The EOB Tape of June 20, 1972

Report on a Technical Investigation

Conducted for the U.S. District Court for the District of Columbia

by the Advisory Panel on White House Tapes

May 31, 1974

Advisory Panel
on White House Tapes
May 31, 1974

Judge John J. Sirica
United States District Court
for the District of Columbia
Washington, D.C.

Dear Judge Sirica:

We are pleased to submit herewith the final report on our technical investigation of a tape recorded in the Executive Office Building on June 20, 1972. This is the tape on which an eighteen and one-half minute section of buzz appears.

The report itself occupies the first fifty pages of this volume. The remaining pages contain appended material concerning our study, followed by a set of detailed Technical Notes on the scientific techniques we used and the test results we obtained.

Respectfully yours,

Richard H. Bolt

Franklin S. Cooper

James L. Flanagan

John G. McKnight

Thomas G. Stockham, Jr.

Mark R. Weiss

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SUMMARY

A tape recording of conversations held on June 20, 1972 in the Executive Office Building contains a section lasting eighteen and one-half minutes during which buzz sounds but no discernible speech sounds are heard. This report describes work done to find out what caused the buzz section.

In November, 1973, Chief Judge John J. Sirica of the U. S. District Court for the District of Columbia appointed an Advisory Panel of persons nominated jointly by the White House and the Special Prosecution Force, and asked the Panel to study relevant aspects of the tape and the sounds recorded on it. In performing this task the Panel has made extensive tests on the tape itself, on electrical signals picked up from the tape, and on recording equipment that was used or might have been used in recording the speech and buzz sounds on the tape. Through analysis of the test results and simulation of alternative ways in which the buzz section might have been produced, the Panel has arrived at a single explanation that accounts for the buzz section observed on the Evidence Tape.

The Panel found no basis for doubting the authenticity of the speech recording. The recording appeared to be an original one made on a Sony 800B recorder, the type reportedly used in the Executive Office Building. The tape showed no signs of splicing, tampering, or copying. The buzz section was made directly on this tape, probably by the Uher 5000 recorder labeled Government Exhibit 60. The buzz sound probably originated in electrical noise on the electric power line that powered the recorder. Any speech sounds previously recorded on this section of the tape were erased in conjunction with the recording process, as is normal in recorders of this kind. The erasure is so strong as to make recovery of the original conversation virtually impossible.

The buzz section, which sounds much the same throughout, contains many "events" such as clicks, pops, changes in loudness, and gaps with no sound. The Panel traced most of these events to specific operations of electrical and mechanical elements of the recorder. This information together with data on the tape motions and recorder characteristics enabled the Panel to infer things that must have been done with the recorder to produce the events observed on the tape. No explanation of the buzz section based on malfunction of the recorder can account for the entire set of observed data and the patterns they form. The only completely plausible explanation found is one that requires keyboard operations of a normally-operating machine. Five or more sets of such operations are involved in the explanation.

This report draws no inferences about such questions as whether the erasure and buzz were made accidentally or intentionally, or when, or by what person or persons. The report does provide a solid basis in experimental fact for concluding that the erasure and the recording of buzz required several operations of the pushbuttons on the control keyboard of the Uher 5000 recorder.

PREFACE

This report concerns work undertaken to examine the authenticity and integrity of tape recordings made in the offices of the President of the United States of America.

In November 1973 Chief Judge John J. Sirica of the U. S. District Court for the District of Columbia appointed an Advisory Panel to undertake this work and specified their task in the following words:

> "(a) By judgment entered on August 29, 1973, this Court directed production of various tape recordings and other materials covered by a grand jury subpoena duces tecum issued to President Richard M. Nixon, and this order was upheld by a judgment of the United States Court of Appeals for the District of Columbia Circuit entered on October 12, 1973;
>
> (b) On October 23, 1973, counsel for the White House stated that there would be full compliance with the order of the Court.
>
> (c) On October 30, 1973, counsel for the White House informed the Court that two subpoenaed conversations had not been recorded and on November 21, 1973, further informed the Court that a gap of approximately 18-minutes duration existed in a third subpoenaed conversation;
>
> (d) The Court determined that it was in the interest of justice to conduct full inquiry into these developments and that it would materially aid the Court's resolution of this inquiry to secure the assistance of experts skilled in examination of such tape recordings;
>
> (e) Counsel for the President and the Special Prosecutor as counsel for the grand jury agreed upon the selection and nomination of six technical experts to examine various tape recordings and to report their findings to the Court;
>
> (f) The Court accepted the nominations of counsel for the respective parties and on November 21, 1973, appointed Richard H. Bolt, Franklin Cooper, James L. Flanagan, John G. (Jay) McKnight, Thomas G. Stockham, Jr., and Mark R. Weiss as an advisory panel of expert witnesses to assist the Court;"
>
> [Excerpt from an Order
> Relating to Expert Witnesses,
> Misc. No. 47-73, December 20, 1973]

The Advisory Panel was chosen to cover a range of technical capabilities relevant to the task of examining the tapes. The six members of the Advisory Panel met together first on Sunday, November 18, 1973, in the Executive Office Building and there attended a briefing session conducted by representatives of counsel for the President and the Special Prosecutor. Immediately thereafter the Panel undertook the preparation of a proposed plan of work and submitted it to the Court on November 21, 1973.

Shortly after the Panel was appointed and commenced its study of the tapes, the Court suggested that the tape recorded in the Executive Office Building on June 20, 1972, was of special interest and would deserve priority attention. In response, the Panel devoted most of its attention to this tape during the first months of its work.

On December 13, 1973, the Panel submitted an interim report on its work and its provisional conclusions about the source of the buzz that appeared on the tape of June 20th.

By January 10, 1974, the Panel had arrived at firm answers to the central questions about the tape of June 20, 1972. Because the Court wished to have this information at the earliest possible time, the Panel submitted a summary report on January 15, 1974, containing the principal conclusions together with brief indications of the nature of the evidence that led to the conclusions. Many added details concerning the Panel's investigation of this tape were reported in sessions of the Court on January 15 and 18, 1974.

The Panel then turned to the preparation of a full report of its tests and analyses concerning the tape of June 20, 1972. Concurrently, in accord with instructions from the Court, the Panel initiated a preliminary study of several other tapes.

After the Panel's conclusions were made public, several persons volunteered ideas and suggestions to the Court, or to one of the legal offices involved in this matter, or directly to members of the Panel. Some of these volunteered submissions described alternative interpretations that differed markedly from the Panel's conclusions. The Panel already had considered several alternatives and believed that its experimental results firmly supported the conclusions made public on January 15.

Nonetheless, the Panel, in keeping with its responsibility to the Court and the public in this unusual undertaking decided to look carefully into every proffered suggestion that might at all contribute to a fuller understanding of what happened to the tape. The Panel took on this added work even though it would delay completion of the final report on the tape of June 20, 1972.

By mid-February the Panel had made intensive studies and tests of proposed alternatives, with results that confirmed the original conclusions. These conclusions and the data and considerations supporting them had been discussed from time to time with representatives of counsel for both parties. In late February and early March, at the request of counsel for the President and with the approval of the Court, this material was discussed also with technical advisors employed by counsel for the President. These various discussions led to further analysis of the origin of certain clicks already noted on the tape of June 20, 1972, and thereby to additional confirmation of one of the Panel's original conclusions.

Completion of these studies and the writing up of results occupied most of the Panel's efforts from March to early May, when we submitted a draft report to the Court. Subsequently we received comments on the draft and gave them careful consideration in preparing this final report.

Scope and Organization of this Report

This report pulls together the results of all our work on the tape recorded in the Executive Office Building on June 20, 1972. Although other tapes are not discussed in this document, the tests and methods of analysis described here are applicable also to our examination of other tapes.

Our study of authenticity and integrity pertains to the entire tape, which contains about six hours of material. However, our preliminary results led us to concentrate attention on a section of the tape containing 18.5 minutes of buzz and other sounds not found in the rest of the tape. Our conclusions relate mainly to the way in which this buzz section was produced.

In this Report we document the conclusions we presented to the Court on January 15, 1974. This volume also contains a large amount of information not reported previously. The added information includes detailed descriptions of all the tests and analyses we have made, full compilations of resulting data, and reports on experiments we have performed to check certain alternative hypotheses regarding the origin of the buzz section.

The Report contains four chapters. The first one describes our general approach to the task: our use of scientific methods to make measurements and hypotheses leading to a simulation of the process that produced the buzz section. Chapter II describes in detail the main methods of measurement and analyses that we used. In Chapter III we show how the results of many tests combine to explain essentially all the "events" in the buzz section. The final chapter summarizes the data and reasoning by which we arrived at each of the seven main conclusions.

Following the Report, this volume contains appended material and several Technical Notes. These Notes, which actually make up the bulk of material in the volume, comprehensively document the tests, analyses, and data. The Technical Notes are addressed to persons who wish to study our results in scientific detail.

In the Report itself, we have minimized technical complexity and terminology in order to explain as simply as possible what we did and how we reached our conclusions. We hope that the interested person who is not a technical specialist will gain from this Report an accurate, interpretive understanding of our findings.

Chapter I

THE NATURE OF THE TASK

1. What We Needed to Find Out

At the outset of this task, the Panel formulated three sets of questions that formed the basis of our work plan. These questions, which were presented in the Interim Report of December 13, 1973, were:

> Is this tape the original one that was recorded on June 20 1972? Does it contain erasures or splices? Or is it a copy that has been edited by operations such as cutting and splicing before re-recording?
>
> How was the 18-minute section of buzzing sounds produced? Was all the buzzing produced continuously at one time?
>
> Can speech sounds be detected under the buzzing? If so, to what extent can the speech be recaptured and made intelligible?

Some of these questions can be answered easily and surely, but others present great difficulty. For example, splices would be easy to find and would probably imply tampering, but absence of splices would not ensure that the tape is an original recording rather than a copy or "dubbing."

2. What We Had to Work With

The principal sources of information available to the Panel were: the tape recording labeled "EOB office - start 6/12/72, end 6/20/72," which we sometimes refer to as the Evidence Tape; the tape recorders that were thought to have been used in making the original recording and, later, in erasing and re-recording a buzz tone on one section of the tape; additional information about how the original recordings were made; and a few other items of equipment.

The principal items of equipment that were provided by the Court and used in our tests were seven Sony 800B recorders (one inoperative) from the Oval Office and Executive Office Building recording installations, a Uher 5000 recorder marked "Secret Service", and another Uher 5000

Figure 1. Photographs of magnetic tape recorders: Uher 5000 and Sony 800B

recorder with associated foot pedal, marked Government Exhibits 60 and 60B. The Exhibit 60 Uher had been twice modified by the Secret Service before we received it, once to disable its recording function and again to restore this function. It was operating normally when we received it, but was noticeably more sensitive to interference on the power line than other Uher 5000 recorders that we used.

3. What We Assumed and How It Affected Our Task

The Panel made certain assumptions in undertaking its studies. One was that the equipment used in the White House and Executive Office Building was substantially as described to us. On the basis of this information, we considered only two types of recorders (Sony 800B and Uher 5000) in seeking an explanation of the buzz section of the Evidence Tape. We were informed also that only the two Uher's were candidates for the machine that produced the buzz section of the Evidence Tape. Our identification of Exhibit 60 as that machine rests on the correctness of this information.

We assumed, in the absence of data to the contrary, that the equipment was functioning more or less normally when the original recording was made and when a part of it was overwritten by buzz. Most of the equipment supplied to us performed normally when we began to use it and continued to perform normally throughout our tests. A notable exception was the Exhibit 60 Uher recorder, which suddenly failed after the Panel had used it for about 50 hours. Throughout the 50 hours the recorder gave no indication of abnormal operation. It responded normally to all operations of the keyboard and footpedal controls. Recordings made on the recorder before it failed showed no signs of erratic operation, such as arbitrary stopping and restarting of the recording or of the motion of the tape. The component that failed was a diode bridge-rectifier. We took it out, made measurements to analyze the failure, and found that one of the diodes had become short circuited. Then we sealed the rectifier

in an envelope, which we signed and gave to U. S. Marshals to keep with the Exhibit 60 Uher in the possession of the Court. We installed a replacement rectifier in the recorder, which thereafter operated normally in all respects, throughout all the remaining tests we performed.

Out initial tests led us to conclude that the erasure rather than the buzz was responsible for obliterating the original recording. As a result, we placed little emphasis on finding the exact source of the buzz, except to note that it resembled power line interference and that the Exhibit 60 Uher was especially sensitive to such interference.

Two additional assumptions were concerned with procedural matters. We interpreted the task set by the Court to mean that we should restrict our attention to scientific analyses of the tape and the equipment that was, or might have been, involved in the recording and re-recording operations. Thus, questions of who made the buzz, or when, or why, did not come within the scope of our investigation.

Also, we interpreted our role as scientific advisors in a situation of evident urgency to mean that we should report our conclusions to the Court as soon as the scientific evidence for those conclusions became definite. We did this in the brief Summary Report of January 15, 1974.

4. How We Found Out What Happened

To determine how the buzz section of the Evidence Tape of June 20, 1972, was produced, we examined the tape and made careful measurements at many points on it, paying special attention to places where we heard clicks, gaps, or other significant changes in the buzz.

We then examined the recorders and other equipment that was supplied to us and made experimental recordings with them to check their various functions and characteristics. When our tests and measurements were completed, we compared the data obtained from the Evidence Tape with data obtained from our experimental recordings. We looked for similarities and differences, to help us identify the machine functions that could have produced each of the transient events on the Evidence Tape.

When we found events on the two tapes that seemed distinctive and very much alike, we assumed, as a working hypothesis, that the event on the Evidence Tape had been made in the same way as the one that we ourselves had made on the experimental tape.

The process described above -- examination of the Evidence Tape and simulation of operations on the Exhibit 60 Uher -- yielded tentative explanations for the source of each event on the Evidence Tape. However, it did not exclude the possibility that an event might have been made in a different way. So we looked for as many potential explanations as we could think of, considered them carefully, and, on the basis of our data, either accepted them as viable alternatives or rejected them. We used several methods to evaluate alternative explanations:

We checked potential explanations against measurements and known facts;

We made additional measurements on the tapes and equipment in order to get additional clues and insights;

We looked for combinations of events that would rule out certain alternative explanations.

Combinations of events, rather than a single event by itself, often provided the most effective means of reducing the number of alternative explanations. Indeed, events in combination provide the firmest basis for rejecting a much-discussed hypothesis that the buzz section might be explainable in terms of recorder malfunction. Furthermore, combinations of events support most strongly the explanation of the buzz section in terms of multiple operations by hand of a Uher-5000's control keys.

In summary, the procedure followed by the Panel in determining how the buzz section of the tape was produced consisted of three levels of inquiry:

1. What is on the tape?

   This question required our making careful measurements at each event on the tape, that is, at each point where there was an audible change in the character of the recording. The tests and analyses that yielded the most useful results are discussed at length in Chapter II.

2. What machine functions produced each event on the tape?

   At this level of inquiry, we sought to identify electrical processes and components in the recorder that could be associated with each event. We compared the data from measurements on the Evidence Tape with data obtained from test recordings made on several Uher 5000 recorders, particularly the one labeled Exhibit 60.

3. What actions initiated the machine functions?

   The action that initiated the production of a particular event could be a human operator action, or the result of a machine malfunction. We proposed trial explanations of how the machine functions that we related to each event might have been initiated. We evaluated these explanations by use of the methods described earlier.

Clearly, facts and a tight logical structure are needed to support conclusions regarding how the buzz section of the Evidence Tape was produced. The factual basis for identifying events on the tape, the testing of potential explanations of the events, and the combining of events to derive logically necessary conclusions form the essential contents of this report.

Chapter II

TESTS AND ANALYSES

The Panel examined the Evidence Tape from many points of view. We listened to the tape, we looked at magnetic marks on it, we analyzed electrical signals picked up from it, and we measured the performance of machines on which the speech and buzz were recorded or might have been. We also examined the circuits of the machines to find out how they were supposed to perform.

This chapter describes the tests that proved most useful to the Panel in seeking answers to its questions regarding the tape. Here we explain in general terms how each test is made, what it measures, and how the results helped us to answer the questions. Technical Notes accompanying this report give detailed explanations and also describe several other tests, which provided supplementary information.

Each method of test and analysis described here is illustrated by an actual example drawn from our study. Usually we combined the results from two or more different methods to identify and explain events on the tape. These combinations of results, which are the subject of Chapter III, provided the factual basis from which we derived the conclusions reported in Chapter IV.

1. Critical Listening

The Panel started its experiments by listening to a 67-minute portion of the Evidence Tape through playback equipment of high quality. The portion contained about 20 minutes of speech, followed by the 18.5 minute buzz section, followed by 29 minutes of speech. The entire tape, including portions to which we were not permitted to listen, ran to about six and one-half hours.

Our experience in working with magnetic tape recording systems, in psycho-acoustic testing, and in listening critically to sounds of diverse kinds helped us to detect and to identify particular clicks, pitch changes, and subtle variations in quality that might offer crucial clues concerning the authenticity and integrity of the tape. Subsequently we studied these and other features by using several kinds of measuring instruments and tests described below. As these tests progressed, we frequently returned to listening as a way of checking out new information and fitting it into a larger pattern of acoustic clues.

2. Magnetic Marks

All the sounds heard when listening to a tape recording stem from signals that are stored on the tape in the form of magnetic patterns. These patterns, at least the stronger ones, can be made visible by a process known as magnetic development. A fluid containing magnetic particles is applied to the tape. The particles collect on the magnetic patterns in proportion to their magnetic strength. Then the fluid evaporates, leaving a visible representation of the magnetic patterns. We call these visible representations the "magnetic marks."

