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

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Technical Note 1

MAGNETIC MARKS AND THEIR RELATION TO RECORDER FUNCTIONS AND CONTROLS

1. Magnetic Marks

"Magnetic marks" is a term we use to describe the visible patterns appearing on a magnetic recording tape that has been "developed" by a fluid containing microscopically fine iron particles. The magnetic marks appear on the oxide surface of the tape, the side that is touched by the record and erase heads, wherever the iron particles collect in the vicinity of the magnetic poles produced by the recorded magnetization.

This development technique resembles a technique used in elementary science laboratories, when iron filings placed in the vicinity of permanent magnets demonstrate the shape of the otherwise-invisible magnetic field. The principal difference in the case of magnetic marks produced on recording tape is that the iron particles are very much smaller than the filings used in the science laboratory. Also, the tape itself, instead of being a single magnet, is in effect a two-dimensional mosaic of many tiny magnets, the strength of each having been adjusted by a magnetizing field usually produced by a varying current flowing through the coils of a recording head in a tape recorder. The magnetic marks visible on a section of recording tape on which ordinary speech or music sounds have been recorded bear a striking resemblance to the widely used motion-picture sound track of the variable density type.

A typical section of recorded speech made visible in the form of magnetic marks appears in Figure 1. When looking at a tape recording by means of magnetic marks, the observer can see not only how the tape's magnetism varies along the direction of travel, but also how the magnetization may change across the width of the tape. In particular, in Figure 1 the magnetic marks occupy less than one-half of the width of the tape, the boundary between the magnetized and unmagnetized parts of the tape being rather sharp. This situation is very common in present-day tape recordings because of the popular use of multiple-track recording.

Figure 1. Magnetic marks on tape in a section of speech

According to records of the U. S. Secret Service, the section of tape depicted in Figure 1 was recorded on June 20th of 1972 on a Sony Type 800B recording machine. This type of machine, as well as the Uher 5000, employs what is known as half-track recording on quarter-inch (6.3 mm) tape. The recording head is adjusted so that it influences less than half of the tape width. In this way, both halves of the tape can be recorded on with the two separate sets of signals far enough apart on the tape so that one is not faintly heard in the background when the other is being played back.

In modest cost tape recorders, such as the Sony 800B and the Uher 5000, the head that makes the magnetic marks during recording is later used as a playback head. Once magnetized by the record head, the tape can be played back by moving it past the same head, which is no longer activated by the recording circuits but is now connected to the reproducing circuits.

The magnetized oxide at the head gap produces a magnetic flux in the core of the head. Changes in this flux induce an electrical signal in a coil on the core of the head. This electrical signal is then amplified to drive a loudspeaker or headphone, which in turn produces an audible acoustic signal. Because the induced electrical signal is a result of the total effect of all the magnetized oxide over the gap of the playback head at any time, this induced signal cannot show variations in the magnetic marks that occur in the direction of the width of the tape. Only the total variations in the direction of tape motion can be observed. Thus while the magnetic marks provide information relating to two dimensions of the tape, length and width, the electric signals provide information relating to only one dimension, length. As we shall see, the two dimensional nature of magnetic marks provided some information that was essential in determining how the 18.5 minute buzz section was produced.

The record head of the Uher 5000 makes a magnetic mark that is approximately 2.4 millimeters wide. The erase head, when de-energized, makes magnetic marks that are three millimeters wide, which is essentially half the tape width. The erase head is wider than the record head in order to ensure the erasure of the entire recorded signal when a previously recorded tape is being reused.

In many tape recorders, including the Sony 800B and Uher 5000 machines, the erase head not only eliminates magnetic marks but also makes distinctive magnetic marks of its own. The erase-head-off mark can be made visible by magnetic development. For both types of machines these magnetic marks appear whenever the electronic circuit that energizes the erase head is de-energized, as when an operator terminates any particular act of recording.

Both the Sony 800B and the Uher 5000 make record-head marks when recording ceases. Record-head-off marks are less distinctive than erase-head-off marks. However, record-head-off marks are easily identified because they always appear a known distance from their erase-head-off mark partners. This distance is equal to the physical distance between the erasing head and the recording head, which for the Uher 5000 is approximately 28.5 millimeters and for the Sony 800B is approximately 24 millimeters.

Distinct magnetic marks are made also by the recording head at the beginning of a recorded section when the recording and erasing electronics are first activated. Magnetic marks made by a record-head-on operation are not greatly different in appearance from a record-head-off mark. The absence of an erase-head-off mark at the appropriate distance would tend to support the hypothesis that a particular record head mark is of the starting type, not a record-head-off mark.

While magnetic marks are capable of revealing the gross forms of the magnetic patterns actually recorded on the tape, the fine and minute detail in the patterns can be seen with clarity only by playing the tape and observing the electric waveforms on an oscilloscope or other high-resolution plotting device. The two-dimensional aspects of the magnetic marks are not seen in the waveform. In the analysis of events on a tape recording, both magnetic marks and electrical waveforms have an important role to play, as Technical Note 2 explains.

In our study of the Evidence Tape, we took elaborate pains to find all magnetic marks coupled with possible starting and stopping of the recorder responsible for the 18.5 minute buzz section, and to analyze these both in terms of the two-dimensional developable marks and their corresponding waveforms. Only through careful study and cross correlations of such information were we able to report with confidence the cause of these marks as related to the functioning characteristics of the recorder which produced them. In addition, for comparison purposes, we produced simulated marks on a test tape by means of known operating sequences. We used those marks to confirm the classification of the marks found on the Evidence Tape.

2. Relating Magnetic Marks to Recorder Functions and Controls

To initiate the process of classifying magnetic marks, the Panel produced a dummy tape using several Sony 800B and Uher 5000 recorders. Some of the machines were part of the court evidence collection and others were purchased specially for this study. Because of its eventual central focus, the Exhibit 60 Uher was used in preparing examples presented here. The machine was operated in a number of modes to produce this tape. These modes were selected to explore the full range of operation capabilities

of the Exhibit 60 Uher. The magnetic marks associated with these operations were then developed for examination and comparison with those found in the 18.5-minute buzz section. One set of these marks is shown in Figure 2.

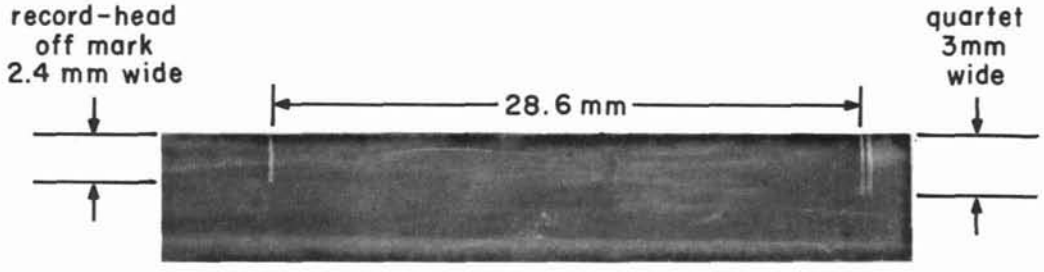


Figure 2. Record-head-off mark and quartet mark from STOP test on Exhibit 60 Uher

These marks were made by developing a tape that was recorded on the Exhibit 60 Uher. The RECORDING LEVEL was set at maximum and no signal was fed to the microphone input. Recording was initiated by pressing the START and RECORDING keys. Then, to produce the marks seen in Figure 2, we pressed the STOP key, thereby de-energizing the record head and erase head. The mark on the left, 2.4 mm wide, was produced by the record head at the instant it was de-energized. This mark appears to be a single line, but in reality can contain several, closely packed lines, as Technical Note 2 explains. The mark on the right, 3.0 mm wide, is a set of four parallel lines produced at the same time by the erase head. We 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 tape. Thus, for example, the quartet is called 3 mm wide, not long. Its length is much less, about 0.5 mm in this case.

The distance between the single line on the left and the quartet on the right is 28.6 millimeters.

This distance checks with the distance measured mechanically between the magnetic gaps of the record head and erase head of the Exhibit 60 Uher. Similarly, we determined that the record head is 2.4 mm wide (extends about 2.4 millimeters in the tape width dimension) and the erase head is 3 millimeters wide.

The reader may observe clearly here how the two-dimensional nature of magnetic marks provides the observer with important information. Not only can the actual width of the sound track made by the recorder be measured, but the difference in the widths of influence possessed by the erase head and the record head can easily be measured. This difference in widths supplies a major point of information for distinguishing between erase head and record head marks.

Now consider the marks in Figure 3. Near the left edge is a record-head-off mark and near the right edge is a quartet. However, this quartet, unlike the one in Figure 2, is partly obscured. Further, a new mark, 2.4 mm wide, shows up about 4 mm to the left of the quartet. This new mark is actually a cluster of lines.

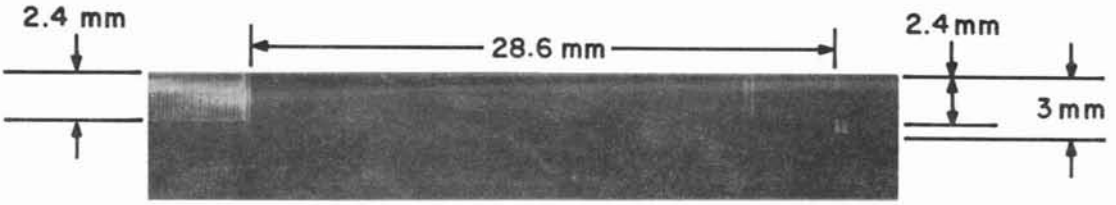


Figure 3. Record-head-off mark, record-head-on mark, and partly obscured quartet from test on Exhibit 60 Uher

To make these marks we started out, as before, by setting the RECORDING LEVEL at maximum, pressing the START and RECORDING keys, and then pressing the STOP key. This time, however, we turned the reels by hand to move the tape forward about 24 mm, and then added another operation: we depressed the RECORDING key, which locked itself down, and pressed on the foot pedal. After the tape had moved forward some distance, we stopped the recorder and developed the section of tape shown in Figure 3.

The mark seen at about 4 mm to the left of the quartet was laid down by the record head after it had been moved forward about 24 mm. The mark was made by the record head at the instant it was energized. When the record head then moved forward it passed over the previously-recorded quartet and partially erased the upper 2.4 mm of the quartet.

Another record-head-on mark appears, all by itself, in Figure 4. This one, like the one seen at about 4 mm left of the quartet in Figure 3, is a 2.4 mm wide (measured across the width of the tape) pair of lines. We made the record-head-on mark in Figure 4 simply by depressing the self-locking RECORDING key and stepping on the foot pedal.

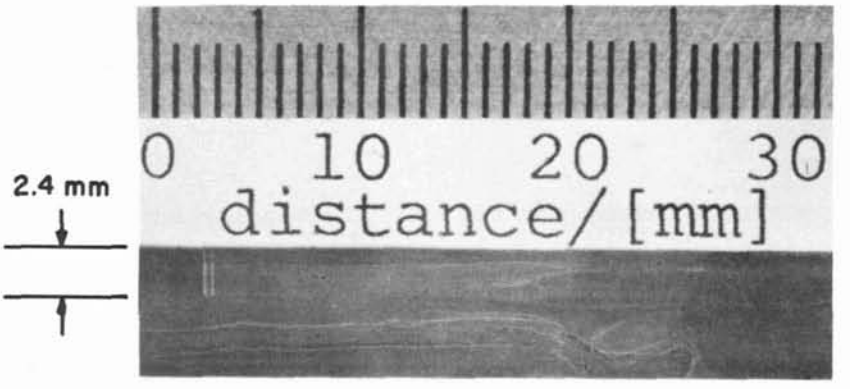


Figure 4. Record-head-on mark from foot pedal test on Exhibit 60 Uher

Figure 5 was made by pressing the START and RECORDING keys, letting the tape advance some, pressing the STOP key, and then immediately pressing the START and RECORDING keys without repositioning the tape.

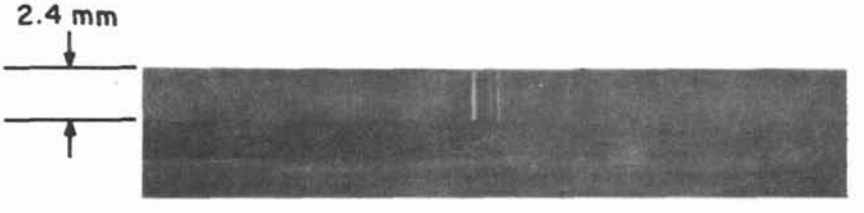


Figure 5. Record-head off and on marks from in-place keyboard stop and restart recording test on Exhibit 60 Uher

Figure 6 was made by first recording a section of the tape, then backing the tape up, pushing the START key of the tape recorder, and while holding the START key depressed, latching the RECORDING key. No input was connected and the RECORDING LEVEL was set at maximum.

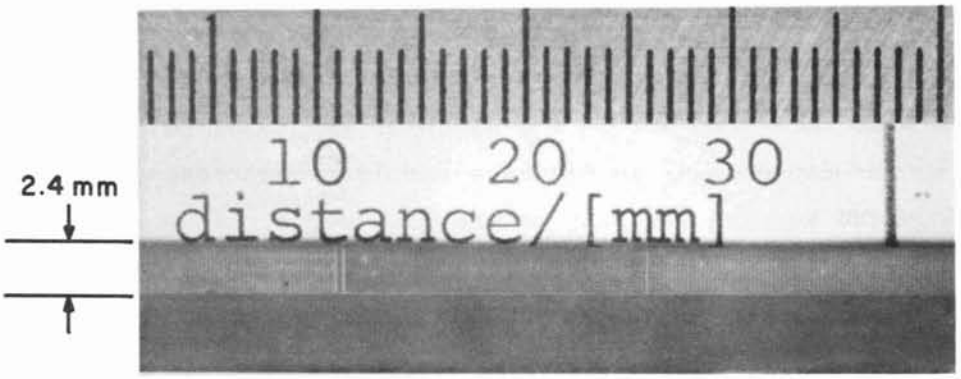


Figure 6. Record-head-on mark from test on Exhibit 60 Uher

These figures reveal the variety of normally expected erase-head-off marks, record-head-off marks and record-head-on marks. Obviously absent from the above collection is any appearance of an erase-head-on mark. The reason for this is that erase-head-on marks cannot exist. Extensive testing and tape development has failed to demonstrate the appearance of any erase-head mark when the erase head is turned on and left on while the tape is moved forward. The erase head erases its own marks.

