Among the original documents and tapes that McCaghren supplied the committee was a crucial November 22, 1963 dispatch tape along with the dictabelts that recorded the transmission from the motorcycle with the open mike. These materials were promptly sent to Bolt, Beranek & Newman.

To supplement the analysis of the tape, B.B. & N. experts also went to Dallas last month to conduct an acoustical reenactment based on the live firing of a rifle in Dealey Plaza.

In these tests, the Dallas Police Department was exceptionally cooperative. It obtained weapons, constructed the bullet "traps" and rerouted traffic during the 5 hours of testing. Police marksmen fired rounds from the Book Depository, as well as from the "grassy knoll."

The final results of this work have only recently been received by the committee. Nevertheless, they have been thoroughly analyzed.

The man in charge of the Bolt, Beranek & Newman acoustical analysis is Dr. James E. Barger, the firm's chief scientist.

Dr. Barger received a B.S. in mechanical engineering from the University of Michigan in 1957, an M.S. in mechanical engineering from the University of Connecticut in 1960, and an M.A. in applied physics from Harvard University in 1962.

In 1964 he received a Ph. D. in applied physics from Harvard University. He has been a sonar project officer in the U.S. Navy Underwater Sound Laboratory, a research assistant at the Harvard University's Acoustics Research Laboratory, a senior scientist and director of the Physical Science Division with Bolt, Beranek & Newman, Inc.

Dr. Barger is the author of numerous scientific papers. He has lectured in the field of applied acoustics in the United States and Canada and currently is a lecturer on sound scattering and reverberations with Bolt, Beranek & Newman's antisubmarine warfare course.

He has been a National Science Foundation fellow and currently is a fellow of the Acoustical Society of America. He is also a member of the U.S. Naval Advisory Board for Underwater Sound Reference Services.

As chief scientist with Bolt, Beranek & Newman, Dr. Barger personally supervised the analysis of the 18-minute gap on the Nixon-Watergate tapes and the analysis, as I noted previously, of the gunfire sounds recorded during the shooting episode at Kent State University.

Mr. Chairman, it would be appropriate at this time to call Dr. Barger.

Chairman STOKES. The committee calls Dr. Barger.

Doctor, would you stand and be sworn?

Do you solemnly swear the testimony you will give before this committee is the truth, the whole truth, and nothing but the truth, so help you God?

TESTIMONY OF JAMES E. BARGER

Dr. BARGER. I do.

Chairman STOKES. Thank you. You may be seated. Mr. Cornwell.

Mr. CORNWELL. Thank you, Mr. Chairman.

Dr. Barger, I would like to first direct your attention to the point in time that our chief counsel just made reference to, namely, when the committee brought to you a tape recording and a Dictabelt of the Dallas Police Department's recordings of transmissions on November 22.

At that point in time, what did the committee ask you to try to do with that tape recording?

Dr. BARGER. Mr. Cornwell, there was a series of questions that were asked in increasing order of difficulty.

The first question and the least difficult potentially to answer was, simply, was the motorcycle with the stuck transmitter likely to have been in Dealey Plaza. If so, was the sound of shots recorded thereon or detectable thereon. And if that turned out to be the case, how many shots. If that could be determined, what was the time sequence between them, and if that could be determined, from what locations were the shots fired. And if by chance that also could be determined, what weapons fired the shots?

Mr. CORNWELL. Would there be some reason to believe that you could answer any or all of these questions?

Dr. BARGER. Well, the reason to believe that there may be answers to the latter questions was, of course, less likely than the former ones, but the answer was generally yes. The tapes had a good deal of noise on them, motorcycle noise, crowd noise, radio frequency interference, and the like. The most serious problem was the motorcycle noise. There is a way to help reduce that. It is a technique called adaptive filtering. It considers that the motorcycle is a repetitive device. As the cylinders fire, they do so periodically. The adaptive filter can learn to understand the event and project what will happen the next time the piston fires and subtract that noise out from the tape.

We thought once the adaptive filtering was conducted, the tape might then be noise-free enough to attempt a detection of the sounds of gunfire.

Now it was perfectly clear that these sounds were not clearly audible. There is in the field of detection theory a favorite approach called matched filtering. The matched filter is a device that is used to detect events that you have some understanding of, even though they are subaudible. Matched filters are used in radar sets commonly to detect the presence of impulsive signals in noise, even though they are not visible or audible in the raw data. There was reason to believe that applying these techniques we might be able to detect the impulsive sounds of gunfire.

Mr. CORNWELL. What, if anything, gave you reason to believe that you might be able to determine the direction from which gunfire came or the fact that it was gunfire?

Dr. BARGER. When an impulsive source of sound is generated in an enclosed or semi-enclosed environment, such as an urban environment, the impulsive sound spreads from the place where the sound was generated in all directions and is reflected, scattered, and diffracted into all possible receivers, such as microphones that might be stuck and such as ears.

Now the impulsive signals that arrive at these receivers—microphones or ears—over all of these paths through the processes of reflection, and scattering, occur in a unique pattern, and that pattern depends on where the source of sound was and where the receiver is at that time. This unique pattern can be learned by, for example, reconstructing the sound of the acoustical event and measuring the unique pattern.

If the microphone or receiver moves from one place to another, the pattern will change, and it is in fact these echo patterns that are the matching patterns that we considered using in the matched filter as a very powerful method for detecting the possible presence of gunfire in the tapes.

Mr. CORNWELL. Let's begin with what you describe as the unique sound of gunfire, and at this point show you JFK exhibit F-357.

First, will you simply tell us what that is?

Dr. BARGER. This is an exhibit that illustrates the acoustical disturbance generated by a rifle firing a supersonic bullet in free space.

Mr. CORNWELL. At this time, Mr. Chairman, I would ask that that exhibit be admitted into evidence so that we may ask Dr. Barger further questions concerning it.

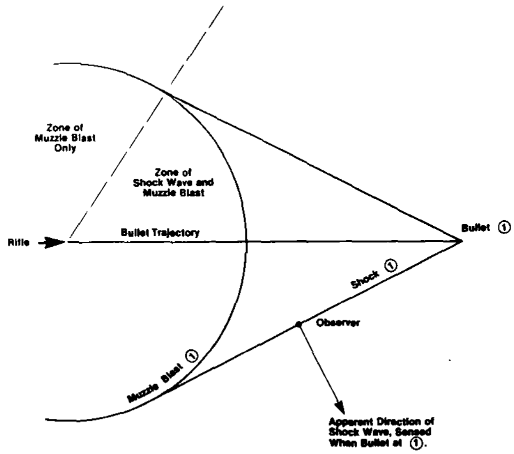
Chairman STOKES. I am sorry, Counsel? I didn't hear you.

Mr. CORNWELL. I would like to ask at this point if that exhibit might be admitted into evidence.

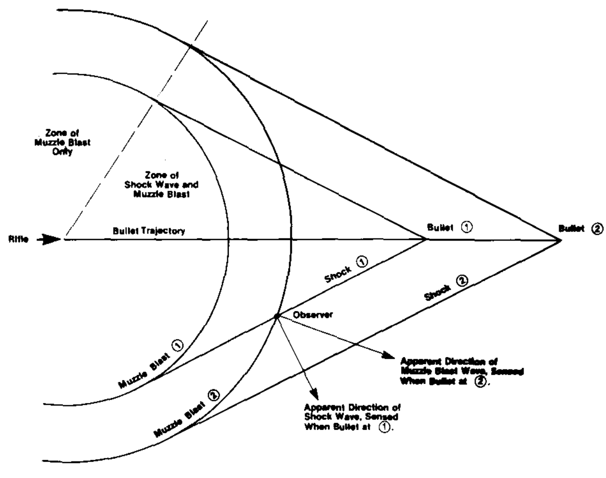
Chairman STOKES. Without objection, it may be entered.

[The information follows:]

Loci of Muzzle Blast and Shock Waves
at Two Times After Firing of Supersonic Bullet



Loci of Muzzle Blast and Shock Waves
at Two Times After Firing of Supersonic Bullet



JFK Exhibit F-357

Mr. CORNWELL. Would you at this point then, Dr. Barger describe this phenomenon using the exhibit?

Dr. BARGER. This simple diagram shows the location of a rifle firing a supersonic bullet along this horizontal trajectory. At the instant in time that this illustration depicts, the bullet is at position 1. The sound generated by the muzzle blast is expanding spherically around the origin of the gunfire, namely, the muzzle of the rifle.

At the time depicted here, that impulsive sound spherical surface has reached the point shown by the circle. The bullet, however, being faster than the speed of sound has advanced beyond the position of the sound wave. It generates a shock wave as a supersonic transport would and the locus of that shock wave is from the bullet itself to the tangent of the sound wave at this point. At a later time [now referring to the second exhibit] the bullet will have advanced, and both the shock wave and the sound wave would have expanded to the position shown here. The sound wave has expanded to this point, and the shock wave has progressed to this region.

If an observer were at this point, at the first time that I showed, when the bullet was at this point, the observer would hear the shock wave because it would pass him at that time.

At the second time that I show here, when the bullet is advanced to the second position, the sound waves of the rifle would reach the observer at that point and he would then hear the muzzle blast.

Mr. CORNWELL. You have emphasized at several points that this is a diagram showing the principles with respect to a supersonic bullet.

What, if any, differences would you find if the bullet were subsonic?

Dr. BARGER. If the bullet were subsonic, at the first time that I have shown when the muzzle blast has reached this point, the bullet would have lagged behind the position of the sound wave at that point, and it would always be behind; getting farther and farther behind, as time went on; and no shock wave is generated by that bullet.

Mr. CORNWELL. If you wanted to look at those principles on a recording, would there be a way that you could do that?

Dr. BARGER. Yes. This observer is the same as the receiver I spoke of earlier. It could be a microphone or an ear, and therefore what I said for this observer holds for the——

Mr. CORNWELL. I would like at this point then to show you JFK exhibit F-364 and ask you if you could tell us what that is.

Dr. BARGER. This is an illustration of the shape of the acoustical waveform generated by two rifles.

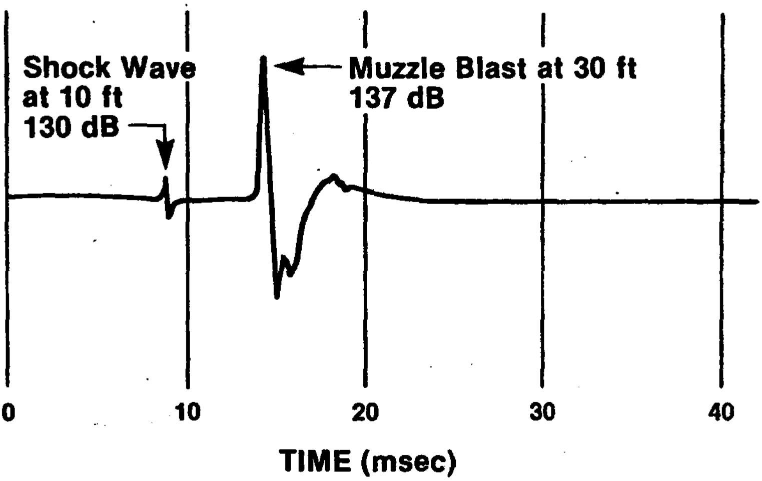
Mr. CORNWELL. At this point, Mr. Chairman, I would like to ask that JFK exhibit F-364 be admitted into evidence.

Chairman STOKES. Without objection, it may be entered into the record at this point.

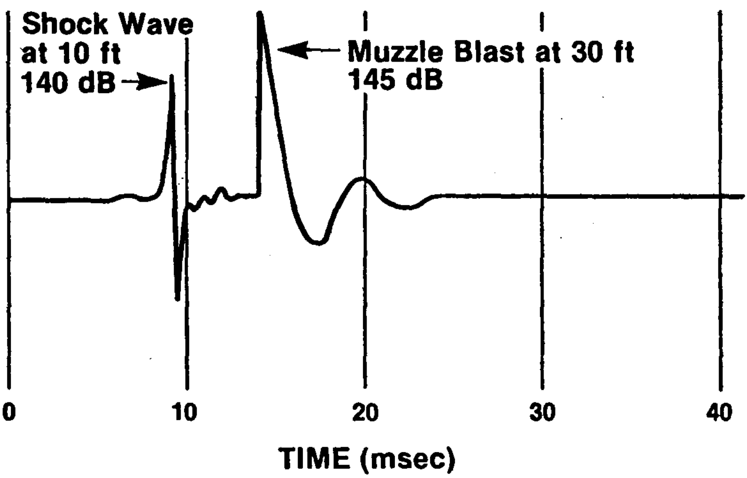
[The information follows:]

Muzzle Blast and Shock Waveforms for Mannlicher Carcano and M-1 Rifles.

MANNLICHER CARCANO



M-1



JFK Exhibit F-364

Mr. CORNWELL. Would you now, Dr. Barger, tell us what that exhibit illustrates?

Dr. BARGER. At the top of the illustration we show the acoustical waveforms of both the shock wave and the muzzle blast from a Mannlicher-Carcano. The shock wave was measured by a microphone 10 feet from the trajectory of the bullet and the muzzle blast was measured by the same microphone which was at the same time 30 feet from the muzzle.

All of the acoustical pressures are plotted here as a function of time measured in milliseconds. The shock wave is a very sharp event looking something like the letter "N," capital letter "N" and in this case, with this weapon, the peak pressure of the shock wave is 130 decibels.

Now let me just briefly describe the decibel as a measure of acoustical intensity. The reference pressure for the decibels that I describe is 2 times 10 to the minus 5 newtons per square meter, the currently standard reference pressure. With respect to that pressure, the shock wave has an intensity of 130 decibels.

The muzzle blast at 30 feet is more intense. It has an intensity of 137 decibels.

Let me just give you a few facts about decibels that will help make this clear.

If two sounds are otherwise similar but have a different loudness, a different intensity by 10 decibels, the louder of the two will sound twice as loud. On the other end of the scale, if two sounds are so slightly different in intensity that you can just perceive that difference, they will be different by 3 decibels.

The muzzle blast then, more intense by 7 decibels, would sound almost twice as loud as the shock wave. It has a very sharp peak, a negative undershoot followed by quiescence, and these are characteristic of the waveforms of that rifle.

A rifle firing a bigger charge is the M-1 rifle. It also has a faster round. The muzzle velocity of the Mannlicher-Carcano is about 2,000 feet per second. The M-1 is close to 3,000. Therefore the intensity of the shock wave radiated by the M-1 is greater—being about 140 decibels when measured 10 feet from the flight path—is twice as loud as the Mannlicher-Carcano shockwave. The muzzle blast is also more intense. At 30 feet it would be about 145 decibels, being something less than twice as loud as the Mannlicher-Carcano.