In Figure 2, the whitish lines seen on the two photographs of magnetic tape are magnetic marks that became visible after the tape was developed. The upper photograph was made from the Evidence Tape at the end of the buzz section, just before the point at which speech resumes. The lower photograph shows a piece of tape recorded by the Panel in order to simulate the marks seen on the upper photograph. Using the Exhibit 60 Uher, we initiated the recording mode by depressing simultaneously the RECORDING and START keys, and then we terminated the recording mode

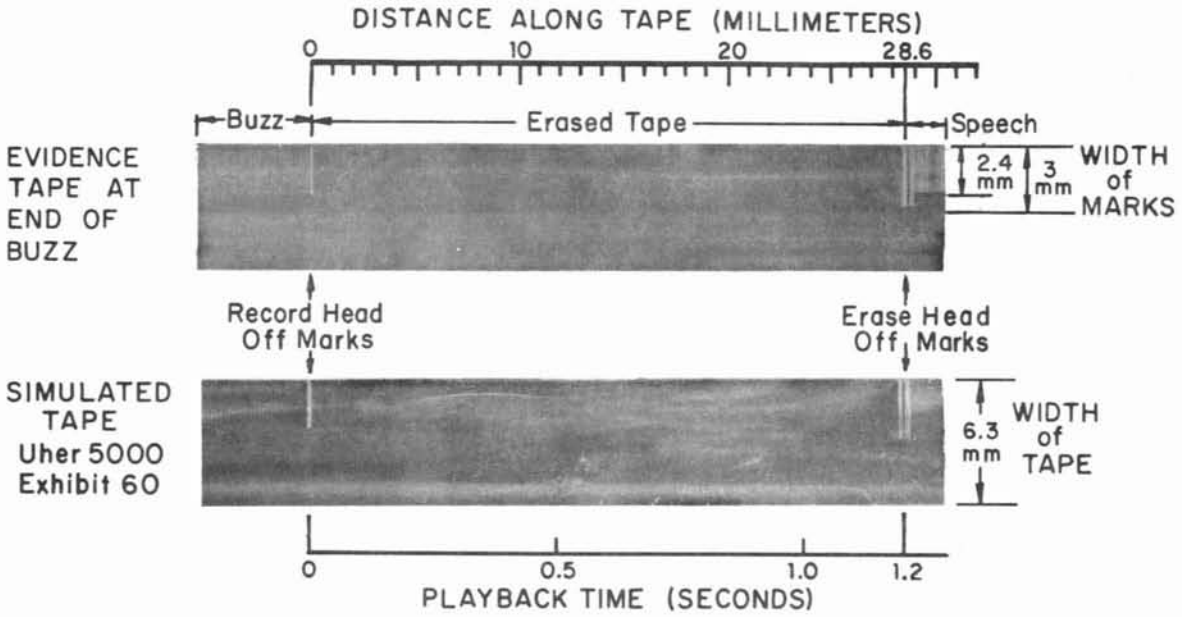


Figure 2. Magnetic marks observed on the Evidence Tape and simulated by using the Exhibit 60 Uher 5000 recorder

by pushing the STOP key. The resulting de-energization of the record head and erase head produced the marks at the locations so indicated.

The marks near the right edge of Figure 2 consist of four parallel lines 3 millimeters wide. We sometimes call this erase-head-off mark a quartet. By convention, the dimensions of marks on magnetic tape are called length when they run in the long direction of the tape, and are called width when they run across the width of the tape. Thus, for example, the quartet is called 3 mm wide, not long; its length is much less, about 0.5 mm.

The width of this quartet coincides with the width of the erase head gap on the Exhibit 60 Uher 5000. Exactly 28.6 millimeters to the left of the quartet is a mark 2.4 millimeters wide. The width of this mark and its spacing from the quartet coincide with the corresponding dimension and spacing of the record head on the Uher 5000. This identifies it as a record-head-off mark.

By contrast, the Sony 800B recorder erase head produces only two lines, and they are spaced about 24 mm from the record head mark, as Figure 3 shows. Thus magnetic marks provide information as to the type of machine used in recording on a particular tape and the type of head used to make a particular mark.

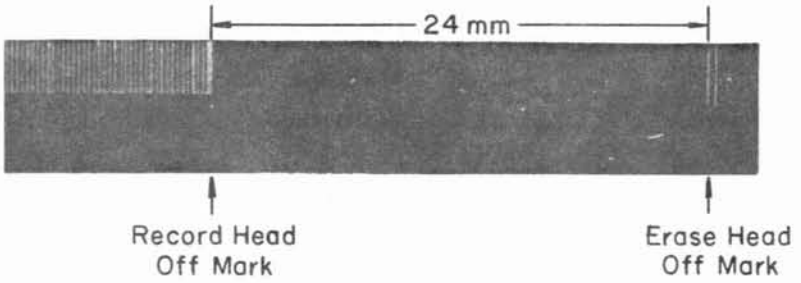


Figure 3. Magnetic marks made by using a Sony 800B recorder

Another kind of information obtainable from magnetic marks relates to the location of the recorded track. Such information sometimes helps in identifying the particular recorder that was used, because the track can occur at various distances from the edge of the tape depending on manufacturing differences among recorders. Figure 4 illustrates this kind of analysis.

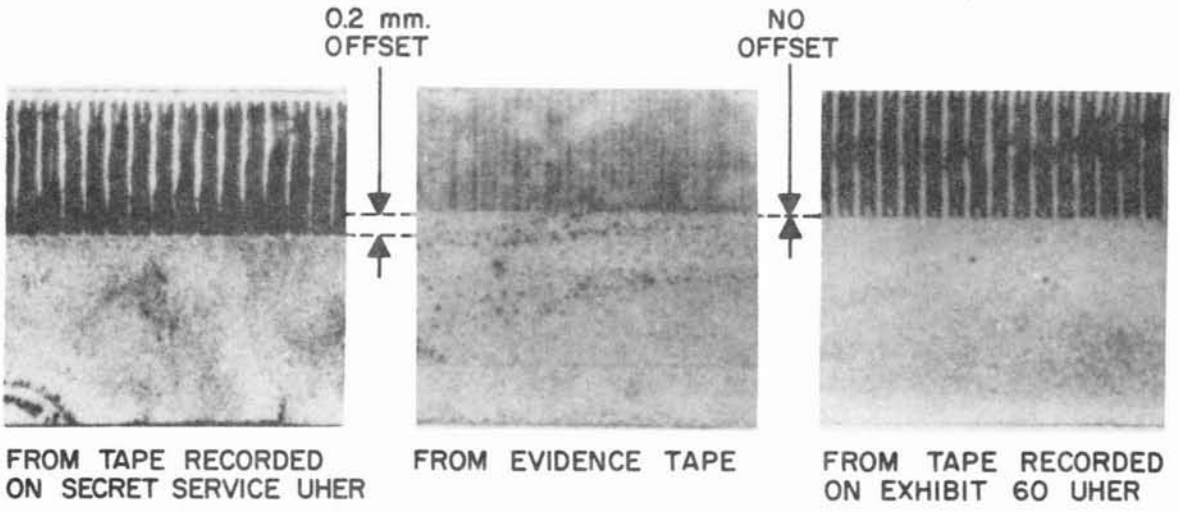


Figure 4. Track offset shown by magnetic marks

Figure 4 shows three samples of tape with a recorded track made visible by developed magnetic marks. The sample in the middle comes from the buzz section of the Evidence Tape. We produced the two other samples by making recordings on the Exhibit 60 Uher and the Secret Service Uher. As indicated in the figure, the track made by the Secret Service machine is offset 0.2 mm in comparison to the tracks on the Evidence Tape and on the sample made by the Exhibit 60 machine. This information together with other data led us to conclude that of the two machines, Exhibit 60 Uher and the Secret Service Uher, only Exhibit 60 Uher could have put the buzz on the Evidence Tape.

Magnetic marks are useful also in determining whether the buzz was recorded directly onto the Evidence Tape or was copied from another tape. If the buzz section were a copy, then the quartet would be only 2.4 mm instead of 3.0 mm wide, because a 2.4 mm wide record head cannot record an entire 3.0 mm mark.

In our investigation, magnetic development provided a relatively fast and easy way to obtain data for making initial judgments about the type of machine that recorded the buzz section. Magnetic marks also provided data about the originality of the Evidence Tape. In order to confirm findings derived from magnetic marks and to obtain different kinds of information about the tapes, we undertook other tests including the ones on waveforms described in the next section.

3. Waveforms

Although magnetic marks provide important information about the actual width of the track made by the recorder and about the differences in widths covered by the erase and record heads, the marks do not give the kind of fine detail that is required in a comprehensive analysis. To obtain further detail, the Panel examined electrical waveforms produced by the magnetic signals on the tape.

Electrical waveforms are made by playing the tape on a recorder and feeding the electrical output into an oscilloscope. The oscilloscope shows the wave on a TV-like screen. The vertical scale represents the amplitude of the wave and the horizontal scale represents time. The Panel employed a similar but more powerful method using digital computers. The computer simplified our task of processing and comparing waveforms in various ways, such as changing scales to "zoom in" on small details.

Figure 5 shows waveforms produced from the signals on the Evidence Tape at the end of the buzz section, just before speech resumes. In producing these waveforms we played the tape back at the original recording speed, nominally 24 millimeters per second (15/16 inch per second), so a distance of 24 millimeters on the tape corresponds to a time of one second in the electrical waveforms. These waveforms correspond to the magnetic marks shown in the upper picture in Figure 2. The waveforms clearly reveal many details that are only weakly suggested or not observable at all in the magnetic marks. The lower part of Figure 5 is an expanded view of sections of interest in the top part of the figure. The expansion was done with a digital computer. In the top part of the figure, the buzz section to the left of the record-head-off pulse shows up as a highly regular, repetitive waveform. The expanded view reveals detailed wiggles in the regular pattern.

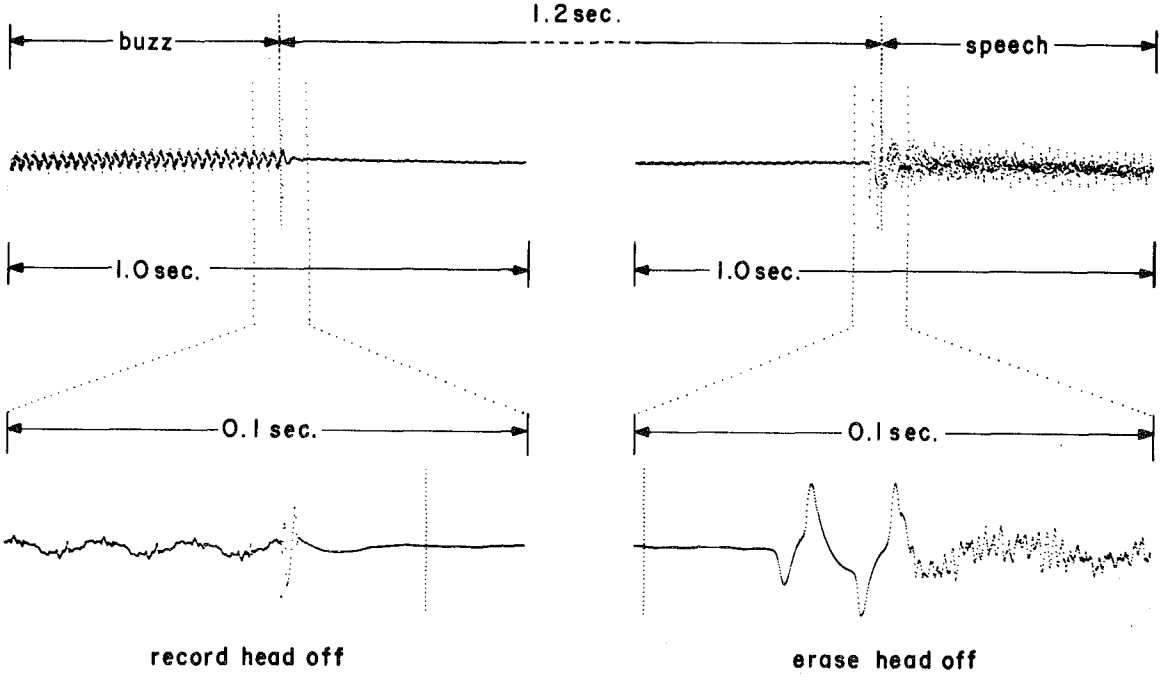


Figure 5. Electrical waveforms from recordings made by the record head and the erase head when they are turned off

The record-head-off pulse, seen on the developed tape as a single whitish line, shows up as a complex of many fast wiggles within a space of about 0.1 mm on the actual tape. The four lines of the erase-head-off mark form a quartet consisting of a valley and peak followed by another valley and peak. The quartet occupies about 0.5 mm on the actual tape and takes up about 0.02 second of playing time. Immediately following the quartet are the irregular patterns of the speech waveform, which appear markedly different from the buzz waveform to the left of the figure.

Waveforms also provide evidence as to whether the tape was moving when a particular magnetic mark was made. For example, the waveform of the quartet is less sharply peaked when the tape is standing still, because the tape is not pressed tightly against the erase head.

Thus waveforms serve as a kind of magnifying glass with which we can see very fine details of information carried on the tape. Such information can confirm the identification of magnetic marks and help to explain how the marks were produced.

4. Spectra of Speech and Buzz

Sound such as the human voice or the buzz on the Evidence Tape are made up of component signals at various pitches or frequencies. A standard method of analyzing voice and buzz sounds is to break them down into the different frequencies that make up the original sound. Analyzing signals in terms of their component frequencies and amplitudes is called spectral analysis. Spectral analysis provides a way of comparing in fine detail the differences and similarities among sounds.

Spectral analysis is typically made with the aid of an instrument that electronically transforms the signal into its component frequencies and displays the result. The Panel used two kinds of analyses and displays. In one kind of analysis the components are displayed along two dimensions, amplitude and frequency. We refer to this kind of display as a spectrum. Figure 6 shows an example.

The other kind of analysis displays the components of the signal in three dimensions: amplitude, frequency, and time. This display shows how the spectral components change from moment to moment. Amplitude is shown by the darkness of the markings on the graph. Frequency is plotted on the

vertical axis and time, on the horizontal. This kind of display is commonly called a spectrogram. An example is seen in Figure 7.

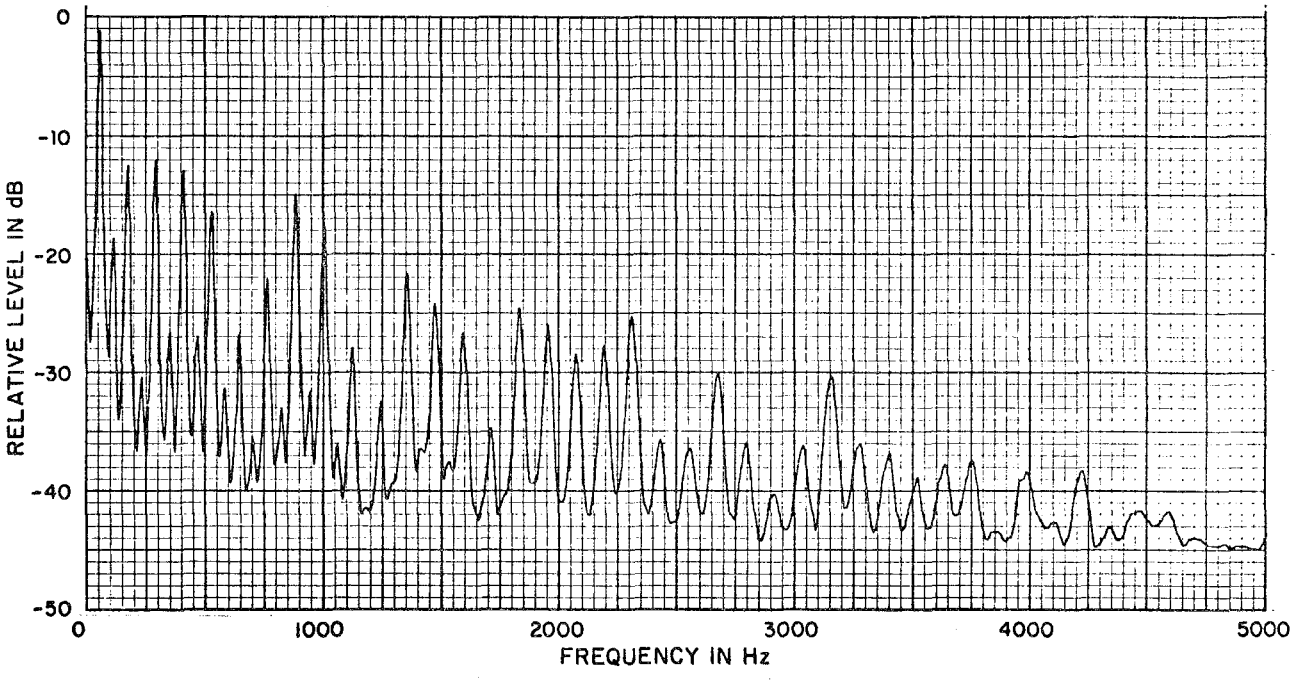


Figure 6. Spectrum of the buzz starting at 1042 seconds

A spectrum shows the amplitudes at various frequencies averaged over some period of time. For example, Figure 6 shows a spectrum of the buzz sound averaged over a period of 12.8 seconds. This process helps to average out short-time, spurious signals and emphasize the more stable signal of interest. In this case the spectrum analyzer measured the spectrum of 128 adjacent intervals, each 0.1 second long, and computed the average value of the spectrum.

Each of the sharp peaks in Figure 6 represents a single frequency. The highest peak occurs at the power line frequency, 60 Hz. Other high peaks occur at odd multiples of 60, i.e., 180, 300, 420, etc. The lower, alternate peaks occur at 120, 240, 360, etc. This spectrum provided some of the evidence on which the Panel concluded that the 60-Hz power line hum was the source of the buzzing sound on the Evidence Tape.

