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

APPENDICES

TECHNICAL NOTES

TECHNICAL NOTE 8

THE K-1 PULSE AS DIRECT EVIDENCE OF KEYBOARD MANIPULATION

The Uher 5000 recorder contains a mechanical switch, labeled 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 a foot pedal or by the switch on the accessory hand-held microphone. 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, whether 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. We have observed this recorded pulse in three ways: as an audible click, as a magnetic mark, and as a spike in the waveform reproduced from the tape. We call these three kinds of data, individually and collectively, a signature. We have established with certainty that the K-1 signature is generated only when the K-1 switch is actuated. It is not and cannot be generated by any other electro-mechanical component in the recorder.

This Technical Note describes the K-1 switch in detail, shows how it operates, explains its function, and reports on magnetic marks made by operation of the switch. It also gives the results of simulations through which we have demonstrated the role of K-1 data in

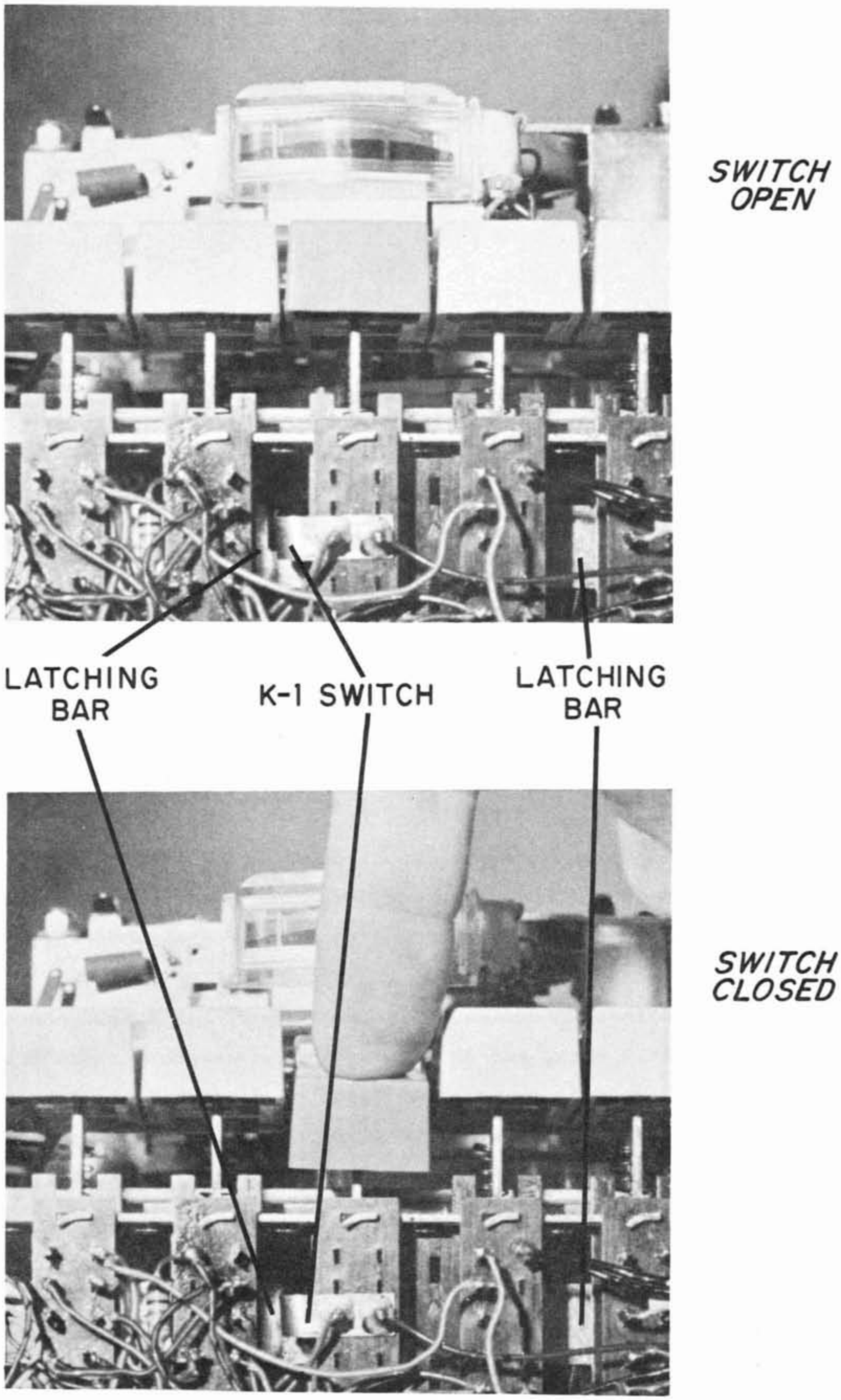

Figure 1. The K-1 switch in the Uher 5000 recorder.

proving certain conclusions about the way in which the buzz section was produced.

Function of the K-1 Switch and Its Construction

The K-1 switch is normally used to restore control of the tape transport to the keyboard when the transport had been under the control of an external device connected into the accessory connector marked "Δ".

The K-1 switch is composed of a leaf spring located underneath the control keyboard, directly beneath the STOP key, and a bar, which is also located under the keyboard and runs its full length. The switch and bar are shown in Figure 1.

K-1 is a normally-open switch. Four keys that close the switch are the RECORDING key, the START key, the REWIND key, and the FORWARD key. When any of these keys is pressed, the shaft that supports the key moves downward. As it descends it shifts the bar, as seen in Figure 1, to the right until the bar contacts the leaf spring, thus closing K-1. As the key is pressed a bit farther, the key shaft latches onto the bar, permitting it to shift slightly to the left, thereby opening K-1.

The START, FORWARD, or REWIND key can close K-1 again if the key is pressed beyond the latch point and bottomed. K-1 will stay closed until the key is allowed to return to its latch point. The construction of the RECORDING key shaft prevents it from closing K-1 again once it is latched.

The K-1 switch also will be closed when the STOP key is pressed. It will remain closed until pressure on this key, which does not latch, is released.

The PAUSE key and the DICTATING key do not close the K-1 switch.

Generation of the K-1 Pulse at the Start of a Recording on the Uher 5000

When a recording is initiated by pressing the START and RECORDING keys at the same time, K-1 pulses will be generated at three instants: (1) just before the keys reach the latch position, (2) when the START key is bottomed; and (3) when it is released from the bottom position. In general, only the pulse generated at the third instant will be unambiguously identifiable, since the earlier ones will be mixed with larger transient pulses generated by other electro-mechanical components at the start of recording. From this it follows that if the START key is not bottomed at the start of a recording, it may not be possible to detect a K-1 pulse.

The K-1 pulse that is generated when the START key is released from its bottom position at the start of a recording has three important characteristics:

(1) It is preceded by a record-head-on waveform by at least one-tenth of a second,

(2) Its amplitude is typically between one-fifth and one-half the amplitude of the record-head-on waveform,

(3) It exhibits a waveform shape that is uniquely associated with the operation of the K-1 switch at that instant.

Typical waveforms of K-1 pulses generated on Exhibit 60 and recorded in the manner just described are shown in Figure 2. The shapes of the pulses fall into two classes: a unipolar pulse about 0.8 ms to 1 ms wide at the base with a rounded overshoot which reaches a maximum about 1.5 ms after the pulse peak (Figures 2a, 2b, and 2c); and a bipolar pulse with both halves about 0.5 ms wide at the base (Figure 2d). As Figure 2c shows, there is some tendency for overlap between these classes.

Three pulses observed on the Evidence Tape exhibit all three of the characteristics of K-1 pulses described above. These pulses occur at Event Times 612 seconds, 684 seconds, and 1065 seconds from the start of the buzz (Events 7, 8, and 12). The pulses are preceded by record-head-on waveforms and are separated from them by intervals of 0.50 seconds, 2.86 seconds, and 0.24 seconds respectively. The amplitudes of the pulses are, respectively, 0.3, 0.3, and 0.5 times the amplitudes of the record-head-on waveforms that precede them. The waveforms of the pulses observed on the Evidence Tape are shown in Figure 3. They are very similar to the waveforms of the K-1 pulses shown in Figures 2a and 2b that were generated by the Panel on Exhibit 60.*

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*The two negative peaks at the overshoot maximum in Figure 3c are almost surely due to the buzz, which was 10 dB larger at this section of the tape than it was at the section in which the preceding two pulses are observed.

