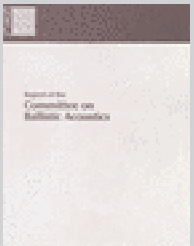

Report of the Committee on Ballistic Acoustics

Committee on Ballistic Acoustics, National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

At the time of the assassination of President Kennedy the Dallas police recorded sounds from an open microphone; these sounds have been previously analyzed by two research groups at the request of the House Select Committee on Assassinations. Both groups concluded with 95% probability that the recordings contained acoustic impulses which provide evidence for the existence of a shot from the grassy knoll area of Dealey Plaza. On the basis of these results and since shots definitely were fired from the Texas School Book Depository, the House Committee concluded that “scientific acoustical evidence establishes a high probability that two gunmen fired at President John F.Kennedy”.

In response to a request from the Department of Justice, the National Research Council Committee on Ballistic Acoustics has over the past year studied these reports and the Dallas Police recording on which they are based.

Since the recorded acoustic impulses are similar to static, efforts to attribute them to gunshots have depended on echo analyses; but in these analyses desirable control tests were omitted, some of the analyses depended on subjective selection of data, serious errors were made in some of the statistical calculations, incorrect statistical conclusions were drawn and the analysis methods used were novel in some aspects and were untested at such high levels of background noise. Furthermore, some of the recorded background sounds, such as the delay in the sounds of police sirens, are not what one would expect if the open microphone had been in the motorcade. For these and other reasons discussed in the report, the Committee concluded that the previous acoustic analyses do not demonstrate that there was a grassy knoll shot. The Committee reached this conclusion prior to the availability of conclusive evidence (which we now describe) that the acoustic impulses were recorded on Channel I approximately one minute after the assassination.

Following a suggestion volunteered by Steve Barber of Mansfield, Ohio, that the acoustic impulses are overlapped by an almost unintelligible voice transmission on Channel I which might be identified as cross talk from Channel II, the Committee had sound spectrograms made of the appropriate portions of both channels. Copies of these sound spectrograms and analyses of them are included in Section IV of the report.

The sound spectrograms show conclusively that the portion of the Channel I recording with the acoustic impulses also contains a weak recording on Channel I of cross talk from Channel II of a message broadcast approximately one minute after the assassination. The Committee has examined the possibilities that the Channel II cross talk might have been overrecorded at a later time on top of the Channel I acoustic impulses or that the Dictabelt examined was a copy with cross talk superposed during copying. The Committee concluded that such scenarios not only are highly contrived and unlikely but also are contrary to physical and acoustic evidence, such as the effect of Channel I heterodyne tones in suppressing cross talk from Channel II. This identification of cross talk between Channels I and II shows conclusively that the previously analyzed sounds were recorded about one minute after the assassination and, therefore, too late to be attributed to assassination shots. A similar conclusion is reached independently by the analysis of the times of the acoustic impulses of intelligible cross talk between the two channels more than three minutes after the assassination. This analysis shows that the previously studied acoustic impulses were recorded after the motorcade was instructed to go to Parkland Hospital.

The Committee report lists a number of possible further studies of the Channel I recording and of related matters, but, because of the strength of the demonstration that the acoustical evidence for a grassy knoll shot is invalid, the Committee believes that the results to be expected from such studies would not justify their cost.

For these reasons and for others given in detail in the report, the National Research Council Committee on Ballistic Acoustics unanimously concludes that:

— The acoustic analyses do not demonstrate that there was a grassy knoll shot, and in particular there is no acoustic basis for the claim of 95% probability of such a shot.
— The acoustic impulses attributed to gunshots were recorded about one minute after the President had been shot and the motorcade had been instructed to go to the hospital.
— Therefore, reliable acoustic data do not support a conclusion that there was a second gunman.

I. INTRODUCTION AND OVERVIEW

At the time of the John F.Kennedy assassination, a microphone, presumably on a police motorcycle, was stuck open and transmitted continuously on Dallas Police Department Channel I during the time of the assassination, making a record of the transmissions on a Dictaphone belt recorder model A2TC. At the request of the House Select Committee on Assassinations, this belt and magnetic tape copies of it were studied by James Barger, Scott Robinson, Edward Schmidt and Jared Wolf (BRSW) of Bolt Beranek and Newman Inc., and later by Mark Weiss and Ernest Aschkenasy (WA) of Queens College. In an initial report to the House Select Committee on Assassinations on September 11, 1978, and in a later report in January 1979, BRSW concluded[1] that the recording contained four sounds, which they attributed to probable gunshots, and that with a probability of 50 per cent, one of them (the third) was due to a shot from the grassy knoll area of Dealey Plaza. Later, WA studied the echo patterns analytically and their conclusion[1] was that “the odds are less than 1 in 20 that the impulses and echoes were not caused by a gunshot from the grassy knoll, and at least 20 to 1 that they were.” BRSW subsequently reviewed the results of WA and concluded[1] that “the probability that they obtained their match because the two matched patterns were due to the same source (gunfire from the knoll) is about 95%.” This conclusion, together with the known shots from the Texas School Book Depository, was the basis of the finding by the House Select Committee on Assassinations that “scientific acoustical evidence establishes a high probability that two gunmen fired at President John F.Kennedy.”

On December 1, 1980, the Federal Bureau of Investigation (FBI) released a report, prepared by its Technical Services Division and dated November 19, 1980, with the findings that the above conclusion of the House Select Committee on Assassinations was not valid and that the acoustical evidence presented “did not scientifically prove that the Dictabelt recording on Channel 1...contains the sounds of gunshots or any other sounds originating in Dealey Plaza....”

The Committee on Ballistic Acoustics was established by the National Research Council in the fall of 1980 in response to a request from the Department of Justice for a review of the methodology employed in the evaluations of the recorded acoustic data and of the conclusions about the existence of a shot from the grassy knoll. The Committee was also asked to recommend the kinds of tests, analyses, and evaluations needed to obtain better information from the recording.

Copies of the BRSW, WA, and FBI reports were distributed to members of the Committee before its first meeting, both for study and to make possible the distribution of questions in advance to guests invited to meet with the Committee. On January 31 and February 1, 1981, the Committee met with James Barger and Francis Jackson of Bolt Beranek and Newman Inc., with Mark Weiss and Ernest Aschkenasy of Queens College and with Bruce E.Koenig and others from the FBI Technical Services Division. Subgroups of the Committee have had many separate meetings and have carried out numerous individual studies, the results of which have been distributed to all members. The Committee as a whole met a second time on November 14–15, 1981. The Committee benefitted from numerous communications it received from various interested persons. In particular, the manuscript for “The Kennedy Assassination Tapes” by James Bowles, Communications Supervisor of the Dallas Police Department at the time of the assassination, and the cross talk identifications, suggested by Steve, Barber, a private citizen of Mansfield, Ohio, were of great help to the Committee. Burn Lewis and Ramesh Agarwal of the IBM Corporation assisted the Committee with the digitized studies of the recordings. The Committee would like to express its appreciation to all these people, as well as to Bruce Koenig and others of the FBI who assisted the Committee in producing crucial sound spectrograms.

In the first months of its existence the Committee studied the analytical techniques used by BRSW/WA. These techniques are briefly summarized in Section II of this report. As a result of these studies, Committee members found errors in the previous studies and faults of methodology, described in Section III. These faults were sufficiently serious that, by the end of the first Committee meeting, no member was convinced by previous acoustic analyses that there was a grassy knoll shot.

The Committee agreed to continue its studies to challenge its own conclusion and to search for additional acoustic evidence. The Committee was greatly helped in its studies by the suggestion volunteered by Steve Barber that in the same tape position as the relevant acoustic impulses there was an almost unintelligible voice communication which he thought was cross talk from the Dallas Police Department Channel II, as recorded on a Gray Audograph disk. On the day of the assassination, Channel I was primarily used for normal police activities and Channel II was used for the presidential motorcade. The quality of the recorded cross talk was so poor that the Committee could not conclude by listening to the recordings the two messages were the same. However, the Committee made sound spectrograms, copies of which are included in Section IV-1. As discussed in that section and in Appendix B, a number of different analyses of the sound spectrograms of those portions of the recordings (identified as the "hold everything..." segments) show conclusively that a segment of Channel II is recorded on the Channel I Dictabelt at the same location as the relevant acoustic impulses. From the Channel II recording it is clear that the message of concern was broadcast one minute after the assassination. Except for the unlikely possibility of an overrecording with two superposed recordings at different times on the Channel I Dictabelt, which is contrary to the evidence discussed in Section IV-4, this identification between the two channels shows that the sounds analyzed by BRSW/WA occurred one minute after the President had been shot and the motorcade had left Dealey Plaza.

A second demonstration of the same conclusion involves a more obvious and later instance of cross talk between the two channels; no sound spectrograms are needed to identify the "Do you want...Stemmons" sections on both channels. This analysis is discussed in Section IV-3 and Appendix C. By tracing time backward from that match on both channels, the Committee found that the President received his mortal shot at least 30.9 seconds before the impulses analyzed by BRSW/WA. The uncertainty in the exact timing discrepancy arises from the fact that the Channel I recorder operated continuously, whereas the Channel II recorder operated intermittently and was supposed to stop after 4 seconds of silence. So in all cases when the Channel II recorder was inoperative, the “missing time” must be added to the “at least 30.9 seconds” noted previously. The Committee's two quite different techniques for determining the length of time between the real assassination and the one deduced from the study of sounds on the Channel II tape can, of course, be brought into agreement, at one minute, by the reasonable assumption that the Channel II recorder was not operating for a total of 44 seconds in a section of the recording in which the recorder operated for 206 seconds and in which there are many places where there are 3 to 6 seconds of recording silence. The recorder may have stopped during some of these times and it definitely did stop for 2.9 seconds during one of them.

It is important to note that this second timing method cannot be brought into agreement with the timing demanded by the BRSW/WA analysis unless one assumes that there are backward skips totaling 30.9 seconds on the analyzed playbacks of Channel II or that there is overrecording; the tapes show no evidence of the backward skips required by the BRSW/WA analyses. For the timing method based on the “hold everything” analysis, the recorded impulses could come from assassination shots only if there were accidental or intentional overrecording. The Committee investigated possibility of overrecording by microscopic examination of the grooves on the Dictabelt, by examining the effects of heterodynes on the intensities of the sound spectrograms and by examining the possibilities by which overrecording could have occurred and then have been hidden, either accidentally or on purpose. These investigations are reported in Section IV-4 and Appendix D. For the reasons discussed there, the Committee concluded that the BRSW/WA timing could not be made compatible with the observed Channel I and Channel II cross talk.

Features of the recorded sounds, especially the siren sounds, strongly suggest that the open microphone was not in Dealey Plaza at the time of the assassination, even though the BRSW/WA analysis required it to be there and, in fact, identifies the open microphone explicitly as on the motorcycle of Officer McLain.

A feature of the Channel I tape that has puzzled most persons who have listened to it is the complete absence of siren sounds for about two minutes after the time BRSW/WA pinpointed as that of the assassination. Witnesses have testified that soon after the assassination many sirens were activated in the motorcade, as anyone would have predicted. Although the sirens could be partially suppressed by the microphone directivity and the high level of background noise, their total absence for two minutes is strange for a microphone in the motorcade, especially when the siren sounds are later so clear. Furthermore, when finally the siren sounds do appear they have the characteristics one would expect for sirens that were moving at some reasonable speed relative to, or passing, a microphone, and not the sounds of sirens moving along with the microphone. An important signature is the gradual rise and fall in the loudness of the siren sounds, over a period of several seconds. The sounds go from inaudible to loud, and then back to inaudible, and one recognizes that there is more than one siren that passes the microphone. It is difficult to devise a credible scenario that takes Officer McLain's motorcycle from its observed position behind the President's car to Parkland Hospital (where Officer McLain was photographed with Mrs. Kennedy as they entered the hospital) and which permits the long absence of siren sounds, followed by the very distinctive sounds mentioned above. The siren sounds are much more compatible with the suggestion in James C.Bowles' manuscript[2] that the open microphone was in the command post near the Trade Mart than that it was in the motorcade. The siren sounds are discussed further in Section II of the report and in Appendix E.

An evaluation of the November 19, 1981 FBI report is given in Section V. In Section VI and Appendix F, the Committee, in response to its charge, lists some of the tests, analyses and evaluations that could be made to obtain better information from the Dallas Police Department recordings, but the evidence against the BRSW/WA conjectured grassy knoll assassination shot is already so strong that the Committee beleves the results to be expected from such studies would not justify their cost. The Committee's conclusions are given in Section VII and the Executive Summary.

II. DESCRIPTION OF STUDIES BY BRSW AND WA

The acoustic studies by BRSW and the further acoustic studies by WA were reported to the House Select Committee on Assassinations, and are printed[1] in volume VIII (Appendix to Hearings) Investigation of the Assassination of President John F.Kennedy, March 1979. This section is a simplified presentation of the procedures described in those two reports, and as later discussed when the committee met with Barger, Weiss and Aschkenasy on January 31 and February 1, 1981. For details one should refer to the original reports [1].

The BRSW team began by listening to tape copies of the recordings of both police radio channels for general orientation. Because the recorders were sound-activated, they could have stopped frequently for varying amounts of time, except that the Channel I recorder ran continuously for 5.5 minutes when a transmitter, presumably on a police motorcycle, became stuck in the transmit mode (the Channel I recorder appears to have run continuously during the period of interest). Using the frequent annotations of time by dispatchers on both channels, BRSW estimated the approximate time of the beginning and end of this 5 1/2 minute stuck-button transmission. Because of the severe noise and distortion on the recording, the BRSW team could neither confirm that this segment contained gunshot sounds, nor eliminate the possibility that they were present, by simple listening or by examining the waveforms of sounds on the tape. Therefore, they went to Dealey Plaza in Dallas August 27, 1978, and made recordings of test shots with various kinds of guns and ammunition, two shooter locations, and many microphone locations along the approximate route of the motorcade. For each combination of shooter location and microphone location, there is a characteristic and complex pattern of echoes in the recording of the test shot, because after the first sounds travel by a direct path to the microphone (usually the bullet shock wave and the muzzle blast sound), subsequent sounds arrive (due to echoes from buildings and other large objects) with varying delays, depending on the length of the path they have taken. A typical test shot waveform, made with a shooter and 3 microphone locations close to those later claimed for an assassination shot from the knoll, is shown in Figure 1.

While the Channel I recording is noisy (as can be seen in Figure 2), distorted and contains many confusing sounds which are not gunshots, the test shot recordings are clean, faithful records of the acoustical response of Dealey Plaza—except for certain noted changes that took place between 1963 and 1978.

The BRSW team then compared, manually, each of 432 test shot waveforms with all the parts of the 5 1/2 minute record that could reasonably have included assassination gunshot sounds. This comparison was done using a binary correlation metric, with a ±6 msec window, applied to strip chart recordings of the relevant waveforms. This means that for each suspected assassination shot and each test shot, the strip chart recordings were aligned for a best match and a score was obtained by calculating the correlation coefficient. The correlation coefficient was defined as the number of impulses (large peaks) in the waveform of the suspected shot that came within 6 msec of an impulse in the test shot, divided by the geometric mean of the numbers of impulses available in the suspected shot and in the test shot. This binary correlation procedure does not make use of all the information available—thus impulses that barely resemble each other affect the score the same as impulses which match each other quite well— but it is a compromise that permits a relatively easy computation of similarity. The BRSW correlation was meant as a selective screen. Only candidate shots that gave a binary correlation greater than 0.6 were studied further. In all, fifteen pairs, involving only six sets of impulses on the Channel I recording, survived this screening.

For each surviving pair, the location of the microphone that recorded the test shot should approximate the location of the motorcycle at the time the suspected assassination shot was fired. This time, in a relative sense, could be determined by the location of the suspected impulses along the length of the tape. A plot of microphone position versus suspected shot time was made. In such a plot, a sequence of actual assassination shots should lie along a line that describes the movement of the motorcycle during the interval of the assassination shots. Unrelated impulses (false alarms) plotted in this manner could lie on this trajectory or elsewhere, depending to some degree on chance factors. Most of the pairs could be identified as false alarms in this way. The remaining pairs were judged, by the closeness of the trajectory fit, to contain at least two assassination shots and at least some false alarms. The hypothesized motorcycle trajectory was subsequently claimed to be consistent with that of the motorcycle driven by Officer H.B.McLain in the Kennedy motorcade based upon an interpretation of photographic evidence.

Of the six sets of impulses that give high binary correlation coefficients with test shots, BRSW selected four as likely assassination shots by eliminating those whose echoes were inconsistent with a reasonable trajectory. One of these four, the third, was judged to have been fired from the grassy knoll, BRSW stated the probability that this set of impulses represents a shot from the grassy knoll is 50%. The impulses associated with this identification are shown in Figure 2, with the muzzle blast as identified by BRSW being at A on that figure.

Judging that the principal limitation on their ability to make a more definitive claim was the microphone spacings for the test shots, which led to the ±6 msec window, BRSW suggested that WA be asked to try a theoretical acoustical modeling technique. This procedure was applied only to the hypothetical third (knoll) shot. Several test shots were examined, with a shooter location on the knoll, and prominent echoes were related to the Dealey Plaza objects that might have reflected or diffracted sound with the proper timing. After a set of echo-producing objects had been identified, a theoretical model of sound propagation in Dealey Plaza, incorporating possible variations in shooter position, microphone position and velocity, and air temperature, was used to predict the relative timings of various echoes that would be expected in the actual Channel I recording if the segment in question contained the sounds of a gunshot fired from the grassy knoll. In effect, for every choice of shooter position, microphone position, microphone velocity and air temperature, WA could theoretically determine the time of impulses of a hypothetical test shot, which they could correlate, using the binary correlation measure previously described, with the Channel I segment identified by BRSW as a possible knoll shot— with the significant difference that matching pulses were required to be within 1 msec rather than within 6 msec. WA did not try all possibilities, but rather used the results of each trial to guide a search until they were able to find a shooter position, etc., for which most predicted impulses in the theoretically reconstructed test shot agreed with actual impulses on the Channel I tape. The best agreement was found for a part of Channel I which is 0.2 seconds earlier than that suggested by the BRSW investigation. On seeing the WA results, the BRSW investigators agreed that their earlier screening procedure had missed the WA identified segment and that the WA identification should be used. The waveform now identified by both BRSW and WA as the sound of a gunshot fired from the knoll is shown in Figure 2 with the WA identification of the muzzle blast being at B. The time scales given in Figure 2 are only approximate and are slightly different from those used by BRSW, by WA and by this Committee elsewhere in the report.

III. EVALUATION OF THE BRSW AND WA METHODOLOGIES AND CONCLUSIONS

A reliable analysis of the Dallas Police Department Channel I recording presents serious difficulties. The noise level is high, there is conflicting evidence as to the location of the open microphone, some of the background sounds are difficult to interpret, the absence of certain expected background sounds is difficult to understand, and the transmitting and recording systems distorted the acoustic signals. As pointed out by WA, to the ear the sounds resemble static much more than they do gunshots and it is only the poor fidelity of the radio dispatching system that might permit the latter interpretation. But such static-like sounds could be generated by a number of other acoustic, electrical or mechanical sources in the environment and in the radio transmission, receiving and recording equipment. Tests and analyses more discerning than the human ear are required to determine the probable cause of the sound impulses. The WA analysis is ingenious but it is novel in some aspects and both the BRSW and the WA echo techniques for gunshot location had not been applied previously by either group to a situation with as high a level of noise and distortion as this one.

Furthermore, the BRSW/WA studies were seriously limited by funds and by the time schedules with fixed deadlines. A number of essential tests to confirm both the analysis procedure and the interpretations were omitted. Some of these are listed in Section VI and Appendix F. The WA studies, for example, were limited to the single conjectured grassy knoll shot from Dealey Plaza. The results of such an analysis should not be considered reliable until the method has been adequately tested on some other cases. In particular, the impulses conjectured to be sounds of gunshots from the Texas School Book Depository should have been analyzed by the same method. Not only would this have provided a control on the method, but it would also have provided much stronger evidence as to whether the open microphone was or was not in Dealey Plaza at the correct time. Similarly, more of the test shots should have been analyzed to compare the observed echo patterns with those predicted from structures identified in the echo patterns with a different neighboring microphone location.

The original BRSW report claimed a 50% probability of there being an additional shot from the grassy knoll. Even this seemingly modest claim is based on both questionable assumptions and on incorrect computations (see Appendix A). This claim was used as a justification for the later more detailed studies of WA. The result of WA's analytic echo-prediction technique in the subsequent analysis of this BRSW conjectured shot would appear to improve the credibility of the grassy knoll hypothesis. However, the Committee noted that the identification of shots and impulses by BRSW was completely different from that by WA as demonstrated by the more than 200 millisecond (or more than 200 ft.) displacement between the two identifications (this is the displacement between A and B in Figure 2). Dr. Barger has pointed out that, if the acceptance window in matching impulses is increased to 14 ms and with the particular locations of most of the assumed reflecting objects and the short 87 msec total time span of the relevant impulses, the two different identifications may be reconciled by assuming that the BRSW echo pattern had been subject to one additional wall reflection. Even with this interpretation there remains a serious flaw; namely, that the BRSW analysis missed the identification that WA considers to be the primary one.

The impulses selected for the BRSW study were not always the largest impulses. Frequently, large impulses were omitted and some impulses close to the noise level were retained. There are far more impulses that do not fall into the BRSW classification of “probable sounds of gunfire” than do. Since the results of correlation coefficient calculations are highly dependent on the impulse and echo selection process, it is especially critical that the scheme used to distinguish these sounds stand up to close scrutiny, with the process used being spelled out in detail so others can duplicate the analysis. From the published reports, it is impossible to do so. Furthermore, weak spikes on the Dictabelt often are selected to correspond to strong patterns, in the test patterns and vice versa.

Although the conclusions of the BRSW analysis were supported by some later interpretations of photographic evidence as being consistent with a motorcycle in the procession at approximately the position indicated by their analysis, it is by no means certain that this was the motorcycle with the open microphone, that its radio was improperly tuned to Channel I, that the open microphone was even in Dealey Plaza, or that the relative times of the four sets of impulses studied by BRSW and WA were consistent with the three known actual shots. There is important evidence to the contrary on all four of these points that should not be ignored.

In his manuscript[2] on "The Kennedy Assassination Tapes," Captain James Bowles proposes the hypothesis that the motorcycle carrying the open microphone was not part of the motorcade that passed through Dealey Plaza but was near the police command post at the Trade Mart at the time of the assassination. He supports this hypothesis by a subjective assessment of the motorcycle engine sounds (both during the motorcade and subsequent to the assassination shots), the absence of crowd noises on Channel I (which are clear on Channel II), the puzzling long-delayed timing of the siren sounds, the voice broadcasts, interviews with police officers, and the fact that all motorcycles in the motorcade were supposed to be tuned to Channel II, not Channel I. The questions raised by Bowles and by others pose serious doubts about the location of the open microphone in Dealey Plaza, a necessary requirement for the BRSW conclusion.

No siren sounds are heard on Channel I at a time when they should have been heard by an open microphone in the motorcade; sirens are not heard for approximately two minutes after the impulses attributed by BRSW/WA to assassination shots, following which clear and unambiguous sounds from a group of sirens occur on Channel I. The sirens seem to come from a group of at least 3 vehicles with the intensity of the sound first increasing and then decreasing. This is consistent with sirens heard at a stationary point if the presidential motorcade had passed close by. It is not the siren sound expected if a motorcycle with a stuck button had been part of the presidential motorcade. In the first quarter mile of the trip to the hospital, the presidential motorcade encountered a complex pattern of underpasses, roads and ramps as it approached the entrance to Stemmons Freeway. But there is no trace of a siren sound in Channel I during this interval of time. This initial long absence of any indication of siren sounds, followed by the pattern of loud and clear sounds of several sirens passing by, suggests that the radio transmitter with the stuck button was not part of the presidential motorcade. This radio transmitter may have been on a motorcycle parked somewhere, perhaps, as suggested by James Bowles, at the Police Command Post near the Trade Mart, where it would be natural for there to be adjacent police radios tuned to different channels, thus accounting for the instances of cross talk described in Section IV. The problems associated with both the presence and absence of siren sounds are discussed in further detail in Appendix E.