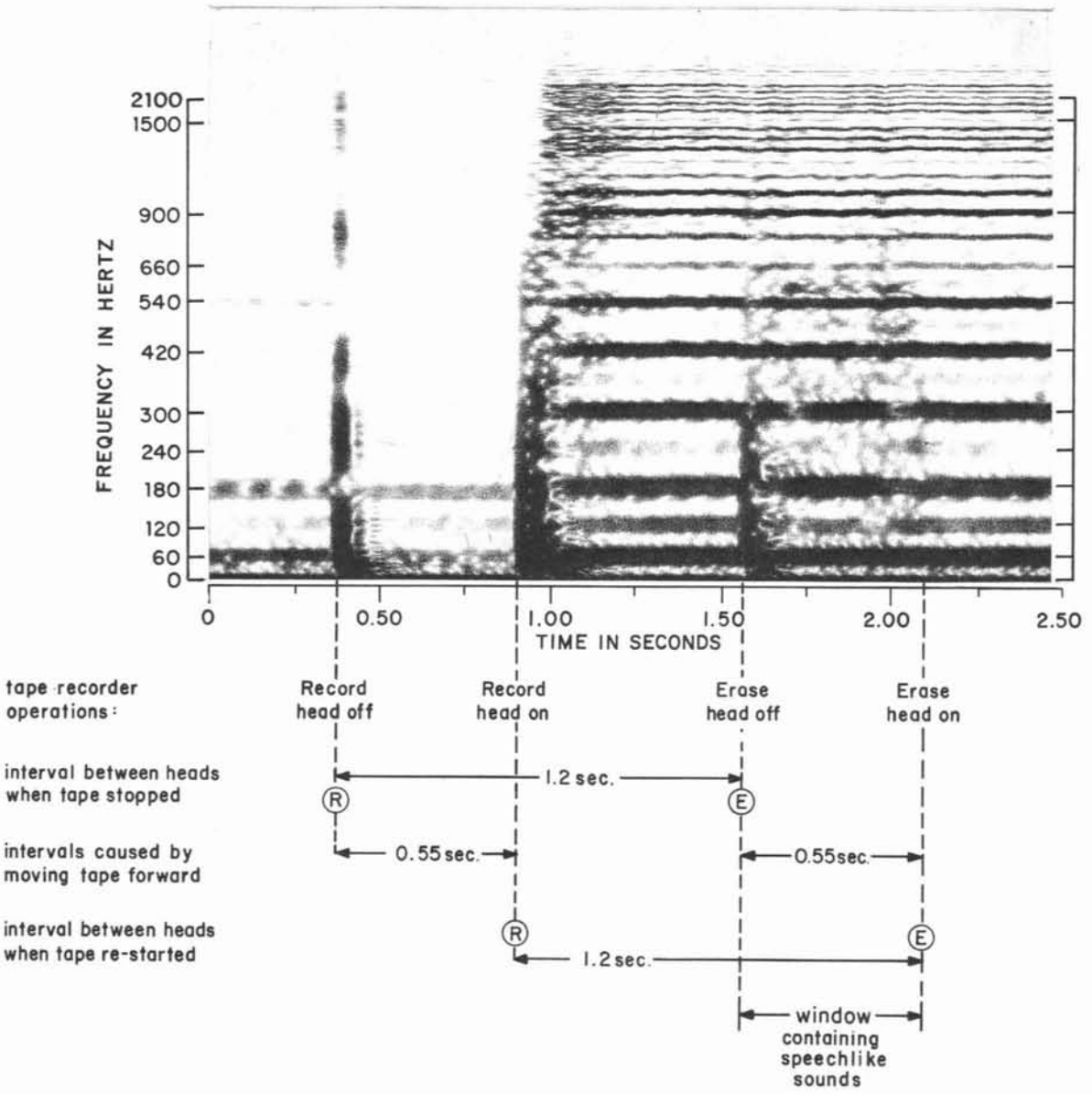


Figure 7. Spectrogram of the buzz starting at about 1041 seconds

Spectra were taken for both speech and buzz portions of the tape. Spectra taken at various locations in the buzz section are similar to each other, in keeping with other indications that all the buzz section was recorded on the same tape recorder. Spectra of the recorded speech before and after

the buzz section are consistent with spectra from original recordings known to have been made on Sony 800B recorders.

The spectrogram in Figure 7 covers about 2.4 seconds, starting at about 1041 seconds after the beginning of the buzz section. The dark horizontal bar just above the bottom edge of the picture represents the 60 Hz fundamental tone in the hum produced by the electrical power. The dark bands at 180, 300, 420, etc. correspond to the high peaks in Figure 6, and the alternate, lighter bands correspond to the lower peaks.

Spectrograms give a direct, vivid picture of the way in which events on the tape change from moment to moment. The sequence of events indicated in Figure 7 leaves a partly unerased gap or "window" of 0.55 seconds length, corresponding to a 13 millimeter movement of the tape. The mottled pattern seen in this window resembles the spectrum of speech sounds and provides evidence discussed later in this report. We refer to this type of pattern as buzz-on-speech. Spectrograms also provide evidence concerning such aspects as acoustic characteristics of the recording system, and occurrences of starting and stopping operations.

5. Phase Continuity and Speed Constancy

The phase of a wave is a measure of the relative locations of the peaks and valleys in the wave. As long as the peaks and valleys follow each other by exactly the same amount, the phase is said to be continuous. If at some point the wave pattern shifts abruptly one way or the other, then a phase discontinuity is said to occur at that point. An example of such a phase discontinuity appears in Figure 8a. In the left hand part of the figure, every third valley lies exactly over one of the equally-spaced vertical lines of the graph. In the right hand part, none of the valleys coincides exactly with a graph line.

The waves in the left and right hand parts of the figure came from the 60 Hz power line hum. The waves in the middle, which run off the graph at the top and bottom, reflect the occurrence of transient electrical signals in the record head. If the tape had kept moving steadily while these transients were being recorded, then the right hand part of the 60 Hz hum wave would have been "phase continuous" with the left hand part; every third valley on the right would have lined up with a vertical line of the graph. The discontinuity shown by lack of alignment means that the tape stopped and then restarted at this location on the tape.

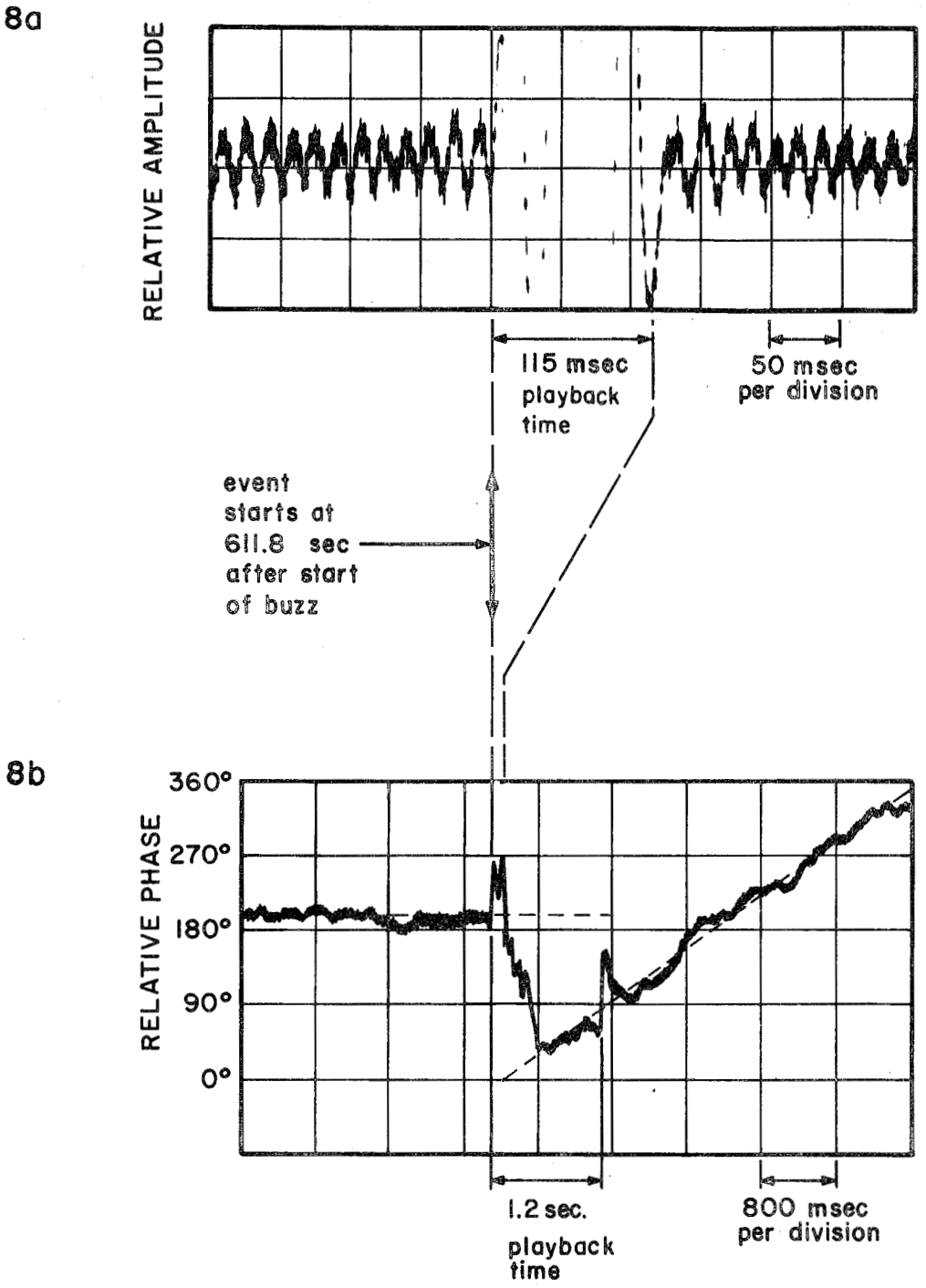


Figure 8. Phase continuity tests on a section of the Evidence Tape starting at 611.8 seconds after the beginning of the buzz. a) Waveform versus time. b) Phase versus time.

A second more sensitive way to measure phase is to use a special instrument called a phase meter. Figure 8b illustrates the kind of results obtained. As long as the horizontal wavy line that starts on the left hand side of the figure remains straight and horizontal, the phase is said to be continuous and the frequency constant. Immediately following the transient events in the middle of the figure, the wavy line shifts abruptly downward. The shift indicates a discontinuity in phase and, therefore, a stopping of the tape. Thereafter the relative phase follows an upward sloping line, which implies a slightly different frequency. The frequency difference, in turn, indicates that the tape has changed speed. In this case the speed change is about 0.3%. Transient speed changes, initially of this magnitude and lasting up to six seconds, occur frequently at the starts of test recordings that we made on Exhibit 60 Uher.

The Panel made phase continuity tests on all the significant events in the buzz section wherever such measurement was feasible, and thereby obtained considerable evidence concerning stop-start operations associated with those events.

6. Flutter Spectra

Every tape recorder has some mechanical irregularities in its rotating elements. These irregularities cause the tape to vary in speed as it goes past the recording and playback heads. Such variations in speed produce an audible wavering or "flutter" of the pitch of the sound recorded.

Suppose that we record a pure tone on a tape recorder that has speed variations. We play this recording on a perfectly steady reproducer, and plot a spectrum of the "pure tone." Because of the speed variations of the tape recorder, this spectrum will now show additional tones above and below the frequency of the original tone. These additional tones are due to the flutter and are called "flutter sidebands." The plot of their spectrum is called a "flutter sideband spectrum." Examples of flutter sideband spectra are shown in Figure 9.

The frequency displacement between the sidebands and the original tone is a measure of the speeds of rotation of the several drive pulleys in the tape recorder. The design of the recorder determines these speeds. The level of the sidebands is a measure of the eccentricity of the recorder's

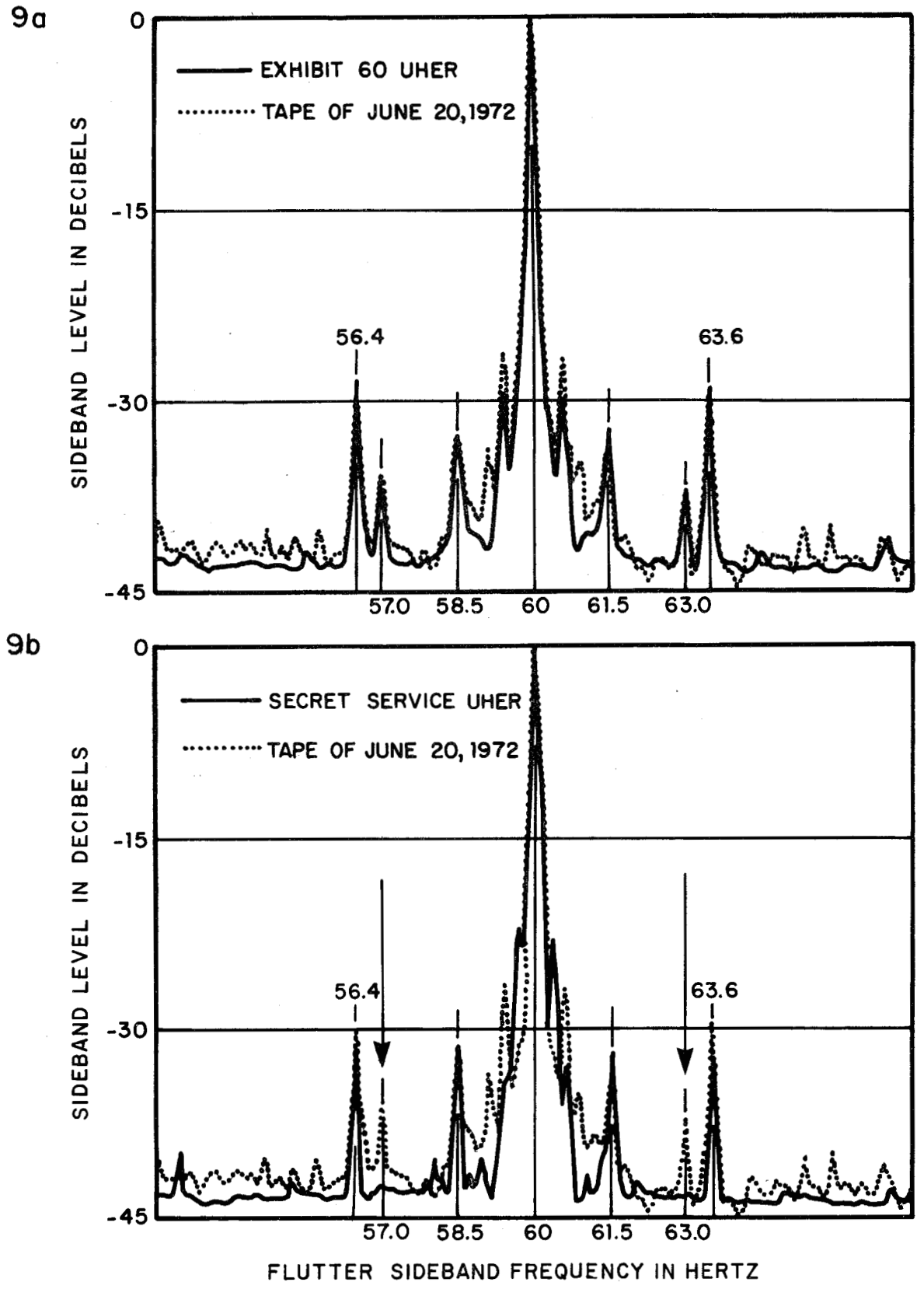


Figure 9. Flutter sideband spectra of the buzz section of the Exhibit Tape.
a) Compared with the Exhibit 60 Uher.
b) Compared with the Secret Service Uher.

pulleys, which depends on the accuracy of the recorder's manufacture and its state of wear and adjustment.

For example, the dotted line in Figures 9a and 9b shows the flutter sideband spectrum of the 60 Hz buzz of the Evidence Tape. For comparison, we recorded on a blank tape a 60 Hz tone on the two Uher recorders, and measured their flutter sideband spectra. These are shown for the Exhibit 60 Uher (Figure 9a) and the Secret Service Uher (Figure 9b).

The high central peak in these flutter sideband spectra represents the original 60 Hz tone. The peaks located symmetrically on either side of 60 Hz are the flutter sidebands. The sidebands at 63.6 Hz and 56.4 Hz are caused by eccentricity of an intermediate idler that is used in the Uher recorders. It rotates 3.6 times per second, and thus produces 3.6 Hz flutter. No element in the Sony 800B recorder can produce a 3.6 Hz flutter. Thus we have evidence that the Buzz section of the Evidence Tape was not produced by a Sony recorder.

The sidebands at 1.5 Hz above and below 60 Hz are caused by the eccentricity of the capstan, the cylindrical shaft that rotates at a speed of 1.5 times per second and drives the tape in the Uher recorder.

Another pair of sidebands appears at plus and minus 3.0 Hz for the Evidence Tape and the Exhibit 60 Uher. These sidebands occur because the capstan is slightly elliptical instead of perfectly circular in cross section, thus causing the tape to speed up and slow down twice during each revolution of the capstan. The Secret Service Uher does not show sidebands at $\pm$ 3.0 Hz, which indicates that this is not the machine that recorded the buzz on the Evidence Tape.

Thus when we know all the models of tape recorder that might have been used to produce a recording, measured flutter frequencies offer a very reliable means of determining which, if any, of these models was used. When we also know all the individual tape recorders that might have been used, the flutter amplitudes measured at each frequency may -- and in the present investigation do -- offer a reliable means of distinguishing among the individual machines.

7. Other Tests and Measurements

Additional tests we made in studying the Evidence Tape included inspecting it for splices and correct length, attempting to recover bias signals, and measuring azimuth angles. (See Technical Note 13)

Chapter III

COMBINING DATA TO RECONSTRUCT EVENTS

In Chapter I we pointed out that facts and logic taken together provide the basis for our conclusions as to how the 18.5 minute buzz section of the Evidence Tape was produced. In Chapter II we described the principal tests used to gather the facts. In this chapter, we present a summary of the facts and explain how we used them to find out what the tape recorder had done to make the magnetic marks we found on the tape.

1. Comparing Data from Different Kinds of Tests

The tests described in Chapter II provide several different kinds of data concerning the Evidence Tape. While each test, taken by itself, provides considerable insight into the recording operations that produced the Evidence Tape, much additional insight has been gained by combining the data obtained from several different tests.

The relationships we found among magnetic marks, waveforms, and spectrograms were especially useful. Figure 10 shows comparative data for a portion of the buzz section centered at about 48 seconds into the buzz. At the top of the figure is a photograph of marks on the tape obtained by magnetic development; in the center is the corresponding electrical waveform; at the bottom is a spectrogram.