In view of the close agreement between the characteristics of the pulses observed on the Evidence Tape and those generated on Exhibit 60, we conclude that pulses on the Evidence Tape at Event Times 612, 684, and 1065 seconds were caused by the operation of the K-1 switch. Specifically, they were generated shortly after the start of the recording of a section of the buzz, at the moment when the START key was released after having been pressed to its bottom position and held there briefly.

Generation of the K-1 Pulse at the End of a Recording

A second type of K-1 pulse will be generated when a recording is ended by pressing the STOP key (or the START, REWIND, or FORWARD key). As any of these keys is pushed down, the key shaft will move the latching bar toward the leaf spring. The bar will contact the spring, closing K-1 and generating a K-1 pulse. Immediately thereafter, as the key is pushed a bit farther, the latch on the RECORDING key will be released. As the RECORDING key shaft rises, the switches operated by this key will open, the relays that control the erase and record heads will be de-energized, and a record-head-off mark and a quartet will be recorded.

Figure 4a shows the waveforms of pulses at three record-head-off marks generated on Exhibit 60. These were obtained for recordings which had been started by pressing the START and RECORDING keys and ended by pressing the STOP key. The K-1 pulse waveform in each trace is the narrow negative spike at about 3.5 graticule divisions from the left-hand edge of the trace. The record-head-off waveform is the cluster of peaks and dips starting about one graticule division (i.e., about 5 ms) later.

Figure 4b shows waveforms which were obtained in the same way with, however, the K-1 switch blocked (that is, insulated from contact with the latching bar). The identification of the negative spikes as K-1 pulses, in Figure 4a, is confirmed by their absence in Figure 4b.

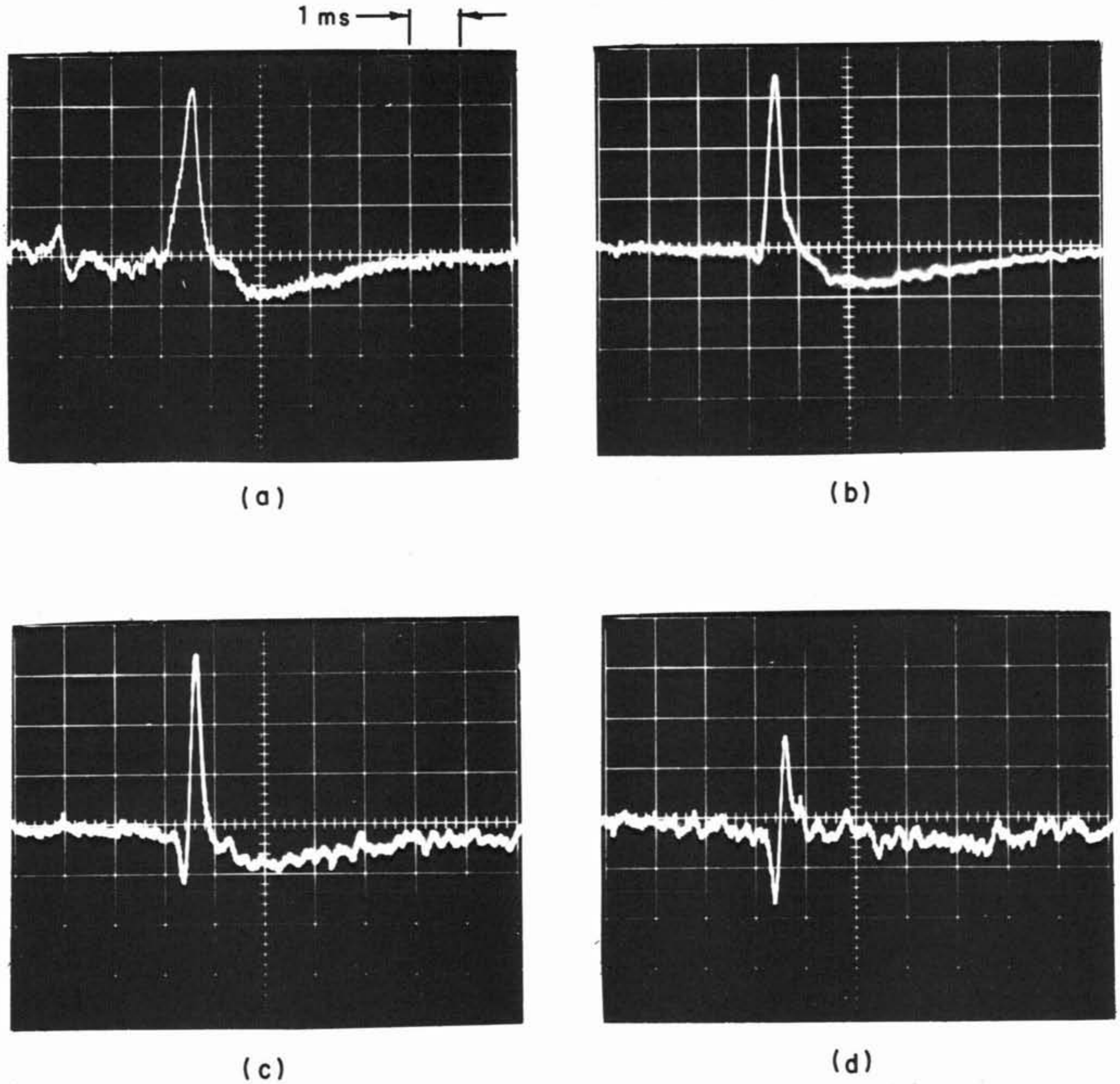
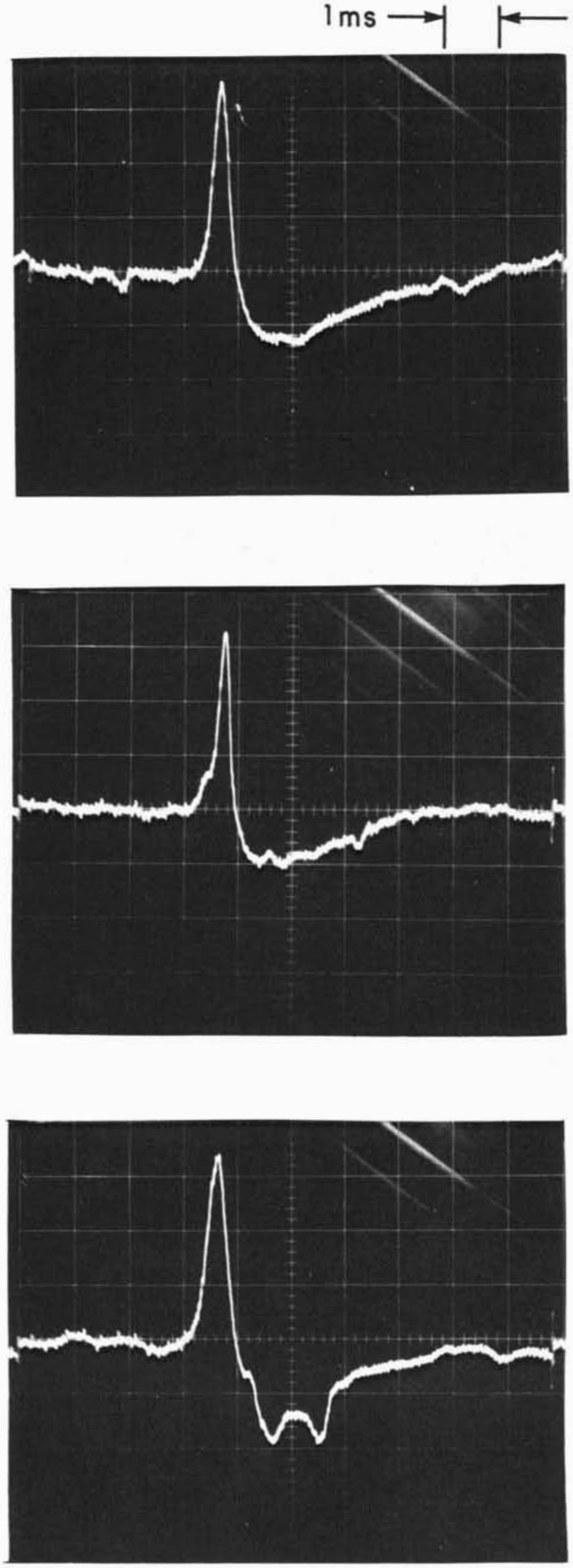


Figure 2. K-1 pulses generated on the Exhibit 60 Uher.

