causes an electric current to flow; its strength is directly proportional to the strength of the light which passes through the image. The electric current is measured by the computer, which breaks the current into a discrete number of intervals and assigns a number, or value, for the amount of current in each interval.
(20) For example, the computer might divide an electric current, ranging from zero to a maximum of "I" amps,* into 1,000 intervals. If the current, when measured, falls into the 350th interval between zero and "I" amps, then the computer would assign the number "350" to that image brightness. By moving the light spot over the entire image, it is possible to extract all the important information. The actual number of samples which must be extracted is governed by a specific mathematical relation which depends on the content of the image. (*8*)
(21) The colloquial interpretation of sampling implies a partial

*Amps is the conventional abbreviation for amperes, the international standard for measurement of electric current. By convention, "I" symbolizes an unspecified amount of electric current.

extraction of information. Nevertheless, engineering usage of the term implies extraction of all relevant information; mathematical theorems prove that proper sampling does, in fact, extract all relevant information. In the context of digital image processing, the term sample refers to the size of the image area that is scanned by the microdensitometer. Thus, if there is a lot of information content (that is, in terms of small detail and fine structure), the samples (that is, areas scanned on the film) must be closely spaced and a large number will be required; if there is not a lot of information content, the samples need not be as closely spaced and a smaller number will be needed. Given typical processing conditions and common camera and film combinations, a matrix of samples ranging in size from 100 by 100 to as many as 1,000 by 1,000 samples or even more will be extracted.

(22) Color images can be sampled and quantized in the same way. The sampling must, however, be repeated three times; each repetition is carried out with a colored filter in the optical path of the microdensitometer. The proper choice of filters (for example, red, green, blue) leads to measurements of relative color strengths which make it possible to recreate any arbitrary color in the image.

(23) After sampling and quantization, the numbers that represent the image are run through a computer. A specific computer operation is selected on the basis of a mathematical model. The physical processes that took place in the creation of the photographic image can be described by mathematical equations. Even processes that resulted in an undesirable degradation of image quality can be described by such models. The numbers measured in the sampling and quantization process represent actual numerical values of the mathematical variables of the model.* The computer is used to solve the equations of the mathematical model, and the solution of the equations will be the numerical representation of an image that has been enhanced in some fashion. The actual type of enhancement will depend, of course, on the particular mathematical model used. *(9)*

(24) The third and final phase is to recreate an image from the numbers representing the enhanced image. There are two basic methods for recreating an image: hard copy and soft copy.

(25) Hard-copy image display can be exemplified by a system similar to the schematic diagram shown in figure I–1 (JFK exhibit F–149). The spot of light, its brightness converted by the computer according to the value of numbers corresponding to each image spot, is run over a piece of unexposed photographic film. When the film is developed, an image emerges, composed of all the small individual spot exposures. This method is known as hard copy because it produces a tangible item, the piece of developed film.

(26) In soft-copy display, the numbers in the computer are transmitted into a special computer memory, that can be used to position a spot of light on the face of a television display tube. The actual position of the light spot and its brightness will depend both on the particular computer memory location and the number occupying that location. By rapidly and repeatedly reading the numbers from the memory and writing light spots on the TV display, a display of the image is

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*A mathematician would say that the measured image's numerical values are "substituted" into the equations of the model.

created. It is similar to the image on a home television set, but is of far superior image quality to any home television display.

(27) Computer displays are referred to as soft copy because the image is transient on the face of the television display rather than a permanent thing. Computer soft-copy displays have a distinct advantage over hard-copy displays. The image is created from the contents of the computer's special memory, that can be altered by the computer. Any such change in the image is instantly visible on the screen. The image analyst can use this instant display of results to interact directly with the computer to produce mathematically an enhanced image with the most desirable visual qualities. Each of the three digital image processing facilities employed by the committee possessed interactive soft-copy display equipment, which played an important role in the creation of enhanced imagery for the Panel.

