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 3

COMPARATIVE STUDIES OF ELECTRICAL WAVEFORMS AND SPECTROGRAMS

This technical note presents waveform and spectrographic analyses of the principal signal events on the June 20, 1972 tape. Waveform details are examined using computer techniques for display and signal location. Excerpted events are delivered to a sound spectrograph for analysis of time, frequency and intensity characteristics. The spectrographic results are displayed in time-registration with the waveform data.

The note also describes laboratory simulations of principal signal events, and it presents computer and spectrographic analyses of the simulations.

The waveform data correspond with those of Technical Note 2 and hence provide direct comparison and a valuable means for interrelating magnetic development and spectrographic analysis. The computer techniques used in the two cases, however, are completely independent, and therefore are mutually supportive in their overlapping areas. Technical Note 3 is a self-contained treatment of the topics listed in the following table.

CONTENTS

Electrical Waveform Studies of the 18.5 Minute Tape

1. Electrical Playback

The signals recorded in the 18.5 minute buzz passage of the June 20, 1972 Executive Office Building tape were studied in terms of the electrical waveforms they produce upon playback of the tape. Electrical analysis of the signal waveforms is independent of and distinct from direct development of magnetic patterns on the tape. In the latter instance, as discussed in Technical Note #1, magnetic patterns are made visible directly on the tape by depositing finely-divided iron particles from a volatile solution.

Independent studies of electrical waveforms were done in four laboratories: Bolt Beranek and Newman Inc. (BBN); Federal Scientific Corporation (FSC); University of Utah (UU); and Bell Laboratories (BTL). The original evidence tape was analyzed directly in the first three locations, and copies of the evidence tape were used in the latter location for confirmatory and corroborative studies. In addition, studies were made at the latter location of the electrical waveforms produced by laboratory recordings with three different recording machines; two Uher 5000's and one Sony 800B.

Electrical playbacks of the original evidence tape were made from Sony 800B recorders set to their 15/16 ips speed. Playbacks of tape copies and laboratory recordings were primarily from a Sony 800B and from an Ampex 440.

2. Digitization of Electrical Waveforms

The waveform studies utilized digital representations of the electrical signals. In each case, the first step of the procedure was analog-to-digital conversion of the signal and storage in a digital memory. Digital computers were used at BBN, UU and BTL, and a special digital machine was used at FSC.

Digital Equipment Corporation PDP-10 computers were used at BBN and UU, with 10 KHz sampling, 0-4 KHz bandwidth and 14-bit quantization. A Honeywell DDP-224 computer was used at BTL, with 10 KHz (and some 20 and 40 KHz) sampling, 0-4 KHz bandwidth and 12-bit quantization. A Honeywell HIS-6070 was also used for graphic display. A Model UA-500 Ubiquitous® Spectrum Analyzer was used at FSC in accordance with the capabilities of its 1,500-word digital memory (9-bit/word).

This technical note centers primarily on the waveform analyses conducted at BTL.

3. High-Fidelity Tape Copies

In order to avoid physical tape wear and the custodial constraints necessary in handling the original tape,* a number of analog tape copies were made for laboratory use. Three copies were made from the original at FSC by playing at four times the original speed (i.e. 3-3/4 ips) on a laboratory Nagra machine and recording on another laboratory Nagra machine. A fourth copy was made from one of these copies by the same technique. Two other analog copies were made at FSC by playing at 15/16 ips from a Sony 800B and recording on a Nagra at 7-1/2 ips. Another analog copy was made by outputting the UU digitization from its PDP-10 computer to an Ampex 440 machine running at 7-1/2 ips. Still another copy of portions of the 18.5 minute passage was made by outputting the BBN digitization from its PDP-10 computer to a Braun TG 1000 machine running at 7-1/2 ips.+ These various techniques provided opportunities for checking and confirming the accuracy of the laboratory copying procedures.

The studies of the 18.5 minute passage described here were made initially from the fourth FSC Nagra-to-Nagra copy and finally from the UU-Ampex 440 copy which was phase-compensated in the laboratory.

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*Custodial procedures were such that whenever the original tape was being studied, it was accompanied by two or more U.S. Deputy Marshals and by attorneys from both the White House and Special Prosecution staffs. Original equipment and tape were always in custody of the U.S. Deputy Marshals.

+Elsewhere tape speeds may appear in metric measure. The nominal metric equivalents are: 24 mm/sec (for 15/16 ips), 95 mm/sec (for 3-3/4 ips), and 190 mm/sec (for 7-1/2 ips).

4. Phase-Compensated Tape Copy

For the greatest accuracy in final analyses and illustrations, a phase compensation procedure was used to produce a high-fidelity copy. The procedure was as follows.

The UU digitization of the original evidence tape was outputted (through the digital-to-analog converter of the PDP-10) to an analog Ampex 440 recorder. At BTL this analog recording was reversed in time and played from an Ampex 440 recorder to a second Ampex 440 which recorded the time-reversed signal. This second tape was then time-reversed and played from the Ampex 440 in the normal forward direction into the analog-to-digital input of the DDP-224 computer. This procedure produced the digitized signals which are used here for waveform and spectrographic display of the 18.5 minute passage.

If one denotes the amplitude and phase characteristics of the record and play procedures as $A_r e^{j\phi_r}$ and $A_p e^{j\phi_p}$, respectively, then the time-reversing procedure produces a total amplitude and phase characteristic equal to

$$A_t e^{j\phi_t} = (A_r e^{+j\phi_r})\ (A_p e^{-j\phi_p})\ (A_r e^{-j\phi_r})\ (A_p e^{+j\phi_p})\ .$$

$$= (A_r A_p)^2\ e^{j0}\ .$$

In other words, this results ideally in zero phase shift, which together with the relatively flat amplitude characteristic of the Ampex 440 produces negligible distortion. That this is indeed the case can be seen from the waveform comparisons shown in Figs. 1 and 2.

Figure 1: Comparison of digitized original tape with digitized phase-compensated copy.

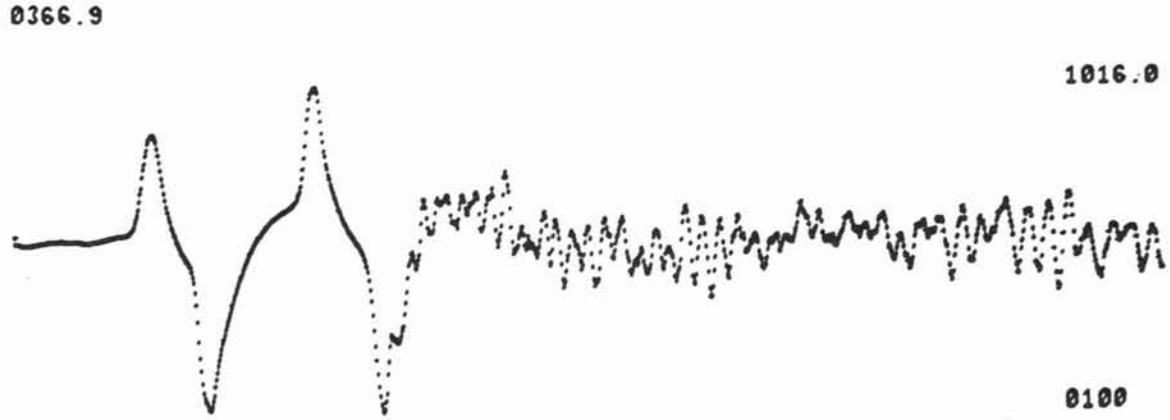
The data show the erase-head off event at 1110 sec. in the 18.5 minute tape (i.e., the end of the buzz section).

The top trace is the BBN digitization from the original evidence tape. The time scale is 0-100 milliseconds.

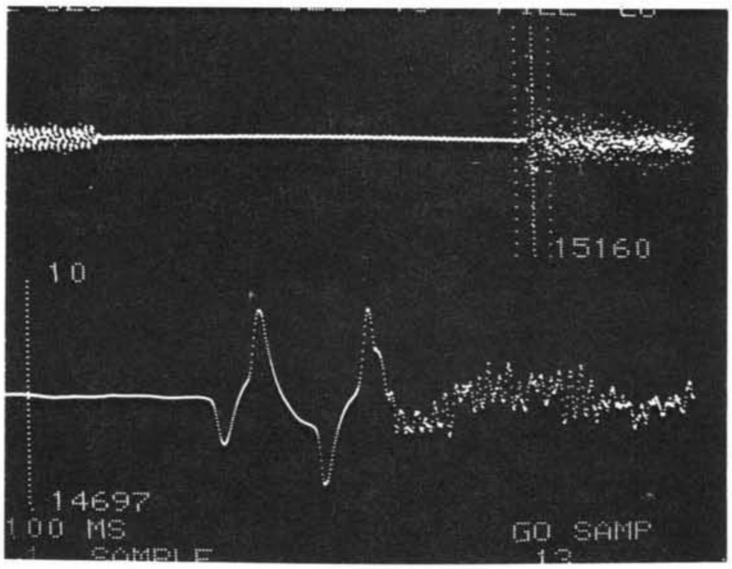
The bottom trace is the BTL digitization of a phase-compensated copy. The time scale is also 0-100 milliseconds.

The phase-compensated copy is made from an analog output of the UU digitization of the original. Polarity inversion of the waveform is not significant and merely reflects the difference in number of amplifier stages in the two digitizations.

See text for explanation of the phase-compensation procedure.



DIGITIZED ORIGINAL TAPE



PHASE-COMPENSATED TAPE COPY

FIG. 1

<u>Figure 2</u>: Comparison of digitized original tape with digitized phase-compensated copy.

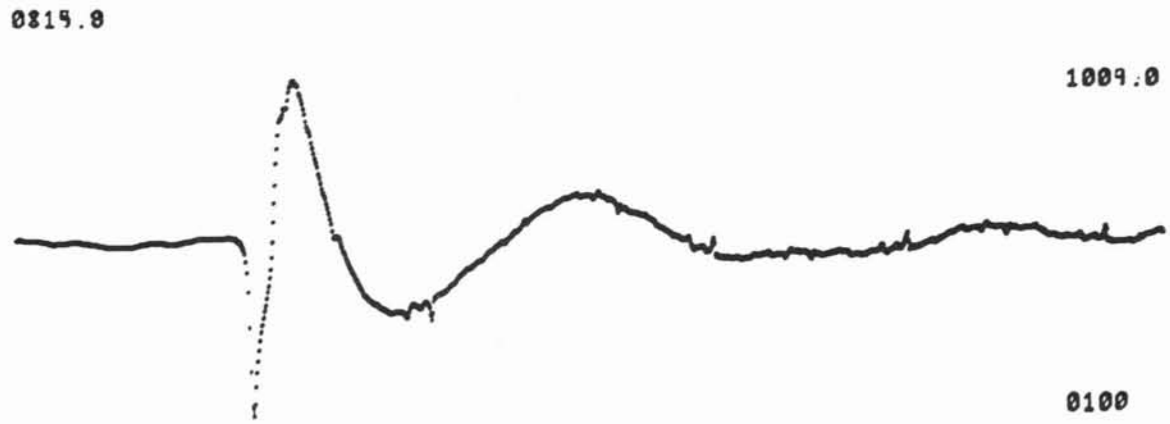
The data show the record-head on transient at 155 sec. in the 18.5 minute tape.

The top trace is the BBN digitization from the original evidence tape. The time scale is 0-100 milliseconds.

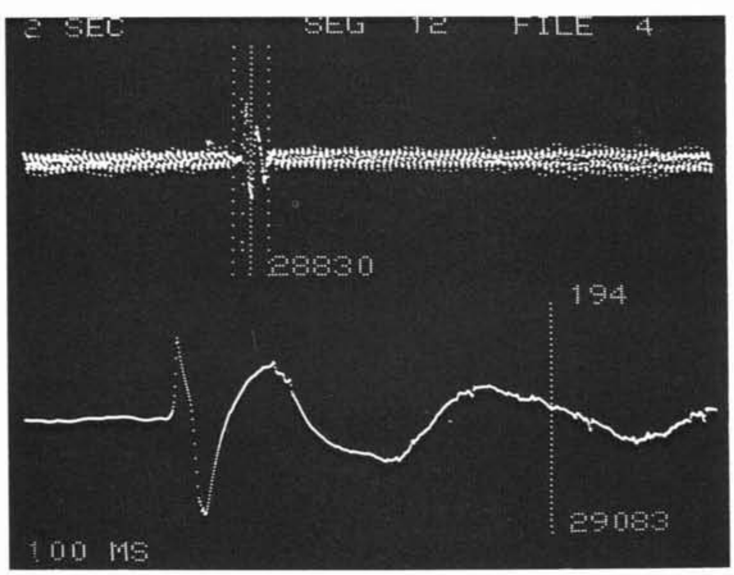
The bottom trace is the BTL digitization of a phase-compensated copy. The time scale is also 0-100 milliseconds.

The phase-compensated copy is made from an analog output of the UU digitization of the original. Polarity inversion of the waveform is not significant and merely reflects the difference in number of amplifier stages in the two digitizations.

See text for explanation of the phase-compensation procedure.



DIGITIZED ORIGINAL TAPE



PHASE-COMPENSATED TAPE COPY

FIG. 2

5. Electrical Signatures of Uher Exhibit 60

The erased and buzz-recorded portion of the June 20, 1972 EOB tape (which is described as originally recorded on a Sony 800B machine running at 15/16 ips) is thought to have possibly been created by a specific Uher 5000 recorder, designated Government Exhibit 60. It therefore appeared relevant to catalog the electrical signatures of this machine. They were examined in some detail by recording on new tape in the FSC laboratory, using various sequences of control operations and gain settings. The resulting tape of start-stop characteristics was digitized and entered into the DDP-224 computer using a Sony 800B (BTL) for playback.

Typical examples of waveforms produced by the erase-head and record-head transients are shown in Figs. 3 and 4. The right-hand column of Fig. 3 shows examples of the erase-head off. The top two examples are produced with the tape stationary and consequently are somewhat weaker magnetizations, probably owing to the tape not being snugly pulled against the erase-head. The bottom two examples of erase-head off are produced with the tape in motion and are plotted with the same amplification. They show strong magnetization, with the tape held snugly to the erase-head. The left-hand column of Fig. 3 shows examples of record-head off. This event is slightly more variable than erase-head off and depends somewhat upon the sequence of control operations.

Figure 4 shows a selected assortment of record-head-on waveforms. These transients typically are longer in duration than the record-head off and typically are more variable, depending upon the control operations which actuate them.

Several facts about the physical configuration of Uher 5000 Exhibit 60 are also relevant. The distance between the erase and record heads is 28.6 mm, corresponding to 1.2 sec. in time at a tape speed of 15/16 ips. Therefore, if tape is in contact with the record and erase heads, an erase-head-off waveform is always paired with a record-head-off waveform at a 1.2 sec. time interval in the electrical waveform.

The erase head is designed with twin air gaps of width 3.0 mm, while the record head has a single air gap of width 2.4 mm. As a consequence, transient magnetizations produced by the erase head "protrude" from the half-track width of the record head and can be seen in direct magnetic development of the tape.

Further, tape on a properly-threaded Uher 5000 is always in contact with the erase head. However, it is brought into contact with the record head only when the pressure solenoid is actuated to put the tape into motion, a notable property that makes tape "cuing" (or positioning) rather difficult, and of some relevance in the interpretation of quiet gaps to be mentioned later.*

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* On this machine, as on most moderate-cost machines, the record head also serves as the play-back head.

Figure 3: Typical transient waveforms produced by de-energizing the recording and erasing heads on the Uher 5000, Exhibit 60.

The waveforms are computer digitizations of events recorded in the FSC laboratory on a new tape by Exhibit 60 with the record gain set at 7. The time scale for each waveform trace is 0-100 msec.

The right-hand column shows four examples of the erase-head-off waveform. The top two are recorded with the tape stationary, and the bottom two are recorded with the tape in motion. The waveform characteristics are relatively stable and are not materially influenced by sequence of control operations that exit the record mode.

The left-hand column shows four examples of the record-head-off waveform. Some variability in the transient form is evident and is a function of the sequence of control operations.

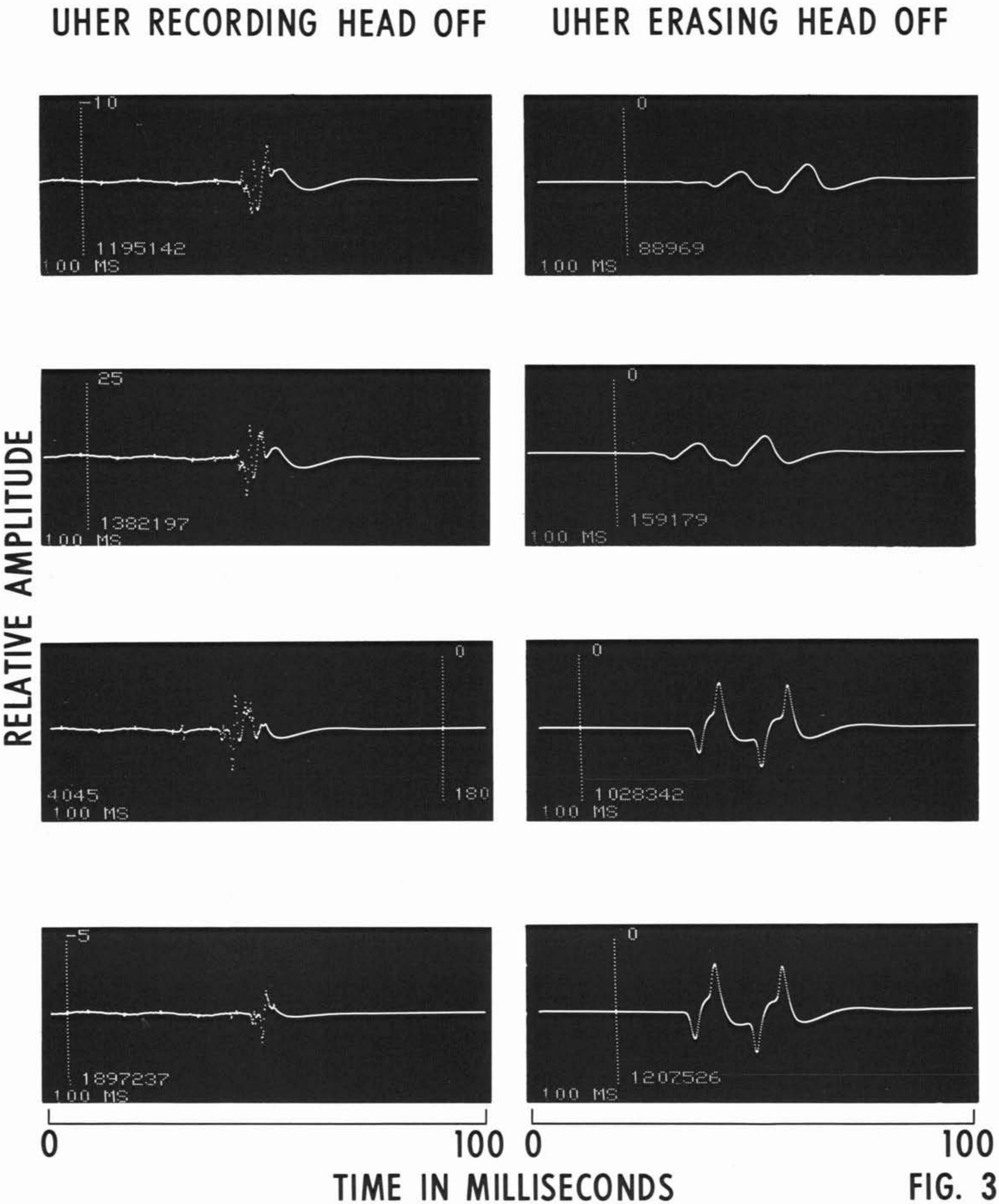
UHER RECORDING HEAD OFF
UHER ERASING HEAD OFF
RELATIVE AMPLITUDE
-10
1195142
100 MS
0
88969
100 MS
25
1382197
100 MS
0
159179
100 MS
0
4045
180
100 MS
0
1028342
100 MS
-5
1897237
100 MS
0
1207526
100 MS
0
100
0
100
TIME IN MILLISECONDS

FIG. 3

Figure 4: Typical transient waveforms produced by energizing the recording head on the Uher 5000, Exhibit 60.