The concluding two sentences of the BRSW report state: “The probability of obtaining just one match by chance in any of 180 independent tries is equal to 5.3×10^{-2}, or about 5%. Therefore, the probability that they obtained their match because the two matched patterns were due to the same source (gunfire from the knoll) is about 95%.” The WA report concludes with a similar statement. Such statements do not allow for the existence of hypotheses alternative to the two primarily considered (the hypothesis of gunshots or the hypothesis of impulses randomly located according to a Poisson distribution in relevant sections of the Dictabelt). Various reasonable alternative hypotheses include non-white (non-Poisson) noise or other typical noise and static distributions which are ordinarily lumped together in time and which thereby may give a higher correlation with the non-random distributions of test shot echoes. Furthermore, even if the only alternative to impulses from a gunshot were the hypothesis of randomly located impulses, a single observed result whose P value under the random location hypothesis is 5% does not imply a 95% probability that there was gunfire from the knoll (the P value or significance level in current statistical theory is the probability, assuming the hypothesis to be true, of observing data as or more extreme than what actually is observed). The situation is analogous to that in a card game where the significance level for the dealer to receive three aces is P=0.044 but 3 aces going to the dealer on the first deal does not by itself indicate a 95.6% probability that the dealer is dishonest if there were no prior reason for suspecting him of cheating. The issue of the probability of gunshots is one of posterior probability and is discussed further in Appendix A-3.

In addition to the above misinterpretations, the BRSW/WA calculation of the P value for the hypothesis of random pulse location is incorrect. There are several errors of which the most serious is the failure to allow in the probability calculations for the fact that the location of the shooter in the WA analysis was adjusted to maximize the number of coincidences. These errors are discussed in Appendix A, where it is shown that, with these corrections and a conservative adjustment, a significant level as high as P=0.223 can be obtained for the hypothesis of random location; this value is much less impressive than the BRSW/WA value of 0.05. Furthermore, as discussed previously, even if it were granted that the hypothesis of randomly located impulses on relevant portions of the tape were in serious doubt, it would not follow that the alternative of gunfire from the grassy knoll was convincing. All plausible alternatives to both of these hypotheses would have to be eliminated, and no convincing effort has been made in this direction.

The analyses reviewed above and in Appendix A lead the Committee to the following conclusions about the probability analyses of BRSW/WA.

(1) The conclusion of a probability of 0.5 of a shot from the grassy knoll on the basis of the BRSW analysis is invalid as is also the conclusion of a probability of 0.95 for such a shot on the basis of the WA analysis.
(2) There are several inaccuracies.
(3) Except for a rather conservative alternative analysis given in Appendix A, the data do tend to cast doubt on the hypothesis of random impulse locations according to a Poisson process.
(4) Alternative hypotheses to a random Poisson process and a shot should have been examined as possible explanations of the coincidences. These might invoke the nature of the bursts of noise prevalent during the period under study and a consideration of other possible non-Poisson distributions.

There are some valid arguments in support of the BRSW/WA conjecture that the impulses may be due to a gunshot from the grassy knoll. The selected impulses fit better than randomly the echo patterns of the test shots, the trajectory of the microphone inferred from the BRSW analysis is reasonable for a microphone attached to a motorcycle, and some interpretations of photographic evidence are consistent with a motorcycle being in approximately the correct location. However these points are not strong since there are many ways in which static like impulses can be nonrandom, unreasonable microphone trajectories were rejected, there were many motorcycles in the area and the impulse and echo selection procedures used by BRSW could affect the results.

For the reasons given above, in Section VI and in Appendixes A and F, no member of the Committee on Ballistic Acoustics was convinced last Spring by the arguments given that there was a grassy knoll shot. The members of the Committee reached their initial negative conclusion prior to the availability of the sound spectrograms and event timings discussed in Section IV and Appendixes B and C, so this negative judgement was in no way a result of the subsequent evidence that the portion of the tape containing the relevant acoustic impulses was recorded about one minute after the assassination. With the added evidence in Section IV, there is now a conclusive case against the impulses studied by BRSW/WA being associated with a shot that contributed to the assassination of President Kennedy.

IV. TIMING EVIDENCE FROM MATCHING FEATURES

A private citizen, Steve Barber of Mansfield, Ohio, voluntarily wrote to the Committee that he was convinced from his own listening that there are clear instances in which phrases recorded on Channel II tape were distinctly audible on the Channel I tape as well. This is quite naturally explained by assuming that the motorcycle with the open microphone (Channel I) was near another police radio receiving a transmission from Channel II, so that transmissions over Channel II would issue from its loud speaker and be picked up by the open microphone and rebroadcast on Channel I. In addition there are simultaneous broadcasts by the dispatcher onto Channels I and II. Both kinds of cross talk are perfectly clear in many cases. The existence of such identical portions of speech on both channels would allow one to establish precise time synchronizations between specific portions of the two recordings. The specific time synchronizations would not apply to the recordings in their entirety, because Channel I ran continuously during the period of interest while Channel II was sound activated and operated intermittently. However, such matching features would enable one to determine the relative timing between many events on Channel I and other events on Channel II.

Barber identified several such matching sections on the two tapes. Four of them are quite clear, but they occur several minutes after the assassination and involve various police communications connected with the follow-up to the shooting; however, they demonstrate clearly that there was cross talk from Channel II to Channel I. As will be seen, they also provide a clear demonstration of Channel I heterodynes suppressing the recording onto Channel I of cross talk from Channel II, which suppression we later also show exists in the interval containing the impulses and shows that the cross talk was recorded through a radio receiver. Two events are especially important for fixing the time of the section of tape analyzed by BRSW and WA relative to the assassination. The first is a 4-second fragment of speech that overlaps the conjectured 3rd and 4th BRSW shots on Channel I. Barber there identifies a phrase, which he says begins with the words “hold everything...” as identical to the phrase “...hold everything secure until the homicide and other investigators can get there...," clearly recorded on Channel II. The significance of this proposed match is that the section on Channel I is concurrent with the last two of the conjectured BRSW shots, whereas on Channel II that communication is part of a clear sequence of emergency communications that followed the shooting and occurred approximately one minute after the assassination. It is, in fact, part of Sheriff Decker's instructions to his men in response to the assassination. This time synchronization, if correct, would prove that the BRSW/WA conjectured shots were unrelated to the sounds of the assassination gunshots. The section of Channel I recording with the BRSW/WA conjectured shots would then correspond to a period of time well after the assassination.

The second crucial event is the transmission "You want me...Stemmons", which occurs several minutes after the assassination and is clearly intelligible on both channels. It provides a common reference point for timing events on the two channels. We used it to determine whether the section of the recording containing the conjectured shots occurred before or after Chief Curry instructed the motorcade to "Go to the hospital."

IV-1. SOUND SPECTROGRAMS

Initially, the poor quality of the “hold everything...” portion of the recording made it appear unlikely that a convincing interpretation of the badly garbled speech on Channel I could be made and the Committee was aware of the power of suggestion, or cueing effect, in which a listener to a garbled message will often be convinced he has heard what he has been coached to hear.

For these reasons, arrangements were made through Bruce Koenig and others of the FBI Technical Services Division for members of the Committee to utilize the Division's excellent sound analysis equipment to obtain sound spectrograms (“voiceprints”) of the relevant communications on Channels I and II. The spectrograms were prepared under the supervision of Committee members. The sound spectrograms first reproduced were from tape recordings kindly provided by James C.Bowles, Radio Dispatcher Supervisor at the time of the assassination, but a sound spectrogram with a similar pattern for the “...hold everything...” phrase on Channel I was also made from a tape supplied by James Barger, essentially identical to that used in the analysis of BRSW; later sound spectrograms were also made from new high quality magnetic tape copies of the original Channel I Dictabelt and Channel II Audograph disc. A sound spectrogram is a plot with elapsed time along the horizontal axis, with frequency along the vertical axis and with the darkness of the trace representing the intensity at that frequency. Since the interpretation of sound spectrograms depends on continuous gradations in darkness, copies in a printed report lose clarity. For this reason photographs of the sound spectrograms will be retained in the National Research Council files.

We began by making sound spectrograms of two of the later proposed matching sections of speech. The match is clear, and establishes unambiguously that identical portions of speech can be identified on both channels. One of these matches is shown in Figure 3, and it demonstrates conclusively that there was cross talk between the two channels. We then made spectrograms of the crucial "hold everything" sections. As discussed in greater detail in Appendix B, Figure 4 is a photograph of composite sound spectrograms for the full four second message. The beginning of the "...hold everything..." phrase is approximately at zero on these time scales and the impulses for the BRSW conjectured grassy knoll shot occur beginning approximately at the arrow marked 145.15s (the time of the conjectured grassy knoll shot on the BRSW time scale) and the WA impulses occur 0.2 seconds earlier. As discussed in Appendix B, the black dots mark 27 corresponding features on the two channels.

It is apparent from Figure 4 that there is a marked correlation between parts of the sound spectrograms of the two channels, even though the Channel I recording has much more noise. The correlation becomes much more impressive when the spectrograms of the two Channels are compared in detail. The correlation is particularly striking when one realizes that only the initial second of the "...hold everything..." phrase can be heard clearly on Channel I, yet the sound spectrograms contain numerous matching features for the entire three and a half second sequence; note for example the impressive match in the final segment from T=3.2 to 3.6 seconds. In all cases of matching features it is clear from the text of the messages and from the signal intensities that a signal from Channel II was duplicated on Channel I and not the reverse.

The sound spectrograms present much more convincing evidence in the present case than in their application to speaker identification. There, words spoken at different times, supposedly by the same speaker, are compared and a trained interpreter is often required to explain why the subjective match is significant. In the present case, the need is to identify two <u>identical</u> messages extending over a three and a half second interval. Not only must individual parts of the two sound spectra be alike but they must occur at exactly correct time intervals and with exactly matching frequencies. The existence of these required time and frequency correlations between the two channels imposes rigid constraints on the messages to be matched. Furthermore, all sounds that appear on both Channel I and II are useful in correlating the channels even though some are not spoken words. For example in listening to Channel II it is apparent that there is an intermittent tone that contributes to the flat portions common to Channels I and II. However, this tone varies in both amplitude and frequency and is also useful in correlating the two channels.

IV-2. ANALYSIS OF SOUND SPECTROGRAMS OF “HOLD EVERYTHING...”

The Committee used three methods in addition to visual inspection to determine whether these critically important sound spectrograms of Channels I and II contained signals from the same source. The studies are described in greater detail in Appendix B and were made on the sound spectrograms shown in Figures 4 and B-3.

In the first method we identified characteristic features that were present on both spectrograms of Figure B-3 and then determined the relation between the times of occurrence of the two sets of features. Twenty-seven features were selected (indicated by the black dots in Figure B-3); a brief description of each is given in Table B-1 in Appendix B along with its frequency and time coordinates. The existence of correlations between the two spectrograms over a long time interval can be demonstrated by plotting T', the time coordinate of the Channel I spectrogram, as a function of T", the time coordinate of the corresponding characteristic on Channel II. The results are shown in Figure 5. The marked linearity of the plot shows that the similar characteristics of the sound spectrograms of the two channels follow the same time sequence, as they must for one to be cross talk from the other. As described in Appendix B-1, a linear fit to the recorded points gives the equation in Figure 5, and the slope of the line or ratio of recording speeds is 1.059±0.002, which corresponds to a (5.9±0.2)% net difference in the recording speed. The ratio of recording speeds independently inferred from the measured frequency ratios of the same points is 1.064±0.006, a value fully compatible with that obtained from the time sequence. As discussed in Appendix B-1, the probability of obtaining such close agreement by random occurrence of the features at their observed average spacing would be about 2.1×10^{-13}, and the probability of randomly obtaining such good agreement on the frequency ratio of the points is about 2×10^{-10}.

The second method, which provides further confirmation of the correctness of the identification of the two patterns, is the calculation of the effective relative speeds from the frequency ratios for five sections with particularly well defined frequencies on the two channels, as discussed in Appendix B-1. Such a calculation gives a ratio of recorder speeds of 1.062±0.005 in excellent agreement with the value in the preceding paragraph. Alternative analyses to minimize subjective errors in the pattern recognition are also discussed in Appendixes B-2 and B-3.

To help in the visual recognition of similarities of the two patterns, sound spectrograms have been made with the speed of Channel I effectively changed by 6.7%. The results are given in Figure 4. Both frequencies and times of the two channels now appear to be quite compatible.

A third approach to the investigation of whether Channel II segments are recorded onto Channel I along with the acoustic impulses was taken by a third member of the Panel and two collaborators. The Channel I and Channel II recordings were digitized and the short-term acoustic spectra were taken and stored in a digital computer. The printouts of these spectra are similar to Figures 3 and 4 and are shown in Figures B-4, B-5, and B-6. These digital spectrograms were computed directly from magnetic tapes and did not involve the use of the FBI sound spectrogram equipment. Many of the features observable in the analog spectrograms of Figure B-3 can be seen in B-6, but no use was actually made of the spectrogram patterns, instead, the actual data were used to test certain hypotheses, without human intervention. An objective measure of similarity of two spectral matches is obtained from the cross correlation coefficient, defined in Appendix B-4. This cross correlation coefficient would be reduced if one of the recordings were played at the wrong speed, or if the recording at one time were compared with the same or a different recording at a different time.

The first cross correlation coefficients were made from the same Channel I and II recorded copies that were used in preparing Figures 3, 4, B-1, and B-2. It was found that the biggest peak for the cross correlation coefficient occurred for a relative warp (or speed ratio) of 1.06, in agreement with the other two manual approaches for comparing Channels I and II; a 1% deviation of warp from optimum diminished the peak substantially. Unfortunately, that Channel II copy contains many repeats caused by the

Gray Audograph machine in playback. Accordingly another tape copy was prepared by members of the Committee directly from the original Audograph plastic disk itself and by the use of a standard turntable and tone arm, thus producing a tape without compensation for the fact that the disk was originally recorded at constant linear track speed. It was this tape that was used in preparing the sound spectrograms shown in Figures B-4, B-5, and B-6. Figure 6 gives the cross correlation coefficient for the "hold everything..." segments when the relative speed was selected to give the largest peak and the 750 correlation coefficients were obtained by sliding 2.50 secs of Channel I along 10.00 secs of Channel II, 0.01 secs at a time, using frequencies in the band 600 Hz to 3500 Hz. For comparison the cross correlation coefficients of the unambiguous segment "You want...Stemmons" are plotted in Figure 7. The shape of the peak is very similar to that for the "hold everything..." segment. The background is somewhat smoother, simply because there is less noise in Channel I at this time. Channel I, however, in neither case gives a perfect reproduction of Channel II. It has lost some of the high and low frequencies, and as one would expect there are tones present on Channel I that are not on Channel II.

The marked narrow peaks of the cross correlation curves clearly show by an objective test that the "hold everything..." segment of Channel II is present on Channel I at the same location as the acoustic impulses. There is no doubt that the voice (and other) sounds of Channel II are present on Channel I to an accuracy in location corresponding to a few milliseconds.

We find these three sets of results to be overwhelming evidence that the "hold everything" sections of the two recordings are traceable back to a single acoustic signal from Channel II. If there is no overrecording on Channel I (as we later show to be the case), the correspondence between these two recordings of "hold everything..." would be conclusive evidence that the events analyzed by BRSW/WA were not the assassination shots, since we know from Channel II that the "hold everything" transmission was made at least 50 seconds after the Chief instructed the motorcade to "Go to the hospital." We will discuss in Section IV-4 the possibility of there having been an overrecording on Channel I and our conclusion that there was not. Indeed, the digital analyses in themselves are used in Section IV-4 and

Appendix D to demonstrate that the Channel II cross talk on the Channel I recording was already present at the Channel I radio receiver and was not added later in copying or as an overrecording.

IV-3. TIMING OF CHANNEL I AND CHANNEL II EVENTS

In the previous section, a synchronization between events on Channels I and II simultaneous with the conjectured shots was obtained by detailed analysis of sound spectrograms. Other examples of matching features on the two channels, occurring several minutes after the assassination, are so much clearer that no special technical procedures are required to establish synchronizations in these parts of the recordings—simple listening is sufficient to eliminate all doubt about these synchronizations. By timing both recordings backwards from the time of these matches, it is possible to relate the times of events in the critical portions of both recordings, independent of the correspondence established in the previous section.

The clear match that occurs closest to the assassination is “You want...Stemmons,” which occurs on Channel II several minutes after the Chief said “go to the hospital.” Figure 3 shows a sound spectrogram of the match. Since Channel II was sound activated and recorded intermittently, we obtain a lower bound on the time between these two transmissions by timing the tape between them. Any halts in the recorder would cause the tape time to be less than the actual clock time between these transmissions.

Time intervals were measured using two different sets of tape recordings. First, we used the tapes obtained from Bowles to time events in critical portions of the recordings. Since relative time between Channels I and II is all that is of significance in this comparison of events, time in this set of measurements was made in somewhat arbitrary Channel I elapsed time units. The timing was difficult to do because there were “repeats” (see Appendix C) on the Channel II magnetic tape and speed differences between segments of it and the Channel I tape. Appendix C describes how these timings were made and how compensations for repeats and speed differences were accomplished. The results of the spectrogram analyses just discussed were used to obtain the speed correction (a factor of about 1.06). The durations of repeats were determined from strip charts of the signal level as a function of time.

The result of these timings, also given in Appendix C is that:

a) On Channel II, "Go to the hospital" occurs at least 189 seconds before "You want me...Stemmons."
b) On Channel I the portion of the tape on which BRSW/WA found "shots" occurs 171 seconds before "You want me...Stemmons."
c) Since Channel II operated intermittently, any time that elapsed while the recorder was stopped would increase the 189 second interval between "Go to hospital" and "You want me...Stemmons." There were five places where the recorder could have stopped.

By this analysis, the last of the conjectured shots occurred at least 20.9 seconds after Chief Curry issued his instructions "Go to the hospital;" therefore, they could not have been the shots of the assassination.

After the preceding analysis of the tapes obtained from Bowles was completed, the Committee gained access to the original Gray Audograph and Dictaphone recordings. These were transcribed, as described in Appendix C, onto tape, with care taken to minimize the 60 Hz hum that was added to the signal and to ensure that no skips or repeats were introduced in the tape recording of either channel. No break interrupted the Channel II recordings as was the case for the Bowles tapes. These recordings, of course, did not eliminate the effects of the intermittent operation of Channel II, and time interval measurements are still lower bounds. The 60 Hz hum from the original recordings was used to determine the relationship between playback speed and original recording speed and to convert the measured-elapsed time intervals to real elapsed time units. (Recall that arbitrary Channel I elapsed-time units were used for the first set of measurements made on the Bowles tapes.) It was easy to make this correction on Channel II, but difficult on Channel I, because the Dictabelt was in poor condition. The conversion method is described in Appendix C. Except for this speed-time correction, obtaining comparable measurements of the time intervals between critical events on Channels I and II and the common “You want...Stemmons” transmission was straightforward.

The result of these timings made on tapes obtained directly from the original recordings, also given in Appendix C, is that:

a) On Channel II, “Go to the hospital” occurs at least 206 seconds (real time) before “You want me...Stemmons.”
b) On Channel I, the portion of the Dictabelt on which BRSW/WA found “shots” occurs 178 seconds (real time) before “You want me...Stemmons.”

By this analysis, the last of the conjectured shots occurred at least 30.9 seconds (real time) after the instructions “Go to the hospital”. This measurement is believed to be more accurate than the one obtained from the Bowles tapes, since the tapes obtained from the original recordings showed no evidence of skips, repeats, or breaks.

Both of these results confirm the previous finding from the sound spectrograms that the section of tape in which BRSW/WA found “shots” recorded events that occurred after the assassination. Note that the results from timing events do not require a match between the two recordings of “hold eveything,” but they do not preclude such a match. Halts in the recorder would increase the time between the conjectured shots and Chief Curry's instructions. Furthermore, any delay between the assassination and the instructions “Go to the hospital” would increase the discrepancy between the timing of the conjectured shots and the actual assassination.

IV-4. POSSIBILITY OF SUPERPOSED RECORDINGS

The Committee has considered seriously the possibility that the impulses analyzed by BRSW/WA might have been overlaid at a later time by the "hold everything..." message. Conceivably such an overrecording could have occurred by an accidental knocking backwards of the Dictabelt or the recording head by about one minute in the first minute following the assassination or by the substitution (either accidentally or deliberately) of a new Dictabelt copy for the original, with the copy being made by audio coupling while a Channel II recording was playing in the background. The Committee found conclusive evidence that this was not the case. The evidence is of four kinds: (1) physical examination of the Dictabelt for indications of overrecording or of substitution of a copy for the original; (2) the unlikely nature of any of the highly contrived scenarios required to provide such an undetectable overrecording either accidentally or deliberately, (3) the compatibility of the timing implied by the "hold everything..." identification with other firmly established evidence, and (4) the conclusive acoustic evidence on the Dictabelt itself that the cross talk recordings were made through a radio receiver with automatic gain control. These different forms of evidence are discussed in Appendix D, where all are shown to be compatible with the recordings being made at the same time and some are incompatible with the hypothesis of later superposed recordings by audio or direct electrical coupling. Only the evidence of catagory (4) will be reviewed in this section.

The digital analyses of the sound spectra can be used to demonstrate that the Channel II imprint on the Channel I recording was already present at the Channel I receiver and was not added later in the recorder or as an overrecording. The by radio nature of Channel II cross talk is demonstrated by its detailed behavior in the presence of Channel I heterodynes when another Channel I transmitter is keyed on with a more powerful carrier signal. The frequency offset between the two carriers gives rise to a heterodyne tone in the Channel I recording. However, the Channel I receiver was fitted with automatic gain control (AGC to hold the output level approximately constant; as a result, the cross talk signals decreases in intensity in a few tens of milliseconds (as does any residual transmission from the original stuck-mike transmitter). At the end of the Channel I heterodyne, the AGC gradually increases the receiver gain, and signals on the stuck-mike transmission increase in intensity in the recording. An excellent probing signal for the Channel I gain would be a Channel II steady tone acoustically coupled from the field loudspeaker to the stuck-mike transmitter. This would come in at constant level, and the variation in level on the Channel I recorder should mimic the AGC action if the Channel II signals were present in this way. Inspection of the digital spectrogram of Figure B-4 (and digital tabulations of the data) show that numerous Channel II brief tones have constant level from beginning to end. However, a crucial demonstration is provided by the Channel I heterodyne beginning in Figure B-6 at time 32.02 seconds. The underlying Channel II brief tone is clearly substantially reduced in intensity at the beginning of the Channel I heterodyne, and gradually grows back when the Channel II brief tone results after the Channel I heterodyne ceases. More detail is available in the two digital plots of Figures B-7 and B-8. This behavior is validated by similar Channel II brief tones underlying Channel I heterodyne signals in the “You want me...Stemmons” phrase and in a phrase “I'll check...”, likewise present on both channels. This is discussed in further detail in Appendix D along with other evidence that has led the Committee to conclude that the acoustic impulses attributed to gunshots were recorded about one minute after the President was shot.

V. EVALUATION OF THE FBI REPORT

Although the Committee agrees with the "Findings" in the November 19, 1980, FBI report[4], it disagrees with one of the arguments used to justify the Findings. It considers invalid the criticism of the WA report on the basis of the high value of the binary correlation coefficient found by the FBI for a match between the supposed grassy knoll shot and one of the recorded gunshots in the unrelated later shootings at Greensboro, North Carolina. Although the FBI obtained a high value of the correlation coefficient, that value was not nearly so significant as the one obtained by WA, which involved many more "time windows" (90 windows were used although this number was erroneously reported as 45 on page 76 of the BRSW report) and 39 Greensboro shots were available from which the most favorable could be selected. Although the Committee considers this particular FBI argument against the BRSW/WA report to be invalid, the Committee, for the reasons discussed in this report, agrees with the FBI conclusions.

VI. POSSIBLE FURTHER STUDIES

Our charter asks us to recommend the tests, analyses and evaluations needed to obtain better information from the recordings. If there were to be further studies of the Dallas Police Department Channel I recording in the hope of demonstrating the validity of the conjectured shot from the grassy knoll, the information listed in Appendix F should be sought. However, as discussed in Sections II and III, the evidence against the BRSW/WA conjectured grassy knoll assassination shot is already so strong that the Committee believes that the results to be expected from such studies would not justify their cost.

VII. CONCLUSIONS

For the reasons discussed above and in the appendixes, the Committee on Ballistic Acoustics has reached the following unanimous conclusions:

(a) The acoustic analyses do not demonstrate that there was a grassy knoll shot and in particular there is no acoustic basis for the claim of a 95% probability of such a shot.

(b) The acoustic impulses attributed to gunshots were recorded about one minute after the President had been shot and the motorcade had been instructed to go to the hospital.

(c) Therefore, reliable acoustic data do not support a conclusion that there was a second gunman.

APPENDIX A

CRITICISM OF PROBABILITY CALCULATIONS

A-L. CRITICISM OF BRSW PROBABILITIES 0.88, 0.88, 0.50, AND 0.75

This criticism refers to the calculation by BRSW of probabilities of 0.88, 0.88, 0.50, and 0.75 for the identification of 4 impulse patterns of the DPD tapes as representing four shots. The third pattern is associated with the conjectured shot from the grassy knoll. These claimed probabilities are, at the very least, larger than the BRSW reasoning should permit, if that line of reasoning were to be accepted.