Further, we have not been able to demonstrate the production of an erase-head-on mark by mounting a tape properly, energizing the erase head, and taking the tape away from the recorder while the erase head is still energized. Evidently any mark created by the energization of the erase head is immediately erased by the erasing action thus initiated.

Occasionally we see a 3 mm mark that is a single line, instead of a set of lines, located at a distance of 28.6 mm from a record-head-off mark. The single line was originally a part of a quartet, but the other three lines were erased by the erase head after the tape moved forward a very small amount.

The Panel made several further tests to study the kinds of magnetic marks that are made by various kinds of operations of the Uher 60 recorder. These tests provided simulated data for comparison with data found on the Evidence Tape. The results provided us with essential information for use in determining what operations of the recorder could or could not have resulted in the magnetic marks observed on the Evidence Tape. Figures 7 through 13 show and briefly explain the results of these further tests.

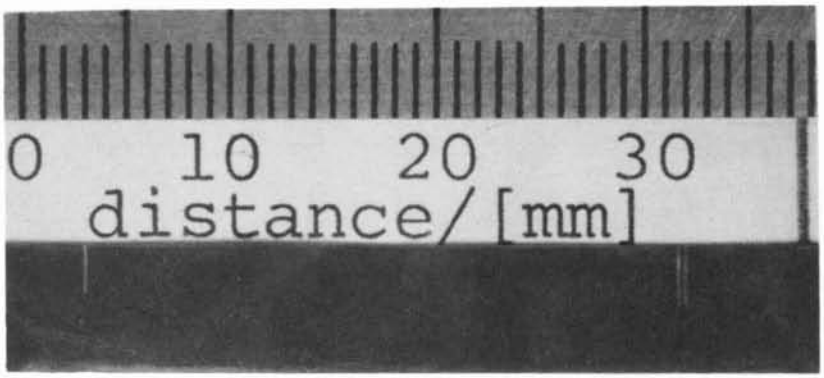


Figure 7. To make these marks we pushed the RECORDING key of Exhibit 60 Uher and then depressed the foot pedal. While holding the foot pedal down, we depressed the STOP key and a few seconds later released the foot pedal. These marks appear on the tape at the point where the STOP key was depressed.

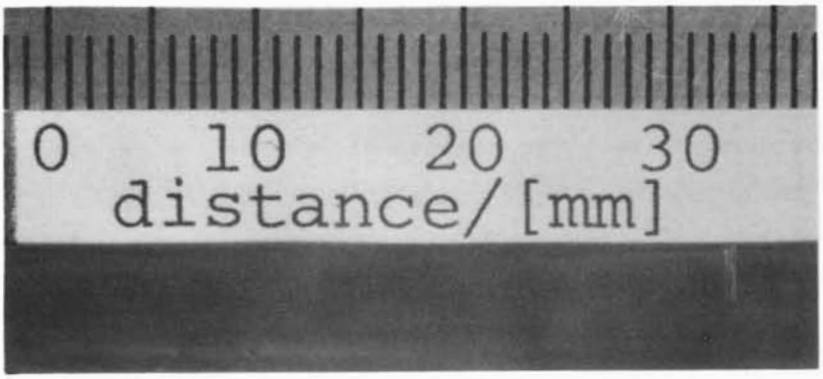


Figure 8. We made this magnetic mark by pushing the RECORDING key of Exhibit 60 Uher and then pushing the STOP key. No tape motion was involved at any time.

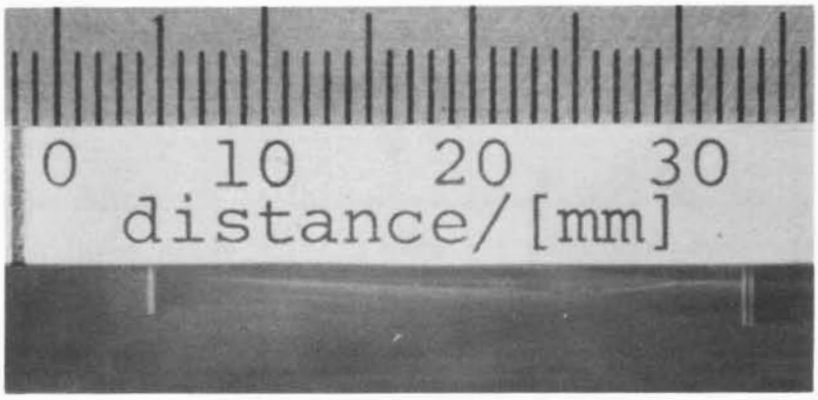


Figure 9. We made these magnetic marks by first pushing the RECORDING key of Exhibit 60 Uher, then depressing the foot pedal, and while holding the foot pedal, pushing the START key. A few seconds later the foot pedal was released and then the STOP key was depressed. The magnetic marks shown were obtained from the tape at that point where the START key was depressed.

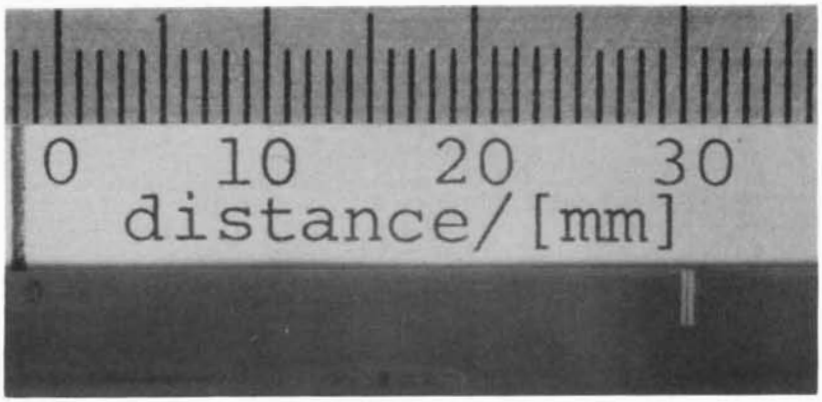


Figure 10. We made this magnetic mark by first pushing the RECORDING key of Exhibit 60 Uher, then, without holding the RECORDING key, pushing the START key. Until the START key was depressed, there was no tape motion. The mark was made on that portion of the tape corresponding to the moment when the START key was depressed.

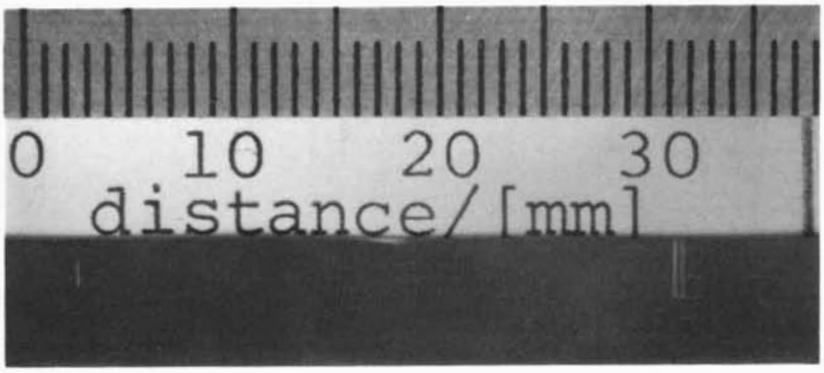


Figure 11. We made these magnetic marks by pushing the START and RECORDING keys on Exhibit 60 Uher simultaneously and then releasing the START key first. A short time later the START key was pushed again. These magnetic marks appeared at the point on the tape corresponding to the second depression of the START key.

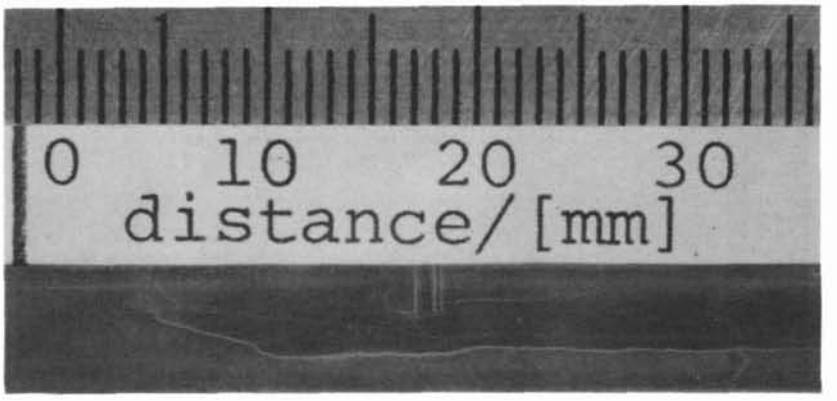


Figure 12. We made the magnetic marks in this photograph by first pushing the RECORDING key on Exhibit 60 Uher, then depressing the foot pedal, and shortly thereafter releasing the foot pedal. A moment later the foot pedal was pressed a second time and after a short period, released again. The magnetic marks appearing here correspond to the point on the tape when the foot pedal was first released and depressed for the second time.

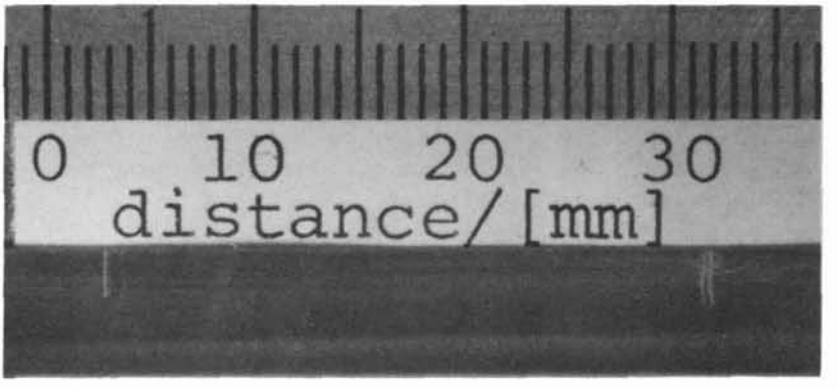


Figure 13. We made the magnetic marks in this photograph by first pushing the RECORDING key of Exhibit 60 Uher, then depressing the foot pedal, and shortly thereafter releasing the foot pedal. After the foot pedal had been released, the STOP key was depressed. The magnetic marks in this photograph correspond to the point in the tape at which the foot pedal was released and the STOP key was depressed.

3. Overlay Types

Now that we have described the types of marks associated with the three major observable events, erase-head off, record-head off, and record-head on, we shall discuss the types of overlays that are possible. An overlay occurs when two recordings are made one after another in such a fashion that the beginning of the second recording falls close to or overlaps the end of the first recording.

Four types of overlay can occur. The tape can move backward or forward from the point at which the first recording stopped, and the tape can move a distance that is greater or less than the distance between the record head and the erase head.

Consider first the overlay type in which the tape is moved backward a distance greater than the distance between the two heads. In a Uher 5000 recorder this means a distance greater than about 28.5 mm. (Individual machines of the same kind can differ; in the Exhibit 60 machine the distance between heads is 28.6 mm.) After the second recording starts up, the erase head passes over the record and erase head marks left by the first recording, so both those marks will disappear. Since the erase head itself leaves no mark when it is energized, the only distinctive mark left on the tape for this overlay type is the record-head-on mark made when the second recording began.

However, something more than the record-head-on mark is left on the tape as a result of an overlay operation of type one. Any signals that had been recorded during the first pass, and that lie between the record and erase heads at the beginning of the second pass, will become partially erased by the record head. Further, the record head may record new signals on top of the ones recorded earlier.

In the tape of June 20, 1972, the first type of overlay produces what we call buzz on buzz. The record head has put a new buzz signal on top of a partially erased buzz signal. The length of the underbuzz is the 28.6 mm distance between the record and erase heads at the point where they started going over the tape the second time.

In the second type of overlay the tape is moved backward by less than the record-to-erase-head distance. The erase head is now between the record-head-off and the quartet left by the first recording, ready to pass over only the quartet. The record head is in position to pass over both the record-head-off and quartet marks. Note that the section of tape between the record-head-off mark and the quartet was completely erased by the first pass.

At the start of the second pass, the record head puts down the record-head-on mark. The record head will now partially erase the segment between the fresh record-head-on mark and the record-head-off mark made in the first pass. Also, the record head will put any new signal on top of the previous signal. After the record head passes the record-head-off mark it will be recording on completely erased tape, and the erase head will have erased the quartet left by the first pass. In the second type of overlay, as in the first, a section of underbuzz appears, but this time it is shorter than the record-to-erase head distance. Its length is equal to the amount by which the tape had been moved backward, which is the distance between the new record-head-on mark and the record-head-off mark of the first recording.

In the third type of overlay, the tape is moved forward by an amount less than the distance between the record and erase heads. As a result, all three kinds of marks will remain on the tape. The one farthest back is the record-head-off mark made at the end of the first section of recording. The next one is the new record-head-on mark. The third one is the quartet located where the erase head stopped at the end of the first recording. However, after the second section of recording starts up, the record head passes over the quartet and partially erases the upper 2.4 mm of it. This "overwritten" quartet is a sure sign that the record head passed by after, not before, the erase head put down the quartet.

The distance by which the tape moves forward in the type three overlay measures off what we call a "window." This is the part of the tape that lies between the quartet made at the end of the first section of recording and the location of the erase head at the start of the second section. The erase head while it was energized has not passed over this window, so whatever signals may have been recorded on the tape before these re-recording operations commenced will show through the window to some extent. Actually,

the record head will partially erase the signals previously recorded in the window area and at the same time will write a new signal in this area. If the original signal were speech and the new signal buzz, then the window would contain a composite recording that may be referred to as "underspeech."