Mr. CORNWELL. I suppose we are all aware that the Dallas Police Department found a Mannlicher-Carcano on the sixth floor of the book depository, and the Warren Commission concluded that was the weapon used in the assassination. So I guess from that we could assume why you chose a Mannlicher-Carcano in the top graph to illustrate the principles you just described. But why did you choose an M-1 to illustrate in the lower portion of the graph?

Dr. BARGER. Well, for one reason we had the data. The principal reason was that it is the loudest rifle that one could conceive might have been used in that environment. And the purpose then is to show that the loudest one we might have conceivably used is less than twice as loud.

Mr. CORNWELL. I would like to now direct your attention to the part of your previous resume that referred to the fact that you might be able to locate the shots and ask you if you would direct your attention at this time to JFK Exhibit F-334.

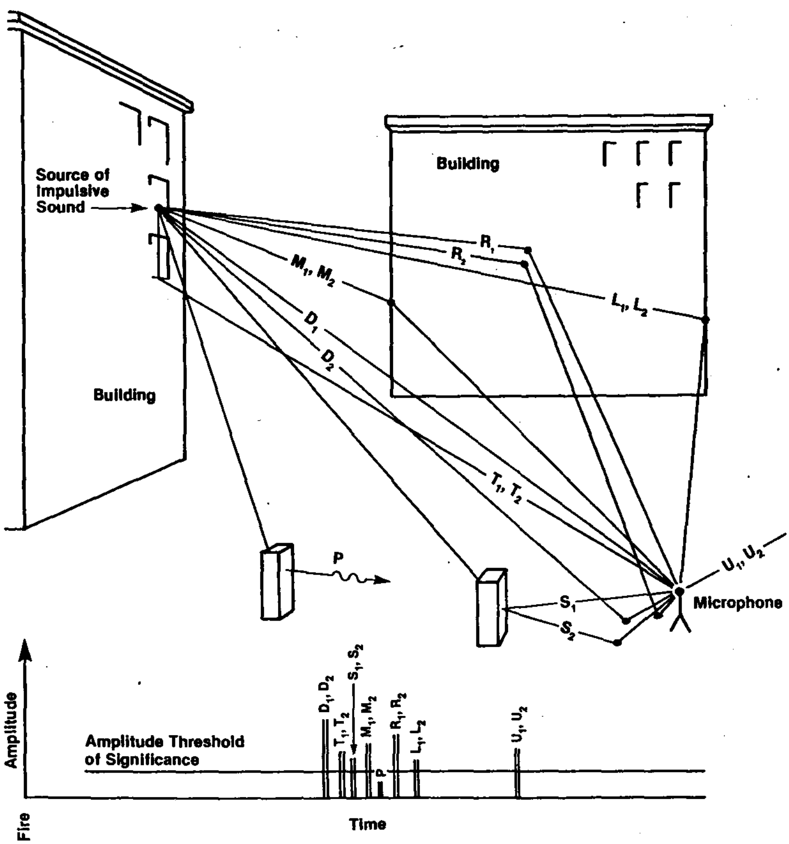
Dr. BARGER. Yes. This is what is known in the field of scientific presentation as a cartoon. It illustrates the formation of echo patterns in urban environments.

Mr. CORNWELL. At this time, Mr. Chairman, I would ask that JFK exhibit F-334 be admitted into evidence.

Chairman STOKES. Without objection, it may be entered in the record at this point.

[The information follows:]

Echo Patterns Caused by Direct, Reflected, Diffracted, and Scattered Impulsive Sounds in an Urban Environment.



JFK EXHIBIT F-334

Mr. CORNWELL. Would you explain then what the principles are that are illustrated by that?

Dr. BARGER. Yes. I have said we are aiming for the application of a matched filter to the Dallas Police tape that Mr. Blakey described, seeking the possible detection of gunfire thereupon.

Now the pattern that will be the match in this filter would be an echo pattern as generated at a receiver, such as a microphone, in an urban environment that has buildings and an impulsive sound source that might have been generated in one of them.

In the lower figure here, we show, along the horizontal scale, time increasing, and in the vertical scale here the amplitude of sound that might arise at any particular time.

Now the sound from the muzzle of the rifle expands as I showed in the first exhibit, and it propagates along this direct path, which is the path having the least length between the source and the microphone. But I have illustrated that there are two here very close together marked D_1 and D_2.

The reason for that is that next to the direct path is another ray of sound that hits the street just below the microphone and reflects up into the microphone. Those two paths have very nearly the same length, therefore, they occur at very nearly the same time, and they have very nearly the same amplitude, and so I have plotted them at this same point.

Now, sound propagating over this direct path loses energy only by spreading out to fill the sphere that I described in the first exhibit. Sound paths having the next highest amplitude are those that are reflected from the surface of a building. Reflection occurs whenever the angle of the sound ray incident upon the building is reflected from it at the same angle. The same sound that hit the building was reflected off. It is still going after reflection in only one direction, just as it was before reflection. Therefore, it has not been diminished in intensity. It has merely had the direction of its propagation changed. It then hits the microphone as does another similar path hit the street and then the microphone. These two paths being longer occur later. They are marked with R_1 and R_2 here, illustrating the reflected direct and reflected surface bounce path.

The sounds that comprise echo patterns that have the next stronger amplitudes are the diffracted paths. These paths hit large edges such as the corner of a building. Now when the sound strikes the corner of that building, it is spread out in a plane that I am now describing with this pointer. It goes into all directions within that plane, including the direction of the microphone. Since some of the sound that hit that corner at that time went in other directions it is diminished in amplitude at the time it arrives at the microphone. Therefore, Path M that I just described, which is clearly shorter than the Path R because this corner is closer to the source than was the reflection path is right there, has a lower amplitude than the reflective path had.

The furtherest corner of the building will give a diffracted path similarly.

Now, we have discussed reflections and diffractions.

The third most important, but generally the weakest method of changing the direction of sound is by scattering. I have illustrated a parallelogram here which represents people or automobiles or anything of small size. When the sound hits an object of small size, it is sent out in all directions, including the direction of the microphone.

Having been sent in all directions in space, it is diminished in amplitude considerably, so only if that scattering occurs close to the microphone, as I have shown here, or if the scattering object, namely this windowsill, is close to the source, as I have shown here, will those paths have sensible amplitude.

In order to have significant amplitude, the scattering object has to lie close to the direct path.

Therefore the traveltime over the scatter path has to be only slightly larger than the traveltime over the direct path. Therefore, right after the loud sound arrival you see lots of weaker sound arrivals that are scattered from small objects.

There are other buildings, of course, in a typical urban environment and in particular, in Dealey Plaza, and so there are diffracted and reflected sound paths coming in, as I have illustrated with a simple "U" here from other directions. They will occur at later times because they come from buildings that are further away and they will be scattered out in time.

A cursory examination shows we would expect echo patterns that would persist for about 1 second. In that period of time there would be on the order of 10 or 12 reflected, diffracted and scattered paths having significant amplitude, namely, amplitudes above some threshold below which exists only noise.

Mr. CORNWELL. If I understand correctly then, the sound would travel at the same rate of speed after it hit any of those surfaces no matter whether it was reflected or scattered or whatever, and therefore the spacing of the marks on a time scale would be determined strictly by the distances that the sound had to travel from its source to the microphone or ear, is that correct?

Dr. BARGER. That is correct.

Mr. CORNWELL. In your hypothetical urban environment that you show there on JFK exhibit F-334, how many different points of sound source, or different locations for a point of sound source, and how many different locations for a microphone, might you expect to produce the exact same spacing of the points on the time scale and amplitude at those points?

Dr. BARGER. It is clear that moving the position of this microphone in any direction will alter the relative length of the sound paths and therefore alter the spacing between them. If there are enough different reflectors and scatterers, then the pattern achieved at any particular point is unique and would not be replicated at any other point.

Mr. CORNWELL. If we had a time scale such as shown at the bottom, you would expect that to be produced from a sound only in one place in the environment and at a point where the microphone or receiving ear was located at only one point?

Dr. BARGER. That is correct. In the absence of noise, if you could measure this pattern precisely it would uniquely fix the position of the microphone.

Mr. CORNWELL. Now, you told us earlier that when you received the tape recording here in question you listened to it and it had a large amount of noise or static in it, is that correct?

Dr. BARGER. That is correct.

Mr. CORNWELL. What did you do after initially listening to this recording?

Dr. BARGER. Initially we listened to the whole tape and we found at one point on the tape a 5½-minute segment in which the sound of a motorcycle engine and other noises were heard continuously. This particular 5½-minute segment was the period of the stuck microphone button that Professor Blakey described earlier.

The sound in that 5½-minutes was mostly motorcycle noise. However, there was a period half-way through it, approximately, where the motorcycle noise diminished. That is a brief description of what we heard.

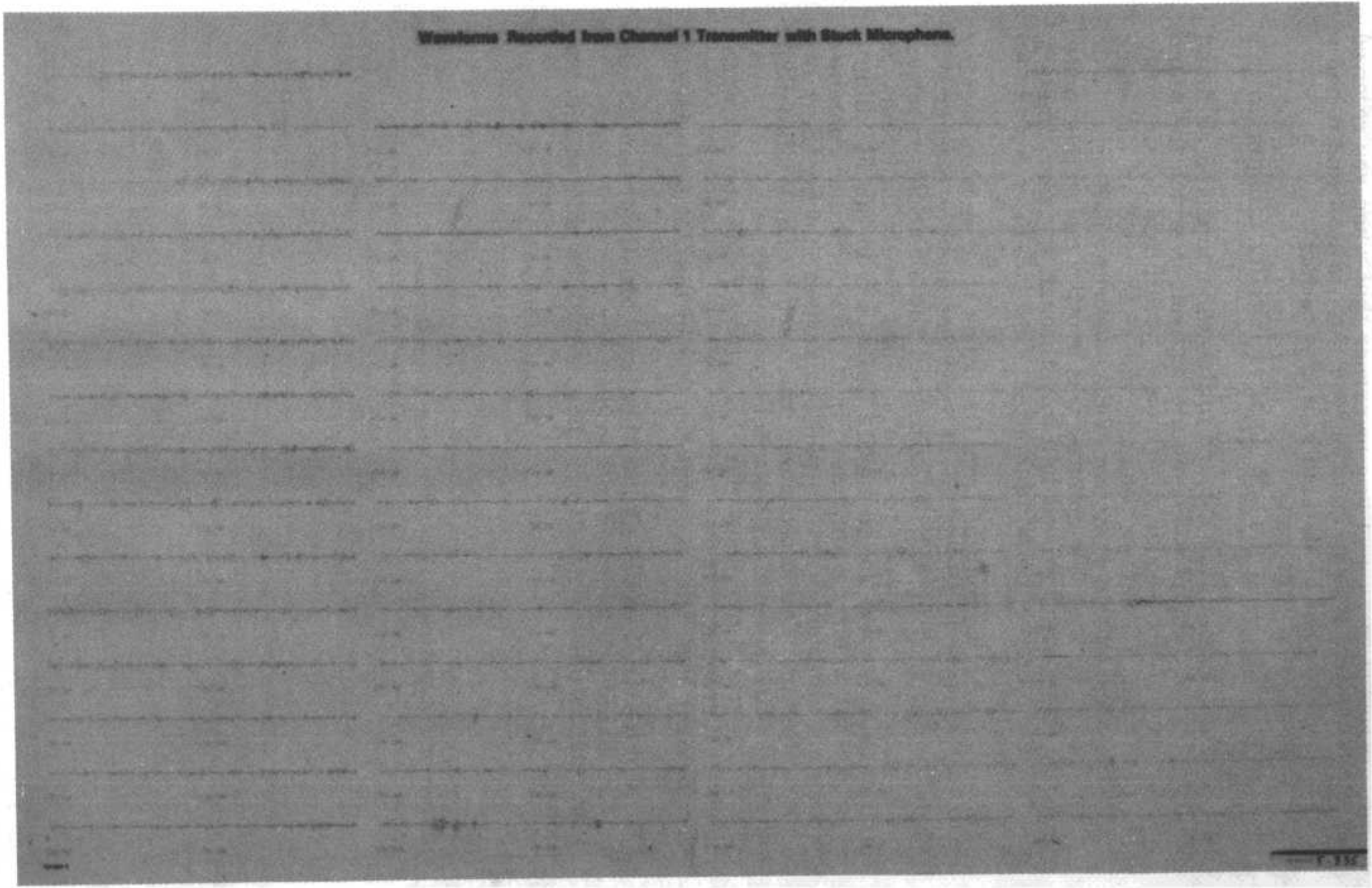
Now, as I said, we realized from the outset that we were seeking to detect sub-audible events, or at least not audibly recognizable events, and this is helped by looking at the electrical waveform that represents the sounds in a form called a waveform chart. So the first thing we did was to digitize the sounds in this 5½-minute tape recording to form a computer file of the information contained by that digitalization, and then plot out a chart showing the waveform on the tape. This process was conducted by Dr. Wolf at BBN and it generated about 234 linear feet of waveform.

Mr. CORNWELL. I now show you JFK exhibit F-335 and ask you if you can tell us what that is?

Dr. BARGER Yes. That is about ten feet of the 234 feet of waveform.

Mr. CORNWELL. I would like at this time, Mr. Chairman, to ask that that exhibit be admitted into evidence.

Chairman STOKES. Without objection, it may be entered into the record.



JFK EXHIBIT F-335

Mr. CORNWELL. What, if anything, did you learn from the production of this type of chart and your analysis of it?

Dr. BARGER. This exhibit shows the waveform of the sounds on the tape displayed at 50 inches per second starting 130 seconds after the onset of the stuck microphone button and extending to the time of 141.6 seconds.

Of course, it is difficult to see here without a telephoto lens but I will describe it to you. This continuation of rather constant level noise is typical of what preceded this segment for about 2 minutes. It is motorcycle noise. At this time, about 132 seconds after the microphone button became stuck, it is clear that the amplitude of that noise is diminishing. Shortly after that time, a series of impulsive events are seen in the tape. We concluded that it is possible that some of these impulsive events are in fact what an echo pattern would look like as transmitted through the radio in question.

Mr. CORNWELL. In addition to the motorocycle noise, did you find on your graph other types of noise or static, something like that?

Dr. BARGER. Yes. I just mentioned briefly that in addition to this continuum of noise which sounds like and apparently is motorcycle noise, there are sharp impulsive events of this type. They occur from time to time. Many of these have become understood by us to be impulsive events caused by other radios when they key in and attempt to transmit on this radio channel as well.

Mr. CORNWELL. After 15 years in what condition was the tape? Did that possibly have any effect on the level of noise that you found?

Dr. BARGER. The possibility that some of this noise was caused by the tape recording process is clearly a real one. The noises generated by the motorcycle are so intense that the noises generated by the recording process are relatively less. Therefore that is not the principal source of disturbance.

Mr. CORNWELL. After reviewing the output in this form, what did you do next?

