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A Study of Alterations to the Baffle of the Clarinet Mouthpiece and How They Affect Tone Quality, Intonation, and Response.

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A STUDY OF ALTERATIONS TO THE BAFFLE OF THE CLARINET MOUTHPIECE AND HOW THEY AFFECT TONE QUALITY, INTONATION, AND RESPONSE

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ABSTRACT

This study of alterations to the baffle of the clarinet mouthpiece was made in order to discover how these alterations affect tone quality, intonation, and response. Experiments using two mouthpieces of the same brand, size, and stock number were performed in an anechoic chamber. Three subjects played six notes, spread over approximately three octaves, using the same clarinet and reed. Spectral analysis of the waveforms was carried out by means of a digital computer. Intonation was monitored by a Stroboconn calibrated to A-440, and volume was controlled by an electronic voltmeter. Alterations consisted of removing material from the baffle by filing, and of building up the baffle with bonding clay. Measurements were taken with a micrometer before and after each alteration at .05 inches apart, both horizontally and vertically. By providing precise measurements of the baffle during the experiments, ambiguous terms of convex and concave could be eliminated when discussing effects of the alterations. The knowledge gained in this experiment may be used in some measure as a guide for further study, and as an aid in the improvement of tone quality, intonation, and response of clarinet mouthpieces.

CHAPTER I

INTRODUCTION

Statement of the Problem

Except for a few studies, such as Wehner's,[1] there has been little documented evidence concerning interrelationship of tone quality, intonation, response, and the clarinet mouthpiece. Wehner acknowledged that the internal dimensions of the mouthpiece seemed to be important for the maintenance of correct intonation and that the inner space was a mystery to most clarinet players.[2]

Hall said that there were clarinet players who believed that if you scooped out the inside of the mouthpiece at a particular spot, or if you made the slot opening between the tone chamber and bore, the perfect mouthpiece would be there.[3]

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[1]Walter Leroy Wehner, "The Effect of Interior Shape and Size of Clarinet Mouthpieces on Intonation and Tone Quality," (unpublished Ed.D. dissertation, University of Kansas, 1961).

[2]*Ibid.*, p. 2.

[3]J. C. Hall, "The Clarinet Mouthpiece," *Conn Chord*, September, 1960, p. 14.

Gibson suggested that the interior surfaces of the mouthpiece should be free of roughness. He said that roughness can cause turbulence which may or may not be audible in the sound.[4]

In Hall's article it was stated that there was a common belief that the lay or facing of the mouthpiece was all important, when actually there were other parts of the mouthpiece which were equally critical; namely, the baffle, the rails, and the tone chamber.[5] He said that the beating of the reed was very greatly influenced by the exact shape of that area which lies opposite the vibrating position of the reed.

According to Hall, the baffle should be slightly concave between the rails. However, Hall cautioned that the concave shape should not be too pronounced--it should not approach a half circle, but neither should it be a straight line. The concave curve should not be symmetrical and not tilted to either side.

Dr. Hall ascribes timbre and response adjectives to the shape of the baffle by saying that a lengthwise convex

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[4]Gibson, "Two Generalizations Upon the Clarinet Mouthpiece - One Necessity, One Option," The Clarinet, III, No. 2 (February, 1976), p. 18.

[5]J. S. Hall, "The Clarinet Mouthpiece," Conn Chord, September, 1960, p. 14.

curve in this area provides a more "open blowing, looser feel" with a "brighter" sound. A straight baffle provides a "tighter feel" and a sound which is less "bright."[6]

Dr. Hall further states that a lengthwise concave curve in the baffle could make the instrument blow "rough" and sometimes "stuffy." As a general rule, the closer the curve approaches the tip rail, the more clearly it becomes a straight line.

He also attributes squeaks to a short convex curve on the baffle near the tip rail. If the instrument blows "hard" or "stuffy" the convex curve is too long. It tends to close the mouthpiece opening.[7]

Erick Brand also placed emphasis upon the importance of the shape of the baffle. In discussing the dimensions of the tip rail, the mentioned that the baffle should not show any bevel after it is trimmed to shape. He also stated that the cross-wise section of the baffle should be almost a straight line.[8]

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[6]J. C. Hall, "The Clarinet Mouthpiece," Conn Chord, September, 1960, p. 14.

[7]Ibid., p. 14.

[8]Erick Brand, How to Reface Reed Instrument Mouthpieces (Elkhart, Indiana: Erick Brand, 1950), p. 18.

The Brand and Hall discussions of the importance of the curve of the baffle both used general and rather ambiguous language in describing the shape of the baffle. For instance, Brand said at one point, "Sometimes a slightly convex shape or a slightly concave shape is satisfactory, but be sure that it is very slight."[9]

The question is: "How much concavity and convexity is to be considered slight or very slight?"

Holdsworth also explained that it was very important to make sure that the baffle was evenly cut and slightly concave in shape.[10] He regulated the tip rail by scraping at the baffle and working gradually back toward the tip rail. He then removed the scraper marks on the baffle with a file covered with fine grit paper. He used a soft buffing wheel to achieve the final polish.[11]

Even though the importance of the baffle as a critical interior surface of the clarinet mouthpiece has been acknowledged, there are no precise measurements of this area given in any of the previously-mentioned articles.

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[9] Erick Brand, How to Reface Reed Instrument Mouthpieces, p. 18.

[10] Frank Holdsworth, "Clarinet Mouthpieces, the Personal Touch," Woodwind World, XIII, No. 5 (May, 1974) p. 28.

[11] Ibid., p. 28.

Brand also attributed mouthpiece squeaks to a convex curve, or bevel, on the baffle near the tip rail.[12] He said that a long curve on the baffle near the tip rail would result in the mouthpiece blowing hard and stuffy.

Wehner attempted to define the baffle in more exact measurements in his dissertation. His work dealt with the effects various tone chamber sizes had upon tone quality and intonation when the bore taper, bore size, and facing remained unchanged.[13] However, the measurements given for the increase in size of the tone chamber were apparently of one dimension. It was not entirely clear what the measurements given represented in terms of area measured. Wehner also used a musical phrase instead of a steady state tone in his tone quality perception tests.

One of more exact measurements given with regard to the baffle area was given by Hall when he stated that often the tip rail will be approximately one thirty-second of an inch wide for optimum performance.[14] Actually, the tip rail is at the top of the baffle area of the mouthpiece and should not be considered as a baffle measurement.

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[12]Erick Brand, How to Reface Reed Instrument Mouthpieces, p. 19.