Two such windows appear in the Evidence Tape and both appear to contain "underspeech." A 7 mm (0.3 sec) window occurs at 49 seconds after the start of the buzz section on the Evidence Tape. Also, a 13 mm (0.55 sec) window occurs at 1042 seconds into the buzz section. The length of each window must correspond exactly to the distance that the tape was advanced in this type of overlay.

A third window of the same general kind, not involving displacement of the tape, occurs at the very beginning of the buzz section. The window is the full length of the spacing between record and erase heads. Because it is carved out of ongoing conversation, it is especially helpful in showing what underspeech should look like when analyzed in various ways.

A fourth overlay type would involve motion of the tape in the forward direction, but by a distance greater than 28.6 millimeters. Hence, at the initiation of the second segment, both the erase and record heads would be farther down the tape than the erase head was when the first section was terminated. This type of overlay would also leave all three types of magnetic marks. But its most distinctive characteristic would be that an island of the original recording would be left intact, bounded by the earlier and later segments of rerecorded signal. No instance of this kind was found on the Evidence Tape.

Technical Note 3 describes overlays in a somewhat different way and shows them diagrammatically. Also, the method of designation differs, as follows:

Designation of Overlay Types

In this Technical Note	In Technical Note 3
Type 1	Case D
Type 2	Case C
Type 3	Case A
Type 4	Case B

Technical Note 2

COMPARATIVE STUDY OF MAGNETIC MARKS AND WAVEFORMS

The White House tape of June 20, 1972, contains an 18.5 minute buzz section of hum noises, clicks, and other non-speech sounds. To find out how the buzz section was produced has been a major purpose of the Panel's study. In seeking the answer we have made extensive use of magnetic marks and waveforms.

A detailed description of magnetic marks, which are magnetic patterns made visible on the tape, appears in Technical Note 1. It explains how the marks are measured and analyzed to give information about the recorder operations that put the patterns on the tape.

In this Technical Note we first describe waveforms and explain how we obtained them from the tape. Then we define "events" on the tape as sets of magnetic marks and waveforms related to various operations of the recorder when the buzz section was recorded. This Note gives a detailed presentation of the observed marks and waveforms from which we derived the existence of 13 events created by starts, stops, and other operations of the recorder.

Waveforms and their Production

A waveform is a graphical time-picture of a signal. It is a graph showing the fluctuations of the signal plotted vertically and the time plotted horizontally. The waveform corresponding to signals recorded on a tape can be obtained by playing the tape, feeding the electrical signals into an oscilloscope, and observing the electrical waveform traced on the screen. The result, which can be photographed as a permanent record, can be matched up with a picture of the magnetic marks obtained from the same signals on the tape. Large pulses or wiggles in the waveform will correspond to strong marks. Small variations in the waveform may come from signals so weak that they cannot be seen in magnetic marks on the tape. Figures 1 and 2 show examples of waveforms.

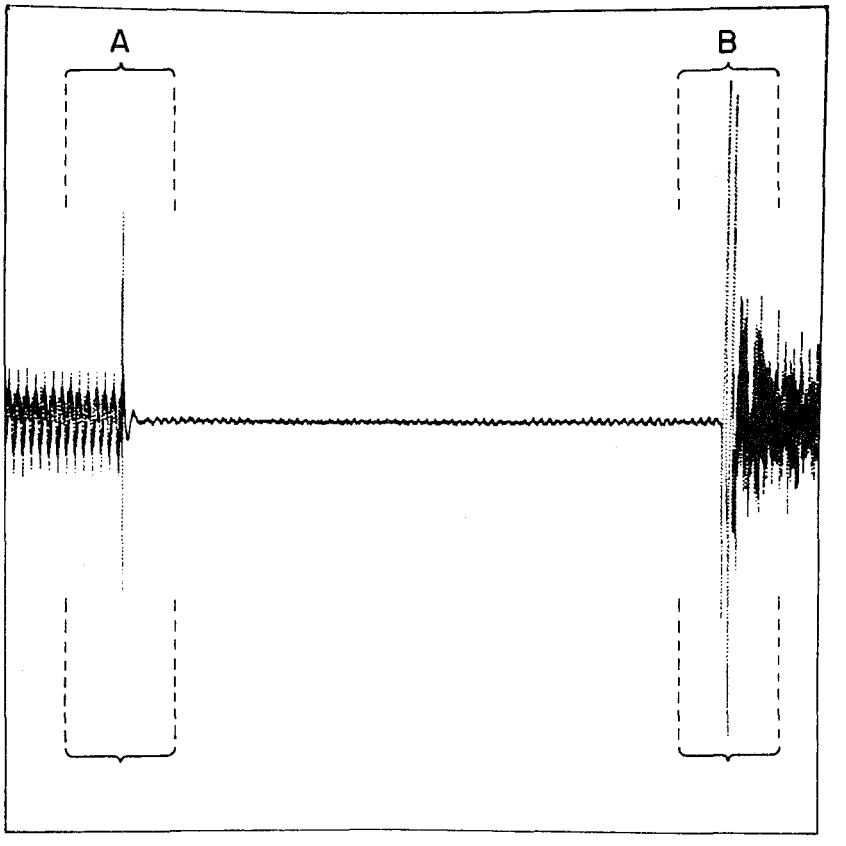
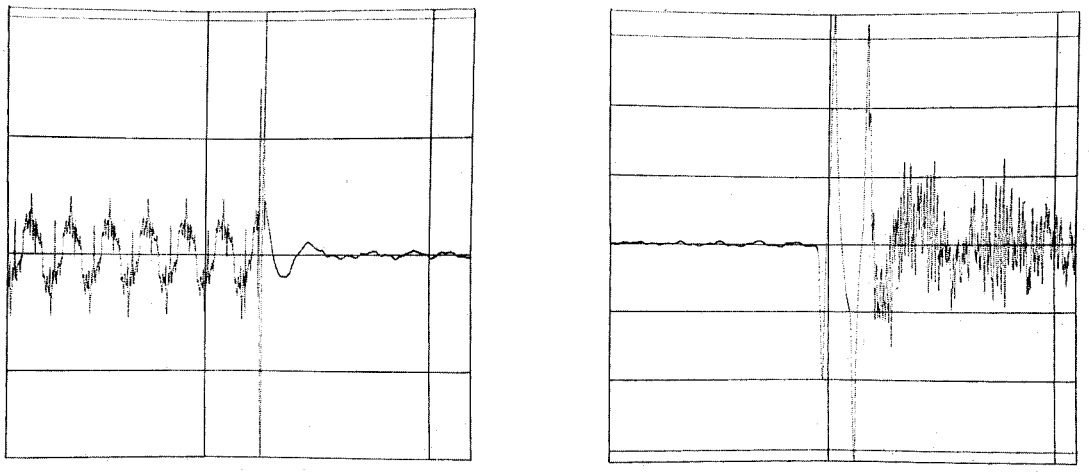


Figure 1. Waveforms corresponding to the magnetic marks seen in Figure 3. Enlargements of waveform Sections A and B appear in Figure 2.

For the most part, the Panel produced the waveforms for its study by using techniques involving digital computers, which offer much more flexibility and power than the simple use of oscilloscopes can provide. We played the tape at its normal speed on a Sony 800B recorder, electrically filtered the output to a bandwidth of 4 kilohertz, and digitized the resulting electrical signal at a sampling rate of 10,000 samples per second. We did the digitizing by using a precision analog-to-digital converter capable of generating 14 bits per sample.

The digitized waveforms thus produced were stored in a magnetic memory. By using a suitable computer program, we could call forth any section of the waveform at will, and we could have it displayed on a digitally-controlled plotter. The program gave us great flexibility in calling up any segment we wished to see and displaying it at various scales. We could look at a long section of the waveform, such as the one in Figure 1, and then easily zoom in on small details such as those seen in Figure 2. To have obtained similar comparisons at various scales without using the powerful digital methods of the computer would have been an enormously tedious undertaking.



2a 2b

Figure 2. Enlargements of sections A and B in Figure 1.

Using digital methods we produced and photographed electrical waveforms corresponding to all the significant events for which we had developed magnetic marks. For each magnetic mark on the tape, we used the corresponding waveform to confirm and extend our explanation of the causes of the mark. All the waveforms shown in this Technical Note were produced and used in this way.

Definition of Events on the Tape

The beginnings and endings of segments on recorded tape carry distinctive marks that indicate the behavior of the recorder when it was making the segment. We call each set of such distinctive marks an event.

The tests we have made on the Evidence Tape show that the 18.5 minute buzz section divides naturally into 13 major events. Two of them occur at the beginning and end of the section, one occurs just before the buzz section, and the other 10 occur within the buzz section.

Each of the thirteen events is plainly audible during normal playback of the tape. Each event shows one or more characteristic magnetic marks. Each event also shows up in the form of characteristic patterns in the waveforms obtained from the tape.

Locating Events on the Tape

The very first tests we made on the Evidence Tape were listening tests. We listened carefully many times to a seventy minute section of this tape, which included the buzz section. Our major objective was to locate unusual sounds that might provide clues to the authenticity or integrity of the Evidence Tape.

When the buzz section of the Evidence Tape and the five seconds preceding it are played under normal conditions through good listening devices, the listener hears a short section of speech followed immediately by a loud buzz. The buzz lasts 18.5 minutes and is interrupted from time to time by a variety of noticeable clicking sounds. The characteristics of these clicking sounds are somewhat varied. In addition, they are sometimes accompanied by momentary changes in the level of

of the buzz. Some of the sounds, although plainly audible, seem more like thumps than clicks.

When all the significant clicks and other sounds had been located on the tape, we developed the corresponding portions of the tape to produce magnetic marks as described in Technical Note 1. Then we categorized the marks, singly or in groups, according to their appearance. We labelled the marks as events and, finally, located each event more precisely as to its time of occurence after the start of the buzz section.

Identification of Events by Analysis of Magnetic Marks and Waveforms

As we have mentioned in Technical Note 1, both the magnetic marks and the waveforms provide essential data. Neither kind of test result by itself can yield a full and accurate explanation of the events on the tape. Now we explain in more detail why both approaches are needed.

Figure 3 shows a photograph of the magnetic marks actually appearing on the Evidence Tape at the point where the buzzing section ends and the speech resumes. We can tell quite a bit from these magnetic marks about the nature of this event. First we see on the left a magnetic track composed of what appears to be regularly spaced marks similar to those left by a caterpillar tractor and terminated in what appears to be a single line. On the right we see a track of more irregular character bounded on its left by a complex of lines. In between there is a section of completely blank tape.

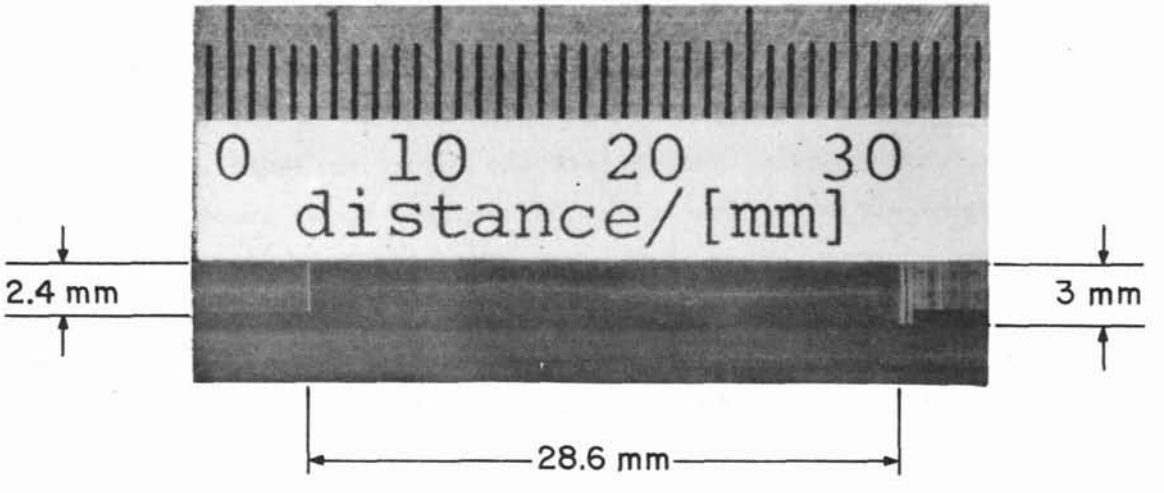


Figure 3. Magnetic marks in standard format.

The magnetic marks on the right in Figure 3 strongly suggest that the set of four 3-millimeter wide lines, or quartet, was made by de-energizing the erase head at the moment when the buzz section was terminated. We arrive at this statement by seeing the quartet located at the end of the buzz section, and by noting the obvious similarity between the quartet and the marks produced by tests involving known machines operated in prescribed modes (see specifically Figure 2 and Section 2 of Technical Note 1). The single strong line on the left of Figure 3, being 28.6 millimeters from the quartet and only 2.4 millimeters wide, would then be a record-head-off mark, which results from the simultaneous de-energization of the record head.

However, the magnetic mark photographs do not provide enough analytical detail to permit detailed examination of this tape. For a better understanding of this statement, let us re-examine Figure 1. This figure shows a photograph of the waveform produced by the segment of tape illustrated in Figure 3. The large sharp pulse at the left in Figure 1 corresponds to the single strong magnetic mark shown at the left in Figure 3. The complex of large pulses near the right of Figure 1 are the waveform representation of quartet marks seen on the right of Figure 3. The separation in time between the record-head-off pulse and the quartet pulses is 1.2 seconds, which is the playing time, at 23.8 millimeters per second. of a tape segment 28.6 millimeters long. The relationship of the magnetic marks in the event shown by Figure 3 is accurately preserved in Figure 1.

