several inches. As a physical anthropologist, Dr. Snow, what have you observed on this issue of height?

Dr. SNOW. I have had a wide experience in examining skeletal cases where we estimate the unknown individual's height from his bones then compare those with police records of missing individuals.

In reviewing many police records, I find that it is not uncommon to have discrepancies plus or minus 1 or 2 inches in height reported between one arrest record and another.

Mr. EDGAR. Would that also vary in the type and method of determining the height of the particular prisoner?

Dr. SNOW. Yes, sir. It varies a great deal with the technique used to measure him, the time of day, and many other variables that influence the height.

Mr. EDGAR. Thank you. I have no further questions.

Chairman STOKES. Are any other members seeking recognition?

[No response.]

Chairman STOKES. Dr. Snow, at the conclusion of the testimony of many witnesses before this committee, under our rules he is entitled to 5 minutes in which he may comment upon his testimony or in any way change his testimony or expand upon it. I would extend to you at this time 5 minutes for that purpose if you so desire.

Dr. SNOW. I would just like to point out that the anthropology consultants will be presenting a detailed final report on our findings for publication by the committee. Also I would like to say—and I speak for my colleagues too—it has been a pleasure to work with the very fine young people that you have on your staff; and that if their energy, efficiency, competence, and enthusiasm is any indication of the kind of talent you can draw on in the Congress, then I think the country is in a lot better shape than a lot of people think it is.

Chairman STOKES. Thank you very much, Dr. Snow. On behalf of the committee, we certainly thank you and all of your panel for the work you have done for this committee, and we look forward to your final report.

The Chair recognizes Professor Blakey.

STATEMENT OF MR. BLAKEY

Mr. BLAKEY. Thank you, Mr. Chairman.

There are other photographs, both still and motion picture, that were taken at the scene of the assassination that suggest to critics a conspiracy. These don't show alleged accomplices or masterminds who possibly could be identified. Rather, they show shapes or blurred images that critics have contended are gunmen. Most of these gunmen are in the vicinity of the grassy knoll.

In the years since the assassination, significant progress has been made in the field of photographic enhancement. New chemical and computer processes have been developed that record and improve picture quality.

The select committee assembled a group of photographic consultants to conduct a thorough analysis of photographic materials to see if there is, in fact, visual evidence of gunmen in Dealey Plaza. The members of this panel are scientists from leading educational

institutions and private corporations whose field of specialization is photographic enhancement.

Representing the panel today is Dr. Bob R. Hunt of the University of Arizona. Dr. Hunt received a B.S., cum laude, in aeronautical engineering from Wichita State University, an M.S. in electrical engineering from Oklahoma State University, and a Ph. D. in systems engineering from the University of Arizona. He has been an adjunct professor of electrical engineering and computer science at the University of New Mexico and an alternate group leader at the University of California's Los Alamos Scientific Laboratory. Currently, he is an associate professor of systems and industrial engineering and optical sciences at the University of Arizona.

Dr. Hunt is a member of the Optical Society of America and the American Society of Photogrammery. He was the recipient of the NEDA Fellowship in 1964 and a NASA Traineeship in 1966.

Dr. Hunt is the author of numerous publications.

It would be appropriate at this time, Mr. Chairman, to call Dr. Hunt.

Chairman STOKES. The committee calls Dr. Hunt.

Will you please raise your right hand?

Do you solemnly swear the testimony you will give before this committee will be the truth, the whole truth, and nothing but the truth, so help you God?

TESTIMONY OF DR. BOB R. HUNT

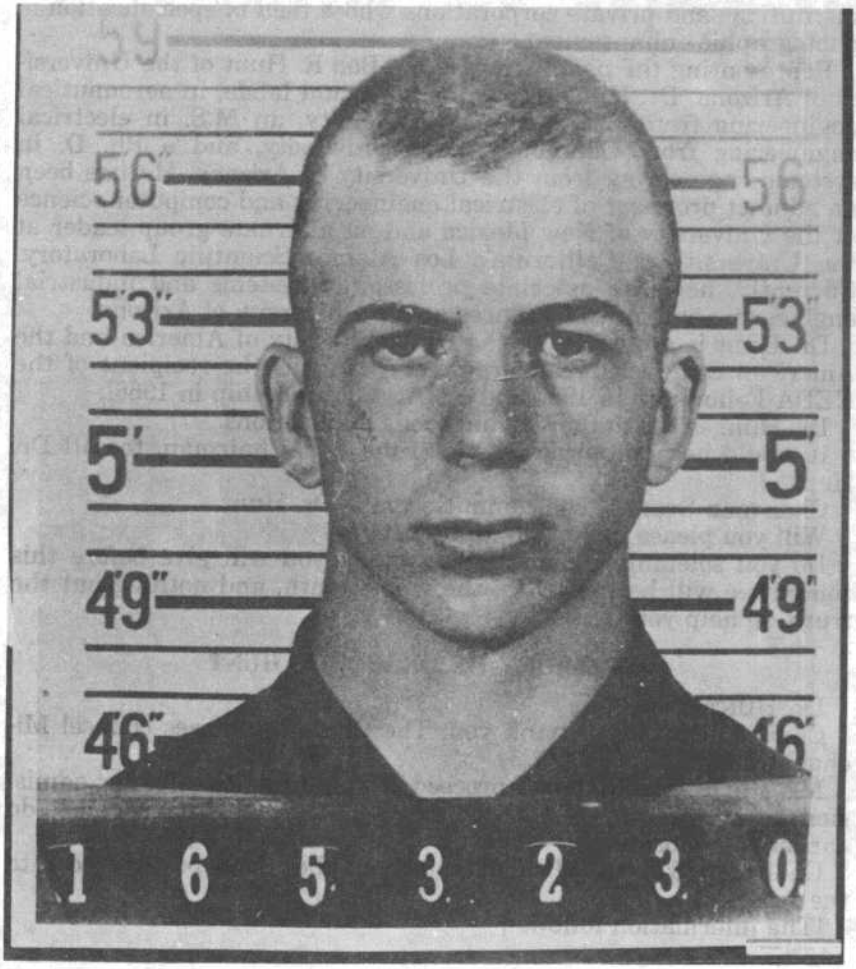
Dr. HUNT. I do.

Chairman STOKES. Thank you. The Chair recognizes counsel Michael Goldsmith.

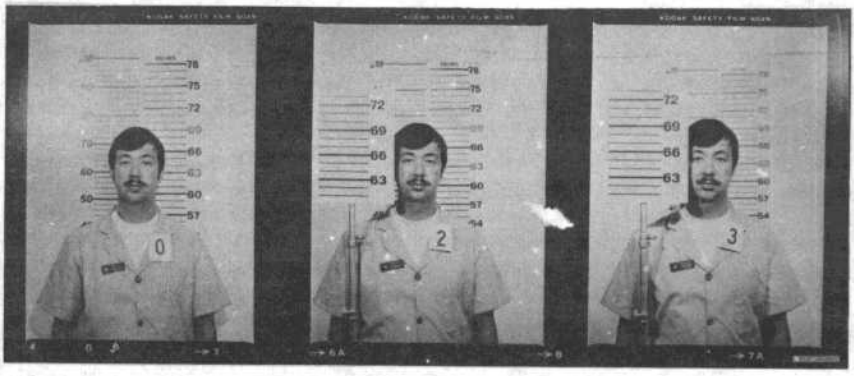
Mr. GOLDSMITH. Before I proceed, I would like to offer for admission into the record JFK F-166 and F-564, which I neglected to do earlier this morning.

Chairman STOKES. Without objection, they may be entered into the record.

[The information follows:]



JFK Exhibit F-166



JFK Exhibit F-564

Mr. GOLDSMITH. Dr. Hunt, what was the photographic evidence panel asked to do with the various pictures and films that have been alleged to show gunmen in Dealey Plaza?

Dr. HUNT. We were given two tasks. The first task was to apply modern technology in the enhancement of imagery. The second task, of course, was to interpret the results of that processing and to bring results of our interpretations and conclusions to the select committee.

Mr. GOLDSMITH. What methods were used to clarify the available photographic evidence so that the best possible images could be used for analysis and interpretation?

Dr. HUNT. There were three different methods utilized by the photographic panel. The first method was common photographic enhancement or photo-optical enhancement, sometimes referred to as darkroom techniques.

The second method of technology utilized was that of digital image processing, and a third area, that of autoradiographic enhancement?

Mr. GOLDSMITH. Would you go into detail as to the photo-optic enhancement?

Dr. HUNT. This process refers to the printing or recopying of the negative by different types of copying papers or films, using different darkroom developers and times, and which results in a feature which was more detailed by expanding the dark and light regions of the image.

Mr. GOLDSMITH. I would ask at this time Dr. Hunt be shown JFK exhibit F-149.

I would ask that you step to the easel to examine this particular exhibit.

You made reference earlier to the term "digital image processing." Using this exhibit, please explain what you meant by this term.

Dr. HUNT. The first obstacle is to overcome the difference in what a computer uses and what an image is. An image is a representation of light which we see with our eyes, but a computer only works with numbers, sequences of digits. So the basic problem is to convert that representation of light into a sequence of numbers.

The way of doing that is to first of all have a source of light. That source of light is imaged through an opaque mask onto a photographic negative. Light passes through the negative and it is then observed and collected by a photocell, which is really no different than you would see guarding the doors of an elevator, except it is a scientific instrument.

From the photocell, we generate electric current, which is measured by the computer.

That photocell is then measured by the computer. The computer converts that electric current into numbers and the numbers are then manipulated in the computer.

The end result of all this is a set of numbers which measure brightness or the darkness of the image in the particular position where the spot is at and then we reposition the spot everywhere

over the photographic negative of the image itself so as to extract all pertinent information.

Mr. GOLDSMITH. Are you able to state, when a negative or piece of film is scanned, how many spots are actually scanned—let me rephrase that: How many spots actually receive assignment of numbers to them?