[13]Ibid., p. 61.

[14]J. C. Hall, "Clarinet Mouthpiece," Conn Chord, p. 14.

It is well known that the clarinet mouthpiece affects the intonation and response of the clarinet. A study was made in 1963 by the Acoustical Research Committee of the American School Band Directors Association. This study was completed in 1967. A total of seventy-eight mouthpieces, with twenty-three different trade names, were tested. The number of different bore measurements was not given, but the report stated that there were forty-six different facings.

According to the chairman, all mouthpieces that were tested were listed in a table in the order of pitch response from the highest to the lowest. The variation in intonation between the highest and the lowest mouthpieces tested was thirty-two cents as measured by the Stroboconn.[15]

The number of variables in the American School Band Directors Association study of mouthpieces pointed up the need for more studies that eliminate the various size bores and facings.

In Brand's book it is stated that if the tone chamber of the clarinet mouthpiece is too small or too short, the instrument will play sharp.[16] No specifications

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[15]E. Elwood Nichols, "A.S.B.D.A. Acoustical Research Study on Clarinet Mouthpieces," Conn Chord, XIX, No. 3 (May, 1968), p. 25.

[16]Erick Brand, How to Reface Reed Instrument Mouthpieces, p. 19.

in terms of cents were given. Brand attributed the sharpness to incorrect manufacturing or over-refacing. He stated that no matter what the cause of the intonation problem, the mouthpiece clearly affected the intonation of the clarinet.

The clarinet reed is another variable that must be considered in any study that deals with timbre, response, and intonation of a mouthpiece. Nederveen stated that, "Although there are certainly other influences, the reed motion cannot be neglected as a factor in the tuning of reed-excited woodwinds."[17] He also stated that the reed motion showed the utmost importance of reed properties for intonation. This, after all, should not be a surprising conclusion for an experienced clarinetist.

The McGinnis, Hawkins, and Sher study stated that the dimensions of the reed must be altered by the player so that these dimensions will suit the design of the mouthpiece, as well as the elasticity of the cane.[18]

Salander, in his discussion of reeds, said that even minute bumps on the surface of the reed tended to lower

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[17]C. J. Nederveen, "Influence of Reed Motion on the Resonance Frequency of Reed-Blown Woodwind Instruments," Journal of the Acoustical Society of America, XLV, No. 2 (February, 1969), p. 53.

[18]C. S. McGinnis, H. Hawkins, and N. Sher, "An Experimental Study of the Tone Quality of the Boehm Clarinet," Journal of the Acoustical Society of America, XV, No. 4 (April, 1943), p. 235.

the quality of response and tone.[19] Therefore, because of the variable qualities of clarinet reeds, and because of the influence that the reed has on intonation, tone quality, and response, it was decided to use one carefully selected reed for this study.

Backus defined tone quality as the characteristic of a tone that can distinguish it from others of the same frequency and loudness.[20] He further stated that the quality of a given complex tone was determined by the number, frequency, and amplitude of the individual partial tones.[21]

Voxman pointed out that there was also a format, which is generally described as a concentration of acoustic energy in one or more relatively small frequency ranges, and that the characteristic tone of the clarinet was due to the concentration of energy in certain partials, not in certain regions of the scale.[22]

Backus suggested that the musician is unable to exert perfectly steady forces or pressures on the instrument,

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[19]Roger Salander, "The Agony and the Ecstacy - The Later Stages in Reed Making," The Clarinet, III, No. 2 (February, 1976), p. 8.

[20]John Backus, The Acoustical Foundations of Music (New York: W. W. Norton & Company, Inc., 1969), p. 94.

[21]Ibid., p. 96.

[22]Himie Voxman, "The Harmonic Structure of the Clarinet Tone," Journal of Musicology, III, No. 1 (January, 1940), p. 11.

and because of this, the musical tones that are produced by humans will show fluctuations in the vibration and frequency of the tone.[23] Voxman states that the acoustic spectrum of a clarinet tone is a function of the intensity levels with the frequency constant, and to a lesser degree, of pitch with the dynamic level constant.[24] In view of Backus' and Voxman's statements, it was decided that in order to get a relatively steady and consistent spectrum display of clarinet tone, the intensity and frequency would have to be carefully monitored and controlled.

Culver says that the term "pitch" is a subjective characteristic of a sound that enables one to classify a sound as being acute or grave.[25] Winckel states that there is no absolute measure for pitch and dynamics for the ear.[26] Therefore, for the purpose of this study, the term "pitch" is used in connection with differences in intonation, as measured by a Stroboconn calibrated to A-440.

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[23]John Backus, The Acoustical Foundations of Music, p. 95.

[24]Himie Voxman, "The Harmonic Structure of the Clarinet Tone," p. 12.

[25]Charles A. Culver, Musical Acoustics (4th ed.; New York: McGraw-Hill Book Company, Inc., 1956), p. 83.

[26]Fritz Winckel, Music, Sound and Sensation - A Modern Exposition, trans. by Thomas Binkley (New York: Dover Publications, Inc., 1967), p. 91.

In a study made by Backus, it was found that the structure of the tone was different in different directions because of interference effects. This made it difficult to analyze the radiated sound. The measurements were further complicated by unpredictable room measurements. Backus suggested that an anechoic chamber would mitigate these difficulties.[27] In order to eliminate as many problems as possible, all of the experiments involved in this study took place in an anechoic chamber.

Of the many studies that have been done concerning tone quality, none could be found that involved intonation and response as they relate to alterations of the baffle of the clarinet mouthpiece. The shape of the baffle has been acknowledged to be important to these aspects of tone, but the words used to describe their shape, such as convex and concave, are very general.

This study was undertaken in order to find out what effects alterations to the baffle of the clarinet mouthpiece would have on tone quality, intonation, and response. By providing a set of abundant and precise measurements for several alterations, it was hoped that it would be possible to: 1) discover what these effects were, and document them

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[27] John Backus, "Resonance Frequencies of the Clarinet," Journal of the Acoustical Society of America, XL, No. 6 (June, 1968), p. 1278.

before and after each alteration, 2) use the same methods of measurements so that similar effects would result, and 3) apply this knowledge to improving the tone quality, intonation, and response of clarinet mouthpieces.