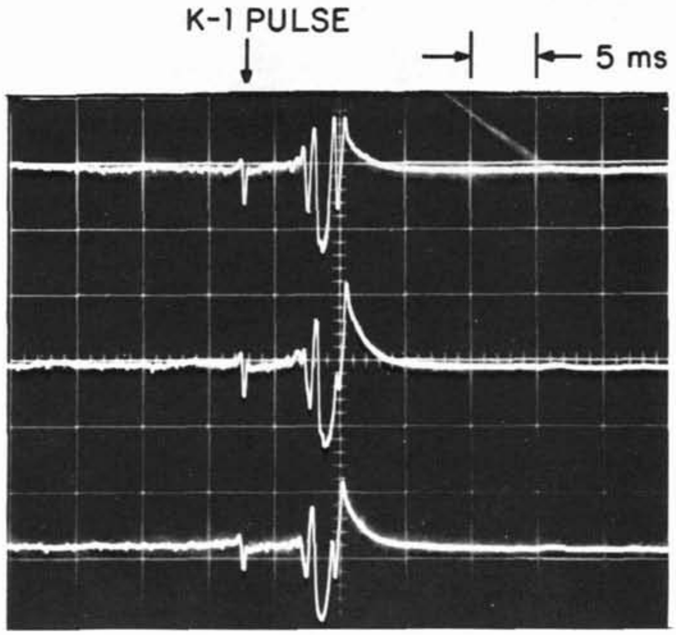


(a)
EVENT 7 (F')
TIME: 612 sec

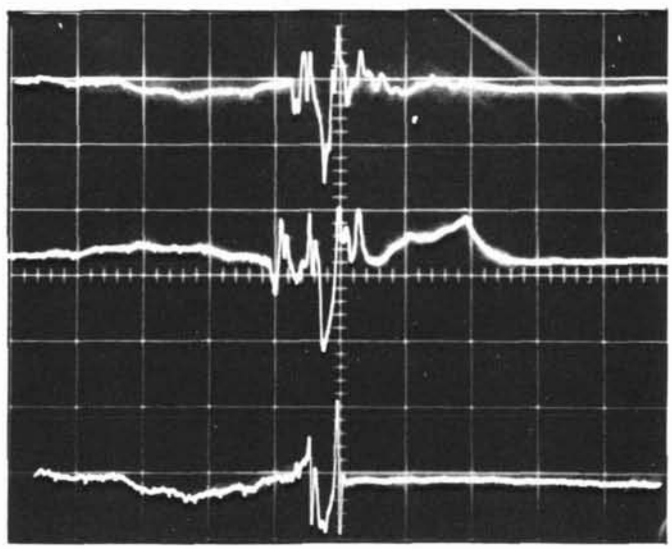
(b)
EVENT 8 (G)
TIME: 684 sec

(c)
EVENT 12 (H_B)
TIME: 1065 sec

Figure 3. Pulses observed shortly after three record-head-on marks on the Evidence Tape.

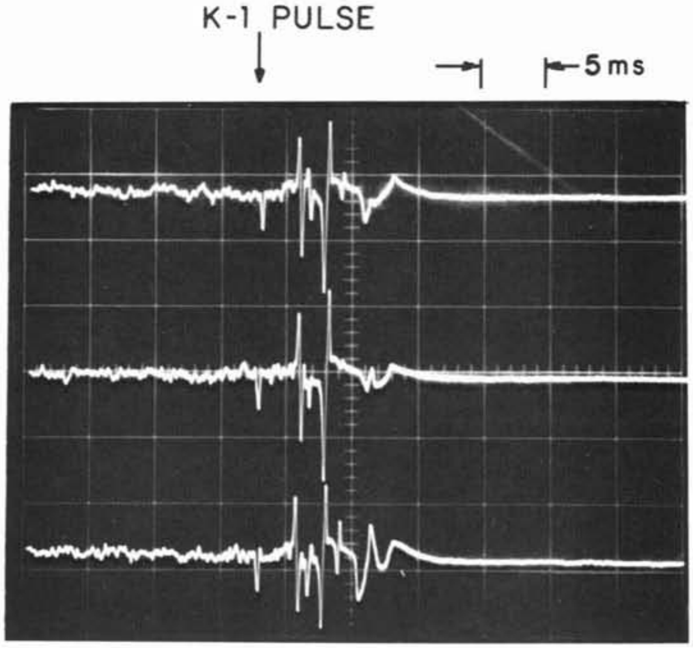


(a) K-1 SWITCH NORMAL

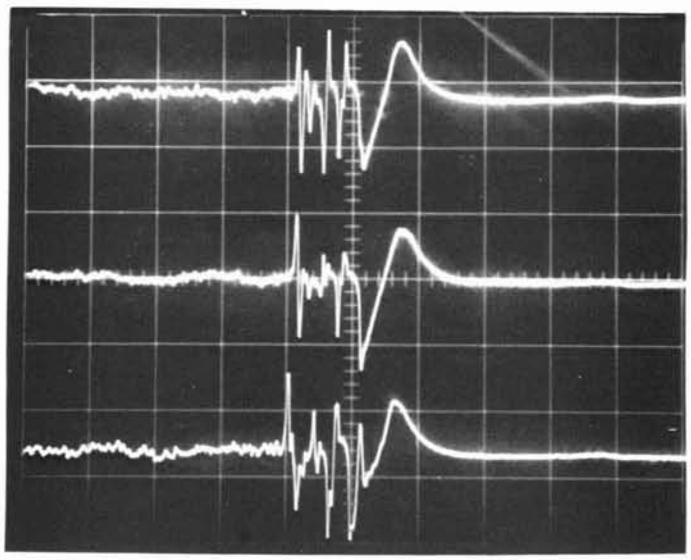


(b) K-1 SWITCH BLOCKED

Figure 4. Waveforms at record-head-off marks generated on the Exhibit 60 Uher.



(a) K-1 SWITCH NORMAL



(b) K-1 SWITCH BLOCKED

Figure 5. Waveforms at record-head-off marks generated on the Haskins Uher.

To determine if other Uher 5000 machines recorded K-1 pulses just before record-head-off marks in the same manner as Exhibit 60, we repeated the tests described above, using a recorder purchased by Haskins Laboratories. The results of the tests, shown in Figure 5, clearly are similar to those in Figure 4. The negative spikes precede the record-head-off waveforms by about 3 ms in this machine; as with Exhibit 60, they are missing when the K-1 switch is blocked.

As seen on these photographs, the record-head-off waveforms vary significantly from one machine to another. They also vary from one recording to another made on the same machine, depending on a number of factors: the setting of the RECORDING LEVEL control; random variations in the timing of the release of the RECORDING and START keys from their latched positions, and the subsequent opening of other electromechanical components controlled by these keys; and the setting of the INPUT SELECTOR control.

Figure 6 shows two sets of amplitude-expanded, record-head-off waveforms. Those on the left, in Figure 6a, were generated by the Panel on Exhibit 60. Those on the right, in Figure 6b, were observed at three places on the Evidence Tape: Event Times 612, 684, and 1109 seconds (Events 7, 8, and 13). The waveforms for Exhibit 60 and the Evidence Tape, particularly the upper and middle pair, obviously are very similar, both in overall structure and in important details, such as the timing and amplitude of the negative spikes that precede the record-head-off waveforms.* The close agreement of the waveforms on the Evidence Tape with the waveforms generated on Exhibit 60 shows conclusively that the recorder was stopped by hand operation of keyboard controls at Event Times 612 seconds and 684 seconds, and just at the end of the buzz section, 1109 seconds.

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* The similarity of the K-1 pulses in the lower pair in Figure 6 is somewhat obscured by the high buzz level at 1109 seconds. This is evident in the waveform that precedes the record-head-off pulse in Event 13, as shown in the lower photograph of Figure 6b.