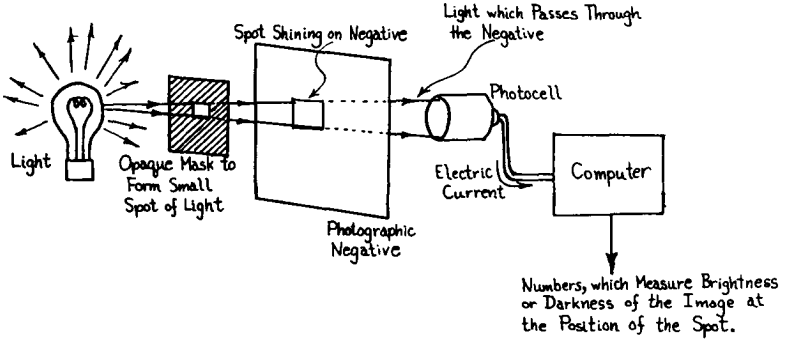
Dr. HUNT. The number of spots to which you have assigned numbers is a thing that is governed in a fairly precise mathematical way by the nature of the image itself. For example, of the photographic material we dealt with and which was provided to us by the committee, the number varied from, say, 16,000 to 20,000 different numbers all the way up to as many as a quarter of a million to a million numbers.

Mr. GOLDSMITH. Mr. Chairman, I move for introduction into the record of JFK exhibit F-149.

Chairman STOKES. Without objection it may be entered into the record.

[JFK exhibit F-149 follows:]

Simple Diagram of Computer Scan of Image



JFK EXHIBIT F-149

Mr. GOLDSMITH. Now you made reference earlier to digital image processing as an enhancement technique, a technique to improve the quality of the photo image. How are the numerical values that you obtained used to improve the quality of the image?

Dr. HUNT. Well, every type of image formation process, even one which results in degradations of the image, every type of image formation process can be described by mathematical models, mathematic equations which, if you substitute the numbers into them which represent the image, can be solved and the solutions of those equations gives you an enhanced or improved version of the image.

Mr. GOLDSMITH. Once a negative has been subjected to digital image processing, how is the resulting image actually displayed?

Dr. HUNT. There are two different methods by which you would display or recreate the numbers and bring forth an image out of the numbers as they exist in the computer.

One of those methods could be exemplified by the diagram I have here except that, instead of putting a negative in the position which I show here on the chart, we would put an unexposed piece of film there. We would then simply reexpose that piece of film by varying the strengths of the light which is shining through onto the film. That one method is referred to as hard copy because it produces a tangible thing, namely, a piece of film which has been exposed and can then be developed.

A second method of recreating imagery for the purposes of viewing it is to use what is referred to as soft copy. In soft copy the numbers which exist in the computer are not used to generate film. In soft copy those numbers are written into a computer memory, the nature of that being such that you can use it to position a beam of light on a TV tube and by very rapidly scanning that TV monitor screen, a display screen is what it is usually referred to, you would get a display of the image which appears for all intents and purposes just like your home television set, with one exception; it is of much higher quality.

Mr. GOLDSMITH. Does the computer display that you refer to as soft copy lend itself in any way to analytical work?

Dr. HUNT. Yes; because if you can use the computer to manipulate the numbers which are in the memory which are causing that TV picture to be created, as you manipulate those numbers you can see the results of it instantaneously and bring what is usually referred to as human feedback, begin to achieve better and better enhancements without having to wait for the process of film development and wet chemistry, as it is usually referred to.

Mr. GOLDSMITH. When you manipulate the numbers, does the image on the computer display actually change in any way?

Dr. HUNT. Yes. You can see it change as you manipulate the numbers.

Mr. GOLDSMITH. And can you describe generally what ways it might change?

Dr. HUNT. For example, you might be able to change the overall brightness and darkness of the image so that things which were in deep shadows become very visible by bringing up the deep shadows into something that would be brighter and then they would show up on your original negative.

Mr. GOLDSMITH. When the committee's photographic evidence panel examined materials that had been subjected to digital image processing, did they rely upon soft copy or hard copy for their analytical work?

Dr. HUNT. Most of our analytical work was done with soft copy.

Mr. GOLDSMITH. And where was that analytical work actually done?

Dr. HUNT. There were three different contractors which carried out the analytical work: the University of Southern California-Los Angeles; Los Alamos Scientific Laboratory in New Mexico, and the Aerospace Corporation, also in Los Angeles.

Mr. GOLDSMITH. Did each of those facilities have soft copy facilities available for analytical purposes?

Dr. HUNT. Yes, they did. In fact they had some of the finest equipment in the world for those purposes.

Mr. GOLDSMITH. Is there any change in the quality of the enhanced photographic image when it is taken off the computer display and converted into hard copy?

Dr. HUNT. Yes; there is a change.

Mr. GOLDSMITH. What is the nature of that change, Dr. Hunt?

Dr. HUNT. The nature of the change is usually that soft copy will look better than will hard copy. The reason for that is modern technology, in cathode ray tube displays, what we usually refer to as TV monitors. That modern technology is so good that you can produce more light, more vivid colors, and equally as good resolution as you would expect on a piece of photographic film.

Mr. GOLDSMITH. How has this change in quality affected the hard copy exhibits that will be discussed today?

Dr. HUNT. We will show some hard copy exhibits today which will probably lack some of the colors and the vividness of the colors which we would see if we were able to bring a cathode-ray tube display or TV monitor into this room.

We would also see, because of the processes of reenlarging some of these images, some loss in sharpness as well.

Mr. GOLDSMITH. But again for purposes of clarification, the photographic evidence panel's analytical work was based largely upon the computer display?

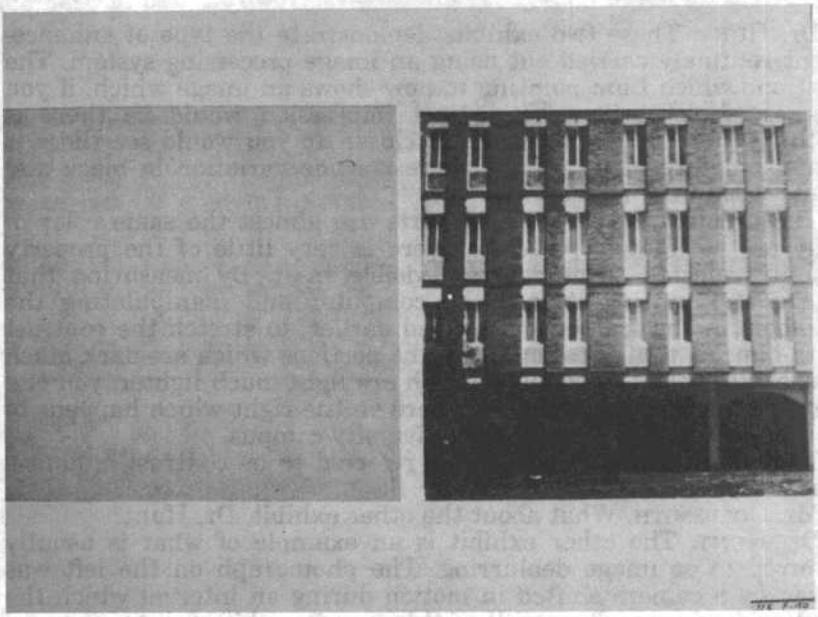
Dr. HUNT. That is correct.

Mr. GOLDSMITH. I would ask you at this time, Dr. Hunt, to refer to JFK F-150 and F-151.

Mr. Chairman, I move for the admission of these two exhibits.

Chairman STOKES. Without objection they may be entered into the record at this point.

[The information follows:]



JFK Exhibit F-150

JFK Exhibit F-151

Mr. Goldsmith. Dr. Hunt, what are these two exhibits designed to demonstrate?

Dr. HUNT. These two exhibits demonstrate the type of enhancement routinely carried out using an image processing system. The first one which I am pointing to now shows an image which, if you were to look at it, your distinct impression would be there is nothing there. If you could see it closer up you would see there is some structure in it, namely there is some variation in black and white within the image.

The problem is the blackest parts are almost the same color of gray as the lightest parts. So there is very little of the property usually referred to as contrast visible in it. By measuring that image and putting it into the computer and manipulating the numbers in the fashion I described earlier, to stretch the contrast of the image, that is to say make the portions which are dark much darker, to make the portions which are light much lighter, you end up with the image you see over here on the right which happens to be a dormitory building on the university campus.

That is an example of what is referred to as contrast enhancement.

Mr. GOLDSMITH. What about the other exhibit, Dr. Hunt?

Dr. HUNT. The other exhibit is an example of what is usually referred to as image deblurring. The photograph on the left was taken by a camera shifted in motion during an interval which the shutter was open. The result of this is quite a bit of distortion and blur.

For example, none of the letters which you see in the upper portion of this exhibit are visible. You would have, I think, a great deal of difficulty recognizing any of the letters. What we do, after converting that picture into numbers, is put together a set of equations which describe the process of blurring, solve that set of equations, and the new numbers which come out are represented by the picture on the right.

You can see how we have sharpened up the edges of all the letters and, most importantly, the fine details in the letters at the tip of the picture are quite visible. You can read things, for example, that this is a project financed by the Zion First National Bank of Salt Lake City.

Mr. GOLDSMITH. Dr. Hunt, are there any limitations on the extent to which the quality of an image can be improved through digital image processing?

Dr. HUNT. Yes; there are. There are fundamental limitations essentially referred to by the engineers as noise.

Mr. GOLDSMITH. Let me show you JFK F-152 and I would ask you to describe those limitations in some detail for us.

Dr. HUNT. Certainly. Anybody who has ever lived in a fringe television reception area realizes that if he turns on his TV set he is likely to see a picture cluttered by quite a bit of salt and pepper effect. The colloquial terminology for that is snow.