(28) It is important to understand the differences in effect between hard-copy and soft-copy methods of image display. Hard-copy displays are not as effective because they may suffer from degradation. A soft-copy display can produce a more brilliant image with a wider dynamic range than can a hard-copy display, i.e., the difference between darkest and brightest regions of the image will be greater. If color imagery is involved, the fidelity of color representation is more accurate in a soft-copy display. Unfortunately, the permanent visual results of an image enhancement process can be recorded only on a hard-copy display.* The quality of hard-copy displays reproduced in this report may be less than that of the soft-copy displays used by the Panel and contractors in their analysis and deliberations; the final conclusions of the Panel, however, were based on the best possible image displays, and not on the displays reproduced in this report.

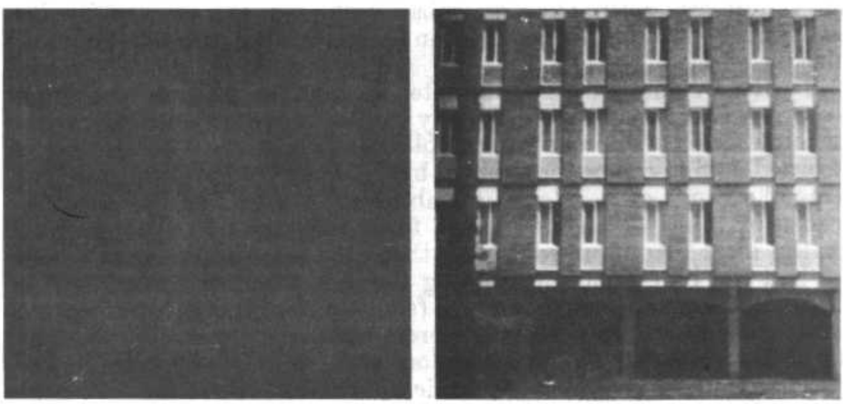


FIGURE I-2.—Computer Contrast Enhancement.

(29) Figure I-2 (JFK exhibit F-150) shows the type of image enhancement that may be achieved by an interactive soft-copy display. The original image, shown on the left, is of extremely low contrast, that is, the maximum and minimum brightnesses of the image are

*The computer tape storing the numerical values that have been assigned to the image samples can also be permanently retained, but this, of course, is not an actual visual record.

virtually the same; little detail is visible. Using an interactive display, the range of contrast was greatly expanded to produce the enhanced image shown at the right of the exhibit. The result is a dramatic improvement. (The "contrast" control on a home television receiver expands contrast in a similar way; however, a computer-controlled contrast expansion has much more flexibility than does a television receiver.)

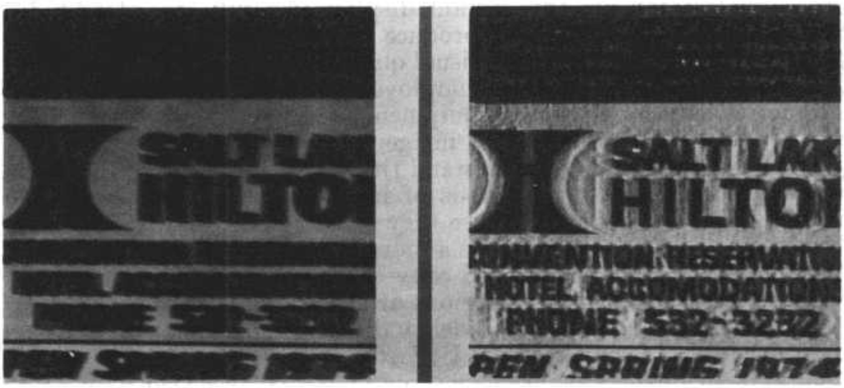


Figure I–3.—Successful Image Deblurring.

(30) Figure I–3 (JFK exhibit F–151) shows the different kind of enhancement that may be achieved with digital image processing. The photograph at the left was taken by a camera that was moved while the shutter was open. The sign is badly blurred, and most of its fine detail has been lost. The objective in enhancing this image is to minimize the effects of the blur.