CHAPTER II

THREE PREVIOUS STUDIES OF TONE QUALITY

Oscillogram

An early study dealing with the analysis of musical tones was done in 1926 by D. C. Miller.[28] He analyzed the sound wave through the technique of an oscillogram. The sound wave was made to strike a thin diaphragm. The varying pressure in the sound wave caused the diaphragm to move. A thread was connected to a small pivoted shaft and to the diaphragm. Whenever the diaphragm moved, the motion was communicated to the shaft. Mounted on the shaft was a small mirror, from which a beam of light was reflected onto a moving strip of photographic film. As the diaphragm vibrated, the spot of light on the flim moved back and forth. In this manner Miller obtained a plot of pressure in the sound wave versus time. The resulting oscillating quantity was then plotted against time on a graph. This representation was called an oscillogram.

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[28]D. C. Miller, The Science of Musical Sounds (New York: MacMillan Co., 1926.

Henrici Method

The Henrici Method, as described in J. Miller's dissertation,[29] required that the tone be recorded by means of an oscilloscope. A photographic enlarger reproduced the curve of the tone drawn to a specified scale. (This curve could have been reproduced by hand.) A carriage was constructed so that it could be moved perpendicularly to the time axis of the curve. A stylus mounted on the carriage traced the curve of the drawing of the sound wave. The tracing of the curve with the stylus was done by hand.

A number of cylinders, spheres, and pulleys were connected in various ways to the carriage. The motion of the carriage caused the system to operate so that coefficients of sine and cosine components could be read on dials.

The readings were then applied to an amplitude-and-phase calculator from which computations of the amplitude could be obtained.

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[29] J. R. Miller, "A Spectrum Analysis of Clarinet Tones" (unpublished Ph.D. dissertation, University of Wisconsin, 1956), p. 21.

CHAPTER III

METHOD OF SPECTRAL ANALYSIS USED IN THIS STUDY

Since an analyzer of the type used by Miller was not available at the time of this study, Professor James Giammanco of the Louisiana State University Electrical Engineering Department designed a method whereby the tones could be analyzed.

Spectral analysis of clarinet waveforms was carried out by means of a digital computer. The method used was a streamlined version of the old Henrici Analyzer. The Henrici Analyzer required that the waveform under study be copied in such a way that it could be traced by a stylus connected to a complex mechanical apparatus. As the stylus traced the waveform, a mechanical linkage caused the sine and cosine coefficients of the Fourier series to appear on an array of dials. It was then necessary to compute the composite amplitude coefficient for each harmonic by applying appropriate algebraic and trigonometric methods.

The digital computer was used to replace the complicated mechanical apparatus of the Henrici Analyzer; however, it was still necessary to permanently record the waveform to be studied, although it was quite possible to computerize

Miller's Sweep Spectrum Analyzer Method

J. R. Miller used a specially-designed audio-wave sweep spectrum analyzer, whereby the direct feeding of the signal to the analyzer eliminated distortion and other variables present in the use of recordings. The spectrum analysis appeared on a cathode ray tube similar to that of a vertical bar graph. A sweep frequency set at 1 cycle per second allowed a complete analysis of a complex tone within a one-second time span.[30]

The same mouthpiece and the same clarinet were used for each subject in Miller's spectrum analysis of clarinet tones; however, two reeds were alternated. Miller's subjects were asked to approximate a level of intensity of one and five-tenths volts throughout the testing. Small deviations from the input voltage desired were controlled with an input alternator potentiometer.[31]

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[30]J. R. Miller, "A Spectrum Analysis of Clarinet Tones," p. 31.

[31]*Ibid.*, p. 40.

the recording operation also. Photography was obviously an appropriate method of recording, but any of a number of methods, including direct digital conversion, could have been employed.

For purposes of this analysis, clarinet tones were picked up by a microphone and immediately amplified by an integrated circuit device. The amplifier output was applied simultaneously to an oscilloscope and to an electronic voltmeter. The voltmeter reading was employed as a means of maintaining constant signal amplitude.

The waveform as displayed on the oscilloscope was photographed with a 35 millimeter camera, and the control settings of the oscilloscope were recorded.

After processing, the waveform photographs were projected in such a way that 32 discrete points, equally spaced over exactly one cycle of the waveform, could be selected. The relative amplitude of each of these 32 points--and only these points--was recorded.

A mathematical formulation known as the Sampling Theorem insured that a waveform could be reconstructed to arbitrary precision provided that a sufficient number of discrete points on the waveform were known.

Mathematically, reconstruction of a waveform was equivalent to knowing the amplitude and phase of each harmonic element included in the waveform. In fact, the

mathematical reconstruction was accomplished by adding together all the harmonic terms.

The selection of 32 discrete points per cycle was not made arbitrarily. Another mathematical relationship, the Nyquist Theorem, related the number of discrete sampled points to the accuracy of reconstruction. The Nyquist Theorem insured that, for 32 data samples per cycle, the reconstructed waveform would be correct to the sixteenth harmonic term in the series. Therefore, with 32 sample points it was possible to determine the strength of the first 16 partials of which the tone was composed.

A computer program was prepared to perform the necessary calculations to determine the relative strengths of the first 16 partials. These partial strengths were printed out in absolute terms and in decibels relative to the first partial (first partial = 0 decibels) in order that graphical comparisons could be made.

CHAPTER IV

METHOD AND DESIGN OF THE STUDY

This study focused on what happened to tone quality, intonation, and the response of two B-flat soprano clarinet mouthpieces when the area known as the baffle was altered. Figure 1 shows the mouthpiece and the baffle.

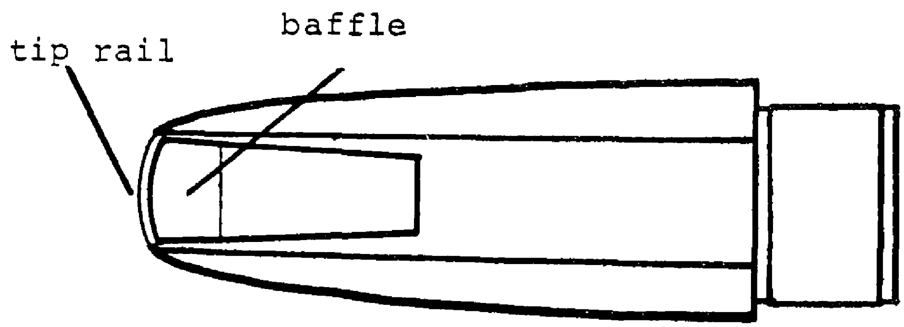

Figure 1. Mouthpiece showing baffle.

The two mouthpieces chosen for this study had identical facings and bore measurements before any alterations were begun. The mouthpieces were designed and used by Paul D. Dirksmeyer, Professor of Music at Louisiana State University in Baton Rouge, Louisiana. They are known as Dirksmeyer No. 1 symphonic bore clarinet mouthpieces.