The upper picture in this exhibit represents an image in which we have a very poor quality of the image and it is cluttered by a great amount of this noise which we refer to as snow. We try to enhance the quality of that image by, first of all, if you wish, smoothing out the snow or noise which exists in it and trying also to sharpen up the edges and details in it in a fashion very similar to the previous exhibit. We were not able to do that with any great

success. Some things are more visible in the image. But by and large, the limits of noise, or snow if you wish, have stayed with us througout the enhancement process and we are not nearly as satisfied with the enhanced image as we would like to be.

Mr. GOLDSMITH. Does the ability to improve the quality of an image depend at all upon the initial quality of the film or negative?

Dr. HUNT. Oh, yes. For example, if you are not presented with an original negative, suppose somebody hands you a copy on a piece of paper, the process of copying itself will cause a loss of information of a kind that will be detrimental to the process of enhancing it.

Mr. GOLDSMITH. Is the quality of the enhancement affected at all by the quality, for example, of the motion picture?

Dr. HUNT. Oh, yes; yes, that too. In fact it is possible to degrade an image beyond which it cannot be recovered, the information in it cannot be recovered.

Mr. GOLDSMITH. If a film has good quality to begin with, in other words a relatively clear picture, is it easier to enhance that film than a film which was of relatively poor quality to begin with, one that is fuzzy and shaky to begin with?

Dr. HUNT. It is; yes.

Mr. GOLDSMITH. What would the reason for that be?

Dr. HUNT. The reason for that would be that there would probably be less severity of the extent of the blur or fuzziness with respect to the amount of noise which had been included in it by the process of forming the image.

Mr. GOLDSMITH. Fine.

You made reference to the term "autoradiographic enhancement." Would you define that process for us?

Dr. HUNT. Yes. Autoradiographic enhancement is the use of a radioactive chemical which fixes itself to the image surface. Every photographic image is composed of small silver grains, literally grains of silver, the same silver we would know as a jewelry component. What we would do is to affix to the silver grains a chemical, which is radioactive and consequently emits a small amount of radiation such as X-rays. You place that radioactive film next to a piece of X-ray film and the picture literally takes an X-ray of itself, which is the source of the term autoradiography.

Mr. GOLDSMITH. I would ask you to refer to JFK F–154. Please describe the effects of autoradiographic enhancement.

Dr. HUNT. Certainly. There is a picture prepared by Stanford Research Institute, which is the corporation which has developed the autoradiographic process, and pioneered most of it.

The upper picture shows an aerial photograph, that is to say a picture taken from a plane flying overhead and looking down at the ground. That aerial photograph has been underexposed by a factor of 12, that is to say there is 12 times less light available in that exposure than there should have been in the optimum case.

The lower image shows the result of using this radioactive chemical to intensify the image and then taking an X-ray of itself. You can see quite a bit of features have shown up; some of it looks like a harbor area, tanks, airplanes, and so on.

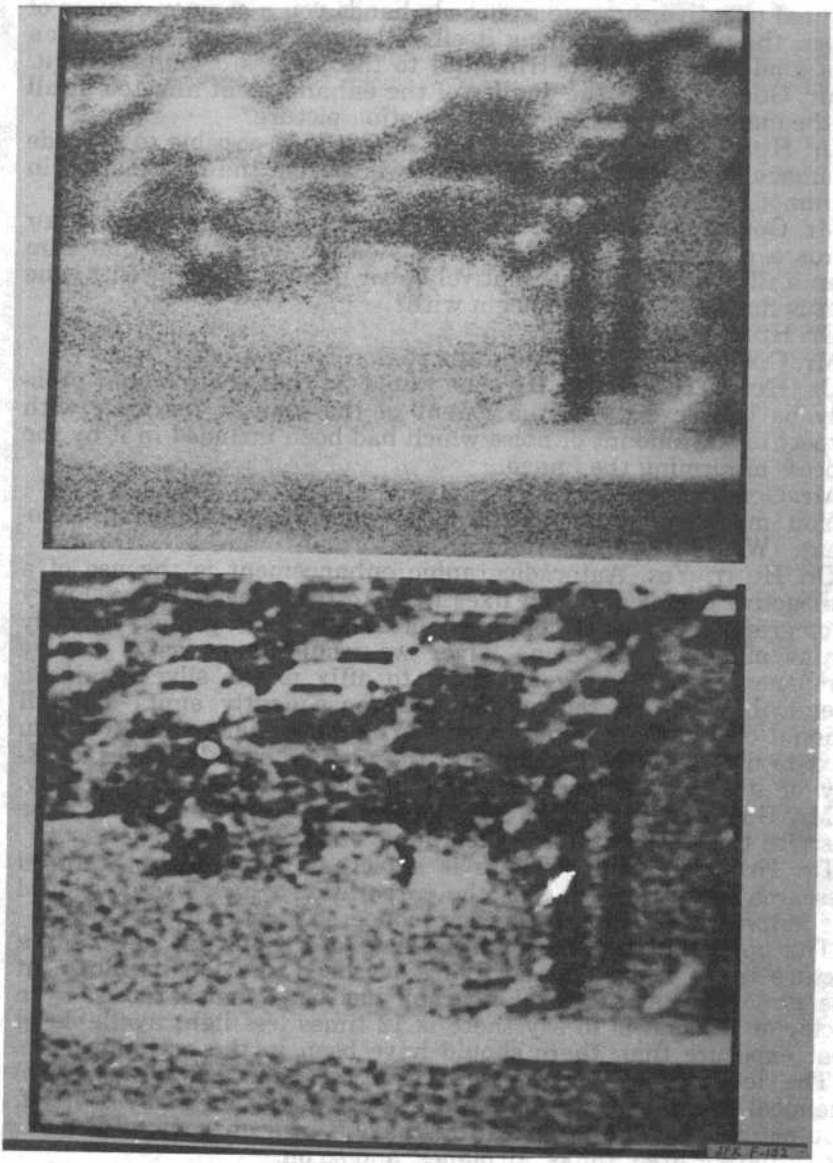
Mr. GOLDSMITH. What types of photograhic materials can this process be applied to?

Dr. HUNT. It can only be applied to black and white film. Color film is not applicable.

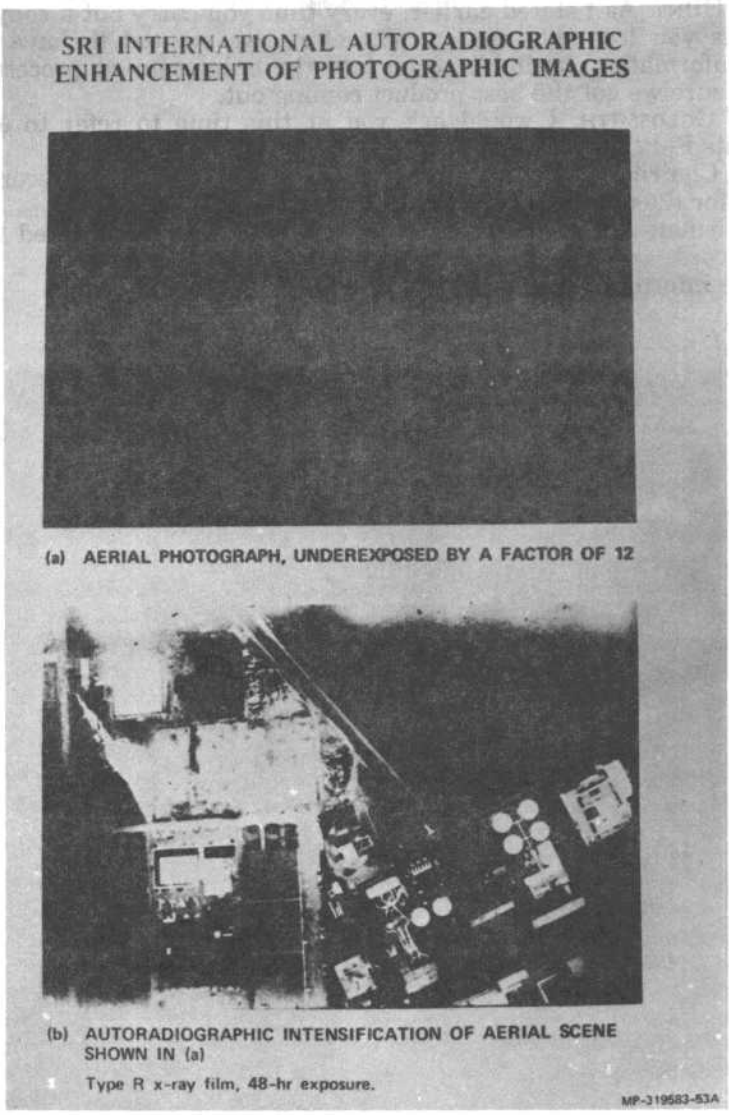
Mr. GOLDSMITH. Mr. Chairman, I move for the admission into the record of JFK F-152 and JFK F-154.

Chairman STOKES. Without objection they may be entered into the record at this point.

[The information follows:]



JFK EXHIBIT F-152



JFK EXHIBIT F-154

Mr. GOLDSMITH. Dr. Hunt, in general what types of photographic materials did the panel subject to these various types of enhancement methods?

Dr. HUNT. We subjected original color slides, black and white negatives, a black and white Polaroid print and color motion pictures.

Mr. GOLDSMITH. What was the reason for limiting your work, your enhancement efforts to original materials?