The three representations of the same event serve to complement one another. The waveforms provide much finer detail about individual marks than does magnetic development. The spectrogram, by analyzing the waveform into its frequency components, often provides information that is easier to interpret than is the detailed shape of the waveform. An instance of this latter advantage is to be seen at the extreme right of the figure, between the edge and the reference line at 49.47 seconds. Here the spectrogram shows more clearly than the waveform that there is a residual signal in addition to the buzz. This kind of signal, identifiable as a speechlike sound under the buzz, is shown in its entirety in the middle picture in Figure 13, Chapter IV. Another example of the usefulness of

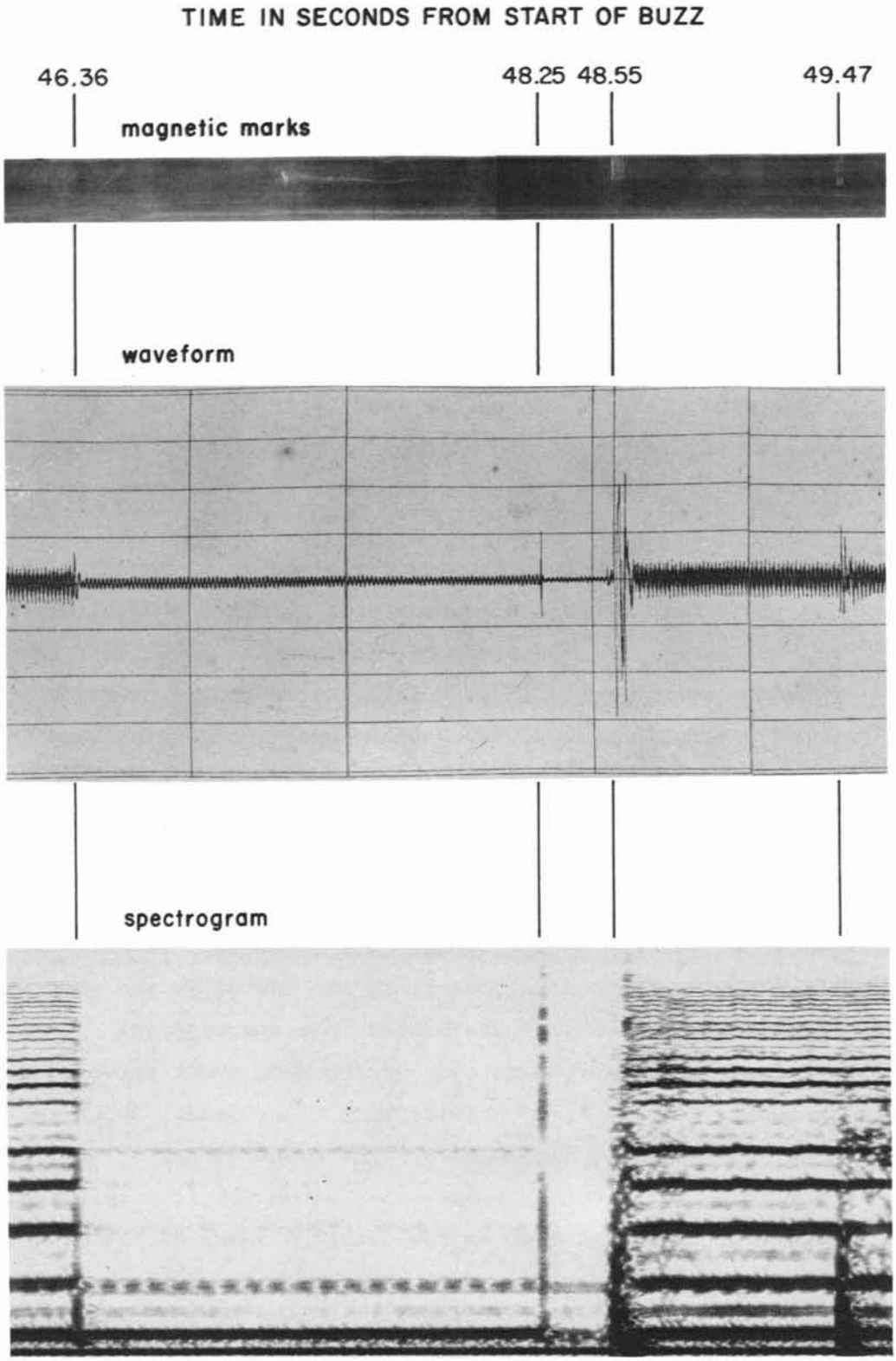


Figure 10. Three representations of the same event on the Evidence Tape: magnetic marks, waveform, and spectrogram.

this spectrogram is the clear difference it shows between the buzz at the left and right edges of the figure as compared with the buzz in the middle portion. The waveforms are different also, though less obviously so except as to height.

Another useful combination of data involves results of tests on phase discontinuities and waveforms. Taken together, these tests served to clinch the interpretation of certain events in the buzz section as being restarts of recording operations. The way in which we make such correlations between observed data and machine functions is described in the final section of this chapter.

2. Summary of the Information on the Evidence Tape

The tests and measurements we made on the Evidence Tape resulted in data on magnetic marks, waveforms, spectra, phase changes, tape speed, and flutter at those places in the tape where we found clicks, gaps, and other abrupt changes in the buzz. Our next step was to organize these data into a chronology of the events in the buzz section and, wherever possible, to decide just what the recorder had done to make the magnetic marks, or sets of marks, that constitute the events. The resulting chronology and identification of events appear in Table I and Figure 11. The diagram in Figure 11 is substantially the same as the one in our Summary Report of January 15, 1974.

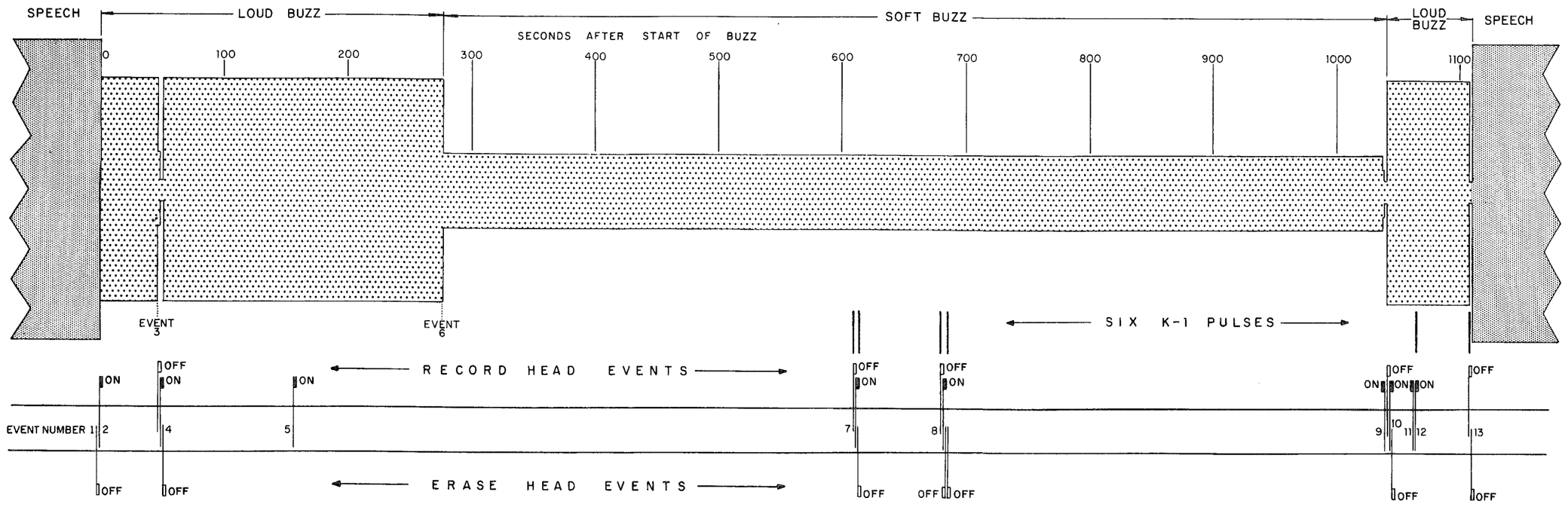
We have been able to relate almost all of the observed events to particular recorder functions that caused them. Therefore the table and figure contain most of the measured events we have found on the tape. A few remaining, minor pulses that we have not identified explicitly are described in Technical Note 12. Whatever the exact cause of these pulses might be, their presence does not affect our interpretation of the major events or our conclusions regarding the way in which the buzz section was produced.

The summary of events in Table I is organized by time of occurrence within the buzz section. Event Number and Event Code are two different labels for the same events. These labels relate events listed in Table I to the detailed illustrations and discussions of those events given in

Table I

SUMMARY OF EVENTS ON THE BUZZ SECTION

Event Time	Event Number	Event Code	Event Occurrences	Time in seconds from start of buzz	Segments and Gaps
-3	1	A_1	erase head off	-2.92	
0	2	A_2	record head on, start of buzz	0.00	1
46	3	B_1	buzz decrease	46.36	
49	4	B_2	record head off	48.25	0.30 s.
			record head on, buzz increase	48.55	
			erase head off	49.47	2
155	5	D	record head on	154.75	
275	6	E	buzz decrease	275.33	
615	7	F'	K-1 pulse	611.81	
			record head off	611.82	0.03 s.
			record head on	611.85	
			K-1 pulse	612.35	
			erase head off (partial)	613.03	3
684	8	G	K-1 pulse	683.72	
			record head off	683.73	0.06 s.
			record head on	683.79	
			erase head off	684.93	
			erase head off (partial)	684.99	
			K-1 pulse	686.65	4
1041	9	C_1	record head on, buzz decrease	1040.57	
1042	10	C_2	record head off	1041.53	0.55 s.
			record head on, buzz increase	1042.08	
			erase head off	1042.74	
1061	11	H_a	record head on	1061.39	5
1065	12	H_b	record head on	1064.93	
			K-1 pulse	1065.17	
1109	13	F	K-1 pulse	1108.79	
			record head off	1108.80	1.20 s.
			erase head off, end of buzz	1110.00	



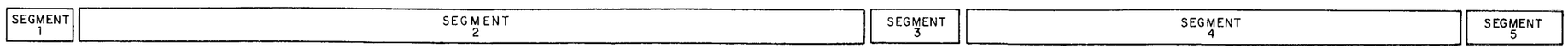


Figure 11. Chronological diagram of events in the 18.5 minute buzz section, EOB tape recording of June 20, 1972.

Technical Notes 2 and 3, respectively. The Event Occurrences listed in the table designate the events in terms of the recorder functions that cause them.

An "event" as we have defined it may contain several occurrences that take place at about the same time and that are related to each other functionally or operationally. The Event Time gives the approximate location of the Event. A more precise location of each occurrence is given in the next to last column. Here the time is given to hundredths of a second. This degree of precision is useful for showing the exact realtionships among several closely spaced occurrences in a single event. However, the time interval between widely separated events cannot be determined so precisely.

The probable error in measuring any time interval along the tape is about one or two percent of the duration of the interval. This means an error of one or two seconds for an interval of 100 seconds, and 10 or 20 seconds error in the measurement of the duration of the entire buzz section. The error arises from a combination of factors including the streching of the tape and the tape speed as dependent on the particular recorder used, the condition of the machine, and the degree of warm-up.

The bold lines associated with the last two columns in Table I indicate the five complete segments and the gaps between them. Each of these segments starts with a record head on, and ends with a record head off and its associated erase head off. Each gap is an interval between a record head off and its immediately subsequent record head on.

3. Identifying the Recorder Functions that Produced the Events on the Tape

In Table I and the chronological diagram of Figure 11, magnetic marks that were found at various places on the Evidence Tape are labeled with names that describe what the recorder did to make the mark; that is, such names as record-head-on and record-head-off are assigned to specific marks on the tape. Examples of the ways in which these identifications could be made have been shown in Chapter II, where the examples were used to illustrate methods of measurement. The logical steps that lead to conclusive identification of the marks are described explicitly in the paragraphs that follow.

A mark found on the tape can be made only by the erase head or by the record head. Because the erase head is wider than the record head, it will write a mark that is correspondingly wider. Thus, the width of a mark can be used to determine which head wrote it.

Both the erase and record heads write distinctive marks on the tape when they are energized and de-energized and the tape is pressed against the head. However, the erase head will immediately erase its own ON mark. The erase head will not erase its OFF mark (or quartet) unless the tape advances by more than 0.1 mm before the head is turned back on. If the tape advances by more than 0.1 mm but less than 0.5 mm (the length of the quartet) before the erase head is turned back on, some of the quartet lines will be erased. However, the lines that remain will still be of erase-head width. Therefore, whenever we find any lines of erase-head width we can be sure they were caused by the de-energizing of the erase head.

Unlike the erase head, the record head will leave marks on the tape both when it is turned off and when it is turned on. It will also leave marks on the tape in response to electrical transients generated inside the recorder or injected from an outside source. All of these marks are of record head width, so further information is needed to distinguish among them.

One way in which a record-head-off mark can be identified is based on the knowledge that whenever the erase head in a Uher 5000 recorder is de-energized to end a recording, and thereby writes its OFF mark, the record head also will write an OFF mark. Moreover, the Exhibit 60 Uher will write that mark exactly 28.6 millimeters from the erase-head-off mark (to the left in all the figures in this report). Therefore, a record head mark that is 28.6 millimeters to the left of an identified erase-head-off mark on the Evidence Tape must be a record-head-off mark.

If a record head mark cannot be associated with an erase head mark in the manner indicated above, other means must be used to classify it. One way is to compare the shapes and durations of the waveforms that the marks produce with those of known record-head-off and record-head-on marks. For example, the mark at the very beginning of the buzz section, shown in Figure 6 of Technical Note 2, is necessarily a record-head-on

mark. The mark at the end of the buzz, shown in Figure 17 of the same technical note, just before the brief silence and the erase-head-off mark, is necessarily a record-head-off mark. We can use these two marks as models in identifying other record-head marks.

The identifications of record-head marks can be confirmed by use of another kind of comparison. When a recording is stopped and then resumed, a definite pattern of marks and waveform characteristics will be recorded. The nature of that pattern will depend on the position of the tape when the recording is resumed relative to the position it occupied when the recording was stopped. By comparing the patterns of data at each of the events on the Evidence Tape with those of known sequences of operations, we can confirm the identifications of the record-head marks and, at the same time, determine the sequence of tape movements during the recording of the tape.

It was this kind of reasoning, supported by the shapes of the waveforms, that let us make firm identifications of the sets of magnetic marks at the beginnings and endings of the five segments that are shown in Table I and the chronological diagram of Figure 11. These segments are discussed in Chapter IV. For example, the erase-head-off mark at 49.47 seconds from the beginning of the buzz section was preceded at just the right time and distance by a mark at 48.25 seconds, which must have been -- and had the right wave shape to be -- a record-head-off mark. The record-head-on operation that started this segment occurred at the very beginning of the buzz section.

In four places on the Evidence Tape, at Event Times 155, 1041, 1061, and 1065 seconds, we found marks that appeared to be record-head-on marks on the basis of their waveforms but that did not immediately follow a record-head-off mark; that is, they occurred in the midst of ongoing buzz. They can be accounted for if the tape had stopped, then moved backward, in the rewind direction, and then started forward again to begin writing a new buzz segment.

In preceding paragraphs we have mentioned some consequences of stopping a recording operation, repositioning the tape, and restarting the recording. Figure 12 illustrates the way in which such recording interruptions produce unique patterns of data on the tape.

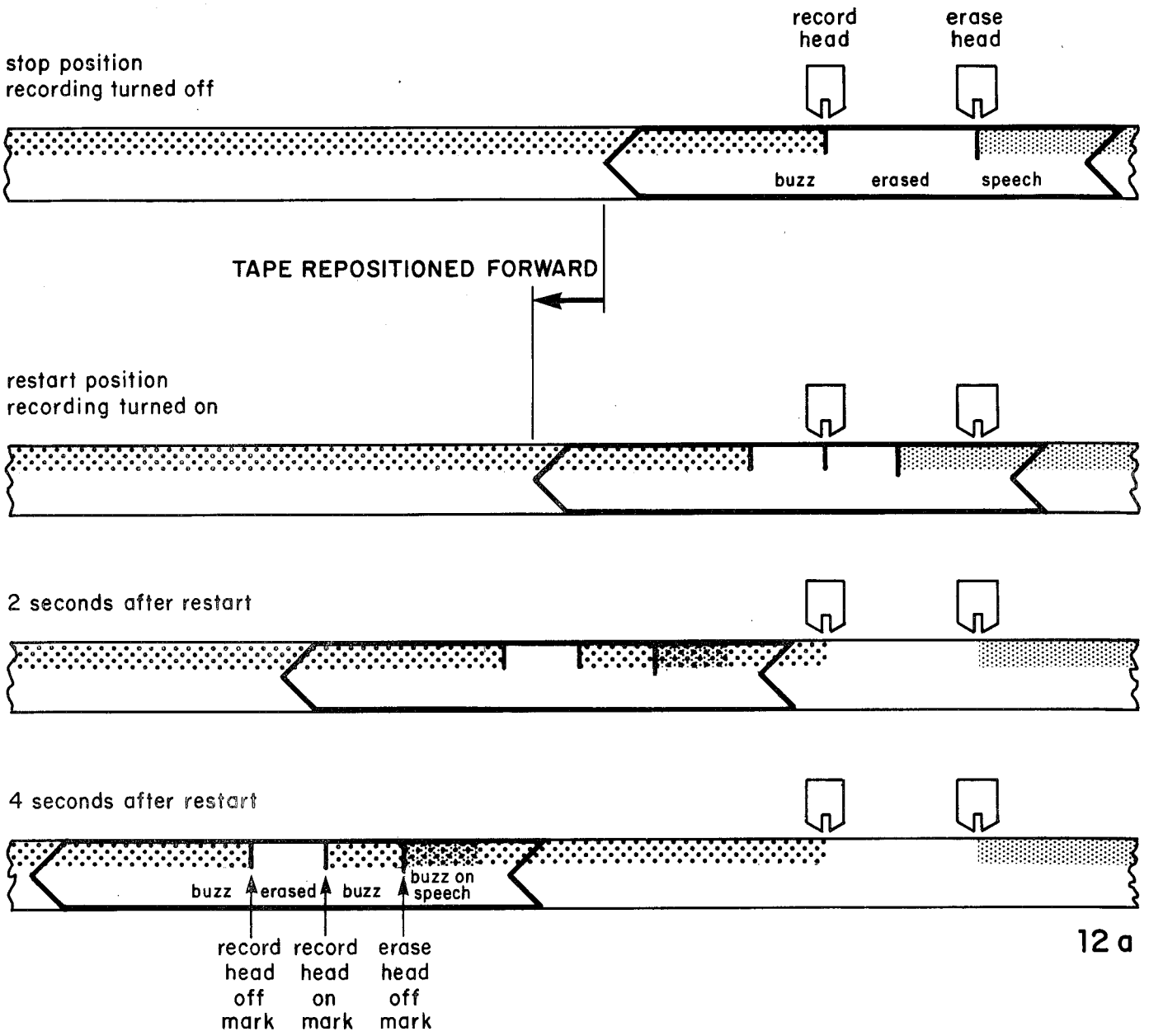
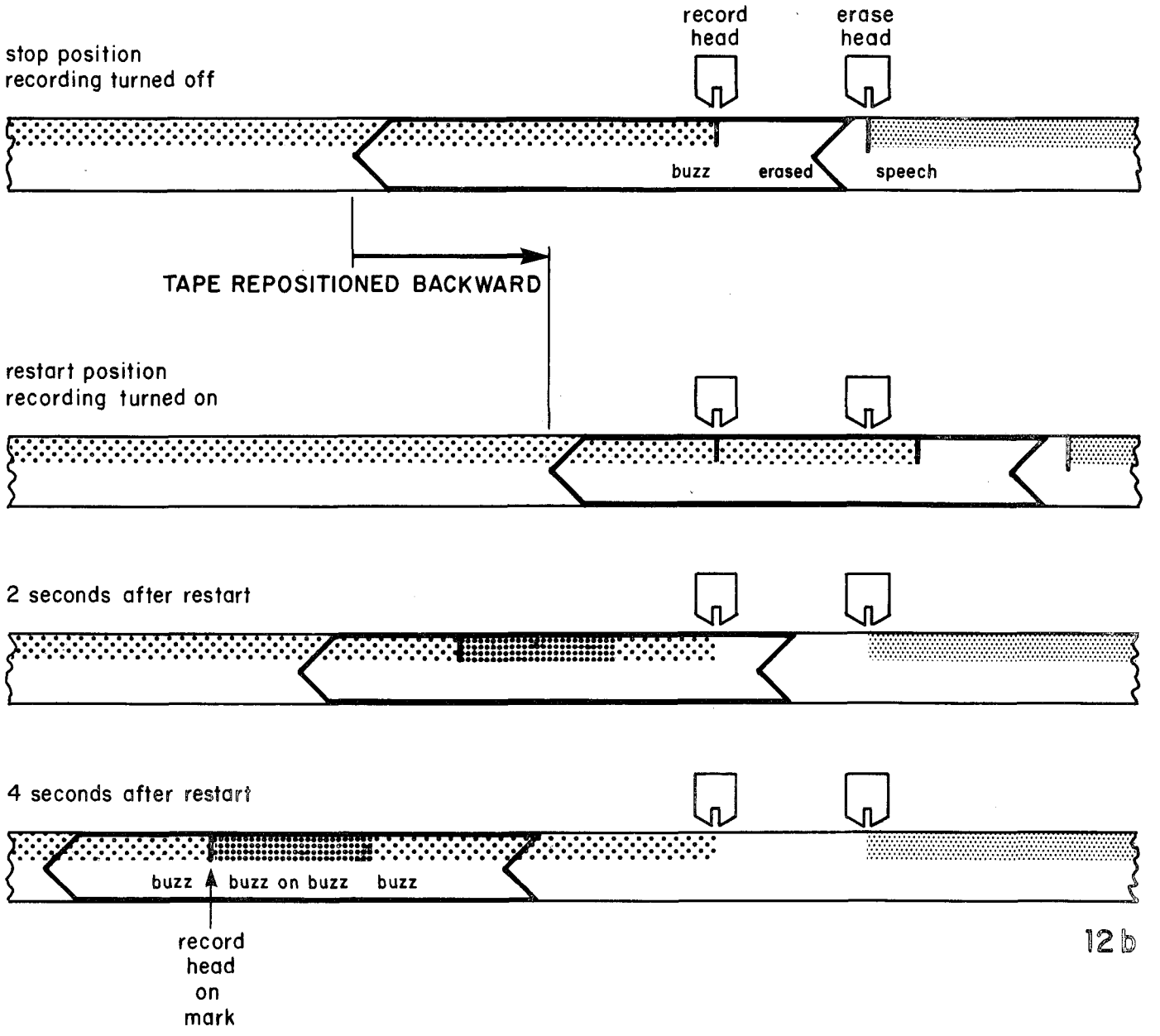