In Appendix C, pages C1-C2, of the BRSW report[2], it is calculated that the 432×4 correlation matches of the 432 echo patterns (derived from the test shots) with the four impulse patterns (on the DPD tapes that were suspected of being patterns from shots) should give an expected 13 false alarms. BRSW found 15 matches, which is within reason. (See Section 5.3 and Figure 22 on pages 60–63 of that report). BRSW applied a 2×2 contingency table test based on the data in their figure 22 to decide that the matches are not randomly located and consequently at least two of those matches must be real. (See page 66 of BRSW).

We shall comment on this conclusion later, but let us grant this conclusion for the time being. BRSW observe that six of the matches are clearly false alarms. This leaves nine points of which at least two are true matches. We quote BRSW on page 66.

> "However, the expected number of false alarms to be found when testing four different impulse patterns is 13 (see Appendix C), and only six have been found. Therefore, it is not unreasonable to expect that there are seven more, although that would be the largest number possible since at least two of the remaining nine

> are probably detections. The best that can be safely assumed is that each of the nine remaining correlations is equally likely to represent a detection or a false alarm."[1]

The intended meaning of that last sentence is that each of the nine candidates has as large a probability of being a true match as any other candidate. We would suggest that a conservative estimate of this probability based on the BRSW reasoning would be 2/9. Instead, BRSW apparently misinterpreted their own words, reading "equally likely" to mean that the probability of a false alarm for each detection is 1/2, an interpretation consistent with the somewhat ambiguous language but not with the reasoning.

From their interpretation they proceed to calculate the probabilities $0.88=1-(1/2)^3$, $0.88=1-(1/2)^3$, $0.5=1-1/2$, and $0.75=1-(1/2)^2$ on p. 67, using the probability 0.5, the questionable assumption of independence and the fact that of the remaining nine matches which are not obviously false alarms three correspond to the first conjectured shot, three to the second, one to the third (grassy knoll) and two to the fourth (see Figure 22 of BRSW report).

Using 2/9 instead of 1/2 would give probabilities $1-(7/9)^3=0.53$, $1-(7/9)^3=0.53$, $1-(7/9)=0.22$, and $1-(7/9)^2=0.40$. These are considerably smaller than the BRSW probabilities.

One may argue that the above calculations are too conservative and that the probability 2/9 should be replaced by a larger number, say 3/9 or 4/9. Certainly the use of 4/9 would be unduly "optimistic" since there are at most four shots.

A-2. CRITICISM OF BRSW CERTAINTY THAT MICROPHONE DETECTED SOUND OF GUNFIRE (P. 64)

One must question the reasoning that led to the inference that at least two of the alarms were “true”. The 2×2 chi-square contingency table analysis used depends on the assumption of 15 independently located alarms. Those alarms corresponded to microphone and rifle locations closely grouped in space. Hence the signals are similar and one should expect that the high correlation coefficients for these alarms are highly dependent events. An informal study of these locations and Figure 22 would suggest that these 15 alarms are effectively equivalent to fewer, say about 7 or 8, independent points. In that case the significance of the layout is considerably reduced and one may question the conclusion on page 64 of the BRSW report that “the motorcycle was moving through Dealey Plaza and did, in fact, detect the sounds of gunfire.” (To be specific, a two by two table with entries 1,3,4,0 yields a significance value $P=0.07$, rather than the $P<0.01$ claimed by BRSW.)

A-3. CRITICISM OF BRSW/WA PROBABILITY OF 0.95 FOR SHOT FROM GRASSY KNOLL

The BRSW/WA conclusion of a 95% probability of a shot or loud noise from the grassy knoll fails to be convincing because (i) the use of subjective procedures which easily lead one to unconsciously biased reporting and make it difficult to reproduce the results by independent observers, (ii) serious errors in statistical reasoning which render the calculated probabilities meaningless, and (iii) the failure to apply the WA methodology to the other suspected shots which leaves the method insufficently tested and calibrated.

We elaborate here on (ii). First the BRSW calculations on page 75, using the claim of coincidence of 10 out of 12 predicted echoes with 10 of the 14 impulses on the DPD tape that exceeded a threshold, should conclude that the probability of observing 10 or more coincidences is less than 0.053 under a Poisson randomness hypothesis. It does <u>not</u> follow that the Poisson randomness hypothesis has probability less than 0.053. Such a conclusion is no more valid than it would be to conclude that the dealer of a bridge hand who deals himself 3 aces on the first deal is dishonest with probability 0.96. This first inference would require the application of Bayes Theorem using prior probabilities for all plausible hypotheses, and the probabilities of the observation of 10 matches under each of these plausible hypotheses. In the case of the bridge dealer, a probability assignment to the hypothesis of honesty would depend on one's prior belief in the dealer's honesty and would also involve the calculation of the probability of his dealing himself 3 aces on the first deal if he were dishonest.

Second, the calculation of 0.053, which is typically called the significance level or P value, should have included an adjustment to allow for the fact that the hypothesis of a shot from the grassy knoll involved 7 “free” parameters that were adjusted to maximize the number of coincidences. These parameters were time of shot, position of shooter (2), initial position of motorcycle (2), velocity of motorcycle and velocity of sound combined with tape recorder speed. The adjustment used by BRSW/WA is somewhat <u>ad hoc</u>, depends mainly on adjusting three of these parameters (initial position of motorcycle and time of shot), and requires review. That adjustment consists approximately of reducing the number of matches by one and multiplying the computed probability (3.13×10^{-4}) of as good a match by a factor of 180. The latter factor was based on the number of plausible initial positions of the motorcycle that could have led to different results in matching predicted echoes against observed impulses. But if they had chosen to consider different plausible values for the other parameters, their reasoning would have produced a greater factor. For example, the 50-foot range of plausible shooter positions along the fence could contribute an additional factor of 5 to 10, since movements of more than ±5 feet could change the relative positions of the predicted echoes by substantially more than could be compensated for by readjusting the initial position of the microphone (see page 29 of WA). A more traditional and possibly overconservative adjustment would consist of subtracting one match for each free parameter. This adjustment would lead to a less significant result (high P value).

Third, alternative hypotheses to the two primarily considered (gunshots or random locations of impulses according to a Poisson process) should have been considered, such as non-white (non-Poisson) noise and static. Such distributions could increase the likelihood of the BRSW and WA results having been obtained by chance.

Fourth, the calculation of 0.053 involved some further errors. On page 75, the BRSW calculations claim that 12 of 22 predicted echoes were loud enough to exceed a threshold. (It seems that 22 should be 26 if Table 4 on p. 27 of WA is the source.) Then 10 of these 12 predicted echoes occurred within ±1 msec. of the occurrence of 10 of 14 impulses on the DPD tape that were loud enough to exceed a threshold. Later there is reference to two time intervals of 90 msec total duration, representing forty-five 2-msec. windows.

The time should be 180 msec representing 90 windows. In two cases a pair of impulses correspond to a single window. (See Figure 7, page 28 of WA.) These are marked (19, 20) and (23, 24). For the BRSW hypergeometric probability calculations to be appropriate, it is necessary to use non-overlapping windows and to count as coincidences the number of windows in which there are at least one predicted echo and at least one observed impulse. Moreover, two of the predicted echoes appear in one window. Thus 10 coincidences among 12 predicted echoes and 14 impulses out of 45 windows should be adjusted to 8 coincidences among 11 predicted echoes and 12 impulses out of 90 windows. If we now reduce the number of concidences by 7 to make a conservative adjustment for the “free” parameters, we would have 1 coincidence among 4 predicted echoes and 5 impulses out of 83 windows. The hypergeometric probability calculation would then yield a significance level of P=0.223, which is not at all impressive in contrast to the claim that P=0.053. However, this adjustment may be unduly conservative.

In summary,

(1) The BRSW/WA conclusion of a probability of 0.5 of a shot from the grassy knoll on the basis of the BRSW analysis is invalid as is also the conclusion of a probability of 0.95 for such a shot on the basis of the WA analysis.
(2) There are several inaccuracies.
(3) Except for the rather conservative analysis above, the data do tend to cast doubt on the hypothesis of random impulse locations according to a Poisson process.
(4) Alternative hypotheses to a random Poissson process and a shot should have been examined as possible explanations of the coincidences. These might invoke the nature of the bursts of noise prevalent during the period under study and a consideration of other possible non-Poisson distributions.

APPENDIX B

ANALYSES OF SOUND SPECTROGRAMS OF "HOLD EVERYTHING..."

B-1. TIME AND FREQUENCY ANALYSIS

Several sound spectrograms were made of the first and second halves of the "hold everything..." expression on Channels I and II. Two of these pairs are given in Figures B-1 and B-2. Although some similar features can be observed in comparing the two channels in Figures B-1 and B-2, it is difficult to tell if the similar features occur somewhat at random or if corresponding features occur at corresponding times over the entire 3 1/2 second duration of the message, as must be the case if the corresponding features are associated with the same transmission. For this reason, the following analysis was made of two successive pairs of sound spectrograms which were butted together, with an overlapping sound spectrogram being used to ensure that the sound spectrograms were combined properly. The result is shown in Figure B-3.

Twenty-seven corresponding features have been marked on Channels I and II in Figure B-3. Since the timings of the corresponding features were to be studied later, two observers were used in the identifications to diminish the danger that human prejudice on the timing would affect the identification. The first observer, looking at the sound spectrograms of both Channels I and II but making no measurements, marked on Channel II 27 points which he felt were sufficiently characteristic and sufficiently well reproduced on Channel I to be identifiable there by an independent observer. Then a series of 27 xerographic copies were prepared of different portions of Channel II, extending 1/2 second to each side of the single identified characteristic and with no indication of time scale on any of the Channel II strips. These strips and the Channel I sound spectrogram were presented to a second observer who was asked to mark on the Channel I sound spectrogram what he considered to be the most similar characteristic to the one marked on each Channel II strip. He was asked to do so by pattern recognition and not by measurement. His marks located the black dots on the Channel I tape of Figure B-3. It was found that the second observer correctly identified 26 out of the 27 characteristics. In the one case of disagreement (characteristic I) the second observer subsequently agreed that the intended identification was better than the one he selected.

Only after all the identifications had been made were the times and frequencies of each characteristic measured and recorded in Table B-1. These are plotted in Figure 4. It can be seen that the points fall markedly close to a straight line with the only exception being the misidentified characteristic I.

Table B-1. Correlation of characteristics identified in Figure 4. The Channel I times and frequencies are given by T' and F' and the corresponding characteristics on Channel II are given by T" and F". $u = \Delta T = T' - T'_{\ell}$ where T'_{ℓ} is the linear fit $T'_{\ell} = -0.0216 + 1.0593T''$. $v = \Delta R = R - \bar{R}$ where $\bar{R} = 1.064$. $w = \Delta F = F' - F''/1.0593$. The capital letter under FEATURE identifies the feature in Figures 3 and B-3. The small letter provides a brief description of the feature with the notation a for maximum, b minimum, c beginning of flat, d end of flat, e middle of flat, and f middle of down slope. D in the last three columns indicates an outlier. The outliers in the u and v columns were discarded in calculating the final linear regressions.

	FEATURE		T' (sec)	T" (sec)	F' (kHz)	F" (kHz)	R= F"/F'	u=ΔT (sec)	v=ΔR	w=ΔF (kHz)
1.	A	a	0.240	0.235	1.47	1.88	1.279	0.013	0.215D	-0.305D
2.	B	b	0.305	0.305	1.12	1.22	1.089	0.004	0.025	-0.032
3.	C	a	0.360	0.346	1.38	1.51	1.094	0.015	0.030	-0.045
4.	D	b	0.408	0.414	1.17	1.28	1.094	-0.009	0.030	-0.038
5.	E	c	0.548	0.530	1.90	1.84	0.968	0.008	-0.096D	0.163D
6.	F	a	0.750	0.727	1.68	1.78	1.060	0.001	-0.004	-0.000
7.	G	d,a	0.885	0.869	1.67	1.78	1.066	-0.014	0.002	-0.010
8.	H	c	0.980	0.946	1.22	1.38	1.131	-0.000	0.067D	-0.083
9.	I	e	1.140	1.195	1.53	1.69	1.105	-0.104D	0.041	-0.065
10.	J	b	1.360	1.315	1.04	1.09	1.048	-0.011	-0.016	0.011
11.	K	c	1.550	1.509	1.58	1.62	1.025	-0.027D	-0.039	0.051
12.	L	d	1.820	1.750	1.57	1.66	1.057	-0.012	-0.007	0.003
13.	M	b	2.050	1.924	1.18	1.18	1.000	0.034D	-0.064D	0.066
14.	N	c	2.168	2.078	1.62	1.75	1.080	-0.012	0.016	-0.032
15.	O	d	2.272	2.160	1.66	1.75	1.054	0.006	-0.010	0.008
16.	P	a	2.374	2.262	2.35	2.40	1.021	-0.001	-0.043	0.084
17.	Q	c	2.440	2.338	1.65	1.70	1.030	-0.015	-0.034	0.045
18.	R	d	2.519	2.419	1.66	1.69	1.018	-0.022D	-0.046	0.065
19.	S	e	2.924	2.750	1.58	1.65	1.044	0.033D	-0.020	0.022
20.	T	e	3.126	2.963	2.59	2.81	1.085	0.009	0.021	-0.063
21.	U	a	3.270	3.097	1.98	2.13	1.076	0.011	0.012	-0.031
22.	V	b	3.420	3.255	1.50	1.57	1.047	-0.006	-0.017	0.018
23.	W	a	3.465	3.290	2.69	2.80	1.041	0.002	-0.023	0.047
24.	X	a	3.520	3.340	2.63	2.82	1.072	0.004	0.008	-0.032
25.	Y	a	3.616	3.435	2.67	2.89	1.082	-0.001	0.012	-0.058
26.	Z	a	3.652	3.465	2.27	2.42	1.066	0.003	0.002	-0.015
27.	AA	f	3.739	3.545	1.63	1.82	1.117	0.005	0.053D	-0.088

A straight line of the form

$$T'=\alpha+\beta T''+u$$

was fit to the (T', T") data. Under the copy hypothesis that the signal on Channel I is a noisy copy of that on Channel II, the values of u are determined by measurement errors in the presence of noise, and there may occasionally be an outlier due to the matching noncorresponding features on the two channels. The robust linear regression routine RLIN in the Minitab 80.1 interactive statistical package[5] yields the estimated fit

$$T'= -0.0253+1.0599T''+u^*$$

A sequence of regressions in which outliers are dropped one or two at a time yields the fit

$$T'= -0.0216+1.0593T''+u.$$

Here, the points 9, 11, 13, 18, and 19 were dropped. The standard deviation of the fitted residuals of the remaining 22 points (adjusted for 20 degrees of freedom) is s_u=0.0092 and the estimated standard deviations of the two coefficients above are 0.0037 and 0.0016, respectively.

The five outliers in the column labeled u=ΔT are marked with a D. All other values of u are less than 0.015 in absolute value.

The ratios R=F"/F' of the measured frequencies at the paired points in the two channels were computed. A sequence of averages in which outliers are dropped eliminates four ratios numbered (1, 5, 8, 13) and yields an average $\bar{R} = 1.064$ and standard deviation s_R=0.0272. $\bar{R}$ is an estimate of β. The standard deviation of $\bar{R}$ is $\sigma_R/\sqrt{22} = 0.0058$ so that $\bar{R}$ is a less accurate estimate of β than that derived from the regressions above. The values of

$$v=R -1.064=\Delta R$$

are listed with the outliers marked by a D. Finally we calculate and list

$$w = F' - \frac{F''}{1.0593} = \Delta F.$$

Except for the two outliers, marked D, corresponding to points (1, 5) all of the values of ΔF are less than 0.09 kHz in absolute value and have a sample mean of −6.92 Hz and standard deviation of 48 Hz.

These data are consistent with the copy hypothesis, a probability of about 1/4 or less of an incorrect match and relatively small measurement errors in the time and frequency measurements. To be more specific, let us suppose (i) that the Channel II markings are precise, (ii) the Channel I markings may be either wrong or correct, but displaced by an amount due to the noise, and (iii) each measurement has a reading error.

For example suppose

$$t' = \alpha + \beta t'' + u_n$$

$$T' = t' + u'_e$$

$$T'' = t'' + u''_e$$

where t' and t" are the exact times of the corresponding events, u_n is the contribution of the distortion due to noise, T' and T" are the observed times, and u'_e and u''_e are the reading errors. Then

$$T' = \alpha + \beta T'' + (u_n + u'_e - \beta u''_e) = \alpha + \beta T'' + \Delta T$$

and, assuming independence of the residuals,

$$\sigma^2_{\Delta T} = \sigma^2_{u_n} + (1 + \beta^2)\, \sigma^2_{u_e} \approx \sigma^2_{u_n} + 2\sigma^2_{u_e}$$

(The lack of statistical independence between T" and u=ΔT raises a technical problem which is minor in the present context and won't be discussed here).

Because the process of discarding outliers tends to bias the estimated standard deviation downwards, one would expect σ_u to be about 0.01 which is consistent with $\sigma_{u_e} \approx 0.005$ and $\sigma_{u_n} \approx 0.007$, although other combinations are also plausible considering, the data and the measurement techniques. The five outliers, one of which is much larger than the others, suggest that the probability of incorrect match may be as large as 1/4.

A similar analysis may be applied to the frequencies. If we write

$$f' = \beta^{-1} f'' + v_n$$

$$F'' = f'' + v''_e$$

$$F' = f' + v'_e$$

where f' and f" are the exact frequencies, v_n is the contribution of the distortion due to noise, F' and F" are the observed frequencies, and v'_e and v''_e are the reading errors. Then

$$F = \frac{F''}{F'} = \beta + \Delta R$$

where the probability distribution of v=ΔR can be approximated by one with mean 0 and standard deviation

$$\sigma_{\Delta R} = (f')^{-1}[\beta^2 \sigma_{v_n}^2 + (1+\beta^2)\sigma_{v_e}^2]^{1/2} \approx [\sigma_{v_n}^2 + 2\sigma_{v_e}^2]^{1/2}/f'$$

which averages out to approximately $\overline{[(F')^{-1}]}[\sigma_{v_n}^2 + 2\sigma_{v_e}^2]^{1/2}$ where $\overline{[(F')^{-1}]}$ is the average of the $(F')^{-1}$ values. Also

$$\Delta F = F' - \beta^{-1} F''$$

has mean 0 and standard deviation

$$\sigma_{\Delta F} = \{\sigma_{v_n}^2 + \sigma_{v_e}^2 [1+\beta^{-2}]\}^{1/2} \approx [\sigma_{v_n}^2 + 2\sigma_{v_e}^2]^{1/2}$$

and

$$\sigma_{\Delta R} \approx \overline{(F'^{-1})}\sigma_{\Delta F}.$$

the relation

$$\sigma_{\Delta R} \approx \overline{(F'^{-1})}\sigma_{\Delta F}$$

is approximately maintained by the estimates.

Could the observed coincidences have occurred even if the message on Channel I were not a copy of that on Channel II? Suppose that as an alternative hypothesis we assume that it was a different message and the time coincidences took place because the features marked maxima, minima, flats, and downward slopes occur frequently on Channel I and a similar feature could, at random, be close by to one being sought. For example, there are 18 peaks in a 3.6 second interval. Thus at random, peaks would occur at an average spacing of 0.2 seconds and, according to the Poisson process calculation, the probability of at least one peak within a time of δ seconds from a specified time would be $p=1-e^{-2\delta/0.2}$.

The frequencies of the other features are no greater than that of peaks; hence, the probability of a coincidence within $|\Delta T|\leq 0.015$ is $p=1-e^{-0.15}=0.14$. We have 22 such coincidences out of 27 trials. Granted that we selected estimates of α and β to increase the number of such coincidences, we may, to be conservative, eliminate two of these coincidences. We then have 20 out of 25 coincidences. Assuming independence, the number of such coincidences has a binomial distribution with mean 25×(0.14)=3.5 and standard deviation 1.73. Then 20 is 9.51 standard deviations away from the mean and the probability of getting as many as 18 coincidences is about 2.1×10^{-13}.

Note that 25 of 27 values of ΔF are less than 0.1 kHz in absolute value. If each of these ΔF were uniformly distributed over a narrow range of ±0.3 kHz, the probability of 25 or more independent absolute values less than 0.1 would be very small (2×10^{-10}). In fact, this probability would be 0.001 even if the range of values of ΔF were cut in half to ±0.15 kHz.

The sound spectrograms shown in Figure 4 are similar to those in Figure B-3 except that one recording is slowed down 6.7% to bring the ratio of apparent recorder speeds closer to unity. The black dots indicate the same features as in Figure B-3 except for a few points, such as I, that have been adjusted for a better fit in Figure 4.

B-2. MEAUSREMENTS OF EASILY IDENTIFIED FREQUENCY RATIOS ON SOUND SPECTROGRAMS

A casual inspection of the original sound spectrograms of sections of Channel I and Channel II recordings for the time interval identified as containing the phrase “hold everything...” show marked similarities, but with the most clearly defined frequencies on Channel I being somewhat lower than those on corresponding sections of Channel II. Since the analysis of the preceding section shows that the measured times between corresponding events on Channel I are longer than on Channel II, by about 6%, it seemed worth measuring the frequency ratios of corresponding signals that were particularly well suited for frequency measurement; if the two sound spectrograms really did originate from a single 3.5 second long signal on Channel II, which was fed by cross talk onto Channel I, then the frequency ratio must depart from unity by that same approximately 6%. This was our working hypothesis at the time, so the frequency ratio measurements provided a test of the hypothesis—if the frequency ratio was not approximately 1.06 the hypothesis would have been totally disproved.

One of the Committee members, therefore, measured the frequency ratio at five corresponding sections of the records. The sections to be measured were selected by a simple criterion that can be used by any interested person. The frequency must stay constant (a horizontal band, by visual inspection) for at least 1/30 second, and it must be clearly visible on both channels at corresponding times. It is not required that the frequency bands originate from speech components of the signals on Channel II. Anyone listening to this section of Channel II will hear, in addition to the sentence starting with “Hold everything secure...,” a number of tones that are both amplitude and frequency modulated. These tones are as useful as the speech components in proving that a signal on Channel II was imprinted by cross talk onto Channel I at the time of the conjectured “shots”.

The above mentioned criterion was satisfied by five sections of the two tapes, which are identified by their original times T', on Channel I. They are as follows:

Section			Time	
1	centered at T'	=	0.67	seconds
2	"	=	2.19	"
3	"	=	3.13	"
4	"	=	3.31	"
5	"	=	3.52	"

The measurement of each frequency was made in the following way: an indentation was made in the surface of the glossy print, near the center of each "band," with a sharp point. The observer then looked at the mark, to check that it was as nearly centered as possible in the vertical direction. On the few occasions that it appeared to be above or below the center of the band, a new mark was made, and checked to be adequately centered. Only after the observer was satisfied that he had placed ten marks correctly— one for each of five bands, on two spectrograms—did the measurements begin. The measurement consisted of a linear interpolation between adjacent kilohertz lines using a millimeter scale as the measuring device. The following five ratios came out of the measurements just as described:

Section	Frequency Ratio
1	1.054
2	1.066
3	1.065
4	1.052
5	1.067
Mean Value	1.061±0.007

This value is consistent with the time ratio 1.059±0.002 found from the slope of the line relating the time coordinates on the two channels in Figure 5.

Another Committee member made independent measurements of the average of the same frequency ratios and found a mean value of 1.063±0.007

In view of the close agreement between this pair of independent measurements, we conclude that the mean frequency ratio is

$$R=1.062\pm0.007.$$

The excellent agreement between the time-derived, and the frequency-derived ratio of tapes speeds lends strong support to the hypothesis that the “hold eveything...” signals observed on Channel I were imprinted by cross talk from Channel II.

B-3. ALTERNATIVE TIME AND FREQUENCY ANALYSES OF SOUND SPECTROGRAMS

The analyses in Appendixes B-1 and B-2 may be subject to some criticism. A certain amount of subjectivity derives from the fact that the first observer was looking at the sound spectrograms from both channels while he marked points on Channel I. The strips in Channel II were one second wide, which is a substantial portion of the entire 3.5 second spectrogram. Consequently the 27 strips had large overlapping parts. To the extent that observer 2 recalled what he did on previous matches or to the extent that he used the same cues in the overlapping portions, the resulting times were dependent observations. A theory that uses estimates and conclusions based on independence assumptions may overestimate the significance or accuracy of these conclusions and estimates.