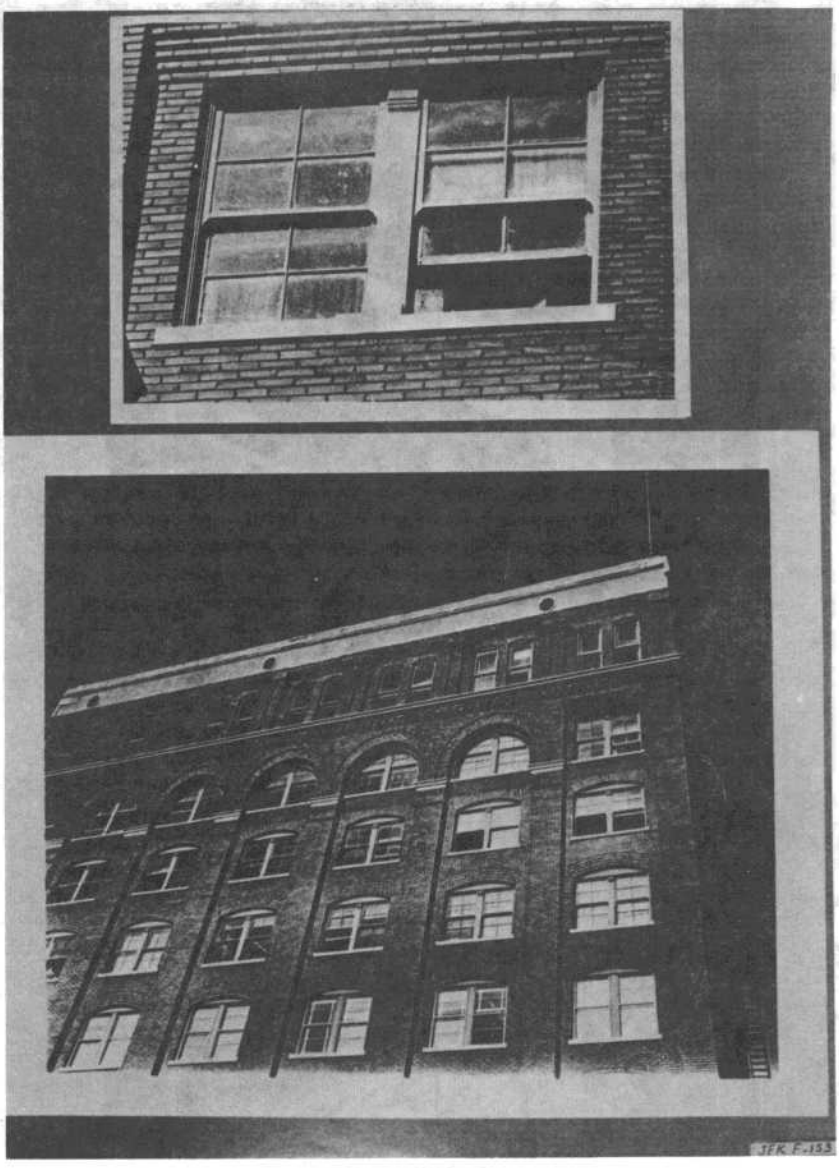
Dr. HUNT. As I stated earlier, every time you carry out a copying process you lose information. Therefore, we wanted to have the best information available to go into the enhancement process to make sure we got the best product coming out.

Mr. GOLDSMITH. I would ask you at this time to refer to JFK exhibits F-121, F-153 and F-157.

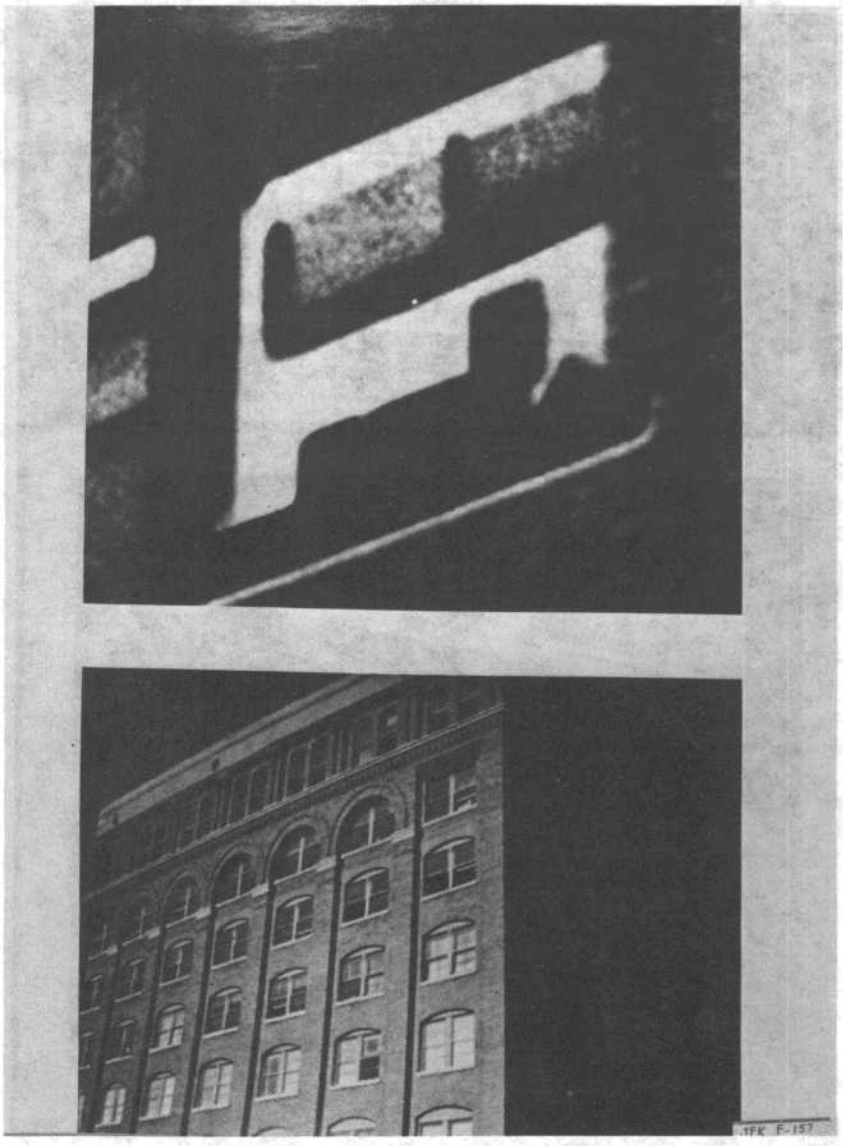
Mr. Chairman, 121 has already been admitted into the record. I move for the admission of JFK F-153 and F-157.

Chairman STOKES. Without objection, they may be entered into the record.

[The information follows:]



JFK Exhibit F-153



JFK EXHIBIT F-157

Mr. GOLDSMITH. Thank you. Dr. Hunt, would you identify these exhibits?

Dr. HUNT. Yes. F-121 is a split view in which the upper portion shows the sixth floor of the Texas School Book Depository, the lower portion of it being an enlargement of the open sixth floor window. This is taken from an 8 millimeter motion picture film which is usually referred to as the Hughes film.

Exhibit F-153 also shows the School Book Depository but it is a black and white image taken by a photographer by the name of

Dillard. The lower portion of the photograph as it was originally on the negative, the upper portion is the increased or enlarged scale of that centering on the sixth floor window.

Exhibit—I can't see the number—F–157 is a third photograph of the Texas School Book Depository. Again the object of interest is the open sixth floor window in the lower portion. This is the original 35 millimeter slide, the print made from the 35 millimeter in the lower portion. The upper portion is the result of a computer enhancement of the contrast as well as computer recoloring the information to bring out extra detail.

Mr. GOLDSMITH. Of these three exhibits, the only one that shows enhancement work I take it is JFK F–157.

Dr. HUNT. That is correct.

Mr. GOLDSMITH. And there only the top photograph has been enhanced, is that correct?

Dr. HUNT. That is correct.

Mr. GOLDSMITH. Do you know the time sequence that separates these three photographs?

Dr. HUNT. Yes. The Hughes film, for example, from which exhibit F–121 was taken, that is a motion picture film which follows the Presidential caravan as it proceeds down the street and makes a left turn directly in front of the School Book Depository. That is about, not about, exactly 88 frames of 8 millimeter motion picture imagery. We know from the position of where the Presidential car turned that it terminates approximately 5 seconds prior to the first, what is believed to be the first shot, and that therefore gives us a time span for those 88 frames of about 10 seconds before the first shot to about 5 seconds before the first shot.

Now the second picture, the Dillard picture, was taken from a press car which was following the Presidential caravan. I believe testimony that Dillard gave before the Warren Commission indicated that he took that picture just a few seconds, his own term I believe, after the last shot was fired.

And finally this third image, taken by Mr. Powell, is believed to have been taken, on testimony by Mr. Powell, 1 to 2 minutes after the last shot was fired.

Mr. GOLDSMITH. What issues were raised by these photographic materials?

Dr. HUNT. The issues principally concern themselves with what is visible within the sixth floor School Book Depository window. I am pointing to the window on the sixth floor and there is evident there a rectangular shape. If you view this motion picture, the Hughes film, for example, as I am pointing to now, if you view this in a motion picture sequence, one notices several things.

First of all, the image formed at this window positions itself near the top left edge of the frame and then, as the camera pans, following the Presidential car, that image begins to drift and move in toward the center. As you watch it do that, you get the distinct impression there is some sort of motion or a change of the object within the window. So the issue, of course, is exactly what are we looking at there? Is that the potential assassin? That is the issue presented by the Hughes film.

Mr. GOLDSMITH. Dr. Hunt, before you proceed to the Dillard photograph, was any other issue presented by the Hughes film aside from the motion in the alleged assassin window?

Dr. HUNT. Yes. There is another set of windows over here immediately to the left and off of this particular print which was made which shows another set of windows in the School Book Depository and there have been assertions or allegations that something can be seen with respect to a person or persons in that window looking out.

Mr. GOLDSMITH. Please proceed now to the Dillard exhibit.

Dr. HUNT. OK.

The Dillard exhibit, since it has been taken presumably just a few seconds after the last shot was fired, if we look at an enlargement of that image, the question we concern ourselves with is the following: There are some objects very definitely visible in front of that window. There is a box, what we interpret to be a box, another box sitting over there. But behind the window there is a great deep shadow. The question is, within that deep shadow is it possible to see things by contrast enhancement techniques of the kind that I described earlier?

Mr. GOLDSMITH. That is essentially the same issue that exists for the Powell photograph?

Dr. HUNT. That is correct, essentially the same issue, namely to look inside, what is the deep shadow in that window.