Figure 12. The diagrams represent a section of tape at four positions relative to the record head and erase head of a recorder. As the tape moves in from the right, the erase head obliterates speech recorded previously and the record head puts a buzz sound on the erased tape. In Figures 12a and 12b, the top drawing shows the tape stopped. Record-head-off marks and erase-head-off marks have been written on the tape.

In Figure 12a, the tape is repositioned forward so that a small segment of the recorded speech lies between the record and erase heads. When recording starts again and this segment goes by the record head, buzz is put on top of unerased speech, resulting in a "buzz-on-speech" segment.



In Figure 12b, the tape is repositioned backward so that the erase and record head marks precede the erase head. Consequently, when recording is resumed, both of these marks will pass by the erase head and be erased. The short segment of tape between the record head and erase head contains a previously recorded buzz that the recording head will overwrite with new buzz.

Figure 12a shows the tape repositioned forward by an amount less than the distance between the record head and erase head. Figure 12b shows the tape repositioned backward by an amount greater than the distance between heads. These and other combinations are explained in detail in Technical Note 3.

The pattern shown at the bottom of Figure 12a contains a record-head-off mark followed by a section of erased tape, a record-head-on mark, a section of buzz, an erase-head-off mark, and a section of buzz recorded on top of speech. This pattern is exactly the one seen in Figure 7, which illustrates Event Time 1042 seconds. The same pattern with somewhat different spacing occurs at Event Time 49 seconds.

When recording has been stopped and the tape displaced backward, the subsequent recording operation will obliterate the erase-head-off mark. If the backward displacement is more than the distance between the erase and record heads, the subsequent recording will obliterate the record-head-off mark also, as Figure 12b shows. However, even if both these marks are gone, the single remaining mark, the one made by the record head when the recording was resumed, can be identified reliably. This is accomplished by using certain supplementary data derived from phase measurement and recorder speed to confirm a tentative identification made using waveform data. If the tape has in fact been stopped and restarted, the buzz signal recorded on it is almost certain to be discontinuous in phase. Further, if the tape has not come fully up to speed before the recording was resumed, a change in tape speed will be detectable.

Using both waveform data and supplementary data as described above, we were able to identify the four marks mentioned earlier as being record-head-on marks. Tests we made on the Evidence Tape showed phase discontinuities at three of the four marks, at Event Times 155, 1061, and 1065 seconds. At the fourth mark, at 1041 seconds, phase measurement was not feasible for reasons explained in Technical Note 4. Further, changes in speed showed up at two of the events at Event Times 1061 and 1065 seconds.

Another type of evidence that confirms the identification of the four marks discussed above as record-head-on marks can be seen in spectrograms, and to some extent in the waveforms as well. Since the erase head did not pass over the brief segment immediately following the mark, this

segment of the earlier buzz recording was not completely erased when the new buzz was written over it. A visible residue was left in the spectrogram and waveform. This phenomenon is referred to as "buzz-on-buzz" as indicated in Figure 12b.

Thus several kinds of evidence converge on the conclusion that the isolated marks of record-head width are actually record-head-on marks. The combined evidence also shows that these marks signify the beginnings of new recording operations that took place after the recording had been stopped and the tape moved backward.

Another type of event is referred to in Table I as the K-1 pulse. The identification of this pulse depends partly on the distinctive character of the pulse waveform and the close agreement between waveforms seen on the Evidence Tape and those produced in experimental tests with Uher recorders, including the Exhibit 60 Uher. In part, also, the identification depends on the time of occurrence of the pulse with respect to other, known marks.

The combination of waveform shape and time of occurrence is very solid evidence for identifying the three pulses at times 611.81, 683.72, and 1108.79 seconds as K-1 pulses associated with record-off operations. The time of occurrence of K-1 pulses that are associated with record-on operations is much more variable, but supports that identification for the pulses at times 612.35, 686.65, and 1065.17 seconds. Technical Note 8 gives an account of the origin of K-1 pulses and shows typical waveforms. It explains why any K-1 pulses that are found must be attributed to keyboard operations, and also why keyboard operations do not always result in K-1 pulses on the tape.

An event without tape motion occurs at time -2.92 seconds. This event is clearly visible in the illustrations of Technical Notes 2 and 3 as an erase-head-off quartet embedded in the recorded speech just before the beginning of the buzz. No record-head-off mark is found at the appropriate distance ahead of it. Such a combination could be made in attempting to start a new segment by pressing the RECORDING key but failing to hold it down until after the START key was pressed. The details of such a sequence are given in Technical Note 3.

Chapter IV

DERIVATION OF CONCLUSIONS

The Panel's study of the authenticity and integrity of the June 20, 1972 Evidence Tape started with the formulation of the questions and plans set forth in Chapter I. Toward answering the questions, we used tests and analyses described in Chapter II to obtain factual data about the tape and the magnetic signals on it, the electrical and acoustical signals generated by playback of the tape, and the properties of the recording equipment that was or might have been used on the tape. The results of these tests, and other ones described in Technical Notes, constitute the solid, objective evidence that any person skilled in such tests can hear, see, measure, and confirm.

Chapter III shows how we combined the test results to identify and explain events on the tape as related to the properties of specific elements in the recording machine. Table I and Figure 11 summarize the events chronologically. Using this chronological sequence of events as a guide, we then interpreted the results in terms of the operations and controls of the recorder, together with plausible operator actions that would account for the overall pattern of magnetic marks and other data obtained from the Evidence Tape.

As pieces of factual information accumulated, we began to see how they might fit together to form answers, or at least trial answers, to some of the questions. In turn, the trial answers or hypotheses suggested further tests and analyses required for confirmation. Through many such rounds of test, hypothesis, and test again, we converged upon a single, self-consistent set of results, which we express in the form of seven conclusions:

1. The erasing and recording operations that produced the buzz section were done directly on the Evidence Tape.

2. The Uher 5000 recorder designated Government Exhibit #60 probably produced the entire buzz section.

3. The erasures and buzz recordings were done in at least five, and perhaps as many as nine, separate and contiguous segments.

4. Erasure and recording in at least five places on the tape required hand operation of keyboard controls on the Uher 5000 machine.

5. Erased portions of the tape probably contained speech originally.

6. Recovery of the speech is not possible by any method known to us.

7. The Evidence Tape, insofar as we have determined, is an original and not a copy.

The following sections explain the principal data and the lines of reasoning from which we derived each of the seven conclusions; the Technical Notes provide further details about factual data and interpretations.

1. <u>The erasing and recording operations that produced the buzz section were done directly on the Evidence Tape</u>.

Magnetic development of the Evidence Tape revealed that the magnetic marks were not all of the same width. Specifically we observed quartet marks corresponding to Uher erase-head-off signatures that are 0.6 mm wider than the record-head marks.

Magnetic recorders are designed so that the erase head erases a slightly wider portion of the tape than will later be written on by the record head. Therefore under normal circumstances erase-head marks should show up wider than record-head marks. This difference in width would not be preserved in making a re-recording or "dubbing."

In a dubbing, the playback head of a recorder reads the magnetic signals on an original tape and feeds the information into a second recorder. The record head of the second recorder copies the information onto a new tape. Regardless of their original width, the magnetic signals will be copied onto the new tape with the width of the recording head on the second machine, which is the only width that the record head can write.

Thus the presence of Uher erase-head marks that are wider than record-head marks means that the buzz section was produced directly on the Evidence Tape.

Waveform analysis of the erase and record signatures are consistent with the visible marks revealed by magnetic development. However, waveforms do not show the width of the original erase-head-off marks and thus do not provide additional information about Conclusion 1.

The fact that the Evidence Tape of June 20th was an original with respect to the buzz portion does not, of course, give any information about whether the portion of the tape containing conversational material was also an original recording (see Conclusion 7).

2. The Uher 5000 recorder designated Government Exhibit #60 probably produced the entire buzz section.

Magnetic development of the buzz section of the Evidence Tape provides sufficient evidence to show that a Uher 5000 rather than a Sony 800B produced the buzz signal on the tape. We restricted our investigation to these two types of recorders on the basis of information given to us by attorneys for the White House and the Special Prosecution Force.

The erase-head-off signature (quartet) of the Uher 5000 recorders that we have examined matches exactly the four-line pattern that appears at several places in the buzz section of the tape. The two-line erase-head-off pattern of the Sony 800B recorders does not match. In addition, the Evidence Tape shows several instances of a quartet following a record-head-off mark at a distance of 28.6 mm. This spacing matches exactly the distance between the erase and record heads of the Exhibit 60 Uher 5000, and not the corresponding distance between the erase and record heads of the Sony 800B, which is about 24 mm.

The differences between individual recorders of the same type are much less evident than the differences between types. As between the Exhibit 60 Uher and the Secret Service Uher, the Exhibit 60 Uher produces features on a tape that much more closely resemble the features found on the Evidence Tape. In fact, the Uher 60 matches closely enough to have been the machine responsible for the buzz section.

The following table gives a summary comparison of recording characteristics of the Exhibit 60 Uher, the Secret Service Uher, and the machine used to record the Evidence Tape. All the values given in the table

were obtained by analyzing magnetic marks or electrical signals on a tape. For the Exhibit 60 and Secret Service Uhers, we made special tape recordings for the purpose of the analysis. In addition, we measured the head geometry dimensions directly on the two machines. The results confirmed the corresponding data obtained from the tape recordings.

Table II

COMPARISON OF RECORDER CHARACTERISTICS

Head Geometry	Exhibit 60 Uher	Machine used to record buzz on Evidence Tape	Secret Service Uher
distance between record head and erase head, in millimeters	28.6	28.6	28.4
erase head track, in mm	3.0	3.0	3.0
record head track width, in mm	2.4	2.4	2.4
azimuth angle, in milliradians	-2.2	-1.7	-3.3
top edge of tape to lower edge of recorded track, in mm	2.4	2.4	2.6
Tape Speed			
measured value, in mm/sec	24.5	24.4	25.3
percent change from nominal value of 23.8 mm/sec (15/16 in/sec)	+2.8	+2.6 (average)	6.1
Flutter Amplitude			
in parts per thousand at flutter frequency of:			
0.35 Hz	-	-	0.9
3.0 Hz	1.4	1.7	-

(The bar "-" means that the flutter amplitude at this frequency is equal to or less than the noise level at this frequency.)

The space between the erase and record head marks on the Evidence Tape is 28.6 mm. Head spacing on the Exhibit 60 Uher is 28.6 mm, and on the Secret Service Uher is 28.4 mm. Although the measured difference in spacing as between the two machines is small, it is significantly larger than the smallest amount that can be measured.

The width of the erase-head-off mark is the same for the two Uhers and the Evidence Tape, within the limits of measurement, and therefore provides no help in distinguishing between the machines. The width of the record-head mark is also the same for the three cases, but the Secret Service Uher has the entire mark displaced by 0.2 mm toward the center of the tape; the distance from the upper edge of the tape to the lower edge of the recorded track on the Evidence Tape is the same as that of the Exhibit 60 Uher, and is significantly different from that of the Secret Service Uher. Hence, the Exhibit 60 Uher resembles the Evidence Tape in this respect whereas the Secret Service Uher clearly does not.

The azimuth angle for the Evidence Tape, which is the angle between the magnetic marks and a line perpendicular to the direction of tape motion, does not agree exactly with the azimuth angle for either Uher. However, the difference is less for the Exhibit 60 Uher. In any case, the differences are close to the limits of accuracy of azimuth measurements on half-track recordings.

Thus, geometrical characteristics favor the choice of the Exhibit 60 Uher. Most of the values depend on screw-driver adjustments that are made and sealed during manufacture, and are unlikely to change during normal service. However, the adjustments, especially the one for azimuth, may be changed and resealed, for instance, during repair or re-alignment. Inspection of the seals on both the Exhibit 60 and Secret Service Uhers showed no apparent differences from the factory-type seals on another Uher 5000 that had been purchased new for comparative tests. Hence, it is probable that both Uhers had the same head geometry when we measured them as when they left the factory.

Tape speed measurements are not highly reliable, because recorders of the Uher 5000 type show some variation in speed with warm-up and with power line voltage. Nevertheless, speed characteristics can be indicative. In this case the tape speed results match the Evidence Tape more closely with the Exhibit 60 Uher than the Secret Service machine.

Flutter spectra provide additional support for the conclusion that the Exhibit 60 Uher was probably the machine that produced the buzz section on the Evidence Tape. Figure 9, in Chapter II, shows flutter sideband spectra for the Exhibit 60 Uher, the Secret Service Uher, and the machine that recorded the Evidence Tape. The pair of flutter sidebands spaced at $\pm$ 3.0 Hz from the fundamental component of the buzz (i.e., 60 Hz) shows most clearly the difference between the Exhibit 60 Uher and the Secret Service Uher, and the close similarity between the Exhibit 60 Uher and the machine that recorded the buzz on the Evidence Tape.

The flutter sideband spectra are the same throughout the buzz section of the tape, leading the Panel to conclude that the buzz section was laid down by just one recorder. This conclusion is strongly supported by the invarient character of the spectrum of the buzz in the 18.5 minute section of the tape. Spectra obtained throughout the buzz section are virtually identical, which would not be true if the buzz was picked up and recorded by more than one recorder.

In this section we have relied in part on measurements made using the buzz to help identify the machine that recorded it. The fact that buzz was recorded is not in itself indicative of which machine was used, since all of the Uher recorders that we tested could be made to produce buzz. The Exhibit 60 Uher differed from the others in this regard only in that it produced a higher level of buzz under some test conditions.

With regard to the source of the buzz, it is highly likely that the buzz was derived from noise on the 110 volt, 60-Hz electrical line that powered the recorder during the erasure of the tape and recording of the buzz. Just how the noise was coupled to the amplifier that fed the record head, which recorded the buzz onto the tape, cannot be determined with certainty. There are several ways that hum and noise related to the 60 Hz power line could have been picked up by the recorder, the most likely being by direct conduction through connection to the power line, and by pickup at an open microphone terminal.

Even if no buzz had been recorded we would still have been able to identify the Exhibit 60 Uher as the machine that erased the 18.5 minute section of the Evidence Tape. The data for head spacing and track offset

shown in Table II would have been sufficient to make this identification. The data for flutter spectrum and tape speed that were obtained from analyses of the buzz serve to confirm the identification. Thus, the recording of buzz was, if anything, fortuitous for the purposes of this investigation.

3. The erasures and buzz recordings were done in at least five, and perhaps as many as nine, separate and contiguous segments.

The data obtained from the Evidence Tape by means of magnetic marks, waveforms, and related observations show that the buzz section contains at least the five contiguous segments identified in Table III. Each of these segments starts with a record-head-on mark, and ends with a record-head-off mark that is followed by an associated erase-head-off mark at a time of 1.2 seconds later in playback time. Because all three of these marks are observed in connection with each of the five segments, we call them complete segments.

In calling these segments contiguous, we mean that the erase-head-off mark at the end of each segment comes after the record-head-on mark that starts the subsequent segment. These relationships are seen in Table I of Chapter III. Because each of these contiguous segments overlaps the adjacent ones, every part of the 18.5 minute buzz section has been subjected to recording of buzz or to erasure or to both.

Within the segments, the tape carries evidence of four additional record-head-on marks, shown in parentheses in Table III. These occur at Event Times 155, 1041, 1061, and 1065 seconds. However, the tape does not show accompanying erase-head-off and record-head-off marks, which presumably were erased by backing up the tape and recording over the marks, as in Figure 12b in Chapter III. We interpret these additional marks to be the beginnings of four recording operations, which start what we call incomplete segments. Thus, the buzz section was almost surely recorded in at least nine separate start-and-stop operations, even though we consider the five complete segments to be established to a higher degree of certainty because of the distinctive character of the erase-head-off quartets that they contain.