Method of Measurement

Before alterations of any kind were begun, the mouthpieces were measured as follows. Each mouthpiece was measured beginning at a point where the taper of the tone chamber begins underneath the tip of the reed to an area extending downward along the wall of the mouthpiece for .3 inch. Vertical measurements were then taken across the baffle to the other side of the mouthpiece at various points.

A grid was drawn on a clear piece of plastic which was shaped and cut to fit the outline of the mouthpiece. The surface area of each square was .0025 square inch. Each point was .05 inch apart. Reading from top to bottom, the horizontal lines were numbered from zero to six. Reading from left to right, and starting at the inside rail tip and ending at the other tip, the vertical lines were numbered from one to ten. Figure 2 shows this.

A wooden rod was placed in a vice so that it was parallel to the table to which the vice was attached. The rod was shaped so that the rounded part of the mouthpiece could be securely placed over the rod.

The clear plastic grid was then taped over the tip of the mouthpiece. At this point each mouthpiece was

measured in the manner described and measurements were carefully recorded in a notebook.

The measurements were taken with a Scherr-Tumico 0-7/8" micrometer with graduations in thousandths of an inch, model T103LR. This particular micrometer was equipped with vertical rods that had conical anvil and spindle faces with 1/64 inch flats on the ends of the points, which allowed for measuring in the small recesses of the corner of the mouthpiece. Other micrometers, because of the size of their cylindrical rods, proved to be unsatisfactory for the task of measuring at such small points on the clarinet mouthpiece baffle.

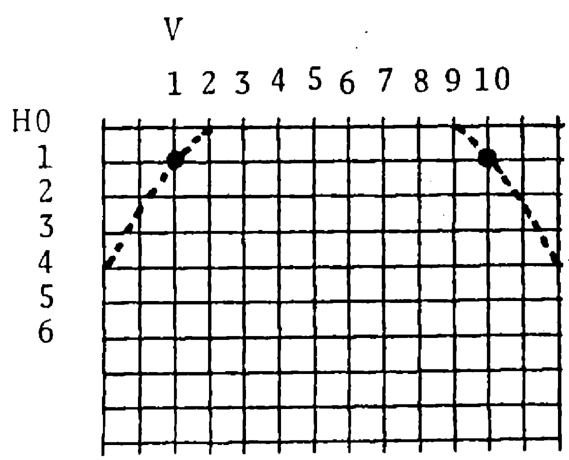

Figure 2. Mouthpiece outline and grid.

<u>Nature of Alterations to the Mouthpiece</u>

The first alteration to the first mouthpiece, which was designated as Mouthpiece No. 1, consisted of removing some of the original mouthpiece material from the baffle

by using a metal file. The filing process was generally limited to the shaded area shown in Figure 3.

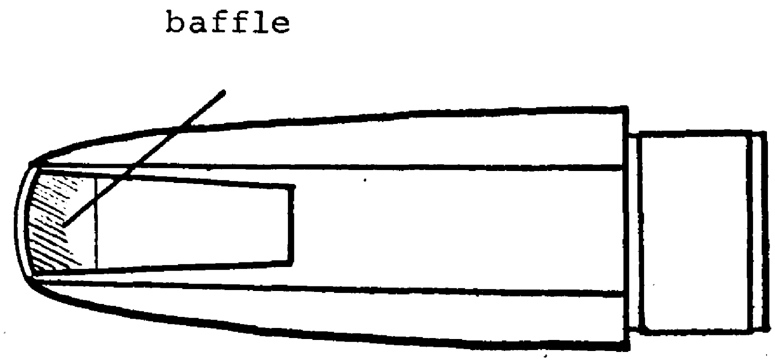

Figure 3. Mouthpiece No. 1 showing area where material was removed.

Since this was the first experimental attempt at removing material, it was decided to remove enough material to register a great difference in the spectrum analysis and response. Much of the flat part of the tip rail, which is the outer part of the rounded tip, was removed for this purpose.

The filing strokes used in this and in remaining removal alterations consisted of back and forth motions with most of the pressure being exerted by the first finger. The mouthpiece was then measured as described on page 19, and the measurements were recorded in a notebook.

The first alteration to the second mouthpiece, which was designated as Mouthpiece No. 2, consisted of building up the baffle area by applying a layer of automotive bonding clay, which hardened rapidly. The

thickness of the layer applied to the mouthpiece is shown in Appendix A on page 86. Special care was used when taking these measurements, because one or two turns of the micrometer adjustment caused the pointed rods to penetrate the automotive bonding clay; thereby making accurate readings difficult to obtain. This alteration was designated as Mouthpiece No. 2, Built Up.

The second alteration of Mouthpiece No. 2 consisted of removing a portion of the automotive bonding clay by filing. The thickness of the layer in the baffle area of the mouthpiece area is shown in Appendix A on page 86. This alteration was designated as Mouthpiece No. 2, After the First Filing.

The third alteration of Mouthpiece No. 2 consisted of removing the remaining automotive bonding clay and then filing material from the baffle area of the mouthpiece itself. This alteration was designated as Mouthpiece No. 2, After the Second Filing. These measurements are found in Appendix A on page 86.

In order to summarize the nature of the alterations to the mouthpiece and to further explain the design of this study, the following titles were used.

Mouthpiece No. 1, Unaltered
Mouthpiece No. 1, After the First Filing
Mouthpiece No. 2, Built Up
Mouthpiece No. 2, Unaltered
Mouthpiece No. 2, After the First Filing
Mouthpiece No. 2, After the Second Filing

Each mouthpiece was measured, the measurements were recorded, and then each mouthpiece was tested. The mouthpieces were then altered, measured, and tested; and the results were recorded. This was the sequence in which these experiments were performed.

The Subjects

Two types of subjects were considered for this study. The first subject was a relatively immature musician who had played the clarinet from one to six years. The second subject could be classified as a professional clarinetist--one who could be considered to be a performing professional studio clarinetist with well-developed playing techniques. Through preliminary experiments it was found that the immature student had difficulty in producing what is subjectively described as a good tone; that is, one that is consistent in harmonic structure from day to day.

In Miller's study only relatively immature musicians were used. His findings produced extremely varying spectrum patterns, even though the same instrument, the same mouthpiece, and the same two reeds were used. As a result of his findings, he recommended that another study

analyzing the tones of professional musicians, as well as students, be made.[32]

Based upon Miller's findings, it was decided that professional, adult clarinetists would be more capable of producing a subjectively good and complex tone at a consistently stable intensity and frequency level from day to day.