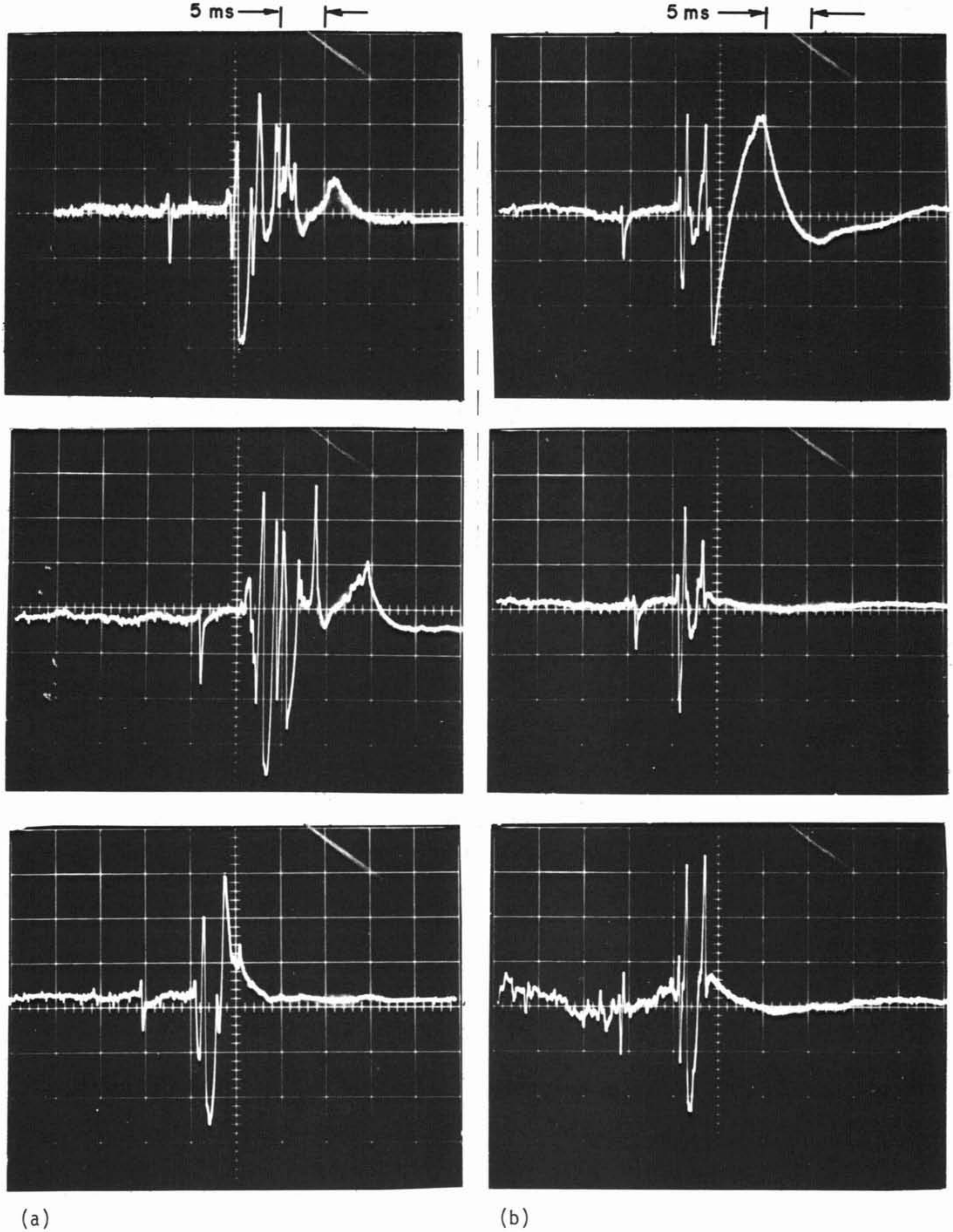

Figure 6. Waveforms at record-head-off marks:
(a) generated on the Exhibit 60 Uher (b) observed on the Evidence Tape.

The absence of a K-1 pulse preceding the record-head-off mark at Event Times 49 seconds and 1042 seconds (Events 4 and 10) does not necessarily exclude the use of keyboard controls at these points on the tape. An explanation of Event 4 is that at 48.25 seconds the PAUSE key (which does not close the K-1 switch) was pressed, stopping tape motion, and then the STOP key was pressed. This explanation is supported by the weak record-head-off mark at 48.25 seconds, which corresponds to the mark recorded when a recording on the Uher 5000 is interrupted by use of the PAUSE key. Added support of the explanation comes from the weak erase-head-off mark at 49.47 seconds, which corresponds to the de-energizing of the erase head with the tape stationary.

Event 10, which consists of a record-head-on mark at 1040.57 seconds, a record-head-off mark at 1041.53 seconds, a record-head-on mark at 1042.08 seconds, and an erase-head-off mark at 1040.57 seconds, can be explained as follows. At 1040.57 seconds the START and RECORDING keys were pressed, the START key was bottomed, and pressure was maintained on both keys. About one second later, at 1041.53 seconds, pressure on the RECORDING key was released, permitting the key to rise to the off position, and causing the record and erase heads to be de-energized. Since pressure was maintained on the START key throughout the one-second interval, the K-1 switch remained closed and so a K-1 pulse could not have been generated prior to the recording of the record-head-off mark at 1041.53 seconds. Recording was resumed 0.55 seconds later, at 1042.08 seconds.

TECHNICAL NOTE 9

ALTERNATIVE HYPOTHESES AND WHY THEY WERE REJECTED

The Panel has given careful consideration to several hypotheses as alternatives to the conclusion that the buzz section was produced in five or more segments requiring hand operation of keyboard controls on the Exhibit 60 Uher recorder. While these hypotheses can explain some of the more apparent features we observed in the buzz section of the tape recording, they are inconsistent with, or fail to account for, other characteristics of the recording or recorder. Consequently, none of them is a viable alternative to our conclusion.

In paragraphs that follow, we describe these rejected hypotheses and explain why we rejected them.

Hypothesis: The buzz section was produced at the time that the tape was recorded originally, on June 20, 1972.

This hypothesis fails on at least two counts. First, the flutter spectra observed in the buzz section of the tape are consistent with those of Uher 5000 recorders and are significantly different from those observed on the speech sections of the tape. The flutter spectra on the speech sections are consistent with those of Sony 800B recorders.

Second, the erase-head-off marks in the buzz section are not consistent with Sony 800B recorders, but are consistent with Uher 5000 recorders. Since these marks and their associated record-head-off marks occur at points where sections of the buzz stop, the buzz and the marks must have been recorded together. Moreover, since the erase-head marks are a full

3 millimeters wide, they must have been recorded directly onto the Evidence Tape and, thus, so was the buzz. The erase-head-off mark at the very end of the tape, ending the recording of speech after the buzz section, is a 3-millimeter wide double mark, characteristic of Sony 800B recorders. Since the buzz was recorded directly onto the Evidence Tape by a machine that was not a Sony 800B, the buzz section could not have been recorded at the same time as the original speech recording.

Hypothesis: The tape was erased and the buzz recorded by a Uher 5000, with the machine set in the recording mode and operated in rewind, perhaps by the use of the footpedal.

Even though the Uher 5000 can be operated in this manner, the hypothesis fails for the following reasons. First, when a tape is erased on a Uher 5000 with the machine operating in rewind, the erasing signal will be recorded onto the tape and will be an audible tone of about 500 Hz when the tape is played back at 24 millimeters per second. No such tone is present on the Evidence Tape.

Second, a tape recording must be played back at the same speed as that at which it was made in order to reproduce the recorded frequencies accurately. The buzz signal consists of a fundamental component, with overtones at integral multiples of the fundamental frequency up to at least a multiple of 70. When the tape was reproduced at a speed of 24 millimeters per second, the fundamental frequency was found to be 60 Hz. This corresponds obviously to the 60-Hz frequency of the 110 volt power line and indicates that the tape was erased and re-recorded at 24 millimeters per second. (The more precise value is 23.8 mm.)

Third, record-head and erase-head marks could not have been recorded in a rewind mode of operation. However, more than 20 such marks were found on the buzz section of the Evidence Tape.

Hypothesis: The tape motion was controlled solely by use of a footpedal throughout the recording, which was done on a Uher 5000 at a recording speed of 24 millimeters per second.

This explanation does not account for the presence of erase-head marks (i.e., quartets) on the tape, which cannot be generated by the footpedal.

A distinctive set of marks is left by the Exhibit 60 Uher when the tape motion is stopped and then restarted under foot pedal control. No marks of this kind were found in the buzz section of the Evidence Tape.

The K-1 pulses found six times in the buzz section cannot be produced by any action of the foot pedal.

Hypothesis: Magnetic marks observed in the buzz section of the Evidence Tape resulted from power supply failure in the recording machine.

In considering this hypothesis, we first observe that the Uher 5000 recorder has two power supplies. One of them, which we call PS-1, supplies power to the bias oscillator, audio output stages, and automatic volume control. The other one, PS-2, supplies power to the relays that control the record/playback modes, the low-level audio circuits, and the solenoid that directly controls tape motion. We must examine the hypothesis in relation to each of the two power supplies separately.