Mr. GOLDSMITH. What type of enhancement method was applied to the Hughes film?

Dr. HUNT. The Hughes film was enhanced in the following way: We took the 88 frames which were available to us from the original film recorded by Hughes and the process of digitizing those 88 frames, as I described earlier, was carried out. After it was carried out, the following things were done: We recognized there was a change in contrast in each frame of the film. By that we mean that the overall brightness and darkness of the image seemed to change from frame to frame which, incidentally, is not an uncommon thing to have occur. So the first thing we did was to use the computer to equalize the contrast in each frame. By that we mean that the same values of brightness and darkness were forced on the image by the computer.

The second thing we noticed was there was a change in focus from frame to frame occasionally as the camera takes its picture and the film moves around slightly in the focal point. We changed those scales slightly to compensate for the change in focus. Once that work was done, we then went into the process of trying to determine what was happening in the way of motion. The way we did that was to put this picture on a soft copy computer TV display of the kind that I described.

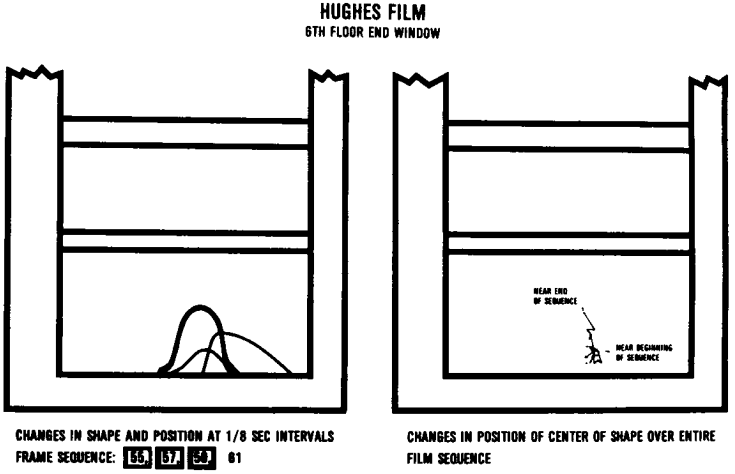
Once it was on that display, an operator has the ability to position the small dot anywhere in the picture which is given on that display. He positions that dot in the center of the object which we see and then, once the dot is positioned, the computer records the coordinates of that dot and from that sequence of dot positions we can ask ourselves the question what motion is seen or not seen.

Mr. GOLDSMITH. At this time I would ask that Dr. Hunt be shown JFK F-159 and F-159A.

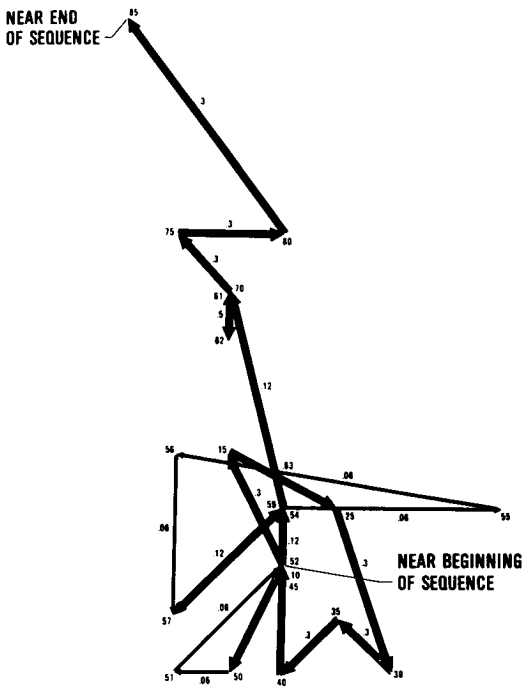
Mr. Chairman, I move for the admission into the record of these two exhibits.

Chairman STOKES. Without objection they maybe entered into the record.

[The information follows:]



JFK EXHIBIT F-159



JFK EXHIBIT F-159A

Dr. HUNT. These two exhibits try to depict graphically the actual form of the motions perceived as a result of this computer processes which were carried out. It is a very cluttered exhibit and we apologize for it, but I think the fact that this exhibit is cluttered indicates something about it.

What we have tried to show here is the direction of motion of the center of this object as it was perceived in each frame, and also the length of the arrow indicates the rough extent of the motion itself.

For example, we start here in the beginning of the motion sequence, we move up like so, over to the right and down, to the right and down some more, like so around, and it goes around like that until it ends up finally at the 85th frame where the motion perceived, position of the object perceived is right there.

Mr. GOLDSMITH. What does the length of each line in that exhibit F-159A indicate?

Dr. HUNT. The length of the line exhibits the extent of the motion of the object in the window.

Mr. GOLDSMITH. Before I ask you to describe JFK F-159, I want to have it moved a little bit so that it is in better view.

Dr. HUNT. This exhibit combines the same information on the large blowup of 159A. But in addition to that, we have isolated on three or four frame sequences, frames 55, 57, 59, and 61 in that film, and show you the change in position at ⅛-second intervals. To most graphically demonstrate that, we put that in color. Red indicates the shape of the object in the window at frame 55, green at 57, blue at 59, and yellow at 61.

I guess the important point is you see quite a great degree of motion change occurred at ⅛-second intervals.

Mr. GOLDSMITH. Was the panel able to attribute that motion to any human object?

Dr. HUNT. No, we were not able to do that; at ⅛ second intervals we are seeing quite drastic changes in shape and if you look at them they are not all that consistent.

For example, from red we move to the green to a position there, we immediately pop down in the blue and then pop way back up again in the yellow.

Mr. GOLDSMITH. In that case, to what was the motion attributed?

Dr. HUNT. The panel's conclusion was that the motion which is perceived if you view the movie is attributable to photographic artifacts, namely the change in contrast frame to frame, the change in focus as the image of the window moves around in the frame of the film.

Mr. GOLDSMITH. Is it possible there was a human object in that window but it simply was not perceptible on the film?

Dr. HUNT. It is very possible that there was a human object there, but it would be beyond the perceptibility of the imagery as recorded on film, is the panel's conclusion.

Mr. GOLDSMITH. What would be the reason for that?

Dr. HUNT. The reason is that it was simply—well, there are several reasons.

First of all, at the edge of a film frame the image is never as good, never as sharp or as crisp or conveys as much information as at the center. Unfortunately, most of these images are captured at the edge of the film frame. That is the position where you have a

number of optical distortions that occur which cause a loss of sharpness and information.

Mr. GOLDSMITH. Is that also explainable in part by the quality of the camera?

Dr. HUNT. Yes, that is, a real high quality motion picture camera of the type that would be used by commercial photography would have much better image retention features in the edge of the frame than would a sort of off-the-shelf hobbyist home product.

Mr. GOLDSMITH. What did the panel conclude about the presence of motion in the adjacent window on the sixth floor?

Dr. HUNT. Those adjacent windows were examined also even though they are not visible on this particular blowup we have. We found no perceptions in motion or even forms in those windows.

Mr. GOLDSMITH. Now the ITEK Corp. reported that, in that adjacent window, there was something that they characterized as a transient anomaly; in other works, motion of some kind. To what would that type of motion be attributed?

Dr. HUNT. First of all, the ITEK Corp. did not carry out any of the elaborate procedure for controlling the contrast that we did, which means they were much more subject to a false perception of motion as a result of contrast failures. By that I mean the following: What you see as an object, if it is in both shadow and light, is strictly dependent upon the photographic processes resulting in the contrast of that object being recorded on film. If there were changes in contrast there would be a much greater probability of motion being perceived. We, of course, tried to hold the contrast constant by our processing.

Mr. GOLDSMITH. Are you saying then that such motion would be characterized as caused by photographic artifact?

Dr. HUNT. Photographic artifact, photographic anomaly.

Mr. GOLDSMITH. What type of enhancement method was applied to the Dillard pictures?

Dr. HUNT. The Dillard pictures being in black and white, being in black and white negative, and one in which we had a deep shadow which we wanted to examine, was an ideal picture to use the autoradiographic enhancement technique on. It was given to Stanford Research Institute, to apply that technique to it.

Mr. GOLDSMITH. Let me show you at this time JFK F-156. Please describe the results of that analysis.

Dr. HUNT. F-156 shows two versions of an autoradiographic enhancement of the image as seen by the panel after the work at SRI. The lower image is one in which the work has been carried out for 17 hours, the upper one, for 138 hours. That is the time in which the radioactive film was in contact with the X-ray film.

It is unfortunate we do not see what the panel was able to perceive on the enhanced negatives themselves. In this open fifth-floor window the enhancement process was quite successful in seeing into the dark shadow. On the enhanced negatives you can actually see a light fixture which is hanging from the ceiling of this fifth-floor window. You can perceive the light bulb which is mounted in the middle of that light fixture.

Mr. GOLDSMITH. In light of the presence of that light fixture in the fifth-floor window, is that the reason why the sixth-floor window was studied under the technique?

Dr. HUNT. That is correct. Once we were able to perceive the enhanced detail within that fifth-floor window, we believed we were justified in using this technique in the open sixth-floor window as well.

Mr. GOLDSMITH. Was the panel able to make a finding as to the presence of someone at the sixth-floor window?

Dr. HUNT. Yes. The enhancement of the sixth-floor window shows there was no one at the window.

Mr. GOLDSMITH. What type of enhancement work was done with the Powell slide?