The three subjects were chosen on the basis of their current status as performing clarinetists. Two of the subjects--each with twenty-eight years of playing experience--were considered to be performing, studio clarinetists. Both of these subjects were doctoral students in the applied area at the Louisiana State University School of Music in Baton Rouge, Louisiana. The third subject had played the clarinet for eleven years and was considered to be a performing clarinetist.

Intonation Control

It was revealed, through preliminary experiments, that by keeping the frequency constant, a more consistent spectrum could be produced for each note tested. Several methods of controlling the intonation were tried. It was decided that the best method would be for the subject to play the note into another microphone that was placed on a

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[32] J. R. Miller, "A Spectrum Analysis of Clarinet Tone," p. 104.

table next to the microphone leading to the oscilloscope and amplifier. This microphone was attached to a Stroboconn tuning machine. The Stroboconn was calibrated at each session with a standard A-440 tuning fork. The subjects were instructed to play the note as naturally as possible, but at the same time to watch the Stroboconn and maintain a steady frequency. If the subject had to lip more than two or three cents sharp or flat, this was noted and recorded in a notebook. The results of this can be found in Appendix C.

Dry and wet bulb temperatures were recorded at the beginning and end of each session. Room temperature did not fluctuate more than six degrees during each period of testing.

According to Robert W. Yound, it takes a temperature increase or decrease of more than ten degrees to affect the intonation as much as one-tenth of a semi-tone, or to noticeably change the harmonic structure of the tone being produced.[33] A later study attributed the temperature in the bore to be a more critical factor than the room temperature.[34]

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[33]Robert W. Yound, "Dependence of Tuning of Wind Instruments," Journal of the Acoustical Society of America, XXIV, No. 3 (March, 1952), p. 267.

[34]Arthur H. Benade, "Thermal Perturbations in Woodwind Bores," Journal of the Acoustical Society of America, XXXV, No. 11 (November, 1963), p. 1901.

Drs. Hall and Kent stated that because of the clarinet's length and physical characteristics, it warms quite quickly with the player's breath, and once warmed, changes less with external temperature.[35] In view of these findings, it was decided to have the subjects play for a full six to eight minutes at the testing site before testing procedures began.

The subjects were instructed to position their barrels as they normally would in order to play with an equal tempered piano whose temperament was set at A-440. This was then checked with the Stroboconn. Any variation from their normal tuning position was noted and recorded.

Response

The three subjects were asked to comment on the response of both mouthpieces before and after each alteration. The choice of words describing certain changes in response were of their own choosing. Their words could not be regarded as being particularly scientific, but to most musicians they were generally familiar descriptions of response. Since these particular subjects were selected because of their maturity, their sincere interest in the experiment, and their overall professional integrity,

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[35] Jody C. Hall and Earle L. Kent, The Effect of Temperature on Tuning Standards of Wind Instruments (Elkhart, Indiana: C. G. Conn Ltd., 1959), p. 4.

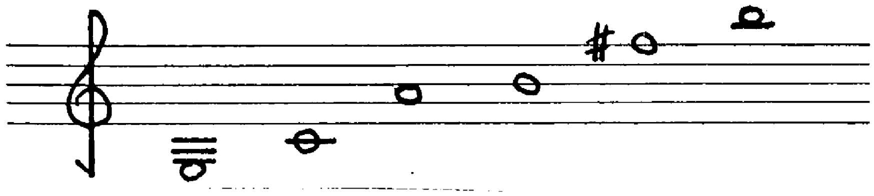
their answers regarding questions of response were honest, carefully considered, professional, and personal opinions.

Collection of the Data

There were four testing sessions involved in this experiment, encompassing approximately three weeks. All four sessions took place in the anechoic room of the Electrical Engineering Building on the Louisiana State University campus at Baton Rouge, Louisiana. The only furniture in the room was a long table, on which the equipment was placed, and a stool. For acoustical reasons the distance and angle of the clarinet from the microphone were exactly the same at each session--the distance being twelve inches and the angle being forty-five degrees. The table and stool were in the same position for each session also.

A Mamiya Sekor 1000 DTL camera was used to take photographs of each waveform which appeared on the oscilloscope. Five photographs of each note were taken over a period of time amounting to no more than twelve seconds for each note. Professor James Giammanco photographed each waveform, during which time one of the other subjects monitored the intensity level to ensure constant frequency level. Professor Giammanco was advised when the intensity level moved slightly above or below eight volts. Each subject played on the same Vandoren medium-hard reed and the same Buffet clarinet.

Because of their span of two and one-half octaves, the following six notes were selected to be tested:



e c^1 a^1 b^1 $f\#^2$ b^2

Figure 4. Six test notes.

After each note was played long enough for five photographs to be made, comments were made by the subject on any lipping--sharp or flat--that had to be done in order to keep a constant pitch level. These comments were recorded in a notebook. The same procedure was followed for each note as it was played in the sequence given above.

Each subject followed the above procedure until all three subjects had finished testing each mouthpiece. Alterations to the mouthpiece and subsequent measurements were performed and recorded at the studio of Professor Paul Dirksmeyer at the Louisiana State University School of Music.

Mouthpiece No. 1 was filed to such an extent that there was a leak at that point where the reed meets the tip rail. After consultation with all three subjects, it was decided that too much material had been filed from the tip rail, making the mouthpiece unresponsive and therefore unuseable for further experiments.

Mouthpiece No. 2 was tested four times in the same manner as described above, and the appropriate alterations and measurements were performed and recorded.

The photographs were developed, mounted, and projected onto graph paper in order that the waveform could be plotted. The numbers were then transferred to a computer that was programmed by Professor James Giammanco. Professor Buck Brown of Louisiana Tech University's Electrical Engineering Department in Ruston, Louisiana, converted these results into graph form for the purpose of analysis.

For the purpose of analyzing the partials of all cases and subjects involved in this study, three ranges were used. These were:

Strong: -23 decibels to 0 decibels

Medium: -40 decibels to -22 decibels

Weak: -55 decibels to -39 decibels

These ranges were based on the actual data collected.

All three subjects were present in the same room during every testing session.

CHAPTER V

SPECTRAL ANALYSIS

BY SUBJECT, NOTE, AND MOUTHPIECE

Subject A, Note e

Mouthpiece No. 1, Unaltered

This case showed fewer partials in the strong range than any of the other cases, with only the second, third, and fourth partials being in the strong area. The second partial was the strongest of the partials, and there were two weak partials. Because of the greater number of weaker partials, this case contrasted sharply with the partials of the other cases.