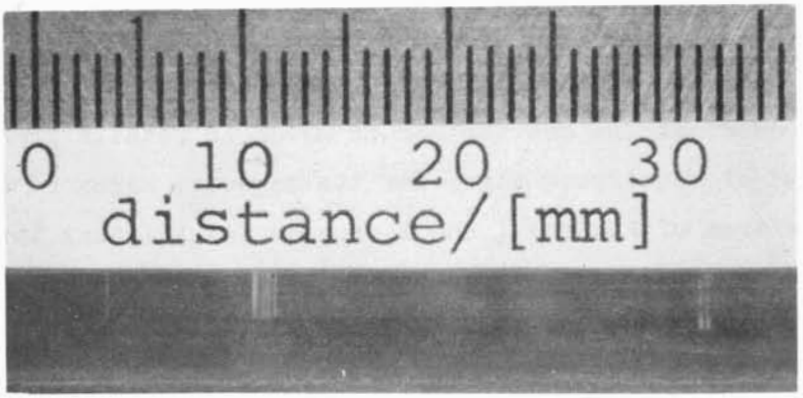
Figure 2, which shows the waveform of Figure 1 expanded by a factor of 4 in the time scale, clearly reveals many minute details only weakly suggested in Figure 1 and not observable at all in Figure 3. For example, in Figure 2a we see the very small detailed wiggles on the regular buzz waveform pattern appearing just before the record-head-off pulse. Indeed the record-head-off pulse itself can be observed to be a complex of many fast wiggles, at least three of which can be plainly observed. The quartet nature of the erase-head-off-pulses are plainly visible in Figure 2b. Immediately following it are the irregular patterns of a speech waveform, which should be compared with the buzz waveform on the left.

By repeated examination and visual correlation of Figures 1, 2, and 3 the reader can see how the minute waveform details in Figure 2 serve as a kind of magnifying glass for the magnetic marks of Figure 3. However, the waveforms of Figures 1 and 2 provide insufficient information for reliable separation of pulses that are record-head related from those that are erase-head related. Specifically, the waveforms depicted in Figures 1 and 2 cannot possibly depict the widths of the marks shown in Figure 3, which positively distinguish between record-head and erase-head activity. (See Pages 1.2 and 1.3 in Technical Note 1.)
Pages 1.2 and 1.3 in Technical Note 1.)

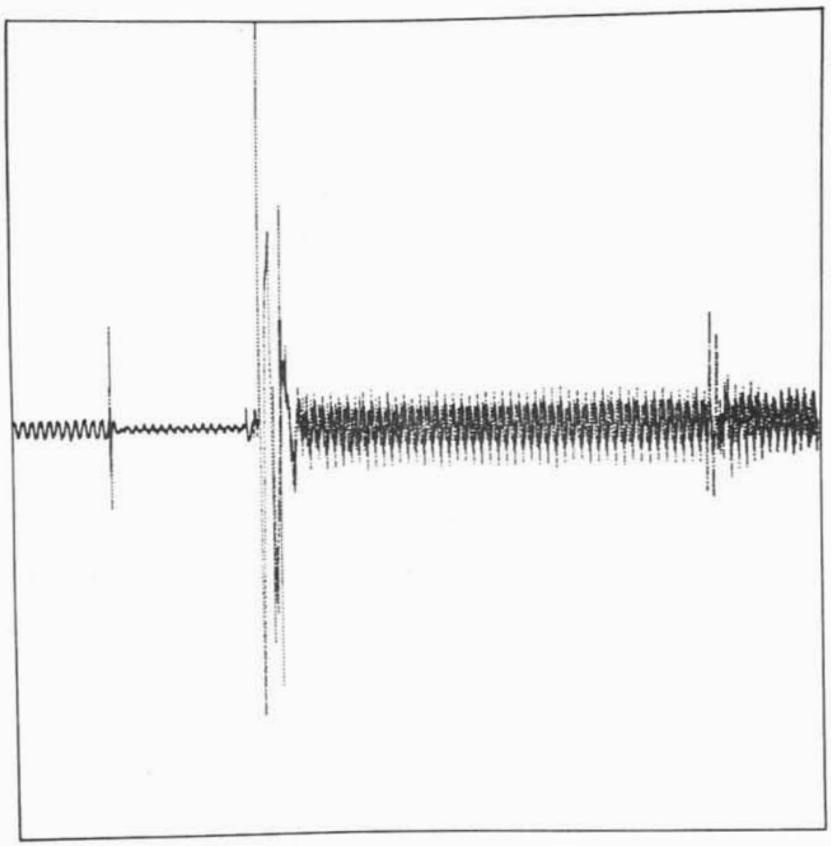
We turn now to a detailed example of the use of magnetic marks and waveforms to elucidate an event on the tape. Figure 4 shows a set of magnetic marks appearing at about 48 seconds into the buzz section of the Evidence Tape. We can see in Figure 4a magnetic patterns similar to those in Figure 3. There is on the left a single line 2.4 millimeters wide and on the right, although somewhat obscured, a group of four lines 3 millimeters wide. In Figure 4a, somewhat to the left of the center is a much broader line 2.4 millimeters wide, different in nature from anything else we see in Figure 3.

Because of its distinctive character, the quartet on the right can immediately be identified as an erase head de-energization mark. The width of the lines is three millimeters, as noted earlier. The 3 millimeter width of the quartet removes all doubt as to the source of this group of four lines. It must be an erase-head mark and specifically an erase-head-off mark. Knowing this and looking 28.6 millimeters to the left, as measured on the scale in the photograph, we see that the single line visible there is a record-head-off mark associated with the erase-head-off mark just mentioned. The similarity with Figure 3 is pretty convincing. But how can we be sure?

In Figure 4b we have the waveform produced by this event. On the left we have the brief complex characteristic of the record-head-off pulse which we identified in Figures 1 and 2a.



4a. Magnetic marks



4b. Waveforms

Figure 4. Magnetic marks and waveforms associated with event B_2.

On the right are the four pulses characteristic of the quartet pulses seen in Figures 1 and 2a, and having the same relative polarity. The separation in time between the pulses of the event shown is the same as in Figure 1. Now we are sure that the mark on the left edge of Figure 4 is a record-head-off mark.

But what of the mark in the middle of Figure 4a? Its waveform can be seen in Figure 4b. Now this is something very different. In order to identify it, we again made comparisons with photographs of test marks and test waveforms (see especially Figure 3 in Technical Note 1 and Figures 4 and 12 in Technical Note 3). The final conclusion was that this mark is a record-head-on mark.

We performed analyses similar to these for all the major events involved in the 18.5 minutes of buzz. We compared and correlated all the available information. We made simulation tapes under known conditions, using the evidence machine and other Uher recorders. In all cases, questionable information was subjected to confirming tests until we removed or reduced the questionable factors insofar as possible.

Compilation of Data and Interpretations Concerning the Events on the Tape

This Technical Note concludes with a compilation of information on the events as derived from a comparative study of magnetic marks and waveforms. Each of the 13 events is described by a figure that illustrates both kinds of tests, accompanied by explanatory text.

In the figures, the developed picture of magnetic marks is associated with a millimeter scale that was photographed at the same time as the tape. This direct association of the scale ensures accuracy of measurements made between marks of interest on the tape, and also allows for unintentional variations in the magnification factor, which nominally was 2.8-to-1. We attempted to reproduce the waveforms and magnetic marks at the same scale. In the actual reproductions printed here, the waveforms turn out to be about one percent longer than the magnetic marks.

The figures that follow appear in the order in which the events occur on the Evidence Tape. To guide the reader, we tabulate the figure numbers and event codes, and indicate the figures that illustrate the corresponding events in Technical Note 3.

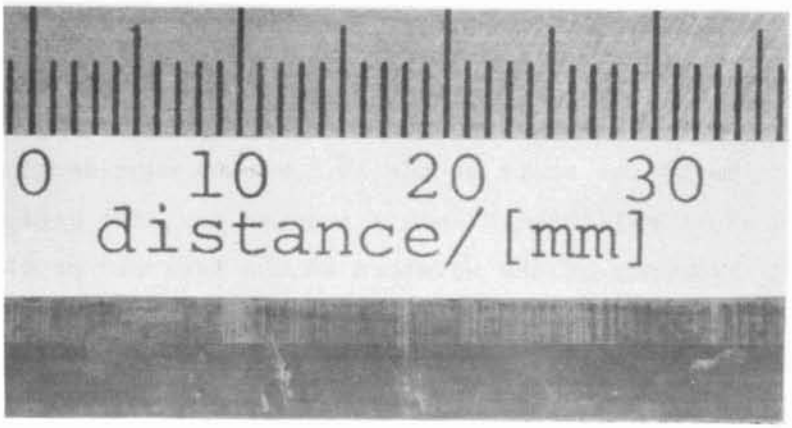
Figure Number	Event Code	Event Time	Corresponding Figure in TN 3
5	A_1	-3	9
6	A_2	0	10
7	B_1	46	11
8	B_2	49	12
9	D	155	13
10	E	275	14
11	F'	612	15
12	G	684	16
13	C_1	1041	17
14	C_2	1042	18
15	H_a	1061	19
16	H_b	1065	20
17	F	1109	21

The Panel did not discover and identify the events in the same order as they appear on the tape. Rather, we worked back and forth, starting with the simpler and more obvious data and gradually unfolding the meaning of the more subtle indications. The reader can recapture some of the discovery experience by studying the events in the following order: A_2, F, B_2, C_1, C_2, D, H_a, H_b, F', G, A_1, E, and finally, B_1.

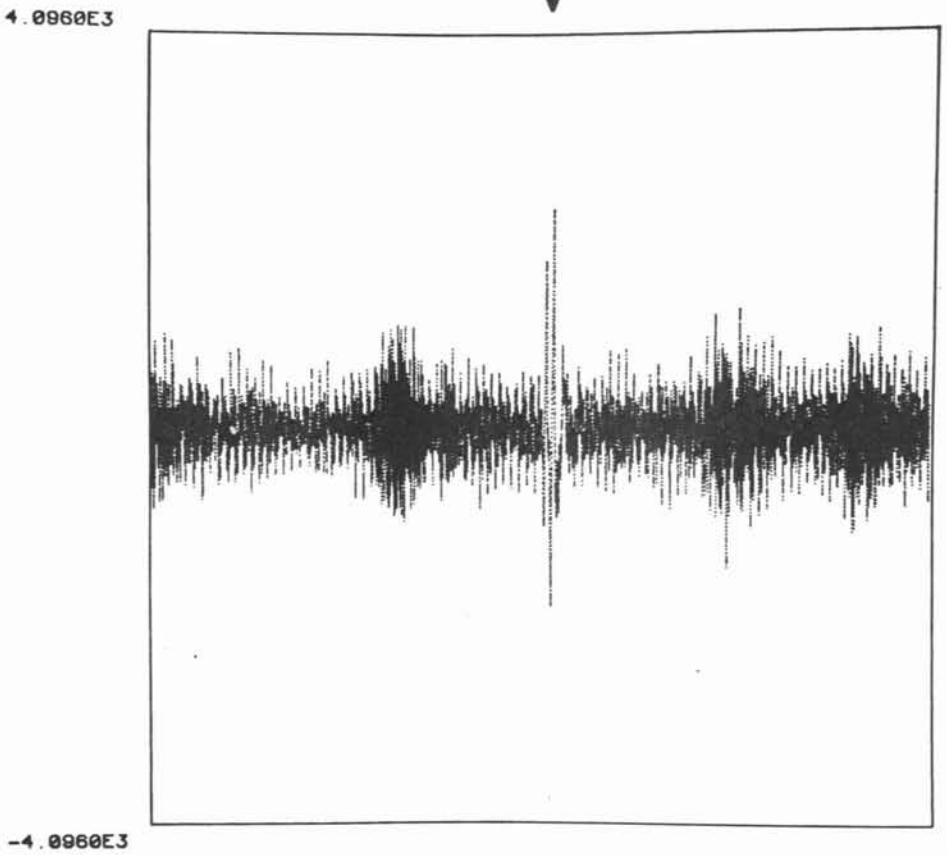
The descriptions of the 13 major events
on the EOB Tape of June 20, 1972
commence on the next page.

Figure 5

Event A_1. This section of tape occurs shortly before the buzz section. Notice the quadruple mark which is three millimeters wide. This is a Uher erase-head-off mark. Its occurrence here is rather surprising. The record-erase electronics must have been energized and then de-energized without any tape motion in the interim. Notice that the magnetic sound track is 2.4 millimeters wide. These magnetic marks are quite typical of speech recorded on a half track of quarter inch tape. (The 2.4 millimeter dimension corresponds to the nominal width of the gap in the record head.)