However, this experiment was supplemented by several variations that derived similar results. Some of these were more careful to avoid the subjectivity and to reduce considerably the dependence aspects of the experiment presented here. These are not reported in detail, because they were carried out using xerographic copies of photographs using several scales, and relatively crude measuring instruments (graph paper in place of rulers). A presentation here would be more complex and the photographs would lack clarity.

a) Initial experiments

In chronological order, an initial experiment was carried out where 28 pairs of corresponding points were measured on both Channel I and Channel II by an observer who studied both spectrograms simultaneously for characteristic features. A least squares analysis of these highly subjective data gave the fitted relation

$$T' = -0.0402 + 1.0673T''$$

and the ratios of the observed frequencies

$$R = F''/F'$$

averaged to 1.0728.

A "robust" analysis of the pairs (T', T") in the first experiment, where three outliers were discarded, gave the estimated relation

$$T' = -0.0235 + 1.0633\, T'' + u$$

where the residual u had estimated standard deviation 0.0159 and the estimated standard deviation of the coefficient β of T" was 0.0028.

An alternate robust linear regression, implemented on the Minitab-1980 interactive statistical package[5] under the command RLIN, gave

$$T' = -0.0295 + 1.0626\, T'' + u$$

A second experiment was by an observer who measured the central frequencies of 5 distinct pairs of broad horizontal sections appearing at comparable times and with relatively high frequencies. The ratios of these central frequencies R averaged $\bar{R} = 1.060$ and had sample standard deviation 0.0072.

b) A more objective experiment on the timing

At this point a more objective procedure was carried out using xerographic copies of a reduced photograph of the spectrograms. The observer was given the experimenter's explanation of the theory that messages were broadcast on Channel II and picked up by the stuck microphone located near a receiver of Channel II. The observer was shown copies of Channel I and II for two other messages that had been well duplicated; Y—"You want...Stemmons" and S—"Says they came from...." It was explained that dark portions meant loud signals and sharp changes that were dark would probably be well reproduced under the theory. The observer was asked to mark about 20 spots on Channel II that would be likely to be well reproduced. The observer was not given an opportunity to study Channel I of H—the spectrogram suspected of being "Hold everything secure...."

Twenty strips of Channel II of H, each between 0.2 and 0.3 seconds long, were reproduced by xerox with the marked point in the center. The estimate

$\hat{T} = -0.0402 + 1.0673T''$ was used to locate corresponding points on Channel I. Strips of a xerox of Channel I were cut out. These strips were 3/4 second long and were centered at a point displaced from $\hat{T}$ by a random quantity uniformly distributed on the interval (−.3, .3) in seconds. Corresponding strips were paired and these pairs were arranged in random order.

A second observer was asked to align the two strips of each pair and to locate on Channel I a vertical mark corresponding to the time of the mark in Channel II. This observer was allowed to use as much context as was available, in the approimxately 0.3 second of Channel II and 0.75 seconds of Channel I in the pair, to help him make the mark. It was not necessary for him to find a feature corresponding to the point marked. He, too, had the theory explained to him, and he was informed that there might be a consistent difference in the frequencies on the two channels.

This experiment requires some balance in selecting the widths of the strips. If both strips are too narrow, one is bound to get (T', T'') points that lie close to the line $T'=1.0673T''-0.0404$ and a good fit will not be convincing. If the strip on Channel II is too narrow and that of Channel I is very wide, it will be very easy for the observer to be misled by similar characteristics elsewhere. This would reduce the efficiency and power of the experiment. If the strip on Channel II is wide, then the different strips will overlap substantially and memory and the cues the observer uses may make results on different strips dependent. As the experiment was carried out the 20 strips of Channel II had pairs with some overlap, but in the random order of presentation these small strips looked quite distinct.

When the times were measured, the deviations, $\Delta T=T'-(1.0633T''-0.0235)$, between the measured time in Channel I and the time anticipated by the robust estimate of the straight line, were calculated. Thirteen of these were no larger than 0.054 seconds, one was 0.075 seconds and the remaining 6 of 0.203 seconds or more. The mean and standard deviation of the thirteen smaller deviations were −0.016 seconds and 0.026 seconds. The root mean square deviation was 0.029 seconds.

These results are consistent with the copy hypothesis if one anticipates misclassifications about 1/4 of the time and measurement error due to noise and measurement accuracy of about 0.03 second (about 0.07 inch on the scales used).

Under the randomness alternative hypothesis, that the two messages are unrelated and any matching of features is randomly located, one may estimate that the probability of being within 0.054 seconds of the expected point to be about 0.2.* The number of such coincidences out of 20 independent trials would be binomially distributed with mean 4 and standard deviation 1.79 and 13 successes corresponds to (13−4−.5)/(l.79)=4.75 standard deviations from the mean and is highly unlikely.

Moreover, subtracting 2 of the 13 successes to compensate for the choice of the linear fit would still make this match very unlikely. Then we would have (11−4−.5)/1.79=3.63 standard deviations with P=0.0006.

The poor quality of the xerographic copies with which this experiment was carried out and the low-quality measuring instruments explain in part why the standard deviation of the observed discrepancies were much larger than those observed with the data presented in Table B-1.

c) A more objective experiment on the frequencies

The experimenter selected 14 dark horizontal bands on a xerox copy of Channel II. The time points T" of these horizontal bands were measured. Corresponding times on Channel I given by $\hat{T} = 1.0633T'' - 0.0225$ were located. The subject was requested to mark the central frequency of the bands on Channel II. Then the subject was requested to locate bands on Channel I at the times marked and to mark the central frequency.

These central frequencies were measured and labeled F_1 and F_2 for the two channels. The ratio $R=F_2/F_1$ was calculated and ranged from 1.337 to 1.024. Deleting 4 outliers, the average was $\bar{R} = 1.0665$ and the sample standard deviation was s_R=0.0116.

*Under the randomness hypotheses, the distribution of the discrepancy corresponds to the sum of the off center random displacement (uniform from −.3 to .3) and an independent random choice in (−.375, .375) along the Channel I strip. Since this latter choice is almost uniform except for a possible bias toward the center, it was modeled as the sum of two uniforms from (−.3 to .3) which has a symmetric triangular distribution from −.6 to .6. The probability that this sum is between −.054 and +.054 is

$$1 - \left(\frac{.6-.054}{.6}\right)^2 = 0.17 \leq 0.2.$$

These data are consistent with a hypotheses that Channel I is a noisy version of Channel II which leads to a wrong pairing about 1/3 of the time and that when the correct pairing is made, the noise distortion and measurement error in the individual central frequency readings corresponds to about $\bar{F}_2 s_R/\sqrt{2} = 0.015$ kHz or about 15 Hz.

By no stretch of the imagination could these readings be consistent with a purely random location of horizontal bands theory. Even a much more restrictive hypothesis, assuming that another speech was uttered in a similar cadence with similar frequencies of vowels and mechanisms yielding strong horizontal bands, was shown to be implausible as long as these bands were allowed to fluctuate at random within narrow ranges determined by the empirical data.

B-4. DIGITAL CALCULATIONS OF CROSS CORRELATIONS BETWEEN CHANNEL I ANDCHANNEL II

If indeed "hold everything..." on Channel II was transmitted to and recorded on Channel I at the time occupied by the assumed "shots", then the digital cross-correlation of the short-time acoustic (energy) spectra of the two Channels should show a correlation substantially larger than that which would be achieved by chance. This was studied by a member of the Committee and two collaborators. The Channel I and Channel II recordings were digitized and the short-term acoustic spectra were taken and stored in a digital computer. The printouts of these spectra are shown in Figures B-4, B-5 and B-6. These digital spectrograms were computed directly from magnetic tapes and did not involve the use of the FBI sound spectrogram equipment.

An objective measure of similarity of two spectral matches is obtained from the cross correlation coefficient, defined as for the functions X and Y by

$$ccc=(\Sigma X\cdot Y)/[(\Sigma X\cdot X)\cdot(\Sigma Y\cdot Y)]^{1/2}.$$

This cross correlation coefficient would be reduced if one of the recordings were played at the wrong speed, or if the recording at one time were compared with the same or a different recording at a different time.

The first cross correlation coefficients were made from the same Channel I and II recorded copies that were used in preparing Figures 3, 4, B-1, and B-2. It was found that the biggest peak for the cross correlation coefficient occurred for a relative warp (or speed ratio) of 1.06 in agreement with the other two manual approaches for comparing Channels I and II, a 1% deviation of warp from optimum diminished the peak substantially. Unfortunately, that Channel II copy contains many repeats caused by the Gray Audograph machine in playback. Accordingly another tape copy was prepared by members of the Committee directly from the original Audograph plastic disk itself and by the use of a standard turntable and tone arm, thus producing a tape without compensation for the fact that the disk was originally recorded at constant linear track speed. It was this tape that was used in preparing the sound spectrograms shown in Figures B-4, B-5, and B-6. The Channel II signals are from the 7.5 ips tape recording of the Gray Audograph record played on a turntable (12/9/81). The tape was played at 3.75 ips when digitized for these experments: hence, the rate of change of the correction factor was assumed to be half the measured rate of 0.0005 per second. The signals were digitized at 20000 samples per second, and a 400-pt Fourier transform was computed every 200 samples (10 millisec), using a 400-pt Blackman window. The correlations were performed on portions of the 200-pt spectra, which have a point spacing of 50 Hz. The high frequencies of the Channel I spectra were boosted at a rate of 6 db per 1000 Hz and then normalized to a constant energy in the band of interest.

Figure 6 gives the cross correlation coefficient for the “hold everything...” segments when the relative speed was selected to give the largest peak that occurred when the Channel II signal was sped up slightly by compressing the time scale by a factor that varied from 0.957 to 0.961 (changing at the rate of 0.00025 per sec). Figure 6 is a plot of the 750 correlation coefficients obtained by sliding 2.50 secs of Channel I along 10.00 secs of Channel II, 0.01 secs at a time, using frequencies in the band 600 Hz to 3500 Hz. For comparison the cross correlation coefficients of the unambiguous segment “You want...Stemmons” are plotted in Figure 7 with the time scale of Channel II stretched by a factor that varied from 1.013 to 1.015. The shape of the peak is vey similar to that for the “hold eveything...” segment. The background is somewhat smoother simply because there is less noise in Channel I at this time. Channel I, however, in neither case gives a perfect reproduction of Channel II. It has lost some of the high and low frequencies and, as one would expect, there are tones present on Channel I that are not on Channel II.

The marked narrow peaks of the cross correlation curves clearly show by an objective test that the “hold everything...” segment of Channel II is present on Channel I at the same location as the acoustic impulses.

Inspection of the spectrograms of Figure B-6 shows the presence of a Channel II brief tone beginning at time 32.00 secs and extending to 32.08 secs. It resumes at time 32.24 and disappears once more at 32.43. The Channel II brief tone is clearly visible in the Channel I spectrogram aligned by the relative timing obtained from Figure 6. A strong Channel I heterodyne is observed to begin at time 32.03 and to end at 32.17 secs. The resumption of the Channel II brief tone in Channel I at 32.24 secs is clearly weak and gradually grows in strength. These observations can be made more quantitatively from Figures B-7 and B-8, which are “printer plots” of the relevant regions of the Channel II and Channel I spectra. The vertical bars outlining the Channel II brief tone (and the same time-frequency bins in Channel I) not only guide the eye, but allow the quantitative calculation of the energy between the bars. The digits printed are the “bin energy” in decibels, each unit corresponding to a 4-db range. By the end of the first Channel II brief tone at time 32.08, it has been suppressed by about 10 db relative to its value before the Channel I heterodyne appeared at 32.03. When the Channel II brief tone reappears at 30.24 secs, the AGC has suppressed it by approximately 20 db, and it recovers to its original value only at about 32.43 secs, some 0.26 secs after the end of the Channel I heterodyne at 32.17 secs. That this AGC action is not due to a later recorder or a re-recording is demonstrated by the fact that much stronger Channel II brief tones are present on the Channel I recording, without showing the drop in intensity which is induced by the Channel I heterodyne.

APPENDIX C

TIMING OF CHANNEL I AND II EVENTS

This Appendix discusses the results of a study of the times of occurrence of certain key events on Channels I and II. The times were determined in two ways: 1) by listening to the Bowles tapes and by measuring the strip charts (in Figures C-1 and C-2) of the tape recording signal levels as a function of time; and 2) by listening to tape recordings made from the original Gray Audograph and Dictaphone records.

C-1. ANALYSIS OF BOWLES TAPES

The Channel II transmission "You want me...Stemmons"* that occurs about 200 seconds after the transmission by Chief Curry, "Go to the hospital," is clearly audible and intelligible on Channel I. It provides a common reference point for synchronizing the Channel I and II tapes, and we can use it to determine whether the events on Channel I identified by BRSW/WA as shots occurred before or after Chief Curry broadcast his instructions "Go to the hospital." If these events occurred after Chief Curry's instructions, they could not be the assassination shots,

The transmission "hold everything..." on Channel I coincides in time with the last of the events BRSW/WA identified as shots. The strip chart timings provide evidence to support an explanation of how this transmission could have occurred at the same point in real time as the matching "hold everything..." transmission on Channel II. They depend only on whether or not the instructions "Go to the hospital" preceded the events identified by BRSW/WA as shots.

Channel I Recording

Measurement of the interval on Channel I between "You want me...Stemmons" and the conjectured shots is straightforward. The logging recorder (Dictaphone) ran continuously over the time of interest (even though it was sound-actuated), and the tape recording that we used for our measurements shows no evidence of skips, repeats, gaps, halts or similar artifacts that would affect the timing. Table C-1 gives the times of the transmissions of interest to us on Channel I.

*A transcript of the relevant portions of both tapes appears at the end of this appendix (Tables C-2 and C-3). It was obtained from J.C.Bowles. The time used by Bowles is retained on the transcript even though it differs from the one favored by the Committee.

Channel II Recording

Measurement of the time intervals on Channel I between "Do you want me...Stemmons" and "Go to the hospital" is more difficult. The logging recorder (Gray Audograph) was sound-actuated and did not operate continuously. So the actual record is shorter than real time. There are repeats in the Bowles' tape recording that occurred when the Gray Audograph playback stylus jumped back to a previous groove in the record much as the stylus on a scratched phonograph record often does. The tape recordings made available to us initially were in two segments, with a break occurring between the two transmissions of interest. The first segment was recorded at a speed different from that of the second segment. All of these artifacts required compensation in order to obtain an accurate determination of the interval between the two transmissions. Compensation was done as follows:

a. Gap

Barger had access to an unbroken recording of the entire interval of interest from which he was able to show that a section of the original Channel II recording 0.4 seconds long had not been captured on the recordings we initially used.

b. Speed Compensation

The relative speed of the two segments of tape can be estimated from the sound spectrographs discussed in Appendix B. From this analysis we determined that times measured from the first segment of Channel II, which we designate Channel IIA, had to be multiplied by a factor of 1.06 to convert them to the time units of Channel IIB, the second tape recorder segment. Further, Barger and Weiss ascertained by an analysis of tones on Channel I and Channel IIB that these two tape recordings were made at essentially the same speed and that no correction was necessary to convert Channel IIB times to equivalent Channel I times.

BRSW reported that the Channel I times had to be multiplied by a factor of 1.05 to convert them to "real" time. We have not made this additional correction but instead have expressed all of our results in equivalent Channel I tape recorder time units. Table C-1 shows the

TABLE C-1 Time measurements using sound level recordings (seconds)

Event	Measured Time Intervals		Cumulative Time w/o Repeats	Cumulative Time (Speed Corrected)	Silence Duration (Speed Corrected)
	Tape	Chart			
CHANNEL 2					
Go to hospital	0	0	0	0	
Hold everything secure	60.2		60.2	63.8	3.7,3.6
repeat 1		(6.2)			
12:32	31.6		85.6	90.7	3.8
repeat 3		(3.8)	5.2		
repeat 5		(3.3)			4.8,5.3
Get'em out of way	70.2		148.7	157.6	
Gap begins	2.3		151.0	160.1	
Gap duration	0.4				5.6
15.2	2.8		154.2	162.9	
repeat 6		(3.5)			
12:34	15.1		165.8	174.5	
You want...Stemmons	14.4		180.2	188.9	5.5
CHANNEL 1					
Hold everything ("shot" 3)	0.		0.	0.	
Bell	7.3		7.3		
You want...Stemmons	16.3		170.6	170.6	

measured time intervals between key transmissions on Channel II and the cummulative time, measured from "hold everything" at which these transmissions occurred, corrected for the speed difference between Channel IIA and Channel IIB.

c. Repeats

Five repeats are evident from listening to the tape. All of these occurred in places where there were distinctive audible transmissions. As explained below, not all of these repeats actually increased the duration of the tape. In two cases the stylus apparently jumped backward to the previous track and started to repeat, but then jumped forward to the correct track before the recorder completed a single revolution. When this occurred, the duration of the tape would not have been lengthened relative to the duration of the original record. The strip charts of Figures C-1 and C-2 provide the detailed information from which we can determine whether the duration of each repeat was an integer multiple of the period of rotation of the record or not, and we used them to identify these two cases.

The three repeats that can be unambiguously identified by listening and by examining the strip chart pattern are:

Repeat 1 at 65 sec.	6.2 sec. added, 6.6 sec. corrected time
Repeat 3 at 122 sec.	3.8 sec. added, 4.0 sec. corrected time
Repeat 6 at 177 sec.	3.5 sec. added, 3.5 sec. corrected time

The repeats are multiples of about 3.5 seconds (corrected time), which time can be taken as the period of rotation of the recorder (the angular velocity of the recording disk on the Gray Audograph is not constant).

The strip charts also can be used to measure accurately the duration of the silences. We found one very long (7 second) silence, starting at 155 seconds that we believe was caused by a repeat during a portion of the tape in which there were no distinctive audible patterns. Therefore, we have:

Repeat 5 at 158 sec. 3.3 sec. added, 3.5 sec. corrected time

All of these repeats caused the Channel II times to be increased and the tape timings must be reduced to correct for them. This is done in Table C-1 in the columns labelled "Cumulative Time."

There are two other possible repeats, one at 96 seconds (repeat 2) and the other at 129 seconds (repeat 4). The first of these is not a repeat that caused the tape to be lengthened, since only a single word (notified) of a longer passage is repeated. The second, repeat 4, is less clear:

Repeat 4 at 129 secs 2.3 secs added, 2.4 secs corrected time

Note that this is not a multiple of 3.5 seconds. In the case of this repeat and repeat 2, the stylus apparently jumped back for a fraction of a revolution and then skipped forward to the correct track, thereby terminating the repeat. The fact that neither of these lasted a complete rotation means that there was not a spurious increase in the tape duration, and the timings should not be corrected.

d. Silences

We are told by James Bowles that the recorders had hold relays which kept them on for approximately 4 seconds after a transmission ended (the time between the end of a transmission and the recorder turnoff depends on sound intensity and is longer for very loud sounds). We do not know the threshold for this hold relay, but it is reasonable to assume that it was about 10 db below the peak signal voltage.

If a silence is less than 4 seconds, the recorder would not stop and the recorder time would correspond approximately to real time. If a silence is longer than 4 seconds, the recorder would stop and there is no simple way of determining the duration of the pause that might have occurred before it restarted.

Note that starting with "Go to the hospital" at zero seconds to silence A at 106 seconds, all silences are less than 4 seconds. The

Channel II recorder must have run continuously during this interval. Starting at 106 seconds, we have a number of silences greater than 4.5 seconds during which the recorder could have paused. They are:

Silence A at 106 sec.,	4.9 sec. duration, 5.2 sec. corrected time
Silence B at 132 sec.,	4.5 sec. duration, 4.8 sec. corrected time
Silence C at 145 sec.,	5.0 sec. duration, 5.3 sec. corrected time
Silence D at 162 sec.,	5.5 sec. duration, 5.6 sec. corrected time
Silence E at 189 sec.,	5.5 sec. duration, 5.5 sec. corrected time

This pattern of pauses means that, although the tape ran continuously for the first 106 seconds, during the second 100 seconds it apparently paused 5 times. During any of these pauses an indeterminate amount of time could have passed before the recorder restarted.

If during these 5 pauses the recorder had stopped for a total of 46 seconds, the “hold everything...” transmissions on the two channels would have coincided with time. We have no data that would allow us to determine how long the recorder actually stopped. It does not seem unreasonable that there would have been 46 seconds that Channel II was not being used during the period that the motorcade was occupied with making the trip to Parkland Hospital at high speed. In Appendix D, definite evidence is given that the Channel II recorder made at least one stop of 2.9 seconds duration between “hold everything...” and “You want Stemmons.”

Results

From Table C-1 we see that:

1) On Channel I, “hold everything...” (which coincides in time with the last of the BBN “shots”) occurs 171 seconds before “you want me... Stemmons”.
2) On Channel II, “go to the hospital” occurred 189 seconds before “you want me... Stemmons”, and 64 seconds before “hold everything...”

By this analysis, the last of the BRSW "shots" occurred at least 18 seconds after Chief Curry issued his instructions "Go to the hospital" and the events identified by BRSW/WA could not have been the shots of the assassination. Except for determining the correction factor for time measurements in Channel IIA, this result does not require that the two "hold everything..." transmissions be identical; it requires only that the two "You want me...Stemmons" transmissions be the same. Note further that this result is deterministic, not based on probabilistic arguments. If one includes the known 2.9 second stop of the Channel II recorder discussed above and in Appendix D, the last of the impulses attributed to shots occurred at least 20.9 seconds after "Go to the hospital."

For the two "hold eveything..." transmissions to coincide the recorder would have had to be inactive for 46 seconds, in which case the conjectured shots would have occurred at least 64 seconds after the chief's instructions, "Go to the hospital." There were five places where the recorder could have stopped, during which the 46 seconds of inactive time could have accumulated. For the events identified as shots by BRSW/WA to have occurred before Chief Curry's instructions, "Go to the hospital," at least 20.9 seconds would have to be deleted from Channel II, or added to Channel I. We see no evidence of anything that would allow us to shorten the Channel II times more than has already been done. Possible mechanisms that might permit us to lengthen Channel I are backward skips in the original Dictaphone recording of Channel I, or forward skips on playback. Backward skips on recording would require manual resetting of the recording stylus, an unlikely event given the automatic operation of the logging recorders, and would result in a superposition of recordings as discussed in Appendix D. Physical examination of the Dictabelt revealed no evidence of superposed recordings.

C-2. ANALYSIS OF TAPES MADE DIRECTLY FROM ORIGINAL RECORDS

After the preceding analysis of the Bowles tape recordings had been completed, the Committee obtained access to the original Gray Audograph and Dictaphone recordings from the Department of Justice. These were transcribed onto tapes carefully so as to keep the amount of 60 Hz hum and other artifacts added to the tapes to a minimum.

Channel I Recording

The Dictabelt (Channel I) was transcribed using a Dictaphone playback unit, with its playback speed adjusted to be equal to the original recording speed. The 60 Hz hum from the original record was used to make this adjustment. The Dictabelt was in poor condition and it was difficult to measure accurately the period of the 60 Hz hum required for the speed adjustment. No skips or repeats were apparent in the process of transcription, nor are there indications of any on the resulting tapes. The time between the “You want me...Stemmons” transmission and the “Hold everything...” transmission, which coincided with the part of the tape where BRSW/WA said they found shots, was found to be 178 seconds. This compares with 171 seconds in the analysis of the Bowles tapes, in which we did not attempt to correct the times to real time.

Channel II Recording

The Gray Audograph disk (Channel II) could not be played on an original Gray playback unit without introducing skips and repeats. It was possible to play it successfully without either of these artifacts being introduced by using a phonograph turntable and phonograph arm, cartridge, and stylus. However, phonograph turntables operate at a constant rpm, whereas the Gray equipment maintains a constant linear velocity of the record relative to the stylus. Moreover, the Gray Audograph records from the inside out, whereas normal records begin at the outside. Thus, when the tapes are played back, there is a speed distortion that causes material at the beginning of the tape (the inside of the record) to be slowed down (time intervals between events are longer and the frequencies are lower than those originally recorded) and material at the end of the tape (end of the record) to be speeded up relative to true speed.

We were able to use the 60 Hz hum present on the tape to correct for this speed distortion. The hum level on the original record was fairly high and is easily discernible in the tapes during the many intervals of relative silence. By measuring the period of the hum at different points on the tape, we can determine the correction factor that must be applied to time measurements to convert them to real time.