The Panel used the Uher 5000 recorder designated Exhibit 60 for making many tests, including tests on the performance of the recorder itself. After several days of such testing, the recorder stopped operating. We examined the machine and found that the bridge rectifier in power supply PS-2 had failed. We then replaced this rectifier with a good one. The machine at once returned to operating condition and continued operating throughout all our subsequent tests.

Even though this power supply did not show any intermittent failure while we were using it, we have considered the possibility that intermittent failure might have been involved in the making of the buzz section. Under this version of the hypothesis, a malfunction of the rectifier, or its associated filter capacitor, or both, could have interfered with the proper functioning of the machine in any of three ways: by putting abnormal transient pulses into the amplifier circuits, by disturbing the operation of the relays, or by disturbing the operation of the pressure solenoid.

Transient pulses could be caused by a sudden change in the DC voltage delivered by the power supply. Such a change could be brought about by a short circuit in the filter capacitor or rectifier, or by an open circuit in the diode connections within the rectifier. Of these possibilities, only a short in the capacitor will result in putting a record-head mark on the tape. However, in such a case the resulting waveform pulse would be quite different in shape from a normal record-head pulse, no phase discontinuity would accompany the pulse, and no quartet would follow the pulse. In all three respects, this aspect of the hypothesis fails to account for results we obtained from tests on the Evidence Tape.

Short circuits or open circuits in the bridge rectifier do not switch off the relays. However, a filter capacitor short circuit of at least 10 milliseconds duration could cause relay switching to occur and would result in the recording of a record-head-off mark and a quartet. The record-head-off mark would be followed by a record-head-on mark when the capacitor ceased to be shorted and the relays were re-energized. Nonetheless, even if the short circuit lasts only long enough to cause the relays to drop out, i.e., about 10 milliseconds, the erase head relay will not resume the energized state for at least another 25 milliseconds. Consequently, the tape will travel about 0.6 millimeters before erasing resumes, a distance which is long enough to ensure that the quartet will not be erased.

An event of the sort just described would produce a record-head-off mark, followed about 0.6 millimeters down the tape by a record-head-on mark, and, some 28 millimeters farther on, by a quartet. This pattern does not match the four places on the Evidence Tape where we found record-head-on marks that were <u>not</u> associated with quartets.

Quartets are observed at four places within the buzz section of the tape, at Event Times 49 seconds, 612 seconds, 684 seconds, and 1042 seconds, (Events 4, 7, 8, and 10 in the tabulation of Chapter III.) At Events 7 and 8, the phase of the buzz in the neighborhood of the related record-head marks is discontinuous, indicating that the tape had stopped. For this to have happened, the pressure solenoid that controls tape motion must have dropped out. It will do so if the filter capacitor were to short for at least 60 milliseconds. However, this means that before the tape finally stops, it will travel at least 1.4 millimeters beyond where the record-head-off mark is recorded. The resulting pattern would consist of a record-head-off mark, followed by a record-head-on mark about 1.4 millimeters farther down the tape, and by a quartet spaced 28.6 millimeters from the record-head-on mark.

The patterns at Events 4, 7, and 10 do not match the one described, since the spacing of record head marks, 7.2, 0.9 and 13 millimeters, respectively, are significantly different from the required 1.4 millimeters. The spacing in Event 8 is close to 1.4 millimeters. However, this event includes other features that exclude this explanation of its origin: there is a fragment of a second erase-head-off mark following shortly after the complete erase-head-off mark (required by the hypothesis under consideration). Even more significantly, the initial record-head-off mark has associated with it a K-1 pulse, which can be produced only by a keyboard operation.

Finally, we consider a hypothesis which has received considerable attention in the public press and which was based, erroneously, on the assumption that PS-1 had failed. Under this version of the malfunction hypothesis, record-head marks and erase-head-off marks, or quartets, would be produced if the voltage supplied to the bias oscillator fell below some critical value. Such a voltage drop could have resulted from intermittent shorting of a capacitor that filters the output of the rectifier in PS-1. At no time during the Panel's tests, did intermittence of this kind occur. Further, we have seen nothing that would suggest that any such malfunction occurred in the Exhibit 60 Uher at any time in the past. However, even had such intermittent shorting of the capacitor occurred, it could not have produced the phase-discontinuities, underbuzz sections, and K-1 pulses that are observed on the Evidence Tape.

Hypothesis: The marks observed in the buzz section were generated by mechanical malfunction in the Uher 5000 recorder.

In addition to hypotheses based on electrical malfunctions, such as those described previously, several hypotheses suggested to the Panel involve mechanical malfunctions such as sticking or intermittent relays, "crossed" wires, and similar low-probability mechanical defects. No such malfunctions were observed at any time during our testing of any of the Uher 5000 recorders. Even had such malfunctions occurred, they could not have produced indications of manual operation of keyboard controls, such as K-1 pulses that precede record-head-off marks by 5 to 7 msec, or that follow record-head-on marks.

Hypothesis: Severe dips in the AC power line voltage, possibly in conjunction with a failing diode in the bridge rectifier of power supply PS-2, produced the observed events.

This hypothesis is based on tests that showed that the record-head and erase-head relays switch from the recording to the reproducing mode when the voltage developed by PS-2 falls from its operating value of about 28 volts to a level of about 15 volts. A further decrease of a volt or two causes the pressure solenoid to drop out. Thus, depending on how much the line voltage falls, the recording can cease with or without a concurrent or subsequent cessation of tape motion.

This hypothesis fails on several counts. First, a drop in the level of the voltage developed by PS-2 will not cause the recording of K-1 type pulses either before record-head-off marks or after record-head-on marks.

The second reason the hypothesis fails is that a drop in the output of PS-2 severe enough to cause the relays to switch would have caused a sizable drop in the amplitude of the recorded buzz just before they switched. An example of the decrease in recording level caused by such a drop in voltage is shown in Figure 1. This waveform was generated by recording a 60-Hz tone on the Haskins Laboratories Uher 5000 and abruptly dropping the AC input voltage sufficiently to permit the relays to switch but not to interrupt tape motion. The sequence of events shown are, from left to right: (1) the recorded 60-Hz tones at a level of about $\pm$ 1.5 graticule divisions; (2) the transient caused by the sudden reduction in the AC input voltage; (3) the gradual decrease in the amplitude of the recorded 60-Hz tone as the voltage developed by PS-2 dropped, starting at the second event and lasting about 300 milliseconds; (4) the sudden disappearance of the tone, when the relays switched from the recording to the reproducing mode. None of the events on the Evidence Tape exhibited this type of behavior immediately preceding record-head-off marks. Although decreases in level were observed, they always were abrupt, not gradual.

Not as apparent in this figure, but equally important, is the fact that the drop in AC input voltage resulted in a 5 percent decrease in

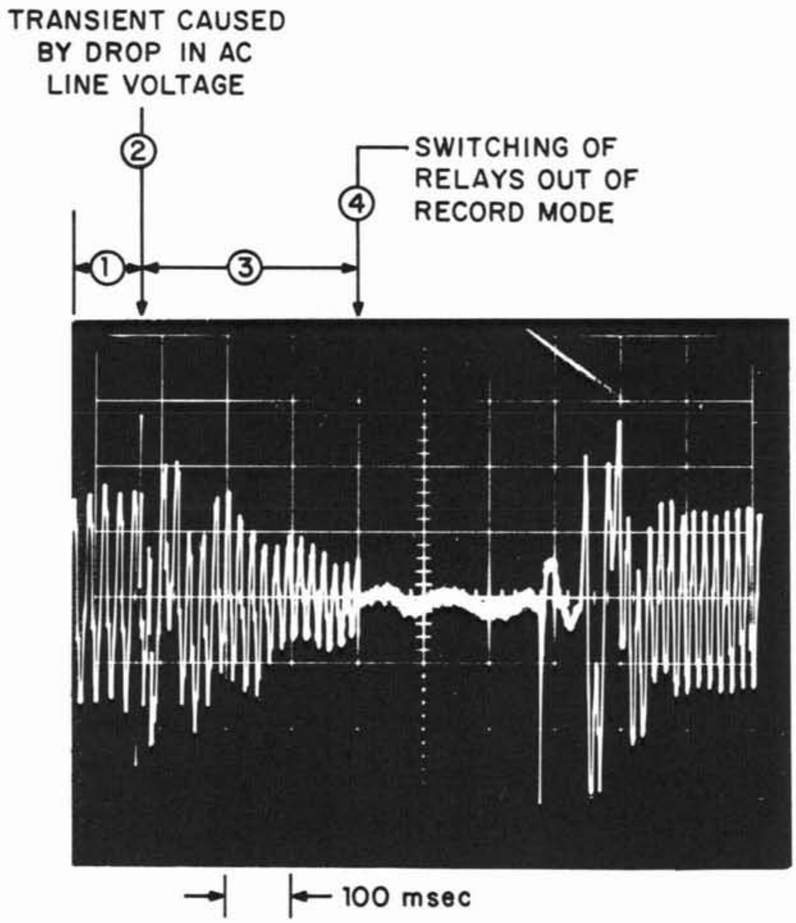

Figure 1. Waveform response of a Uher 5000 recorder when the AC line voltage drops sharply during a recorder operation.