Dr. BARGER. We realized that we could see impulsive events occurring at times after the motorcycle noise diminished of its own accord. We have then to determine whether such impulsive events might also be present in the tape recording at earlier times before the motorcycle in fact quieted down. We decided the best way to do that, as I mentioned briefly before, was to filter this tape recording through an adaptive filter that would, as I described it, learn about the motorcycle noise, project slightly ahead, and subtract it out.

Mr. CORNWELL. There might be members of the committee who are familiar with some types of filters, but the particular type that you needed for this process, was it available in 1963?

Dr. BARGER. No.

Mr. CORNWELL. When, approximately, would it have been developed, if you know?

Dr. BARGER. I am not exactly sure. The type of adaptive filter we used is called a Widrow adaptive filter. We used the least means squares logarithm to compute the filter weights. I don't believe that process was described in the literature until 1968 or so.

Mr. CORNWELL. I would like to show you JFK exhibits F-336A and F-336B. Would you tell us what those are, please?

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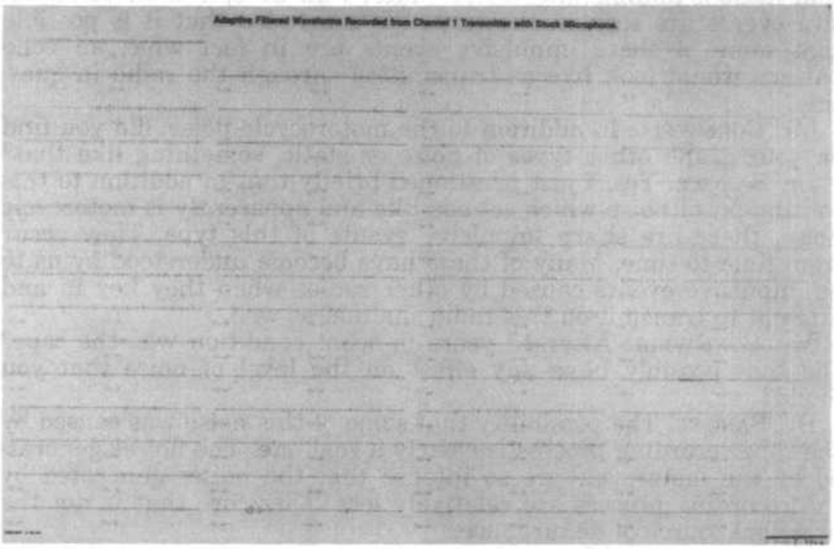
Dr. BARGER. These are about 18 feet of the waveforms that were obtained by filtering the motorcycle tape through the adaptive filter. The beginning time of this segment is 130 seconds after the onset of the stuck button, as was the previous exhibit. In this case, the terminating time is 150 seconds.

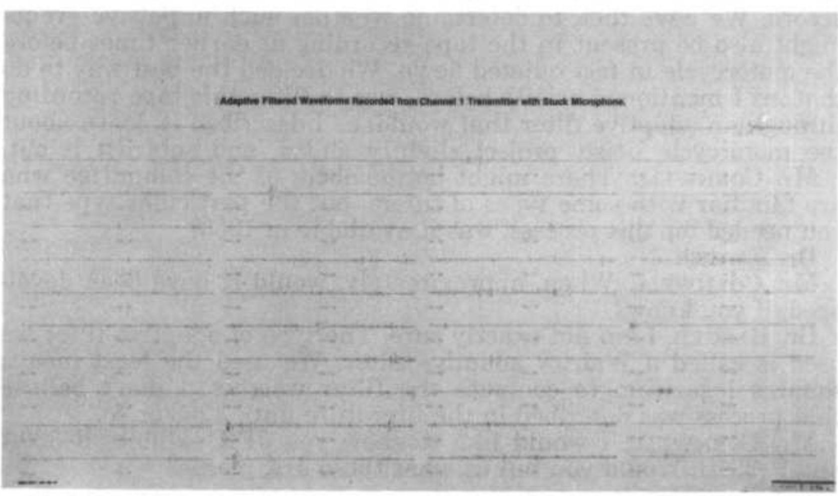
Mr. CORNWELL. I would ask at this point, Mr. Chairman, that JFK exhibits F-336A and B be admitted into evidence.

Chairman STOKES. Without objection, they may be entered into the record at this point.

[The information follows:]



JFK EXHIBIT F-336A



JFK EXHIBIT F-336B

Mr. CORNWELL. Did you learn anything new from reviewing the data in this filtered form?

Dr. BARGER. Yes, we did, but these waveforms are sufficiently indistinct to you that you wouldn't be able to tell it from where you are sitting.

The amplitude of the noise in the portions of the record where the motorcycle was heard most loudly have been reduced relative to the amplitude of the signals in the period where the motorcycle noise had previously and is still quiet.

It, therefore, enabled us to examine those portions of the tape that were recorded when the motorcycle was running faster and during which time the noise of the motorcycle was perhaps obscuring any impulsive sounds that might in fact appear to be echo patterns.

Mr. CORNWELL. What, if any, technique did you apply to learn more about the data after receiving it in this filtered form?

Dr. BARGER. After examining the 234 feet of filtered waveforms we discovered there were no other impulsive events on the tape that had been masked by the motorcycle noise, with one exception. That impulsive series of events came near the end of the 5-minute segment and was very unlike the series of impulsive events that we see before us here, at times around 130 seconds after the stuck button.

Mr. CORNWELL. What, specifically, did you do to determine what the nature of the impulsive events were?

Dr. BARGER. At this stage we conducted a series of tests which we call screening tests, to determine whether those impulsive events might be ruled out as gunfire. I might add before we did that we did attempt some different analyses beyond those that I have described so far, that would help us understand the nature of the impulsive events that we did in fact perceive.

The first of those analyses, in fact, was a calculation of the spectrographic analysis of some of the transient events.

Mr. CORNWELL. I would like to show you JFK exhibit F-356 and ask you, Would it be possible for you to use that exhibit to illustrate the analysis, the spectrographic analysis you just mentioned?

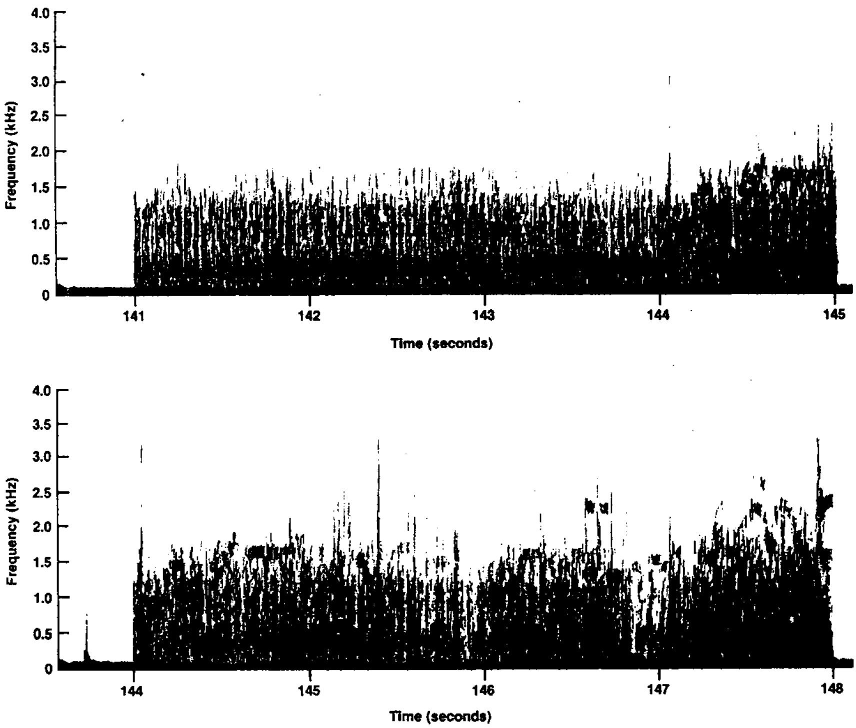
Dr. BARGER. Yes. This exhibit is made up of two spectrographs of two segments of the tape recording that help explain the presence of some of the impulses on the tape.

Mr. CORNWELL. May we have JFK exhibit F-356 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection it may be entered at this point.

[The information follows:]

Spectograms from Waveforms Recorded from Channel 1 Transmitter with Stuck Microphone



JFK Exhibit F-356

Dr. Barger. There were a series of impulsive events on the tape that were particularly numerous at times about 145 seconds to 150 seconds. These are shown in a spectrogram as follows:

The time on the spectrogram is marked on the horizontal scale in seconds.

The frequency of the energy in the sounds on the tape at each time is marked on the vertical scale in kilohertz. At this point, half a kilohertz, is the frequency approximately equal to the pitch of middle C on a piano. The height of these spikes—the distance the spike reaches upward in this coordinate indicates how sharp it is, how much high frequency content it contains, but that is about all.

The interesting thing shown are these horizontal dark bands. The horizontal dark bands are the sounds made visible in the spectrogram that are caused by the heterodyning between two radio transmitters. The radio transmitter with the stuck microphone is transmitting for sure. There are other radios that transmit on the channel, which puts their carrier frequency onto the air as well.

The carrier frequencies of the two radios are not exactly the same. They beat between each other and generate what is called a heterodyne tone, a beep. The indication of that beep, which would be determined by where it was positioned in the vertical dimension of the spectrogram, is dependent on the exact radio in question and what its carrier frequency really is.

We see there are heterodyne tones with this pitch, this pitch and this pitch, and even with this pitch. That indicates that during this time there were at least four other radios that were briefly trying to transmit by pressing their talk buttons.

When they realized the channel was still in use, they let it up. So the time between when they push the button, which generates a transient, until the time they let up the button, which also generates a transient, there is a heterodyne tone observable in the spectrogram. These tones were subaudible on the tape so the spectrogram revealed their presence. Whenever there were a pair of impulses with a heterodyne tone between them, we knew those impulses were generated by another transmitter and should be eliminated from consideration as possible members of an echo pattern.

Mr. CORNWELL. In addition to the spectrographic analysis you have just described were there any other techniques that you utilized in order to determine whether or not the impulses on the tape were in fact associated or might be associated with gunfire.

Dr. BARGER. Yes, there was one in particular. We wanted to demonstrate there were audible acoustical sounds on the tape. The sound of a bell toll at 152 seconds from the time of the stuck button was vaguely evident. We wished to analyze that segment of the tape with an energy spectrum.

Mr. CORNWELL. I show you JFK exhibit F-355 and ask you to tell us what that is.

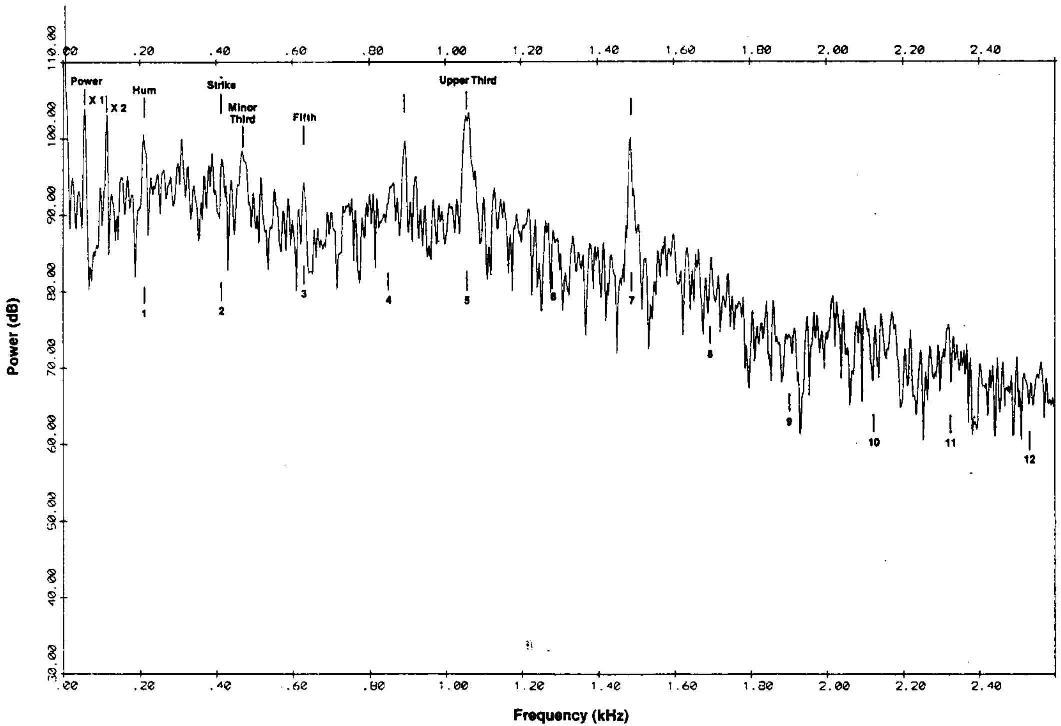
Dr. BARGER. This is what I just described. The energy spectrum of the segment of the tape that contains the toll of the bell.

Mr. CORNWELL. May we have JFK exhibit F-355 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection, it may be entered into the record at this point.

[The information follows:]

Energy Spectrum of Tape Segment Containing the Sound of a Bell.



JFK Exhibit F-355

Dr. BARGER. In this exhibit the frequency of each component of sound is plotted on the horizontal scale and the loudness of that component is plotted on the vertical scale, again in decibels.

The nature of an energy spectrum, if you have nothing in the record except noise, is a rather jiggly line, sometimes described as a hairy line, that is rather gently undulating in the frequency domain.

However, if there are periodic components in the sound, such as generated by a bell or an overtone of a bell, they will generate a spike in the spectrum such as these spikes that are clearly visible in this exhibit. In fact, there is a harmonic series of periodic events that are visible in this record and we have labeled them with the number 1 to represent the fundamental, and the numbers 2, 3, 4, 5, 6, to represent the harmonic overtones.

This particular spectrum, which was calculated by Mr. Schmidt, has been done over a third of a second of the tape that was identified by the audible, but barely audible, sound of this bell.

Now, there is a very interesting feature in this spectrum and that is in particular this particular peak. The reason this is of significance is as follows: It is characteristic of the design and manufacture of carillon bells that they contain a harmonic series such as I have numbered here.

The fundamental frequency is in the description of carillon sounds called the hum note. The second harmonic is called the strike note and that is the note to which the bell is tuned.

In this case that is 440 hertz, which is A below middle C.

The strike note characteristically has a minor third above it and this peak in the spectrum is at the right frequency ratio to the strike tone to be the minor third of a carillon bell. They typically have a fifth and an upper third above them and both of those overtones are clearly evident in the spectrum of this bell. It is not at all unlikely that a strong seventh overtone of the hum note would appear. This, therefore, is a very clear indication that the bell is a large carillon bell. The sound of it would reach this tape recording only through an acoustical path.