The waveforms are computer digitizations of events recorded in the FSC laboratory on a new tape by Exhibit 60 with the record gain set at 7. The time scale for each waveform trace is 0-100 msec.

The data show eight examples of record-head on. The transient waveforms vary in shape and are strongly conditioned by the sequence of control operations which produce them. As the waveforms show, the time required for the record-on transient to settle can range up to around 90 msec.

Two traces, the middle two in the right-hand column, also show record-head off transients preceding the record-head on. These two examples are produced by a stop and re-start in place.

UHER RECORDING HEAD ON

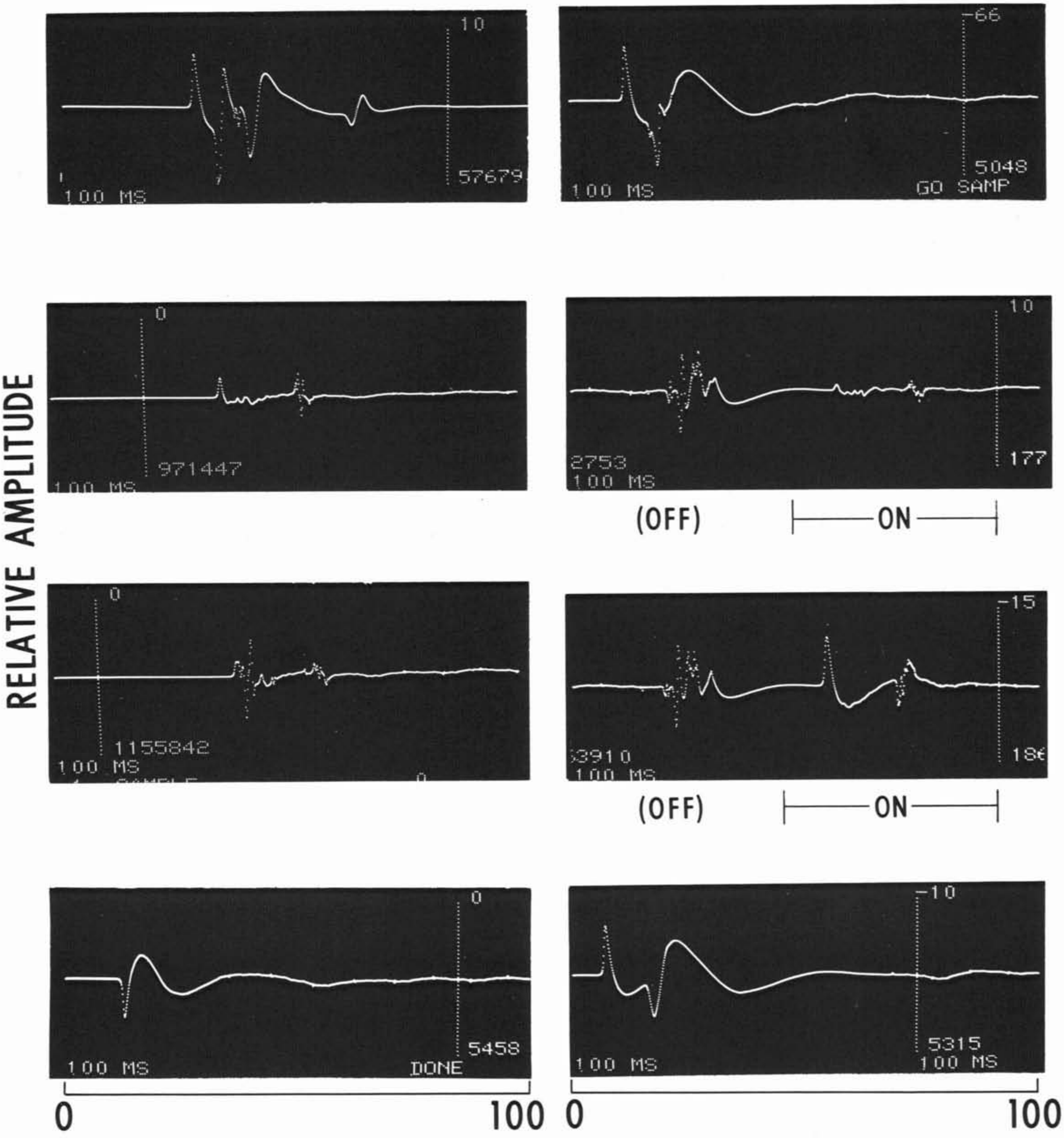

FIG. 4

6. Distinctive Modes of Re-Record

Because it is suggested that the 18.5 minute buzz passage might be the result of erasing and re-recording over a previously-recorded speech passage, it is relevant to consider in what patterns might such re-recording occur.

Several distinctive possibilities for re-recording (i.e., recording over a previously-recorded signal) can be outlined. These conditions assume that the tape is properly threaded and in contact with the record and erase heads at the times that the record electronics are switched on and off (i.e., record-on and record-off).

Consider, first, the condition where an erasing and re-recording process is interrupted, the tape is re-positioned, and the erasing and re-recording process is resumed. Consider four possibilities:

Case A: The tape is re-positioned forward by less than the record-to-erase head spacing on the recording machine.

Case B: The tape is re-positioned forward by more than the record-to-erase head spacing.

Case C: The tape is re-positioned backward by less than the record-to-erase head spacing.

Case D: The tape is re-positioned backward by more than the record-to-erase head spacing.*

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* These conditions correspond to "overlay types" discussed in Technical Note #1. The correspondence in terminology is:

Case A = Type 3
Case B = Type 4
Case C = Type 2
Case D = Type 1

Note, too, that equality conditions (i.e., spacing forward or backward by exactly the record-to-erase head distance) demark the boundaries between Cases A and B and between Cases C and D. A third special condition corresponds to exactly zero displacement of the tape before re-starting (i.e., stopping and re-starting in place).

If a previously-recorded speech tape were being erased and re-recorded with buzz, and if the process were interrupted and then resumed, the distinctive patterns corresponding to Cases A, B, C and D are diagrammed in Figs. 5 and 6.

Secondly, the process, if in progress, must first have been started. This initial start also has a distinctive pattern, designated Case S. And finally, too, termination of the process leaves a distinctive pattern, designated Case E. These two cases are diagrammed in Fig. 7.

As will evolve in the subsequent discussion, waveform analysis of the subject tape suggests that the 18.5 minute buzz portion contains the following patterns:

(a) One instance each of Case S (at 0 sec.) and Case E (at 1109 sec.), as there must be if original speech were erased and buzz re-recorded.

(b) Four clear instances of Case A, two with relatively large gaps, G (at 49 sec. and 1042 sec.) and two with relatively small gaps, G (at 612 sec. and 684 sec.).

(c) No instance of Case B, which would leave a clear portion of unerased original speech.

(d) No clear instance of Case C, re-recording after backup and overlap less than the record-to erase distance.*

(e) And, three instances of Case D (at 155, 1061, and 1065 sec.), re-recording after backup and overlap greater than the record-to-erase distance.

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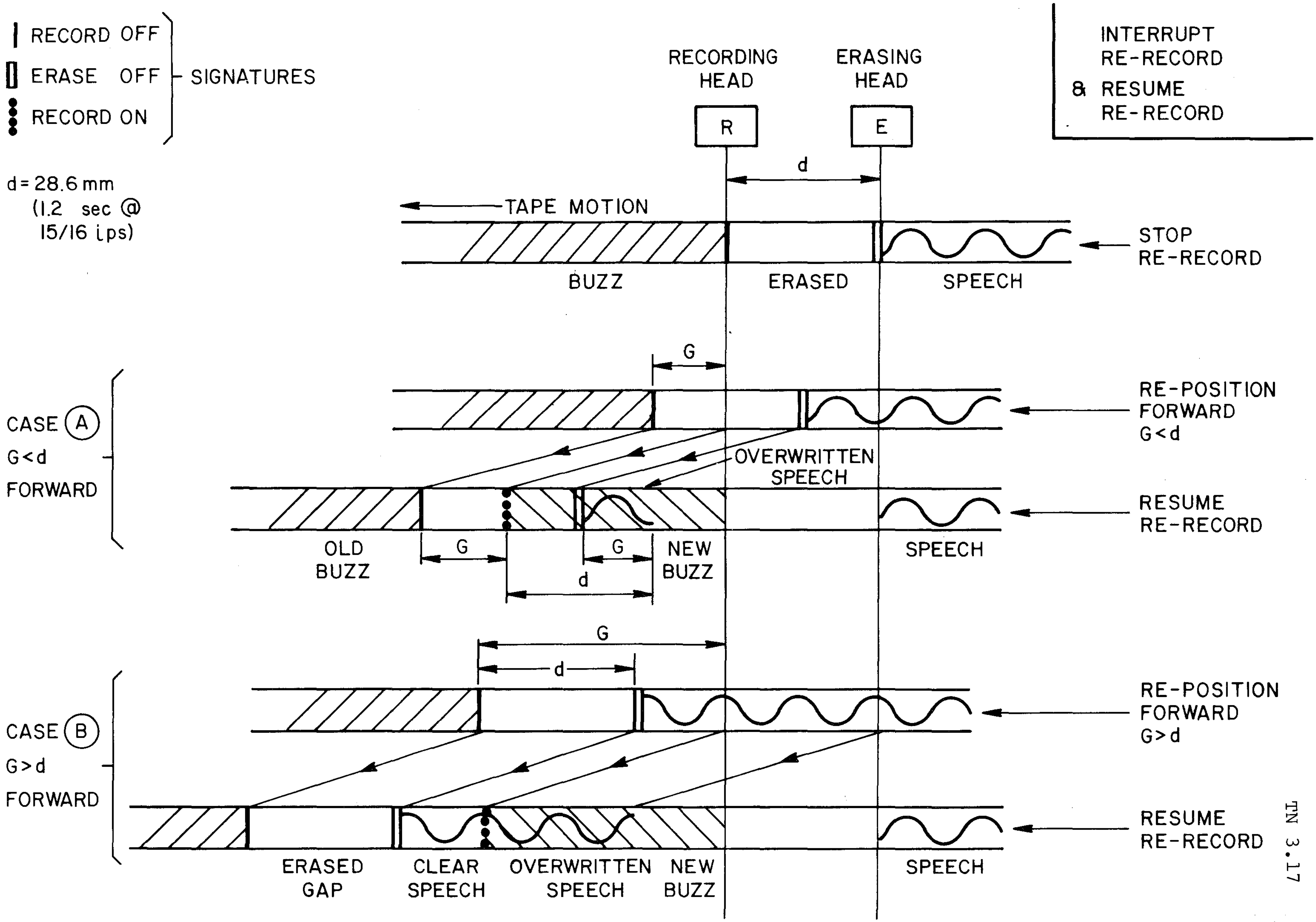
* A possible Case C or Case D may exist at 1041 sec., but this is not clear.

Figure 5: Distinctive patterns produced by interruption of a re-record operation, re-position the tape forward, and resume re-record.

Case A corresponds to re-positioning the tape forward by a distance G which is less than the record-to-erase-head distance, d.

Case B corresponds to re-positioning the tape forward by a distance G which is more than the record-to-erase-head distance, d.

For each case, a bracketed pair of diagrams is shown. The top of each pair gives the stationary tape position before the motion is re-started. The bottom diagram of each pair shows the signal conditions after the motion is re-started.


RECORD OFF
ERASE OFF
RECORD ON
SIGNATURES
d=28.6 mm (1.2 sec @ 15/16 ips)
RECORDING HEAD
ERASING HEAD
R
E
INTERRUPT RE-RECORD & RESUME RE-RECORD
d
TAPE MOTION
BUZZ
ERASED
SPEECH
STOP RE-RECORD
G
CASE A G<d FORWARD
RE-POSITION FORWARD G<d
OVERWRITTEN SPEECH
RESUME RE-RECORD
OLD BUZZ
G
G
NEW BUZZ
SPEECH
d
G
d
CASE B G>d FORWARD
RE-POSITION FORWARD G>d
RESUME RE-RECORD
ERASED GAP
CLEAR SPEECH
OVERWRITTEN SPEECH
NEW BUZZ
SPEECH

TN 3.17

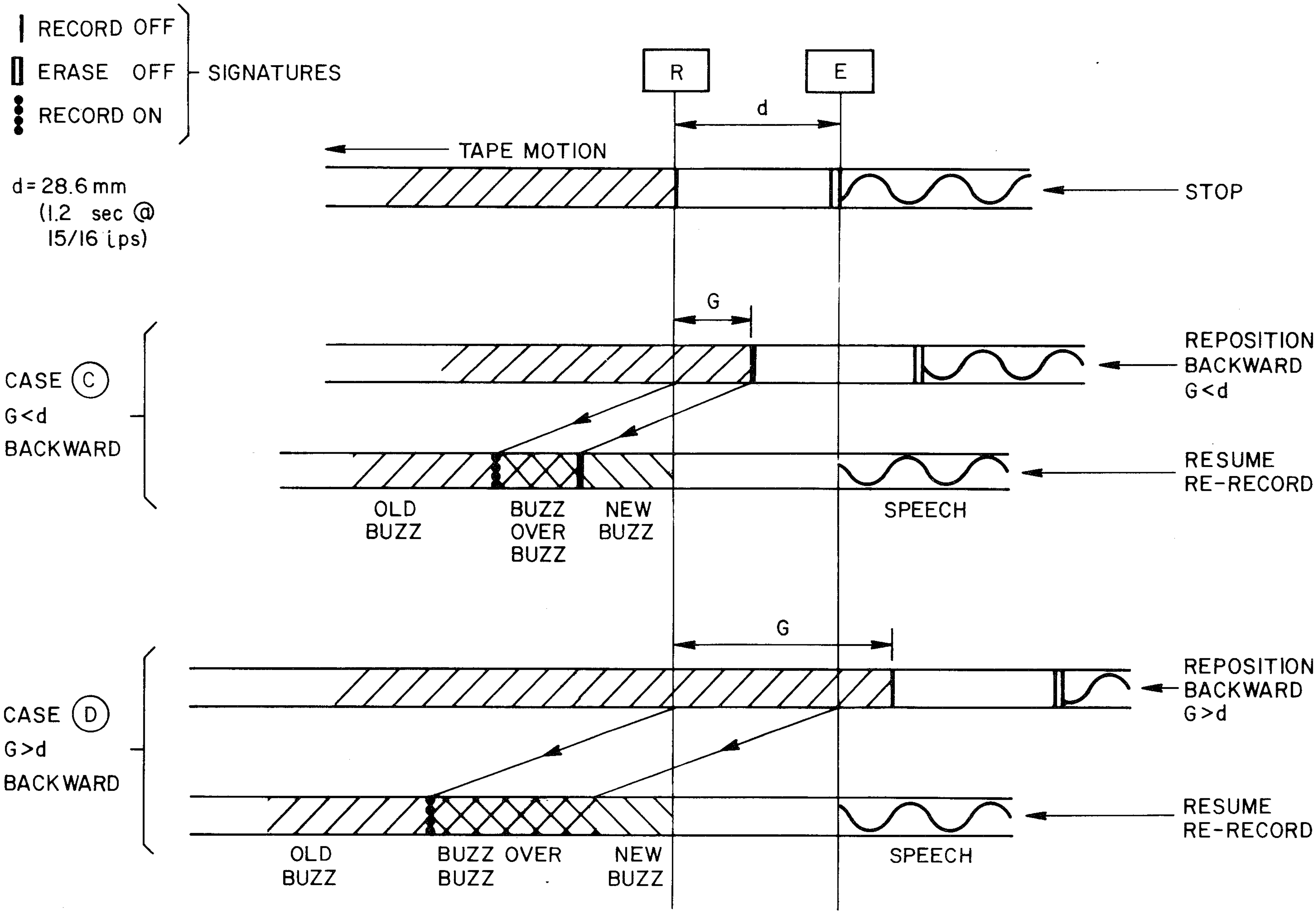
FIG. 5

Figure 6: Distinctive patterns produced by interruption of a re-record operation, re-position the tape backward, and resume re-record.

Case C corresponds to re-positioning the tape backward by a distance G which is less than the record-to-erase-head distance, d.

Case D corresponds to re-positioning the tape backward by a distance G which is more than the record-to-erase-head distance, d.

For each case, a bracketed pair of diagrams is shown. The top of each pair gives the stationary tape position before the motion is re-started. The bottom diagram of each pair shows the signal conditions after the motion is re-started.


RECORD OFF
ERASE OFF
RECORD ON
SIGNATURES
R
E
d
TAPE MOTION
d = 28.6 mm
(1.2 sec @
15/16 ips)
STOP
G
CASE C
G<d
BACKWARD
REPOSITION
BACKWARD
G<d
RESUME
RE-RECORD
OLD
BUZZ
BUZZ
OVER
BUZZ
NEW
BUZZ
SPEECH
G
CASE D
G>d
BACKWARD
REPOSITION
BACKWARD
G>d
RESUME
RE-RECORD
OLD
BUZZ
BUZZ OVER
BUZZ
NEW
BUZZ
SPEECH

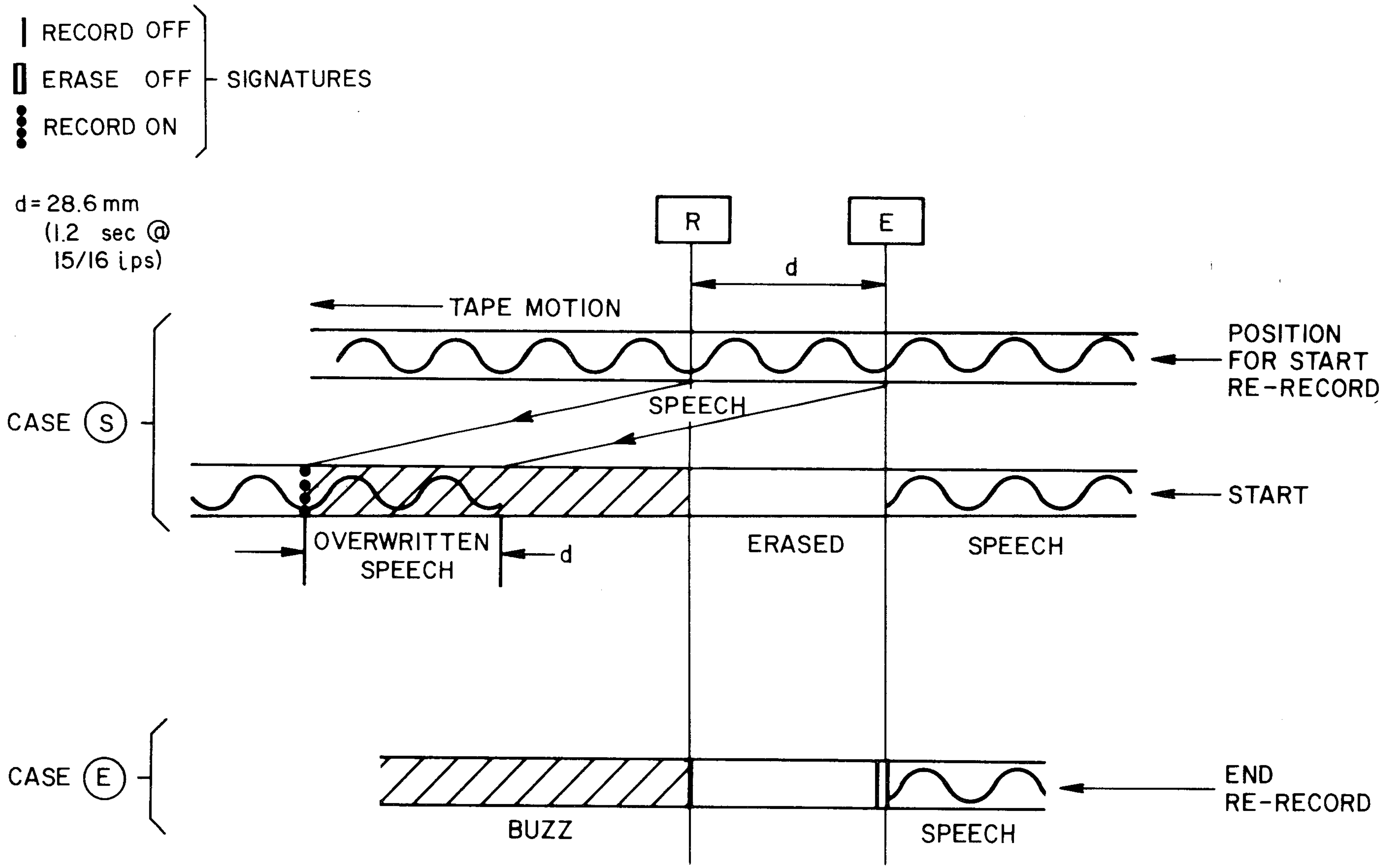
TN 3.19

FIG. 6

Figure 7: Distinctive patterns produced by start of re-record and end of re-record.