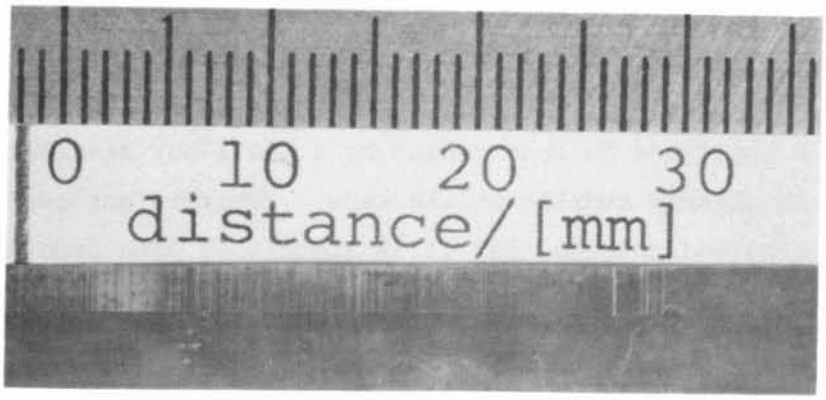
2.92 seconds before start of buzz



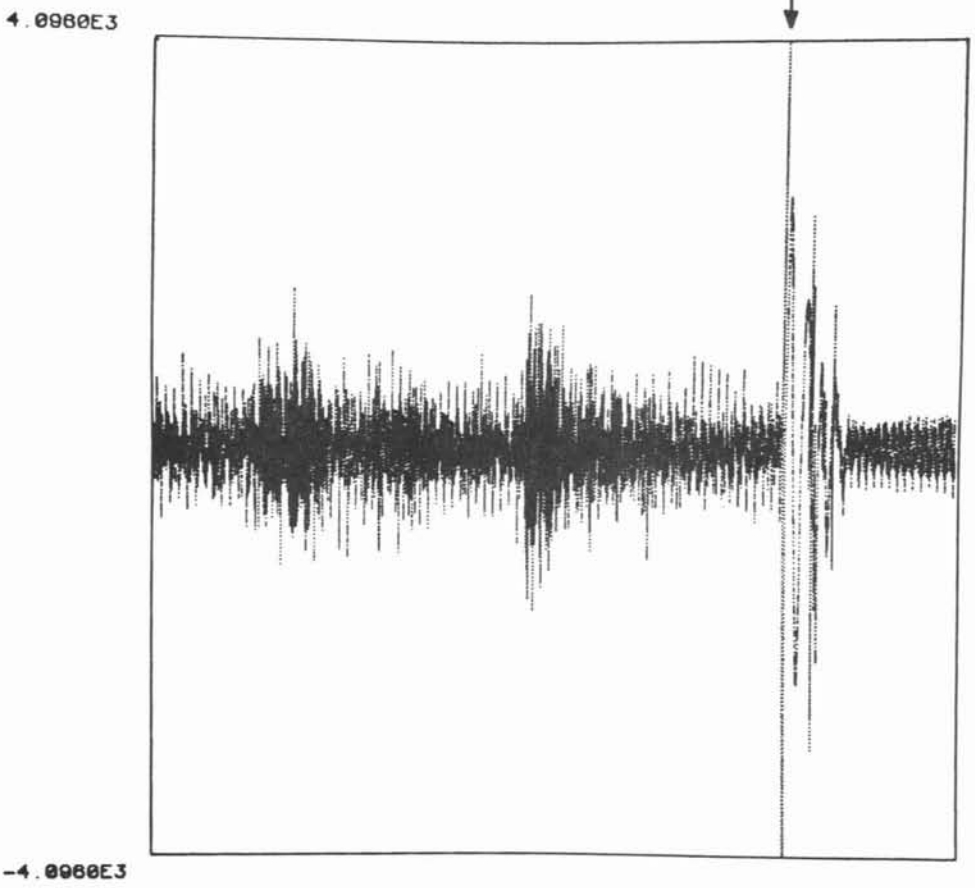
ENLARGEMENT OF RECORD 4-6

Figure 6

Event A_2. The first 29 millimeters of the track in the photograph shows a normal recording of speech. A complex of magnetic marks, about 3 millimeters long, marks the start of the 18.5 minute buzz section. The last six or eight millimeters show a regular periodic pattern of magnetic marks. The frequency of the waveform in the last six or eight millimeters is 60 Hz corresponding to the power line frequency. The complex of magnetic marks and the corresonding waveform pulses that are located at the transition between the speech and the buzz section clearly identify this as a record-head-on event. These record-head-on marks and pulses are typical of the Uher 5000 machine when recording without input and the RECORDING LEVEL is at maximum. In general, record-head-on pulses are 80 to 100 milliseconds in duration but are variable in the detail of their characteristics.



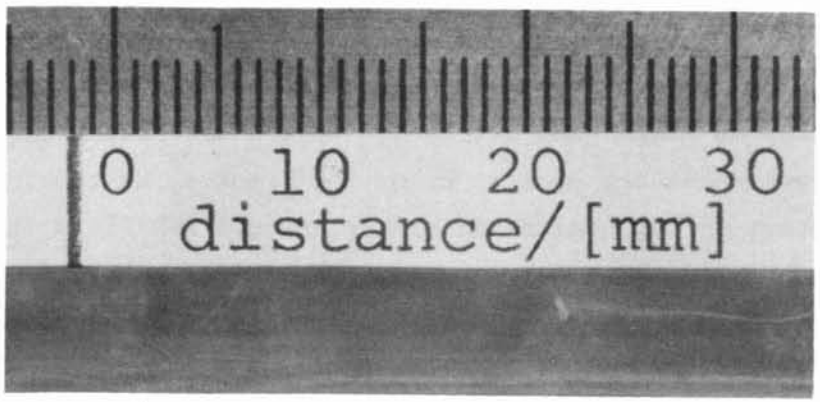
start of buzz: 0.00 seconds



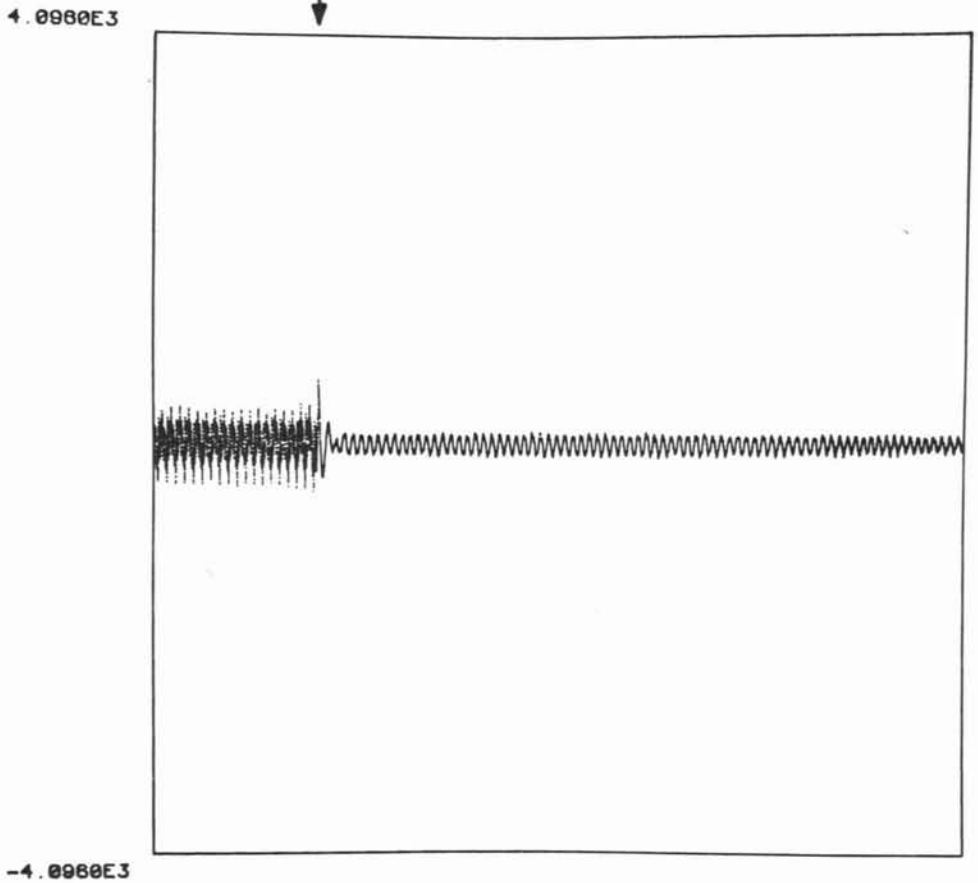
ENLARGEMENT OF RECORD 7-9

Figure 7

Event B_1. At this point on the tape, 46.36 seconds after the beginning of the buzz section, the amplitude of the buzz drops markedly. This drop in amplitude is accompanied by a small but distinct pulse. This event is clearly audible on the tape. However, our tests on this event uncover no indications that it is associated with record head start or stop activities in the way that other major events on this 18.5 minute section are.



46.36
time in seconds after start of buzz

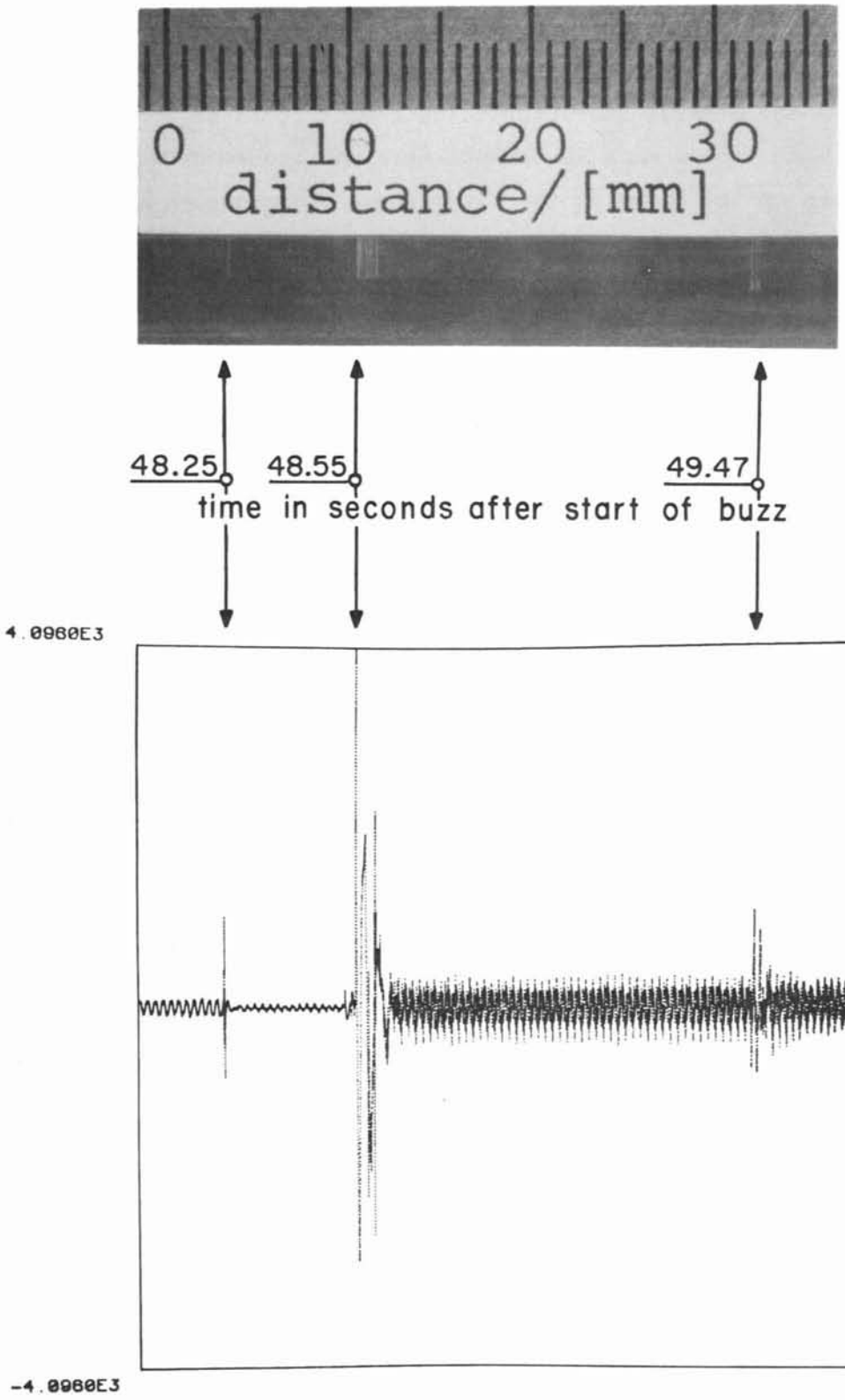


ENLARGEMENT OF RECORD 65-7

Figure 8

Event B_2. The event shown in this figure contains three major magnetic marks. The characteristic 3 millimeter quartet near the right hand edge is clearly an erase-head-off mark. Notice the rather clear 0.5 millimeter section of the quartet below the track. The remaining upper 2.4 millimeters of the quartet is rather smudged and indistinct but nonetheless clearly identifiable. In the Uher 5000 recorder, the separation between the record-head gap and the erase-head gap is 28.6 millimeters. We use this dimension to identify the fine 2.4 millimeter line nearest the left hand side of the photograph as a record-head-off mark associated with the erase-head-off mark just described. Having identified this fine line on the left as a record-head-off mark through this geometric argument, we turn our attention to the waveform. We see that in this case a record-head-off waveform is extremely brief and "bipolar." Compare this with Event F where the identification problem is greatly eased by the fact that the marks there correspond to the termination of the 18.5 minute buzz section.

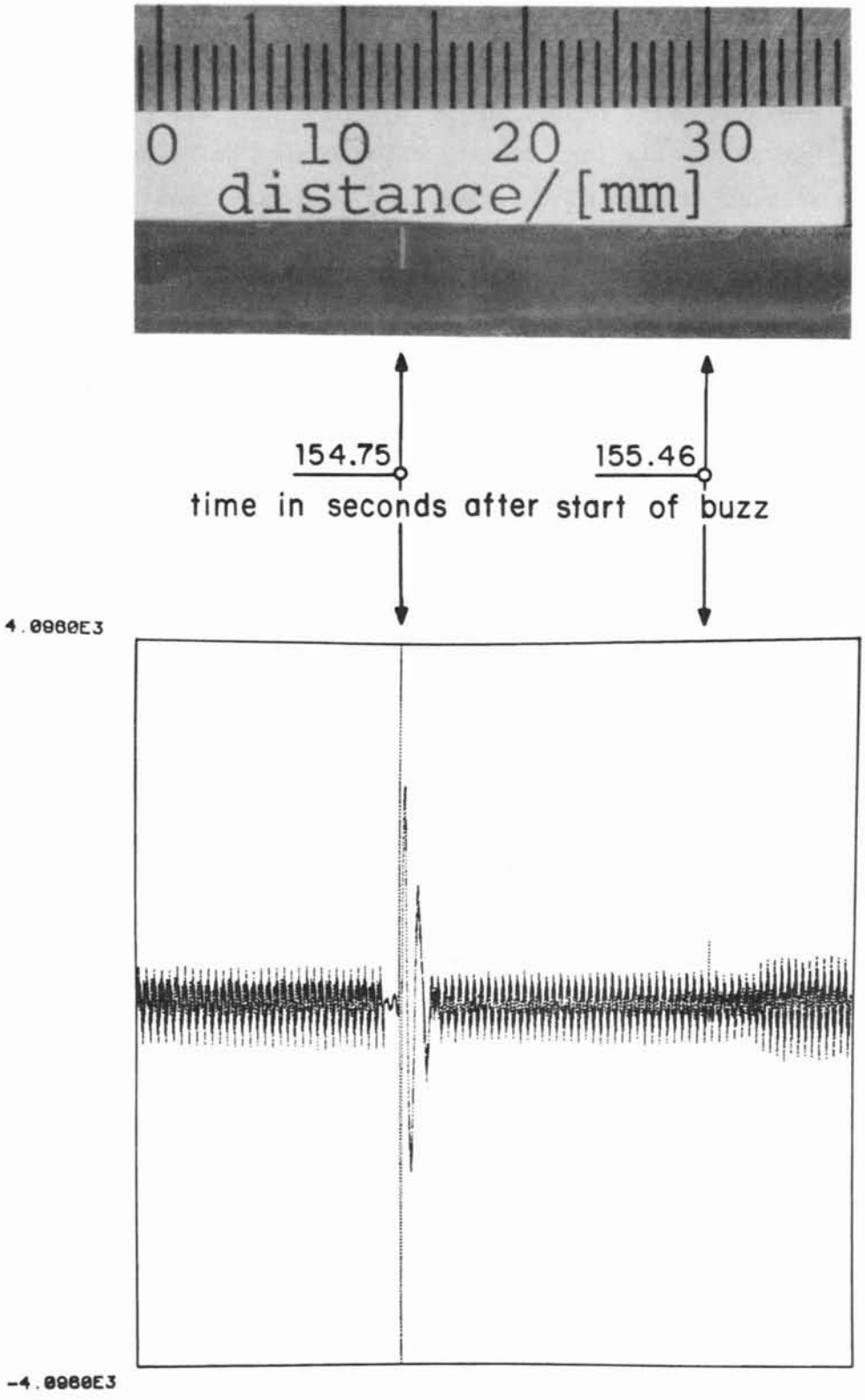
The middle mark in the photograph is clearly identified as a record-head event by its 2.4 millimeter tape width dimension. Since the other two magnetic marks have been associated with a tape recorder stopping action and since the buzz section does not terminate here, we are led to the logical conclusion that this mark is a record-head-on mark. Comparison of the middle pulse in the waveform with the pulse in Event A_2 reinforces this assumption, as does the fact that loud buzz resumes immediately after it. In addition, the 2.4 millimeter smudged portion of the quartet on the right strongly implies that the waveform beginning at the middle mark was recorded on top of, and therefore after, the erase-head-off mark. These three marks constitute a type 3 recording overlay.