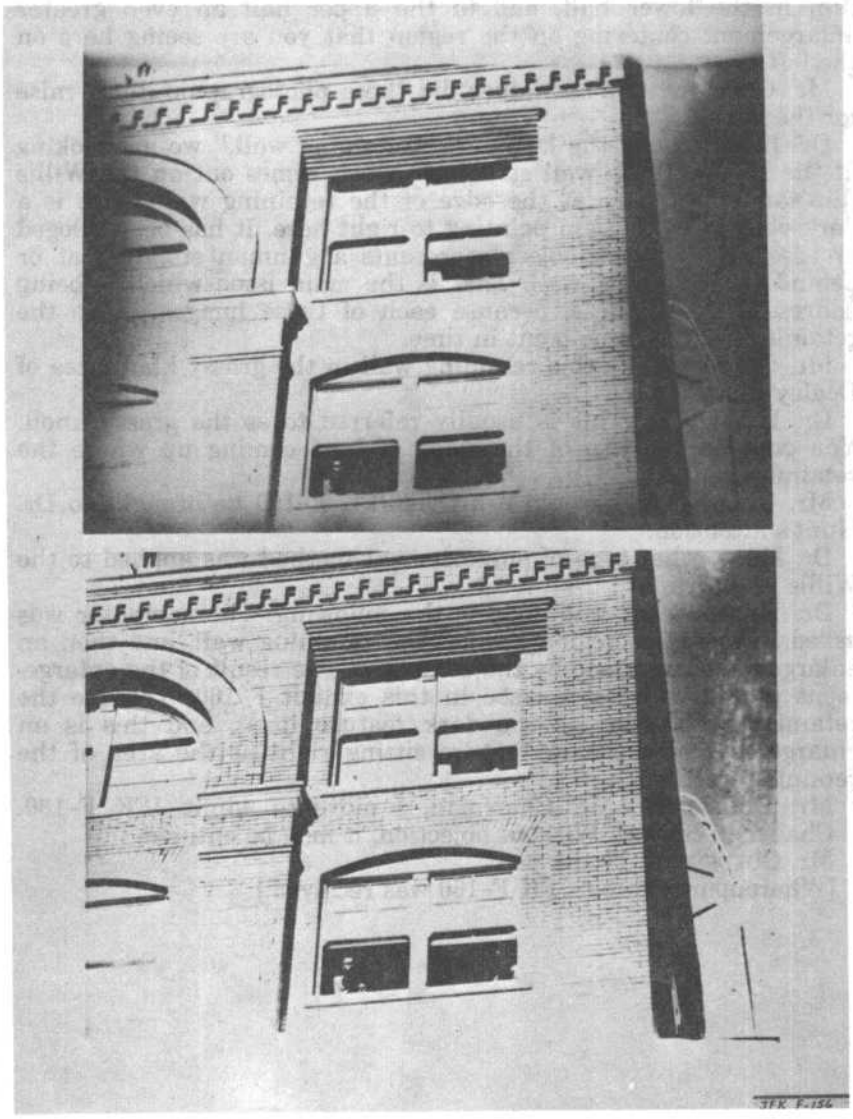
Dr. HUNT. The Powell slide, being a color slide, was enhanced by a computer contrast enhancement technique which would be very similar to the one I showed a previous exhibit on, yet it was done in color. We had a color film so we applied the contrast enhancement in color. You can turn the colors inside out in some cases.

What was a very deep or black area has become a white area in the enhancement. The important point is the following. Again, looking within that window, you see no details of a human form or face.

Mr. GOLDSMITH. I ask that Dr. Hunt be shown F-155, F-129, and F-161. While that is being done I would request that F-156 be admitted into the record.

Chairman STOKES. Without objection, it may be entered into the record at this point.

[Whereupon, exhibit F-156 was received.]



JFK EXHIBIT F-156

Mr. GOLDSMITH. Dr. Hunt, would you identify these exhibits?

Dr. HUNT. Yes. F-155 is an enlargement from a slide taken by a gentleman by the name of Willis. It is looking down towards the caravan from the back as the caravan proceeded down the street. It is a 35 millimeter color slide.

The next exhibit, F-129, shows an enlargement from a black-and-white Polaroid print, usually referred to as the Moorman film. The third exhibit, F-161, shows a segment, one print if you wish, from a film made by a gentleman named Nix. You are showing an enlarged piece of that film cropped out from the original 8 millimeter

film in the lower half, and in the upper half an even greater enlargement centering on the region that you are seeing here on the left.

Mr. GOLDSMITH. What issues did these photographic items raise for the panel?

Dr. HUNT. Using the label, "the retaining wall," we are looking at the Dealey Plaza wall structure which comes out on the Willis film, and right here at the edge of the retaining wall there is a dark object, which I am pointing to right here. It has been alleged or asserted the dark object represents a gunman standing at or behind the retaining wall. That is the main issue which is being addressed in all these, because each of these images shows the retaining wall at some point in time.

Mr. GOLDSMITH. Is this retaining wall in the grassy knoll area of Dealey Plaza?

Dr. HUNT. Yes. This is usually referred to as the grassy knoll. You can see the rise of the slope of land coming up where the retaining wall sits.

Mr. GOLDSMITH. I would ask that JFK F-160 be brought to Dr. Hunt's attention.

Dr. Hunt, what type of enhancement method was applied to the Willis photograph?

Dr. HUNT. What was done is the following. The computer was asked to scan this region around the retaining wall, and then an enlargement was made by the computer. The result of the enlargement process is what we see in this exhibit F-160. You see the retaining wall. Here is the dark feature itself, and this is an enlargement of the dark feature sitting right at the area of the retaining wall.

Mr. GOLDSMITH. Mr. Chairman, I move to admit JFK F-160.

Chairman STOKES. Without objection, it may be entered.

Mr. GOLDSMITH. Thank you.

[Whereupon, exhibit JFK F-160 was received.]

JFK EXHIBIT F-160

Mr. GOLDSMITH. Dr. Hunt, in attempting to identify this image, what analytical work, if any, was done?

Dr. HUNT. We did two things. The first thing we did was to attempt to remove some of the evident blur in the image. If you look at the original and concentrate upon the freeway sign, you see a blur. We hoped to remove that blur. That attempt was carried out at the University of Southern California. It was not successful.

Mr. GOLDSMITH. Are you able to say why it was not successful?

Dr. HUNT. Yes. The picture was just simply not that good. There is quite a bit of blurring when you look at this gross enlargement

of the kind we have here. There was, in addition, when the picture was received by the panel, a grayish coating of some kind on it. This was probably another thing that was detrimental to the effort.

Mr. GOLDSMITH. What analytical work was done to determine whether that image is a human object?

Dr. HUNT. When we look at this image upon a soft-copy display, we display it on a color CRT. This is where the soft copy is superior to the hard copy I have here on the exhibit. The perception is quite dramatic and distinct, that there are flesh tones within the region of what appears to be the head of this object at the wall, and that there are more flesh tones in what appears to be the hands of this object at the mall. What we tried to do was to make analytical and numerical measurements of those flesh tones and compare those with the flesh tones of another individual in the photograph.

What we did for comparison purposes was measure flesh tones upon the legs and face of this woman standing next to Mr. Zapruder, his secretary.

Mr. GOLDSMITH. What was the panel's conclusion?

Dr. HUNT. Based upon the flesh-tone measurements which we took off of the object at the wall, and comparing those to similar measurements on the flesh tones on Zapruder's secretary, we concluded this was a person standing at the wall.

Mr. GOLDSMITH. Did the panel make any effort to determine whether that person was holding a rifle?

Dr. HUNT. Yes. We tried to examine the nature of this linear feature which you see right here. If you look at this object you perceive something like a head or face with flesh tones, shoulders and arms, with flesh tones in the region I am pointing to here, and then you perceive this linear object which runs out of the hands roughly at a 45-degree angle. We would have liked to deblur the image. Since we couldn't, the only thing we could do was to ask ourselves: what is the probability of this being a rifle? We could not make a conclusion on that because there is another evident blur at the 45-degree line throughout this image. This linear object we perceive runs at the same direction as the blur which is apparent in the image. It is equally likely, therefore, that this is either a real object of some kind, or simply a small dark object in the image which was stretched out by the motion blur of the camera during the period in which the picture was taken.

Mr. GOLDSMITH. Dr. Hunt, I would ask you to refer now to JFK F-129 which was the Moorman enlargement at the far left. I would ask what type of enhancement method was applied to this photograph.

Dr. HUNT. This photograph in its original form was a black and white Polaroid print. As such, it was not well suited to being scanned by computer. There is in the region of the retaining wall a great amount of dark area. What we did, therefore, was to use contrast enhancement techniques of the photo-optic kind.

We tried to bring out, through photo enhancement, details against the retaining wall.

Mr. GOLDSMITH. What conclusion, if any, did the panel reach concerning this photograph?

Dr. HUNT. We found no evidence of the person that is visible in the Willis photograph in the Moormon photograph.

Mr. GOLDSMITH. What is the time sequence among these three photographs?

Dr. HUNT. Willis came first, approximately 5 seconds later came the Moormon photograph, and the Nix photograph spans most of those times plus some time later.

Mr. GOLDSMITH. Why is that?

Dr. HUNT. Because the Nix picture is a motion picture film. The picture started running prior to the fatal shot and kept running during and after.

Mr. GOLDSMITH. Drawing your attention to JFK F-129 in the upper left-hand region of that exhibit, there is a stockade fence. Perhaps you could point to it for the committee. Was any effort made to study that area to see if there was any evidence of a gunman there?

Dr. HUNT. No. No effort was applied to it. First of all, the results carried out in this region were negative.

Mr. GOLDSMITH. You are pointing now to the retaining wall?

Dr. HUNT. Yes. The print was of quite poor quality. As I said, this is a black and white Polaroid print and it had been manhandled quite a bit during the years. We concluded the results over here would be probably the same. When we look at the quality of the image in this region it seems even poorer than the quality where we already had negative results.

Mr. GOLDSMITH. The region you were just referring to is the region of the stockade fence?

Dr. HUNT. That is correct.

Mr. GOLDSMITH. Referring your attention to JFK F-161, what type of enhancement work was applied to the Nix film?

Dr. HUNT. This particular frame out of the Nix film was subjected to an enhancement operation at Aerospace Corp. in Los Angeles in which the nature of the enhancement was to bring the image more into focus. We know there is a slight blur in it, from the nature of the camera's image system. We tried to remove that blur.