(31) Removing an image blur after the picture is recorded on film is a process that has been extensively studied in recent years. The basic principle can be summarized as follows. The blurred image that is recorded on film can be represented by an image formation equation as being the result of an ideal (or unblurred) image that has been degraded by blur. (*10*) If the image formation equation can be solved for the ideal or unblurred image, then an image is produced which has had the blur removed. Solving the image equation requires the solution of hundreds of thousands (sometimes millions) of algebraic equations. The magnitude of this process made it impossible to carry out until the introductioin of new computing algorithms in the 1960's and the availability of large scientific computers.

(32) The image at the right in figure I–3 (JFK exhibit 151) shows the result of deblurring by this process. The increased legibility of fine detail and letters is dramatic when compared with the original.

(33) The process of image deblurring can be so dramatic that it is frequently misinterpreted as a magical "cure-all." There are fundamental limitations, however, on the extent to which a blur can be removed. These limitations are due to what is called "noise." Anyone who has lived in a "fringe-area" for television reception has seen noise in an image: the speckled or "salt-and-pepper" graininess visible in a weak television image (colloquially referred to as "snow") is the

result of random fluctuations in the weak electronic TV signal. Noise represents random uncertainties in the values of the image and is not attributable to any particular cause.

(34) Since these image values are used to solve the equations to produce a deblurred image, uncertainties or inaccuracies in these values lead to errors or inaccuracies in the solution. The more noise present in a blurred image, the more unsuitable a deblurred image will be. Figure I-4 (JFK exhibit F-152) illustrates this situation.

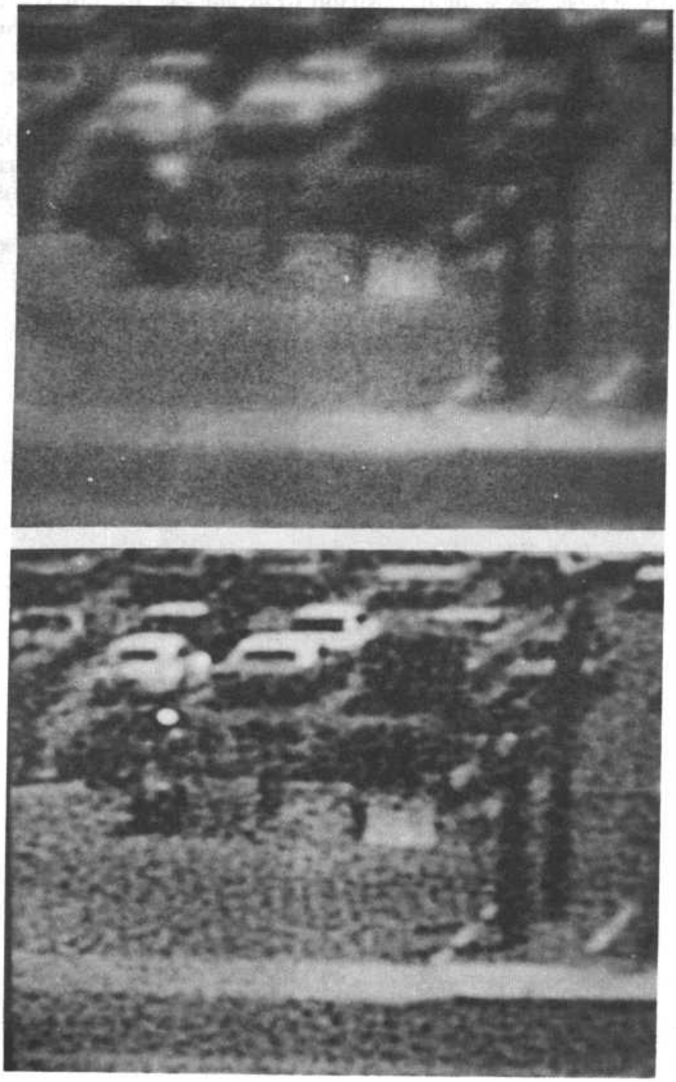


FIGURE I-4. Unsuccessful Image Deblurring

The original image on top is blurred and very noisy. The deblurred image on the bottom shows virtually no improvement in image quality due to the limitations imposed by noise.