the speed of the motor. The result is that when the tape is played back at constant speed, the frequency of the tone increases by 5 percent (about a semitone in music) just before the signal ceases. This increase in pitch is readily perceived simply by listening to the tape. A similar decrease in pitch is perceived where the recording was resumed after the normal AC input level was restored and the relays switched back to the recording mode. No such changes in the pitch of the buzz were detected on the Evidence Tape.

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To summarize, we have examined all the alternative hypotheses that have been brought to our attention, or that we ourselves have been able to suggest, and we find that while each one of them can account for one or another of the observed facts, none of the alternative hypotheses can explain the entire set of facts. Most of the proposed alternatives are based on internal malfunctions of the recorder. There are two main reasons for rejecting them: such malfunctions cannot stop the tape and then produce forward and backward motion of the tape of the kind we observe in connection with various overlays, as described in Chapter 3; and such malfunctions cannot produce K-1 pulses, which appear in at least six places on the Evidence Tape.

Technical Note 10

ON DETERMINING THE ORIGINALITY OF THE EVIDENCE TAPE

Several different kinds of tests can be applied to a tape to determine if the tape is a re-recording. While such tests can suggest, or even prove conclusively, that a given tape is a re-recording, they cannot prove that the tape is an original. Thus, the Panel's conclusion that the Evidence Tape is an original is based on the absence of any data to the contrary.

The several tests that we undertook are summarized briefly below. None of these tests led us to doubt the originality of the Evidence Tape. One of the tests, involving the starting and stopping dynamics of the recorders, yielded certain results that initially raised questions about the Tape's originality. However, further work satisfied us that the anomalous features we were observing could be traced to a peculiarity of one of the recorders used in the White House recording system and therefore did not imply re-recording.

1. Tests for Originality by Use of Signals Related to the Starting and Stopping Dynamics of the Recorder

When a normally operating Sony 800B tape recorder records a tone of constant frequency, such as a power-line hum, the tone in playback will be heard to rise in pitch at points on the tape where the recorder was stopped. The rise in pitch occurs because the slowing of the tape transport causes the recorded wavelengths to become progressively shorter until the tape stops. This shortened wavelength is heard in playback as a rise in pitch. Similarly, when a constant tone is to be recorded, and the recorder is restarted, the pitch of the tone in playback will sweep downward to the normal pitch as the recording machine goes to the normal operating speed.

In listening to the permitted portions of the speech sections of the Evidence Tape, we heard a rather loud hum originally recorded from the power line. In listening to this hum, we noted that its pitch went up at those points on the tape where the original recording machine had been started by the voice-activated switch (VOX). When the VOX stopped the tape, the hum frequency went down. In other words, the pitch of the power-line hum changed in a manner precisely opposite to what should be expected of a normal recorder. Furthermore, the pattern of hum change with stops and starts seemed to be more or less what should be expected of a normal machine operating in the reproducing mode.

These findings raised the possibility that the Evidence Tape might be a re-recording. Using various combinations of the Sony recorders to make re-recordings, we attempted to simulate the rising and falling pitch characteristics that we found on the Evidence Tape. We found, however, that we were unable to match the characteristics seen on the Evidence Tape.

We did find one of the Sony 800B recorders (referred to as EOB-Sony C) that has an anomalously functioning capstan servo system. In the Sony C, when the remote control function is actuated, the capstan motor operates at approximately four times the intended speed for about one-half second and then drops to the normal speed. Thus, if a recording were made on this machine, or another machine with similar peculiarities, the pitch of the hum would in fact drop when the machine is first actuated.

We were not able to locate a Sony 800B recorder that exactly duplicated all of the characteristics shown on the Evidence Tape (see TN 6 and TN 7).

However, the existence of at least one machine that produces anomalous pitch changes resembling the ones heard on the Evidence Tape means that the hypothesis of re-recording is not logically necessary, and that such anomalies can be explained in terms of a defective capstan servo system like that observed on Sony C.

The Panel made exhaustive tests on anomalous pitch changes as related to the originality of the Evidence Tape. However, most of the tests were made before we received the Sony C machine, so the results of the tests are not germane to our final conclusions. Therefore we have not included in this report a discussion of the more than one hundred pages of data that we obtained in studying anomalous pitch changes.

2. Other Tests

The other kinds of tests that we conducted in order to determine whether the tape was a re-recording are summarized below. These tests yielded no results that would indicate a re-recording, and for that reason we mention them without including data.

We examined the Evicence Tape for "through tones", i.e., tones that were recorded from a constant frequency but that do not rise or fall in pitch with VOX stops and starts. The presence of such tones could imply a re-recording. We did not find any evidence of through-tones.

We examined the Evidence Tape for extraneous start or stop clicks that might have been introduced during a re-recording. We found no such clicks.

We examined the Evidence Tape for anomalous changes in spectrum. Slow-speed recorders such as those used at the White House have a frequency response that falls in a characteristic way at high-frequencies. If a recording displayed a high-frequency characteristic that fell much more rapidly than other similar recordings, we would have had reason to suspect a re-recording. We found no such spectrum changes.

We examined the Evidence Tape for added noise, hum, or flutter. If a recording had contained noise, hum, or flutter of different amount or character than a Sony 800B, we would have considered the possibility that these features might have been added in a process of re-recording. We found no evidence of added hum, flutter, or noise.

We examined certain mechanical and electronic characteristics of the various recroders that might have recorded the Evidence Tape. The characteristics we studied included tape speed, magnetic marks, flutter, frequency response, and head geometry (gap dimensions, spacing, locations, and number; vertical displacement of record and erase heads and azimuth angle of the record head). These tests and their correlation with marks on the Evidence Tape are detailed in many other parts of this report. The results of each of these tests were consistent with the assumption that the Evidence Tape is an original recording and not a re-recording.

Technical Note 11

ON THE POSSIBILITY OF RECOVERING INTELLIGIBLE SPEECH

One of the main objectives of our study of the 18.5 minute buzz section of the Evidence Tape was to determine whether the signal originally recorded in this section could be recovered, and if so to perform such recovery. Two things were apparent at the start of this investigation: recovery of intelligible speech was highly unlikely, and any method of signal recovery would be based by and large on the assumption that the erasure of the original signal was imperfect. In this technical note we describe two approaches that we took in our attempts to recover the signal, neither of which proved to be successful.

Our first approach to recovery of the signal was based on the possibility that the erase head might have been placed too high or too low across the width of the tape. Had this occurred, the head might not have covered the entire track recorded by the Sony 800B, and so might have left an unerased fringe at one of the edges of the track. To test this idea, we first developed selected portions of the buzz section and examined the visible tracks for patterns indicating the existence of residual speech at either edge of the track. No such patterns were detected. We then tried playing back the buzz section, using a special playback head that reproduced only the portion of the tape at one or the other edge of the buzz track. Once again, we obtained no indication of sounds other than the buzz. Finally, we played back the normally unrecorded tracks of the tape in the remote hope that faintly audible speech sounds might be detected, but none were.

The second approach we tried was based on the possibility that the erasure of the original signal might have been a weak one. If a weak erasure had in fact occurred, and had the buzz sound not been recorded onto the tape, we might have been able to hear speech-like sounds beneath a background of hissing noise by playing the tape back through a sufficiently powerful amplification system. Obviously, to test this assumption we had to first eliminate the buzzing sound in the reproduced signal and then listen, through suitably powerful amplification, to the signal that remained.