Mr. CORNWELL. So somewhat similar to the spectrographic analysis technique, by applying the energy spectrum analysis you were again able to identify transients or short peaks in the data which were not associated with gunfire?

Dr. BARGER. That is correct.

Mr. CORNWELL. At this point then you had filtered the tape and you had eliminated both background noise, such as the motorcycle, and a number of other transients using the techniques you just described, what conclusions were you able to draw at this point from your analysis?

Dr. BARGER. We concluded there were sounds of acoustical origin on the tape, giving us confidence that the acoustical part of the otherwise partially malfunctioning transmitter was working.

We found that there are impulses on the tape that are unique to the segment following 130 seconds from the onset of the stuck button and a cursory examination of those impulses indicated that we could not rule out the possibility that they were in fact echo patterns.

Mr. CORNWELL. What did you do next?

Dr. BARGER. Well, it seemed prudent to do something more than a cursory examination of the echo patterns so we devised six screening tests to determine if they might in fact be the sounds of gunfire. If the echo patterns passed these six screening tests we would proceed to the filter detector which I described before as the most powerful test we could perform.

The first screening test was: Did the impulsive patterns on the tape occur at the time of the assassination? The second screening test was, simply: Were these patterns that occurred at this time in the data unique throughout the 5.5-minute segment? In other words, could they be shown to have occurred only once?

Third, we asked, did the span of time occupied by the impulse patterns cover at least 5 seconds? Because if they had not, they could not possibly represent the entire span of the gunfire as given by analysis of the Zapruder film.

Fourth, we asked, do the shape of the impulses on this tape recording resemble the shape of impulses of gunfire transmitted through that type of radio? They certainly didn't resemble the wave forms of gunfire I showed in the first exhibit, as the radio would be expected to distort them. Would it have distorted them in the way that they appear on the tape?

The fifth screening test was: Does the narrow range of observed amplitudes of the impulses on the tape correspond to the expected range of amplitudes for the wide range of echo amplitudes as compressed upon transmission through the radio?

The sixth one was: Do the number of impulses that we would expect in an echo pattern in Dealey Plaza approximate the number of impulses that are seen in the tape to occur at this time? Those six questions were asked and they received an affirmative answer.

Mr. CORNWELL. Let me ask you—I believe your explanation perhaps was clear that you wanted to find out if they occurred at the right time of day; if they were unique, in other words, if they were not so thoroughly scattered throughout the data that they were the cause of something else; that their shape was appropriate; that they had the right amplitude or height after the compression of the radio; and that there was approximately the right number of impulses. But you also stated—I believe your third item was that the time span had to be at least 5 seconds.

Do I understand—you made reference to the Zapruder film—is that simply a matter of looking at the head shot at 313, or 312, and going back into the film at which point I suppose everyone would agree that the participants, the President and Governor Connally, are clearly reacting, and saying that there was at least a minimum period of time of 5 seconds that the shots had to cover. Is that accurate?

Dr. BARGER. That is accurate.

Mr. CORNWELL. So no matter what else might ultimately be found out about the number of shots, or the timing, or sequencing, or anything else, you at that point were looking to see if it at least covered a 5-second span?

Dr. BARGER. That is correct.

Mr. CORNWELL. Then, let's go to the first test and show you JFK exhibit F-366 and ask you if you can tell us what that is?

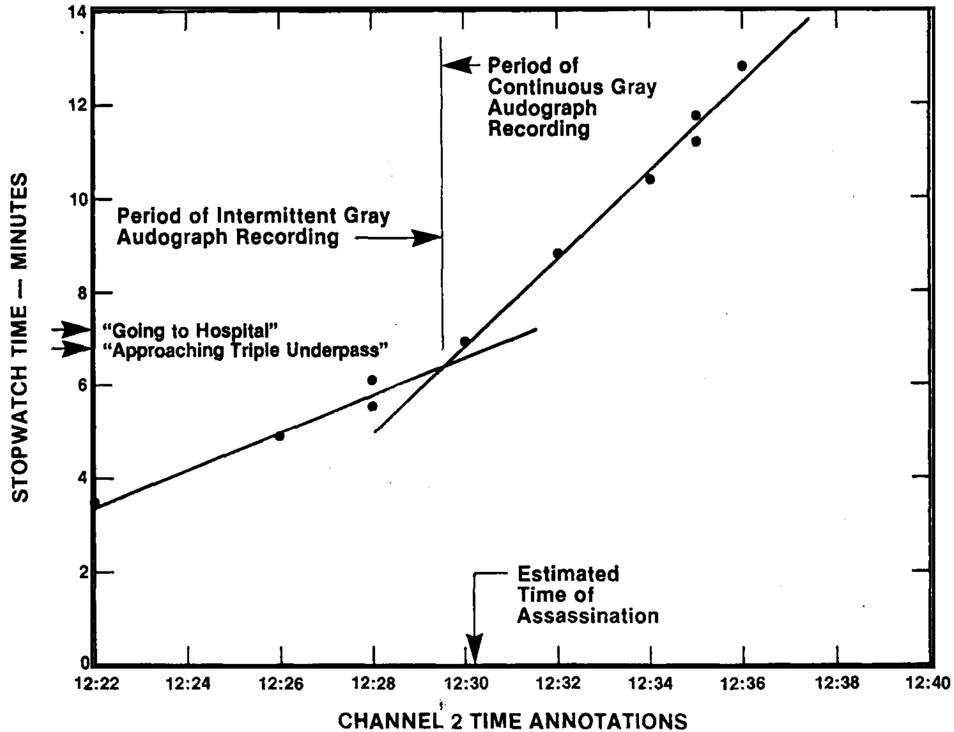
Dr. BARGER. Yes. This is an illustration of how we attempted to achieve our best estimate of the time of the assassination.

Mr. CORNWELL. May we have JFK exhibit F-366 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection, it may be entered at this point.

[The information follows:]

Least-Squares Fits to Channel 2 Dispatcher's Time Annotations Showing Times of DPD Chief's Radio Transmissions.



JFK EXHIBIT F-366

Dr. Barger. The data depicted in this exhibit were obtained by listening to channel 2 of the Dallas Police Dispatcher System. Channel 2 was in use on that day and at that time by, among others, the chief of police, who was in the lead car just ahead of the President.

Channel 2, like channel 1, was recorded; the sounds that were carried over channel 2, like 1, were recorded. They were recorded on a Gray Audograph which unfortunately records intermittently. When a radio is broadcasting a signal, the recorder turns on and records the sounds. When no one is recording, the recorder stops. This saves recording space.

As a result of that feature, we, in the laboratory, while listening to that tape recording, with a stopwatch, timed the annotations that the dispatcher read out from reading his clock. These times are plotted on the horizontal scale, each time he gave an annotation.

For example, if he said 12:28 and our stopwatch read 5.5 minutes we would put a dot there.

If he then said 12:28 a half minute later, which was not uncommon—in other words, he would only annotate the tape to the nearest whole minute—we would then note the time that that was heard and plot that point.

Now we have then obtained the stopwatch time, or we might say the laboratory time, plotted against the clock time that the Dallas police dispatcher on channel 2 had at that time, and the data follows this bent line.

When one has data of this sort one draws a straight line through them by a mathematical procedure called the least squares fit. This straight line that you have drawn becomes your best estimate of the time correspondence between your watch in the laboratory and between the channel 2 dispatcher's clock at the Dallas Police Department.

At times prior to 12:30 the best estimate by the least squares procedure of the correspondence between laboratory time and Dallas police channel 2 time is a line that has a slope less than one. This indicates that on the average the recorder used to record the dispatcher's voice was running very slowly. The reason that perception is given is that it was actually off part of the time when no one was speaking. However, at about 12:30 the voice traffic increased so much on channel 2 that the recorder operated then continuously and thereafter our estimated correspondence between laboratory time as measured on the stopwatch and Dallas dispatcher 2 time has the slope of one. That means the recorder is on all the time.

Well, that is not tremendous information. However, the purpose for doing this was to note with the stopwatch that at this time, as we listened to the tape, we hear the chief of police say, "We are approaching the triple underpass." And 19 seconds later on the stopwatch we heard him saying, "We are going to the hospital."

It has been recorded that the chief of police heard the shots and he has testified that he had heard them. It is unlikely that he would give a routine position report after having heard them, so it can be presumed or we should presume that the assassination occurred sometime between those two voice transmissions by the police chief.

If one then goes over horizontally from that time estimate to our estimated correspondence of channel 2 time to stopwatch time we have our best estimate for the time of assassination, which is 12 seconds past 12:30.

Mr. CORNWELL. I now show you JFK exhibit F-365 and ask if you can identify that.

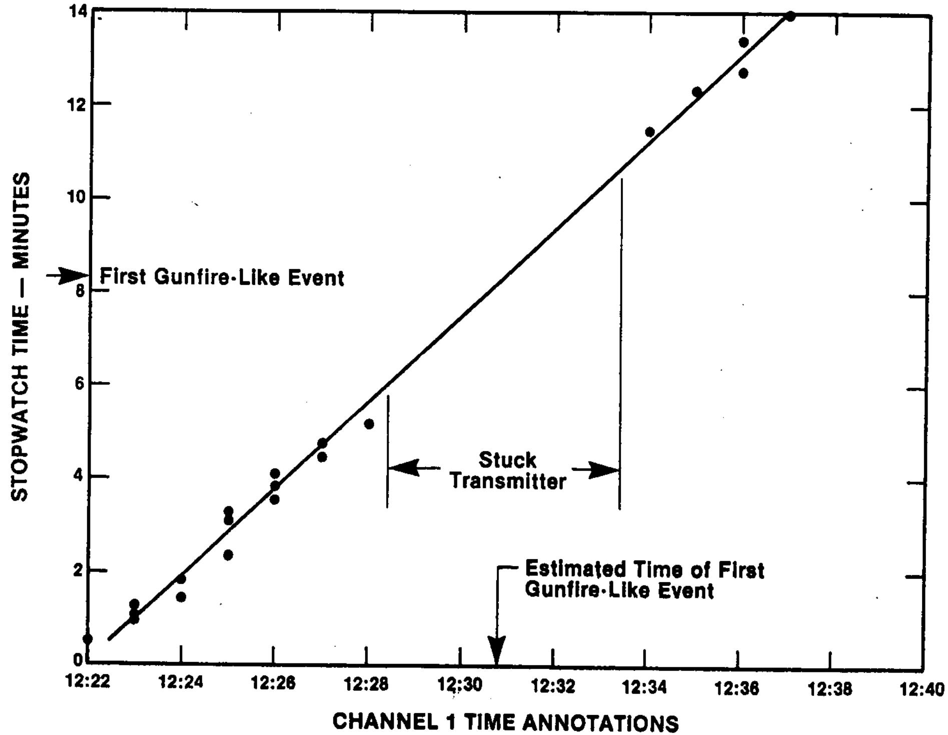
Dr. BARGER. This is the same kind of activity but conducted when listening to the sounds on the channel 1 tape.

Mr. CORNWELL. May we have JFK exhibit F-365 admitted into evidence, Mr. Chairman.

Chairman STOKES. Without objection, it may be entered into the record.

[The information follows:]

Least-Squares Fit to Channel 1 Dispatcher's Time Annotations Showing Time of First Set of Gunfire-Like Events.



JFK Exhibit F-365

Dr. BARGER. The purpose here is to determine at what time the impulsive sounds on channel 1 occurred to see if they were at the same time as the time of the assassination.

Here is the time read on the stopwatch that is observed by the dispatcher on channel 1 in the Dallas Police Department, which is a different clock than that observed by the dispatcher on channel 2. This is channel 1 dispatcher time; this is laboratory time measured with a stopwatch.

This dispatcher was more talkative and the time annotations that he gave are more numerous—for example, he gave three time annotations at the time 12:26 and so we have more data here upon which to base a time estimate, using the least squares technique.

The straight line indicates the result of that time estimate.

There is nothing audible during this 5½-minute period because mostly all you hear is motorcycle noise and so the channel 1 dispatcher made no time annotations there. However, before and after he did—and that gave us the possibility of forming the estimate for how his clock read them. We measured on the tape the time of the first impulsive sequence that we think may possibly be gunfire and we come over to our time estimate and down and find that we estimate the first impulse to have occurred at 12:30 and 47 seconds.

Now, the estimate for the time of the first impulse then is about 35 seconds after the estimate of the assassination. If both dispatchers had been looking at the same clock, I would have had to conclude that the impulses on the tape would not pass this first screening test.

In other words, the impulses occurred too late. On the other hand, each dispatcher was looking at a different clock. I have read in testimony in the Warren Commission report that the two clocks are not synchronized except once a month at the first of the month. This was the 22d. The two clocks were subsequently found by the FBI to be 1 minute off, so the variation in the times that we have discovered here is within the known accuracy of the two clocks. We have to conclude that the possibility that the impulses represent gunfire passed the first screening test; namely, that they apparently occurred at the time of the assassination.

Mr. CORNWELL. So I take it then that the question of whether the impulses occur at approximately the time the shots were fired has been answered in the affirmative using a comparison of both channel 1 and channel 2.

Dr. BARGER. That is right.

Mr. CORNWELL. You have referred, of course, throughout your testimony to the fact that it was a motorcycle which you believe had its button stuck and that, of course, according to the last exhibit and your previous testimony was a thing that caused the 5-minute gap or a continual transmission from the stuck button on channel 1. Is channel 1, however, the channel on which you would expect to find that type of motorcycle transmission?

Dr. BARGER. Channel 1 was the normal channel in use in Dallas. Channel 2 is used for special occasions such as the motorcade. In fact, the chief of police was speaking to the motorcycles at the head of the motorcade on channel 2. Some of those motorcycles near the limousine were known to have been switched to channel 2.

On the other hand, listening to the voice communications on channel 2 at times before and after 12:30, I discovered the presence of the call numbers of several motorcycle policemen in the motorcade that were on channel 1.

Mr. CORNWELL. Moving next to the second screening test that you mentioned, namely, whether the impulses were unique, I would like to ask you if you would describe what you did to determine the answer to that question.

Dr. BARGER. Yes. We examined the full 234 linear feet of the waveform representing the output of the channel 1 recording when the button was stuck to see if there were any other impulsive patterns that occurred that were similar to these that we are looking at on channel 1.

We found that there was one other sequence of impulsive events. It was dissimilar from the one we have looked at principally in that its timespan was less than 5 seconds. It occurred about a minute later than the period of impulses in question. We found no other impulsive patterns on the tape.

Mr. CORNWELL. So the answer to the second question is again in the affirmative?

Dr. BARGER. Yes.

Mr. CORNWELL. Going into test No. 3, which was the question of whether there was a timespan of at least 5 seconds, I would like to direct your attention to JFK exhibits F-336A and B.