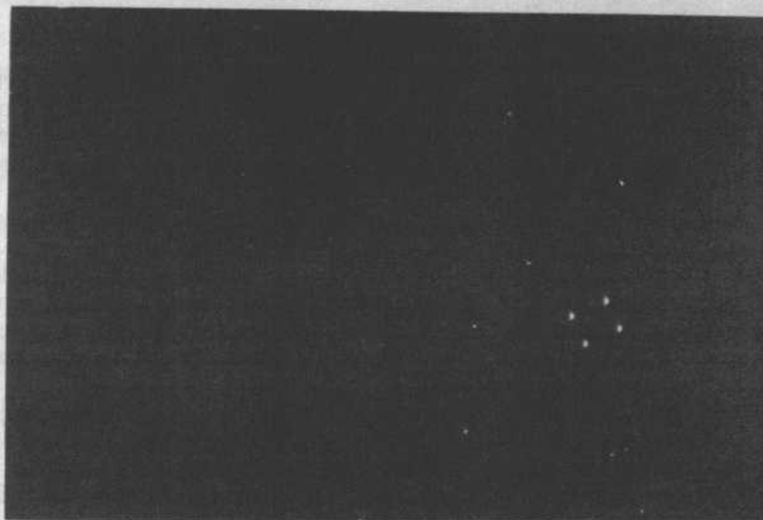
3. AUTORADIOGRAPHIC ENHANCEMENT

(35) Autoradiographic enhancement involves the use of a radioactive chemical to achieve enhancement of image contrast rather than the removal of image blur. (*11*) Autoradiographic enhancement is applicable only to black and white films.

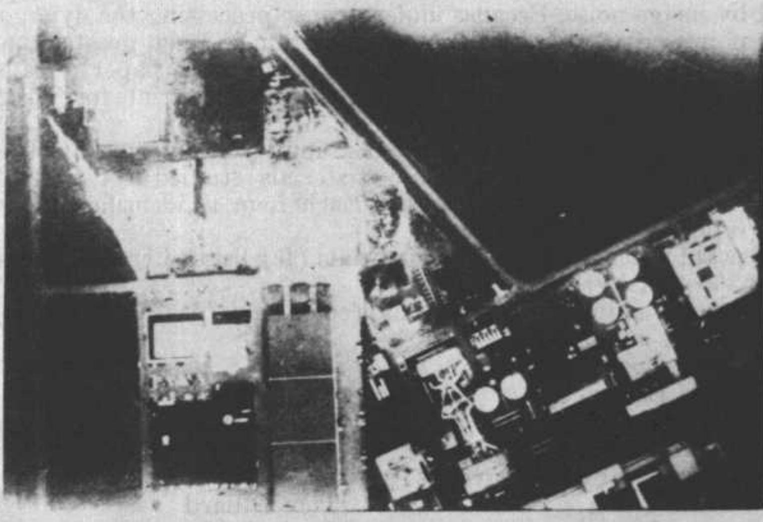
(36) As noted earlier, a photographic image is created by the deposition of minute silver grains. A minimum number of grains must be deposited for the image to be visible. Any weak light falling on a piece of film will cause some deposition of silver grains, but the number may be too small for interpretation. Autoradiographic enhancement tries to strengthen this weak image.

(37) This is attempted by bathing the film containing the weak image in a radioactive chemical that binds to silver, thereby making every silver grain a source of radioactivity. The radioactive film is placed in contact with a piece of X-ray film, which is exposed by the radioactive silver grains. The longer the X-ray and radioactive films are in contact, the greater the radioactive exposure of the X-ray film. When the X-ray film is developed, even very small numbers of silver grains in underexposed areas of a film will be made visible.

SRI INTERNATIONAL AUTORADIOGRAPHIC ENHANCEMENT OF PHOTOGRAPHIC IMAGES



(a) AERIAL PHOTOGRAPH, UNDEREXPOSED BY A FACTOR OF 12



(b) AUTORADIOGRAPHIC INTENSIFICATION OF AERIAL SCENE SHOWN IN (a)

Type R x-ray film, 48-hr exposure.

MP-319583-53A

(38) Figure I–5 (JFK exhibit F–154) illustrates the application of the autoradiographic enhancement procedure. The original image is severely underexposed; there was only one-twelfth as much light as was needed to expose the negative properly. The enhanced image is the result of the autoradiographic technique.