We eliminated the buzz by passing the reproduced signal through a filter that was designed to pass only those components of the signal that were not at the frequencies of the buzz components (see Technical Note 5). For the most part, the frequencies of the buzz components, which fell at integral multiples of about 60 Hz, were constant for periods of up to several seconds. By contrast, the components of speech, if any were present underneath the buzz, would probably have varied continuously during intervals of such duration. Therefore, by passing only those components that fell outside narrow bands centered at the frequencies of the buzz components, we were able to eliminate virtually all of the buzz while at the same time eliminating only a small portion of any speech that might have been under the buzz.

The technique described above is commonly called comb filtering. We used it to process segments of the signal at various places in the buzz section of the Evidence Tape. For this task, signal processing was performed by a large scale digital computer, which was programmed to generate at each segment a comb filter that exactly matched the frequencies of the buzz components in that segment. We greatly amplified the signal that remained after the buzz had been removed, to insure that we would be able to hear any speech that might be present. However, although we carefully listened many times to each segment that was processed in this manner, we were never able to detect even the faintest indication of a speech-like sound beneath the residual tape hiss.

As noted elsewhere, there exist three short segments in the buzz section of the Evidence Tape in which speech-like sounds can be heard. The first is located at the very beginning of the buzz and extends for 1.2 seconds. The second is located at 49.47 seconds into the buzz and extends for 0.3 seconds. The third is located at 1042.74 seconds into the buzz and extends for 0.55 seconds. For these three sections, especially for the latter two, it is possible upon repeated and careful listening to the tape to discern a faint speech-like sound underneath the buzzing sound. After filtering, these speech-like sounds are rendered much more readily recognizable as being almost certainly associated with human speech activity. However, the sounds, generally muffled in nature, are not sufficiently loud or sufficiently crisp to be understandable.

The panel also considered several other techniques that were proposed for recovery of the erased signal. One method involved 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 possibility involved 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 we might be able to distinguish between signals recorded in June, 1972, and those added more than a year later. 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.

In view of the results of our tests, we concluded that recovery of the original signal recorded in the buzz section of the Evidence Tape is not possible by any method known to us. Moreover, since the ear is the best detector of speech-like sounds that we know of, and since we were not able to detect even a hint of speech-like sounds in the buzz section of the tape, it is likely that recovery of the original signal will never be possible.

Technical Note 12

MINOR TRANSIENTS IN THE BUZZ SECTION

After the Panel had analyzed the major events in the buzz section, we listened carefully for any other, weaker sounds that might contribute further to our understanding of the buzz section. We observed about a dozen of these minor transients, which sound like very faint clicks barely discernible above the background noise. The amplitudes of their waveforms are smaller than those of the major events produced by turning the record and erase heads off or on.

Waveforms of four of these minor transients appear in Technical Notes 2 and 3, in the illustrations given for Event Times 46, 155, 275, and 684 seconds, respectively. As the discussion of those illustrations indicates, those minor transients are of uncertain origin. The remaining eight minor transients are illustrated here in Figure 1.

In the figure, each pulse is shown in two pictures of waveforms. The waveform is much more spread out in the picture on the left than in the one on the right. A segment one millimeter long in the picture on the right spreads out over a length of about 50 millimeters in the picture on the left. In terms of playback time, the picture on the right represents a total duration of 1.67 seconds, whereas the one on the left represents only 50 milliseconds.

The pictures on the right were made by the system that made the waveform pictures given in Technical Note 2. The pictures are printed at about 40 percent of the size at which they are printed in Technical Note 2. The pictures on the left were made by the system that made the enlarged waveform pictures given in Technical Note 3, but here they are printed about 10 percent larger.