These are exhibits that have already been admitted into evidence. Could you use them to illustrate your analysis with respect to the third test?

Dr. BARGER. The impulsive events that we felt hypothetically might represent echo patterns began at approximately 137 seconds after the stuck button commences and continue through this portion at about 147 seconds. This period of impulses, this period, this period, and this period, represent four typical segments of the tape. The span between them is 10 seconds and that is more than 5.

Mr. CORNWELL. Now, with respect to test 4, that the impulses were of approximately the correct shape, how did you go about resolving that question?

Dr. BARGER. In this case we were familiar with the shape of transient waveforms generated by rifle fire and those were shown in the second exhibit. However, we saw that those waveforms did not appear in the tape that we were analyzing.

We knew, however, that the loudness of the impulses from gunfire so near—well, anywhere in Dealey Plaza—would be so loud as to overload the radio, to exceed its capacity to transmit without distortion of the waveforms in question.

In order to test whether the Dallas radio distorted the gunfire impulses in the way, or in the approximate way, that we see in these records, Mr. Robinson found a similar Motorola FM radio in use with the MDC Police in Massachusetts. He was able to test that radio by playing sounds of the Mannlicher-Carcano rifle, as tape recorded, electrically into its microphone connection, through an electronic circuit that mimicked the electroacoustical behavior of the microphone. He then went back to the receiver at the police station and made a recording of the distorted sounds that were in fact transmitted. The next exhibit illustrates those distorted waveforms he measured.

Mr. CORNWELL. I show you JFK exhibit F-368. As you just noted, that is an exhibit which would help you illustrate the techniques you have just described, is that correct?

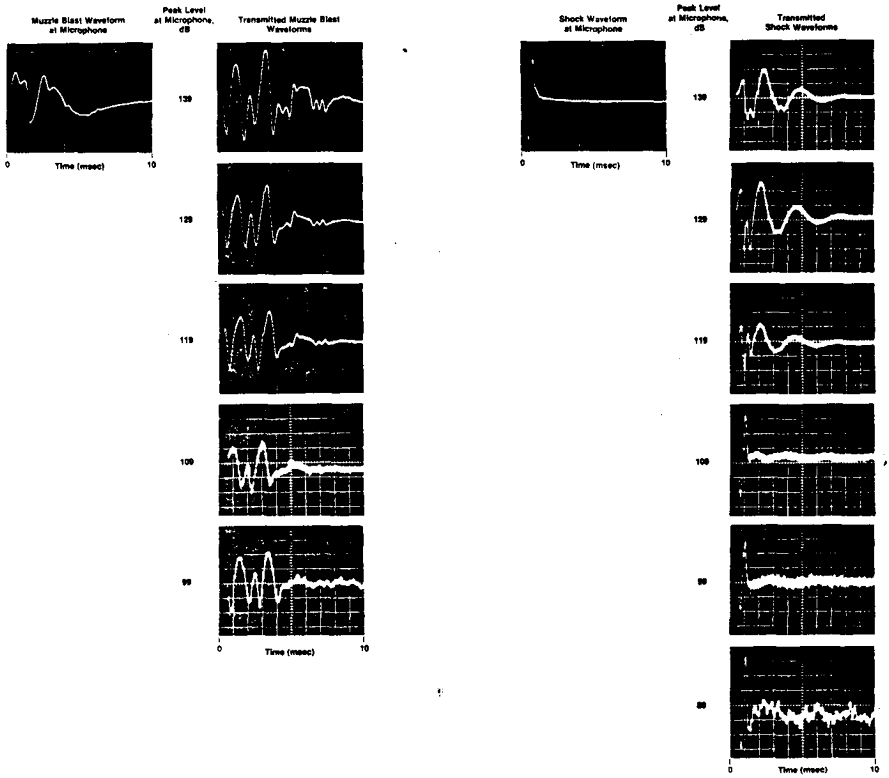
Dr. BARGER. I anticipate that that will be the one.

Mr. CORNWELL. May we have JFK exhibit F-368 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection, it may be entered into evidence at this point.

[The information follows:]

Muzzle Blast and Shock Waveforms Transmitted by a Police Radio Similar to the One Used by DPD Motorcycles for Several Different Loudnesses.



JFK EXHIBIT F-368

Dr. BARGER. This illustration shows on the left side waveforms due to muzzle blasts and on the right side waveforms generated by shock waves from the Mannlicher rifle.

In this photograph we see the waveform of a muzzle blast that was measured, with a good microphone, from a Mannlicher-Carcano. The amplitude of the muzzle blast is shown in time covering a total span on this illustration of 10 milliseconds.

In this case we have the waveform, which is that sharp N shaped waveform shown that was measured from the shock wave of a bullet from a Mannlicher-Carcano, also on a scale covering 10 milliseconds.

In this column we show the waveform transmitted by the radio to the receiver and subsequently analyzed at the receiver, as a function of the level of the loudness of the muzzle blast that was played into the radio; 139 decibels, very loud, 129, half as loud in terms of human response, 119, half again as loud, 109, half again as loud, 99, half again as loud.

We see that the relatively simple shape of the muzzle blast waveform is made more confused by the radio. It oscillates more; it lasts longer in time and its shape in fact depends on how loud it was. The radio therefore was performing nonlinear distortion and compression on these waveforms at the levels indicated.

Here the N wave coming in at 139 decibel level has a nice pristine N shaped waveform and comes out of the radio as a lower frequency oscillation. That is true even at a 10-decibel lower level, et cetera. But when you get down 30 decibels lower than this one, the radio now is capable of transmitting that waveform in an undistorted form.

Mr. CORNWELL. So we can see the basic distortion at different decibel levels.

Do I understand that the various decibel levels are shown because they would correspond perhaps to different distances that the blast might be from a receiver such as a microphone?

Dr. BARGER. We have observed that the loudness of the muzzle blast waveforms during the test reconstruction in Dallas measured at the microphones closest to the rifle were 135 decibels, virtually the same as the loudest here. The loudest sounds measured at the most distant receivers were about 20 decibels lower than that, so the range of the loudest sounds is easily covered in this investigation.

It shows that one cannot hope to identify, for example, the type of rifle fired by looking at the waveform; because the waveform that is characteristic of the rifle is severely distorted by the radio because it is too loud for the radio.

Mr. CORNWELL. I now would show you JFK exhibit F-369 and ask you if you can tell us what that is?

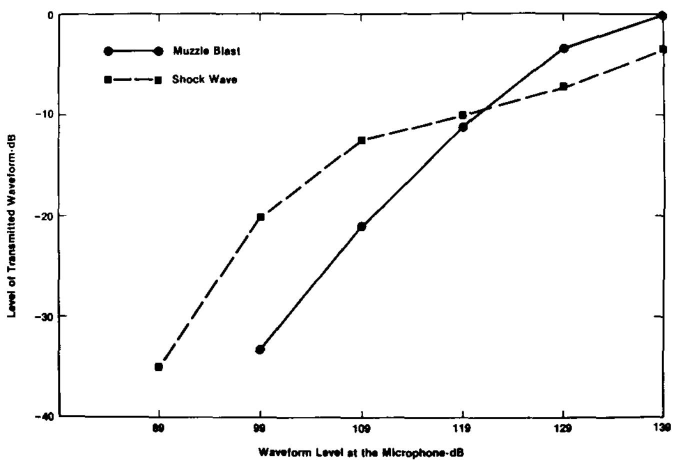
Dr. BARGER. This is a graph that quantifies, better for people who think in terms of graphs, the capacity of this radio not to accept and transmit loud sounds as efficiently as it transmits weak ones.

Mr. CORNWELL. Mr. Chairman, may we have JFK exhibit F-369 entered into the record?

Chairman STOKES. Without objection, it may be entered at this point.

41-371 O - 79 - 4 Vol. 2

Level of Transmitted Waveforms as a Function of Waveform Level at the Microphone.



JFK Exhibit F-369

Dr. Barger. Down here in decibels on this scale, increasing to the right, are the loudness of sounds introduced into the microphone. On this scale reading upwards are increasing loudnesses of sounds that are transmitted by the radio. These lines up in the region of loud sounds, where I said the levels of sounds in Dealey Plaza were, 109–139 decibels, are quite flat.

In other words, if the loudness of the signals that were actually heard in Dealey Plaza were 30 decibels in range from the loudest to the softest, then, the loudness of the sound transmitted by the radio would only differ by 10 decibels. This is described as amplitude limitation. It would indicate that all of the loud and even the softer echos in the echo patterns at Dealey Plaza would have about the same loudness on the tape that was made after transmission through the radio. It was necessary to see if the radio caused this limitation, because this removes the subjective impression of gunfire from listening to these compressed sounds.

Mr. Cornwell. Perhaps you could be seated at this point. I will ask you finally with respect to the final screening test No. 6, concerning the question of whether or not the number of impulses roughly corresponded, what did you do to answer that question?

Dr. Barger. We took a map of Dealey Plaza and calculated a rough approximation, using the mathematics of reflected, diffracted, and scattered sounds, the number of echoes that we thought would be loud enough to be audible over the noise of a motorcycle. We found there would be about 10 for a typical microphone location. Then we counted the number of impulses in each pattern of impulses that we see in the waveform records of the tape and we saw there were about 10. We realized there was still a possibility that these impulsive sounds that we saw in the record of the tape were in fact caused by gunfire.

Mr. Cornwell. At this point then you had devised six screening tests, any one of which I take it might have been sufficient to rule out these impulses as being gunshots, and they in fact passed all six tests, is that correct?

Dr. BARGER. Quite so.

Mr. CORNWELL. Now, at this point did you have any conclusions or, on the other hand, did you feel that further testing was required?

Dr. BARGER. At this point we felt we were justified in suggesting to the committee that a matched filter detection trial was warranted on the tape. As I said, the patterns that formed the basis for the match would have to be obtained by an acoustical reconstruction. The reason for suggesting the matched filter procedure for detecting the events was it is the most powerful method we know of with which to do that.

Mr. CORNWELL. How about telling us in just plain, common language what you are referring to when you say an acoustical reconstruction?

Dr. BARGER. The objective is to obtain echo patterns of the sort that I described briefly before, and the purpose for having these patterns is to become the basis of the match in the matched filter detector. In order to get these echo patterns, it was necessary to design a test that would get echo patterns that would in fact match with the events on the tape if in fact there were events on the tape that were gunfire.

Mr. CORNWELL. In other words, you suggested to the committee they go back to Dealey Plaza and fire a rifle there so you could record it and see exactly what it looked like in that urban environment?

Dr. BARGER. That is correct.

Mr. CORNWELL. Before doing so, did you seek any independent opinion or consultation on this recommendation that you had made to the committee?

Dr. BARGER. Yes, we did. I think the committee felt that it would be wise for them to obtain a second opinion on the wisdom of conducting this test, and in order to do that they obtained the agreement of professors Mark Weiss and Ernest Aschkenasy of Queens College to look at the results of our six screening tests that I just described and to look at our preliminary design for this echo pattern test or acoustical reconstruction and to form an opinion about whether they agreed with us that it was a reasonable and necessary thing to do.

Mr. CORNWELL. For the record, Mr. Chairman, Prof. Mark Weiss, whom Dr. Barger has just referred to, received a bachelor of electrical engineering degree from the City College of New York in 1952, and an M.S. in electrical engineering from Columbia in 1957. He has been a staff engineer at the Columbia University Electronics Research Laboratories and a project engineer and vice president for Acoustics Research at the Federal Scientific Corp. Currently, he is professor of computer science at the Queens College in the City University of New York. Mr. Weiss has written numerous scientific articles and technical reports. He is a fellow of the Acoustical Society of America and a member of the Institute of Electrical and Electronics Engineering. Mr. Weiss served on a panel of experts appointed to examine the Nixon-Watergate tape recordings during the grand jury investigation.

The other individual Dr. Barger just referred to, Ernest Aschkenasy, received a bachelor of electrical engineering degree in 1967 and a master of electrical engineering degree in 1972, both from the City College of New York. He has been involved in the analysis and enhancement of acoustic signals for over 10 years and was an associate professor with Professor Weiss in the examination of the White House tape recording in 1974. He is currently a senior research associate in the Department of Computer Science of Queens College.

Did Professor Weiss and Mr. Aschkenasy agree that testing in Dealey Plaza was a necessary and proper thing to do?

Dr. BARGER. Yes.

Mr. CORNWELL. After consultation with the authorities of Dallas, Tex., the committee, of course, ultimately agreed that you should conduct the testing. What problems did you focus upon at this point in time that you would face in designing and conducting a valid test?

Dr. BARGER. If I may just make a comment before I answer that question, I remember something I was going to say before, that I forgot.

In fact, I did not supervise the Judge Sirica panel that examined the tape recordings that President Nixon had made. Dr. Richard Bolt, of B.B. & N., did that. I happened to have been director of one of the divisions of the company in which some of that work was done.

Now I remember your question, so I can answer it.

The first problem that had to be solved in designing the test was the fact that we didn't know where the motorcycle was, if, in fact, it was there at all. The second problem was, although we had evidence about the type of rifle used that was fired from the Texas School Book Depository, we had no evidence about the alleged weapon that might have been on the knoll. For example, we didn't even know whether it was a rifle or a pistol. The allegation didn't include that information.

We had to consider, also, where to put the targets at which to fire the bullets. As I have explained, the pattern of the N wave shed from the bullet is distinct, so the echo pattern at any one point depends upon the direction in which the rifle is pointing, as well as the place where it is fired from. So we need to decide where, in fact, to fire the bullets. There was evidence the bullets, of course, had hit the limousine, the occupants in the limousine. There was evidence that a bullet had struck the curb on Main Street, down by the triple underpass, and there are the other indications by the presence of the impulses in the tape that there may have been a shot fired up near the corner of Houston and Elm, so we used those results to place the targets.

The next problem we had to figure out was what ammunition to use; since the N waves are important. You have to have the muzzle velocity correct, and we needed to find ammunition that had a nearly similar muzzle velocity to that used by Oswald, or alleged to have been used by him.

We had to consider as a matter of practical significance the amount of time it would take to conduct the acoustical reconstruction. Requiring live ammunition as it did, of course people had to be excluded from the area, and that can only be done for a short period of time. We had also to accommodate the listening tests that were conducted by Dr. Green, and which he will describe later.

Mr. CORNWELL. I would like to show you now JFK exhibit F-337. I would ask you if you could use that exhibit to illustrate how you solved some of the various problems in setting up the test you have just mentioned.