Case S shows conditions for start of a re-record operation.

Case E shows conditions for end of a re-record operation.


RECORD OFF
ERASE OFF
RECORD ON
SIGNATURES
d = 28.6 mm
(1.2 sec @
15/16 ips)
R
E
d
TAPE MOTION
POSITION
FOR START
RE-RECORD
SPEECH
CASE (S)
START
OVERWRITTEN
SPEECH
d
ERASED
SPEECH
CASE (E)
END
RE-RECORD
BUZZ
SPEECH

TN 3.21

FIG. 7

7. Construction of Signal Event Pattern for the 18.5 Minute Section of the June 20, 1972 Tape

One objective is to ascertain what sequence of machine actions occurred in the 18.5 minute passage. Toward this end, a useful technique is to begin with the most unequivocal, identifiable signatures as anchor points, and to utilize the known physical constraints of the machine to build confidence and reliability in establishing and assessing other signatures. Considerations can be formulated as follows:

(1) The most distinctive and detectable signature (both electrical and magnetic) is the erase-head off. Tape on a properly threaded Uher 5000 machine is always in contact with the erase head, and the erase-off signature is planted whenever the machine normally exits from the record mode (i.e., the record key is released or "unlocked").

(2) The record-to-erase head distance is fixed (28.6 mm on Exhibit 60, corresponding to a time interval of 1.2 sec. at 15/16 ips tape speed). Whenever tape is in contact with the record head, the record-off signature is planted at the same instant as the erase-off, but 28.6 mm (1.2 sec.) further along the tape. The record-head-off signature also is fairly stable in waveform, and typically shorter in duration than the record-head on.

(3) Clearly established erase-off and record-off signatures imply at least one record-on occurrence at a point earlier, for consistency. Re-recording with halt, backup (overlap) and re-start can lead to more than one record-on.

(4) Initiation, termination and interruption of a re-record lead to the cases described by the diagrams of Figs. 5-7. Resulting conditions of quiet (erased) gaps, speech-like remnants, and buzz-on-buzz are explained by these diagrams, as are the relations

for forward positioning and backward positioning of the tape. Some of these distinctive patterns can supply strong data.

(5) The interlocking design of the key controls and the sequence in which they actuate machine switches also provide constraining logic for assessing signatures. Detailed circuit data for the machine further permits testing alternative hypotheses concerning normal and abnormal operation.

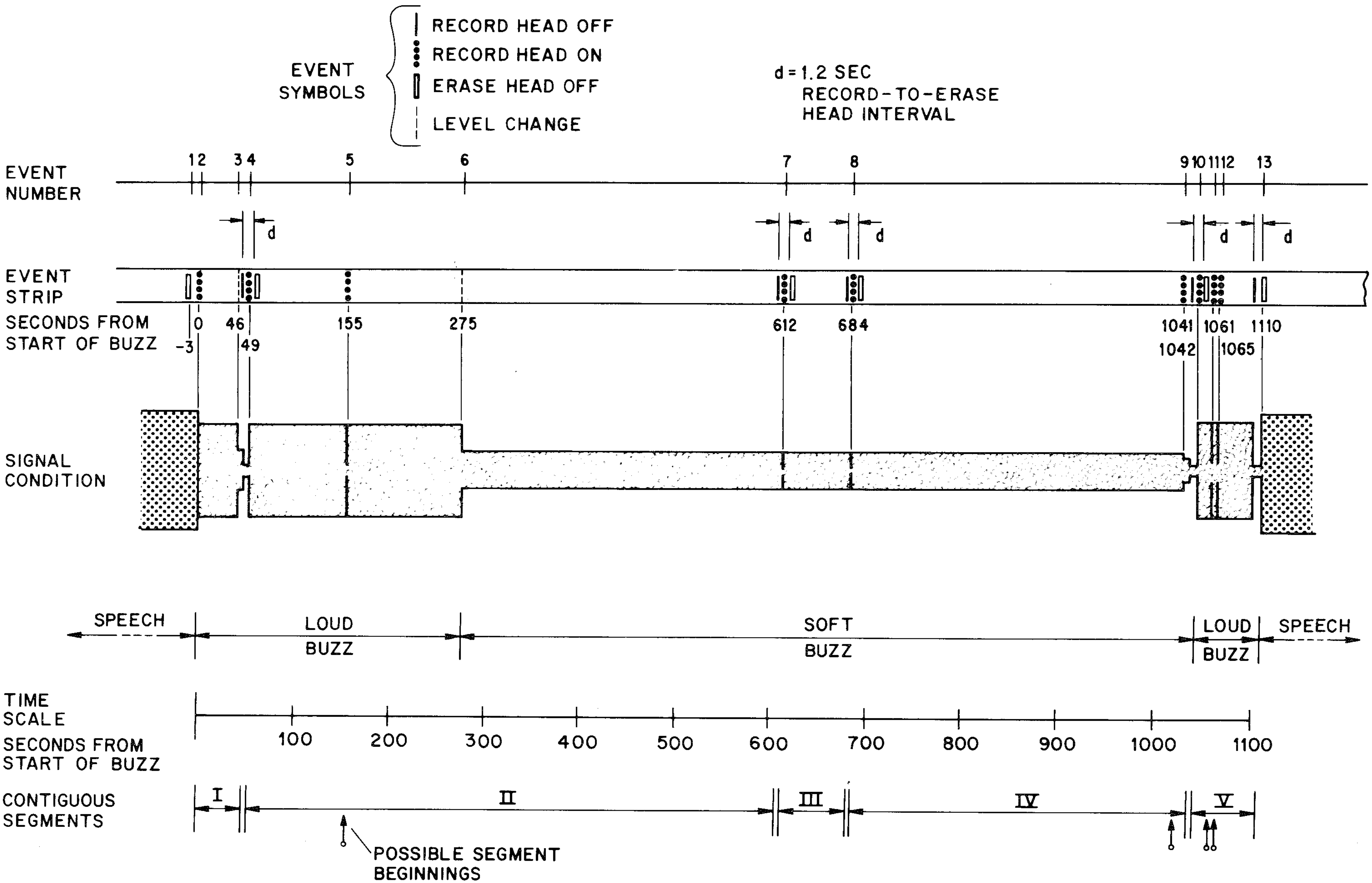
These techniques can be combined with several others; namely, critical listening of computer excerpted passages, repeated and microscopic viewing of waveforms on the computer display scope and spectrographic analyses of critical sections. Such effort leads to the principal signal events shown in Fig. 8.

Each of these signal events will be illustrated and discussed individually. The event numbers and the event times (in seconds) shown in Fig. 8 key the discussion to follow.

Figure 8: Diagram of principal signal events in the 18.5 minute passage.

The diagram illustrates the variation of signal condition and amplitude with time. The event strip schematizes signal events which are consistent with observed waveforms and spectra. Principal events are identified in terms of seconds from start of buzz, and also by event number. The event nomenclature is the same as used in Figs. 5-7.

The signal-condition diagram corresponds in outline to that given in the January 15, 1974 report of the Tape Panel. The contiguous signal segments described in that report are shown at the bottom of the figure. The event strip of Fig. 8 does not include a second, partially-erased erase-head-off event at 684 sec. This event was located mainly by magnetic development, rather than by waveform examination. It can be detected, however, in the insert photo of Fig. 16.



TN 3.25

PRINCIPAL EVENTS IN THE 18.5 MINUTE TAPE

FIG. 8

8. Waveforms and Corresponding Spectrograms of Signal Events in the June 20, 1972 Tape

Signal events depicted in Fig. 8 can conveniently be examined by time-registered displays of waveforms and spectrograms. To accomplish this, 2 seconds of computer-excerpted signal is displayed on the computer scope. The excerpted passage is also outputted from the computer through a 6 dB/octave pre-emphasis network and recorded on an Ampex 440 for spectrographic analysis. The recorded excerpts are mounted directly onto a sound spectrograph (Voiceprint Laboratories Corporation Series 700). The sound spectrograph plots time-frequency-intensity analyses of the signal. The scope waveform display can be photographically enlarged to match the time scale of the spectrogram (i.e., 10 inches = 2 seconds). Such time-registered displays of signal events 1 through 13 are shown in Figs. 9 through 21, respectively.

Each figure (9 through 21) shows the waveform and spectrogram analysis of a 2-second piece of signal which is excerpted from the computer digitization. A broad-band spectrogram of the 2-second interval is shown at the bottom of the figure. The broad-band spectrogram is produced with an analyzing filter width of 300 Hz, and hence provides good time resolution. A narrow-band spectrogram is shown at the center of each figure. It is produced with an analyzing filter width of 45 Hz, and hence gives good frequency resolution.

The time-registered 2-second waveform display is shown above the spectrograms. The waveform taken from the computer scope displays 1000 sample points, or every 20th sample of the signal which is digitized at 10 KHz. It therefore omits some waveform detail.

Immediately above the 2-second waveform is an event strip which schematizes the signal events consistent with the observed data. Symbols are the same as used in Figs. 5-7, with the additional symbol of four vertical open circles, which represents a salient click transient.

Expanded time-scale photos of transient events are shown as inserts, generally positioned near the event they depict. The insert photos also plot 1000 samples of the waveform, and are either 100 msec. or 200 msec. in time scale.

One important point about the computer waveform display must be emphasized. The computer scope and hard-copy device can display only 1000 sample points of the time waveform. Hence, for 10 KHz sampling, the 2-seconds of time-registered waveform displays only every 20th sample of the waveform. The 2-second waveform display consequently undersamples the signal, and brief and fine detail may not be preserved.* The time-registered waveform is valuable, however, for showing the timing of events and their relative durations.

To offset the loss of detail in the time-registered 2-second waveforms, the insert photographs are added. They show enlargements of significant waveform portions. The expanded inserts are shown either on a 0-100 millisecond time scale (which plots every sample of the 10 KHz sampling and accurately reflects frequency components up to 5 KHz) or else on a 0-200 millisecond time scale (which plots every other sample and hence accurately reflects frequency components up to 2.5 KHz). The time scale of each insert is displayed by the ms number on the photo.

Figures 9 through 21 show the data for the events labelled 1 through 13 in Fig. 8. All data are derived from digitization of the phase-compensated UU-Ampex 440 copy in accordance with the techniques described in Section 4.

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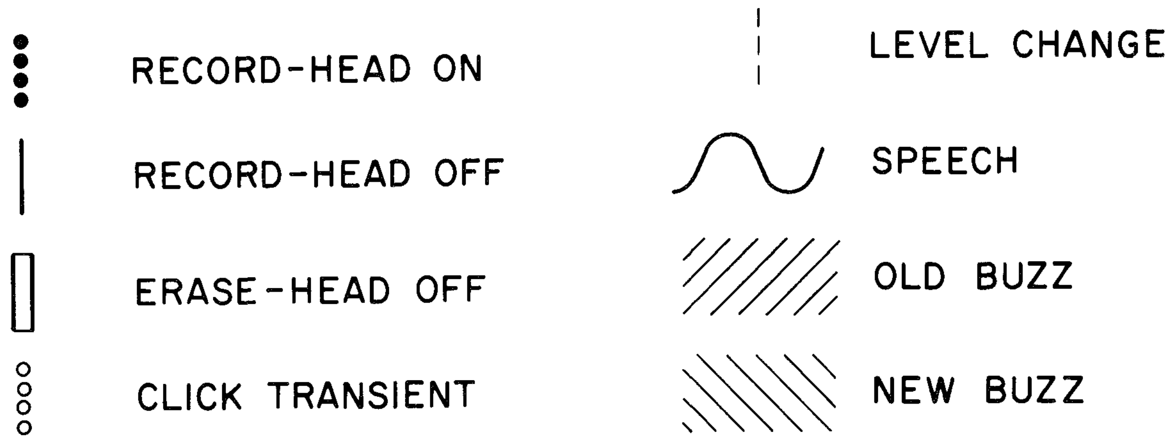
* Note this point especially when comparing waveforms between Technical Notes 2 and 3.

Event symbols used in Figs. 9-21 are:



<u>Figure 9: Event (1), -3 Seconds</u>: The event at -3 sec. is a single erase-head off planted onto recorded speech. The spectrograms show the position of the erase-head off (which produces a noticeable gap in the spectrograms), and they also reflect the noisy, reverberant characteristics of the speech recording. The waveforms (both time-registered and expanded) reflect the characteristic shape of the erase-off waveform superposed on the previously-recorded speech.

A possible origin of this event is the following sequence of operations. The tape is positioned for start of re-record. The record key is pushed down, locked, <u>but not held</u>. The start key is then pushed. This action releases the record key and allows it to pop up, superposing the erase-off transient onto the previously-recorded speech. The pressure solenoid carries the tape to the (now de-energized) record head, and tape motion starts. The start (but without recording) is then terminated about 3 sec. afterward, normally by the stop key. Alternatively, any equivalent sequence which releases the record key prior to tape motion would also superpose the erase-off pulse onto the recorded speech.

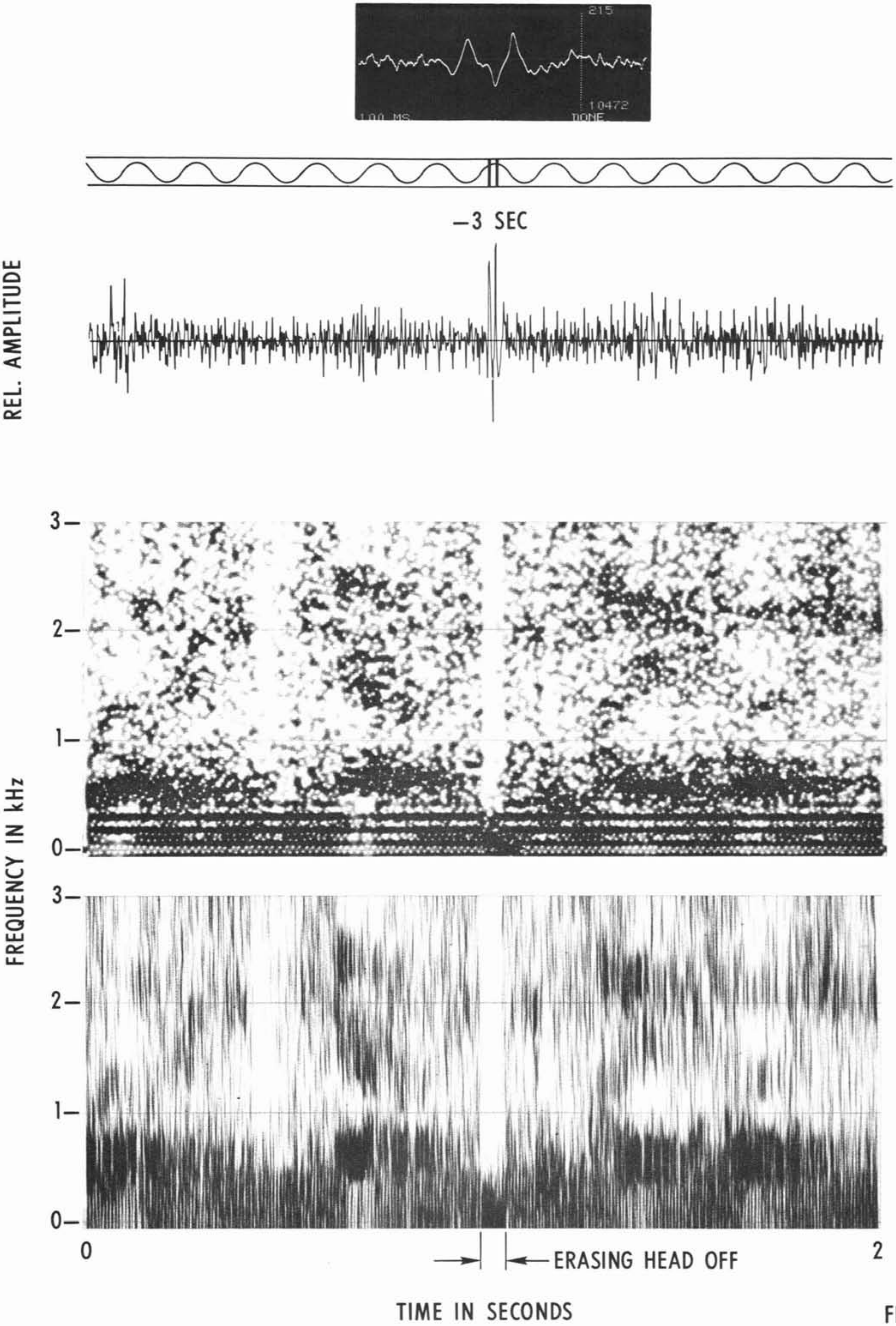

215
1.0472
100 MS
DONE
−3 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
2
ERASING HEAD OFF
TIME IN SECONDS

FIG. 9

Figure 10: Event (2), 0 Seconds: The event at 0 sec. shows a record-head on, followed by overwritten speech equal in duration to the record-to-erase head transit time.* Notice the clear speech-like characteristic of the overwritten (but not erased) signal remnant. The record-head on transient marks the beginning of the 18.5 minute buzz section. This is the case of start re-recording and explained diagramatically in the discussion of distinctive modes of re-record (Case S in Fig. 7).**

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* In all the spectrogram figures, critical time intervals are marked in seconds to two decimal places. These values may differ in the second decimal place from corresponding values determined elsewhere. The differences reflect the precision to which the spectrograms can be read and the accumulated speed differences in the tape-copying operations. Typically the interval differences may be of the order of 0.02 sec or less.

** A click transient may also be present in the complex at 0 sec., following close after the record on. This click transient may be associated with the sub-keyboard switch called K-1, an issue which will be mentioned again shortly.