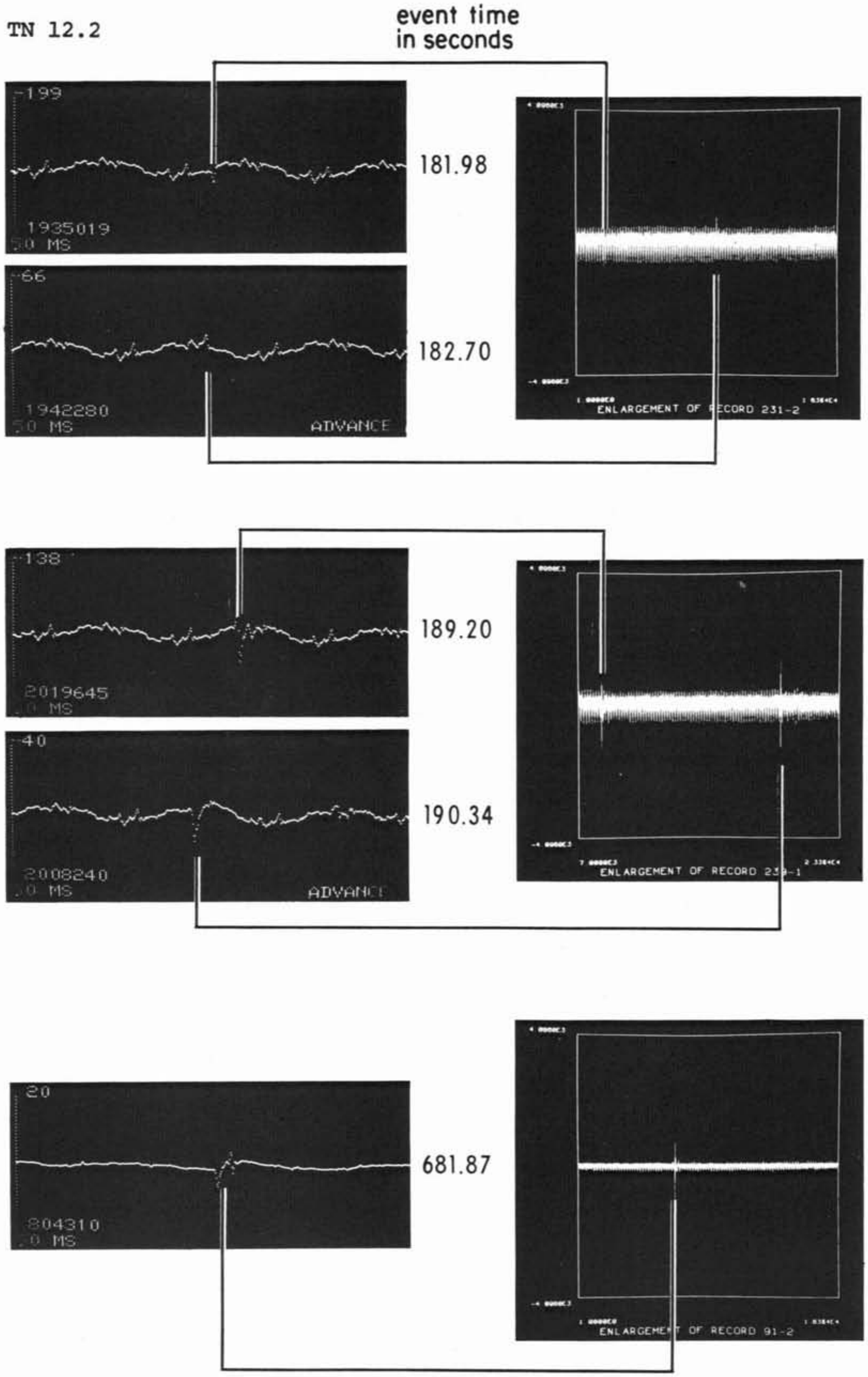

Figure 1. Waveforms of minor transients

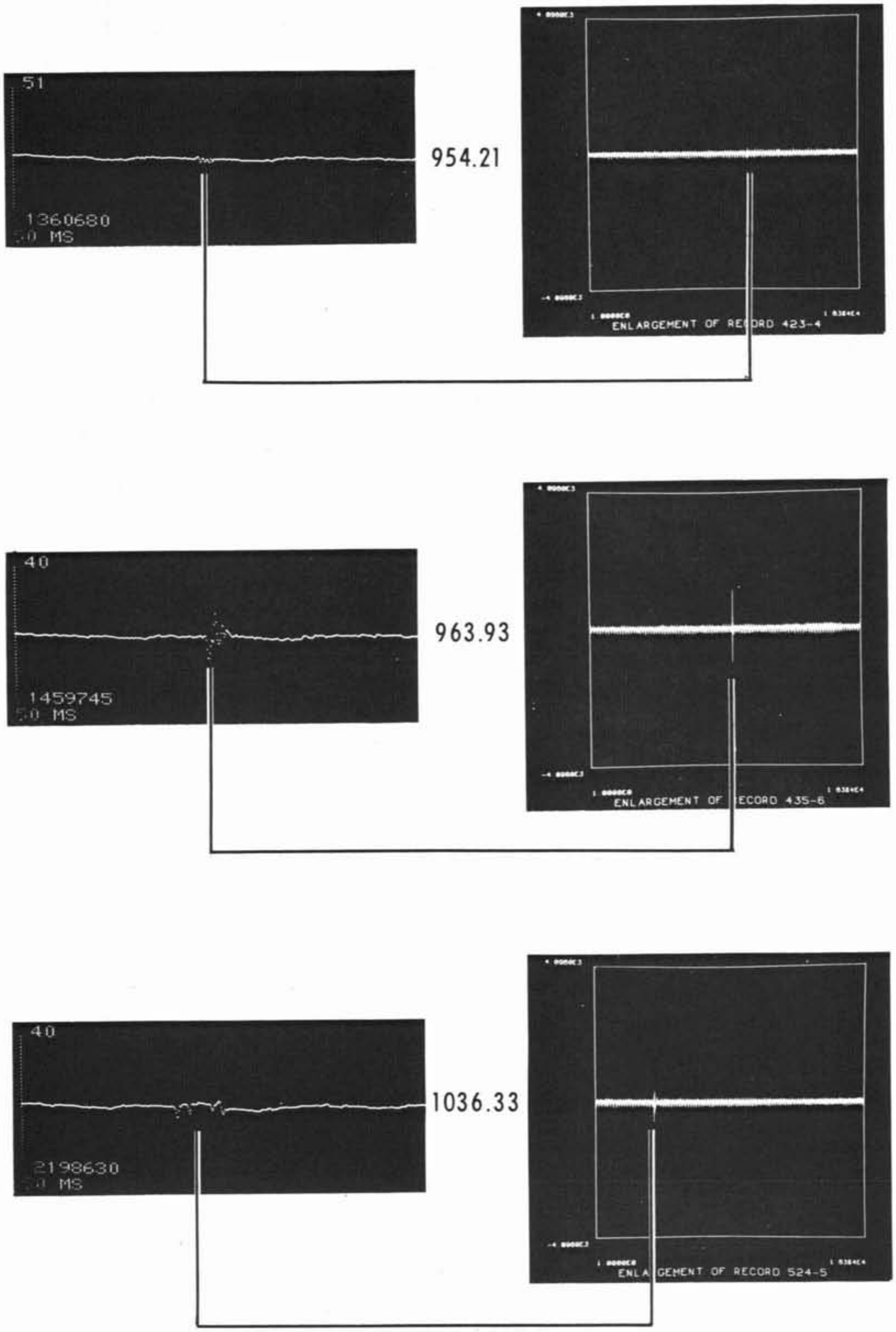

Figure 1. (Continued)

Both kinds of pictures are useful for studying transient pulses. A very small pulse, such as the one shown in Figure 1 at the event time of 182.70, is easier to detect in the compressed time of picture on the right; but the spread out version is needed to show waveform details that might help in identifying the cause of the pulse.

In attempting to explain how these transient pulses were generated we considered four different kinds of explanations.

The pulses are related to the principal events in some manner. This explanation is contradicted by the apparently random distribution of the pulses in the 18.5 minute buzz section. Moreover, with the exception of the transients at event times 155 and 684, none of these pulses occurs near enough to the principal events to be functionally relatable to them.

The pulses are related to machine functions in the Uher 5000. This explanation fails because the amplitude of the minor pulses is very much lower than those generated by operation of any of the keys and controls on the recorder. Some of the pulses were so much lower than the buzz that they were barely detectable either by listening or by examination of the buzz waveform in which they were embedded.

The pulses were caused by brief failures of components in the recorder. Here, too, the low amplitude of the pulses is inconsistent with the explanation. Moreover, considering that the buzz section is 18.5 minutes long, relatively few pulses occur.

The pulses were the result of extraneous noise pickup. While this explanation can never be proved, it is supported by two observations. The pulses are similar to weak recorded clicks and pops that are caused by extraneous noise pickup in normally functioning tape recorders, particularly those used in practical recording environments. Some of the larger of the clicks are synchronous with periodic noise pulses that occur in the buzz waveform, and may simply be larger versions of these pulses.

This fourth explanation is the one most strongly supported by the evidence. Such small, extraneous pulses are easily produced by such occurrences as switching on and off lights and starting and stopping electrical appliances and devices.

Technical Note 13

MEASUREMENT OF TAPE LENGTH, SPLICES, BIAS FREQUENCY, AND AZIMUTH ANGLE

1. Tape length measurement

The Panel measured the lentgh of the tape with a commercial "tape timer," Lyrec Model TIM 4-A, Serial Number 10 398, which is a precision pulley combined with a built-in counter. We wound the tape at high speed over the pulley and measured the number of revolutions of the counter. From the resulting data we calculated the length of the tape.

The Evidence Tape is 553.06 meters long (1814.5 feet). This is well within the normal range of lengths for tapes sold as 550 meters (1800 feet) in length.

2. Search for physical splices

Although physical splices in a tape can be felt or seen with the naked eye, such methods are very slow and subject to human error, especially considering the length of tapes examined in this study. To check for physical splices, the Panel devised an instrument using a sensitive accelerometer, which is capable of detecting extremely small changes in tape thickness. In simulation tests, the instrument reliably detected actual splices and even smaller changes in tape thickness than would occur from the use of splicing tape in normal splicing operations. Tests conducted on the Evidence Tape using the splice detector showed no physical splices.

3. Azimuth angle measurement

The "azimuth angle" of a tape recorder is the angle between the line of the head gap and a line perpendicular to the direction of the tape motion. The azimuth angle is an individual mechanical characteristic of a tape recorder.

We directly measured the azimuth angles of the heads on two Uher recorders and three Sony recorders, by playing on them a "Difference Method Azimuth Adjustment Test Tape," Cat. Nr. 22A108, manufactured by Magnetic Reference Laboratory of Palo Alto, California. We measured the level differences between the output signals from tones originally recorded on that test tape at two different azimuth angles, and calculated the azimuth angle according to the manufacturer's instructions. The measured azimuth angles were as follows: Sony A, -1.7 mrad (milliradians); Sony B, -1.7 mrad; Sony C, -16 mrad; Exhibit 60 Uher, -2.2 mrad; and the Secret Service Uher, -3.3 mrad.

We indirectly measured the azimuth angle on the Evidence Tape by playing it on a Sony 800B purchased by Bolt Beranek and Newman Inc. for the tests. We set the azimuth angle of the BBN Sony by listening to the sound, and adjusting the azimuth angle to achieve maximum audible high-frequency response. The point of correct adjustment is both obvious and repeatable. Then we measured the azimuth of the reproducing head with the MRL Azimuth Difference Test Tape. The angle of the speech before the buzz was -4.4 mrad, and the angle of the buzz at its start was -1.7 mrad.

The azimuth angle of the speech before the buzz on the Evidence Tape does not agree exactly with that of any of these recorders, indicating that the speech recording was probably not made on Sony A, B, or C. We did not further pursue this investigation.

The difference between the azimuth angle of the buzz on the Evidence Tape and the azimuth angle of the Exhibit 60 Uher is 0.5 mrad which is within the limits of angular error involved in guiding the tape in the recorder. The difference between the Evidence Tape and the Secret Service Uher is 1.6 mrad, which is a significant difference.

We conclude from these measurements of azimuth angle that the buzz on the Evidence Tape was more likely to have been recorded on the Exhibit 60 Uher than on the Secret Service Uher.

4. Bias frequency measurement

Audio recording normally involves the use of a high-frequency ac bias current added to the audio signal current. The frequency of the bias in the Sony and Uher recorders that we studied is approximately 50 kHz. The ac bias performs its function whether or not the bias itself is actually recorded onto the tape: sometimes it is and sometimes it is not. When the bias is recorded and measureable, it can be of assistance in identifying the machine on which the tape was recorded.

We made several attempts to recover the bias signal and were unable to do so. At the low tape speed of 24 mm/s (15/16 in/s) at which the Evidence Tape was recorded, the bias wavelength is only 0.5 micrometers (0.0005 mm). We know of no tape reproducer, either commercial or research-type, that can recover signals of such short wavelength.

Conceivably we could have developed a special device that could recover such signals. We did not undertake to do so because we found that hum tones available on the buzz section enabled us to obtain the same kinds of information that a bias signal might have yielded.