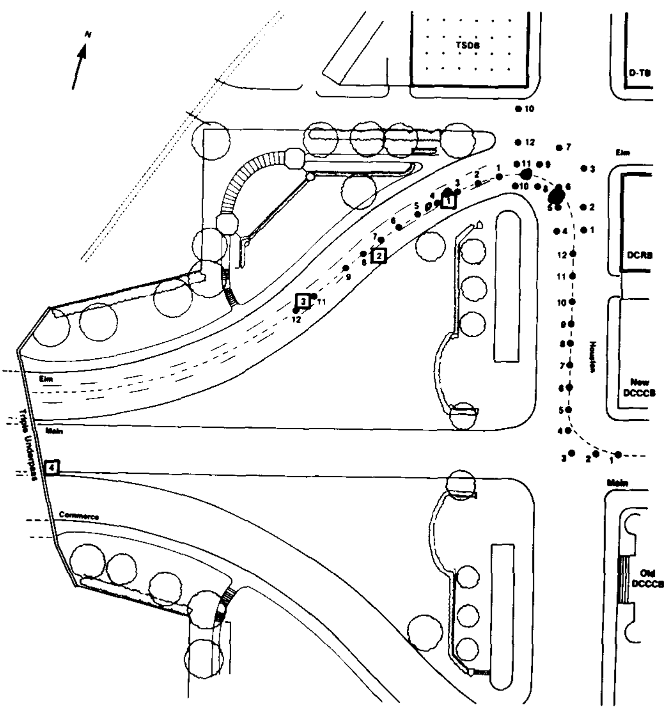
Dr. BARGER. Yes. This exhibit illustrates the positions of the microphones, the targets and everything else.

Mr. CORNWELL. Mr. Chairman, may we admit into evidence at this time JFK exhibit F-337?

Chairman STOKES. Without objection, it may be entered into the record at this point.

[The information follows:]

Microphone Locations at Dealey Plaza



JFK EXHIBIT F-337

Dr. BARGER. We positioned 12 microphones, as an array of microphones, in each of three positions: This group of 12; this group of 12; and this group of 12. The objective here was to cover all of the positions where the motorcycle may have been, and still expect to hear the sounds of gunfire in a dense enough way so that the echo patterns received on adjacent microphones would not be so different that no match could ever be achieved should the motorcycle have been halfway between two of them.

The target locations that we selected, based on the evidence that I cited earlier, were here, No. 4; here is Zapruder frame location 313, target 3 at this point; and target 1 there.

Rifles were fired from here [indicating the T.S.B.D.], as evidence indicates it was. A rifle and a pistol were fired from here [indicating the grassy knoll], as allegations have indicated there may have been.

Mr. CORNWELL. OK, when you say "from here and from here," simply for the record, you were pointing at that point to the Texas Schoolbook Depository as being where a rifle was fired from and the grassy knoll where both a pistol and a rifle were fired.

Dr. BARGER. That is correct.

Mr. CORNWELL. I would like to ask you now to look at JFK exhibit F-344 and tell us what this shows.

Dr. BARGER. This simply shows the sequence of shots executed for each microphone array position in turn.

Mr. CORNWELL. May we have JFK exhibit F-344 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection, it may be entered into the evidence.

[The information follows:]

SEQUENCE OF SHOTS

Array 1

	No. 1	No. 2	No. 3	No. 4
TSBD (Muzzle in plane of window)	1	3	6	10
TSBD (Muzzle 2 feet inside plane of window)	2	4	7	11
Knoll (Rifle)		5	8	12
Knoll (Pistol)			9	

JFK EXHIBIT F-344

Dr. BARGER. Here are shown the four target locations. The first rifle position was in the depository, with the muzzle of the rifle in the plane of the window.

Here the rifle was in the same position, but the muzzle was withdrawn 2 feet from the plane of the window. This was done because we had no clear evidence about where the muzzle, in fact, was relative to the plane of the window, and that small difference makes a noticeable difference in the loudness of the muzzle blast as perceived in the plaza.

The third location was from the knoll, firing with the rifle. The fourth was from the knoll firing with the pistol.

The shot numbers here indicate the sequence in which the shots were fired and the absence of any number in any place indicates there was no corresponding shot fired.

Mr. CORNWELL. Now, the numbers across the top where it says "No. 1, No. 2, No. 3," what does those correspond to?

Dr. BARGER. These correspond to the numbers of the targets, 1, 2, 3, 4, that were fired at.

Mr. CORNWELL. And the rifles which were used both from the window and from the grassy knoll were of what type?

Dr. BARGER. I am sorry; I missed that.

Mr. CORNWELL. The rifles which were used both from the Texas Schoolbook Depository and from the knoll were of what type?

Dr. BARGER. They were both of the Mannlicher Carcano type.

Mr. CORNWELL. And the pistol was of what type?

Dr. BARGER. It was a 38-caliber pistol, of what manufacture I don't remember.

Mr. CORNWELL. But the pistol would have been a subsonic weapon, is that correct?

Dr. BARGER. It was chosen to have a subsonic missile; that is correct.

Mr. CORNWELL. Then, if we were to read JFK exhibits F-344 and F-337 together, would it be accurate to state that the sequence of shots in each array was pursued in numerical sequence for each array of microphones indicated on the plot of the plaza.

Dr. BARGER. That is correct. The sequence indicated here was fired three times in repetition, once for each array location and each time ammunition of Norma manufacture was fired. The shot sequence was then repeated a fourth time when our recording equipment was recording the microphones in the third position, with Western Cartridge Co. ammunition. This type of ammunition was of the same sort thought to have been used by Oswald.

Mr. CORNWELL. Why were the first 3 arrays of 12 shots—actually, 11 shots with a rifle; 1 with a pistol—why were they fired with Norma ammunition instead of Western Cartridge Co.?

Dr. BARGER. I understand that the Western Cartridge Co. ammunition of this type is no longer manufactured and is hard to obtain, and the committee could only get enough to fire through the sequence once; so Norma was used the rest of the time.

Mr. CORNWELL. So at least the results could be compared to see if there was any substantial difference between Norma and Western Cartridge Co.

Dr. BARGER. That is correct.

Mr. CORNWELL. Now, I would like to direct your attention to JFK exhibits F-339, F-340, F-341, and F-342.

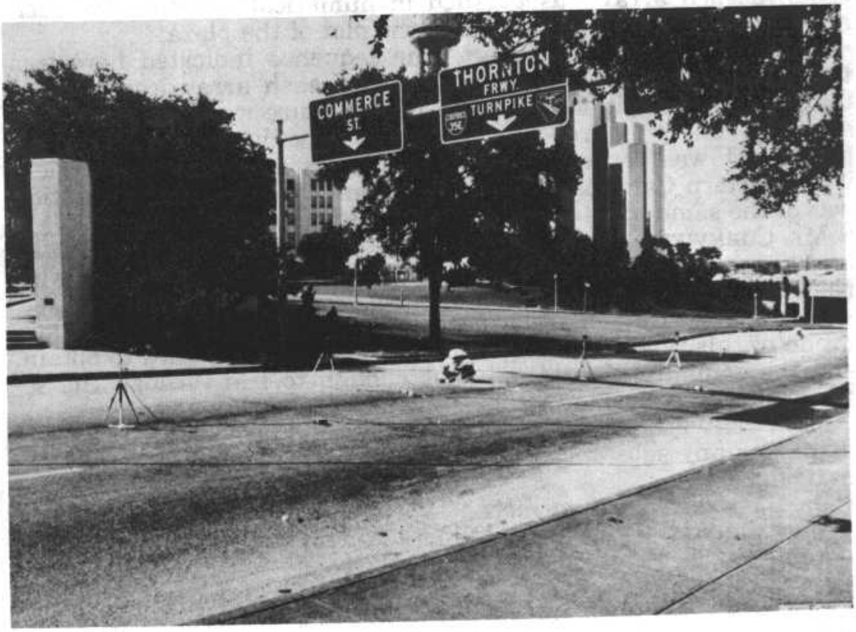
Dr. BARGER. These are photographs that were taken during the period when we were setting up the acoustical reconstruction in Dallas.

Mr. CORNWELL. May we have these four exhibits admitted into evidence, Mr. Chairman?

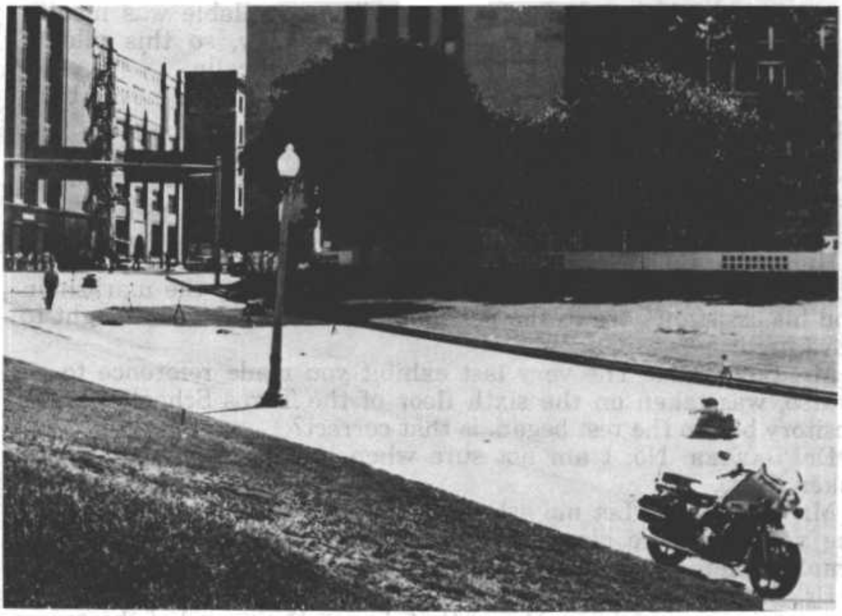
Chairman STOKES. Without objection, they may be entered into evidence.

[The information follows:]

JFK Exhibit F-339



JFK Exhibit F-340



JFK EXHIBIT F-341

JFK EXHIBIT F-342

Dr. BARGER. This one shows a portion of Houston Street, and all of Elm Street. The yellow x's on the street correspond to the position of the black dots on the previous exhibit and were where the microphones were placed. These sandbags that are observable here, barely observable here and there, are the first three of the four targets. The total number of sandbags available was insufficient to set up a fourth target simultaneously, so this pile of sandbags was transported to that location periodically.

Mr. CORNWELL. So the sandbag targets 3 and 4 were moved back and forth, and you pointed to the place.

Dr. BARGER. That is right. This photograph simply shows a ground level view of the microphones used to record the sounds at array position 3, and the sandbags with sand leaking out of them. So the experiment was problably over by that time.

Here is a photograph from the knoll, looking up at the microphones in array position 3, and the sandbags. Here the marksman and his assistants are in the position where Oswald was thought to have fired.

Mr. CORNWELL. The very last exhibit you made reference to, of course, was taken on the sixth floor of the Texas Schoolbook Depository before the test began, is that correct?

Dr. BARGER. No; I am not sure when it was taken, but it was taken there.

Mr. CORNWELL. Let me ask you this. At least during the testing the windows were closed down to the way they were in photographs taken about the time of the assassination, is that correct?

Dr. BARGER. That is a question I can testify about. It was known from the photographic evidence that during the period of the assassination the windows in the sixth floor were down with the exception of this one through which Oswald is thought to have fired, and it was half-way down. It was important to the accuracy of the reconstruction that all those windows be in that position exactly during the shots, and they were. However, it was a hot day, and the people in this room opened the windows between shots to air themselves out.

Mr. CORNWELL. I now show you JFK exhibits F–358 and F–359.

Dr. BARGER. These appear to be aerial photographs of Dealey Plaza that would be quite recent, because they include several structures that were not there in 1963.

Mr. CORNWELL. May we have those admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection, they may be entered into evidence.

[The information follows:]

JFK Exhibit F-358

JFK Exhibit F-359

Mr. Cornwell. There is simply one part of those exhibits I would like to direct your attention to, Dr. Barger, and that is the very large new hotel structure which would appear somewhat to the south of the plaza. Would you tell us whether or not that, of course, was there the day that you did the testing?

Dr. BARGER. The echo patterns that we expected to receive and did, in fact, receive had a maximum time span of 1 second. There were other echoes that came in at later times that were very weak, so weak that they were not considered in any of the matches and could not have been represented on the DPD tape because they were so weak relative to the loud echoes.

So, the only echo patterns we ever needed or used were never longer than 1 second. The time required for sound to travel from the depository to that structure and back is a little more than 3 seconds. Since the interval between each test shot was much more than 3 seconds, the echoes from that remote structure had no effect on the matching process whatsoever.

Mr. CORNWELL. You then have indicated that the large structure was present on the day you did the testing. It would not have been present, I take it, in 1963, but, nevertheless, it was so far removed from the plaza, that it would not have affected in any manner the results of the test.

Dr. BARGER. That is correct. It did not. Its echo came in much later than any of the echoes on the echo patterns that we used.

Mr. CORNWELL. What did you obtain from the testing?

Dr. BARGER. As a result of the four sequences of 12-shot firings, we had 432 different test shot recordings on magnetic tape.

Mr. CORNWELL. Were they of the quality that you had hoped? Did the equipment function properly, et cetera?

Dr. BARGER. We monitored the recorded signals at the time that they were recorded to see if they were noise free and to see if they used the entire dynamic range of the recording system. In other words, to see that they were being recorded with the highest fidelity possible. We observed for each of those records that we had achieved that. We did no other analysis of the records at that time.

Mr. CORNWELL. I would like to now show you JFK exhibit F-338.

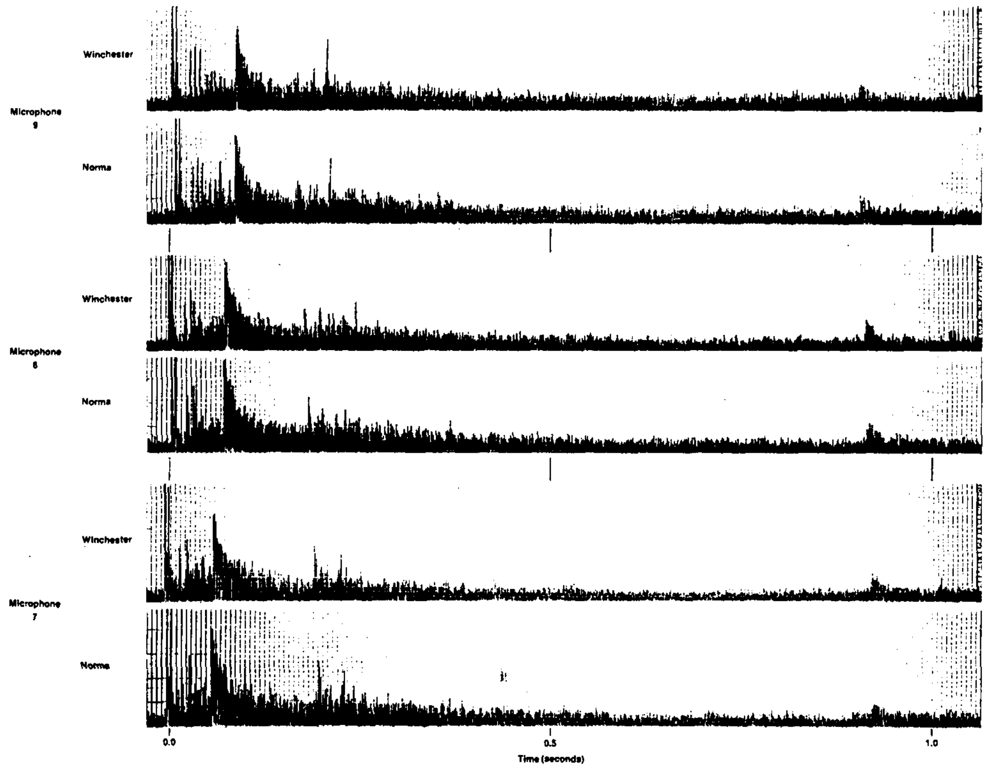
Dr. BARGER. This exhibit is an illustration of the test patterns, and it shows six of them.