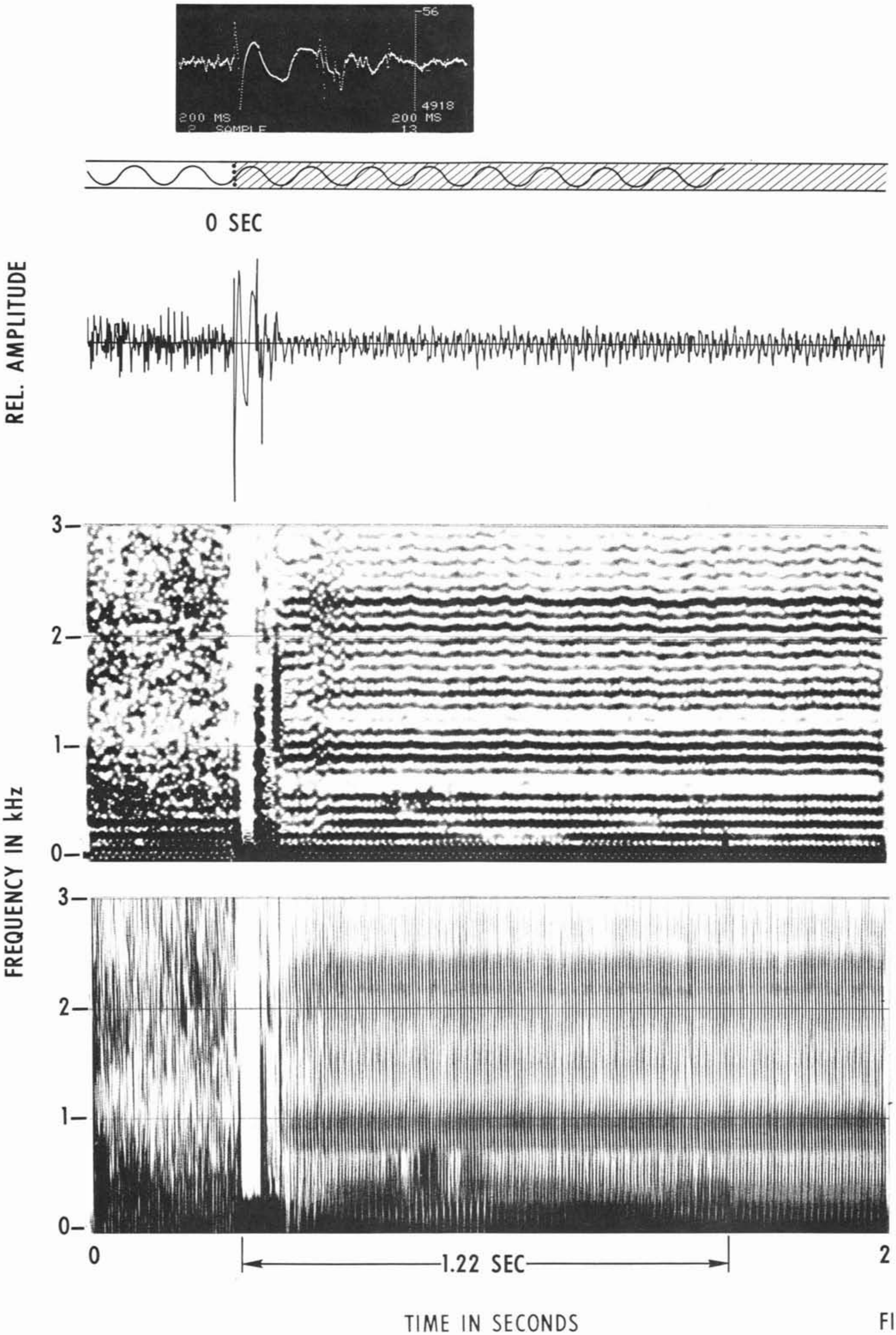
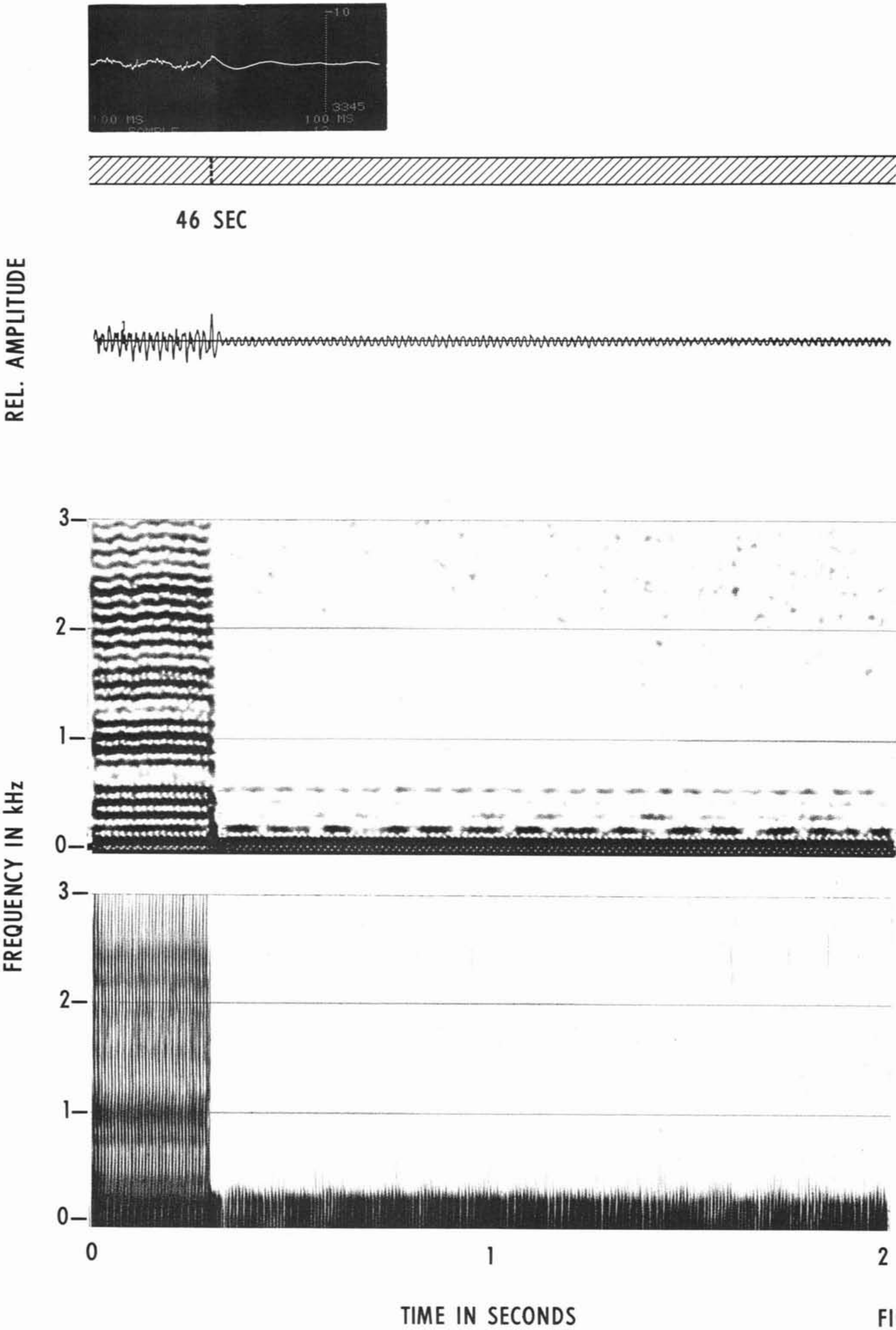

-56
4918
200 MS
200 MS
2 SAMPLE
13
0 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
1.22 SEC
0
2
TIME IN SECONDS

FIG. 10

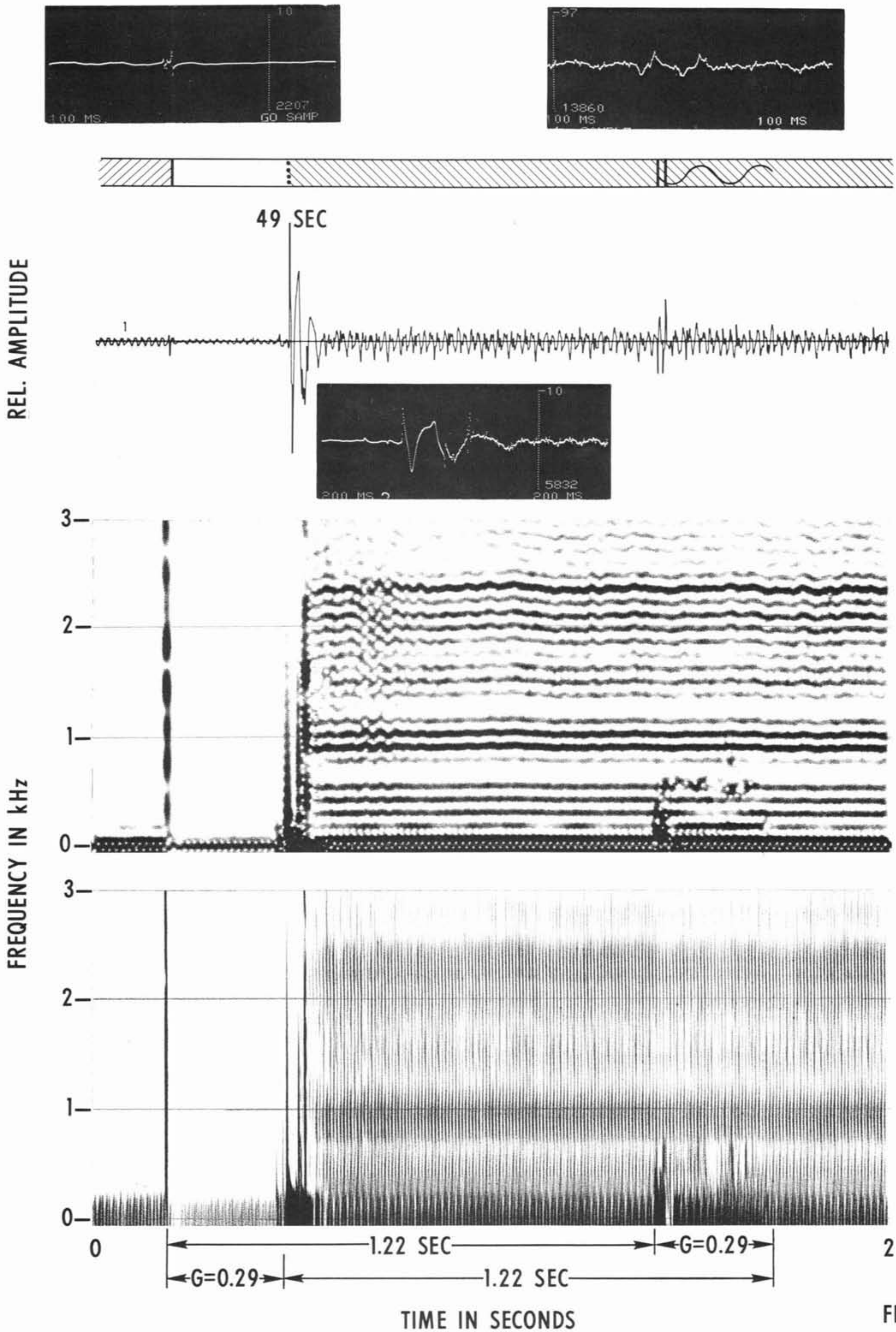
<u>Figure 11: Event (3), 46 Seconds</u>: The event at 46 sec. apparently corresponds to an abrupt drop in the re-recorded buzz level.



3345
100 MS
100 MS
46 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
1
2
TIME IN SECONDS

FIG. 11

Figure 12: Event (4), 49 Seconds: The event at 49 sec. corresponds apparently to an interrupt re-record, position forward and resume re-record (see Case A in Fig. 5). The operations are characterized by a record-head off, a record-head on (produced in this case 0.29 sec. later) and an overwritten erase-head off, followed by an overwritten speech-like remnant equal to the gap duration, G = 0.29 sec. (see the discussion of distinctive modes of re-record and Fig. 5 for a sequence of operations). The duration G = 0.29 sec. appears consistent with human reaction time in replaying the recorded buzz and, by listening, stopping the machine just as the buzz signal ends. (Additional discussion of this point is given in Section 9, Laboratory Simulations.) The forward positioning also appears consistent with a start-record operation in which the start key is pressed and held and the tape allowed to advance some distance before the record key is pressed to commence recording.



100 MS.
2207
GO SAMP
13860
100 MS
100 MS
49 SEC
REL. AMPLITUDE
200 MS
5832
200 MS
FREQUENCY IN kHz
3
2
1
0
0
2
1.22 SEC
G=0.29
G=0.29
1.22 SEC
TIME IN SECONDS

FIG. 12

Figure 13: Event (5), 155 Seconds: The event at 155 sec. seems consistent with an interrupt re-record, overlap backward by more than the record-to-erase head space, and a resume re-record so that buzz-on-buzz is produced (see Case D in Fig. 6). The diagram consequently shows a record-head on followed by buzz-on-buzz for a duration of 1.22 sec. As can be the case, the hypothesized buzz-on-buzz appears quite subtle, but may be discernible in the low-frequency components of the spectrograms.

Also shown at a duration H = 0.72 sec. following the record-head on is a click transient which may be consistent with release of a sub-keyboard switch on the Uher 5000, called the K-1 switch. (The time at which this click appears seems strongly conditioned by how rapidly one removes pressure from the keyboard. If the control keys are rapidly "bottomed" and released, the switch pulse can rapidly follow the record-on pulse and be "masked" by it. If the keys are not "bottomed," the click apparently may not appear at all.) Note especially the change in intensity of several buzz-harmonic frequency lines at the time the click transient occurs. In this instance, the click transient is relatively low in amplitude and it is not well confirmed as a K-1 pulse. It consequently is not shown in Table 3.1 and Fig. 3.2 of Chapter III.

An alternative candidate for this event might be an interrupt re-record, with a re-position backward by less than the record-to-erase distance. In this case, the click transient at H = 0.72 sec. should correspond to an overwritten record off, as discussed in the distinctive modes of re-record. However, from the laboratory simulations with the Uher machine (see Section 9) this notion fits less well than does the K-1 switch hypothesis.

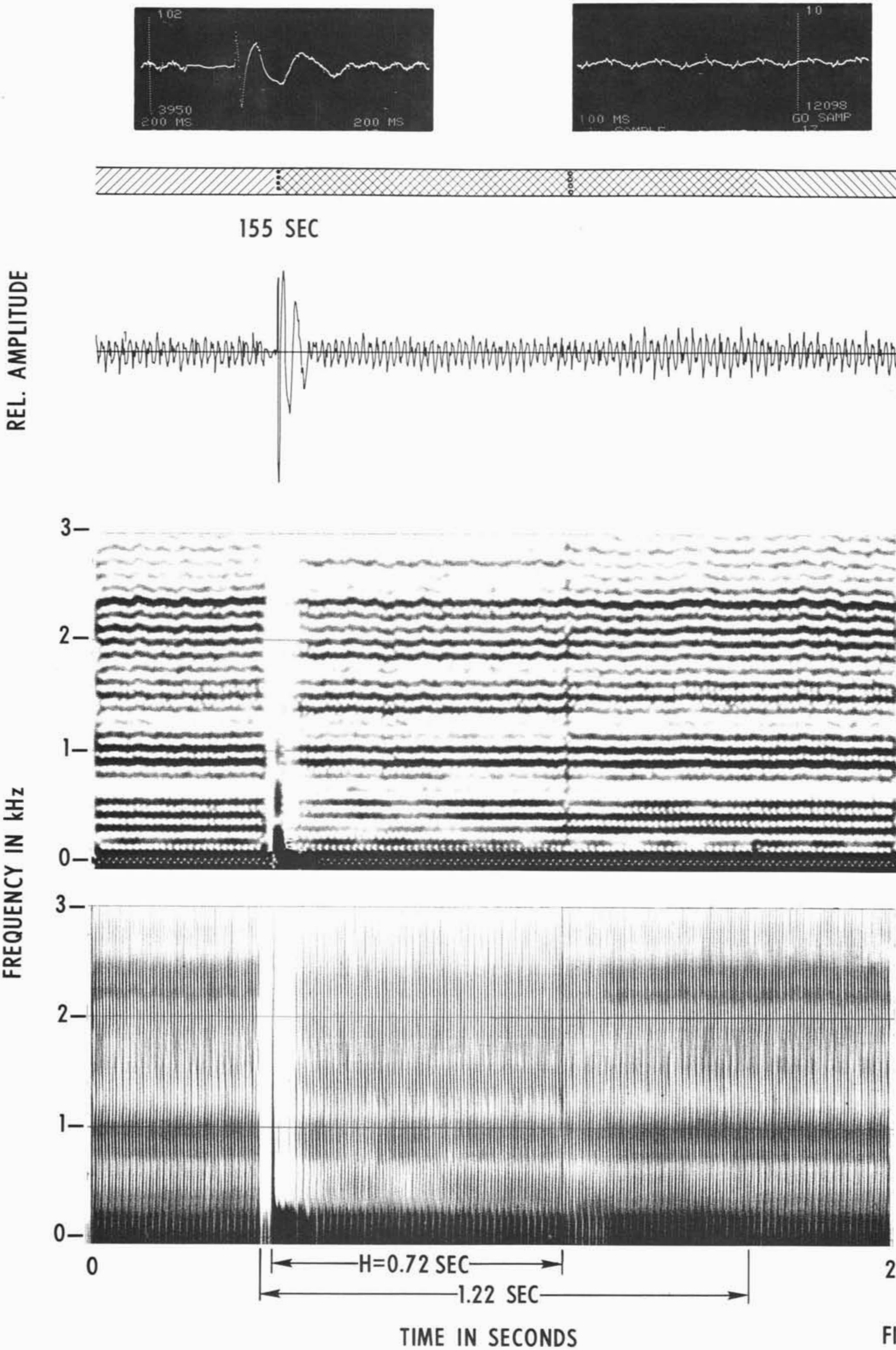

102
3950
200 MS
200 MS
10
12098
100 MS
GO SAMP
155 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
2
H=0.72 SEC
1.22 SEC
TIME IN SECONDS

FIG. 13

<u>Figure 14: Event (6), 275 Seconds:</u> The event at 275 sec. is a pronounced reduction in level with a noticeable transient pulse. At the junction, the transient click is a possible candidate for record-on but related measurements of phase and speed continuity make this possibility unlikely.

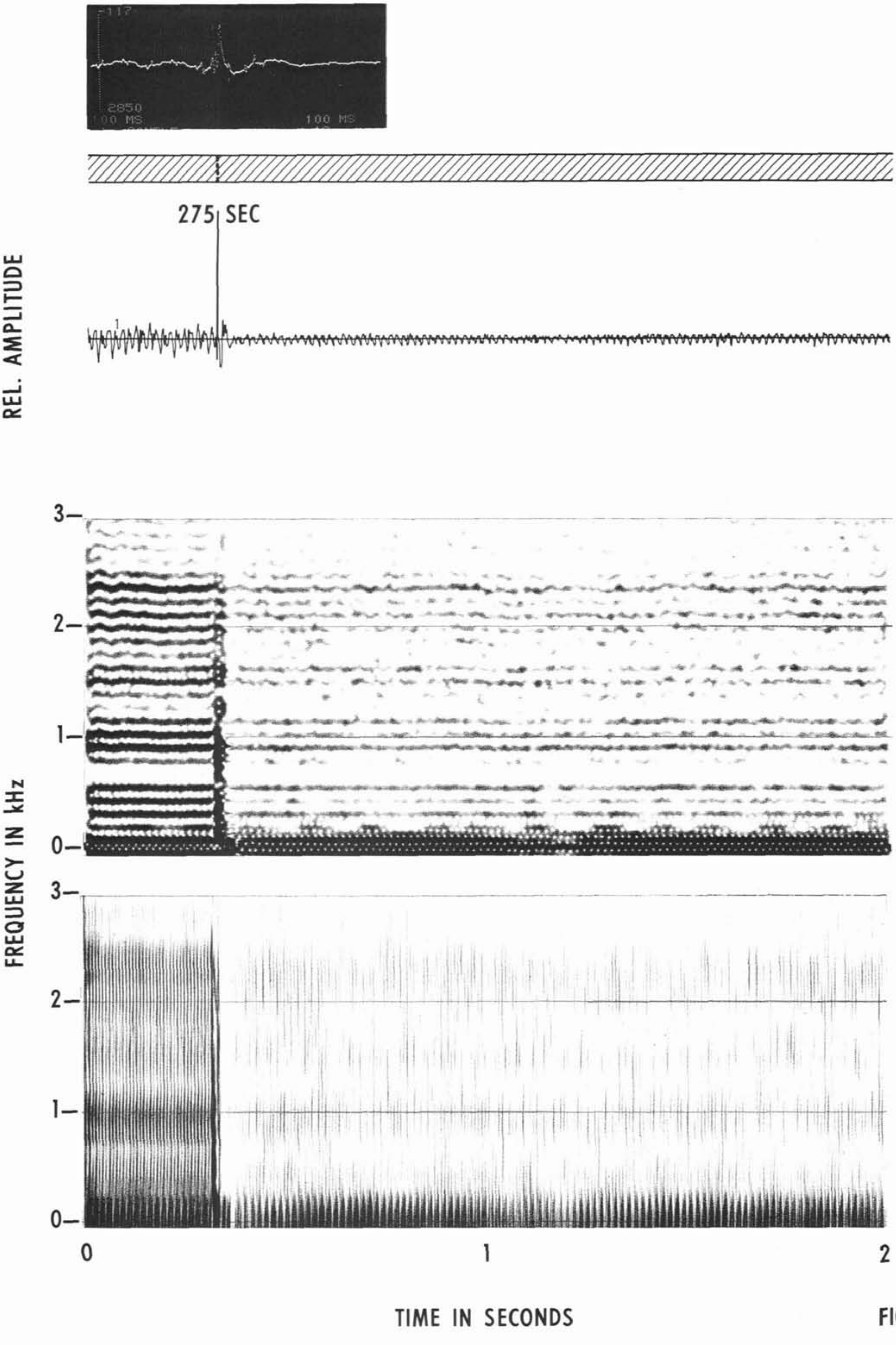
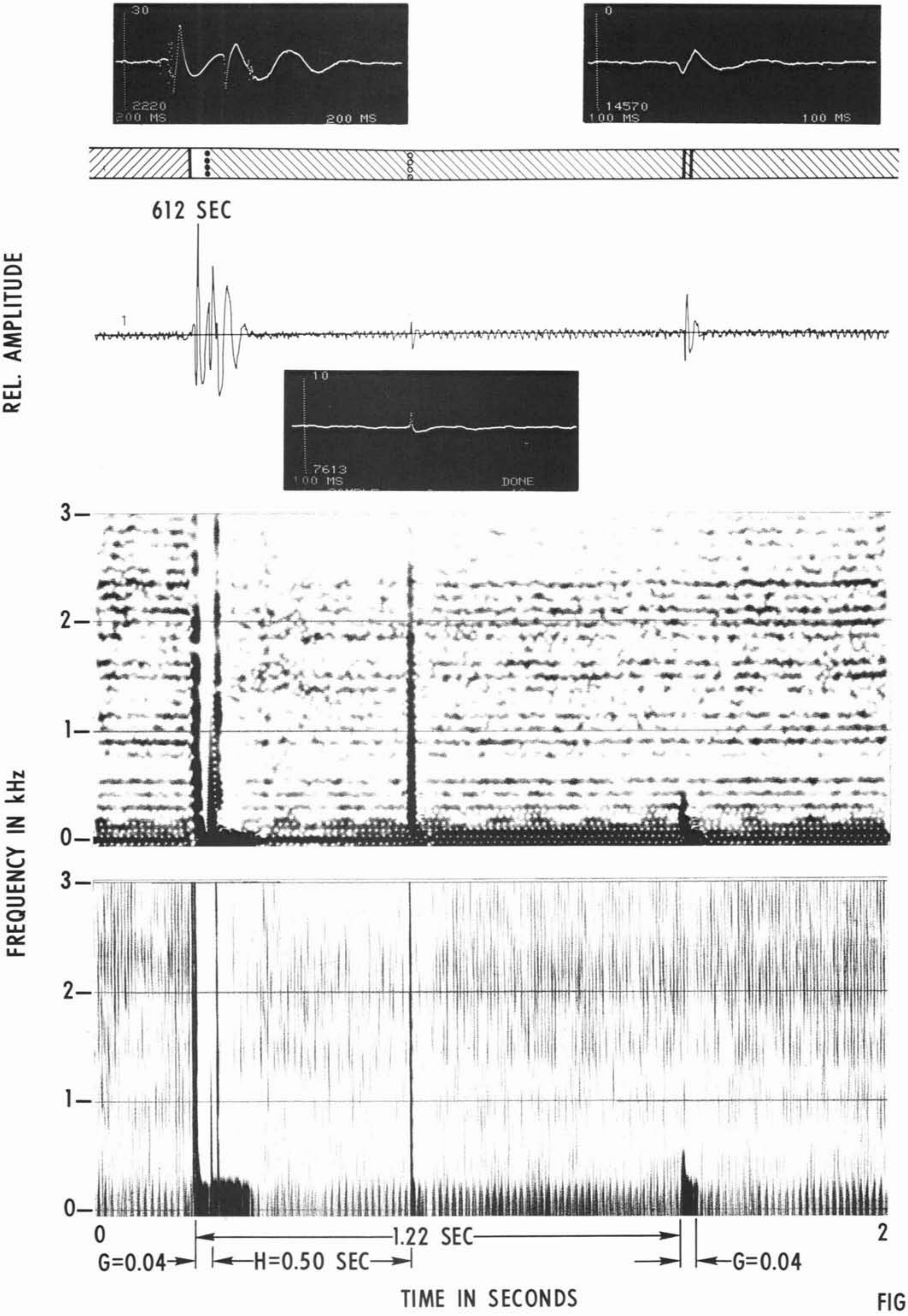