C. Source Materials for Enhancement

(39) Image enhancement can result in dramatic photographic clarification, but the extent of improvement is limited by the quality of the original images. That is, an image may be so severely degraded that no combination of enhancement techniques can improve it. One parameter already mentioned that limits enhancement is image noise.

(40) Any photographic copying process will introduce some noise into a copy. In most cases, this new noise will not be detrimental. Moreover, in general, there are so many other potential difficulties in image copying such as loss of sharpness and resolution, loss of contrast, and loss of gray tones that it is undesirable to attempt to enhance these copies. The Panel made a decision to work only with original images for enhancement.

(41) The Panel also adopted a policy of working with transparency images as much as possible as distinct from prints that are on an opaque base. An important property of any image is the dynamic range of values of brightness from smallest to largest. Given a certain level of photographic noise, an image with a wide dynamic range is preferable to one with a narrow dynamic range because the accuracy of brightness representation increases as the dynamic range increases. In effect, the wider the dynamic range, the less interference is occasioned by image noise. Because under proper processing the dynamic range of images recorded on transparency film is much greater than with opaque film (for example, photographic print paper), transparency film images are preferable as source material for image enhancement.

(42) Following is a list of the most important original (unless otherwise indicated) photographic materials studied for possible enhancement and analysis purposes. Each item is identified by its photographer's name:

1. Oswald "backyard picture" materials (for list of items, see paragraphs 366–370, *infra.*)
2. Kennedy autopsy photographs (color and black and white), transparencies and X-rays.
3. Color photographs:

Wilma Bond	Jim Towner
*Robert Croft	Phillip Willis
James Powell	

4. Black and white photographs:

William Allen	Tom Dillard
James Altgens	*Joe Laird
*Jack Beers	Mary Moorman
*Hugh Betzner	*Jim Murray
Richard Bothun	Arthur Rickerby
*Tom Cablack	*George Smith
*Frank Cancellare	*George Weaver
*Malcolm Couch (movie stills)	*David Weigman (movie stills)

5. Motion picture films:
*Thomas Alyea
Mark Bell

Dallas Cinema Associates combined sequences taken by 18 photographers, including John Martin and Charles Mentensana; for others see H. Weisberg, *Photographic Whitewash: Suppressed Kennedy Assassination Pictures* (published by author, 1967), p. 254.

Elsie Dorman	*Patsy Paschell
Robert Hughes	Tina Towner (Barnes)
Marie Muchmore	Abraham Zapruder
Orville Nix	

NOTE: Initially, Robert Groden, a photographic consultant to the committee advised the panel as to pertinent photographic issues and related materials. Committee investigators located many of the suggested films and photographs, however, some items were never located, i.e. the Babushka Lady film, a color photograph by Norman Similas, and the original negative of the Betzner photograph.

D. Panel Procedures

(43) The Photographic Evidence Panel was responsible for establishing the guidelines and procedures under which all of the committee's photographic enhancement and analytic work was to be accomplished. Because of the large quantity of material to be examined, it contracted with several laboratories to perform, under its general direction, all necessary photographic enhancement work and, on occasion, some analytic work as well.

(44) Photo-optical/photo-chemical enhancement was undertaken by a team of professors at the Rochester Institute of Technology, and digital image processing was performed by the University of Southern California Image Processing Institute, the University of California Los Alamos Scientific Laboratory and The Aerospace Corp. Once these contractors had completed their work, the results were submitted to the Panel for interpretation and its own independent analysis.

(45) The Photographic Evidence Panel first met with the committee and representatives of the laboratories in February 1978. At that time, the Panel was apprised of the issues that the photographic evidence touched upon, and assigned the overall task of examining the photographic material compiled by the committee.

(46) After the Panel had reviewed these materials, enhancement and analytic projects were outlined and assigned to the laboratories. Analytic studies were also assigned to individuals and groups within the Panel, according to their respective specialties. The work was conducted with periodic reviews by the Panel, between February and mid-July, when the Panel held its final conference to evaluate all the results.

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*Copy prints.