Mr. CORNWELL. May we have JFK exhibit F-338 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection.

[The information follows:]

Comparison of Test Echo Patterns Produced by both Winchester and Norma Ammunition Fired from TSDB (Muzzle Withdrawn) at Target No. 3 and Received at Array 3, Microphones 7, 8, and 9.



JFK Exhibit F-338

Dr. BARGER. Here we show six echo patterns in alternate array. They were generated by Western Cartridge Co. ammunition, which is somewhat incorrectly labeled here as Winchester ammunition, and then Norma for test shots fired from the depository with the muzzle 2 feet behind the plane of the window fired at target No. 3, received on microphones 7, 8, and 9 in array 3, namely, halfway down Elm Street. Time is plotted on the horizontal scale.

From here to here we have the total time span of 1 second. We have the intensity of sound in decibels plotted on the vertical scale in each of the six graphs. We see initially a very loud pair of impulses; if you look very closely, you see there are two of those. The first of those is the shock wave of the bullet passing overhead. The second of those is the reflection of the shock wave from the street just below the microphone. Then there are three rather distinct echoes and several others here that you can see if your eyes are very good.

This type of graphical data is on an ultraviolet recording, which is hard to photograph, but here is the arrival of the muzzle blast. It comes later than the arrival of the shock wave because the bullet is supersonic. Here is an echo in this case from the Records Building, and here almost nine-tenths of a second later is the echo from the Post Office Annex which is across Dealey Plaza.

Now when you repeat that shot in every way except using Norma ammunition instead of Winchester, you see the same pattern. If you look at it in great detail, you find that the spacing between the shock wave and the muzzle blast using the Western ammunition versus that with the Norma is 5 percent greater. In other words, the bullet is 5 percent faster, giving a shock wave that occurs 5 percent sooner than the muzzle blast.

That is an inconsequential time difference to the matching process, and is certainly not evident when looking at these records just with the eye.

The similarity between these pairs of patterns, which differ only in the types of ammunition that were used, is very great, thereby establishing that the substitution of Norma ammunition for Western was an acceptable one.

As one looks down farther in the street, one sees that these patterns change somewhat. For example, the strength of the Post Office Annex echo is a little bit larger at microphone 8 than it is at microphone 7, as an example.

Mr. CORNWELL. Then, after determining that your test had gone well, that you got the type of data you were looking for, and that there was no substantial differences that would affect the validity of the test, depending on whether you used Norma or Western ammunition, what did you do next?

Dr. BARGER. The next project then was to begin the comparison of the test patterns with the impulse patterns on the police tape. Let me describe the process of doing this now.

We first divided the motorcycle tape into segments, each containing at least one of those patterns of impulses that we were testing for the possibility that they were caused by gunfire.

We then matched each of these 432 echo patterns that are exemplified by that exhibit with each of those 6 segments of the tape. Those six segments that we analyzed comprised the entire part of the record of the Dallas police tape that passed the six screening tests that I decribed.

The procedure for conducting this match is a mathematical one, and it is known as a correlation. The type of correlation that we used is a binary correlation, and this is a description of a fairly simple process, which I will now attempt to make entirely clear.

The echo patterns were each examined to find the loudest echoes thereon, some patterns had only 5, others as many as 17. Any one echo that was loud enough to exceed the threshold of audibility was accepted.

Then each of the six segments of the tape were examined, after having presented them in the same way, loudness in decibels on the vertical scale, and time on the horizontal scale. Those records were initially made at a horizontal scale of 16 inches equal to 1 second.

Once those six segments of the tape had been thus prepared, they were similarly thresholded, and I will illustrate this more graphically in a minute, to determine all of the impulses on each that exceeded a threshold. They were then numbered, and their location in time was noted.

Now the design of the test included the feature that each microphone was 18 feet from the next. It is possible that the motorcycle at any time was halfway between two microphones, so a microphone could at worst be 9 feet from the motorcycle if in fact there was a motorcycle present. That means that there is at least a 9-foot uncertainty in the location of the microphone with respect to where the motorcycle may have been at each time that we are examining.

This was accommodated in our procedure by adding an uncertainty window 6 milliseconds on either side of each impulse found in the Dallas tape. In other words, each impulse was considered to be 12 milliseconds wide, so as to include any echo received by a motorcycle that had been in fact anywhere it could have been with respect to the nearest microphone.

Having prepared the echo pattern and the impulse pattern from the tape in that way, the correlation was performed as follows: Each of the echo patterns were compared to all impulse patterns on the tape for a total of about 2,600 possible correlations. The correlation coefficient was calculated for each match, and this coefficient was calculated as follows:

The number of coincidences between impulses and echoes was the numerator, and the denominator was the square root of the product of the number of echoes by the number of impulses. If two patterns perfectly matched in this way, the cross-correlation coefficient that you obtained would be equal to unity. If they only matched at one point and at no other, it would be 0.1 or less. The bigger the value of the correlation coefficient, the better the match.

Mr. CORNWELL. The closer, in other words, that the number, which would be in percentages, point something, approaches one, the better the match?

Dr. BARGER. That is correct. That was the procedure.

Now once that was done, we had a big pail full of 2,600 numbers, and we exhibited to ourselves then for the first time on the blackboard all of those numbers that were larger than a threshold value, which was set at 0.6. I will describe the reason for that in a moment.

From this time on, I will mostly talk about those matches that exceeded a correlation coefficient of 0.6.

Mr. CORNWELL. I would like to show you JFK exhibit F-347, and ask you if you would tell us what that is.

Dr. BARGER. This illustrates two types of data. Here are three test patterns. These three test patterns were generated by a shot from the depository with the muzzle 2 feet behind the plane of the window and fired at the target No. 1, which was located just at the head of Elm Street in a position previously described, and it was received by microphones 4, 5, and 6 in the second array position.

Those microphones were on Houston near Elm, and we see in each of these that the first sound that arrived was the muzzle blast. There is no shock wave that precedes the muzzle blast, and that is to be expected because in this case the shot is fired in this direction, and the microphone is over here, and according to the first exhibit I showed, the shock wave would not be seen 90° laterally.

As you look at the arrival of the muzzle blast, you see that in each channel it occurs progressively later in time, so that if you connect the peaks, they slant. This is because channel 4 microphone is farther away from the rifle than is the channel 5 and channel 6 microphone. However, if you look at these peaks out here near one second, these are the echoes from the Post Office Annex.

As the microphone moves away from the location of the rifle, it is moving toward the Post Office Annex. Therefore, the echo in fact comes in sooner, so when you connect the dots signifying each of those echoes, they have a slope in this direction.

One selects all of the significant impulses on these test patterns. We have placed dots on them. Some of the dots are obscured in these dark areas where the photographer has overexposed them, but nevertheless, they are there. We have connected all of those that we think are caused by the same echo-generating device by lines, to show how the time that that echo arrives is changing continuously as you move the position of the receiver.

Up here is shown a portion, a segment, of the Dallas police tape that was also prepared at the same time scale, 16 inches equals a second with intensity vertical on the scale in decibels. The threshold has been made, and all of those impulses that exceeded have been identified and numbered, and the plus or minus 6 milliseconds acceptance regions have been marked, these to accommodate the uncertainty of the exact position of the motorcycle.

I am prepared to show how this echo pattern matches the test pattern—and I knew I would probably forget which one it is that matches with it, but it is quite evident. If you tried to match this pattern with this shot, the significant impulses at this point would not in fact match with the significant impulses in this pattern, even though with this setting the echo from the Post Office Annex does.

However, if you match it with the test impulse obtained at channel 5, which is a different place, then they match quite admirably in fact. If you count the dots signifying significant echoes in the echo pattern with the marks signifying the significant impulses in the Dallas tape, you find there are 12 matches out of 17 possible impulses, and if you count these, 15 possible echoes. The cross-correlation coefficient for that match is 0.75, above our threshold value of 0.6.

Mr. CORNWELL. Given the amount of noise in the Dallas Police Department tape, would you expect that you would ever get a complete match, all 17 out of 17 in this case?

Dr. BARGER. Many of the impulses on the tape, on the Dallas police tape, this segment of it in particular, that correspond to the total number that were above the threshold value of 17 are caused undoubtedly by nonacoustical events. Examples are the key transients that I described when I was showing the results of the spectrographic analysis.

However, none of those impulses in this particular segment of the tape have been conclusively identified as being any of those. The noise from whatever its origin that is present in the police recording tape, there is demonstrably noise there, in addition to any impulses that may be caused by gunfire, those would rise up and compete with the impulses caused by gunfire and reduce the value of the correlation coefficient to some number less than one.

Mr. CORNWELL. So in spite of the fact that the correlation coefficient was not one, the match was not perfect, your words were that this was a quite adequate match. In other words, it had a correlation coefficient which approximated one; is that correct?

Dr. BARGER. Well, it was not possible to reach that judgment by looking at one alone. We looked at 2,600 of them, and reached our conclusions from that. This was to illustrate just one.

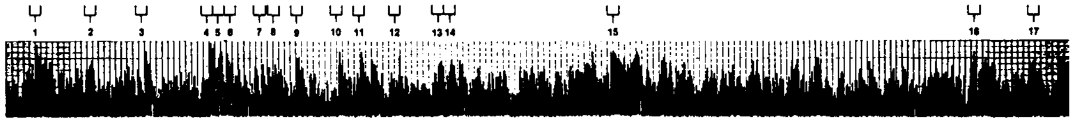
Mr. CORNWELL. Now I believe, Mr. Chairman, we forgot to ask that that last exhibit be admitted into evidence. May we do so at this time?

Chairman STOKES. Without objection, it may be entered into the evidence at this time.

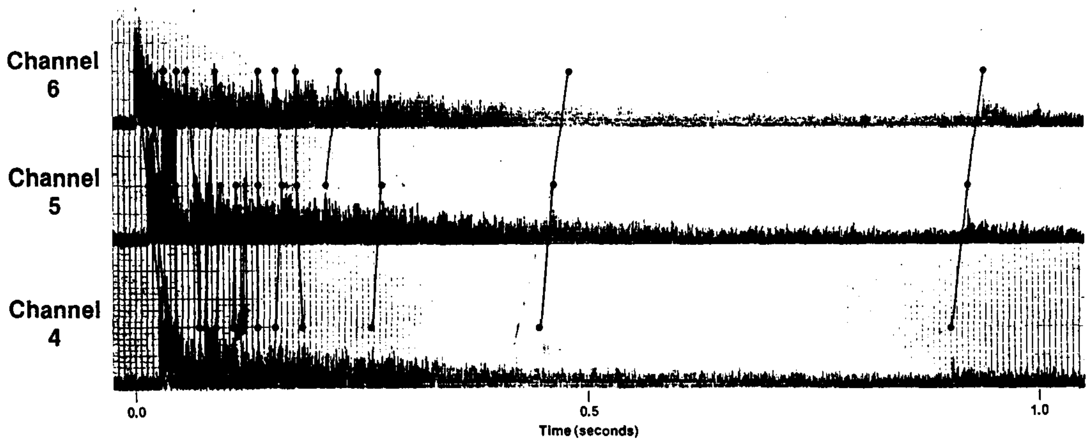
[The information follows:]

41-371 O - 79 - 5 Vol. 2

Test Pattern for Shot 2 (TSBD, Muzzle Withdrawn, Target No. 1) Received at Array 2, Microphones 4, 5, and 6.



Echo Pattern from Stuck-Transmitter Recording, Beginning at Time 137 Seconds.



JFK Exhibit F-347

Mr. CORNWELL. I would now like to direct your attention to JFK exhibit F-367, and for your assistance ask that F-337 and F-344 be placed up there simultaneously.

Dr. BARGER. Yes. This one and this one have been introduced as evidence. This is new.

Mr. CORNWELL. Would you tell us what F-367 is?

Dr. BARGER. It is a list of those 15 matches that—of the 2,600 approximate matches we attempted—that did in fact exhibit a correlation coefficient higher than 0.6.

Mr. CORNWELL. May we have JFK exhibit F-367 admitted into evidence, Mr. Chairman?

Chairman STOKES. Without objection, it may be entered into the evidence.

[The information follows:]

List of All 15 Correlations Between Impulse Patterns Occurring in 6 Segments of the DPD Record and Echo Patterns from 432 Test Shots (2592 Separate Correlations) Having a Correlation Coefficient Higher than 0.5

Beginning Time of First Impulse on Tape Segment	Microphone Array and (Channel Number)	Rifle Location	Target Location	Correlation Coefficient**
136.20 sec	No Correlations Higher Than			0.5
137.70 sec	2 (5)	TSBD*	1	0.8
"	2 (5)	TSBD*	3	0.7
"	2 (6)	TSBD	3	0.8
"	2 (6)	KNOLL	4	0.7
139.27 sec	2 (6)	TSBD*	3	0.8
"	2 (6)	TSBD	3	0.6
"	2 (10)	TSBD	3	0.6
140.32 sec	2 (11)	TSBD*	3	0.6
139.27 sec	3 (5)	KNOLL	2	0.6
145.15 sec	3 (4)	KNOLL	3	0.8
"	3 (7)	TSBD*	2	0.7
"	3 (8)	TSBD	3	0.7
145.61 sec	3 (5)	TSBD	3	0.8
"	3 (6)	TSBD	4	0.8
"	3 (8)	TSBD*	2	0.7
146.30 sec	No Correlations Higher Than			0.5

*Indicates Muzzle Withdrawn 2 ft from Plane of Window.

$$\text{**Correlation Coefficient} = \frac{\text{Number of Echoes Matched with Impulses}}{\sqrt{\text{Number of Echoes X Number of Impulses}}} \leq 1.0$$

JFK EXHIBIT F-367

Dr. BARGER. Very well. There are 15 descriptors here. Each one describes a case where an acoustical test pattern matched better than the threshold value of 0.6 with a segment of the Dallas tape.