117
2850
100 MS
100 MS
275 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
TIME IN SECONDS

FIG. 14

Figure 15: Event (7), 612 Seconds: The event at 612 sec. appears to be an interrupt re-record and re-start in place. This results in a forward-spaced gap that is very brief (in this instance G = 0.04 sec., Case A). The amount of forward spacing is conditioned by factors such as the inertia of the tape drive, the tension of the tape, the time constants of the electronic and mechanical components, and the sequence of control operations.

In this instance the forward spacing is so short that the erase-head-off pulse is partially erased upon re-starting. No significant signal remnant therefore follows the erase-head-off pulse. Also appearing in the diagrams is a click transient at H = 0.50 sec. following the record on, which appears consistent with hypothesized operation of the K-1 switch.



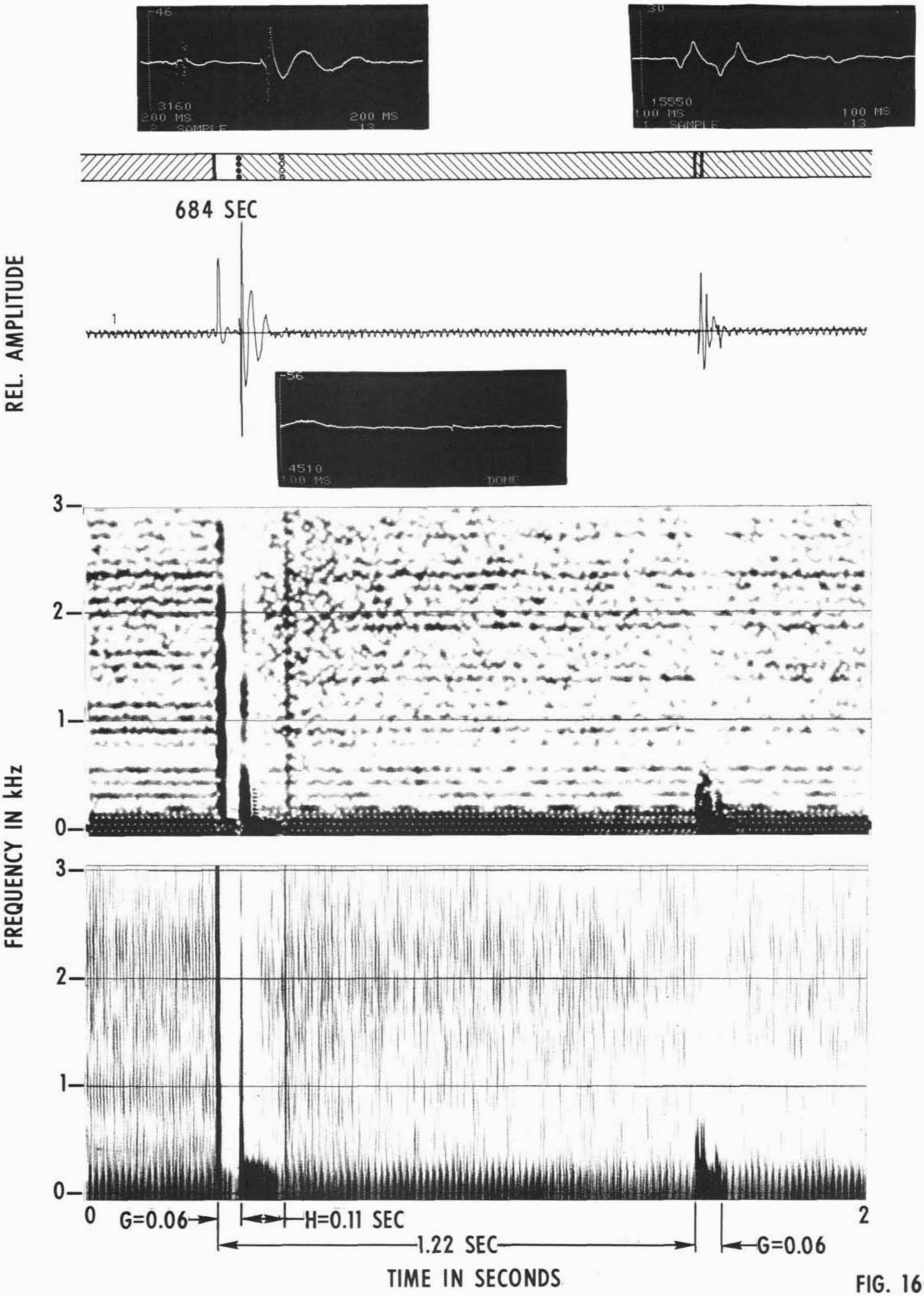
30
2220
200 MS
200 MS
0
14570
100 MS
100 MS
612 SEC
REL. AMPLITUDE
10
7613
100 MS
DONE
FREQUENCY IN kHz
3
2
1
0
TIME IN SECONDS
1.22 SEC
G=0.04
H=0.50 SEC
G=0.04

FIG. 15

<u>Figure 16: Event (8), 684 Seconds</u>: The event at 684 sec. corresponds to an interrupt re-record and re-start in place. This leads to a very brief forward positioning of the tape as described in the preceding event, 7. In the present case, however, the forward spacing is slightly greater (G = 0.06 sec., Case A). The record-head-off pulse is, therefore, followed immediately by record-head on, and the overwritten (but not erased) erase-head-off pulse appears at the interval 1.22 sec. from the record off. In this case, the gap G is long enough to see a noticeable amount of overwritten, but not erased, signal remnant immediately following the erase-head off.* A click transient appears at H = 0.11 sec. This particular transient appears different in waveform from others which seem correlated with K-1 switch activity.

---

* This signal remnant, as determined by magnetic development and as described in the caption to Fig. 8, includes a partially-erased erase-head-off pulse.



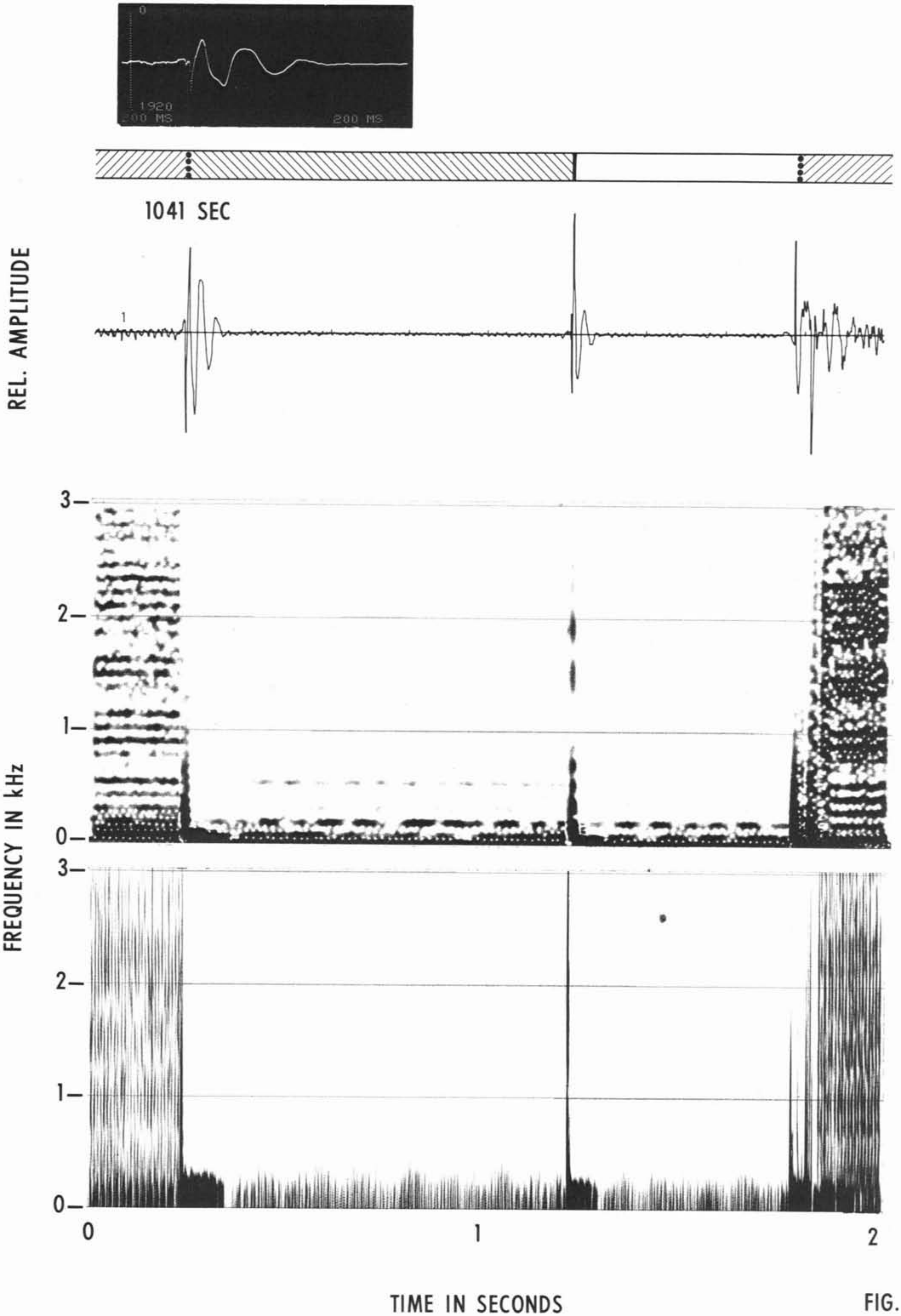
684 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
G=0.06
H=0.11 SEC
1.22 SEC
G=0.06
TIME IN SECONDS

FIG. 16

<u>Figure 17: Event (9), 1041 Seconds</u>: The event at 1041 sec. appears to be an interrupt re-record with possibly a backup that would lead to buzz-on-buzz. However, the new level of signal is very low and interfering patterns typifying buzz-on-buzz cannot be well identified. Furthermore, the re-record is terminated in about 1 sec. by a record off and a forward spacing of G = 0.55 sec., and then a record on to resume re-record (note: the spectrograms of Fig. 17 overlap in time those for the following event, Fig. 18).*

---

* Note the convention chosen for representing old and new buzz in these overlapping figures. To emphasize the relevant points in each figure, new buzz is shown after the first record-on pulse in Fig. 17 and old buzz after the second record-on. These roles are reversed in Fig. 18, to show new buzz following the record-on.



0
1920
200 MS
200 MS
1041 SEC
REL. AMPLITUDE
1
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
1
2
TIME IN SECONDS

FIG. 17

Figure 18: Event (10), 1042 Seconds: The event at 1042 sec. depicts an interrupt re-record, re-position forward by G = 0.55 sec. (consistent with human reaction time in listening for the end of a re-recorded buzz and immediately stopping the machine), and a resume re-record (Case A). The gap of 0.55 sec. leaves an appreciable overwritten speech-like remnant immediately following the overwritten erase-head-off pulse, as is consistent with the discussion of distinctive modes of re-record. The pattern is also consistent with laboratory simulations of the effect (see Section 9).

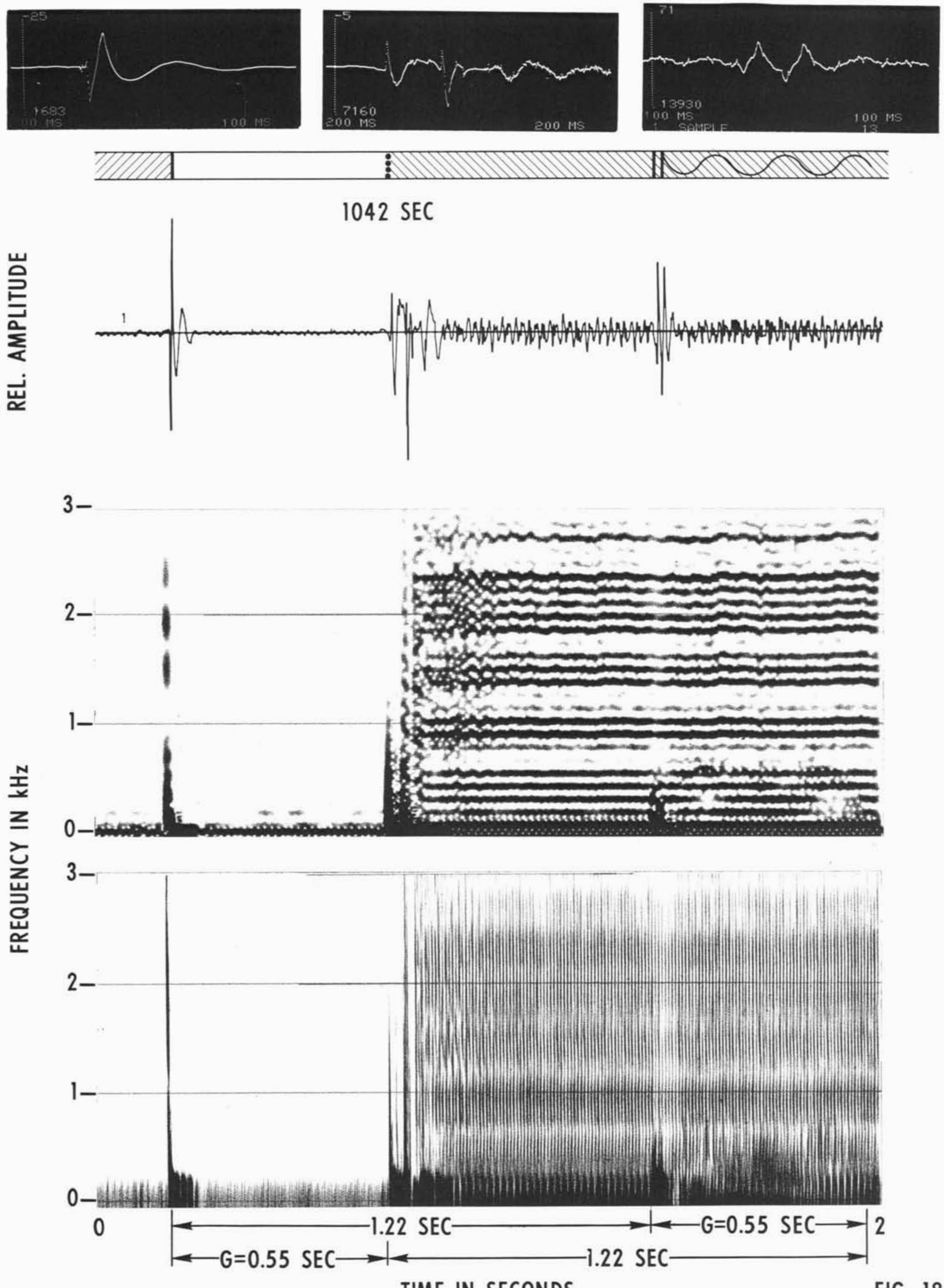

-25
1683
00 MS
100 MS
-5
7160
200 MS
200 MS
71
13930
100 MS
1 SAMPLE
100 MS
13
1042 SEC
REL. AMPLITUDE
1
FREQUENCY IN kHz
3
2
1
0
0
1.22 SEC
G=0.55 SEC
2
G=0.55 SEC
1.22 SEC
TIME IN SECONDS

FIG. 18

Figure 19: Event (11), 1061 Seconds: The event at 1061 sec. is consistent with an interrupt re-record, a backup of more than the record-to-erase distance and a resume re-record, leaving an interval of buzz-on-buzz of 1.22 sec. following the record-head on (Case D).