Mouthpiece No. 1, After the First Filing

There were nine partials in the strong area, six in the medium area, and none in the weak range. The odd partials were very strong throughout the gamut of partials. The fifth partial showed slightly less intensity. This case can be termed complex when compared with the spectral display of the first mouthpiece, unaltered.

Mouthpiece No. 2, Built Up

This case showed fourteen partials in the strong area. More strong partials were found in this case than

in the other five cases, and the partials were much stronger in this case than in the first mouthpiece, after the first alteration. The third and fifth partials were the strongest. There was only one partial in the medium range and none in the weak area.

Mouthpiece No. 2, Unaltered

There were twelve partials in the strong area, three in the middle area, and none in the weak area. Partials two through twelve were all in the strong area. The even partials, four and six, were stronger than the other cases. The third and fifth partials were at the same intensity level. The fourth, fifth, and sixth partials were the strongest of the other cases.

Mouthpiece No. 2, After the First Filing

Twelve partials were in the strong range, three in the medium range, and none in the weak category. The eighth and tenth partials were unusually strong in this case. There was generally a decrease in intensity levels of the first ten partials when compared with the unaltered second mouthpiece.

Mouthpiece No. 2, After the Second Filing

This case showed a significant decrease in the intensity levels in the upper partials and had only two weak partials. There were eight strong partials and five medium partials.

Comparisons and trends

The first unaltered mouthpiece showed fewer partials in the high area than the other cases; and because of this, contrasted sharply with the other cases. The second mouthpiece, which was filed once, showed a general decrease in intensity levels when compared with the second mouthpiece. The third and fifth partials were strong in all cases, and the second mouthpiece, after the first filing, showed stronger upper partials than the same mouthpiece, after the second filing.

Subject B, Note e

Mouthpiece No. 1, Unaltered

This case showed thirteen partials in the strong range, two in the medium, and none in the weak range. The third and fifth partials were the strongest, and the eighth was the third strongest partial. The eleventh through the thirteenth partials were at approximately the same intensity level. Generally, these partials were weaker when compared with the other cases of this note for Subject B.

Mouthpiece No. 1, After the First Filing

The distribution of partials in the three ranges was the same as the previous case; however, in general, these partials were stronger when compared with the previous case.

Mouthpiece No. 2, Built Up

There were fourteen partials in the strong area, one in the medium, and none in the weak range. The upper partials generally increased in strength beyond the ninth partial.

Mouthpiece No. 2, Unaltered

The upper partials of this case were generally stronger in intensity than the partials of the first unaltered mouthpiece. The distribution and number of partials within the ranges were the same as in the second mouthpiece, which was built up.

Mouthpiece No. 2, After the First Filing

There were thirteen partials in the strong range, two in the medium, and none in the weak area. Until the twelfth partial, there was not much difference in intensity between this case and the second mouthpiece, after the second filing.

Mouthpiece No. 2, After the Second Filing

Ten partials were in the strong range, five in the medium, and none in the weak area. This case displayed a weaker array of partials than most of the partials of the other five cases. This is especially true when compared to the partials shown on the graph for the first unaltered mouthpiece.

Comparisons and trends

The most significant trend was the decrease in the upper partials of the second mouthpiece after the second filing. All cases showed strong odd-numbered partials until the ninth partial.

Subject C, Note e

Mouthpiece No. 1, Unaltered

This case had the fewest number of strong partials. Only one was in the strong range, and nine were in the weak area. Five partials were in the medium range. The second partial was the strongest partial; and there was a steady drop in the intensity level through the seventh partial. The eighth was slightly greater, but then the partials continued to decrease until the eleventh partial. This case contrasted greatly with the others.

Mouthpiece No. 1, After the First Filing

Ten partials were in the strong range, with the third and fifth being the strongest. The seventh was also strong, but the eighth was stronger. There were five partials in the medium area and none in the weak range.

Mouthpiece No. 2, Built Up

There were the same number of partials in the strong, medium, and weak areas as the first mouthpiece, after the

first filing. The fourth, fifth, ninth, tenth, twelfth, thirteenth, fifteenth, and sixteenth partials were stronger than in any previous case. The third and fifth partials were the strongest, with the third being the strongest of the partials in this case. This indicates a general increase in intensity levels in the upper partials.

Mouthpiece No. 2, Unaltered

The fourth, fifth, ninth, tenth, and eleventh partials were stronger than in any previous cases. There were nine partials in the strong area, six in the medium area, and none in the weak range. The lower partials showed an increase in intensity; whereas, the upper partials showed a decrease in intensity when compared to the previous cases. The third and fourth partials were the strongest in this case.

Mouthpiece No. 2, After the First Filing

There were thirteen partials in the upper range, two in the medium range, and none in the lower range. Partials five, six, and seven were stronger than any of the previous cases for this subject and note, with the fifth partial being the strongest. The third was also very strong. This case showed the second strongest set of partials.

Mouthpiece No. 2, After the Second Filing

Fourteen partials were in the strong area and one in the medium range. There were no weak partials. Partials eight through fifteen were stronger than in any of the previous cases. The eighth partial was unusually strong, and the third and fifth partials showed the same intensity level on the graph.

Comparisons and trends

The first unaltered mouthpiece and the second mouthpiece, after the second filing, represented the greatest contrast of relative intensity in decibels on the graph. The first unaltered mouthpiece displayed much lower intensity levels than any of the other cases. As the alterations occurred, the partials became stronger in intensity levels.

Subject A, Note $\underline{c}^1$

Mouthpiece No. 1, Unaltered

The second and fourth partials were stronger than the second and fourth partials of the other cases. This was a sharp contrast to the partials of the others. The second partial was the strongest and the fourth was the second strongest. Generally, the even-numbered partials were stronger than the odd-numbered partials. There were four partials in the strong area, eleven in the medium area, and none in the weak area.

Mouthpiece No. 1, After the First Filing

This case contrasted with the previous case in that the third and fifth partials were the strongest, and the odd-numbered partials were stronger than the even-numbered ones. There were four partials in the strong area, eleven in the medium, and none in the weak range. Until the eleventh partial, most of the partials were stronger than the first unaltered mouthpiece.

Mouthpiece No. 2, Built Up

There were seven partials in the strong area, eight in the medium, and none in the weak area. With the exception of the second and fourth partials, and up to the eleventh partial, this case had slightly stronger intensity levels. There were no other consistent trends.