The correction factor measurements for many points in the part of the tape of interest to us are plotted in Figure C-3. Note that in the interval between “Go to the hospital” at 22 seconds and “You want me... Stemmons” at 238 seconds the correction factor varies linearly with time. It has a value of about 0.95 at 130 seconds, the midpoint between these two events. We can relate the corrected (real) time, t_c to the measured time, t_m, by

$$dt_c=K_o dt_m+K' t_m dt_m$$

where K_o is the time correction factor at the midpoint and K' is the slope of the correction factor line from Figure C-3. If the midpoint is taken as the time origin and this equation is integrated over the interval “Go” to “You,” we obtain

$$T_{c,You}-T_{c,Go}=K_o(T_{m,You}-T_{m,Go})+K'(T^2_{m,You}-T^2_{m,Go})/2$$

where K_o=0.95 and K' the slope of the regression line in Figure C-3 is 0.0005. Since the $T^2_{m,Go}=T^2_{m,You}$, given that the time origin is midway between them, the second term on the right is zero, and

$$T_{c,You}-T_{c,go}=0.95(T_{m,You}-T_{m,Go}).$$

Substituting the values for $T_{m,You}$ and $T_{m,Go}$, we find that

$$T_{c,You}-T_{c,Go}=206 \text{ seconds}.$$

Results

By this analysis Chief Curry instructed the motorcade to go to the hospital at least 206 seconds before the "You want me...Stemmons" transmission. The events identified by BRSW/WA as shots occurred 178 seconds before the "You want me...Stemmons" transmission, or at least 28 seconds after Chief Curry instructed the motorcade to "Go to the hospital." This is a lower bound on the interval, because Channel II was sound-operated and halted when there were long periods of quiet. This second analysis confirms the findings from the Bowles tapes that the events identified by BRSW/WA as shots could not have been the assassination shots. If one includes the known 2.9 seecond stop of the Channel II recorder that is discussed in Appendix D, the impulses attributed to shots occurred at least 30.9 seconds aftr the instruction "Go to the hospital."

The two sets of measurements are in reasonable agreement. The two Channel I times, 171 and 178 seconds (original record), show that the Bowles tapes played back about 4% faster than real time. If we apply this same correction factor to the Channel II time obtained from the Bowles tape, we obtain 197 seconds as the estimate of the elapsed time between "Go to the hospital" and "You want me...Stemmons". This compares with 206 seconds obtained from the tapes made directly from the original records. The difference, only 9 seconds, is probably due to the artifacts of the Bowles tapes: undetected skips, a sequence interpreted incorrectly as a repeat, or too low an estimate of the gap duration. We tried to be conservative in correcting for the artifacts on Channel II of the Bowles tapes and it is not surprising that the time interval between "Go" and "You" obtained from the Bowles tape is smaller than that obtained from the tape of the original recording. The tapes from the original records have fewer artifacts and a more certain history. They are believed to provide more accurate estimates of the time intervals than the Bowles tapes.

TABLE C-2

Channel I Transcript

from J.C.Bowles

~12:30 to ~12:37

(Including changes suggested by Bowles in a letter dated December 30, 1981. The times indicated are those in Bowles reports; the times and time intervals determined by the Committee are somewhat different).

Bowles' Times		
12:29:20	?	...Market Office...
12:29:27	?	...All right...
12:31:00		(Motorcycle engine slowed down.)
12:31:02	?	I'll check it. (discounted by sound spectrograms)
12:31:10		(Motorcycle engine slowed to idle speed.)
12:31:12		"Hold everything secure..." (confirmed by sound spectrograms to be Sheriff Decker in a crossover from Channel II.
12:31:20		(Single tone of a bell.)
12:31:24		(Motorcycle engine at very slow idle.)
12:31:32		("Bonk" sound-motorcycle engine revved up.)
12:31:40		(Motorcycle sound like it started moving.)
12:31:48		(Motor slowed down; perhaps another approached.)
12:31:52	?	...on the phone. (Motor slow to idle.)
12:31:56		(someone whistling a tune in background.)
12:31:58		("Bonk-Bonk" sound again.)
12:32:04	?	(Unreadable-sounds like...87...)
12:32:05		(Hetrodyne sound of Morse Code "V" and motor seems to speed up.)
12:32:08	603	603 out, Baylor.
12:32:22	36	36...(Motor slowed down just before "36")
12:32:35	36	36...(Motor slow and irregular)
12:32:38	91	91 clear, request a "5".
12:32:39	Dispatcher	531 testing, 1–2–3–4.
12:32:42		(Someone whistling again-unidentifiable tune.)
12:32:46	?	Loud and Clear.
12:32:48	48	48, lound and clear.
12:32:56	Dispatcher	56...(Motor revved up)
12:32:56	91	91...
12:33:00	(91)	91, request a "5".

12:33:01		(Blending with the ending of 91's message the sound of sirens can be heard, faintly but increasing in loudness.)
12:33:03	Dispatcher	10–4... Anybody know where 56 is? (sirens continue.)
12:33:08	?	He checked out on traffic
12:33:18	75	75, signal 5? (Sirens continue-motor slow and irregular.)
12:33:26	76	76 clear. (Sirens continue-motor revved up.)
12:33:34		(Sirens fade to inaudible.)
12:33:35		(Someone whistling again.)
12:33:38	(DSO?)	Attention all units, all units...
12:33:50	?	(unreadable.)
12:33:52	191-Ch. II	You want me to still hold this traffic on Stemmons until we find out something, or...
12:33:57	(103)	clear. (Motor idling.)
12:33:59	Dispatcher	Clear, 12:34. (Motorcycle engine revved up.)
12:34:00	76	76 clear. (Motor revved up.)
	76	76 clear.
12:34:09 (12:34)	Dispatcher	76 clear, 12:34. (Motorcycle sounds like it is moving.)
12:34:18	75	75 a “5”. (Motorcycle seems to gain speed.)
12:34:19		(Microphone closed .)
12:34:22	Dispatcher	24...
	24	24...(unknown 3...)
12:34:25	Dispatcher	Report to Inwood and Stemmons and cut all traffic for the ambulance going to Parkland. Code 3.

12:34:30	?	(Unknown__seventy...) (Probably 75)
12:34:32	(24)	Inwood and Stemmons?
12:34:35	Dispatcher	Inwood and Stemmons where they come off Stemmons going to Parkland.
12:34:40	(24)	10–4.
12:34:43	Dispatcher	Make your assignment Code, 3, 24.
12:34:45	(24)	10–4.
12:34:46 (12:35)	Dispatcher	35 a signal 9 A at Lobello's, Ames and Northwest, 12:35. (Motorcycle transmitter stuck open again.)
12:34:52	Dispatcher	Location, 93? ... Disregard...21...
	21	21.
12:34:58	Dispatcher	Code 3, Stemmons and Inwood, cut traffic.
	21	10–4.
12:35:01	348/75	348...75...
12:35:03	Dispatcher	75
12:35:04	75	Signal 5?
12:35:05	Dispatcher	10–4.
12:35:06	65	65 clear, (heterodyne)
12:35:07 (12:36)	Dispatcher	65 clear (4 interrupts), 12:36...4, did you call? (motor at slow idle.)
12:35:12	4	...Cedar Springs and Mockingbird... (Noisy signal-unreadable...motor slow and irregular.)
12:35:22	Dispatcher	4, we have a mike butt stuck...bike... button stuck open. We can't hear snything.
	4	(Still unreadable...motor slow and irregular.)
12:35:36	Dispatcher	93...
12:35:38	Ch. II	Attention, all emergency equipment...
(12:36)	Dispatcher	Attention, all emergency equipment... Do not use Industrial Blvd... Do not use Industrial Blvd., 12:36. (Motor slow, irregular)
12:35:47	93	93. (Motor idled down.)
12:35:48	Dispatcher	Location?
12:35:49	93	Sylvian and Ft. Worth, (motor still slow.)

12:35:54	(4)?	El...uh...Eleven...(unreadable.)
12:35:57	260–Ch.II	...came from the 5th floor (Channel I dispatcher 24...) of the Texas Depository.. Bookstore...(sic)
12:36:04		(Transmitter closed with this message.)
12:36:05	Dispatcher	35, did you receive?
12:36:07	(35)	I got it.
12:36:08	Dispatcher	10–4.
12:36:10	61	61 clear.
12:36:15 (12:37)	Dispatcher	61 clear, 12:37.
12:36:21	4	4 to 11...1131...
12:36:26	21	21...(Siren slowing in background.)
12:36:28	Dispatcher	21...continue...(Interrupted...)
12:36:31	24	24...
12:36:35	93	93...(Dispatcher followed with:)

TABLE C-3

Channel II Transcript

from J.C.Bowles

12:30 to 12:38

(The times indicated are those in Bowles report. The times and time intervals determined by the Committee are somewhat different).

BOWLES TIMES	
Approx. Dispatcher	12:30 KKB364.
12:31:16/17 125	125 to 250...
Approx. Dispatcher 12:31:23	15-2...(then, overriding the dispatcher...)
Channel II 12:31:08	Go to the hospital...("On our way")..Parkland
Channel I	Hospital. Have them stand by...... Get men on top of that there over...underpass. See what happenend up there. Go up to the overpass. (At least one transmitter was open for a while, now.)
?	(Unreadable-sounds like "91 Champion.")
?	...to 1...
1	Have Parkland stand by.
Dallas 1	1...Dallasl...
Dispatcher	Go Ahead, Dallas.1.
Dallas 1	Tell my men to empty the jail, and up on the railroad, uh, right-of-way there... I'm sure it's going to take some time for you to get your men in... Pull everyone of my men in there.
Dispatcher	Repeat, 1... I didn't quite understand all of it.
Dallas 1	Have station 5 to move all men available out of my department, back into the railroad yards there in an effort to try to determine...just what and where it happenend down there, and hold everything secure until the homocide and other investigators can get there.

Dispatcher	10–4, Dallas 1, Station 5 will be notified.
57	57...
Dispatcher	1...... Any information whatsoever?
1	Looks like the president's been hit... Have Parkland stand by.
12:32 Dispatcher	10–4, Parkland has been <u>notified</u>, 12:32.
4	4...
Dispatcher	4.
4	We have those canine units in that vicinity don't we?
Dispatcher	Stand by...1...
5	5 to 1...
1	(We're) headed for Parkland...(sirens loud in background)
?	Is something the matter with Channel I?
5	5 to 1...
1	Go ahead.
5	You want... What disposition do you want to make on these men I have with me?
1	Just go on to Parkland Hospital with me. Just go on to Parkland. (Sirens loud in background)
5	10–4.
Dispatcher	3...
?	Dispatcher on numb...uh...on “1” seems to be..have his mike stuck...(loud sirens covered any remaining comment)
?	(Unreadable-may be 20 or 220)
(1)	Get these trucks out of the way... Hold everything... Get 'em out of the way.
Dispatcher	15–2...
15–2	15–2.
Dispatcher	There is a motorcycle officer up on Stemmons with his mike stuck open on Channel I. Could you send someone up there to tell him to shut it off?

15–2	10–4.
12:34 Dispatcher	12:34.
(190)	I'm up on Stemmons. I'll check all these motorcycle radios.
Dispatcher	10–4.
190	190...
Dispatcher	190.
Appx 190 12:33:52 Ch. I (1)	You want me to still hold this traffic on Stemmons until we find out something, or let it go? (Hetrodyne) Keep everything out of this emergency entrance.
190	10–4.
136	136...
Dispatcher	136.
136	A passer-by says—The Texas School Book Depository... stated the shots came from that building...
(1)	Get everything out of the way. (Referring to the vehicles clustering about the emergency dock.)
Dispatcher	10–4. Get all that information, 136.
136	10–4.
12:35 Dispatcher	12:35.
142	142...
Dispatcher	142.
142	142.. I talked to a guy up here at the scene of this...where the shots were fired at... and he said that he was sitting here close to it...and the very best he could tell, they came from this Texas Schoolbook De.. pository...Building here, with that Hertz Rental sign on top.

12:35 Dispatcher	10–4. Get his name, address and phone number, and all the information that you can, 12:35.
15–2	15–2...
Dispatcher	15–2.
15–2	(The) Captain advises, have all emergency traffic use some route besides Industrial... Have 283 cut the traffic at Hines and Industrial.
Dispatcher	10–4...283, cut traffic, Hines and Industrial.. 283, cut traffic Hines and Industrial... (then, using simultaneous broadcasting:)
12:36	Attention all emergency equipment... Attention all emergency equioment.. Do not use Industrial Blvd... Do not use Industrial Blvd., 12:36.
260	260...
Dispatcher	260.
260	I have a witness that says they came from fifth floor of the Texas..uh..Depository Bookstore (sic) at Houston and__Building.
12:36 Dispatcher	10–4, 12:36.
220	220...
Dispatcher	220.
220	Where do you want traffic cut going into that area?
Dispatcher	Keep all traffic off of the emergency entrance to Parkland Hospital, and all emergency equipment off Industrial Blvd.
220	10–4.
Dispatcher	1...
(125)	We have the emergency entrance secure at Parkland.
12:37 Dispatcher	10–4, 125, 12:37.
22	22...
Dispatcher	Go ahead.

22	Get some men up here to cover this building... This Texas Schoolbook Depository. It is believed that these shots came from that... As you're facing it on, uh, it'll be Elm Street, looking toward the building, it would be your upper.. righthand corner...at the second window from the end.
Dispatcher	10–4... How many do you have there?
22	I have one guy that was possibly hit by a ricochet, from a bullet off concrete, and another one that seen the president slump, and another one here that..that.. (137 covered 22 here)...
137	137...
12:38 Dispatcher	10–4, 12:38...137...
137	We have a man here that said he saw 'em pull a weapon back through the window off the second floor on the south...east corner of that Depository Building.

APPENDIX D

POSSIBILITY OF SUPERPOSED RECORDINGS

The Committee considered seriously the possibility that the impulses analyzed by BRSW/WA might have been overlaid at a later time by the “hold everything...” message; if that had occurred the presence of the message would not automatically imply that the impulses occurred well after the assassination. The Committee examined four kinds of evidence on the possibility: (1) physical evidence concerning overrecording or Dictabelt substitution, (2) likelihood of possible scenarios for overrecording, (3) compatibility of “hold everything...” timing with other firmly established evidence, and (4) recorded acoustic evidence on the recordings such as the characteristics which show that the recorded cross talk passed through a radio receiver with automatic gain control (AGC). These four kinds of evidence are discussed below.

(1) Physical evidence concerning overrecording or Dictabelt substitution

The original DPD Channel I Dictabelt was examined by some Committee members and by William Sturtevant of the Dictaphone Corporation for possible physical evidence of a double recording. No indications of superposed recordings were found. The track in the region of the “hold everything...” expression was examined with particular care. The tracks were remarkably clear and parallel and showed no indications of superposed recordings.

There was considerable writing with a china marking pencil on the surface of the Dictabelt. The markings give in one handwriting “11–22–63, PL2” and an encircled “10”. The times 12 5 and 12 40 in a different handwriting also appear as do the letters J and H. These markings were similar to those on the other Dictabelts made that day. A photograph of the Dictabelt has been submitted to Ms. Doris Schwartz, who serviced the recorder during the period in question and who now lives in Duncanville, Texas. Although Ms. Schwartz does not recognize the other handwriting, she does identify the “11–22–63, PL2, 10” as her own handwriting. She uses an unmistakable 2 and feels that the specimen is the original belt. With this identification, any substitution of a different Dictabelt for the original could not have been accidental; it would have had to be deliberate, and it would have involved counterfeiting the writing for the date and belt number.

(2) The likelihood of scenarios for overrecording

Although there is good reason to believe that the belt examined was the original one, the Committee also considered the possibilities that the belt examined might itself have been a later copy of an earlier Dictabelt with a double recording, in which case the physical examination would not show evidence of superposed recordings, or might have been a copy substituted for the original with the “hold everything...” superposed while copying. To explain in one of these ways the presence of the “hold everything....” phrase except by deliberate intent would require an incredible array of accidents, each of which is highly unlikely. For such accidents to have occurred immediately following the assassination, the Dictabelt would have had to be knocked backward by just one minute of recording time, this unprecedented accident would have had to occur within the first minute following the assassination, it would have had to occur in a manner to leave no acoustic evidence, and in addition someone irresponsibly would have had to copy the Dictabelt, counterfeit the identification writing, substitute the new Dictabelt for the old one, and throw away the original, despite both the importance of the case and the well known police requirement not to destroy evidence.

Comparable difficulties confront the hypothesis that there was an accidental superposed recording at a later time. In that case, the Dictaphone playing potential evidence of a presidential assassination would have had to be carelessly set to record instead of listen, and a recording of Channel II at the same time would have had to be playing accidentally in the background. In addition the Channel II playing would have had to be set accidentally to the very narrow range that could indicate incompatibility; if the setting had occurred one minute earlier it would have produced no problem and one minute later it would have been detectable as an impossible timing. The double recording would have had to continue at least two minutes to account for the cross talk discussed in Appendix C. Further, there would have had to be an irresponsible substitution of a copied Dictabelt, with counterfeited written identification and a subsequent loss of the original, to obscure physical evidence of a double recording. For all this to occur by accident again seems highly unlikely. Similar difficulties face the hypothesis that the original Dictabelt was copied to another Dictabelt, that the cross talk was picked up during the copying, that the second Dictabelt was accidentally substituted for the original, and the original was destroyed.

There are comparable difficulties in attributing the presence of the “Hold everything...” message to a deliberate superposed recording and a deliberate effort to conceal this action. It is particularly difficult to believe that within the first minute after the assassination someone deliberately knocked backward the Dictabelt to confuse the interpretations of the transmission from the open microphone. No one knew in advance, or even at the time, that there was to be an accidentally open microphone or where it might be located. No one could tell in advance how much to displace the Dictabelt to assure that the next transmission of cross talk between Channels I and II would be exactly superposed on the assassination. No one knew in advance there were impulses that would years later be interpreted as assassination shots or that the cross talk between the two Channels would eventually be interpreted at an even later time. Anyone who substituted a copy of the tape to hide the physical evidence of a superposed recording, and who counterfeited the written identification exposed himself to a serious risk of being caught in exchange for a potential benefit that was remote and unlikely to materialize.

Similar difficulties are presented by the hypothesis that the “hold everything...” message was deliberately added at a later time. Since the message appears on the original Dictabelt and on a copy made by James Bowles in March 1964, the deliberate superposed recording would have had to be made before this date, long before the BRSW/WA analysis indicated there might be information worth confusing. It could not be apparent in advance that the "hold everything..." expression would ever be correctly interpreted. The person deliberately faking this evidence and then substituting a new recording with a counterfeit identification for the original one faced a large chance of being caught in exchange for only a very small chance that the deception would be either necessary or helpful. It seems equally unlikely that such an elaborate and risky substitution of forged evidence would have been made for any other reason, such as to cover up a broadcast of an embarrassing remark.

In summary, all the possible scenarios by which a copied Dictabelt with a forged identification could have been substituted for the original seem highly unlikely.

(3) Compatibility of "hold everything..." timing with other firmly established evidence.

Since the "hold everything..." expression on Channel II occurs approximately one minute after the expression "Go to the hospital...," hence, more than one minute after the assassination, and since the Channel I recorder ran continuously during much of the subsequent time, the cross correlation between the two channels has implications for the timing of some other events following the assassination. Some of this other evidence is unreliable, but some is firmly established. The Committee examined such evidence to be sure there was no incompatibility between the timing sequence implied by the "hold everything..." identification and the firm limits established by other evidence. Some of these limits are discussed in Appendix C where it is noted that later cross talk between the two channels is compatible with this identification.

A quite different test is implied by the sounds of sirens, as discussed in Appendix E, where it is shown that the time interval between the assassination and the appearance of siren sounds is compatible with a reasonable speed of the motorcade to the hospital, provided that the microphone picking up the siren sounds is at the Trade Mart or some other point closer to the hospital.

Finally, the time announcements on Channel I provide further support to the assumption that there was no double recording. The last time announcement on Channel I before the conjectured shots and the “hold everything...” statement was “12:28” and the first time announcement thereafter was “12:34,” a nominal difference of six minutes. When the Channel I recording is run at a speed that reproduces the recorded hum at 60 Hz, the elapsed time between these two announcements is 389 seconds or 6 minutes 29 seconds in full agreement with the six minute nominal difference, since the time announcements were at irregular intervals and never included seconds. If the recording head had been moved back by 64 seconds of recording time to superpose a later “hold everything...” on top of earlier recorded acoustic impulses, the elapsed time between the 12:28 and 12:34 time announcements would have been 453 seconds or 7 minutes 33 seconds in disagreement with the time announcements. It should be noted, however, that the time announcements were not highly reliable since they were obtained from a variety of different time indicators, so this evidence alone while being supportive of the Committee's position, should not be regarded as conclusive. It should also be noted that by timing measurements over a wider range, the BRSW report, page 33, concludes that the Channel I recorder “operated continuously”; a 64-second recording overlap would be a marked discontinuity. If it were argued that a superposed recording occurred by a Dictabelt displacement which corrected itself before the 12:34 time announcement, a groove cutting at a different angle and spacing should have been observable, and no such groove was seen during the physical examination of the Dictabelt. Furthermore, such a scenario would leave intact the evidence from Appendix C that the relevant acoustic impulses occurred well after the assassination.

(4) Recorded acoustic evidence on the Dictabelt, such as characteristics which show that the recorded cross talk passed through a radio receiver with automatic gain control (AGC).

From Figures B-4, B-5 and B-6, it is apparent that there are heterodyne tones present on Channel I which do not exist on Channel II. In fact, these tones are the key to the demonstration that the underlying Channel II sounds present in Channel I were recorded via radio and not at some later time.

Close attention to these Channel I heterodyne tones which are not present in Channel II at the same time, shows that this tone is followed immediately (over a period of about 30–50 milliseconds) by a rapid suppression of the Channel II signal, which then assumes a constant value for the duration of the tone. At the end of the Channel I tone, the Channel II transmission rises over a period of 100–200 milliseconds to its original value. This is to be understood if the Channel I tones are heterodynes caused by additional transmitters appearing on the Channel I band, and dominating the open-mike transmission. Thus, the radio receiver will readjust its automatic gain control (AGC) to maintain a steady (intermediate-frequency) signal level in its output. (See the heterodyne beginning at “A” in Channel I on Figure B-4.) This is natural for such radio receivers. At the end of the presence of the strong carrier signal, the AGC readjusts to provide a steady output level for the open-mike transmission. Hence, any probing tone on the microphone will suffer this same variation due to the AGC action in the presence of a sudden interfering carrier on Channel I.

In many cases, however, there is present in the Channel I output a brief tone, of strength similar to those noted in the previous paragraph, which is present also in Channel II. These brief tones in no case show a change in level at the beginning and end. (See the Channel II heterodyne marked “C” on Fig. B-4.) This is to be understood because they enter the open microphone and are broadcast at a steady carrier level on Channel I. Whatever behavior there was of AGC on Channel II is reflected in the level of the heterodyne on Channel II, and there should be no further distortion of this level by action of AGC on Channel I.

This analysis demonstrates that cross talk from Channel II was directly recorded onto a Channel I recorder through a radio receiver and not at some later time coupled either by electrical or acoustical coupling into a recording of Channel I. Had this latter taken place, there would have been no difference in AGC action on the heterodynes recorded only on Channel I from that of the brief tones present in Channel II as well. This is true, independent of any assumption that might be made of automatic level control on subsequent recordings.

The crucial evidence within the "hold everything..." interval itself occurs in a 0.5 seconds region of the Channel I recording shown in Figure B-6. This corresponds to Channel II times of 32.00–32.50 seconds, aligned with the corresponding signals on Chanel I. Note that the Channel II recording is the recent one made by this Committee from the gray Audograph disk, without "repeats." The suppression of a Channel II heterodyne is seen in Figure B-6 and has been demonstrated quantitatively by the digital data plotted in Figures B-7 and B-8.

Although the above evidence on the recordings shows conclusively that the "hold everything..." and other cross talk phrases were recorded through radio communication and not by later copying, there is other acoustic evidence on the recordings as well that supports the conclusion that the Channel II cross talk was recorded on Channel I at the actual time and not in later copying. The phrases "You want me..." and "I'll check all these motor cycle radios" present on Channel I are derived from Channel II. However, on Channel I, the time difference between the beginning of these two phrases is 15.70 seconds, while on Channel II it is 12.80 seconds —a difference of 2.9 seconds. This time difference can not be due to a forward skip of Channel II on playback or a backward repeat on record since 2.9 seconds is not an integral multiple of the 3.58 seconds Audograph turntable period at this time, as measured by observable print through on the recording. If the Channel I recording is made at the actual time, this difference is easily attributed to the sound actuated Channel II recorder having stopped for 2.9 seconds between these two phrases, while the Channel I open microphone recording continued on without interruptioon. This accounts naturally for the 2.9 second difference; but if the Channel II reocording had been later overlaid onto Channel I the timing of the two would normally have been identical, not differing by 2.9 seconds. The timing analysis was made between tapes for which the best warp between “You want me...” on the two tapes was 0.988 while that for “I'll check all these...” was 0.991.