ENLARGEMENT OF RECORD 67-9

Figure 9

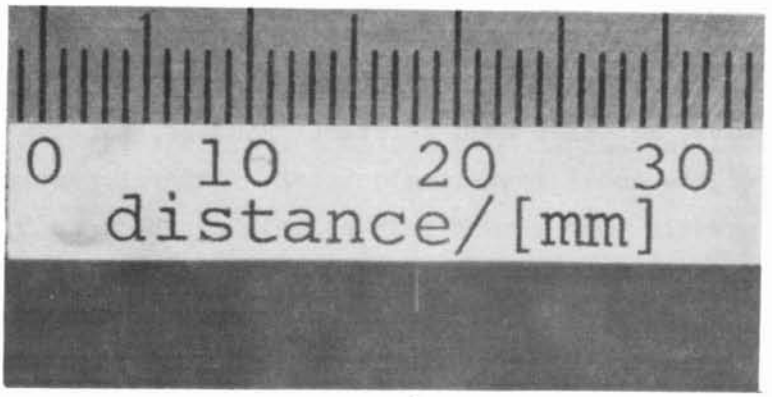
Event D. This picture shows two magnetic marks. The first one is very obvious and appears slightly left of center. Its width of 2.4 millimeters and its general characteristics reveal it to be a record-head-on mark. The second mark is much fainter and occurs approximately 17 millimeters to the right of the first one. Its presence is seen in the waveform diagram as a very narrow-sharp pulse. We suspect that this pulse is a K1 pulse which is described fully in Technical Note 8. This event is a type 1 recording overlay.



ENLARGEMENT OF RECORD 197-9

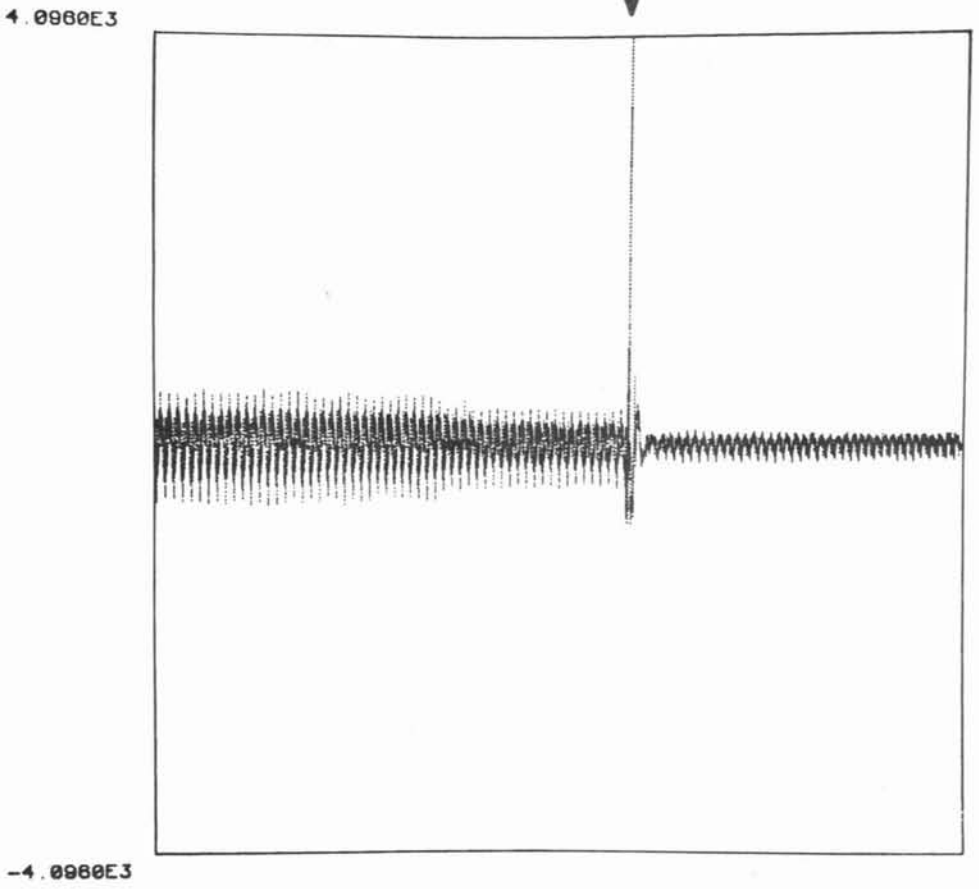
Figure 10

Event E. The magnetic mark seen in this figure is almost certainly not associated with any record head stopping or starting characteristics. We do not know its exact cause, but we conclude that its presence does not alter our interpretation of other major events as being related to start and stop activities of the recorder. See also Event B_1.



275.33

time in seconds after start of buzz



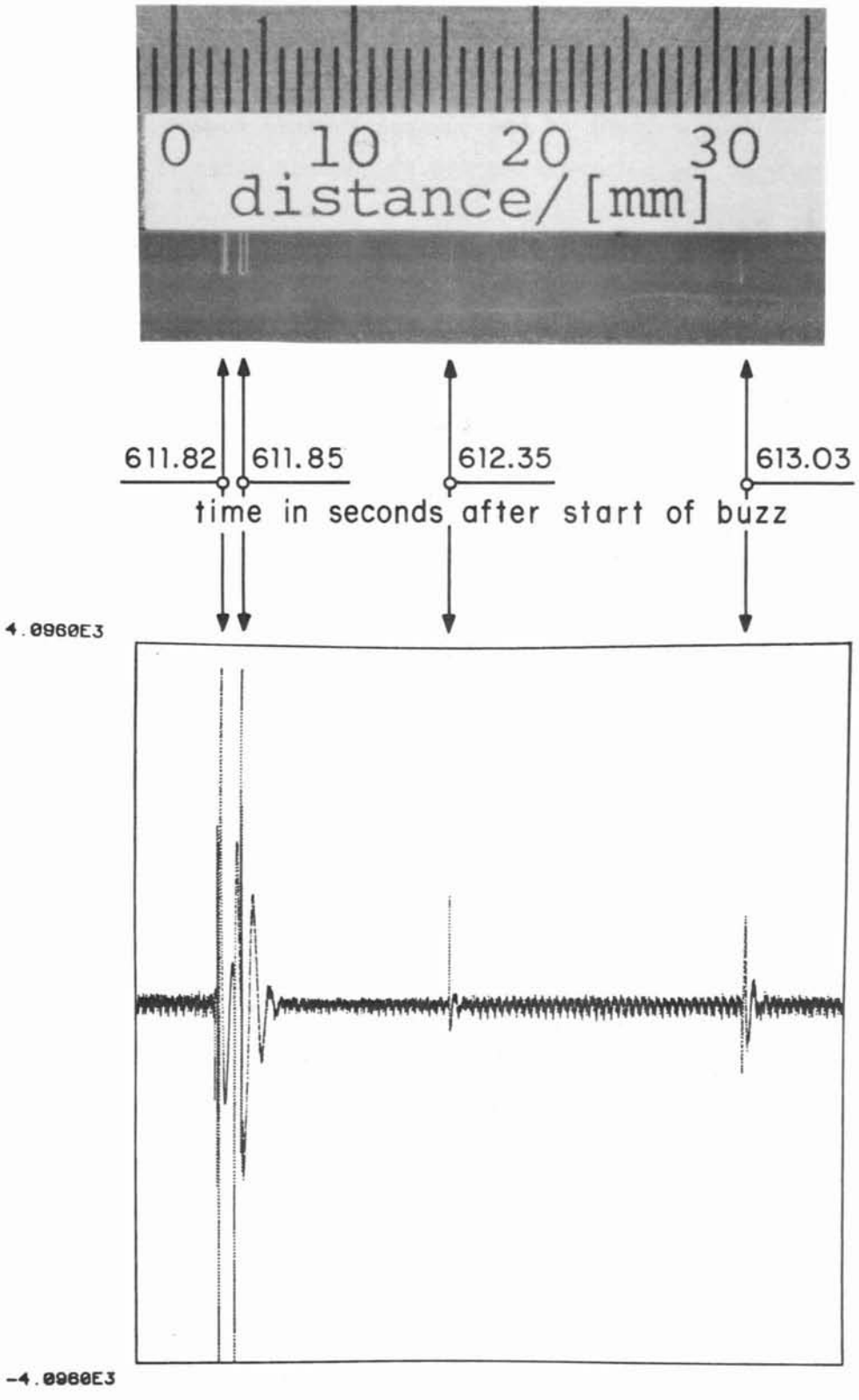
ENLARGEMENT OF RECORD 344-5

Figure 11

Event F'. This figure shows four major magnetic marks. Let us consider the one farthest to the right first. Its 3 millimeter width clearly identifies it as erase head related. However, here we see only one line instead of the usual four-line quartet. Careful testing of the UHER 5000 machine reveals that a mark such as this can be made by first producing a quartet and later partially erasing it by a reactivation of the erase head, after a small tape displacement in the direction of tape motion. Having identified this mark as an erase-head-off mark, we are led to look 28.6 millimeters to its left for the corresponding record-head-off mark. We find this to be the left-most magnetic mark on the photograph. Compare the general nature of the corresponding waveform pulse with the left most pulse in Event C_2. Both of these pulses are identified as record-head-off pulses.

The mark occurring about one millimeter to the right of the left-most mark in this figure must also be a record head mark by virtue of its 2.4 millimeter width. This mark is identified as a record-head-on mark by the smudged nature of the erase-head mark on the far right of the photograph. Further indication comes from the 100 millisecond duration of the corresponding pulse which is quite characteristic of a record-head-on waveform and should be compared with the others so categorized in this collection. The waveform of the second mark from the left in Event G is very similar. Notice that the record-head-on mark in Event F' and that shown in Event G are the only two associated with the soft buzz section. This observation suggests the possibility that high but not maximum record gain was probably in effect when they were created.

The final mark in this figure occurs slightly left of center. It is the 2.4 millimeter type and is quite weak in the photograph but clearly visible in the waveform diagram. This mark is not unlike two others present in the 18.5 minute buzz section, one of which is the second shown in Event H_b. As described in Technical Note 8, these marks are produced by the operation of switch K1 of the Uher 5000 machine. This switch can only be operated mechanically by pressing keys on the recorder's keyboard.