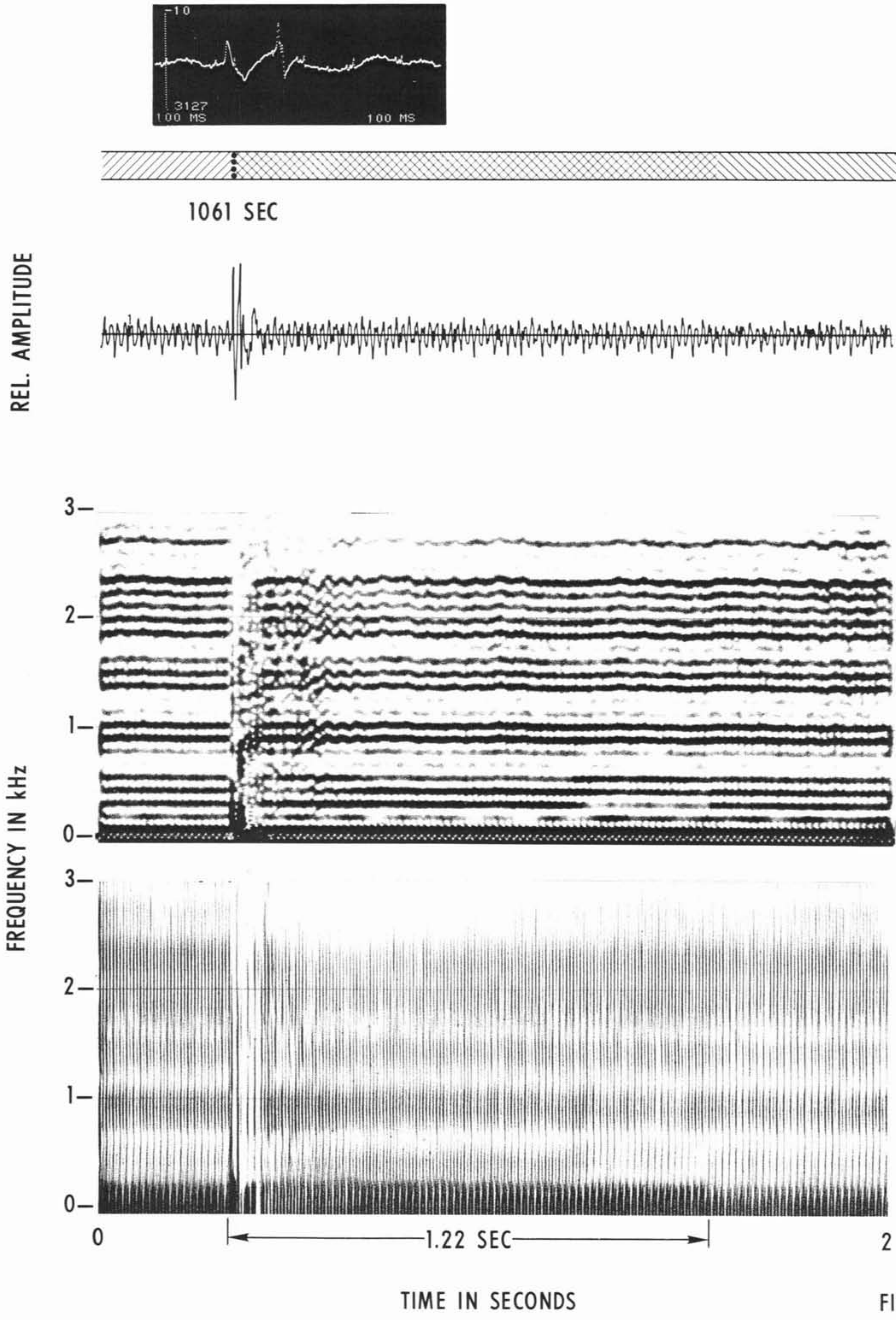
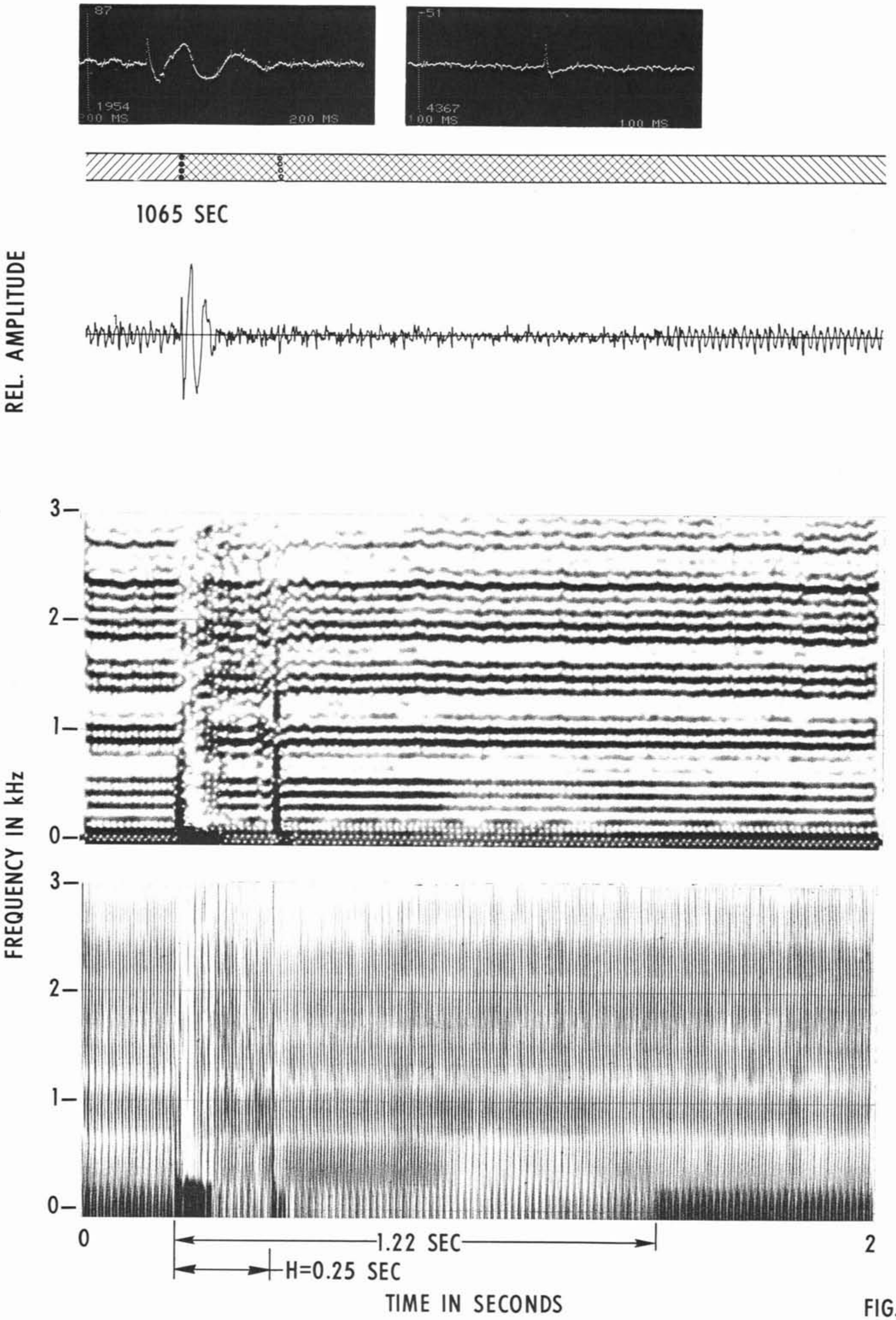

-10
3127
100 MS
100 MS
1061 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
1.22 SEC
0
2
TIME IN SECONDS

FIG. 19

Figure 20: Event (12), 1065 Seconds: The event at 1065 sec. appears to be an interrupt re-record, with a backup greater than the record-to-erase distance and a resume re-record which leaves buzz-on-buzz for 1.22 sec. (Case D). Also appearing in this event is a click transient following the record-head on (at H = 0.25 sec.) which appears consistent with keyboard-actuated K-1 switch activity in the Uher 5000.



87
1954
200 MS
200 MS
-51
4367
100 MS
100 MS
1065 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
0
2
1.22 SEC
H=0.25 SEC
TIME IN SECONDS

FIG. 20

<u>Figure 21: Event (13), 1109 Seconds</u>: The event at 1109 sec. is a clear case of end re-record (Case E), showing the record-head off followed at an interval of 1.22 sec. by the erase-head off which is neither overwritten nor erased, followed by the originally-recorded speech signal.

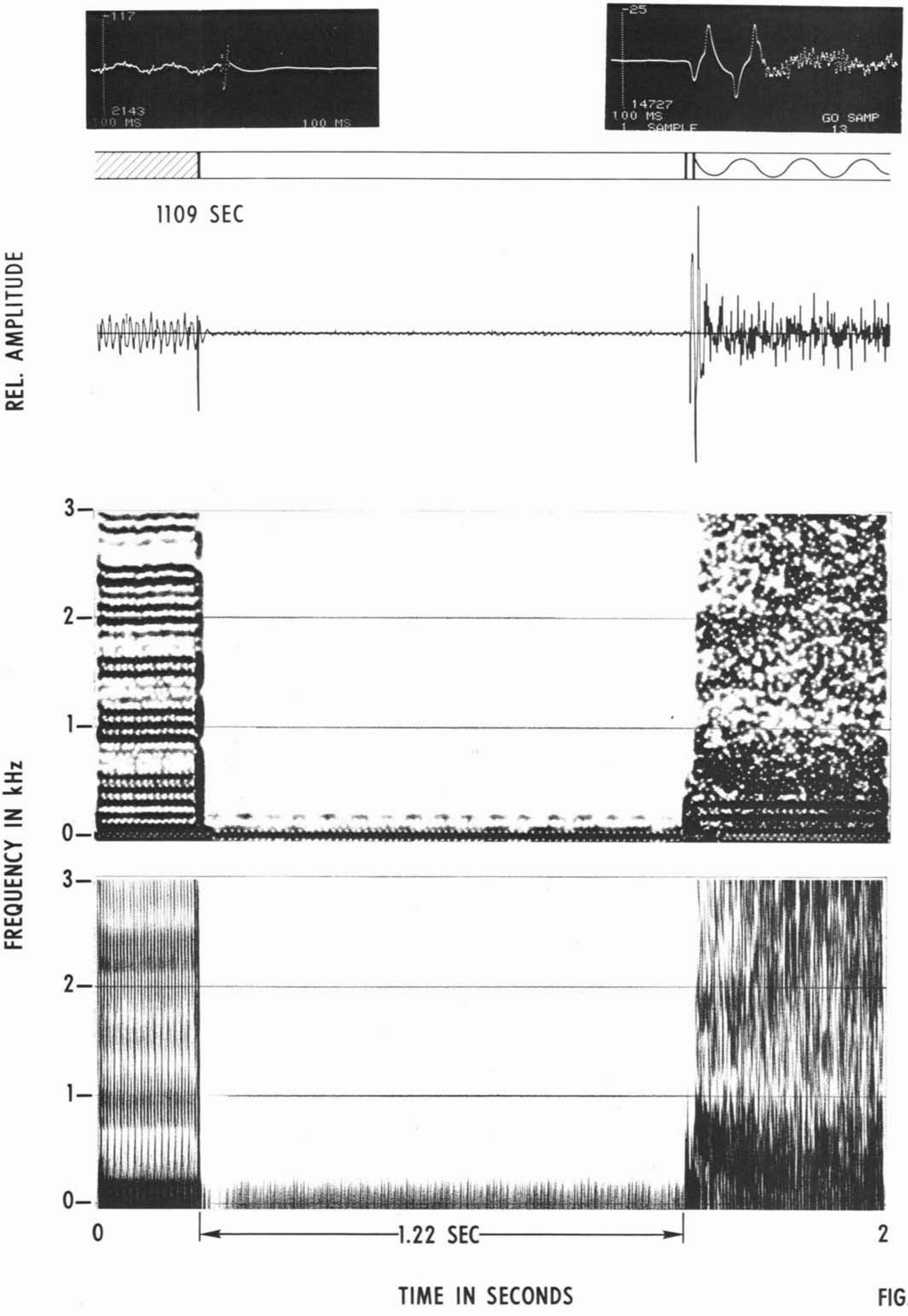

-117
2143
100 MS
100 MS
-25
14727
100 MS
1 SAMPLE
GO SAMP
13
1109 SEC
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
1.22 SEC
2
TIME IN SECONDS

FIG. 21

9. Laboratory Simulations of Electrical Events

Events reflected in the waveform and spectrographic analyses of Figs. 9 through 21 were simulated in the laboratory by making test recordings on three different machines. The three machines were:

1. Uher 5000, Government Exhibit 60
2. Sony 800B, BTL property
3. Uher 5000, Haskins Laboratories property.

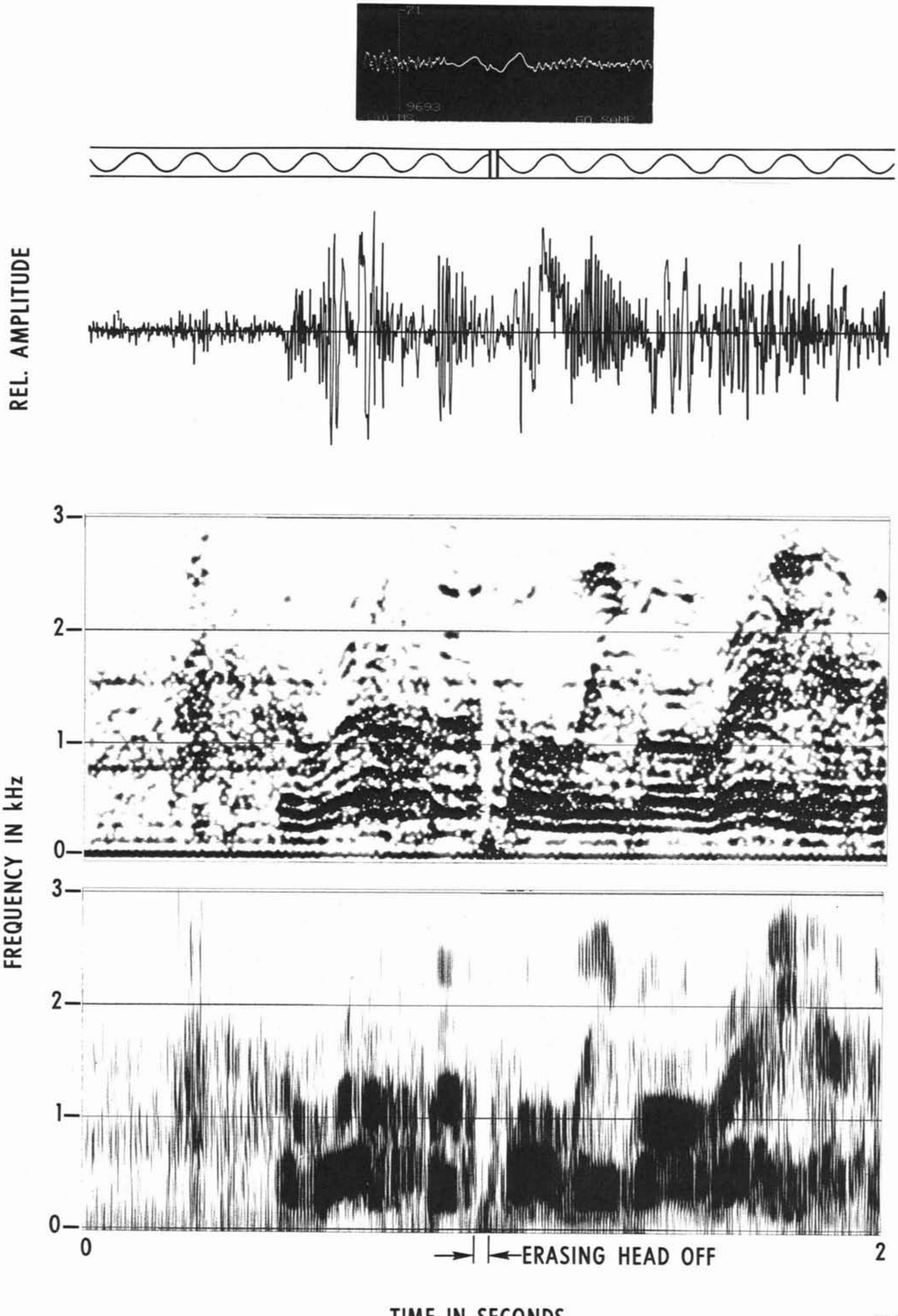
All test recordings were made at the 15/16 ips speed setting of the recorders, consistent with the 18.5 minute tape. Both sets of Uher recordings were made at the FSC laboratory and the Sony 800B test recordings were made at BTL. The recordings were played back from the Sony 800B (consistent with digitizations made directly from the original evidence tape) and the electrical signal was digitized by the DDP-224 computer, as described previously. After computer digitization, waveform and spectrogram analyses were made of the laboratory simulations. These data are displayed in the same form as used for the 18.5 minute tape.

Laboratory simulation constitutes an analysis tool for studying gross features of the principal signal events. In general, the simulations do not replicate all fine details of the events but, rather, provide overall analogies to the events.

9(a) Simulations with Uher Government Exhibit 60

Uher Exhibit 60 was used to simulate several distinctive modes of re-record. Speech was first recorded onto a new tape at FSC, using a microphone in a reverberant laboratory room. A pick-up connection was then arranged to produce a buzz signal to be used in simulating the conditions of erasing and re-recording over portions of the previously-recorded speech. The conditions simulated are illustrated in Figs. 22 through 27.

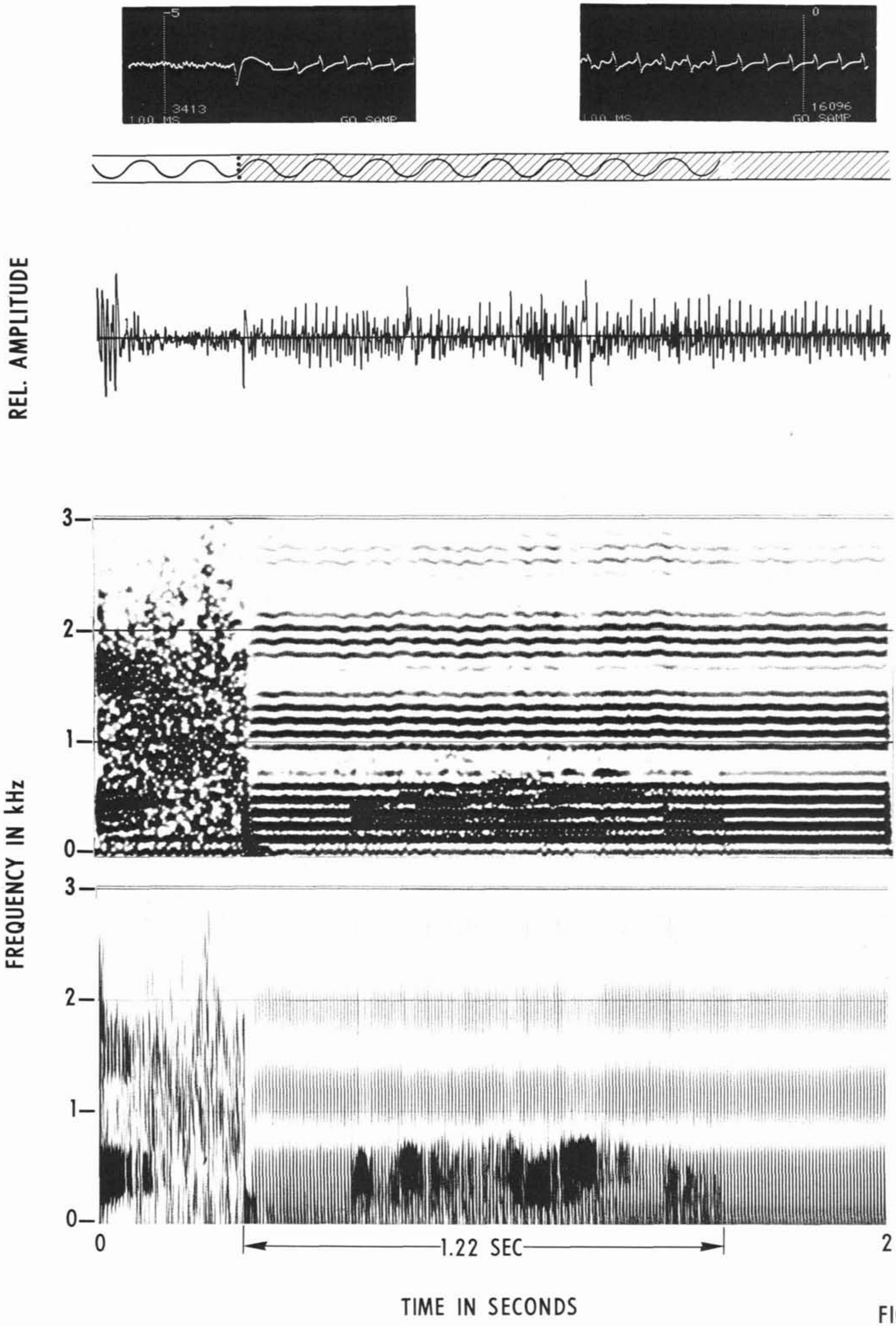
Figure 22: Figure 22 simulates an unsuccessful re-record start at a point in the speech recording. The tape is positioned for erasing and re-recording over the previously-recorded speech. The record button is first pushed (but is not held down) and then the start button is pushed which unlocks the record button, letting it pop up and superposing an erase-off pulse onto the speech signal. The tape is then carried into contact with the (now de-energized) record head and tape motion proceeds. This result should be compared with the erase-head off event at -3 sec. in the 18.5 minute tape (see Fig. 9). Notice that the relative intensity of the speech signal in the simulation is somewhat stronger than in the 18.5 minute passage.



REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
2
ERASING HEAD OFF
TIME IN SECONDS

FIG. 22

Figure 23: Exhibit 60 was used to simulate the condition of start re-record (Case S) using a relatively intense laboratory produced buzz signal to overwrite the previously-recorded speech. The figure shows the characteristic 1.22 sec. of overwritten (but not erased) speech remnant resulting from the start re-record. Compare this result to the event at 0 sec. in the 18.5 minute tape.



-5
3413
100 MS
GO SAMP
0
16096
100 MS
GO SAMP
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
1.22 SEC
2
TIME IN SECONDS

FIG. 23

<u>Figure 24</u>: Exhibit 60 was used in the laboratory to simulate the end-record condition (Case E). The figure shows the characteristic 1.22 sec. spacing, the clear erase-head-off pulse and the following speech. Compare this simulation to the event at 1109 sec. in the 18.5 minute tape.

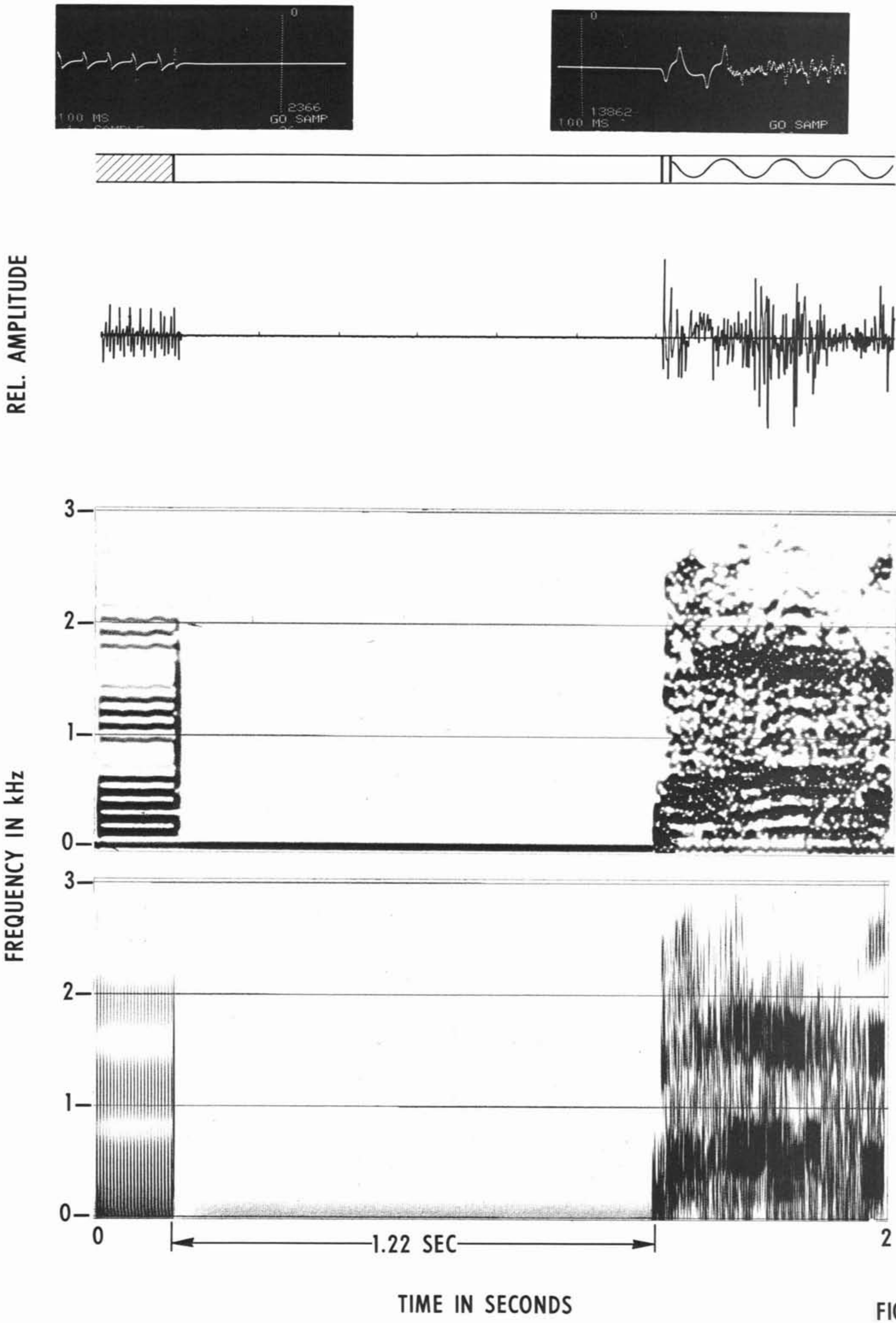

0
100 MS
2366
GO SAMP
0
13862
100 MS
GO SAMP
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
1.22 SEC
2
TIME IN SECONDS

FIG. 24

Figure 25: Still using a laboratory buzz signal, but at a somewhat reduced intensity, Exhibit 60 was used to simulate interrupt re-record, re-position forward by less than the record-to-erase head distance (G = 0.34 sec. in this case), and resume re-record (Case A). This process leaves a clean gap of G, and a speech remnant equal in duration to G following the overwritten erase-head-off pulse. Compare this simulation to the events at 49, 612, 684 and 1042 sec. in the 18.5 minute tape. Notice, too, that a click transient consistent with K-1 switch activity is evident in the simulation. Also, the relative intensities of some buzz-harmonic lines change noticeably at the time of the click transient.

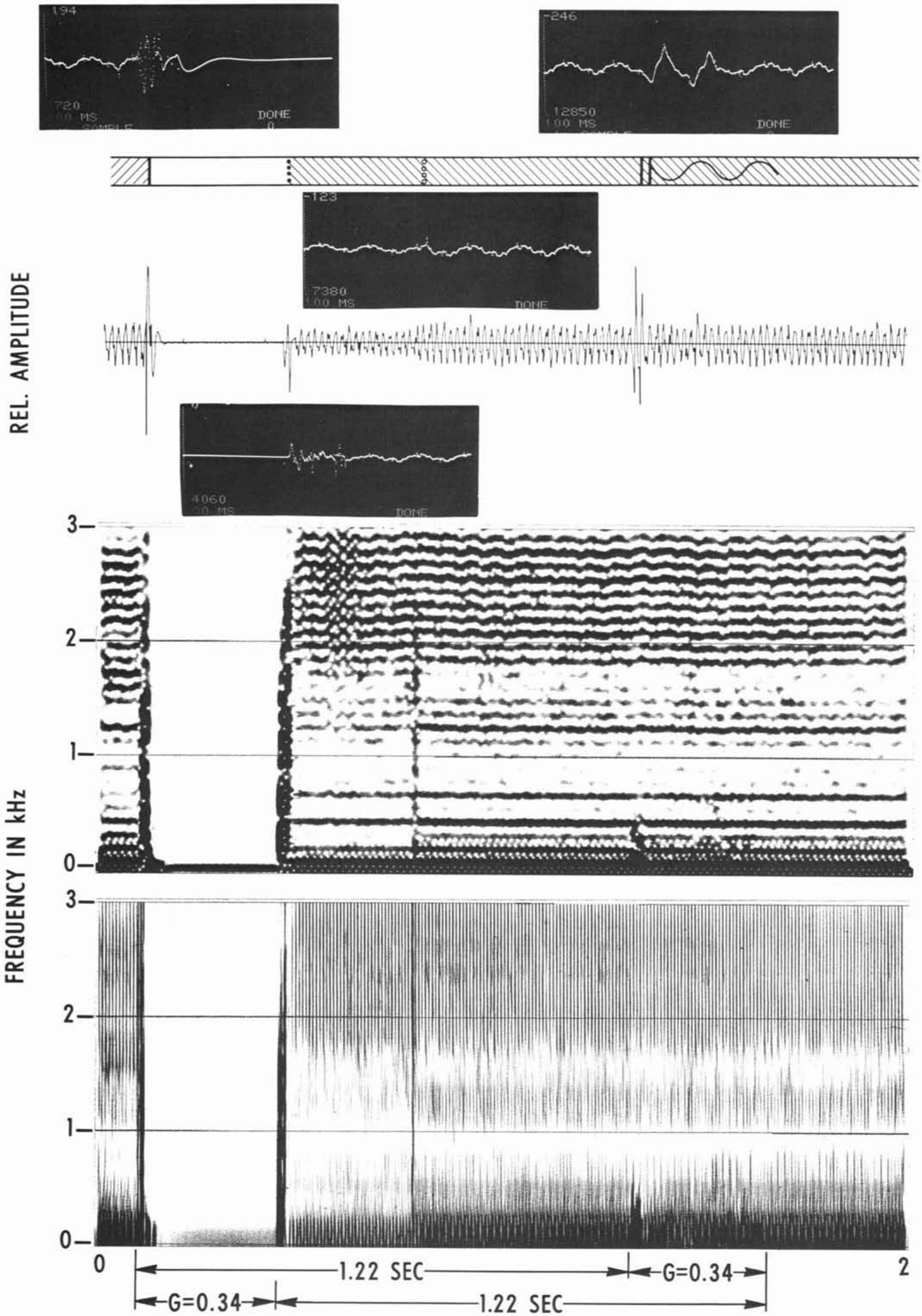
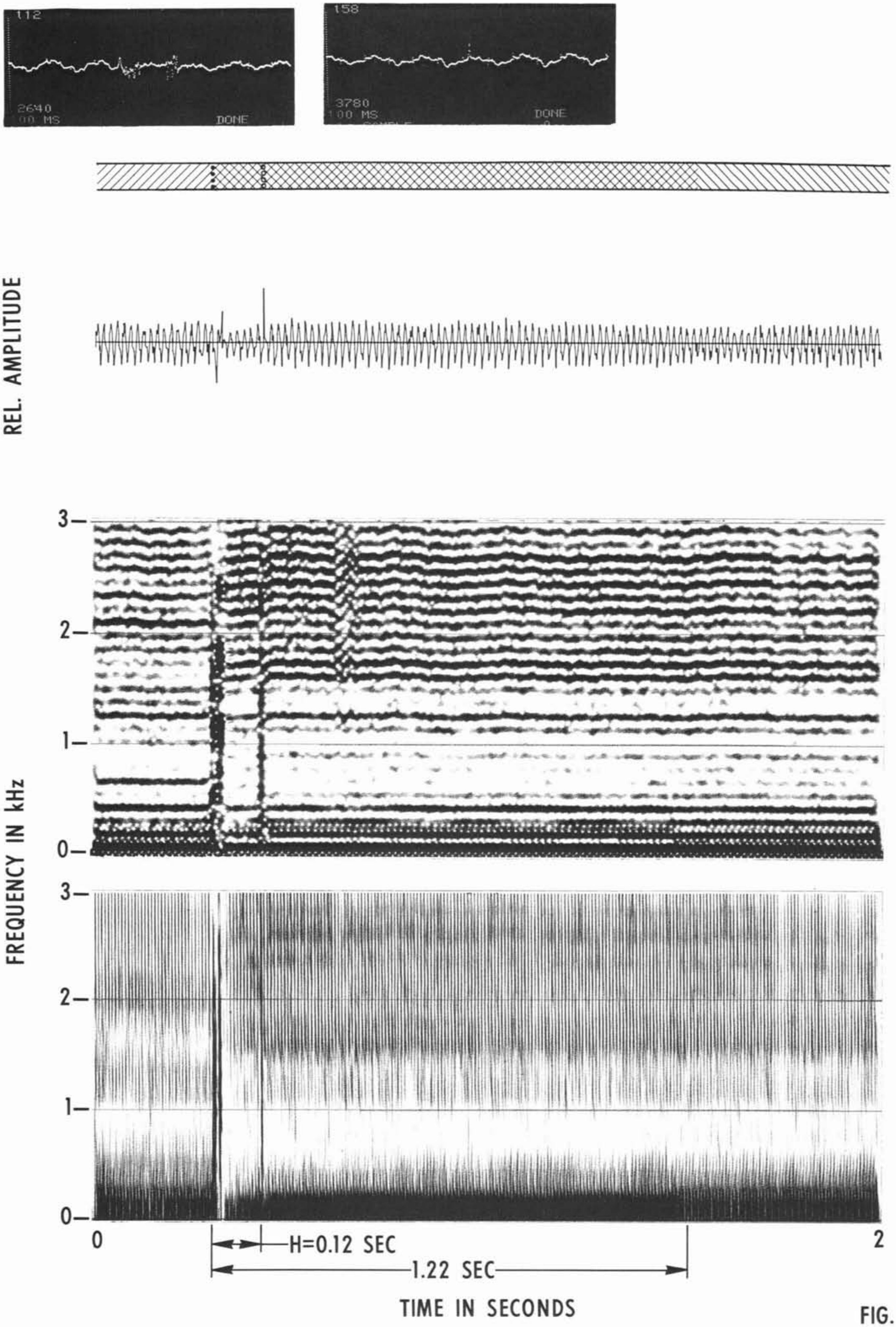

194
720
100 MS
DONE
-246
12850
100 MS
DONE
-123
7380
100 MS
DONE
4060
DONE
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
2
1.22 SEC
G=0.34
G=0.34
1.22 SEC
TIME IN SECONDS

FIG. 25

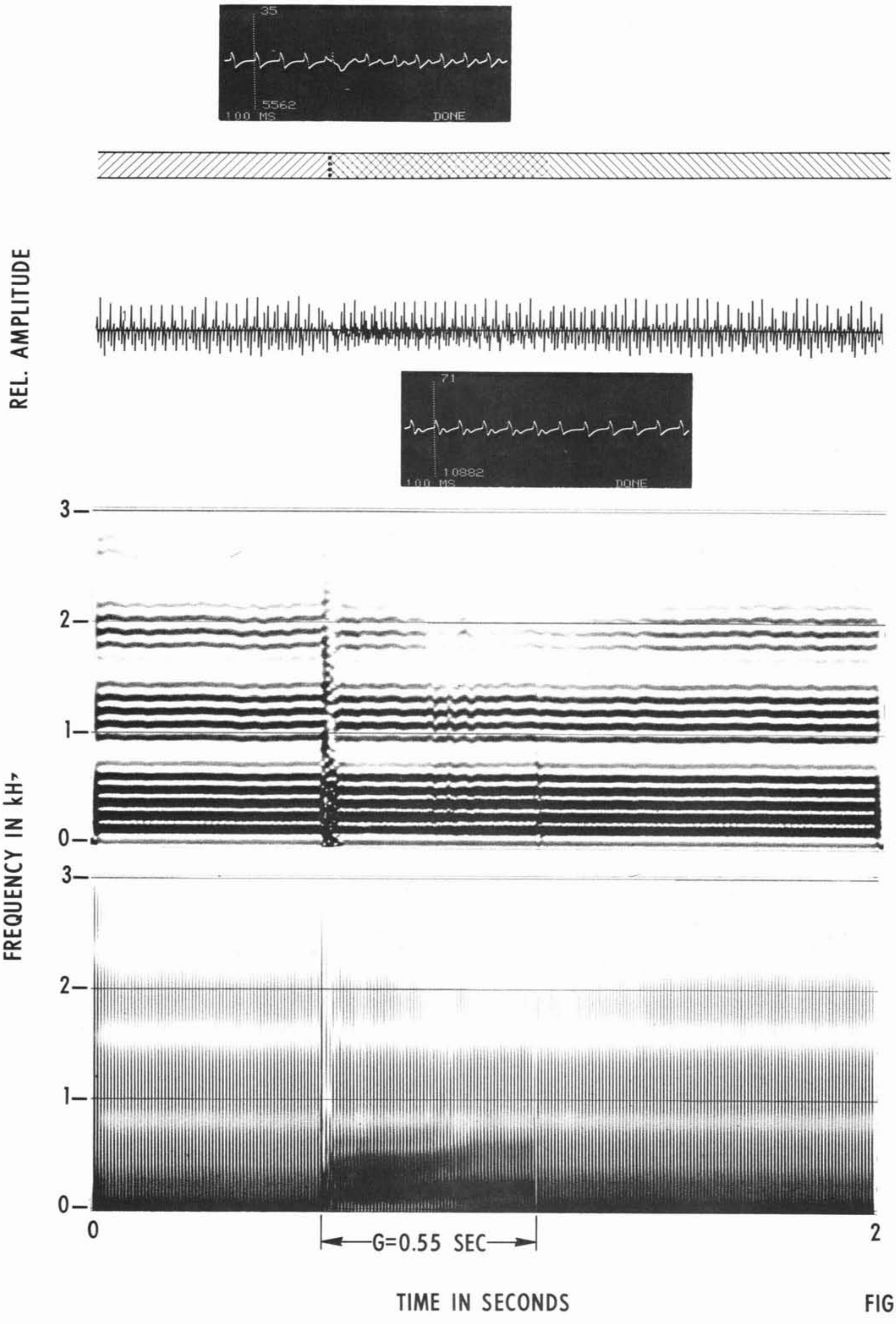
Figure 26: Uher 60 was used to simulate interrupt re-record, back space by more than the record-to-erase distance, and resume re-record (Case D). Figure 26, made with moderate intensity signal, shows buzz recorded on buzz, producing a subtly interfering pattern for the duration 1.22 sec. The figure also shows a pulse apparently associated with release of the K-1 switch at H = 0.12 sec. Note the change in the intensity of some spectral components of the buzz at this point. Compare this simulation to the events at 155, 1061 and 1065 sec. in the 18.5 minute tape.



112
2640
00 MS
DONE
158
3780
100 MS
DONE
REL. AMPLITUDE
FREQUENCY IN kHz
0
1
2
3
H=0.12 SEC
1.22 SEC
TIME IN SECONDS

FIG. 26

Figure 27: Uher 60 (using the more intense laboratory buzz signal) was used to simulate interrupt re-record, re-position backward by less than the record-to-erase-head distance, and resume re-record (Case C), producing buzz-on-buzz following a record-on pulse and for a duration less than the record-to-erase spacing (G = 0.55 sec. in this instance). Note that the over-written record-off pulse is not discernible, which strengthens the interpretation favoring K-1 switch activity in the event at 155 sec. in the 18.5 minute passage.



35
5562
100 MS
DONE
REL. AMPLITUDE
71
10882
100 MS
DONE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
G=0.55 SEC
2
TIME IN SECONDS

FIG. 27

9(b) Laboratory Simulations with the Sony 800B

A Sony 800B recorder (BTL) was used in the laboratory to test several conditions of re-record. Tape with previously-recorded speech was over-recorded at the 15/16 ips speed setting, using a 500 Hz tone to simulate a re-recorded buzz signal.

Figure 28: The condition of initiate re-record, using the Sony 800B, is illustrated in the figure (Case S). Note the 1.0 sec. of overwritten but unerased speech. This 1.0 interval is characteristic of the 800B record-to-erase head distance and is less than the Uher 5000. Also note the speed fluctuation of the tape transport in coming up to speed when actuated from the keyboard. This, too, is distinctive in comparison to the Uher 5000.*

---

* The record-on pulse for the Sony appears relatively brief and low in amplitude. The record-off pulse and the erase-off pulse are larger in amplitude and are shown in expanded form in Fig. 30.