Mr. GOLDSMITH. Was the panel able to reach any conclusion as to the presence of a gunman by the retaining wall?

Dr. HUNT. Over here at the retaining wall area we see some pattern of light and dark, shaped roughly like a triangle. You see that better in the enlargement, which we have shown here. The panel could not conclude this was a person. We see no flesh tones associated with that region of the sort we find over here on Zapruder and his secretary.

Mr. GOLDSMITH. Was this particular photograph subjected to digital image processing?

Dr. HUNT. Yes.

Mr. GOLDSMITH. Was the panel able to discern any sign of a flash or puff of smoke?

Dr. HUNT. No. They found no flash or puff of smoke in that retaining wall area of this film.

Mr. GOLDSMITH. The retaining wall area in this particular frame seems to be on the periphery of the frame. What effect, if any, does that have on the quality of the image?

Dr. HUNT. Well, it is in fact on the periphery of the frame. If you look on the frame itself it cuts off a little to the right where the photograph was printed.

By and large, the edge of a frame is the region of greatest degradation in the photo, a region where you are likely to find ragged edges of the frame, a region where you will find misfocusing of different colors, a region where you will find the greatest amount of blurring.

Mr. GOLDSMITH. Might that account for claims made by some that in that area of the photograph a flash or puff of smoke was perceived?

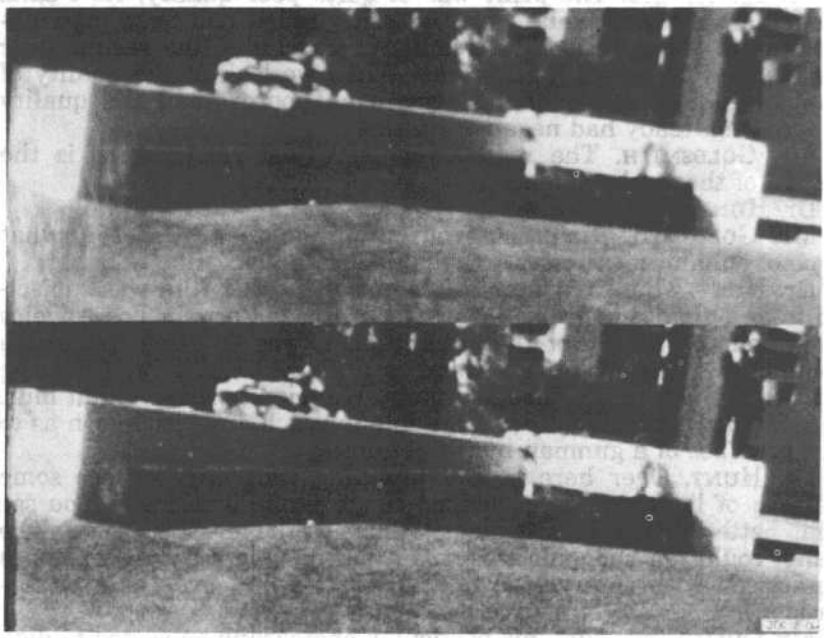
Dr. HUNT. Certainly it could. For example, an object in the background which might have been perceived as something easily recognizable in the center might be out of focus at the edge and simply not properly perceived.

Mr. GOLDSMITH. I would ask Dr. Hunt be shown JFK F-162.

Mr. Chairman, I move for the admission of this item.

Chairman STOKES. Without objection it may be entered into the record at this point.

[Whereupon, exhibit JFK F-162 was received.]



JFK EXHIBIT F-162

Mr. GOLDSMITH. Would you identify this exhibit, Dr. Hunt.

Dr. HUNT. Yes. We are looking at another frame out of the Nix film. The upper version is the original version and the lower version is the enhancement, which I will talk about in greater detail in a moment.

We are looking at the region of the Nix film which shows the retaining wall area, where Zapruder and his secretary are at the right of this area which we are examining at the left.

Mr. GOLDSMITH. What issue was raised by this particular frame?

Dr. HUNT. This has what is referred to as the classic gu[illegible]man. You will perceive in the region that I am pointing to, which is an

area above the retaining wall itself, something which looks like the way an individual firing a fairly large rifle would be positioned. By that I mean, I would be holding the stock out in front of me with the left arm essentially dropping down at the angle you see, and with my right arm abruptly out from the body at about a 90° angle from the vertical, and the rifle therefore would be presumably pointing somewhere toward the plaza. The rifle would have to be pointing directly at the lens of the camera across Dealey Plaza.

Mr. GOLDSMITH. What type of enhancement work was applied to the Nix film or to this particular film?

Dr. HUNT. This frame was enhancement—I should say eight frames were enhanced. The eight best frames were chosen and digitized at Los Alamos. Once they were digitized, we did the following:

Each frame was registered. "Register" is a term we use to indicate that we superimpose one frame on top of another, by computer, to line up common points of the frame with all other common points. Once they were registered, each point in an image was identical in a frame right next to it; we then added all those together. The purpose of adding those together was to reduce the noise in the image; that portion of the image which is random noise will tend to be suppressed by the addition. That portion which is constant will tend to be reinforced. Once the noise is reduced we then use another enhancement technique, that I described earlier, of putting the image back into focus, refocusing by the computer, if you wish.

Mr. GOLDSMITH. After performing this enhancement analysis, what conclusion, if any, did the panel reach concerning the image at issue?

Dr. HUNT. We concluded that this was not a gunman.

Mr. GOLDSMITH. What was the reason for your conclusion?

Dr. HUNT. There were several reasons for that. First of all, the result of the enhancement processing. If you compare the region to the right and above the so-called classic gunman, you see a great amount of clarity has been introduced by the processing and you are able to perceive what this region is. It appears to be shadow patterns on a wall structure behind the plaza as a result of sun shining through the trees in the adjacent region.

The panel, looking at that, believed what we were seeing was just a particular shadow being created on the back wall. Furthermore, when we tried to make measurements to arrive at flesh tones to compare with flesh tones over here on Zapruder, the flesh tone analysis was not similar. We found no relationships between the colored regions here and the colored portions on Zapruder or his secretary.

Mr. GOLDSMITH. Did the panel come to a conclusion of any sort?

Dr. HUNT. No, with one exception. In a couple of frames this right position, which would be the arm extended horizontally, vanished in a couple of frames. If we were looking at a real individual, it would be impossible for that to abruptly disappear and reappear again. That was another thing that led us to believe it is a possibility of some variation of shadow, caused by leaves.

Mr. GOLDSMITH. Was there any evidence of a rifle?

Dr. HUNT. There was no evidence of a rifle.

Mr. GOLDSMITH. Was there any evidence of a flash or puff of smoke, Dr. Hunt?

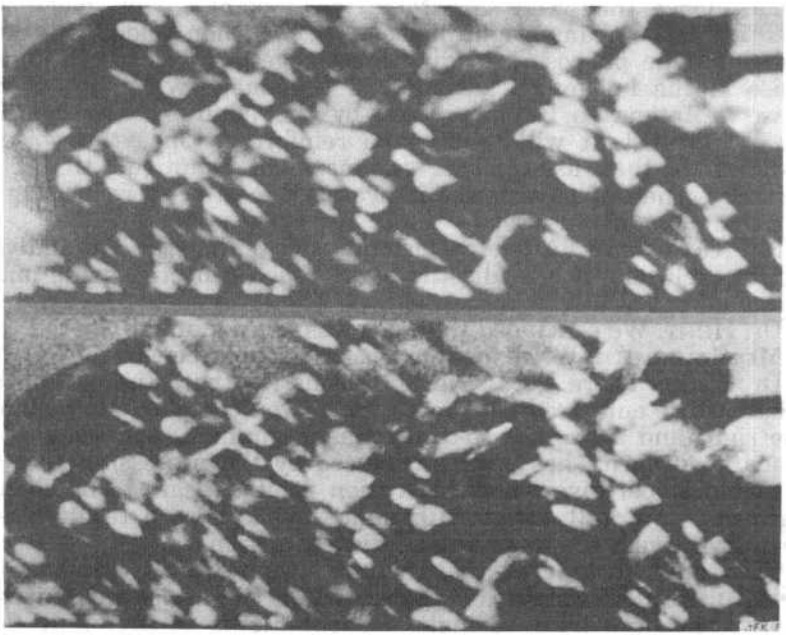
Dr. HUNT. No, there was not. We were being particulary sensitive to that. What we did, besides the enhancement and the averaging technique I described, we subtracted each frame from its neighbor. The business of subtraction has the property of enhancing anything which is distinctly different from its neighbor because everything which is common in the two images goes to zero. That which is not common stands out like a sore thumb. There was no visibility of flash or smoke.

Mr. GOLDSMITH. At this time I would ask Dr. Hunt be shown JFK F-164.

Mr. Chairman, I move for the admission of this item.

Chairman STOKES. Without objection, it may be entered into the record.

[Whereupon, exhibit JFK F-164 was received.]



JFK EXHIBIT F-164

Mr. GOLDSMITH. Would you identify this exhibit, Dr. Hunt.

Dr. HUNT. Yes. This is a section out of the Zapruder motion-picture film. This is one frame out of that film. In particular, it is frame 413, using the numbering sequence which was established by the Warren Commission. The top half of this exhibit shows the original frame as it was received by the photographic panel. The lower half of it shows the result of enhancing it.

Mr. GOLDSMITH. What issue was raised by this particular frame?

Dr. HUNT. The issue raised by this particular frame is the visibility of this head. If you look in front of and behind this frame, you will see Zapruder is following the limousine as it exits the plaza. A

bush becomes visible in the right side of the frame, moving toward the left. Visible also in the bush is this head or this head-like object which we see here. What is important with respect to it is the following feature. If you look at the head, you can see a linear feature starting where I show my pointer, a very narrow feature, running through the leaves of the bush, so to speak. There is a darker feature here which is much thicker. And if you line them all up, it is alleged that what you are seeing is the barrel of a rifle and the stock of a rifle, and this of course is the man who is holding the rifle.