ENLARGEMENT OF RECORD 6-7

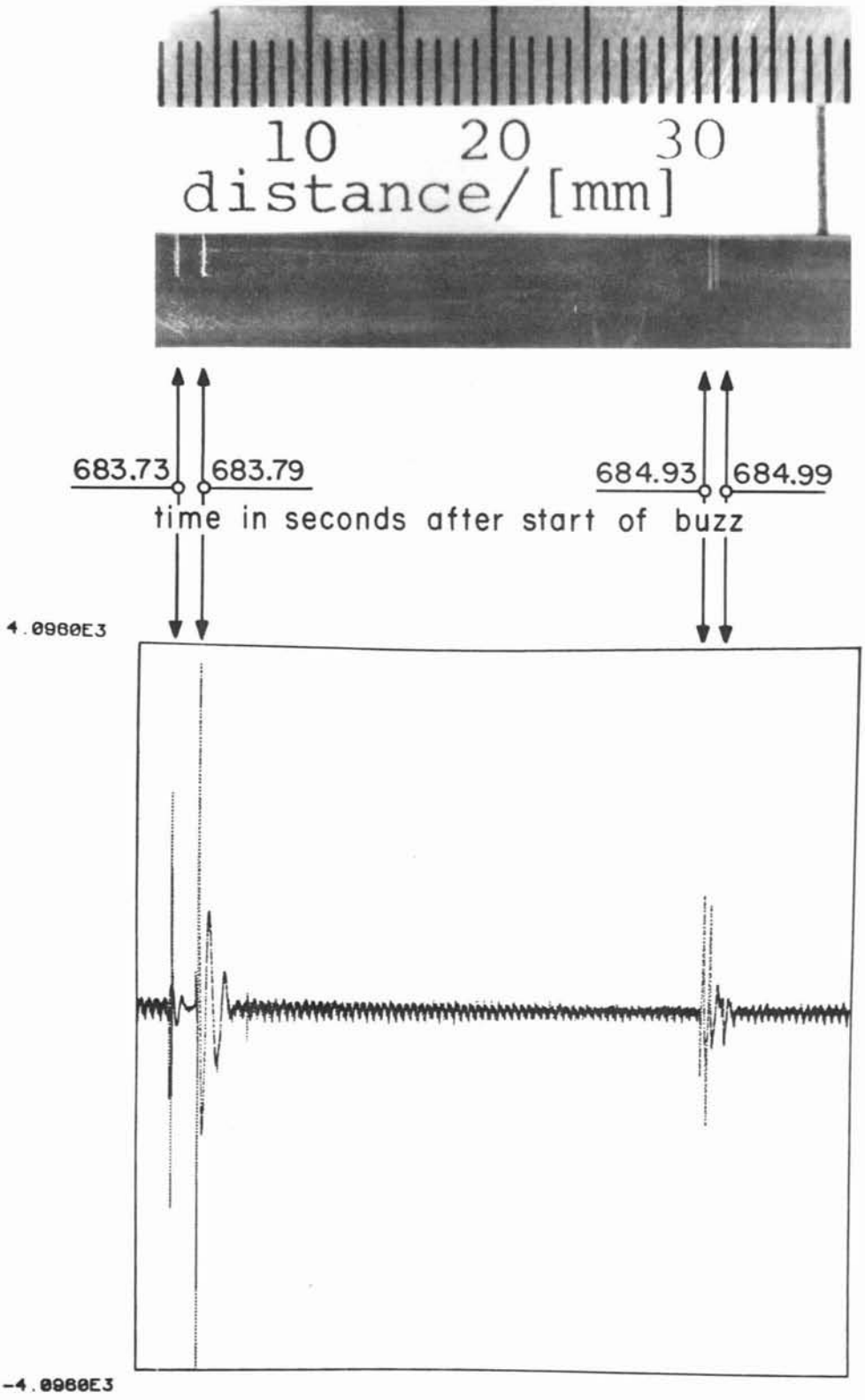
Figure 12

Event G. First inspection reveals three magnetic marks in this picture. There is a fourth however. Upon close inspection it can be seen about one millimeter to the right of the quartet located towards the right of the picture at the point marked 684.99 seconds after the start of buzz.

The clearest mark to be seen here is the quartet occurring near the right hand side of the picture. Its three millimeter width and its quadruple nature clearly classify it as an erase-head-off mark. Looking 28.6 millimeters to the left we find the left-most mark in the photograph to be the associated record-head-off mark. The 2.4 millimeter width of this mark confirms this conclusion. In addition, the brief and bipolar nature of this pulse put it clearly in the same category as the left-most pulse in Event B_2. Compare it also with the left-most pulse in Event F.

The obvious similarities between this event and Event F' lead us to identify the 2.4 millimeter wide mark occurring approximately 2 millimeters to the right of the just identified record-head-off mark to be a record-head-on mark. The second mark in Event F' is similar.

We turn our attention again to the faint 3 millimeter mark at 634.99 seconds. We notice that it is exactly 28.6 millimeters to the right of the record-head-on mark just discussed. Extensive testing has shown, however, that erase-head-on marks cannot be produced. Since this faint single three millimeter type pulse must be erase head related, we must conclude that it is a partially erased, erase-head-off mark. The implication is that after the UHER 5000 recorder had first been stopped at this point on the tape, it was subsequently put in and taken out of the recording mode without any tape motion in the interim. Finally, recording was resume again, this time with tape motion.

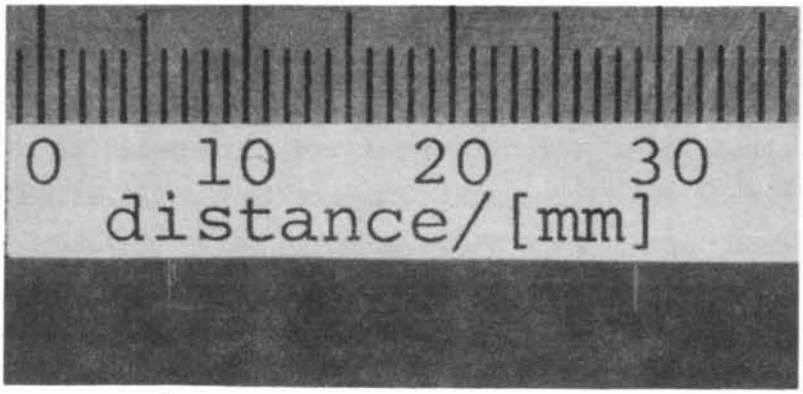


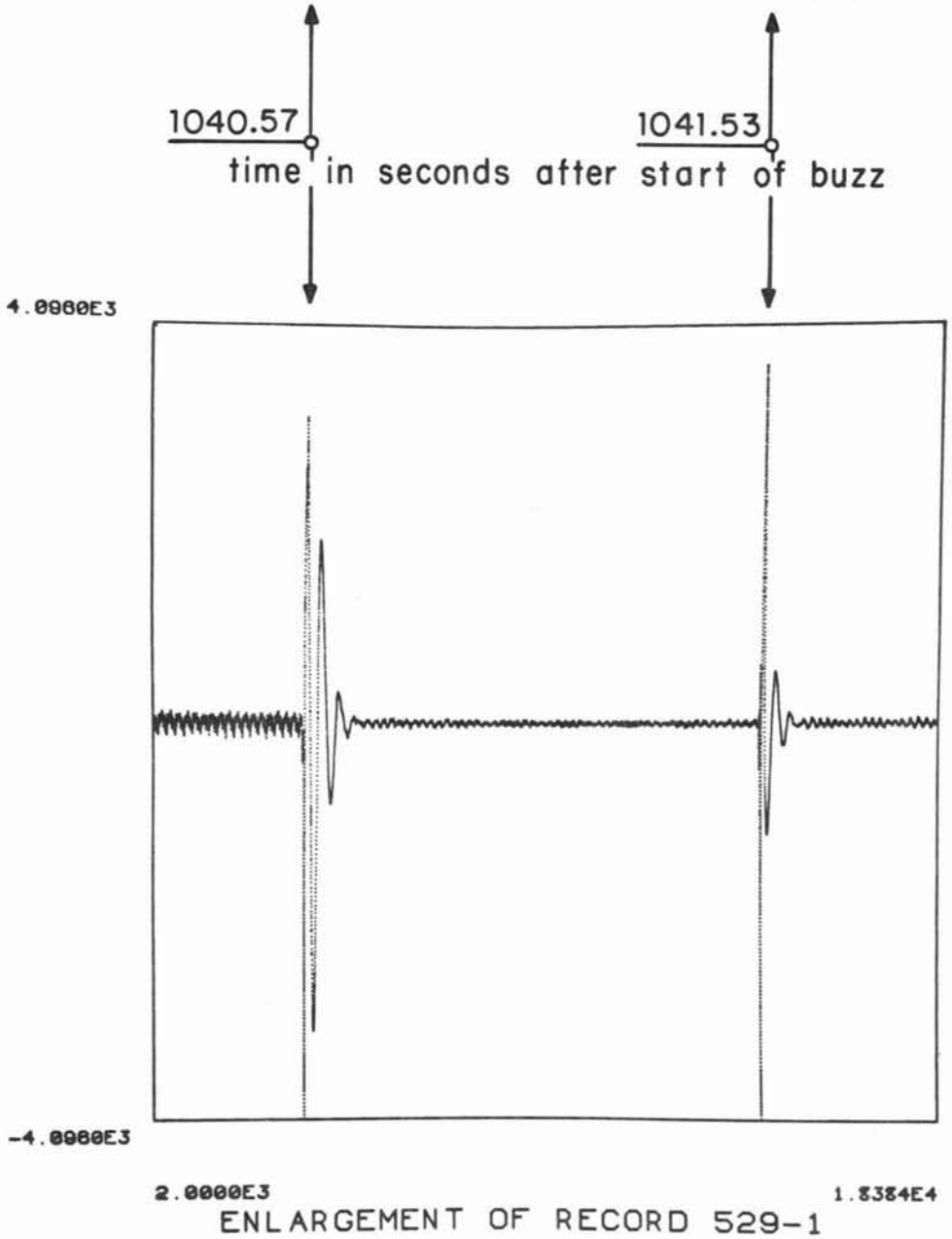
ENLARGEMENT OF RECORD 93-5

Figure 13

Event C_1. The magnetic mark on the far left of this picture is 2.4 millimeters wide. This identifies it as a record head mark. Comparison with similar marks shown in Event F' and its relationship to the other mark in this figure, i.e., the distance between the marks being 23 millimeters and not 28.6 millimeters, indicate that it is a record-head-on. The waveform analysis reveals that the pulse corresponding to the left-most mark has a duration of 100 milliseconds. This also confirms the identification as a record-head-on mark.

The magnetic mark on the right appears also as the left-most mark in Event C_2 and is discussed fully there.





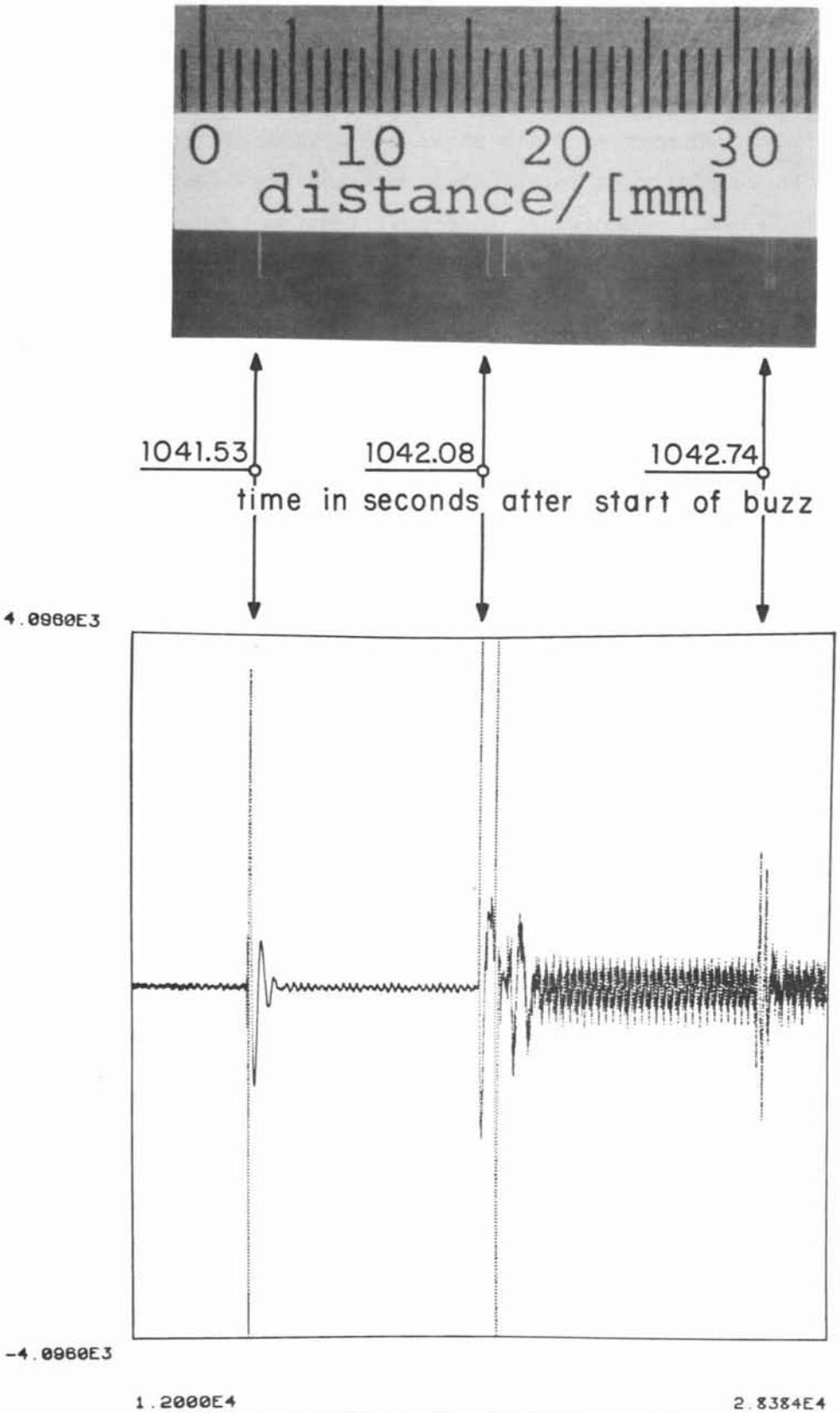
ENLARGEMENT OF RECORD 529-1

Figure 14

Event C_2. This figure shows three magnetic marks. The first and left-most mark was also shown in Event C_1. The second (which seems double) is located near the middle of the picture. The third is located at the far right of the photograph. Compare this event with Event B_2. As we have already seen, the easiest magnetic mark to identify is the erase-head-off mark. The mark at the extreme right of Event C_2 is clearly of this type. Its uppermost 2.4 millimeters appear smudged as in the case of the similar mark in Event B_2.

Looking 28.6 millimeters to the left of the quartet, we come to the left-hand-most mark. This distance and the 2.4 millimeter width clearly identify it as a record-head-off mark. Comparison with the left-hand-most marks in Event B_2, Event G and Event F reveals that while this pulse is bipolar it does not possess the same extremely brief nature as the others. In this respect, it is far more like the left-hand-most mark in Event F'. The stretched out nature of this record-head-off mark is explained by the fact that although the recording electronics was de-energized at the moment that the record head passed this point on the tape, tape motion did not cease as is the case when a recording is terminated by the STOP key. A stop such as this is called a "running stop" and can be easily produced. One method is simply to push the START key during a recording. Another is to release the RECORDING key a little too early just as a recording is started by the simultaneous depression of the RECORDING and START keys.