The first situation where this occurred I will label with blue. There were four test patterns that corresponded with the segment of the tape that began at 137.7 seconds after the stuck button, with coefficient, correlation coefficient, larger than 0.6, and these are the four. I will note with a 1 that that is the first time in the tape that any of the test patterns correlated with any of the impulse patterns in the police tape with a score better than 0.6, and it occurred four times.

Mr. CORNWELL. So at that point you are telling us that there is a segment of the Dallas police tape which very closely approximates or at least has a correlation coefficient of over 0.6 with respect to the various test shots?

Dr. BARGER. Yes. This section may contain the sound of gunfire. Then going on down in the list, we have what I will label the second time, the second place on the Dallas tape where correlations or matches were achieved that were good enough to exceed the threshold value, and I will label that with red brackets to highlight it, and there were five of them.

Then in the same way at a later time, around 145.15 seconds, in green, I will label and highlight the three test shot patterns that correlated with that part of the tape better than 0.6, and, finally, at 145 seconds—yellow is not the best, is it—well, the fourth part of the tape at 145.61 seconds had three different test patterns that achieved the correlation score greater than 0.6.

Let me rummage through my briefcase and see if I can find another color. Black is the obvious choice.

Now a feature of a detection by a receiver that was designed to detect the possibility of otherwise subaudible events by using the threshold correlation procedure is that it can give threshold exceedences, the threshold having been 0.6, under two circumstances. One, it exceeds the threshold when it has correctly detected the event, and the other is, it exceeds the threshold when it has incorrectly detected the event. The latter circumstance is called a false alarm. [Laughter.]

It is the purpose of the rest of my testimony now to examine the question: Which, if any, are false alarms?

Mr. CORNWELL. Before you do that, I take it that you took each of the four segments of the Dallas Police Department tape, which you have indicated with the numbers 1, 2, 3, and 4, and compared them with all of the test patterns, and what you have simply illustrated on the chart is a match very similar to the one that you showed us physically how you performed earlier with respect to a shot in the first time frame. Is that correct?

Dr. BARGER. That is correct.

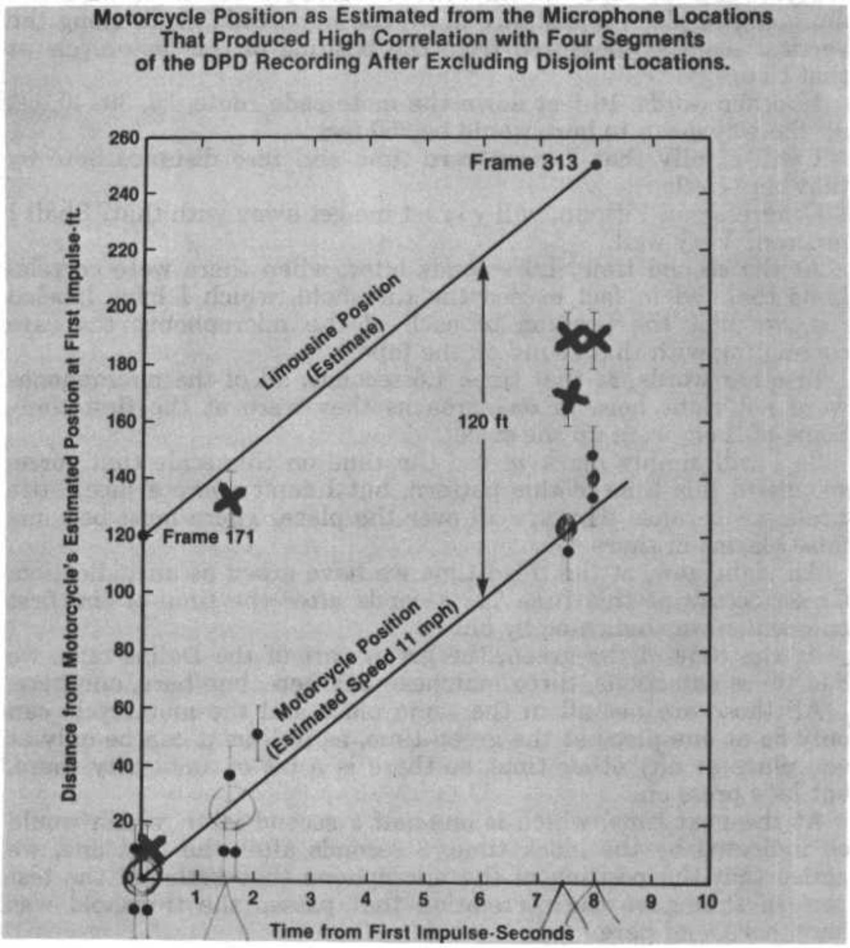
Mr. CORNWELL. Then would you use the exhibits which are presently in place and tell us what that means in terms of the other diagrams as to the location of the microphones and the direction and location of the shots.

Dr. BARGER. I can say a few preliminary things about that with these exhibits, a few preliminary things. The results suggest that there are detections at four different times of day.

If the motorcycle were in Dealey Plaza, it would only be at one place at each of those times of day and would either be standing still or moving in some reasonable pattern.

The correlations achieved, or the matches achieved, at the first time when any matches were achieved are either at microphone 5 or 6 in the second-array position. There are four correlations there, so that at this time on the tape, we would tentatively estimate that the motorcycle was there.

Mr. CORNWELL. Let me show you at this point then JFK exhibit F-370, and ask you if you would tell us what that is. Could we put the two exhibits, the latest one, F-370, over next to the——



JFK EXHIBIT F-370

Dr. BARGER. This would best be in this position I think, thank you. We want to examine now the meaning of these detections that passed the threshold level to see if there is any reason to believe that they are not all false alarms, possibly. I will attempt it in this way.

The first time all day that we saw any matches was at this time which I have labeled in blue, and, the indication is internally fairly consistent, and it indicates that the location of the microphone at that time is between microphones 5 and 6.

So I put a blue dot there because that location was derived from the matches made at the first time of day at which any matches were made, and then I will begin to construct a plot.

It would be best if I could draw this for you if you didn't see what is already on there before I start, but if you will attempt to follow the pointer, I am going to plot here time of day with zero representing the time that this first occurrence was observed, and I am going to plot the distance down the motorcade route along the vertical scale as measured from the position of the motorcycle at that time.

In other words, 10 feet down the motorcade route, 20, 30, 40, 50, all the way down to here would be 250 feet.

I will signify that I mean zero time and zero distance here by that blue circle.

Congressman Fithian, will you let me get away with that? Shall I proceed? Very well.

At the second time, 1.6 seconds later, when there were correlations that did in fact exceed the threshold, which I have labeled red, we plot the position of each of the microphones that are correlating with that sound on the tape.

In other words, at that time, 1.6 seconds, all of the microphones were not right here in one area as they were at the first time. Some of them were up the street.

So I will simply mark in red the time on this scale that corresponds to this time of this pattern, but I can't make a nice, little circle yet because they are all over the place. There must be some false alarms in there.

All right now, at the third time we have green as an indication. Green occurs at this time 7½ seconds after the time of the first one, which was indicated by blue.

At the time of the green, the green part of the Dallas tape, we had three detections, three matches—one here, one here, one here.

All those are not all in the same place and the motorcycle can only be at one place at the green time, as well as it can be only at one place at any other time, so there is a bit of ambiguity there, but let's press on.

At the next time, which is one-half a second later, which would be indicated by the black time, 8 seconds after the first one, we notice that the position of the microphone that gathered the test pattern that gave the correlation that passed the threshold was here, here, and here.

All right, now I have explained where those 15 dots came from. Those 15 dots represent these 15 correlations that passed the threshold of 0.6, and they are illustrated as a function of the time when they occurred and the position down the street where the microphone was that picked up the test pattern that gave the correlations.

Mr. CORNWELL. May we have JFK exhibit F-370 entered into the record?

Chairman STOKES. Without objection, so ordered.

Dr. BARGER. Now, we look at these and immediately see the motorcycle can't be at all these places, but there is a high degree of order in this diagram.

The negative hypothesis would be that the motorcycle was not in Dealey Plaza. If that were true, then this scale that describes the distance down the street of the motorcade would be meaningless in the data, and the data would occur in time and in distance down the street at random.

But the eye can see that they tend to follow a sloping line. It can particularly see that because of these prior lines that I drew in.

There is a lot of order in the occurrence of these 15 correlations.

Now, how much order? Well, if one segments the position of microphones along the street into four bins, or four compartments, and segments the time at which they occurred into the four compartments that are naturally the four compartments into which the data are segmented, then one can question what is the likelihood that this ordered pattern could have occurred by chance. In other words, was it likely this pattern would have occurred if the motorcycle wasn't there.

There is a test for that sort of thing, and it is called the Chi square test. If you segment the data into four times and four places, as I have done, it is a test done with nine degrees of freedom. The Chi squared, value, which is a measure of orderliness, is 17½. For those of you that have tables of the Chi square distribution, the meaning of that number is this much order would occur only 5 times out of 100 if this was caused by chance.

In other words, if the motorcycle was not there and so the data were distributed at random, there is only a 5-percent chance that that would have occurred. This much order in the data suggests there is a 95-percent likelihood that the motorcycle was moving in the motorcade.

That is just about at the level of statistical significance that gives a person confidence that there are correct detections in the data. On the other hand, there are demonstrably also false alarms.

This can be seen by observing that if some of those correlations, in fact, indicate the position of the motorcycle, then some of them must be wrong because the motorcycle can't be in two places at once.

Mr. Cornwell, I could proceed with what I am doing now or we could put up those other three. I think it might be easier if I proceed.

Mr. CORNWELL. Go right ahead and proceed.

Dr. BARGER. It is now the task of the committee and me to try to identify the best we can which of these detections are false alarms and which ones are not. We have a good deal of confidence that many of them are not.

Now, in order that the motorcycle could achieve this position 130 feet down the street from the blue position in the 1.6 seconds, it would have to go 55 miles an hour.

There is no evidence to indicate that it did that, and so this particular detection is labeled a false alarm. It couldn't be true. It leaked through because we lowered our threshold of detection to the point where we had enough correlations so we could be reasonably certain that the true answers would emerge. We wouldn't want to shut them out.

Now, if you assume that the trajectory of the motorcycle is from the blue position, at which we can be reasonably confident, through these, the slope of that line is 11 miles an hour. That is approximately the speed of the motorcade.

If one said, perhaps these are false alarms and that is the correct trajectory of the motorcycle, in that case the motorcycle would be going 18 miles an hour approximately. It would be going from behind the limousine—I mean, 120 feet behind the limousine and drawing close to it. I had better explain what I mean by that right now.

If we assume that one of these last two occurrences represents the so-called head shot, then we know at that time where the limousine was. It was at frame 313. Frame 313 is 250 feet down the street from the blue dot, so 250 feet at that time of occurrence is here, so this must be where the limousine was at that time.

It was going at about 11 miles an hour as determined by photographic evidence. If one plots back at 11 miles an hour, one finds at the time of the first occurrence the limousine was somewhere 120 feet ahead of the motorcycle, which would have put it right there.

Now, again, I am examining the question about whether these three or these three are candidates for false alarms. If these three are truth, then the motorcycle was going 18 miles an hour, catching up with the limousine, and, in fact, having achieved a position only 40 or 50 feet behind it at the time of the head shot.

Now, if you recall the first thing we noticed on the tape was that there was a diminution of the sound due to the motorcycle 3 seconds prior to the first impulsive pattern that we originally suspected could be caused by gunfire.

There was no obvious explanation for that, until one sees that at that time the motorcycle was just beginning a 110° turn, and on the inside track apparently, and he would therefore have to slow down to execute the turn.

Now, it was further observed that the motorcycle sound stayed diminished after the turn. It did not increase to the level that it had formerly had. Therefore, it would seem that it couldn't have increased speed, which it would have had to do to achieve this position in 8 seconds.

If, on the other hand, it had continued at the same speed of the motorcade, it would have achieved this position in that time.

There is, therefore, the diminished sound of the motorcycle that indicates that these are false alarms. Now, that is an example of the kind of corroborating or disqualifying evidence that is of nonacoustical origin. We are inferring that the motorcycle didn't speed up because the noise didn't increase, this allows us to identify as false alarms some of these correlations we have accepted by lowering the threshold sufficiently to catch the correct detections.

In other words, indications of detection that were accepted by the test, but that were shown by other reasons not to be possible, are therefore, found to be false alarms.

As a result of that judgment, the estimate of the motorcycle position at the time of the second impulse, the red one, would be there, which is right there, and the estimated position then of the motorcycle at the time of the third occurrence, which is here, is right there.

I lost my graphical symbolism a little, and that is right there, and at the time of the last segment labeled No. 4, which at this time we would estimate it to be halfway between those two right there, and that is there, 120 feet behind the limousine at the time of the head shot, if in fact these impulses represent the sound of the head shot.

There is the possibility of labeling one of these four threshold crossings as a potential false alarm because it involves firing from this place at this target at the time that the limousine was here.

That is almost 180° out. It is inconceivable that anyone would do that, and on that basis one of these can be judged a false alarm.

The fact that some of those are thought to be correct detections was illustrated by all of the order in the data, as I explained earlier.

Mr. CORNWELL. Dr. Barger, does that conclude your description of the analysis that you performed?

Dr. BARGER. Yes, it does.

Mr. CORNWELL. Let me then ask you in sum, is it fair and accurate to state that after all of the analysis there is evidence of four shots on the Dallas Police Department tape, and that the acoustical sounds that may represent those shots are spaced as follows: between the first and second approximately 1.6 seconds, between the second and third approximately 5.9 seconds, and between the third and fourth approximately 0.5 of a second?

Dr. BARGER. Yes, that is a possible conclusion.

Mr. CORNWELL. I have no further questions. Thank you.

Chairman STOKES. Thank you very much.

Doctor, I would just like to say you are a fascinating teacher. I am just glad I don't have to take a test on what you have taught us here, today.

May I consult with the committee for just a moment regarding recessing at this time.

At this time the committee will recess until 1:30 p.m. this afternoon.

[Whereupon, at 12:15 p.m., the committee recessed, to reconvene at 1:30 p.m., the same day.]

AFTERNOON SESSION

Chairman STOKES. The committee will come to order.

The procedure this afternoon will be for the Chair to, first, recognize the gentleman from Indiana, Mr. Fithian, who will be permitted to consume such time as he may need in order to fully and extensively question the witness. After that, the Chair will operate under the 5-minute rule as to other members of the committee.

The Chair at this time recognizes the gentleman from Indiana, Mr. Fithian.

Mr. FITHIAN. Thank you, Mr. Chairman.

Dr. Barger, we want to thank you for your excellent, very technical, and very complete testimony this morning. And as you must be