Finally, if one wishes to criticize the “hold everything...” evidence on the grounds that the Dictabelt is a copy and not the authentic original Dictabelt, then he must also recognize that all the acoustic evidence interpreted as favoring gunshots also comes from the same unauthentic source.

As a result of all these considerations, including especially the ones showing that the cross talk passed through a radio receiver with AGC, the Committee determined that there was conclusive evidence that the “hold everything...” expression was recorded on Channel I at the same time as on Channel II and that the acoustic impulses attributed to gunshots were recorded well after the President was shot and the motorcade had been instructed to go to the hospital.

APPENDIX E

SIREN SOUNDS

Two of the most conspicuous features of the Channel I recording are the complete absence of siren sounds for the first two minutes following the BRSW/WA conjectured shots and the clear presence of such siren sounds for the next 36 seconds. Several sirens are heard in succession each in turn rising and falling in intensity as would be the case if a motorcade were rapidly passing an open microphone. The siren sounds provide critical tests of both the BRSW/WA scenario and that of the Committee.

The absence for two minutes of siren sounds, at a time when they should be heard, presents a serious difficulty for the BRSW/WA hypotheses. According to that scenario, the motorcycle with the open microphone was located in a precisely known position behind the President's car in the motorcade as it passed through Dealey Plaza when the President was assassinated. Many witnesses agree that sirens were activated shortly after the final shot and as the motorcade speeded up for its dash to Parkland Hospital. The complete absence of siren sounds for two minutes is difficult to explain on this scenario, and the sounds, when they do appear do not seem appropriate for a motorcycle in the motorcade, or even one catching up to the motorcade. If Officer McLain had the open microphone, it is particularly surprising that he picked up no siren sounds while accompanying the motorcade to the hospital but, at the same time, his microphone was so sensitive that it could pick up the Channel II cross talk from a nearby vehicle.

The absence of siren sounds for two minutes is fully compatible with the Committee's scenario, which does not require the open microphone to have been in the procession. James Bowles' hypothesis that the motorcycle was at the Trade Mart can be supported by reasonable arguments but there is no firm evidence for that location. Although the two-minute absence of the police sirens is obviously compatible with the Committee's scenario, the timing of the appearance of the sirens requires careful examination. The cross correlation between the “hold everything...” phrases on Channels I and II provides a relative timing of events that can be tested for reasonableness with respect to the siren sounds. Absolute times were obtained by running Channels I and II from the original Dictabelt and audograph disk, with the speeds adjusted to provide the correct frequency for the 60 Hz hum on the original recordings. In this operation it was found that “hold everything...” on Channel I begins 123 seconds before the siren sounds and on Channel II there is 64 seconds of continuous recording between “...Go to the hospital...” and “hold everything...” which gives 187 seconds between “...Go to the hospital...” and the beginning of the sirens. Since the distance from the assasssination site to the Trade Mart is 2.273 miles, this corresponds to an average speed of 43.8 miles per hour if the trip began at the time of “Go to the hospital”. At first consideration this appears to be surprisingly slow for a trip to the hospital, but there were turns, traffic, a heavy car, Mrs. Kennedy and a Secret Service Agent crawling over the back of the car, and a critically wounded passenger to slow the average speed. The speed we estimate is compatible with the testimony of Agent Greer, the driver of the President's car, in volume II page 121 of the Warren Commission Report[3]: “...I was getting through traffic and through streets as fast as I could get through... I would estimate that I must have been doing between 40 and 50 at least 50 miles per hour at times. We might have been going as fast as 50 miles an hour I am sure....”

If one assumes that on the streets and access ramps the average speed is 40 miles per hour, that the average acceleration in a turn is 0.2g, and that the Zapruder film gives the time to leave Dealey Plaza, the above 187 seconds would require an average speed on the Stemmons Freeway of 58.5 miles per hour, which seems reasonable in view of Agent Greer's testimony. It should be noted, however, that there is considerable uncertainty as to the speeds attained, the location of the open microphone, and the time following the assassination at which the “Go to the hospital” was broadcast. Although this discussion shows the compatibility of the

"...hold everything..." identification with the known firm data, it should not be misinterpreted as a proof of this interpretation or as a reliable determination of the location of the vehicle with the open microphone, since there is considerable uncertainty as to speed of the vehicle. There is also contradictory evidence about the time interval between the assassination and the "Go to the hospital...." As this time is lengthened the average speed is reduced. However, it should be noted that the assumption of a long time interval makes more acute the difficulty with the BRSW/WA scenario discussed in Appendix C.

APPENDIX F

POSSIBLE FURTHER STUDIES

This Appendix is written in response to the Committee's assignment to recommend the kinds of tests, analyses, and evaluations needed to obtain better information from the recordings. However, the existence of this Appendix should not be misinterpreted as a Committee recommendation that these tests and analyses should be carried out. If there were to be further studies of the Dallas Police Department Channel I recording in the hope of demonstrating the validity of the conjectured shot from the grassy knoll, the information listed below could be sought.

1. The original Dictabelt could be studied more extensively for possible evidence either for or against the possibilities of the Dictabelt being a copy or containing superposed recordings. No evidence favoring either of these possibilities has so far been found in a physical examination of the belt or in studies of the recording. Further studies could include a careful search on the original belt for a second hum at about 60 Hz which would characterize a copy and an examination of the 60 Hz signal for continuity and possible indications of interceptions. Such studies, however, will now be difficult and may require the constuction of a special drum playback machine for the shrunken and stiffened Dictabelt which now causes marked flutter when it is played back on the normal machine.
2. With the information on the timing of the Channel I recording provided by the cross correlation between Channels I and II discussed in Section IV, the Channel I recording could be examined more carefully for the existence of possible shots in the portion of the recording that corresponded to the time of the assassination (between 65 and 95 seconds on

the BRSW time scale). However, it is unlikely that evidence for shots will be found in that region, since the noise level was much higher there and that portion of the recording has already been examined by BRSW, as described on page 35 of the BRSW report, and no impulse patterns identifiable as gunfire were found; furthermore, there is some evidence that the open microphone was not in the motorcade.

3. There could be an independent analysis following generally the WA procedure but applied to all four of the conjectured shots. In the case of the conjectured grassy knoll shot, it would be of interest to see if the P value for the hypothesis of random locations of impulses cast doubt on that hypothesis. Analysis by the WA method of the impulses attributed to the three Texas School Book Depository shots would be a test both of the method and of this attribution, which contradicts the evidence that the relevant impulses occur approximately one minute after the assassination. If these impulses do fit the hypothesis of three shots, is the open microphone trajectory the same as in the BRSW studies and does it fit with the best limits that can be photographically inferred?
4. The BRSW analysis of the three shots attributed to the Texas School Book Depository could be repeated with a well defined, normalized, and objective selection process for the impulses and echoes to see if the indications of three shots associated with a reasonable microphone trajectory persisted when the unnormalized and subjective selection of impulses and echoes was eliminated.
5. Attempts could be made to see if the reliability of the analyses could be improved by utilizing the availability of amplitude information even though it is recognized that amplitude information can sometimes be misleading. Acoustic spectra and logarithmic Fourier transform studies might help. Unfortunately, one cannot deal with the Dictabelt recording as a faithful reproduction of the sound pressure at the microphone due to the distortion of the radio and recording systems, which include automatic gain control, so it will be difficult to untangle the distortion effect in retrospect.

6. Independent analyses could be made of the probabilistic calculations both by BRSW/WA and by the present committee, with a critical review of the hypotheses on which the calculations are based. The studies could include the investigation of alternative hypotheses such as other sources of non-random impulse locations and studies of prior and posterior probabilities.
7. A study could investigate means for confirming that the open microphone was actually in Dealey Plaza. This study could examine the recording for the presence and absence of sounds of crowds, the lateness of siren sounds, the possibility of detecting a Doppler shift in the siren sounds, study of the motorcycle sounds to determine if they indicated speeds compatible with the course of the motorcycle presumed by BRSW/WA to have the open microphone, identification of the kind of motorcycle from its sound, cepstral analysis, AGC effects, etc. Bowles[2] reports that Officer McLain, after hearing recordings of Channels I and II stated that there was “no way” that his mike could have been the one stuck open. As the present report was about to be printed, Officer Leslie Beilharz (who was not in Dealey Plaza at the time of the assassination) told the Committee chairman by telephone that there was a “good possibility” that his microphone may have been the one stuck open. Additional testimony could be obtained as to the location of the open microphone and attention should be given to the many questions raised in the report of James C.Bowles, including those on the microphone location.
8. A detailed analysis could be made of the interpretation of the more than 200 millisecond time displacement between the conjectured shots of the BRSW and the WA studies.
9. The Zapruder film could be analyzed further to see if the apparent incompatibility between the conjectured shots and the data inferred from the camera's angular accelerations can be removed.

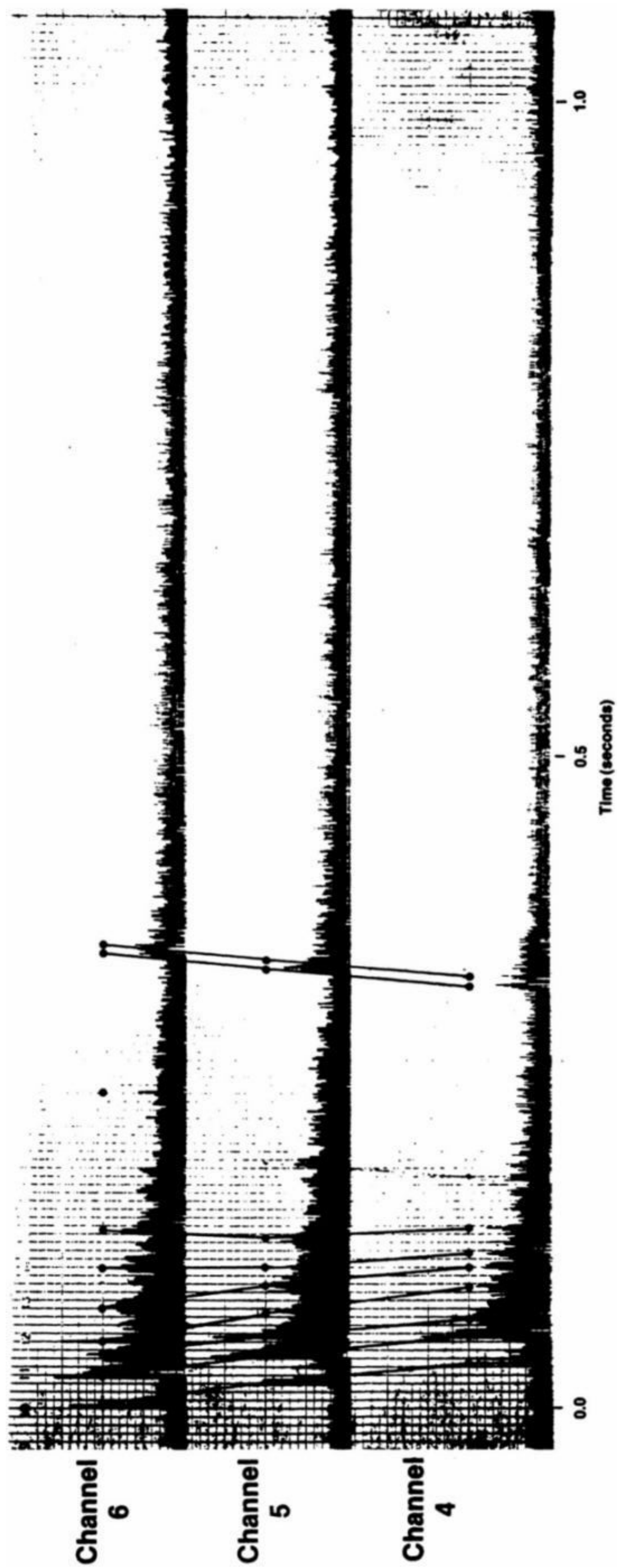


Figure 1. Echo pattern for BRSW test shot 8 (knoll, target no. 3) received at array 3, microphones 4, 5, and 6.

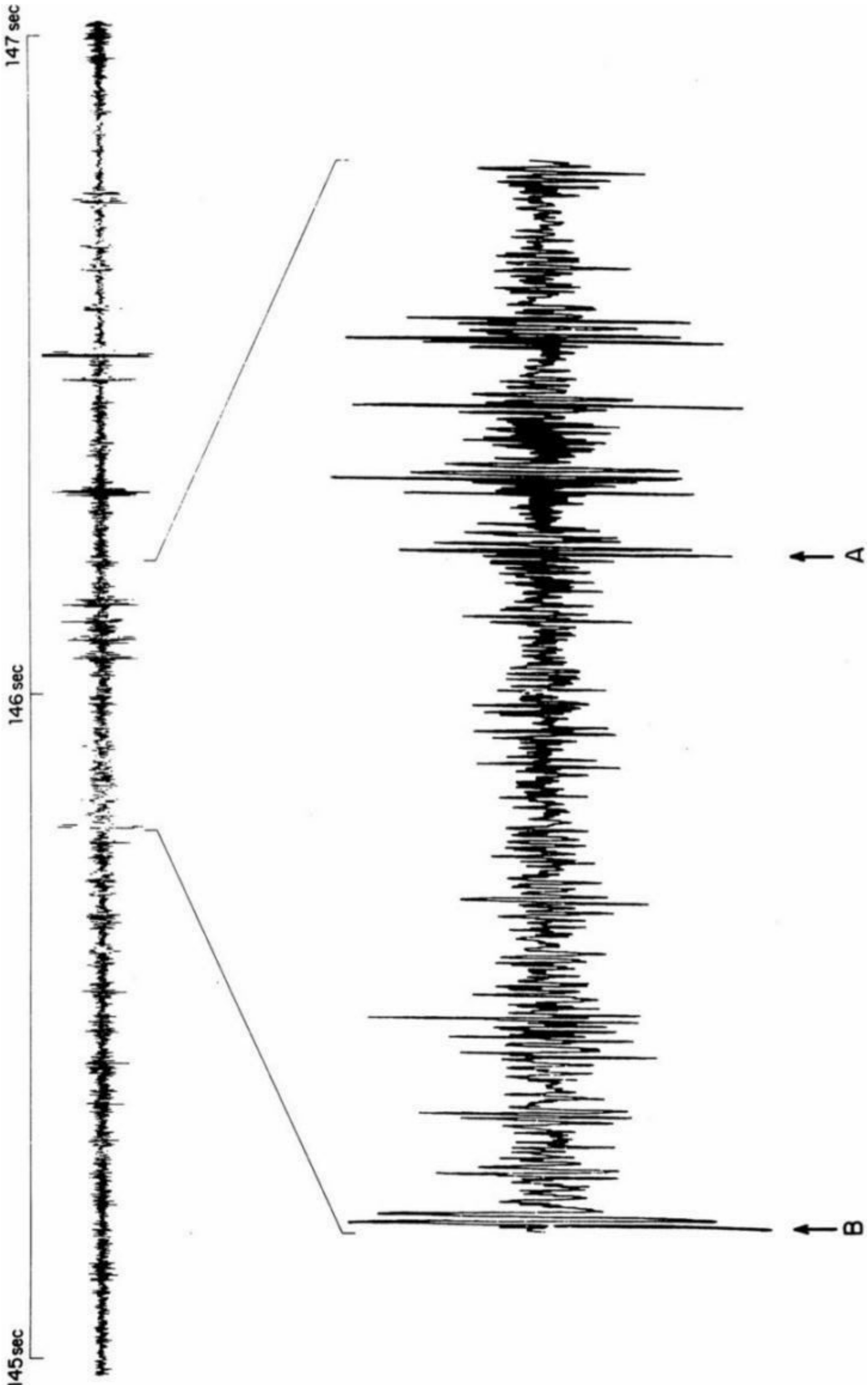


Figure 2. Impulse pattern on Channel I associated with BRSW/WA conjectured grassy knoll shot. The muzzle blast for the original BRSW analyses was at A and that for the WA analyses at B. The marked time scale is different from that of BRSW. Approximately 0.9 second should be substracted from the scale to make it agree with BRSW, since A on the Figure is at 145.15 seconds on the BRSW time scale and B occurs about 0.2 second earlier than A.

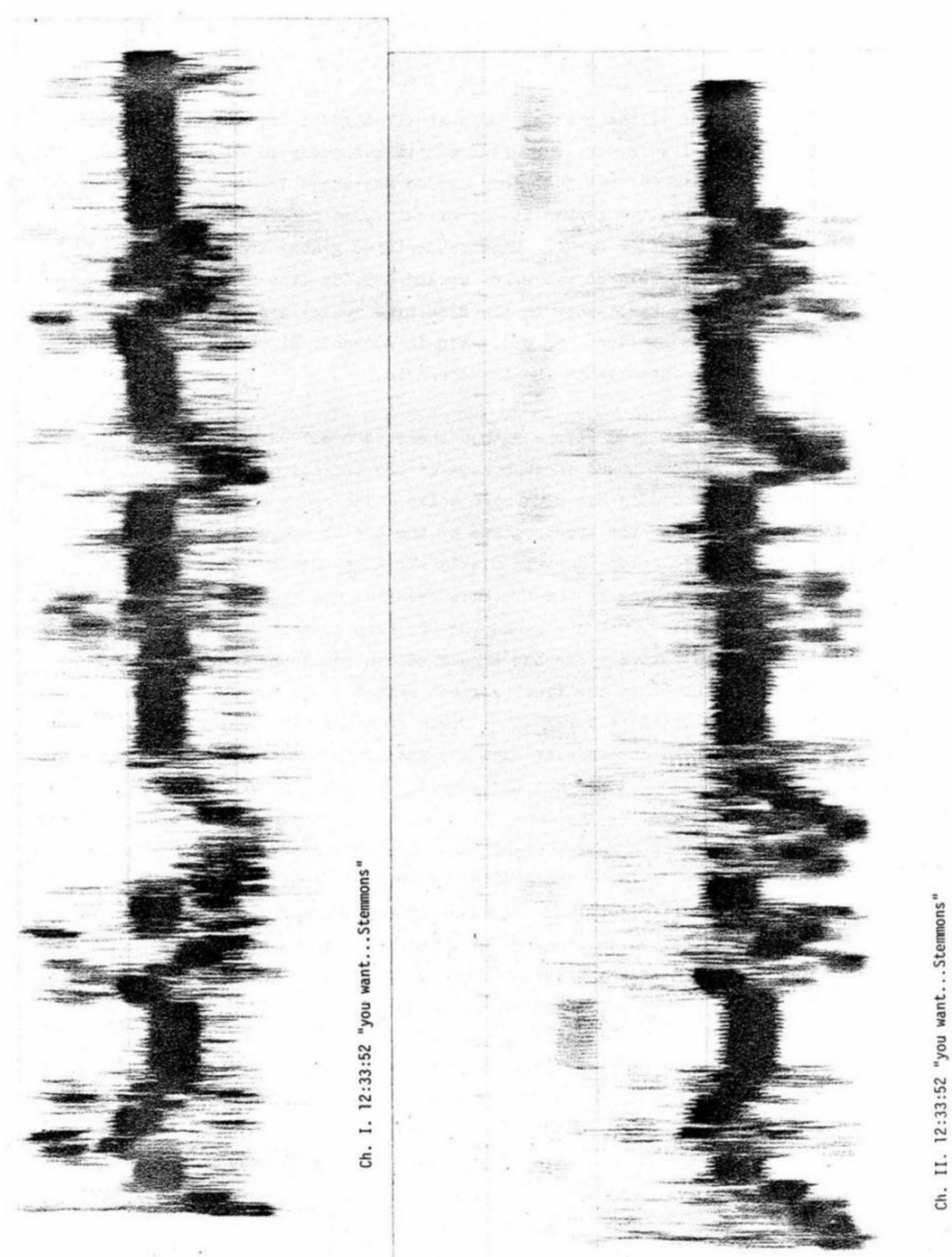


Figure 3. Sound spectrogram of a message on Channel II that is picked up on Channel I and is clearly understandable on both channels.

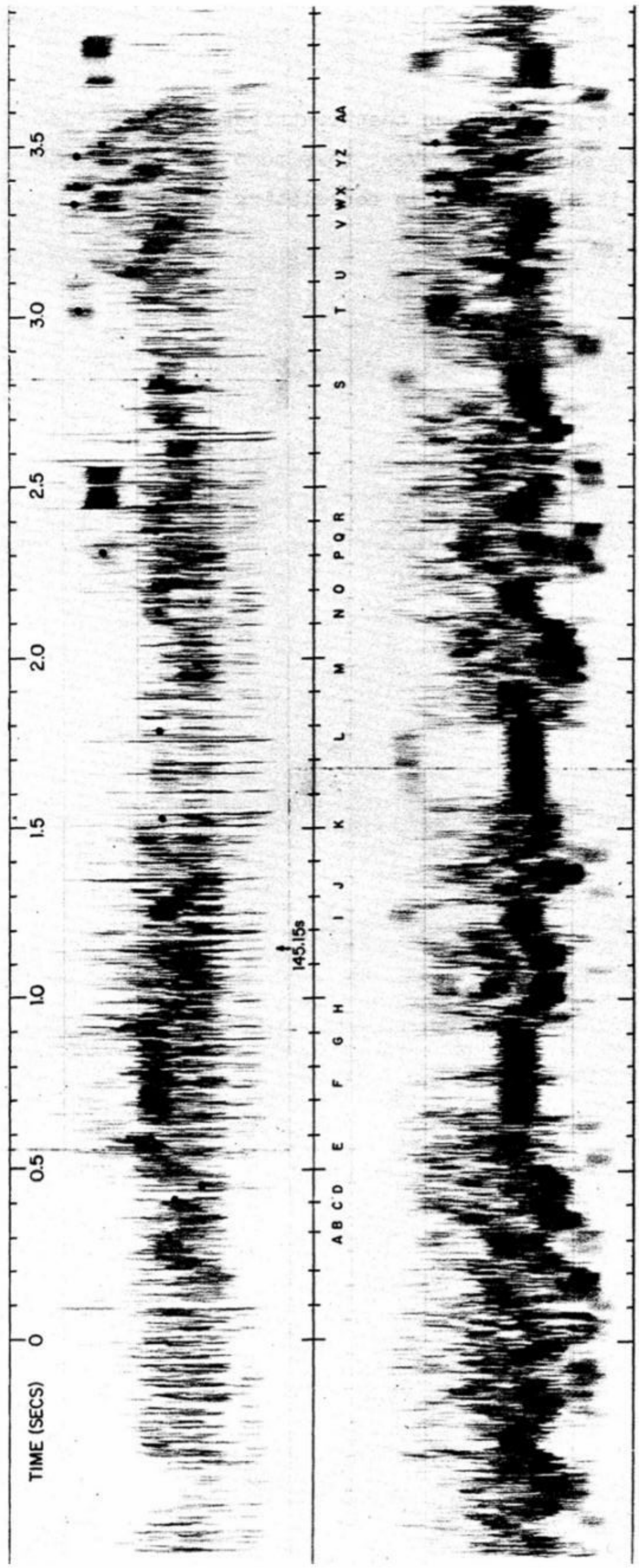


Figure 4. Composite photograph of sound spectrograms on each of Channels I and II, with Channel I being the upper sound spectrogram and Channel II the lower. The audible "...hold everything..." phrase begins at approximately zero on both channels, but there is no special significance to the exact location of zero time on either channel. The impulses initially identified by BRSW as arising from their conjectured grassy knoll shot occur above the arrow marked 145.15s, and those identified by WA occur 0.2 second earlier; the proper location for this arrow was determined by comparing this sound spectrogram with that of Figure 5 in the BRSW report. The letters and black dots designate corresponding characteristic features. For the reasons discussed in Appendix B, one recording was speeded up by 6.7%. Since the interpretation of sound spectrograms depends on continuing gradations on darkness, copies in a printed report lose clarity. For this reason, photographs of the sound spectrograms will be retained in the National Research Council files.