Mr. GOLDSMITH. What type of enhancement technique was applied to this frame?

Dr. HUNT. This frame was enhanced by a technique that had the property of bringing the whole frame more into focus, using a computer to focus the camera, after the fact. The result of that, I think, is quite visible because if you look at the barrel of the rifle, as you see it in the lower picture, it is much more distinct, it is better outlined and is easier to follow.

Mr. GOLDSMITH. In examining this frame for evidence of a person with a gun, what analytical work was done?

Dr. HUNT. The important analytical work which we can do in examining the frame, first of all, I will use the topograph——

Mr. GOLDSMITH. Excuse me. Dr. Hunt has referred to JFK F-133.

Dr. HUNT. This is an overhead survey map of Dealey Plaza. the black outlined area is the retaining wall we have been looking at in other photos. Mr. Zapruder was standing at roughly this portion of the wall. By examining the film and letting the U.S. Geological Survey do analytical plots, we were able to place the limousine in its path down the street at approximately this position.

Zapruder's camera was centered roughly on the limousine, so if we were to draw a line from Zapruder to the limousine we would be able to see what we were looking at in the line of sight of the camera. You can see that it crosses the center of this sidewalk, this concrete walk which leads down from the top of the knoll to the street level. That is roughly the positions you would have involved.

Mr. GOLDSMITH. You are drawing a line in effect between Mr. Zapruder and the position of the vehicle in frame Z413?

Dr. HUNT. Yes.

Mr. GOLDSMITH. Having done that, what conclusion did you reach?

Dr. HUNT. We did that, and then after having done that we went one step further. We looked at the relative sizes of the head which we perceived in the bush and the heads which we perceived out in the automobile. For example, we see here the head of a Secret Service agent who is just climbing into the back of a limousine. There is a principle of camera optics that states you can relate the size of the head which we see in the bush to the size of the head which we see out here in the street, and you can use those two relative sizes to determine relative distances between the camera, the head in the street, and the head which we see in the bush.

By measuring the width of these heads and carrying out that calculation, we were able to do the following. I made three different measurements, and if I were to place again that line between Zapruder and the car and then position the heads, I would find

that the closest that I am able to calculate that the head in the bush would lie to Zapruder would be exactly in that sidewalk. The farthest away would be about 10 or 15 feet on the other side of the sidewalk.

Mr. GOLDSMITH. You are referring to the sidewalk that runs from the retaining wall down to Elm Street?

Dr. HUNT. That is correct.

What that means is the following. We find that the head must be at the sidewalk or beyond it. If we go back to the original exhibit itself and look at what we perceive about this rifle barrel, which has been asserted to be a rifle barrel, we notice that in this bush the rifle barrel actually falls in front of several different leaves we see in the bush. It is a geometrical and physical impossibility to appear in front of leaves in the bush if the individual himself is physically located far beyond the bush. The bush actually exists in this region about 10 or 15 feet from Zapruder, right near the point of the retaining wall. Consequently we conclude that this was not a head in the bush. This was literally a man standing out near this area of the sidewalk in the plaza.

Mr. GOLDSMITH. Thank you very much, Dr. Hunt.

I have no further questions.

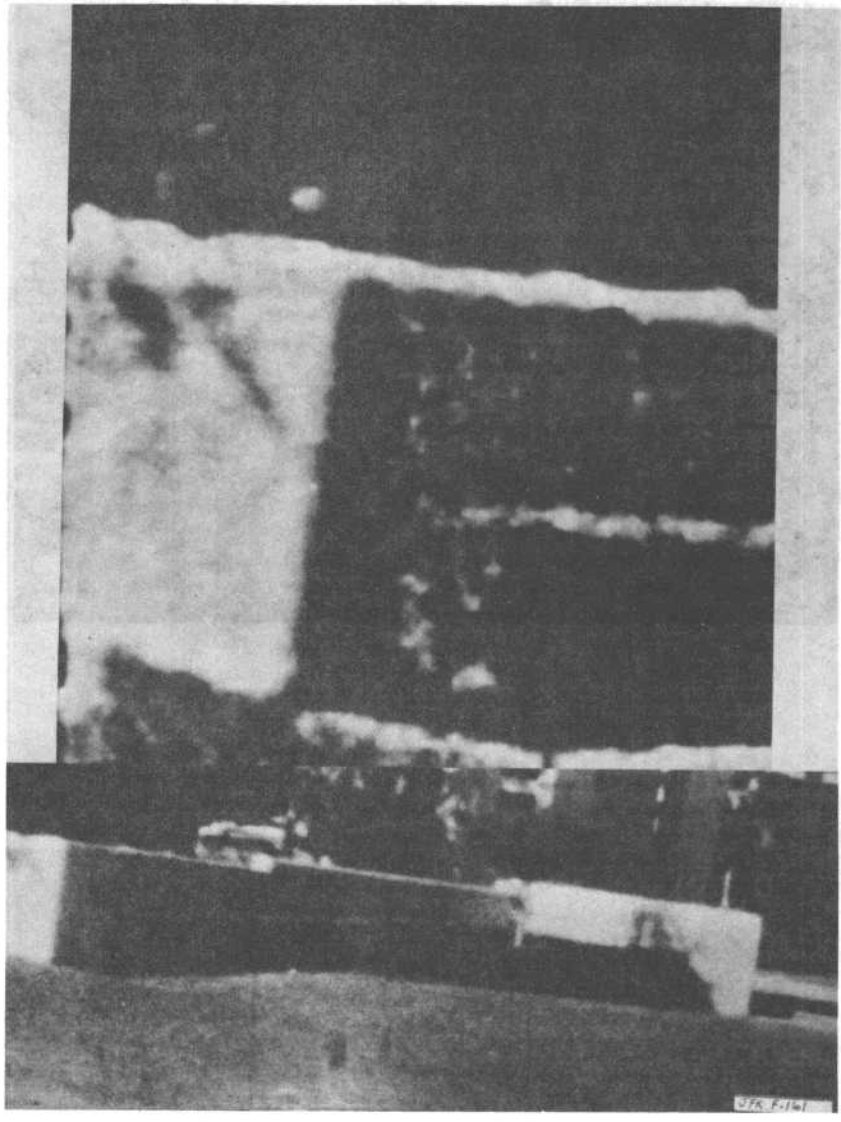
Mr. GOLDSMITH. Mister Chairman, I move the entry of JFK F-129, F-155, F-161, and F-163.

Chairman STOKES. Without objection, they may be entered into the record at this time.

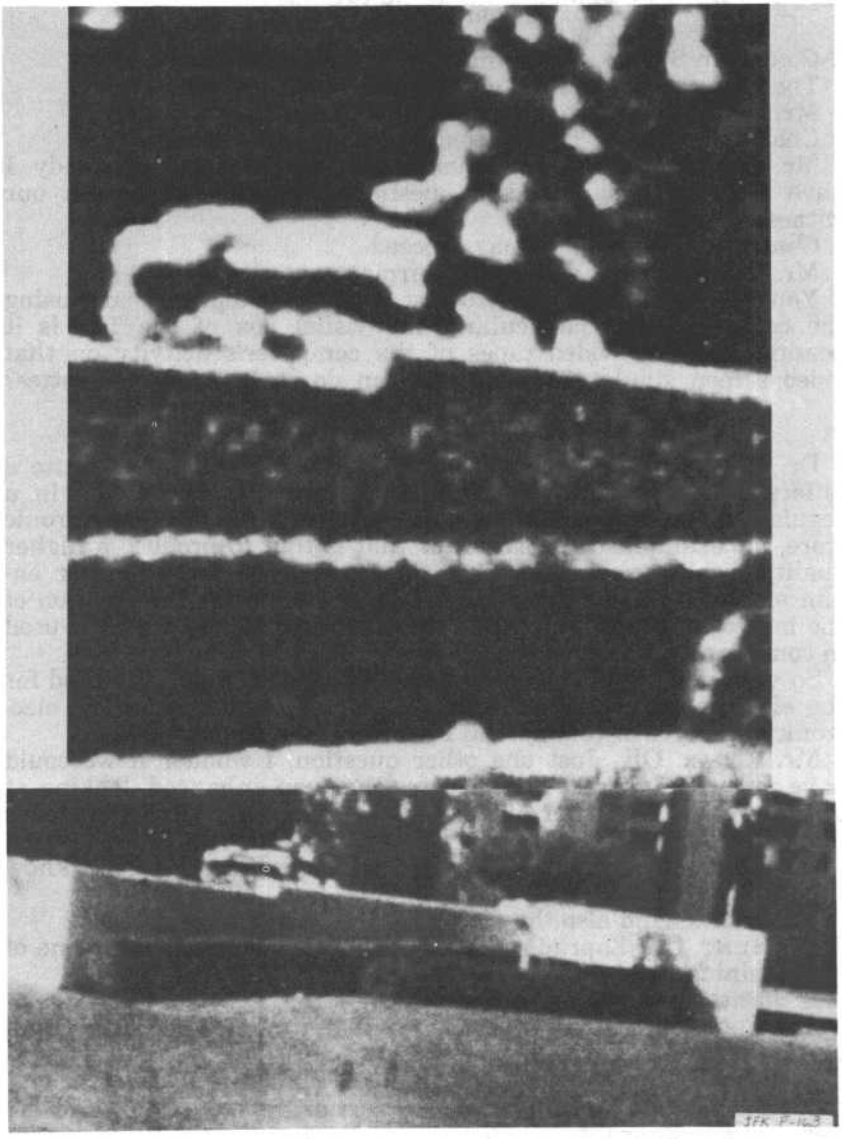
[The information follows:]

JFK EXHIBIT F-129

JFK Exhibit F-155



JFK Exhibit F-161



JFK EXHIBIT F-163

Chairman STOKES. It is now 12:30. This is an appropriate time for us to take a recess.

Accordingly, the committee will stand in recess until 2 p.m. this afternoon.

[Whereupon, at 12:32 p.m., the hearing was recessed, to resume at 2 p.m.]