Table III

ANALYSIS OF SEGMENTS IN BUZZ SECTION

The table shows the time in seconds from the start of the buzz section to the beginning (record head ON) and ending (record head OFF) of five intervals of continuous buzz, and also shows the duration of those intervals. Figures in parentheses refer to other times when a new recording operation was started, overlapping the previous buzz recording and erasing its OFF marks. All figures give playback time in seconds at a tape speed of 24 millimeters per second.

Segment	Record Head ON	Record Head OFF	Duration of Buzz Interval	Duration of Gap after Buzz	Buzz Plus Gap
1	0.0 sec	48.25 sec	48.25 sec	0.30 sec	48.55 sec
2	48.55	611.82	563.27	0.03	563.30
	(154.75)				
3	611.85	683.73	71.88	0.06	71.94
4	683.79	1041.53	357.74	0.55	358.29
	(1040.57)				
5	1042.08	1108.80	66.72	1.20	67.92
	(1061.39)				
	(1064.93)				
			Total duration of buzz section		1110.00 sec

Note to Table:

The gaps shown in this Table are the same as those in the right-hand column of Table I, Chapter III. The final gap, after Segment 5, is of course the interval by which the erase head always precedes the record head and so contributes to the total duration of the buzz section. Figure 12a shows how the gaps result from forward displacement of the tape after a segment ends and before the next one begins. Figure 12b shows how overlapping of two segments results from backward displacement of the tape.

Figure 12 in Chapter III illustrates the ways in which certain recorder operations and tape motions produce the kinds of data that led the Panel to identify the separate segments. A forward displacement of the tape between the turning off and the turning on of a recording operation produces a pattern of data like the one seen at the bottom of Figure 12a. This pattern includes an erased gap, which is the gap referred to in the next to last column in Table III. The length of this gap is the amount by which the tape was repositioned forward. The pattern also includes a section of buzz on speech, which is of the same length as the erased gap. We identified the speech-like sound by using spectrographic analysis and by listening. At each point on the Evidence Tape where one complete segment joined an adjacent one, the tape carried the entire pattern of data seen at the bottom of Figure 12a.

Figure 12b shows the pattern of data produced when the tape is repositioned backward rather than forward before turning a recording operation back on again. Here only one mark survives, a record-head-on mark, and it is followed by a section of buzz on buzz. This is the pattern of data observed at the beginning of each of the four incomplete segments discussed above.

In concluding that the buzz section was recorded in "separate and contiguous segments" the Panel used magnetic marks and their associated waveforms as the primary evidence. This conclusion was corroborated by results of tests on phase shifts in the 60 Hz powerline hum. Such phase shifts occur at those locations on the tape where magnetic marks and waveforms indicate a stop-start operation. The phase shifts and their precise association with the magnetic marks and waveforms provide strong evidence that stops and starts did indeed occur.

4. Erasure and recording in at least five places on the tape required hand operation of keyboard controls on the Uher 5000 machine.

In Conclusion 3, we dealt exclusively with machine functions in explaining the buzz and distinctive marks and signals on the Evidence Tape. In Conclusion 4, we deal primarily with actions performed by an operator in order to cause certain events observed on the tape.

Inspection of the circuit diagram and of the electrical connections between the evidence foot pedal and the Exhibit 60 Uher clearly shows that no operation controlled by the foot pedal alone will put the recorder into erase-record mode. This observation is confirmed by direct trial. The foot pedal can control only tape motion: make the tape go forward at the normal record/playback speed, go backward at high speed, or stop.

All other functions are controlled by hand, using the keyboard or other manual devices on the recorder itself. In particular, manual operation of a keyboard control is required to put the recorder into erase-record mode. Moreover, the foot pedal cannot take the machine out of erase-record mode. If the machine remains in record mode, stopping and starting the tape with the foot pedal leaves a distinctive set of marks of a kind that we have not found on the Evidence Tape (see Technical Note 1).

The RECORDING key latches mechanically and can be released only by pressing some other key, such as STOP or START. When the RECORDING key is released, OFF marks will be written on the tape by the erase head. The record head will also write OFF marks if it is in contact with the tape when the RECORDING key is released. Thus, the presence on the tape of an OFF mark -- especially the highly distinctive quartet from the erase head -- requires hand operation of a Uher 5000 recorder if the machine is operating normally. The possibility that malfunctioning of the recorder could have accounted for all the distinctive marks and signals on the Evidence Tape is considered in Technical Note 9, and conclusively eliminated.

Evidence of a different kind provides independent confirmation of Conclusion 4. The Uher 5000 recorder contains a mechanical switch, labelled K-1 by the manufacturer, which opens and closes only as a result of pushing certain keys on the keyboard of the machine. The K-1 switch cannot be operated by an external control such as a foot pedal. Further, no kind of malfunction in the electronics of the recorder, such as intermittent failure of a diode transistor or capacitor, can actuate the K-1 switch.

Operation of the K-1 switch, either opening it or closing it, generates a transient electrical pulse. If the machine is recording on tape when K-1 is actuated, the pulse will be recorded as a brief, characteristic magnetic mark. The K-1 mark may, or may not, be sufficiently separated from other, stronger marks to be recognizable, depending on the exact way the keys were pressed. Thus magnetic marks that can be positively identified as K-1 marks provide unambiguous evidence of manual operation of keyboard controls.

By making test recordings on a Uher 5000 recorder, the Panel produced magnetic marks known to be caused by the K-1 switch. The same kinds of marks were found at six places on the Evidence Tape. Waveform analysis corroborated the identification of these marks as K-1 pulses. The Panel considers that these six marks observed on the Evidence Tape strongly support Conclusion 4.

Conclusions 3 and 4 taken together require that several sequences of manual operations were needed to produce the signals and marks observed in the buzz portion of the Evidence Tape. The Panel rejects the hypothesis that all the observed marks could have been caused by some combination of foot pedal operations after the machine had been put into erase-record mode and before it was returned to playback mode, i.e., that the buzz was produced as the result of a single depression of the RECORDING key. The presence of five or more distinctive erase-head-off marks argues strongly against this hypothesis, as does the absence of magnetic patterns characteristic of stop-start operations of the recorder by means of the foot pedal.

In summary, the organization of the controls for the Uher 5000 recorder is such that normal operation of a normal machine cannot result in an erase-record operation without using the manual keyboard or an equivalent hand-held control device. The existence of several erase-record operations, as attested by distinctive magnetic marks on the tape, necessarily implies corresponding sets of manual operations by the person using the recorder. Finally, the presence of certain electrical pulses made by the K-1 switch can be accounted for only if hand operation of the keyboard controls was involved.

5. Erased portions of the tape probably contained speech originally.

Several kinds of evidence independently indicate that the buzz section was recorded over erased speech. The evidence relates to the operating characteristics of the recording system, to the pattern of speech preceding and following the buzz, and to the presence of incompletely erased segments within the buzz section.

The system used to record the conversations of June 20, 1972, onto the Evidence Tape contained a voice-operated switch, or VOX, to control the recorder. In such a system the VOX starts the tape moving when people start talking and stops the tape during silent periods of more than a few seconds. Actually the VOX responds to any sound that is as loud as speech and that lasts for more than a fraction of a second. As long as the VOX is operating normally, the tape cannot move very far, certainly not the 87 feet (27 meters) corresponding to 18.5 minutes, unless speech or equivalent sound is present.

Was the VOX operating normally? Was it actuated by speech or by some other kind of sound? We tested the VOX that had been used in connection with the recording of the Evidence Tape and found that it performed as it was supposed to. Further, we examined the entire tape itself for possible signs of VOX malfunction. We did this with the tape running at four times normal speed, in order to honor the confidentiality of the recorded conversations. We found no abnormal gaps.

In another test, by making allowances for the effect of the high-speed playback on the sound quality, we were able to identify sounds of speech throughout the length of the tape except for the part occupied by the buzz section. Since this section occupies only a small fraction of the entire tape, about 1/20, the absence of speech under the buzz would be statistically unlikely.

We made a more detailed statistical test on the 67-minute section to which we were permitted to listen. We studied the conversational pattern of the speech by using spectrograms to identify VOX interruptions and then measuring the durations of the talking periods in between. We found an average value of about 5 interruptions per minute of playing time, which means an average talking period of about 12 seconds between silences sufficient to let the VOX turn off. This average value remained constant

throughout the 20 minutes before the buzz section and the 29 minutes after the buzz section. This result indicates statistically that the VOX was operating normally on conversation before and after the buzz and, therefore, was probably operating normally also during the recording of that portion of the tape now occupied by the buzz.

Figure 13 illustrates an entirely different kind of evidence. At three places, a small stretch of tape was not erased in the course of recording the buzz section. The first place occurs at the very beginning of the buzz section, where the stretch of 1.2 seconds, or 28.6 millimeters along the tape, was partially erased by the recording head as it recorded the buzz, but was untouched by the erase head. The resulting "window" contains a spectrographic pattern of speech that is concluding an ongoing sentence. Two other windows, of 0.3 and 0.55 seconds duration, respectively, show up as a result of forward motion of the tape by those amounts between the stopping and the starting of the recorder in erase-record mode. Throughout the 18.5 minute section, these three windows are the only places where any residual speech could have survived if speech had been present under the buzz. All three windows do in fact show speech-like spectra and they sound speech-like in a listening test. This makes it seem likely that speech was present originally in other parts of the buzz section also. The windows and their contents imply that the buzz we observe was laid down directly over speech. But we can be reasonably sure about this only near the beginning and ending of the buzz section. The rest of the buzz section contains no evidence to exclude erase-record operations that might have preceded the ones we have measured and reported.

In summary, several kinds of evidence converge on the conclusion that the buzz section of the Evidence Tape probably contained speech originally.

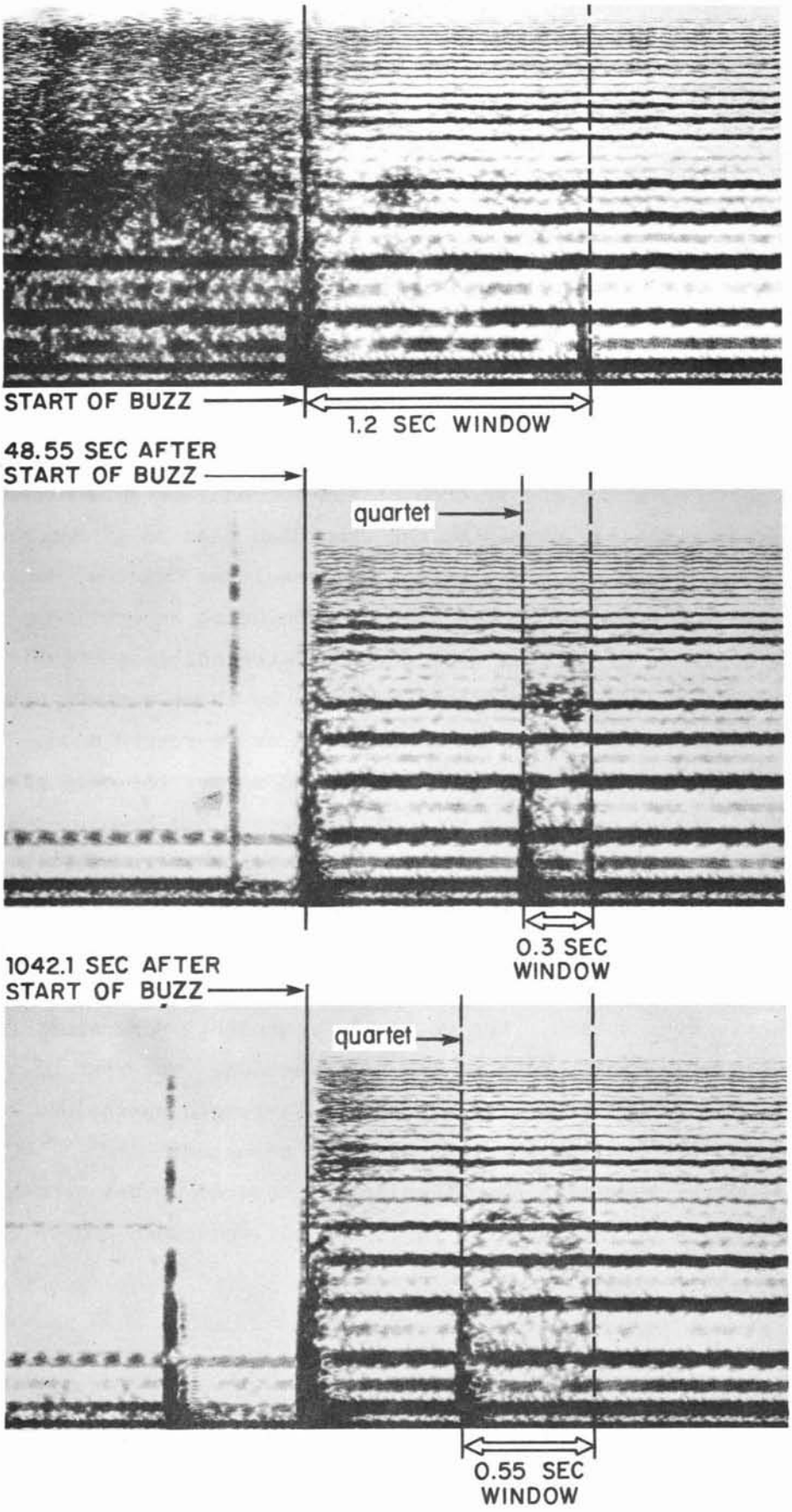


Figure 13. Spectrograms of speech-like sounds in windows.

These spectrograms show frequency on a logarithmic scale, whereas those in Technical Note 3 use a linear scale; see page TN 3.46.

6. Recovery of the speech is not possible by any method known to us.

When the 18.5 minute buzz section was recorded, the erasing head of the recording machine eliminated virtually all the original signals on that section of the tape. Just the erasure by itself would have made the recovery of previously recorded signals essentially impossible. The presence of the buzz, which masks any signals that survived erasure, compounds the difficulty of recovery. A double-gap erasing head, which the quartet marks and other evidence show was used, erases with great thoroughness. Further, erasure is especially effective at the low speed of 24 millimeters per second (15/16 inch per second).

Nevertheless the Panel investigated several techniques for the possible recovery of speech. None was successful. We used a very narrow playback head in an attempt to pick up signals along the extreme outer edge of the tape, where erasure conceivably could have been incomplete. We detected only buzz noise.

In another attempt, we used an electronic "comb filter" to reduce the strength of the hum components that make up the buzz. We applied this filtering to the three short "window" segments where speech-like sounds show up on spectrograms. In yet another attempt, we subtracted hum signals digitally. These filtering techniques allowed us to perform listening tests and spectrum analysis on the window signals with much less interference. These tests further convinced us of the decidedly speech-like character of the sounds, though we were still unable to understand anything that might have been said.

Several interested persons outside the Panel suggested various techniques for recovering speech from an erased tape. One possibility would involve the use of X-ray diffraction to observe patterns in the magnetic domain structure. Although this idea offers an interesting research problem, we did not pursue it because it would take months if not years to accomplish and in our opinion would have a negligible chance of yielding results of value to our investigation.

Another possiblity would involve trying to detect magnetic skew, a distortion of the domain structure brought about by the off-axis magnetic field of the record head. Skew becomes gradually "annealed" into a permanent shift, which suggests that it might be possible to

distinguish between signals recorded at two different times a year apart. However, the test would destroy some evidence because skew detection requires the erasure of the normal magnetic signals on the tape. Since the chance of success appeared negligible, we did not pursue this approach.

7. The Evidence Tape insofar as we have determined is an original and not a copy.

This conclusion is based primarily on lack of evidence that might raise serious questions about the Evidence Tape. We examined certain obvious, even if unlikely, possibilities. Measurement showed that the total length of the tape was within the normal range for tapes sold as 1800 feet (550 meters). Thus we assumed that no substantial part had been detached. We found no physical splices. The beginning and end of the recording contained no anomalous signals such as might be associated with re-recording. A single erase-head-off signature of the correct width to have been made by a Sony 800B recorder was found at the end of the Evidence Tape, indicating that the tape had been recorded on a machine of the type used in the Exeuctive Office Building system.

We examined the tape for any spurious tones or hum signals that might have been added if the tape had been re-recorded. We would expect such tones to remain essentially unchanged throughout the length of the tape. We found no evidence of such additional tones.

In our early tests, we observed some initially suspect features on the Evidence Tape. Where the VOX had started and stopped the tape, the signal "scooped" down to a lower frequency in a way that suggested an abnormality of some kind. However, in our further tests on the Sony 800B recorders used in the White House offices, we found one machine that operated with a slight abnormality and produced features much like those observed on the Evidence Tape. The machine did not exactly match the scoops and other observable marks on the Evidence Tape so we could not conclude with certainty that it was the same machine that was used to record the Evidence Tape. Still, the scoops produced by the machine were close enough in character to those on the Evidence Tape that the Panel was convinced that an abnormal recorder and not a re-recording operation was responsible for the scoops.

8. Explanation of the buzz section

These seven conclusions, which we first reported to the Court on January 15, 1974, fit together to form a single, consistent explanation of the buzz section on the EOB Tape of June 20, 1972:

> The erasure of the 18.5 minutes of speech and concurrent recording of buzz in its place was done on a Uher 5000 recorder, probably the one labeled Government Exhibit 60. The recording was started and stopped several times by the pushing of keys on the keyboard of the machine. Sometimes the tape was repositioned backward or forward by a small amount before recording was resumed. The buzz sound probably originated in hum and noise derived from the power line that supplied electrical power to the recorder.

When viewed apart from the total body of data, certain individual marks on the Evidence Tape might be accounted for in ways other than we have described. However, only one explanation, the one given here, accounts for the data in their entirety and the patterns they form. Every possible alternative that we considered, including those proposed by other persons, ignores one or more vital aspects of our total findings. Our confidence in the seven conclusions is based on the plausibility and self-consistency of the explanation, the thoroughness of the tests and analyses, and the failure of any other alternative known to us to yield a factually coherent and complete account.

Appendix A

INFORMATION AND EVIDENCE MATERIALS SUPPLIED TO THE PANEL

Certain information was provided to the Panel in its initial briefing and at various later times by the Court and the two legal staffs. This information can be summarized, at least as to type, under the following headings:

Recording installation in the Executive Office Building. Several miniature microphones in the President's office were connected to the signal input of a Sony 800B recorder. The signal from the microphones also operated a voice-actuated switch (VOX) which started and stopped the tape motion of the Sony recorder. Two recorders were used, one or the other being enabled on alternate days (except on weekends) by a clock-controlled switch. Only Sony 800B recorders were used in the Executive Office Building system. No circuit drawing was provided.