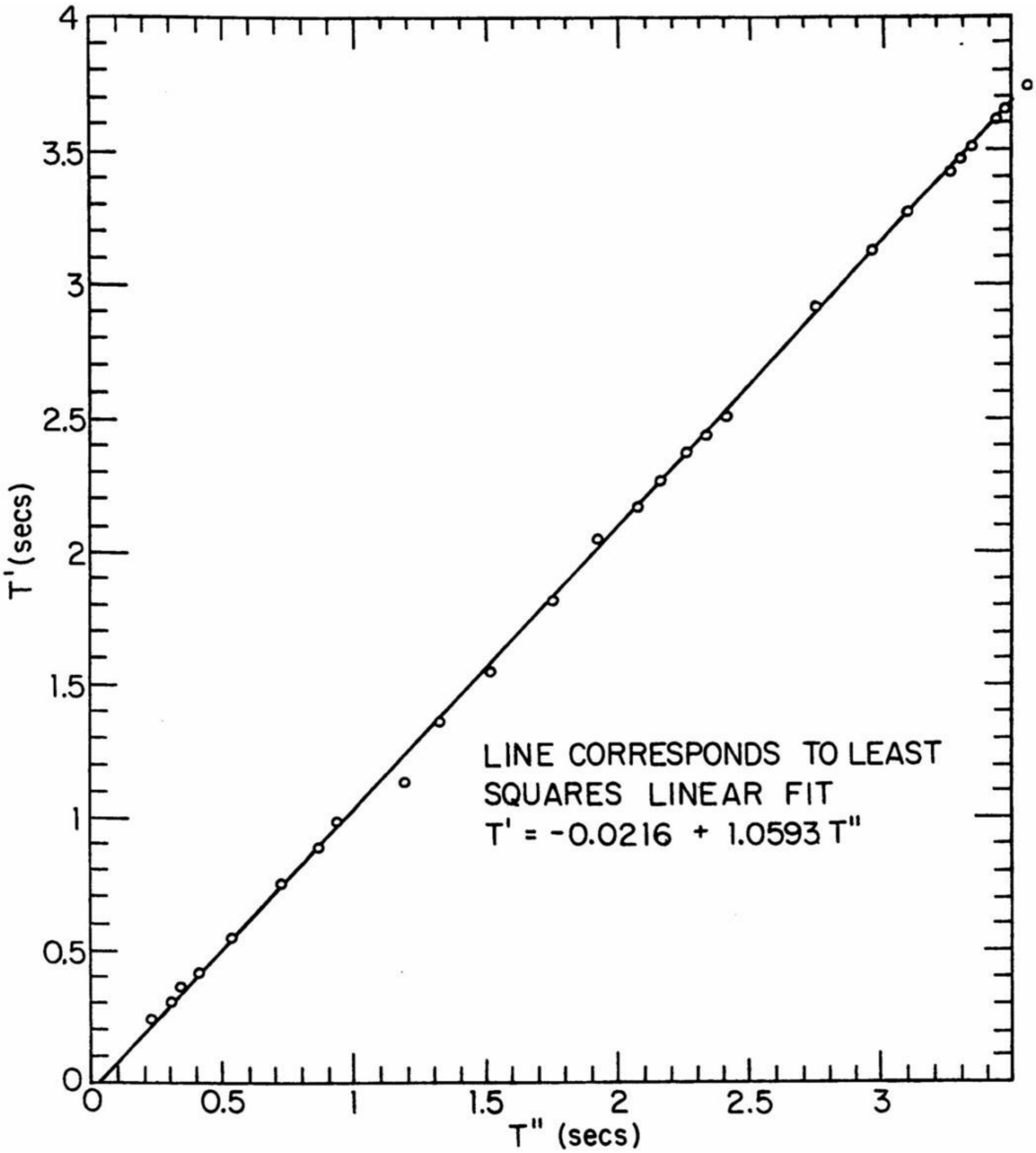


Figure 5. Plot of T' versus T'' for corresponding characteristics with the values of Table B-1. The marked linearity of the curve demonstrates the validity of the identification. The straight line in the figure is a plot of the given equation, which in turn is a robust linear regression fit to the plotted points. The analysis leading to this figure is given in Appendix B and Table B-1. The point furthest off the line is at T''=1.195s and is for the incorrectly identified characteristic I, as discussed in Appendix B.

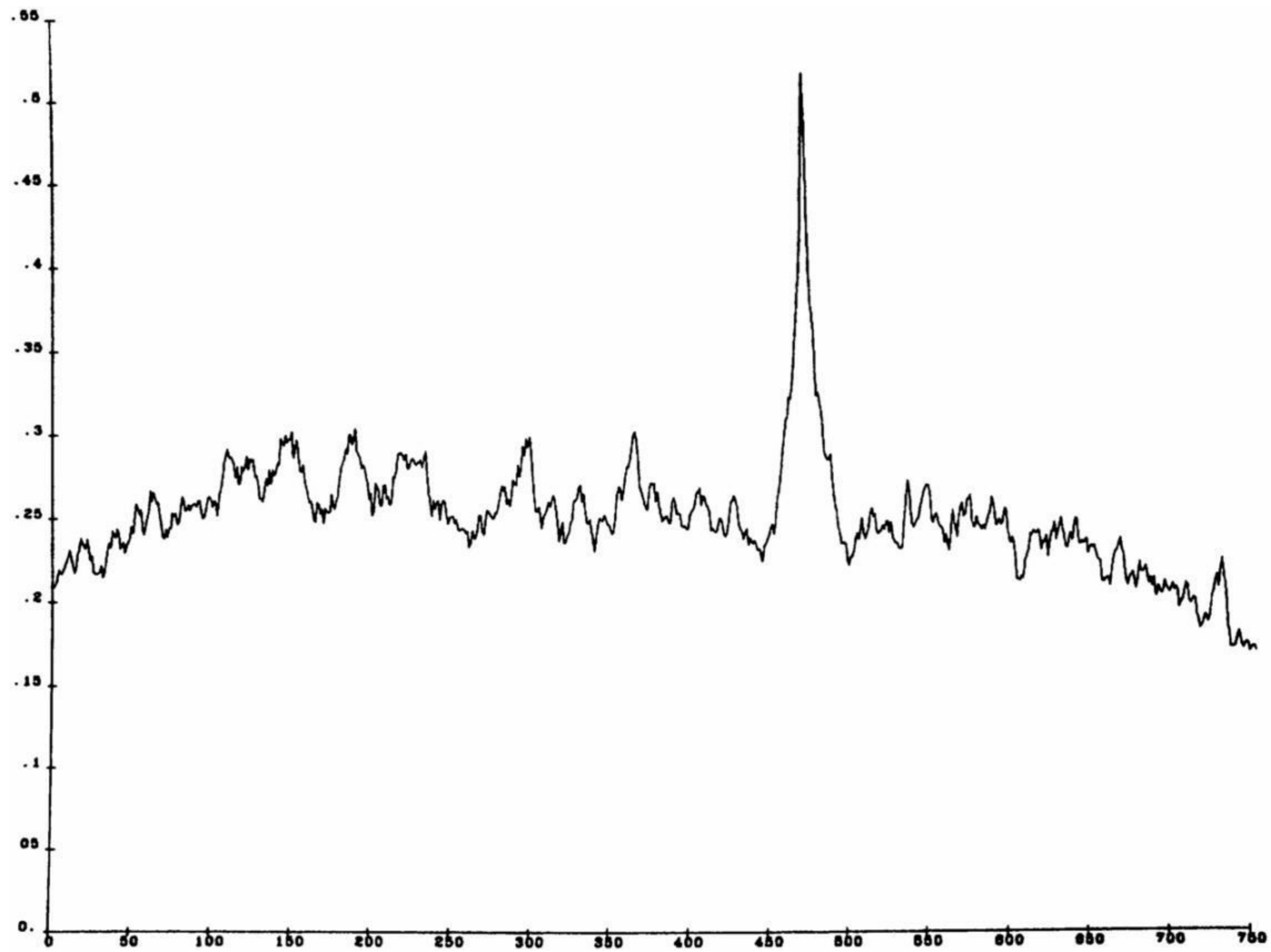


Figure 6. Cross correlation between “Hold everything...” segments of Channels I and II sound spectrograms with time scale slightly compressed to produce the best correlation peak. The curve is produced by sliding 2.50 secs of Channel I along 10.00 secs of Channel II, 0.01 sec at a time, using frequencies in the band 600–3500 Hz.

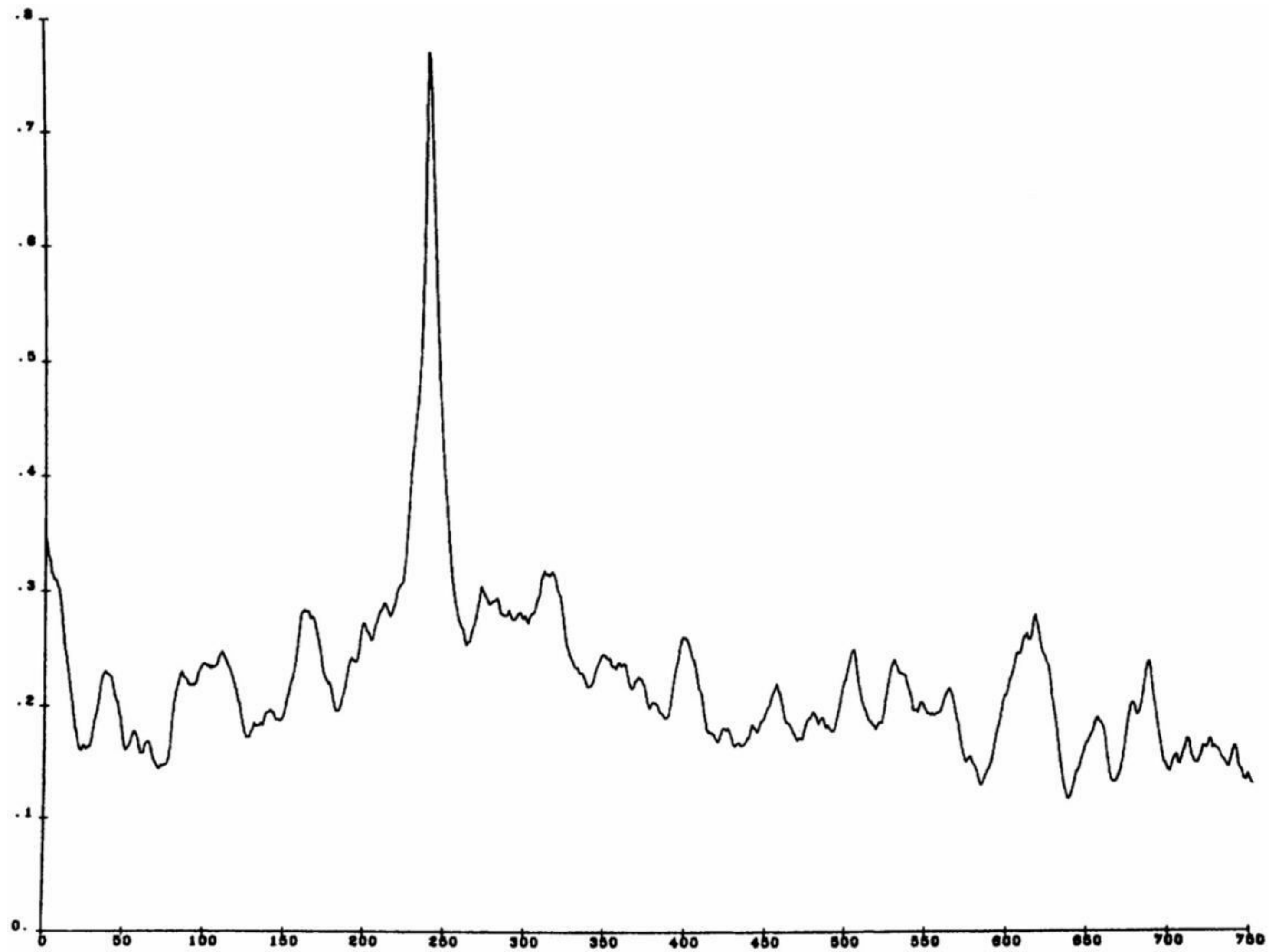


Figure 7. Cross correlation between “You want...Stemmons” segments of Channels I and II sound spectrograms with time scale slightly compressed to produce the best correlation peak. The curve is produced by sliding 2.50 secs of Channel I along 10.00 secs of Channel II, 0.01 sec at a time,

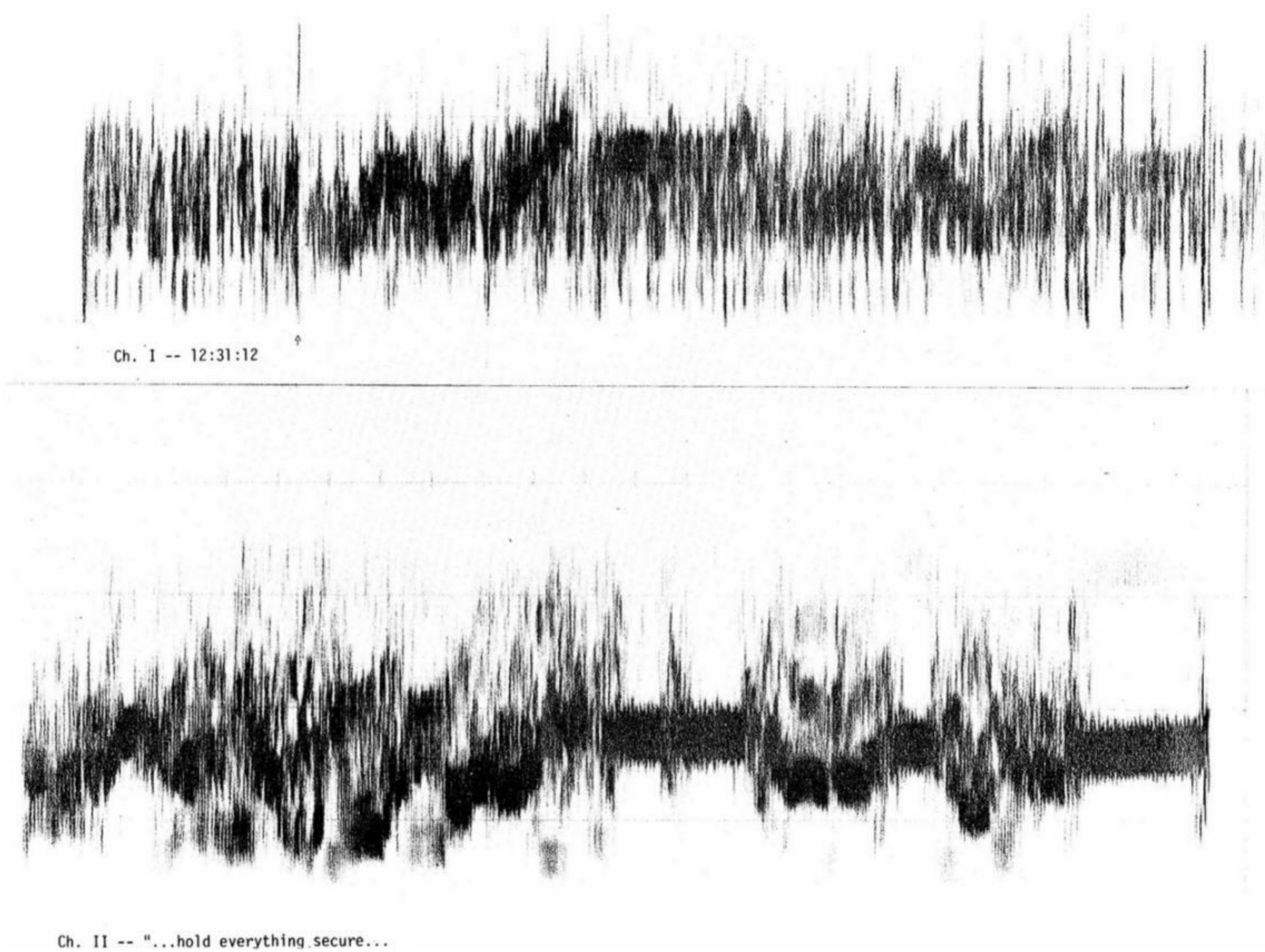


Figure B-1. Sound spectrogram of approximately the first two seconds of the “Hold everything...” expressions on Channels I and II. The expression “Hold everything...” begins at approximately the positions indicated by the arrows.

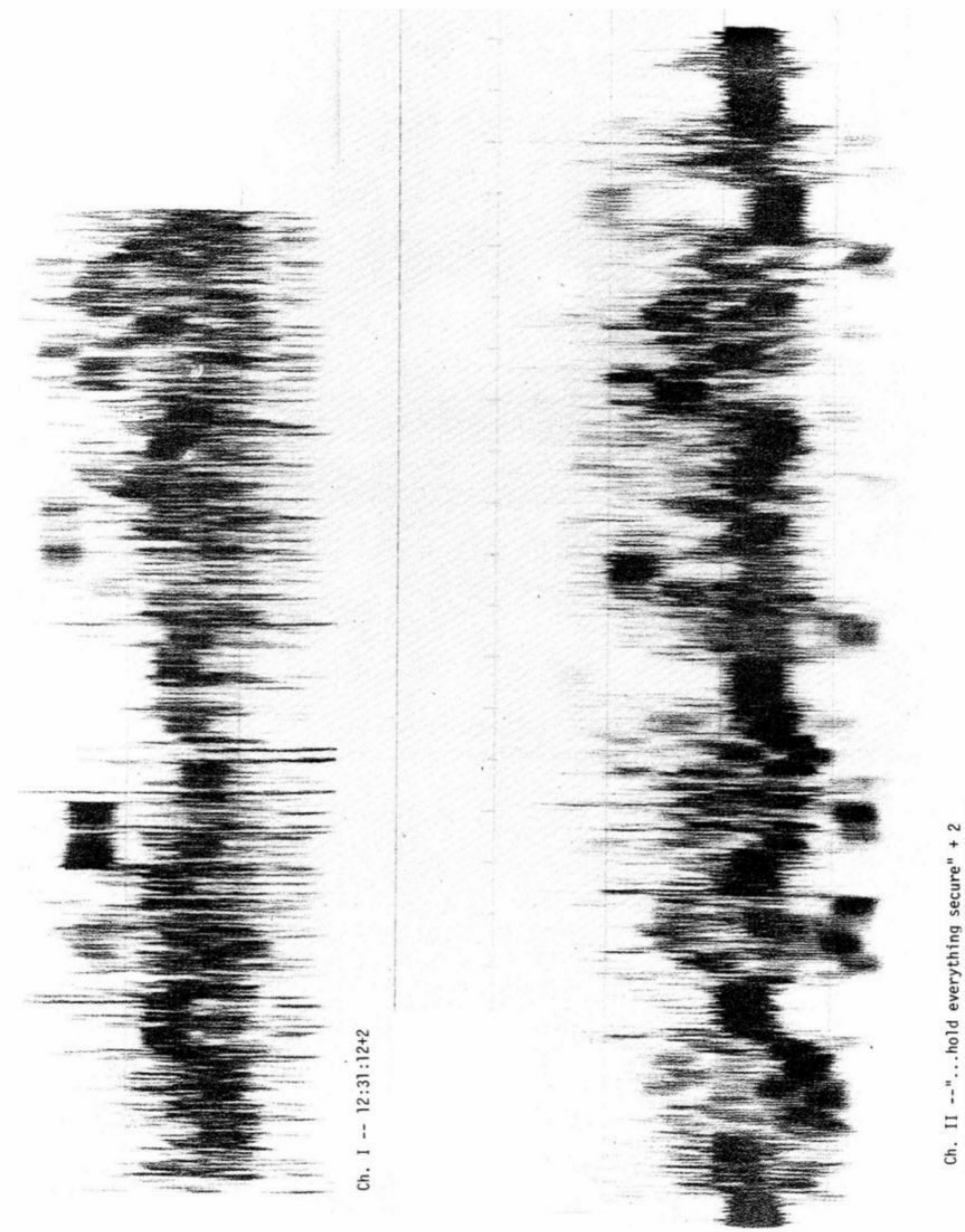


Figure B-2. Sound spectrograms for the two seconds immediately following the sound spectrograms of Figure B-1.

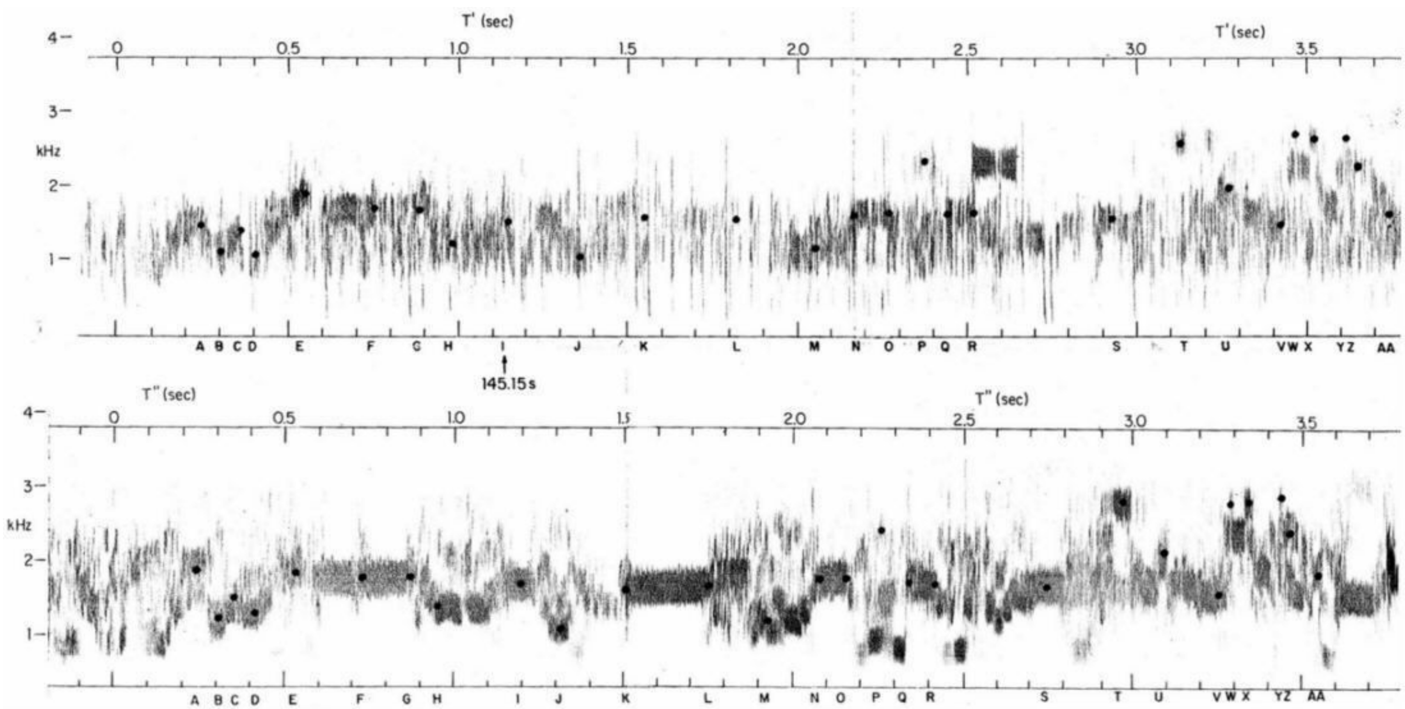
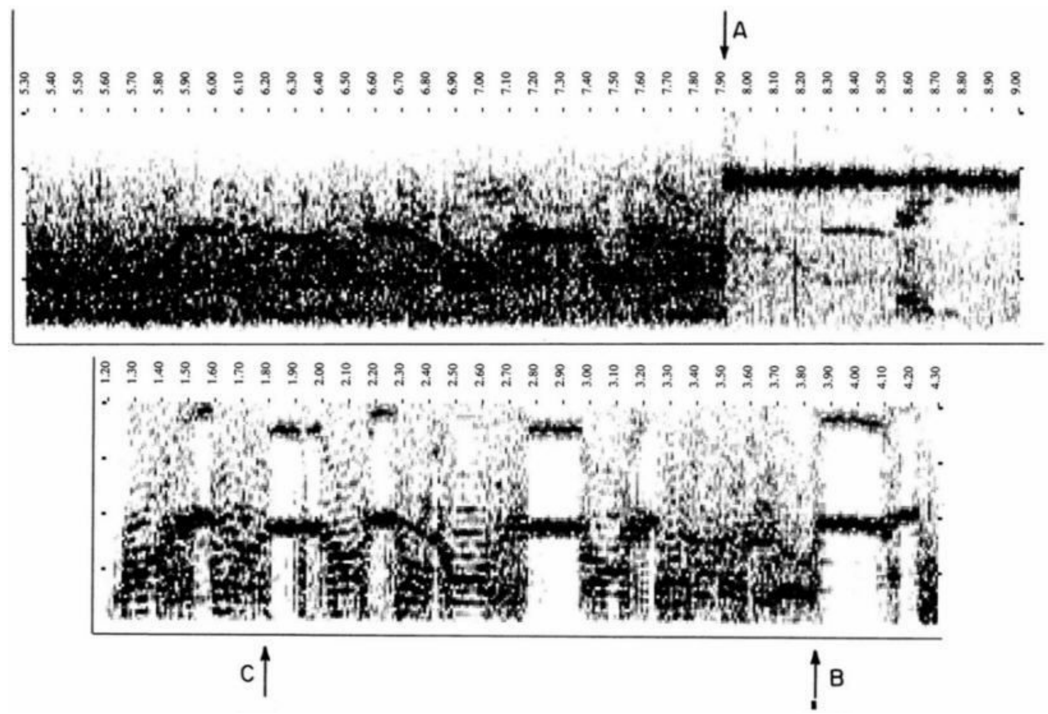


Figure B-3. Composite photograph of sound spectrograms on each of Channels I and II, with the apparent time on Channel I being indicated by T' and T". The audible "...hold everything..." phrase begins at approximately zero on both channels, but there is no special significance to the exact location of zero time on either channel. The impulses identified by BRSW/WA as arising from their conjectured grassy knoll shot occur above the arrow marked 145.15s; the proper location for this arrow was determined by comparing this sound spectrogram with that of Figure 5 in the BRSW report. The letters designate the characteristic features of Table B-1, with the black dot identifying the characteristic point. The black dots were located by the procedure described in Appendix B.