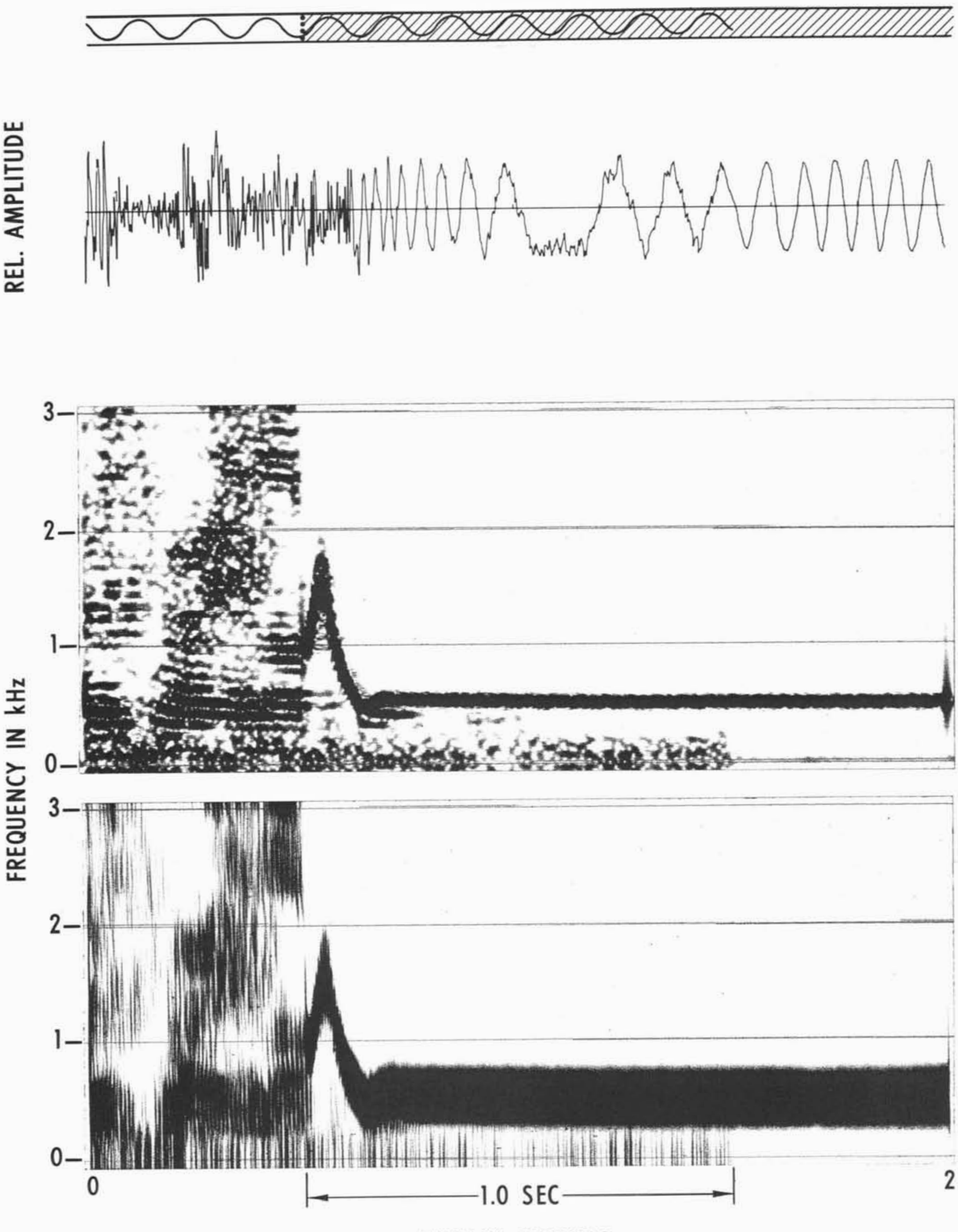

REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
0
1.0 SEC
2
TIME IN SECONDS

FIG. 28

Figure 29: The Sony 800B was used to simulate the condition of interrupt re-record, position forward by less than the record-to-erase distance (G = 0.55 sec. in this instance) and resume re-record (Case A). The re-recording with the 500 Hz tone produces an overwritten speech remnant equal in duration to G following the overwritten erase-head off-pulse.

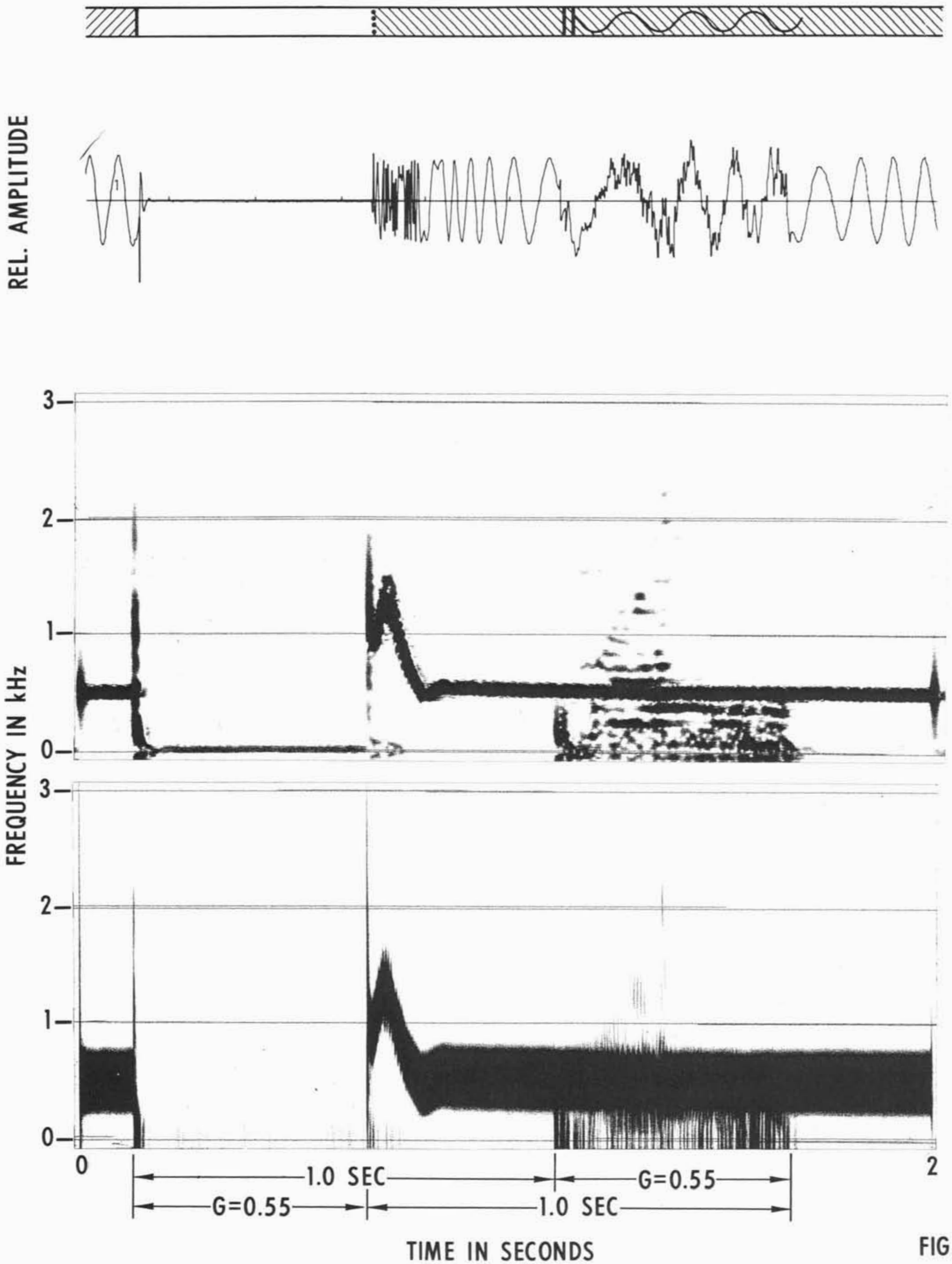

REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
2
1.0 SEC
G=0.55
G=0.55
1.0 SEC
TIME IN SECONDS

FIG. 29

<u>Figure 30</u>: The Sony 800B was used to simulate termination of re-record, still using the 500 Hz tone to over-record a previous speech signal (Case E). The figure reflects the 1.0 sec. interval corresponding to record-to-erase-head distance for the Sony 800B, and the clear erase-head-off pulse followed by the original speech. Note, too, the character of the Sony 800B erase-head off pulse, and its distinctive difference from the Uher 5000 erase-head-off pulse. The Sony erase head has a single air gap whereas the Uher erase head has a double air gap.

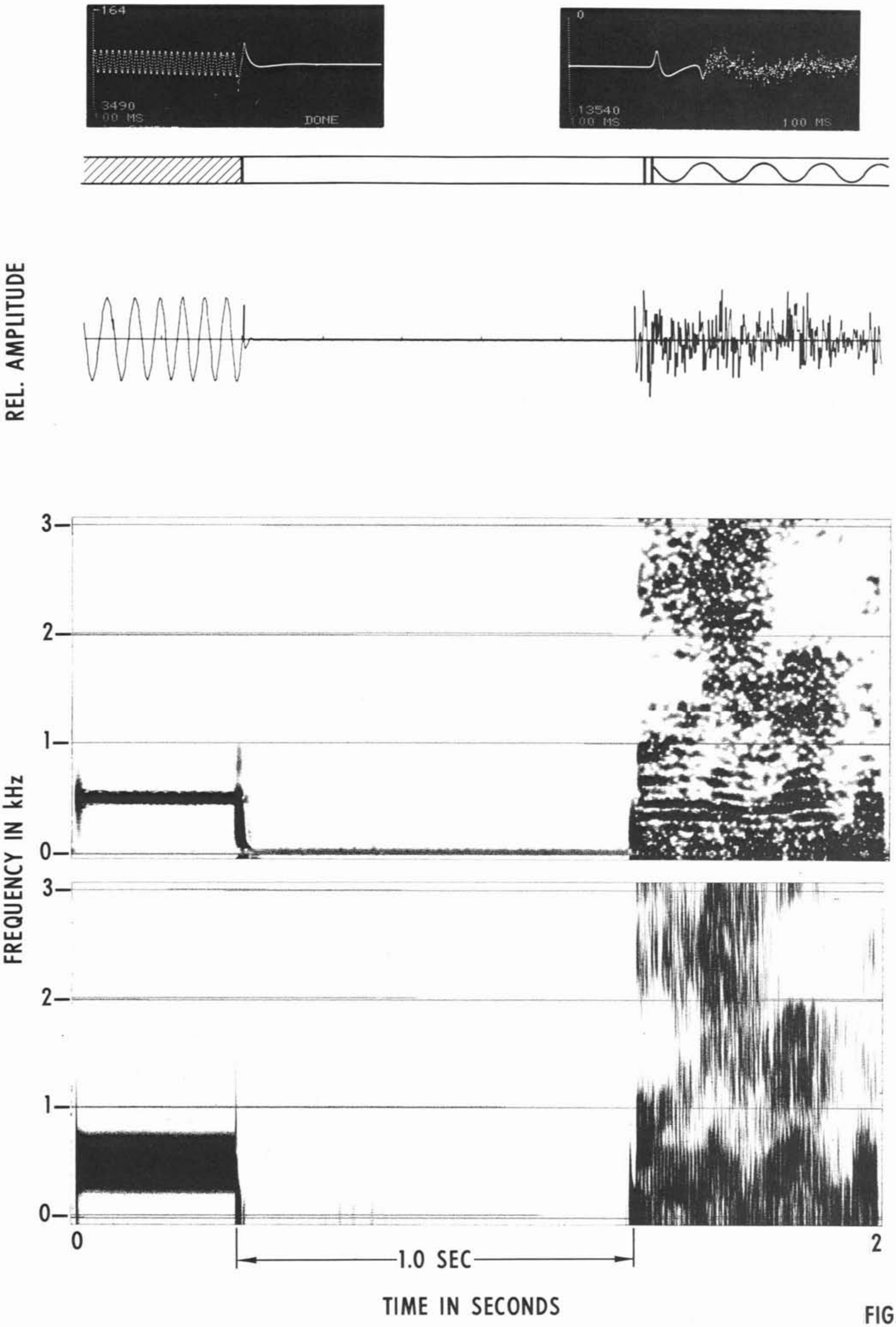

-164
3490
100 MS
DONE
0
13540
100 MS
100 MS
REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
0
1.0 SEC
2
TIME IN SECONDS

FIG. 30

9(c) Laboratory Simulations with the Haskins Uher 5000

The Haskins Laboratories Uher 5000 machine was used in the laboratory (at FSC) to simulate several conditions of re-record.

Figure 31: The figure shows a 500 Hz tone used to over-record a previously-recorded speech signal. The figure shows the condition of start re-record (Case S). An overwritten speech remnant of 1.20 sec. is produced. This interval appears distinctively shorter than the corresponding interval for Government Exhibit 60.* Also the transient speed buildup of this Uher 5000 machine appears somewhat different from Uher 60.

---

* The record-to-erase-head distance of the Haskins Uher was measured at FSC and found to be 28.1 mm. This distance is 0.5 mm shorter than that for Uher Exhibit 60. In tape playback, the BTL Sony 800B converts this distance into the interval 1.20 sec.

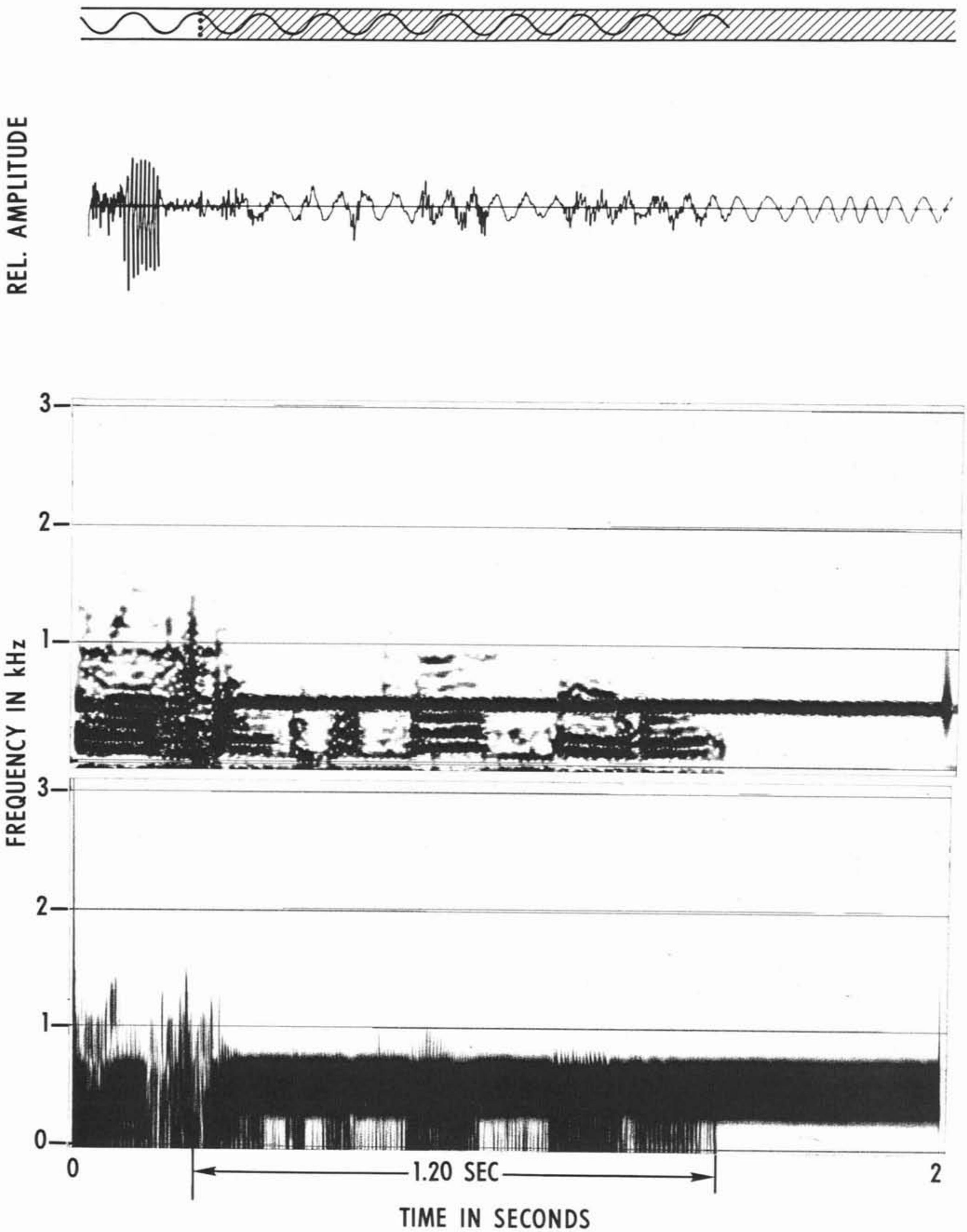

REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
3
2
1
0
0
1.20 SEC
2
TIME IN SECONDS

FIG. 31

Figure 32: The Haskins Uher 5000 was used in the laboratory to simulate interrupt re-record, re-position forward and resume re-record, with a 500 Hz tone being re-recorded onto the previous speech (Case A). This forward-spaced gap corresponds to an actual human reaction time in listening to a playback of the recorded tone and stopping as soon as possible upon hearing the end of the recorded tone. In this case G = 0.47 sec., and a corresponding speech remnant of that duration follows the overwritten erase-off pulse. This value of G from the simulation can be compared to those measured at 49 sec. and 1042 sec. in the 18.5 minute tape.

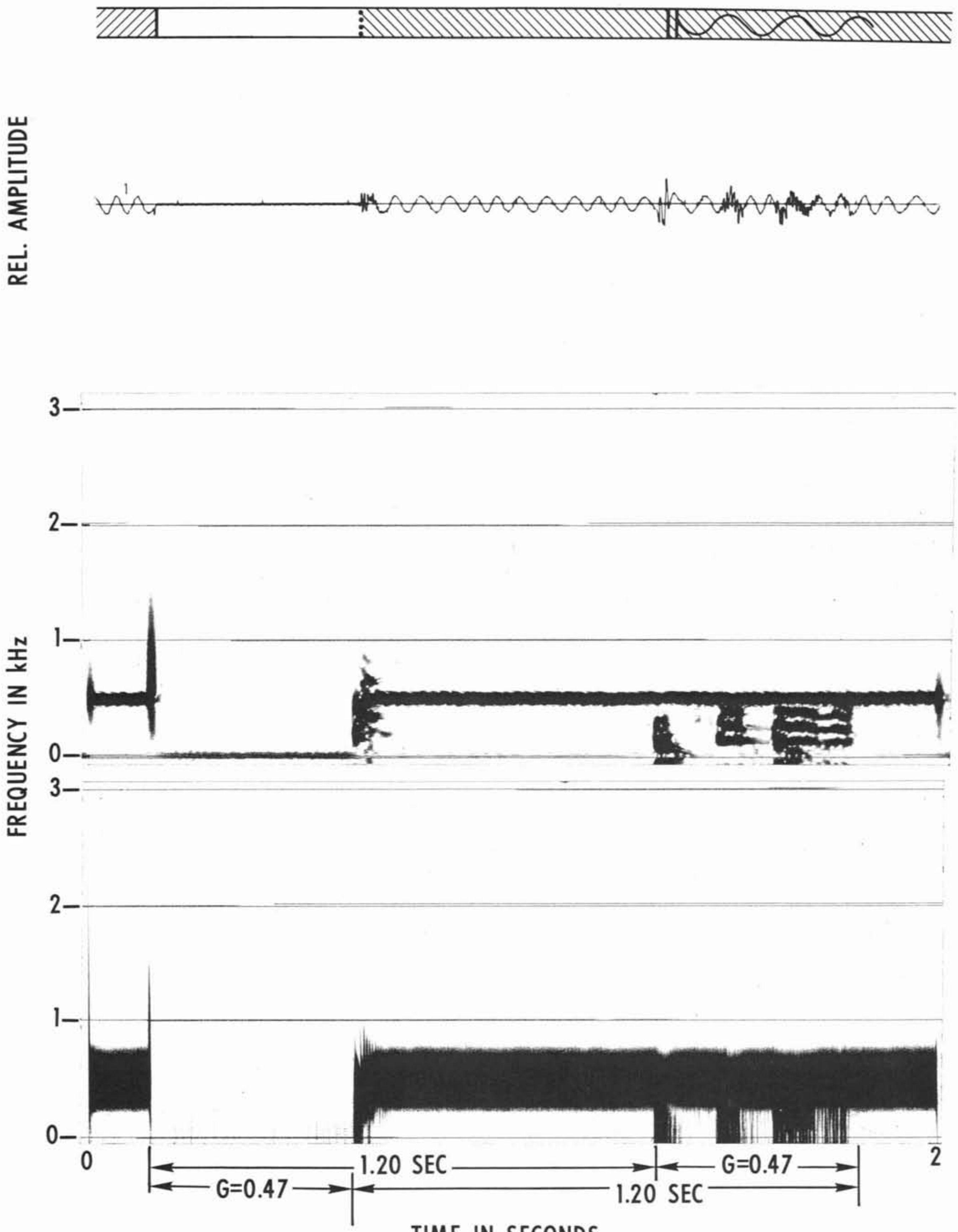

REL. AMPLITUDE
FREQUENCY IN kHz
3
2
1
0
3
2
1
0
0
2
1.20 SEC
G=0.47
G=0.47
1.20 SEC
TIME IN SECONDS

FIG. 32

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