Mouthpiece No. 2, Unaltered

From the second through the fifth partials, there was little difference in intensity between the first mouthpiece, after the first filing, the second mouthpiece built up, and the second mouthpiece, after the first filing. The ninth and tenth partials were the same intensity as the second mouthpiece built up. Generally, the odd-numbered partials were stronger.

Mouthpiece No. 2, After the First Filing

This case showed strong odd-numbered partials. The sixth and seventh partials were unusually strong. There

were eight partials in the strong area, six in the medium, and one in the weak range.

Mouthpiece No. 2, After the Second Filing

The most obvious thing about this case was that almost every partial was weaker than the other cases on the graph. The odd-numbered partials were generally stronger than the even-numbered ones.

Comparisons and trends

There was not much difference between cases. The third and fifth partials were strong. The first unaltered mouthpiece showed unusually strong second and fourth partials. The second mouthpiece, after the second filing, showed weaker partials.

Subject B, Note $\underline{c}^1$

Mouthpiece No. 1, Unaltered

The first six partials were in the strong area, with the second partial being stronger than any of the second partials in the other cases. The third and fifth partials were the strongest of any partials in this graph. This case showed the greatest number of strong partials, with seven in the strong area. Only one partial was in the weak area. Partials nine and eleven were unusually strong.

Mouthpiece No. 1, After the First Filing

The odd partials were weaker in this case than in the first mouthpiece, unaltered. Generally, there was a weakening of intensity in most partials when compared to the first unaltered mouthpiece. There were no partials in the weak area and ten were in the medium range. The third and fifth partials were significantly stronger than the other partials.

Mouthpiece No. 2, Built Up

This case showed five partials in the strong area and, similar to the previous two cases for Subject B, note $\underline{a}^1$, the ninth partial, was in the strong area. The third and fifth partials were weaker in intensity than the previous two cases for Subject B. This was also true for partials two, six, and eleven. There were no partials in the weak range and ten in the medium area. As in the previously-mentioned cases for Subject B, Note $\underline{c}^1$, the third and fifth partials were strong.

Mouthpiece No. 2, Unaltered

The third and fifth partials most resembled the first unaltered mouthpiece. The fourth and sixth partials were stronger than the first unaltered mouthpiece. The upper partials showed no similar pattern when compared with this case. There were no partials in the weak range,

ten in the medium, and five in the strong area. The third and fifth partials were the strongest in this case.

Mouthpiece No. 2, After the First Filing

Partials two through six showed a decrease in intensity when compared with the first unaltered mouthpiece. This case showed the fewest number of strong partials, with three. The upper partials were relatively strong even though twelve were in the medium range. There were no partials in the weak area.

Mouthpiece No. 2, After the Second Filing

The most obvious thing about this case was that almost all partials were weaker in intensity when compared with the first unaltered mouthpiece. Partials three and five were the strongest with five being stronger than three, and six being stronger than four. The sixteenth partial was the weakest.

Comparisons and trends

All cases showed strong third and fifth partials, with those two partials being generally equal in intensity for all cases. The most obvious aspect of this graph was the significant difference of partial intensity between the first unaltered mouthpiece and the second mouthpiece, after the second filing. Another noticeable fact was that this note displayed many strong partials. Only two partials on the graph were below the medium range.

Subject C, Note $\underline{c}^1$

Mouthpiece No. 1, Unaltered

This case had the greatest number of weak partials, with ten in the weak area; and this was the most noticeable aspect of this graph. The second partial was by far the strongest of the partials. The second, third, and fifth partials were at approximately the same intensity level. The eighth partial was unusually strong, even though it was in the medium range.

Mouthpiece No. 1, After the First Filing

There were four partials in the strong area, ten in the medium, and one in the weak area. The third, fifth, and sixth partials were the strongest partials, with the fifth partial being the strongest of the partials. The partials decreased with intensity beginning with the seventh partial.

Mouthpiece No. 2, Built Up

This case showed the greatest number of partials in the strong area, with six in this area. Partials three through seven and partial nine were in the strong range. The third and fifth partials were the strongest of the partials, with the third partial being the strongest in this case.

Mouthpiece No. 2, Unaltered

Five partials appeared in the strong range, ten in the medium range, and none in the weak area. The third and fifth partials had the same intensity levels. This case also had a strong ninth partial, but was the only case to show a fourth partial that was not in the strong range.

Mouthpiece No. 2, After the First Filing

The third and fifth partials were strong, but the fifth partial was stronger than the third. From the fifth to the thirteenth partial there was a general decrease in partial intensity; then there was a slight format until the sixteenth partial. There were ten partials in the medium range and none in the weak area.

Mouthpiece No. 2, After the Second Filing

There were five partials in the strong range, ten in the medium, and none in the weak area. The third and fifth partials were the strongest, and both showed the same intensity level on the graph. The ninth partial was very strong; and this case had the greatest number of strong partials past the ninth, even though they were in the medium range.

Comparisons and trends

The first unaltered mouthpiece showed the greatest number of weak partials on the graph and had the most

contrasting spectrum display of the six cases. It had an unusually strong second partial and then dropped dramatically after the sixth partial. All cases showed strong third partials, and all cases except the first unaltered mouthpiece, had strong fifth partials. The only trend was that all cases showed fewer weaker partials when compared to other notes. There were no apparent consistent patterns to be found in the six cases other than those that have been mentioned.

Subject A, Note $\underline{a}^1$

Mouthpiece No. 1, Unaltered

This case showed a very strong second partial. The third partial was weaker by about twenty-three decibels, and it was within the medium range. The third, fourth, and fifth were at nearly the same intensity and in the high medium range. The seventh partial was very strong, as was the eighth. The eleventh and twelfth partials also appeared strong. The weakest partials were the thirteenth and sixteenth; and the second partial was the only partial to appear in the strong range. The sixteenth partial was the weakest.

Mouthpiece No. 1, After the First Filing

This mouthpiece showed a more normal second partial and a stronger third partial. Only the third partial was in the strong category, and there were partials that were

below forty decibels. The upper partials--thirteen, fourteen, and fifteen--were in the high medium range and were only ten decibels from the strong category.

Mouthpiece No. 2, Built Up

A third strong partial appeared in this case, with the second, fourth, and fifth also in the strong category.

Mouthpiece No. 2, Unaltered

The highest number of strong partials were apparent in this case, with ten partials being in the strong area. The third, fifth, and seventh partials were the strongest. As the partial number increased, the intensity decreased. The tenth, twelfth, and sixteenth partials were much stronger than on the other mouthpieces and were at approximately the same intensity level.