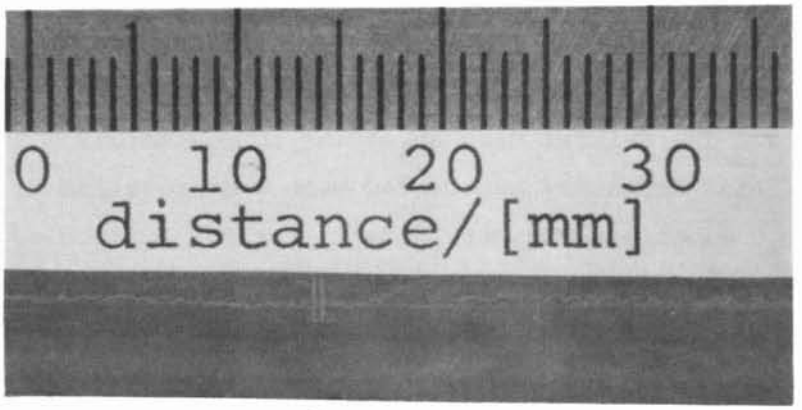
The pair of marks in the approximate middle of the picture is actually a single record-head-on mark. The record head affiliation is easily established by its 2.4 millimeter width. Further confirmation is obtained through the waveform diagram in comparison with the record-head-on waveforms found in Events A_2, B_2, D, H_a and H_b. Again the 100 millisecond duration of the waveform supports the identification. In addition, it should be noticed that this mark is immediately followed by the onset of loud buzz. The similarity to Event B_2 is quite striking. Again the smudged quartet indicates that the recording started at this point must have been made after this erase-head-off mark was produced.



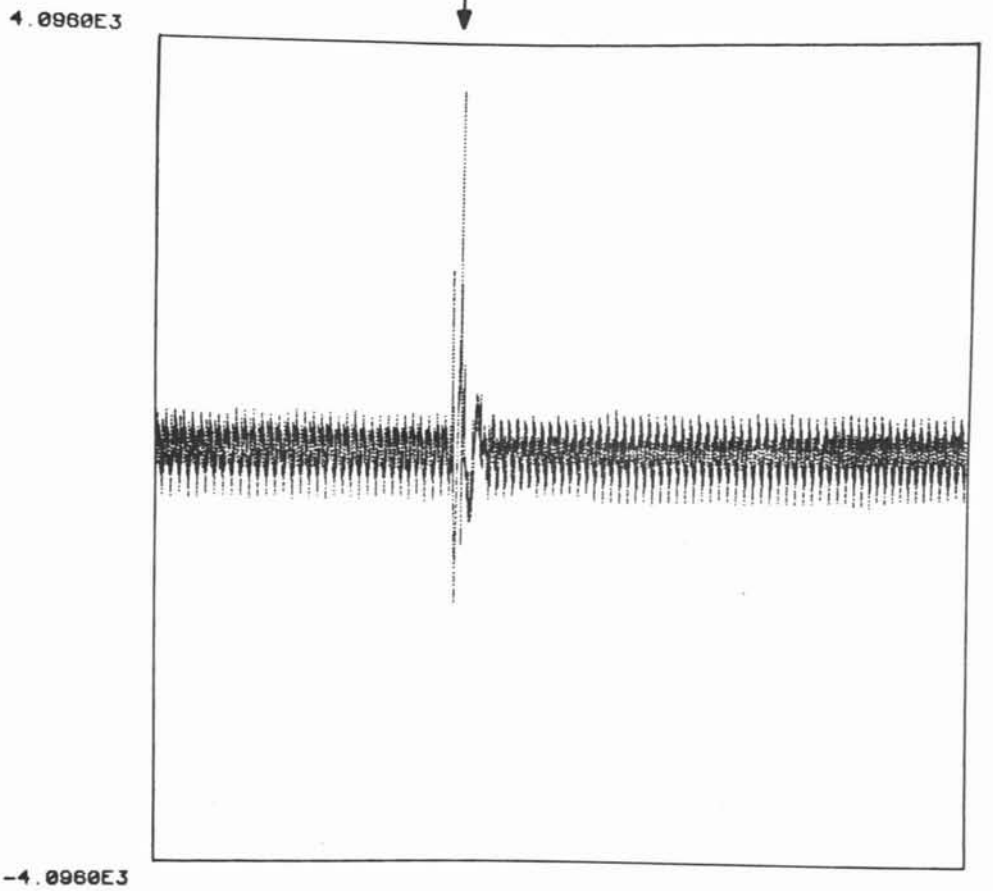
ENLARGEMENT OF RECORD 530-2

Figure 15

Event H_a. The single magnetic mark appearing in this picture occurs slightly left of center. Its 2.4 millimeter width affiliates it with the record head. Comparison with marks and waveforms obtained during tests with known equipment reveal this mark and its waveform to be a record-head-on mark. Concerning underbuzz and the type of overlay see Event D and discussions in Technical Note No. 3 about this particular event.



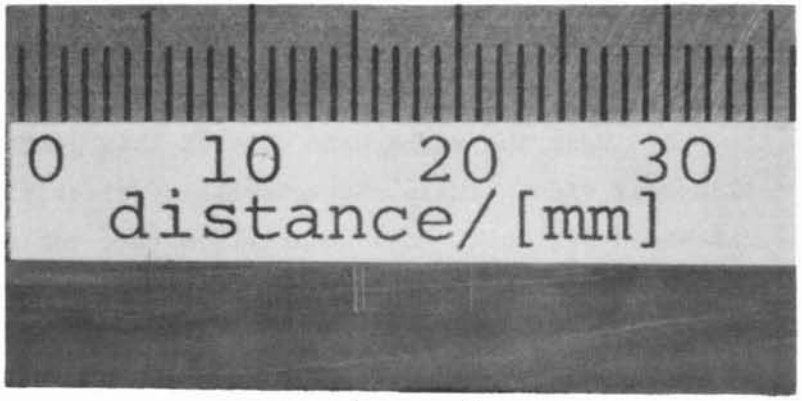
1061.39
time in seconds after start of buzz



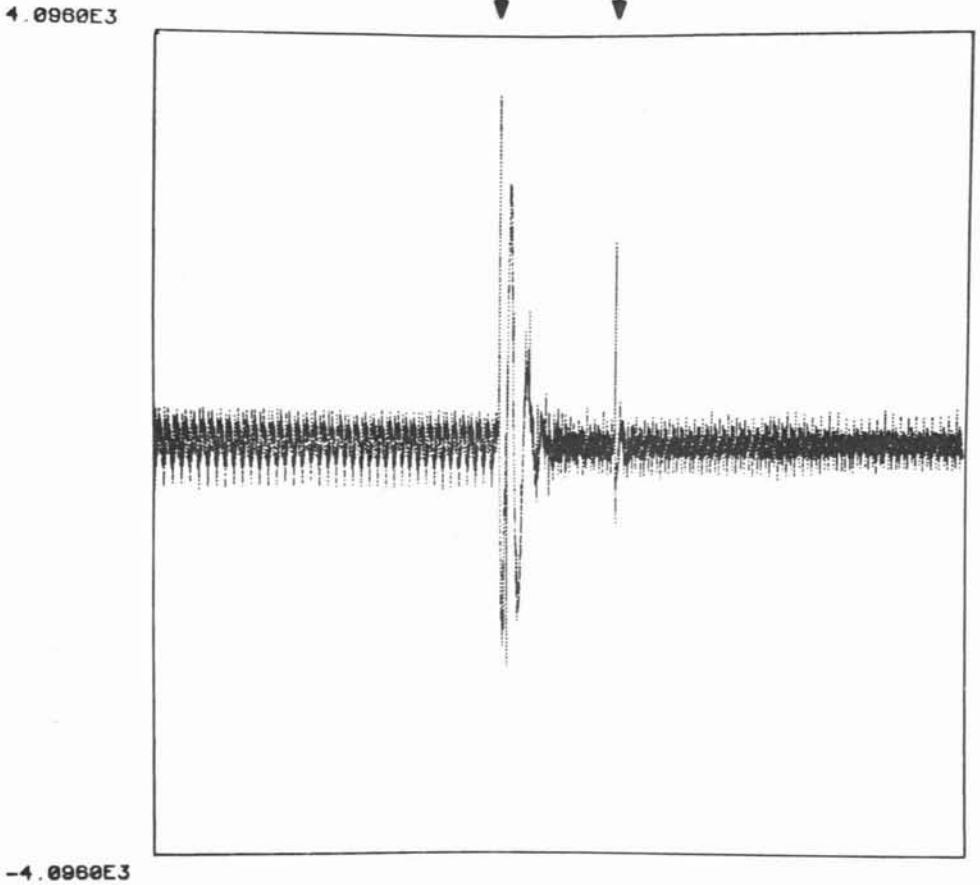
ENLARGEMENT OF RECORD 554-6

Figure 16

Event H_b. The situation here is very similar to that in Event H_a. The major mark occurring almost in the center of the photograph is a record-head-on mark. The fainter mark appearing approximately 6 millimeters later, is almost certainly associated with the operation of switch K1 of the UHER 5000 machine. For more detail, see the caption of Event F'.



1064.93 1065.17
time in seconds after start of buzz

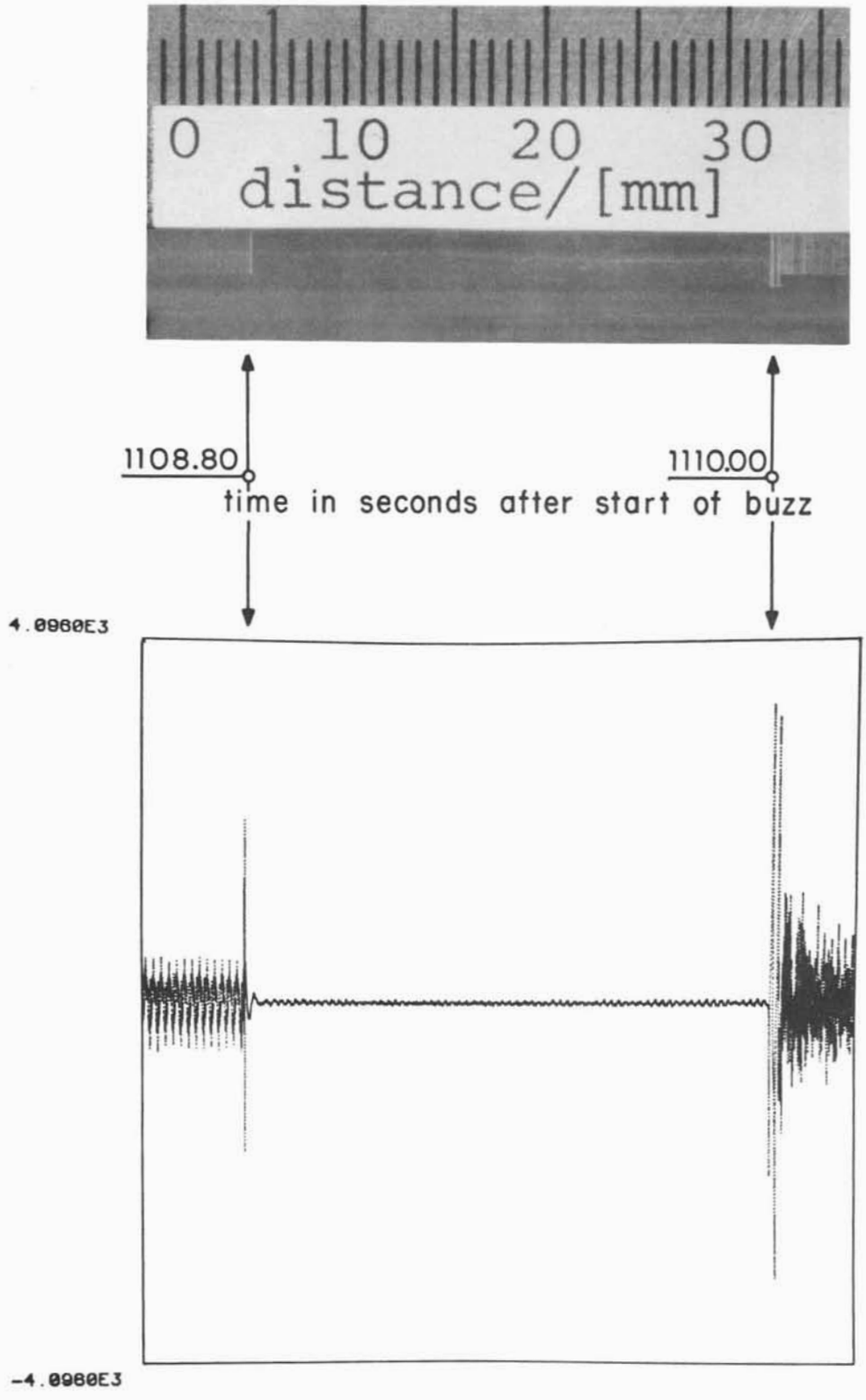


ENLARGEMENT OF RECORD 558-0

Figure 17

Event F. The marks in this figure correspond to the very end of the 18.5 minute buzz section. In this respect, Event A_2 is the beginning and Event F is the end. Near the right hand edge of this picture we see a quartet 3 millimeters wide. These characteristics clearly identify this mark as an erase-head-off mark. Its quadruple nature can also clearly be seen in the waveform. As can easily be determined through mechanical measurement, the record head and erase head of UHER 5000 recorders are separated by approximately 28.5 millimeters and for the Exhibit 60 UHER by exactly 28.6 millimeters. If we look this distance to the left of the quartet just described, we find the single mark near the left of the figure whose width is 2.4 millimeters. 2.4 millimeters is the width of the record head gap for a UHER 5000 and in particular for the Exhibit 60 UHER.

Through these geometric properties and especially its 28.6 millimeter separation from the quartet on the right of the figure, the single mark on the left can be clearly identified as a record-head-off mark. Notice the very brief nature of this mark as indicated in the waveform diagram. Also notice the bipolar (i.e., up-down) characteristic of this pulse. Notice, too, the repetitive 60 Hz pattern to its left. This is the very end of the 18.5 minute buzz section. The more random waveform on the right of the figure is the resumption of speech. The more or less straight horizontal line connecting the two marks in the waveform diagram of this figure, corresponds to erased tape. (The small wiggles correspond to very small interference signals picked up by the electronics of the machine which played the tape for the production of these waveform diagrams.) Similar blank tape sections should be expected in Events B_2 and C_2. A third might be pointed out in Event G, although its extent is very short.



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