Normal Operating Procedures. The recording system was operated and maintained by the Secret Service. The Panel received general information about the layout of the system and operating procedures. Apparently, detailed records on the assignment of particular recorders and the details of maintenance and repair were not kept.

White House Office Equipment. The Secret Service provided the White House with a Uher 5000 recorder (Exhibit 60), equipped with a Fidelitape foot-pedal control (Exhibit 60B) for the purpose of transcribing tapes. Before we received the recorder, it was twice modified by the Secret Service, once to disable its recording function, and again to restore this function. A high-intensity lamp and an electric typewriter from the White House were also provided for test as possible sources of the buzzing sound on the Evidence Tape. Access to the office was arranged on one occasion for tests of local interference on the electric power lines.

Transcript of Testimony. We were given transcripts of public testimony before the Court dealing with the buzz section of the Evidence Tape.

The principal items of equipment provided by the Court were as follows:

2 - Voice-operated switches

2 - Shure mixers

2 - Clock-operated switches

3 - Sony 800B recorders, marked "EOB"

4 - Sony 800B recorders, marked "Oval Office"

(One of the seven Sony's was inoperative and was not used in our tests.)

1 - Uher 5000 recorder, marked "Exhibit 60"

1 - Uher 5000 recorder, marked "Secret Service"

1 - Fidelitape foot pedal, marked "Exhibit 60B"

2 - Voice control systems

1 - Electric typewriter

1 - High-intensity lamp

Appendix B

PROCEDURES AND PRECAUTIONS USED IN EXAMINING THE TAPES

Whenever the Panel was conducting tests on the actual Evidence Tape and on recorders introduced into evidence, we carefully observed certain precautions. Two or more Deputy U. S. Marshals were present throughout the testing of the Evidence Tape. A Marshall watched over the tape at all times.

Staff members of the Office of the Counsel to the President and of the Special Prosecutor's Office were present whenever the Panel was examining the Evidence Tape. We gave these persons whatever information they wished to have concerning our ongoing studies, and we did our best to keep them informed about our tests and results.

We were permitted to make measurements on the entire Evidence Tape of June 20, 1972. However, our listening to the tape was restricted to a marked portion that included the buzz section, about 20 minutes of conversation preceding the buzz section, and about 29 minutes of conversation following the buzz section. Whenever we played back other parts of the Evidence Tape, we did so at four times normal speed, in order to protect the privacy of the recorded conversation.

We made copies of the marked portion containing the buzz, for our use in studies that did not require the actual Evidence Tape. No restriction was imposed on our use of these copies other than the general instruction to the Panel to regard its work for the Court as confidential.

The recorders and other items of equipment provided by the Court for our use were likewise under constant supervision by Deputy U. S. Marshals. For some of the tests, we wished to adjust or partially disassemble recorders of the same type. For this reason, and to minimize our demands on the time of the Deputy Marshals, we purchased new recorders and used them in our tests whenever possible.

Appendix C

PROFESSIONAL BIOGRAPHIES OF THE PANEL MEMBERS

A diversity of skills and specialized knowledge is required in the analysis and authentication of a tape recording. This diversity is reflected in the choice of the six Panel members, each of whom brings to the task a different background of needed specialization combined with a general, shared background of scientific and engineering competence.

All members of the Panel have in-depth experience and first-hand familiarity with the theory and practice of speech recording. More importantly, however, all Panel members have the necessary backgrounds in mechanics, acoustics, electronics, and magnetic phenomena to understand the complex interrelationships between sounds and sound-recording devices. All Panel members are broadly experienced in making physical measurements and interpreting technical data in connection with research and experimentation.

Each member of the Panel brought to this task specific capabilities and a depth of understanding in one or more specialized areas, including the following: instrumentation of data acquisition systems; analysis of acoustic waveforms in the time and frequency domains; recovery of speech from background noise; use of digital computers to process and analyze electronic signals; theory of phonetics and speech production.

The professional biographies that follow summarize the education and experience of the six Panel members, with emphasis on aspects relevant to this task.

Richard H. Bolt

Dr. Bolt is Chairman of the Board of Bolt Beranek and Newman Inc., a research, consulting, and development company founded in 1948 and specializing in acoustics and computer technology.

He received a Ph.D. in physics in 1939 from the University of California, pursued post-doctoral work under a National Research Council Fellowship, and taught physics at the University of Illinois. At the Massachusetts Institute of Technology during World War II, he was Technical Director of the Underwater Sound Laboratory, which developed mechanical noise-making devices used by the U. S. Navy to sweep acoustic mines.

He established the M.I.T. Acoustics Laboratory in 1945 and served as its Director until 1958. Also at M.I.T. he has held positions of Associate Professor of Physics, Professor of Acoustics, and Lecturer in Political Science. He was Associate Director of the National Science Foundation and Director of NSF's Science Resources Planning Office from 1960 to 1963. During 1963-64 he was a Fellow in the Center for Advanced Study in Behavioral Sciences at Stanford.

Dr. Bolt is a Fellow of the Acoustical Society of America, chairman of its Coordinating Committee on Environmental Acoustics, Past President (1949-50) of the Society, and recipient of the Society's biennial award in 1942 for noteworthy contributions to acoustics. He was the first President of the International Commission on Acoustics and has served on the Governing Board of the American Institute of Physics, the NASA Committee on Operating Problems, and the Commission on Engineering Education. At present he serves on the Board of Directors of the American Association for the Advancement of Science, the NPA Committee on National Goals and Resources, and the Trustees Council of the University of Massachusetts. He is a Fellow of the Institute of Electrical and Electronic Engineers, the American Physical Society, and the American Academy of Arts and Sciences. He is a member of Phi Beta Kappa, Sigma Xi, Eta Kappa Nu, and the Cosmos Club.

He is co-author of Sonics, an internationally used book on mechanical and electrical systems for industrial applications of sonic energy, and he has contributed to a number of other books and publications. He is the author of many reports and more than 70 technical papers on topics such as sound waves in enclosures, pulse statistics, speech intelligibility, and speaker identification by use of spectrograms.

Franklin S. Cooper

Franklin S. Cooper has served as President and Research Director of Haskins Laboratories since 1955. Prior to that, from 1939-1955, he was Associate Research Director of the Laboratories.

He received his B.S. in Engineering Physics (honors) at the University of Illinois, 1931, and Ph.D. in Physics at Massachusetts Institute of Technology, 1936. He served as teaching and research assistants at both institution (Illinois, 1931-34; M.I.T., 1934-36).

During World War II, he served (on partial leave from Haskins Laboratories) in the National Defense Research Committee and the Office of Scientific Research and Development as Liaison Officer, 1941-1943, and as Senior Liaison Officer (in charge) 1943-1946. He was awarded the President's Certificate of Merit, 1948.

Since 1949 the major part of Dr. Cooper's research activities has centered around the acoustic and articulatory nature of speech and the perceptual processes involved in its reception. Much of his research has involved use of synthetic speech based on spectrographic displays and controlled psychological testing to find the acoustic cues for the perception of the phonemes of American English and various other languages. This work has led to other research directed more broadly to the relations between speech production and perception and to relationships between speaking and reading. The development of new instrumentation for such research has been a continuing part of his career. He has co-authored some forty technical publications in speech-related areas. His research in other fields has resulted in more than twenty other technical papers.

Other science-related activities include service as a staff member of Survey of Research in Industry, National Research Council, 1940; Scientific Consultant to the Atomic Energy Commission Group, United Nations Secretariat, 1946-47; Consultant, Office of the Secretary of Defense, 1949-50; Visiting Committee of the Modern Language Department, Massachusetts Institute of Technology, 1952-55; Advisory Committee of the Research Division of the College of Engineering of New York University, 1949-1965; Adjunct Professor of Phonetics, Columbia University, 1955-1966; Fellow of the Center for Advanced Study in the Behavioral Sciences, 1964-65; Trustee, Center for Applied Linguistics, 1969-1974; Member of Communicative Sciences Study Section, National Institutes of Health, 1964-1968, 1974- ; Adjunct Professor of Linguistics, University of Connecticut, 1969- , and Senior Research Associate in Linguistics, Yale University, 1971- . He is a member of the Institute of Electrical and Electronics Engineers (Fellow), Acoustical Society of America (Fellow), American Speech and Hearing Association, Linguistic Society of America, Sigma Xi, Council on Foreign Relations, and the Cosmos Club (Washington). Scientific awards include Honors of the American Speech and Hearing Association and Pioneer in Speech Communication, Institute of Electrical and Electronics Engineers.

James L. Flanagan

James Flanagan joined Bell Laboratories in 1957 after completing post-doctoral study at the Massachusetts Institute of Technology. In 1961 he became Head of the Speech and Auditory Research Department, and in 1967 he was made Head of the Acoustics Research Department. He currently directs the research of approximately 30 scientists, engineers and technicians working in communications and computer techniques.

Dr. Flanagan received the Sc.D. degree and the S.M. degree, both in electrical engineering, from the Massachusetts Institute of Technology. He received the B.S. degree, also in electrical engineering, from Mississippi State University. He served in the U. S. Air Force in non-commissioned and commissioned grades.

His technical interests have centered on voice communication and digital techniques for signal analysis and transmission. He has been concerned with signal processing methods for bandwidth conservation, and with fundamental acoustical studies of speech and human hearing.

He holds approximately 30 U. S. patents in the fields of speech-coding, digital processing and underwater acoustics, and has published some 90 technical papers in these and related fields. He is the author of a book Speech Analysis, Synthesis and Perception, which has been translated into Russian and Spanish.

Dr. Flanagan is a Fellow of the Institute of Electrical and Electronic Engineers, a Fellow of the Acoustical Society of America, a member of the Board of Governors of the American Institute of Physics, and a member of Tau Beta Pi and Sigma Xi. He has served on and headed a number of boards for government organizations and professional societies, including committees of the National Academy of Sciences and National Academy of Engineering.

John G. McKnight

Mr. McKnight is a consultant in magnetic recording, audio systems, and audio standardization. He also serves as Vice President of Engineering for the Magnetic Reference Laboratory (MRL) in Palo Alto, California.

He received a Bachelor of Science degree in electrical engineering at Stanford University in 1952. Upon graduation, he joined Ampex Corporation where he was involved in the design and development of audio tape recorders. With the U. S. Army from 1953-56, Mr. McKnight worked in the Armed Forces Radio Service Studio in New York City as an operator of sound-recording equipment. He returned to Ampex Corporation in 1956 and served in a number of that company's divisions before becoming a private consultant in 1972. While at Ampex, Mr. McKnight was involved in many aspects of research, engineering, and design related to magnetic tape recording systems and their elements. He is the author of more than forty technical papers and presentations. He is also a principal author

of standards on audio flutter measurement and tape flux measurement published by the American National Standards Institute.

He is a member of numerous sound-recording standards committees, both national and international. A Senior Member of the Institute of Electrical and Electronics Engineers since 1962, Mr. McKnight served on the administrative committee of that Society's Group on Audio and Electroacoustics and its standards committee. He is a Fellow of the Audio Engineering Society, a member of the AES Editorial Board, past chairman of the AES Standards Committee, and he has twice served as Governor of the Society. In 1971 Mr. McKnight received the AES Award "for outstanding services in furthering theory and practice of magnetic recording..."

Thomas G. Stockham, Jr.

Dr. Stockham is a Professor of Electrical Engineering in the Computer Science Department at the University of Utah. Prior to joining the University of Utah in 1968, Dr. Stockham conducted research in signal processing at the M.I.T. Lincoln Laboratory. He research there led to an invention used in eliminating subjective noise in audio tape recordings. Earlier he served as an Assistant Professor of Electrical Communications at M.I.T. One of his research activities during this period involved him in a digital signal processing experiment to isolate the effects of room acoustics from the effects of a loudspeaker. His principal research since 1958 has been in the field of information processing, with a strong emphasis on digital processing of acoustic waveforms. At the University of Utah Dr. Stockham directs a large digital signal processing research project.

Dr. Stockham holds S.B., S.M., and Sc.D. degrees in electrical engineering from the Massachusetts Institute of Technology. While in graduate school, he served as a teaching assistant and as an instructor. He received the Goodwin Teaching Award in 1957 for "conspicuously effective teaching."

Dr. Stockham is a member of Tau Beta Pi, Sigma Xi, Eta Kappa Nu, the Institute of Electrical and Electronics Engineers, and the Association for Computing Machinery. In 1969 he was joint recipient of the IEEE Audio and Electroacoustics Senior Award. He is also the 1973 recipient of the award for outstanding technical achievement from the Utah Chapter of the IEEE.

Mark R. Weiss

Mr. Weiss is Vice President for Acoustics Research at Federal Scientific Corporation (FSC). He became affiliated with FSC in 1957, at the time the company was formed, and has been responsible for its acoustics programs since 1962.

He has conducted and directed research aimed at the development of analog instruments and digital computer techniques for the analysis, classification and processing of a variety of audio signals. Much of his work has centered on the use of instruments and instrumentation techniques for spectrum analysis of acoustic waveforms. His major interest has been the development of methods for analyzing speech and for increasing the detectability and intelligibility of speech that is obscured by noise.

Mr. Weiss has a B.S. in electrical engineering from the City College of New York, and an M.S. in electrical engineering from Columbia University.

He is a Fellow of the Acoustical Society of America, a member of its Technical Committee on Speech Communication, a member of the Institute of Electrical and Electronics Engineers, and Eta Kappa Nu. He has written or co-authored two dozen papers and reports, most of them in the area of speech analysis.

Appendix D

INTERIM REPORTS SUBMITTED BY THE PANEL

1. Plans for a Study of the White House Tapes:
   a Draft Proposal Submitted to the Court on November 21, 1973.

2. Interim Report of December 12, 1973.

3. Summary Report of January 15, 1974.

4. Memorandum about Further Work, January 29, 1974.

5. Letter Report of February 15, 1974.

1. Plans for a Study of the White House Tapes:
a Draft Proposal Submitted to the Court on November 21, 1973.

The following Draft Proposal was submitted to Chief Judge John J. Sirica, United States District Court for the District of Columbia, on November 21, 1973:

NATURE OF THE PROBLEM

Determining the authenticity of a tape recording is something like determining the authenticity of a painting. Many different tests can be used to look for signs of forgery. A single positive sign can say conclusively that forgery was in fact committed. The complete lack of any positive sign can give the appearance of authenticity without proving it.

Again, a painting can be tested without seeing it and a tape can be tested without hearing it. However, the lack of access to the substance -- the picture or the words -- greatly increases the complexity of the testing process, prolongs the task, and reduces the chance of ending up with definite results. Access to the substance enables the investigator to focus attention on the very fine details, which often are the most difficult to forge convincingly.

In the case of tape recordings, relatively simple tests performed without listening may suffice to detect an unsophisticated alteration such as direct splicing of the tape or erasure of words on the original recording. However, even such simple forgeries may take an inordinate amount of time to find if the investigator can not first listen, because he is, in effect, searching for a "needle in a haystack."

Sophisticated alterations are much more difficult to identify, even with the aid of human listening to help recognize subtle patterns of sound. As with measure and counter-measure in technological warfare, the making and detecting of acoustic forgeries involves a continuing evolution of ever more powerful analytical techniques. Therefore, in undertaking the present task, we can not entirely rule out the possibility of failure to detect an existing forgery, simply because the detection technique required might not yet have been invented.

SOME POSSIBLE OUTCOMES AND RELATED FACTORS

The results of tests made to determine the authenticity of tape recordings can lead to conclusions of four types:

1. Definitely the tape has been altered.
2. Definitely the tape is a re-recording, not an original.
3. Perhaps the tape has undergone some alteration or re-recording, but the results are inconclusive.
4. No indications of alteration or re-recording have been detected.

These four types are listed in the order of increasing likelihood of occurrence for an increasing sophistication of technique used in tampering with the tape. The first listed conclusion is most likely when the technique used is least sophisticated. The fourth type of conclusion suggests that the tampering -- if there is any at all -- was done with a highly sophiticated technique.

Further, the outcome in a particular case can be affected by defects in the tapes or in the recording system used. Such defects might obscure certain features of the recorded speech that otherwise might have provided useful clues. In some cases the investigator will not be able to determine whether such defects lie within the normal bounds of performance of the tape and recording equipment or, conversely, whether the defects are the result of tampering.

Aside from the level of sophistication that might have been used to effect an alteration, two other factors will strongly affect the level of certainty of the technical findings and the time required to reach them. One factor is assistance in locating sections of the tape

to which intensive testing could be directed, as opposed to unguided tests of the entire set of relevant recordings. Such assistance would speed many of the tests by a large factor and would, indeed, be the only condition under which some of the tests would be feasible.

A second factor is the degree to which the relevant portions of the tapes can be heard by the experts, in order to permit their trained listening skill to be used as a tool in searching for possible alterations. Such listening would add substantially to the quality of the tests and would further focus the instrumental testing.

Many of the tests proposed herein need not involve access to substantive content. Thus, the technical experts could be assisted in locating sections for intensive testing by a court-appointed person who is entitled to listen to the tapes.

SUGGESTED PLAN

We propose to undertake this study in a sequential manner, starting with a series of pilot tests, which we call Phase One. The results obtained in Phase One would serve to guide the planning of one or more subsequent phases, which would entail intensive tests intended to yield more definite results than are likely to result from the pilot tests. The remainder of this draft proposal sets forth our plan and procedure for Phase One.

The pilot tests would include items of the following kind:

1. Comparative measurements on the lengths of recorded and unrecorded tapes.
2. Physical examination of the tapes to look for splices and other possible alterations.
3. Analysis of background noise on the tapes and of spurious components such as hum and bias signals.
4. Analyses of short-term and long-term spectra.
5. Analyses of time intervals and of rates of change in the starting and stopping of the tapes.
6. Some measurements on the recording equipment used in making the recordings being studied.

The purpose of these tests is to orient us on the general nature of the tapes and equipment involved and to give us a means for exploring the relative effectiveness of several different kinds of tests that might be performed. The results should enable us to select just those tests that are most likely to shed light on authenticity and are therefore worth carrying out in detail.

MATERIALS AND FACTILITIES REQUIRED

Our efforts in conducting the proposed study will require the use of materials and facilities of three kinds: magnetic tapes, equipment that was used in recording on the tapes, and laboratory facilities and instruments for our use in analyzing the tapes and equipment. The following outline indicates the requirements as we now foresee them:

A. Tapes

Access to the original tapes, supervised by a person authorized to listen to them. We would use the tapes:

To make recorded copies of selected, non-sensitive sections,

To measure directly the lengths of the tapes, the bias signals on the tapes, and certain other non-textual, mechanical and electrical features,

To measure directly the average spectrum of the speech sounds uttered in several successive sentences, for each of four samples, including two samples on tapes not yet subpoenaed and one each from the tapes of June 20, 1972 and April 15, 1973, respectively.