B-4. Graphic plot of the digitized short-term acoustic spectra of the “I'll check all radios...” segment on Channels I and II. Times are in seconds; the frequency range is 50–4000 Hz. Energy range shown is 20–50 dB. Channel I spectra on top, Channel II below. Note the Channel II brief tone at “C” reflected faithfully in Channel I, while the Channel II brief tone at “B” is suppressed by the Channel I heterodyne beginning at “A”.

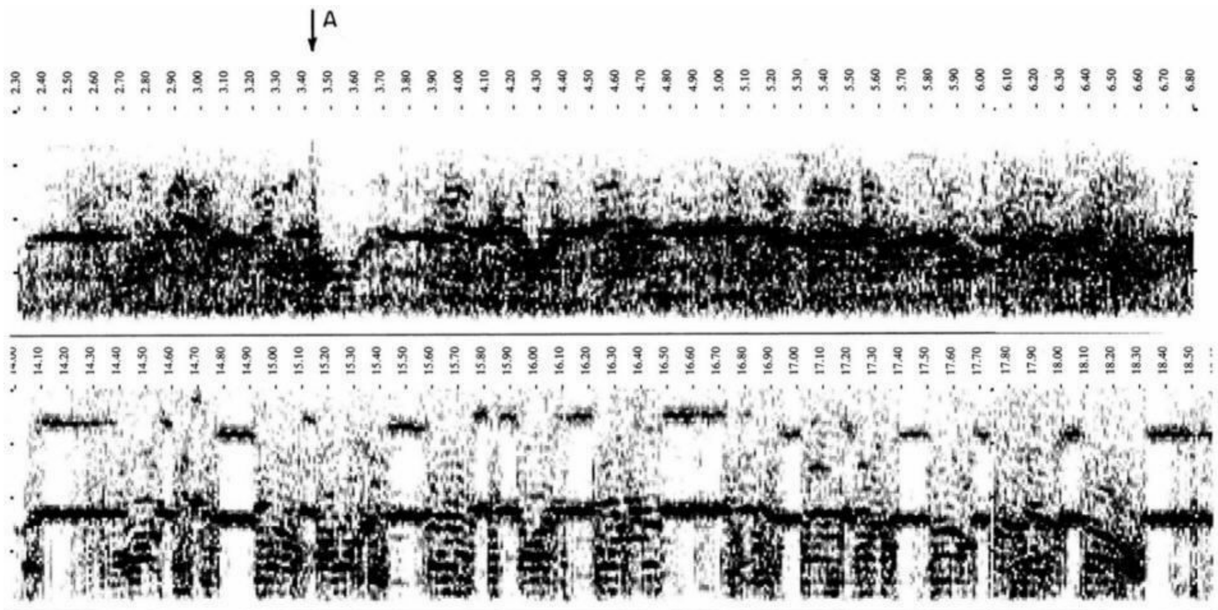


Figure B-5. Graphic plot of the digitized short-term acoustic spectra of the “You want me...Stemmons” segment (as in Fig. B-4). Note the broadband noise at “A” which suppresses the imprint of Channel II.

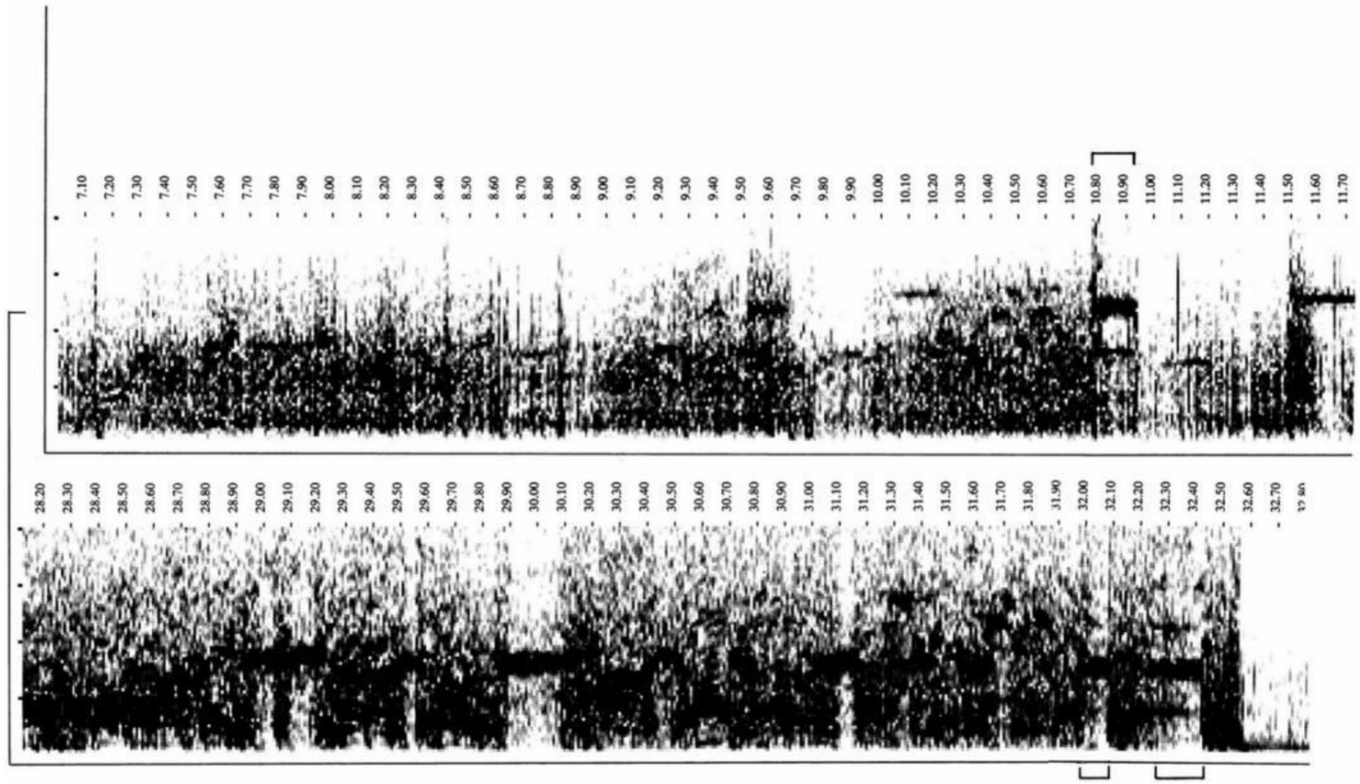


Figure B-6. Graphic plot of the digitized short-term acoustic spectra of the “Hold everything...” segment. Channel II plot has been compressed by a factor 0.91125 to 0.91320 for best cross-correlation peak. Note the Channel II brief tones at 32.00–32.08 and 32.24–32.43 secs, and the interaction in Channel I spectra with the Channel I heterodyne at 32.03–32.17 secs. (Care must be taken to avoid confusing the Channel I reproduction of the Channel II brief tones with the more conspicuous Channel I tone that is 250 Hz higher in frequency. The analysis can best be made by comparing Figures B-7 and B-8.)

```
INDIVIDUAL SPECTRA ARE 10 MSEC. APART. FREQUENCY BINS ARE 50 HZ APART.
CHANNEL II BRIEF TONES ARE INDICATED BY TWO VERTICAL DASHED LINES.
THE LAST COLUMN INDICATES THE ENERGY IN THE CHANNEL II BRIEF TONES
(TWO BINS BETWEEN THE DASHED LINES).

SPECT.  TOTAL  ENERGY IN INDIVIDUAL FREQUENCY BINS.  DIGIT 'D'    ENERGY
NUMB.   SPECT. REPRESENTS ENERGY (IN DB) FROM 20+4*D TO 24+4*D    IN
        ENERGY BINS HAVING ENERGY LESS THAN 45 DB ARE NOT         BRIEF
               PLOTTED.                                           TONE
        (DB)                                                       (DB)

   3199 57.4                 6     66     6
   3200 58.0                     6     6|77|6                     53.2
   3201 57.6                           6|78|                      54.9
   3202 57.8                            |78|7                     55.5
   3203 59.2                            |78|86                    56.7
   3204 59.2                           6|88|7                     57.1
   3205 59.6                           6|89|7                     58.2
   3206 59.1                            |88|7                     57.7
   3207 59.6                            |89|8                     57.9
   3208 59.7                          68|88|6                     58.0
   3209 59.2       6776                6 77 6
   3210 61.4      67877876
   3211 61.4         8986
   3212 62.2        7997776                    66
   3213 61.3  7776 666 786 666                6
   3214 61.9 776     7897                     66
   3215 60.9        66887                    66
   3216 61.6         78886
   3217 61.9         68986
   3218 60.2         68866  67
   3219 60.8         678886                  6
   3220 60.9          66888776              6
   3221 60.4           7986
   3222 60.4           79876
   3223 60.1           8886
   3224 59.6         67887                6 66
   3225 57.2                            |77|6                     53.1
   3226 56.3                           6|77|                      54.1
   3227 56.1                            |77|                      54.1
   3228 56.3                            |77|6                     54.3
   3229 58.1                           7|87|                      54.5
   3230 59.4                           7|88|6                     56.6
   3231 59.6             66            7|88|6                     57.3
   3232 59.3                           6|88|6                     57.9
   3233 58.8                           7|88|                      57.6
   3234 59.4                           7|88|7                     58.0
   3235 59.2                            |88|7                     57.8
   3236 59.6                           7|88|7                     57.8
   3237 59.2                           7|88|6                     57.7
   3238 59.3                           7|88|7                     58.0
   3239 58.7                            |88|7                     57.9
   3240 58.6                           7|88|6                     57.3
   3241 58.1                           6|88|6                     57.1
   3242 58.1                           6|88|6                     57.0
   3243 59.1        6666666            6|77|                      53.4
   3244 59.5   6677777             6
```

Figure B-7. Printer plot of the Channel II spectra towards the end of the “Hold everything...” segment. The BRIEF TONE window is delimited by the vertical bars (for which space has been made in the plot).

```
INDIVIDUAL SPECTRA ARE 10 MSEC. APART.  FREQUENCY BINS ARE 50 HZ APART.
THE MIRRORED CHANNEL II BRIEF TONES ARE INDICATED BY TWO VERTICAL DASHED
LINES.  NOTE THE PRESENCE OF A STRONG CHANNEL I HETERODYNE FROM 3203 TO
3216 AND THE AGC ACTION FOLLOWING IT.

SPECT.  TOTAL  ENERGY IN INDIVIDUAL FREQUENCY BINS.  DIGIT 'D'  ENERGY IN   ATTEN
NUMB.   SPECT. REPRESENTS ENERGY (IN DB) FROM 20+4*D TO 24+4*D  CHANNEL II  OF
        ENERGY ALL BINS WHICH ARE PLOTTED ON CH.II ARE PLOTTED  BRIEF TONE  CH.II
               HERE UNLESS THE ENERGY IS LESS THAN 24DB. OTHER              BRIEF
               BINS ARE PLOTTED ONLY IF THEY EXCEED                         TONE
        (DB)   (TOTAL ENERGY - 11) DB.                              (DB)    (DB)

  3199 54.3                 3     34565  4
  3200 54.9         66          5     5|43|3                       40.3   -12.9
  3201 55.8         66                5|55|                        44.4   -10.5
  3202 59.2                            |54|4                       44.8   -10.7
  3203 61.5                            |53|44               88     40.8   -15.9
  3204 62.6                           1|23|3               899     34.1   -23.1
  3205 62.5                           2|12|2               899     31.0   -27.1
  3206 61.0                            |23|4               798     36.8   -20.9
  3207 59.1                            |44|4                88     39.5   -18.5
  3208 57.0                          24|43|2               787    39.3   -18.7
  3209 54.5       3333                3 34 2                 77
  3210 53.3       22221                                      77
  3211 53.7         1  1                                     77
  3212 54.9        2232223                    43            677
  3213 56.2   124 422 223 555                5               77
  3214 56.0   2     1212                     54              77
  3215 56.6        44322                    45               87
  3216 56.8         43223                                   687
  3217 55.3         44432                                   676
  3218 54.5         44444  45                                6
  3219 51.4         322333   55             2
  3220 43.1          22111 133             23
  3221 41.8           1111  33
  3222 39.9        22  11
  3223 41.9           221
  3224 41.8         2221             2      1
  3225 45.0         333       33       |  |                        25.9   -27.1
  3226 45.6          3         3       |  |                        23.5   -30.5
  3227 41.9                    2       |1 |                        27.4   -26.8
  3228 41.0                    22     2|2 |                        31.6   -22.7
  3229 41.8         2                 2|32|                        34.6   -19.9
  3230 42.6                           2|33|1                       37.1   -19.5
  3231 45.0        33   1      3      2|32|3                       36.0   -21.2
  3232 45.2        33                 2|31|3                       33.1   -24.8
  3233 46.7                           2|31|                        34.1   -23.5
  3234 47.8                           1|32|                        34.3   -23.6
  3235 46.4   3      3                 |32|                        36.6   -21.2
  3236 44.7   3                       2|43|1                       38.2   -19.6
  3237 48.5                           3|44|2                       40.9   -16.7
  3238 49.0                           3|44|2                       42.1   -15.9
  3239 45.1                            |44|2                       41.0   -16.9
  3240 50.5                      45    |44|3                       40.9   -16.4
  3241 51.7                      55   2|45|4                       43.7   -13.3
  3242 49.0                      4    2|55|3                       44.2   -12.8
  3243 48.3        34431 2            2|55|                        43.8    -9.5
  3244 48.7   12333344           2      45
```

Figure B-8. Printer plot of the Channel I spectra for the same time range as Channel II in Fig. B-7. The attenuation of the brief tones delimited by the vertical bars demonstrates that Channel II was received by the Channel I radio receiver and not added later.

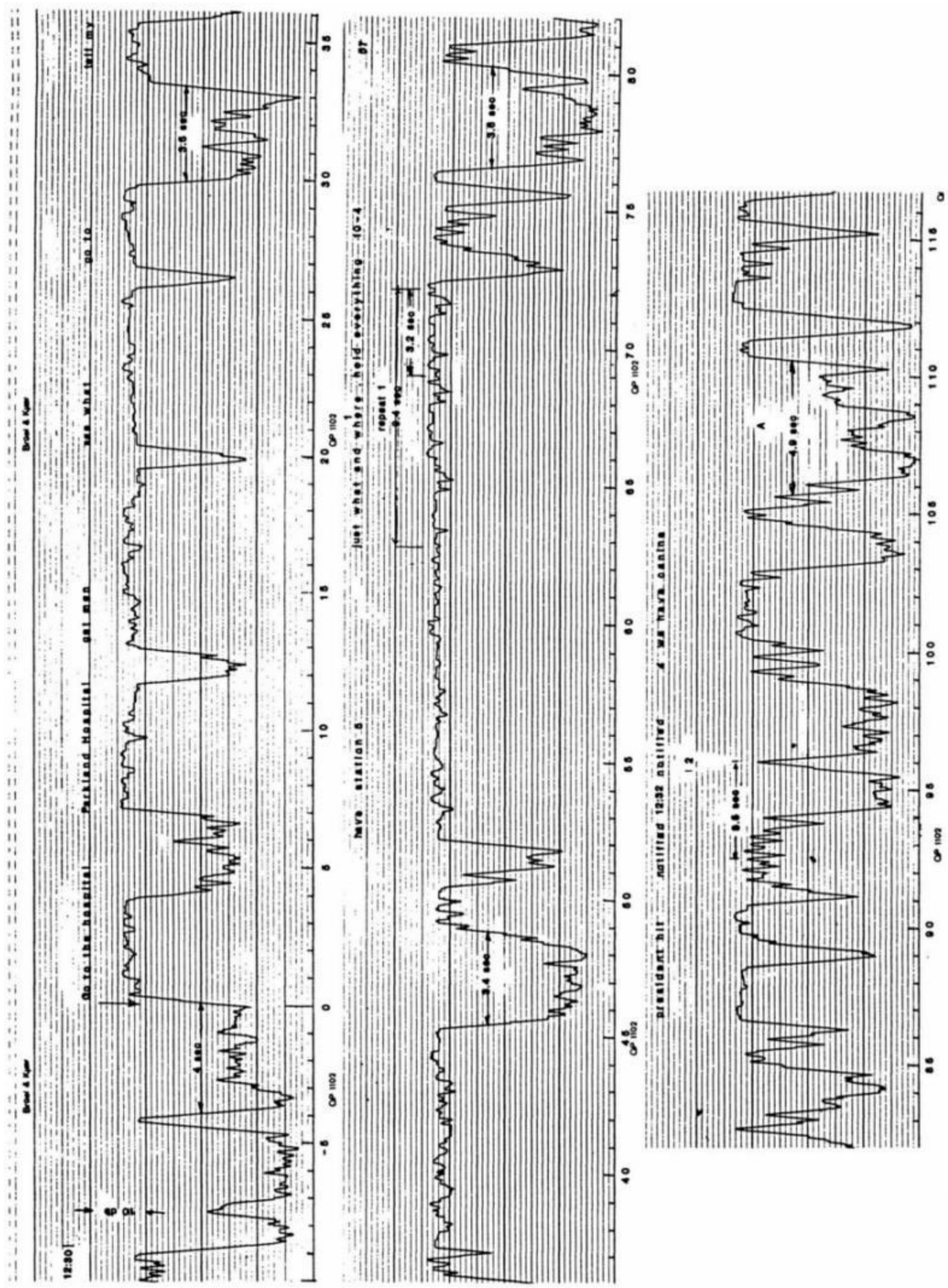


Figure C-1. Strip charts of Channel II sound level as a function of time in Channel I seconds from minus 10 to 117 seconds.

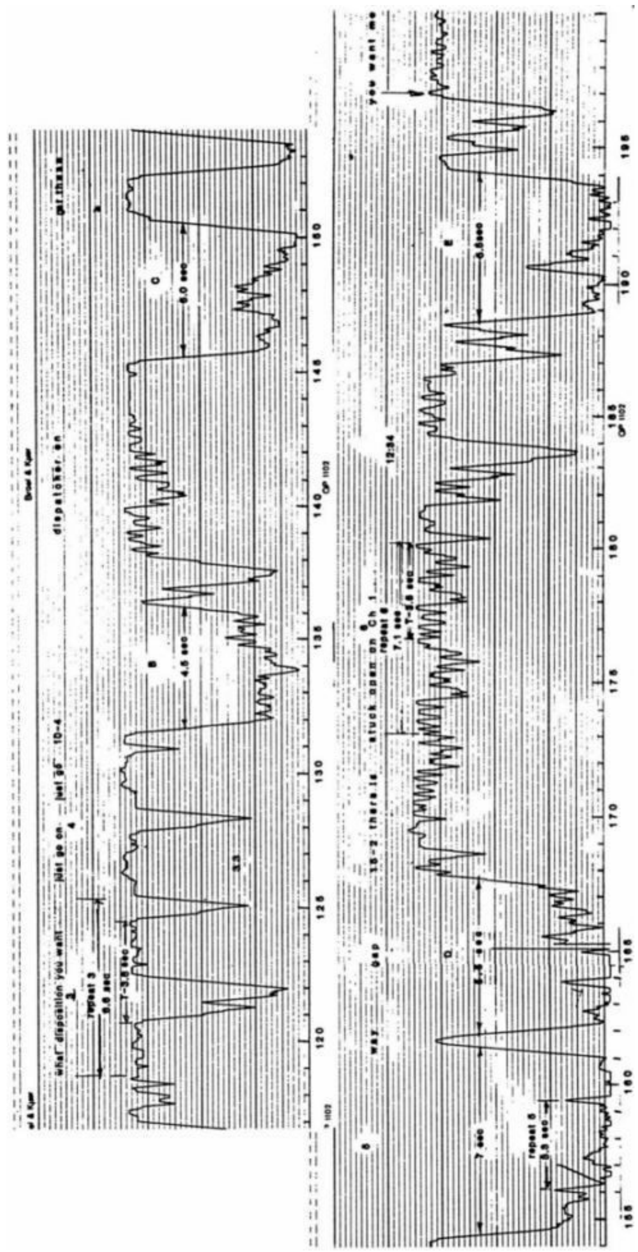


Figure C-2. Strip charts of Channel II sound levels as a function of time in Channel I seconds from 118 to 200 seconds.

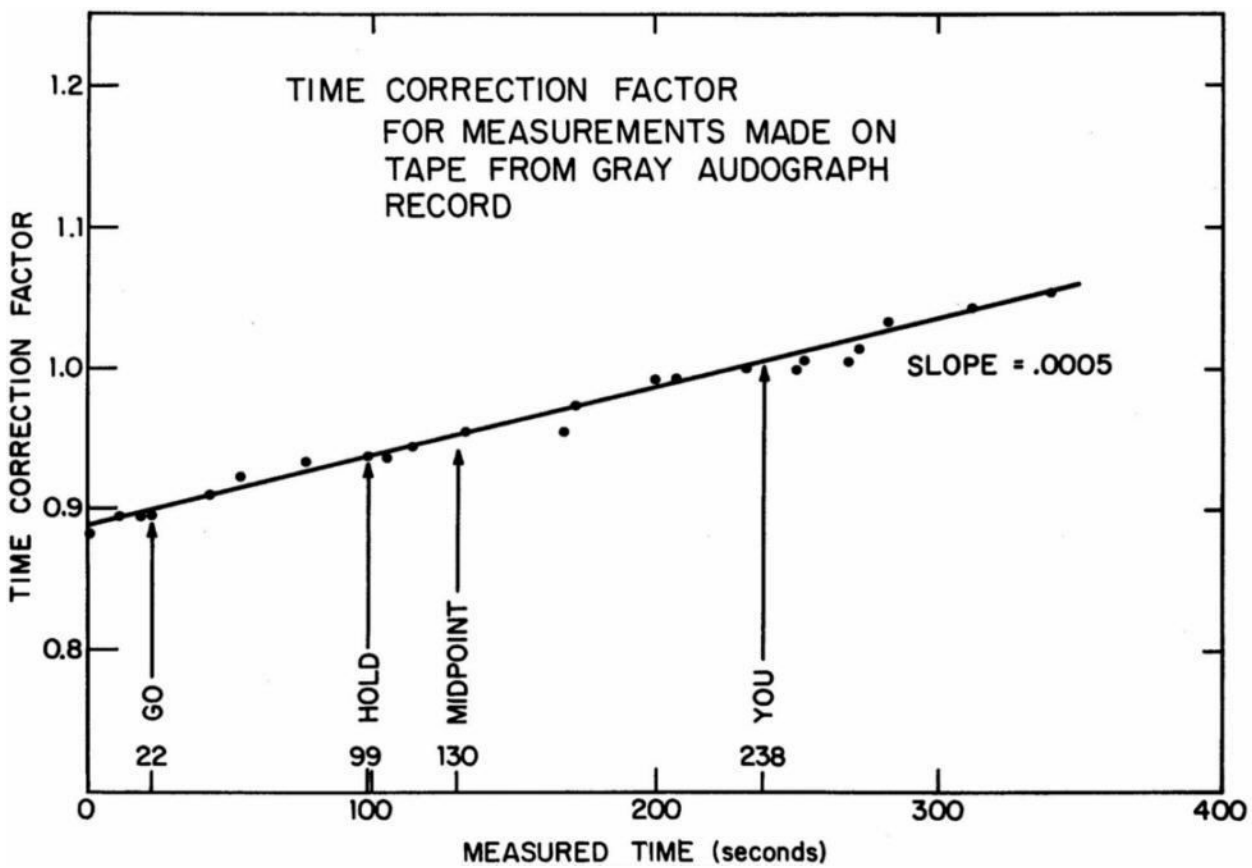


Figure C-3. Time correction factor for measurement of intervals on the tape recording of Channel II, obtained directly from the original Gray Audograph record. The correction factor is a function of the location on the record and tape.