For some of the tests we will require several lengths of blank tape cut from the ends of reels of tape that contain the sensitive material.

We also will require up to 10 blank reels of tape of the same kind as that used in recording on the tapes involved in this study.

B. Equipment used in making the recordings

The magnetic tape recorders.

The voice-operated devices that turned the recorders on and off.

C. Facilities

To perform the tests and analyses we will require laboratory facilities, and specialized instruments that we would obtain.

In addition to the items outlined above, we might find that we need to make measurements on the complete recording systems, reassembled in the original locations and wired up in their original conditions.

PROCEDURE

Some of the tests proposed will require the use of highly sophisticated skills, equipment, and research set-ups. These are available in certain university, industry, not-for-profit, and government laboratories. Members of our panel are associated with some of the laboratories that possess the resources required. We suggest that we conduct the tests in non-government laboratories whether or not similar tests are performed also in government laboratories.

We plan to complete the pilot tests, analyze the results, and submit a report on this Phase One work by about the middle of January 1974.

We have not yet had time to work out a budget, but we guess that the costs involved in Phase One would run to a few thousand dollars.

FOOTNOTE

The six of us met together for the first time on the afternoon of Sunday, November 18, 1973, and not all of us have been able to participate directly in the final writing of this draft proposal. We, therefore, may need to make some changes in this draft before we would consider it to represent our concensus.

[Biographical data for the six members of the Panel were attached.]

2. Interim Report of December 12, 1974

December 12, 1973
Interim Report to Judge John J. Sirica
From the Advisory Panel on Tapes

In response to your expressed interest in our work to date, we submit this report on the nature of our inquiry and our progress. The report spells out the questions that we are endeavoring to answer, describes briefly the tests and techniques we are using to search for answers, and gives some preliminary results concerning the tape of June 20, 1972.

At your request we have been concentrating our initial efforts on this particular tape. In doing so, however, we also have made substantial progress in developing the procedures and experience that we shall need to conduct our broader study on the authenticity and integrity of the White House tapes in general. The questions that we have been addressing are these:

> Is this tape the original one that was recorded on June 20, 1972? Does it contain erasures or splices? Or is it a copy that has been edited by operations such as cutting and splicing before re-recording?
>
> How was the 18-minute section of buzzing sounds produced? Was all the buzzing produced continuously at one time?
>
> Can speech sounds be detected under the buzzing? If so, to what extent can the speech be recaptured and made intelligible?

In order to answer these questions, we must obtain information on many technical details. Toward finding the information, we have set up and started to use several tests and approaches described briefly as follows:

Critical listening: using human analytical capabilities to check for anomalies in the signals recorded and for inadvertent signals such as hum, which might provide useful clues for studying the tape.

Flutter signature: a unique "finger print" that may help us to identify the particular recorder on which a given tape was recorded.

Bias signal: a high-frequency tone that "carries" the audio signals on a tape and may help us to identify the recorder and recording events.

Magnetic images: direct visual observation of "developed" tape to find track widths, the type of recorder used, and the presence or absence of residual speech signals.

Physical measurements: lengths of tapes and presence or absence of physical splices, to provide further evidence on tape integrity.

Long-term frequency spectra: sensitive analysis technique to help in characterizing the acoustic quality of the buzzing sounds and in identifying their source.

Computer processing and graphic display: sophisticated techniques for analyzing frequency spectra, start and stop transients, and other features of speech and noise.

Voice operated switch: measurement of operating characteristics of devices used in the White House recording system, for our use as signature information.

Recorder performance: various electrical and mechanical measurements of standard and modified recorders for use in finding possible origins of buzz sounds, hum, etc.

These tests involve the use of facilities and equipment of many kinds, both standard and specially adapted for this project. The items we have been using include: frequency spectrum analyzers of several types, advanced digital computers and special computer programs; visual graphic displays and hard-copy graphic printers; fixed and adjustable filters; specially modified tape recorders; techniques for direct visual inspection of magnetic traces on tapes; and meters and specialized electronic instrumentation.

The results obtained from the many, different kinds of tests and instruments bear a resemblance to the pieces of a jig saw puzzle. The first few pieces give almost no clues as to how they fit together. As the picture unfolds some of the pieces are seen to be misplaced and must be moved. And when many pieces combine to suggest the overall pattern, then each piece begins to corroborate the correctness of adjacent pieces and the solution to the puzzle seems to rush toward completion. However, the analogy when applied to tapes must be extended in a most important way: some of the pieces of the puzzle are lost and probably can not be found, and some of the pieces really belong to a different puzzle.

Because of the inherently fragmented nature of the technical evidence that we can obtain, owing to missing pieces, and because of the large number of related pieces of evidence in this tape puzzle, reliable answers will be slow to emerge and many of the answers will have to be stated as probabilities -- not certainties.

At the present time we have reached two conclusions that appear to be correct with a high degree of probability. The electric typewriter most probably did not cause the 18-minute section of buzzing sounds. And, the tensor lamp probably did not cause this buzzing. Our tests made with sophisticated instruments have failed to give any indication that either of these devices causes such sounds to be recorded on the tape.

We have reached preliminary conclusions on some other questions also. Our several exploratory attempts to identify speech sounds within the 18-minute section of buzz have not succeeded. We now doubt whether recovery of intelligible speech from this section will ever be possible, but we withhold final judgment on this point.

Also in a preliminary way, we report that we have been able to operate a Uher recorder, the one identified to us as the one that Miss Woods used, in such a manner as to produce and record a buzzing sound that closely resembles some of the sounds in the 18-minute section. This buzzing was recorded with the tape moving forward at 15/16 inch, but did not show up in high-speed rewind operation with the record button depressed. Tests in progress or being analyzed should lead us to a reasonably firm conclusion about the source of the buzzing in a week or so.

The preparations and tests reported here have resulted from a very large amount of intensive work. During the three weeks since November 21,

the day on which you announced our appointment, the six of us collectively have spent about 50 man days working on the problem of the tapes. Added effort amount to about 100 man days has been spent by some 20 other specialists working for us under our direct, personal, and intimate supervision. The work has been done at several locations, especially including the laboratories of the Federal Scientific Corporation in New York City and of Bolt Beranek and Newman Inc. in Cambridge, Massachusetts.

According to our present best estimate, we expect to complete our study of the tape of June 20, 1972 and submit a report on it to you early in January, 1974. Then we shall be prepared to pursue the more general study of the tapes if you so desire. If you have any questions about the material contained in this interim report, please feel free to call upon us for clarification.

Respectfully submitted,

Richard H. Bolt
Franklin Cooper
James L. Flanagan
John G. (Jay) McKnight
Thomas G. Stockham, Jr.
Mark R. Weiss

3. Summary Report of January 15, 1974

January 15, 1974
Report to Chief Judge John J. Sirica
From the Advisory Panel on the White House Tapes

In response to your request we have made a comprehensive technical study of the White House tape of June 20, 1972, with special attention to a section of buzzing sounds that lasts approximately 18.5 minutes. Paragraphs that follow summarize our findings and indicate the kinds of tests and evidence on which we base the findings.

Magnetic signatures that we have measured directly on the tape show that the buzzing sounds were put on the tape in the process of erasing and re-recording at least five, and perhaps as many as nine, separate and contiguous segments. Hand operation of keyboard controls on the Uher 5000 recorder was involved in starting and again in stopping the recording of each segment. The magnetic signatures observed on the tape show conclusively that the 18.5-minute section could not have been produced by any single, continuous operation. Further, whether the footpedal was used or not, the recording controls must have been operated by hand in the making of each segment.

The erasing and recording operations that produced the buzzing section were done directly on the tape we received for study. We have found that this tape is 1814.5 feet long, which lies within a normal range for tapes sold as 1800 feet in length. We have examined the entire tape for physical splices and have found none. Other tests that we have made thus far are consistent with the assumption that the tape is an original and not a re-recording.

A Uher 5000 recorder, almost surely the one designated as Government Exhibit #60, was used in producing the 18.5-minute section. Support for this conclusion includes recorder operating characteristics that we measured and found to correspond to signal characteristics observed on the evidence tape.

The buzzing sounds themselves originated in noise picked up from the electrical power line to which the recorder was connected. Measurements of the frequency spectrum of the buzz showed that it is made up of a 60 cycles per second fundamental tone, plus a large number of harmonic tones at multiples of 60. Especially strong are the third harmonic at 180 and the fifth harmonic at 300 cycles per second. As many as forty harmonics are present in the buzz and create its "raucous" quality. Variations in the strength of the buzz, which during most of the 18.5-minute section is either "loud" or "soft," probably arose from several causes including variations in the noise on the power line, erratic functioning of the recorder, and changes in the position of the operator's hand while running the recorder. The variations do not appear to be caused by normal machine operations.

Can speech sounds be detected under the buzzing? We think so. At three locations in the 18.5-minute section, we have observed a fragment of speech-like sound lasting less than one second. Each of the fragments lies exactly at a place on the tape that was missed by the erase head during the series of operations in which the several segments of erasure and buzz were put on the tape. Further, the frequency spectra of the sounds in these fragments bear a reasonable resemblance to the spectra of speech sounds.

Can the speech be recovered? We think not. We know of no technique that could recover intelligible speech from the buzz section. Even the fragments that we have observed are so heavily obscured that we cannot tell what was said.

The attached diagram illustrates the sequence of sound events in the 18.5-minute section. Also illustrated is a sequence of Uher operations "erase-record on" and "erase-record off" that are consistent with signatures that we measured on the evidence tape. The five segments that can be identified unequivocally are labeled "1" through "5." In addition, the diagram shows four segments of uncertain ending.

In developing the technical evidence on which we have based the findings reported here, we have used laboratory facilities, measuring instruments, and techniques of several kinds, including: digital computers located in three different laboratories, specialized instruments for measuring frequency spectra and waveforms, techniques for "developing" magnetic marks that can be seen and measured directly on the tape, techniques for measuring the performance characteristics of recorders and voice-operated switches, and statistical methods for analyzing experimental results.

In summary we have reached complete agreement on the following conclusions:

1. The erasing and recording operations that produced the buzz section were done directly on the evidence tape.

2. The Uher 5000 recorder designated Government Exhibit #60 probably produced the entire buzz section.

3. The erasures and buzz recordings were done in at least five, and perhaps as many as nine, separate and contiguous segments.

4. Erasure and recording of each segment required hand operation of keyboard controls on the Uher 5000 machine.

5. Erased portions of the tape probably contained speech originally.

6. Recovery of the speech is not possible by any method known to us.

7. The evidence tape, insofar as we have determined, is an original and not a copy.

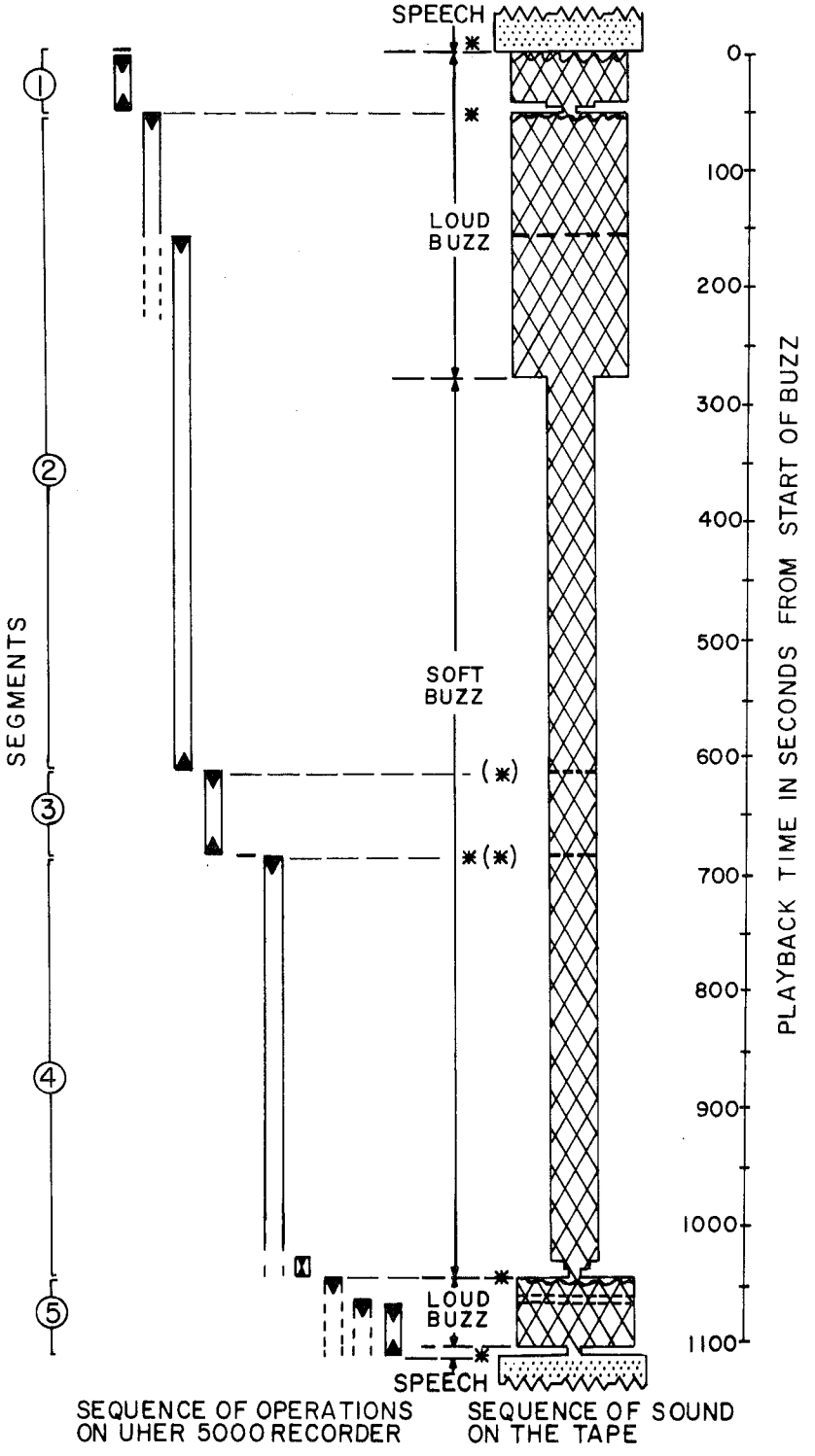
Respectfully submitted,

Richard H. Bolt
Franklin S. Cooper
James L. Flanagan
John G. (Jay) McKnight
Thomas G. Stockham, Jr.
Mark R. Weiss

KEY TO BUZZ SECTION IN WHITE HOUSE TAPE OF JUNE 20, 1972

SYMBOLS:

- ▼ ERASE-RECORD ON
- ▲ ERASE-RECORD OFF
- — ERASE-RECORD ON AND OFF
- ~~~ SHORT SEGMENT OF SPEECH-LIKE SOUND UNDER BUZZ
- --- START/STOP CLICK WITHIN BUZZ
- * ERASE-HEAD-OFF SIGNATURE OF UHER 5000
- (*) ERASE-HEAD-OFF SIGNATURE PARTIALLY ERASED
- SEGMENT WITH UNCERTAIN ENDING



1/14/74

4. Memorandum about Further Work, January 29, 1974

January 29, 1974

Memorandum to Chief Judge John J. Sirica

From the Advisory Panel on Tapes

We are preparing the detailed report on the tape of June 20, 1974, giving the technical basis for the conclusions that we submitted to the Court on January 15th. Completion of this report, including adequate explanation of points raised in the Court proceedings, will require more time than we estimated previously. Further, our experience in making and writing up the investigation of this first tape suggests that a comparable amount of time might be needed on each of the several other tasks to which you have directed our attention.

Therefore, and in view of the urgency expressed in your memorandum of January 18, we wish to obtain your guidance on the planning of our work schedule. Should we complete this report before we start working on the other tasks? In what order should we undertake the other tasks so as to do first those tasks that the Court considers to be most urgent? Can some of the tasks be given less intensive study or even be eliminated from the list?

We should appreciate having your guidance at an early date and we should be happy to meet with you to discuss this matter if you wish.

Richard H. Bolt
Franklin S. Cooper
James L. Flanagan
John G. (Jay) McKnight
Thomas G. Stockham, Jr.
Mark R. Weiss

Copies to the White House Counsel and to the Special Prosecutor

5. Letter Report of February 15, 1974

The Court Panel on Tapes

February 15, 1974

Chief Judge John J. Sirica
United States District Court
for the District of Columbia
Washington, D. C.

Dear Judge Sirica:

We thank you for your helpful memorandum of February 5, 1974, concerning our future work priorities. We have decided to divide our efforts between completing the technical report on the tape of June 20, 1972, and concurrently pursuing tests on the other items to which you have directed our attention.

While working on the report during recent weeks, we have received communications from several persons offering suggestions and information. Some of the material has come to us by way of your office or one of the counsel's offices. We have found particular interest in two of the communications, one giving an alternative hypothesis on the origin of the 18.5 minute buzz section and the other suggesting a new possibility for recovering lost speech. Because of the potential importance of these topics, we have taken some time away from report preparation in order to give these two communications prompt consideration.

The alternative hypothesis says that intermittent functioning of a failing component in the Uher recorder might have produced the observed magnetic signatures, which according to our finding resulted from operations that involved keyboard manipulations. We have studied the documented hypothesis and its relation to the circuits and operating characteristics of a Uher 5000 recorder. We have carried out a series of relevant tests including phase measurements to detect tape starts and stops. We have re-examined the data that we had obtained previously from the original tape and the Uher recorder, Exhibit 60. Our results do not support the alternative hypothesis, and we see no reason to alter the general conclusion that we reported to the Court on January 15, 1974.

The second communication describes a new technique that uses magnetic "skew" to search for residual signals. This technique offers some possibility of recovering speech signals even after they have been erased and had a buzz recorded over them. However, our study shows that the technique would involve a complicated procedure and would offer only marginal promise of success if applied to the tape in question. Therefore, even though we recognize the importance of recovering speech if possible, we shall pursue our further study of this technique at a lower priority.

The report that we are preparing will include technical explanations of these two ancillary studies. As we have indicated previously, the report will contain full technical backup for all the conclusions that we presented to your Court in January. We shall complete the document as soon as we can on a schedule that allows us also to pursue the concurrent tests expeditiously.

Respectfully yours,

Richard H. Bolt

Franklin Cooper

James L. Flanagan

John G. McKnight

Thomas Stockham

Mark R. Weiss

Copies to: Leon Jaworski
James D. St. Clair
Charles S. Rhyne