Mouthpiece No. 2, After the First Filing

There were five partials that were in the strong range on this mouthpiece. The tenth through the twelfth partials were approximately the same strength. Only the sixteenth partial was weak.

Mouthpiece No. 2, After the Second Filing

This mouthpiece showed only one partial in the strong category. There were six weak partials, with the seventh and thirteenth through seventeenth being weak.

Comparisons and trends

The second mouthpiece, which was unaltered, showed the highest number of partials in the strong area, with the odd partials being generally stronger than any other mouthpiece. Mouthpiece No. 2--that is, the one whose baffle was built up--showed the next highest number of strong partials. After partial number three, Mouthpiece No. 2, after the second filing, showed a decreasing intensity with each subsequent partial. Each mouthpiece registered a different array of relative intensity values in decibels from the other ones, although they were similar on the third, fourth, and fifth partials.

Subject B, Note $\underline{a}^1$

Mouthpiece No. 1, Unaltered

There were four partials in the strong area and seven in the medium range. Four partials appeared in the weak range. Partials three, five, and six were the strongest in a decreasing order of intensity levels beginning with partial three and continuing with five and six.

Mouthpiece No. 1, After the First Filing

After this alteration, Subject B registered two partials in the weak range and twelve in the medium range. Only the sixteenth partial was below forty

decibels. The third partial was the strongest of the other partials, and of the other five cases. Partials seven through ten were at approximately the same level, as were partials eleven through fifteen.

Mouthpiece No. 2, Built Up

Three partials appeared in the strong range and seven appeared in the medium range. Five partials registered in the weak intensity category. The third partial was the strongest of this mouthpiece. Beginning with the eleventh partial, this mouthpiece generally produced the weakest upper partials.

Mouthpiece No. 2, Unaltered

Two partials were above twenty-three decibels, the high range, seven were in the medium range, and six partials were in the weak range. Partials three and five were strong, and even though partials four and six were in the medium range, they were very strong. The eleventh through the sixteenth partials were weak. The difference in the relative intensity between the second and third partials was almost minus twenty-five decibels.

Mouthpiece No. 2, After the First Filing

In the strong range only three partials appeared, and five appeared in the medium category. Seven partials were below minus forty decibels. The third, fourth, and

fifth partials were stronger than the remaining partials. The fourth partial was the strongest of the other five cases on this graph. The seventh, eighth, and ninth partials were stronger than the second partial.

Mouthpiece No. 2, After the Second Filing

Three partials appeared in the strong range, four in the medium range, and eight in the weak category. Generally, all partials, beginning with the seventh, gradually diminished in intensity, with the sixteenth partial being the weakest. The second partial was at the same level as the second mouthpiece, after the first filing.

Comparisons and trends

The third partial was strong in every case, and the second partial was comparatively weaker in every case although it appeared in the strong range in the first unaltered mouthpiece and the second mouthpiece, which was built up. There was a trend for the second mouthpiece, after the second filing, to show a gradual decrease in intensity levels in the upper partials. All cases showed strong third, fourth, and fifth partials; and the sixth partial was the next strongest, with the exception of the second mouthpiece, after the second filing. The most unusual spectrum display was in Mouthpiece No. 1, after the first filing. All of the

partials of this mouthpiece, after the seventh partial, were in the medium area, but were very strong and close to the same intensity level.

Subject C, Note *a*[1]

Mouthpiece No. 1, Unaltered

There were ten partials in the medium range, two in the strong intensity range, and three in the weak category. The second was very strong, as was the third and fifth. The fourth partial was relatively strong. There was a general increase and decrease in the partials that resembled a format in the vicinity of the eighth through the twelfth partials. The sixteenth partial was the weakest of all the other partials.

Mouthpiece No. 1, After the First Filing

The same number of weak and strong partials--three of each--appeared on this graph. The third, fourth, and fifth partials were strong. All of the remaining partials were in the medium range except the sixteenth, which was very weak. The third and fifth partials were relatively strong. The fourth partial was fairly strong, but was weaker than the third and fifth.

Mouthpiece No. 2, Built Up

There were three partials in the strong range, but eleven were in the medium range. Only the sixteenth

partial was weak. All of the partials were stronger in intensity when compared to the first mouthpiece, which was unaltered. The third, fourth, and fifth partials were the strongest.

Mouthpiece No. 2, Unaltered

The same three partials that appeared in the strong range of the second mouthpiece, which was built up, also appeared in the strong range of this case. There were six partials in the medium range.

Mouthpiece No. 2, After the First Filing

There were two strong partials, nine medium ones, and four weak ones. The fourth partial was next in strength after the third partial. After the fourth partial, all the remaining ones were medium or below. The tenth partial was extremely weak as were all partials after the tenth.

Mouthpiece No. 2, After the Second Filing

Two of the partials were strong, seven were medium, and five were weak. The second partial was the weakest and showed the greatest contrast in intensity levels between the second and third partials. The distance was thirty decibels. The fourth partial was the second strongest, and the fifth partial was the next strongest. Generally, there was a gradual decrease in intensity levels in the upper partials.

Comparisons and trends

All cases were similar in general appearance, as all cases had strong third partials and strong second partials. The third partial in most cases was the strongest. The mouthpiece that was built up showed an increase in all partials when compared with the first mouthpiece that was unaltered. The second mouthpiece, after the second filing, showed more of a gradual decrease in partial intensity than the remaining cases. Generally, the second mouthpiece, after the second filing, showed a decrease in the intensity of upper partials.

Subject A, Note $\underline{b}^1$

Mouthpiece No. 1, Unaltered

There were three strong partials, seven medium partials, and five weak partials. The third partial was the strongest, and the fourth was the second strongest. All of the remaining partials were in the medium range up to the ninth partial.

Mouthpiece No. 1, After the First Filing

The second partial was considerably stronger than the second partial of the first mouthpiece, which was unaltered. There was a marked constrast in all partials when compared with all of the partials of the first unaltered mouthpiece. Nine of the partials were in the

medium range, two in the weak range, and four in the weak range. The fourth, fifth, and sixth partials were of almost the same intensity.

Mouthpiece No. 2, Built Up

Only the third partial appeared in the strong area. The upper partials were gradually weaker as the partial number increased. The third, fourth, and fifth partials were the strongest. There were almost as many weak partials as medium partials, with the numbers as follows: strong, one partial; medium, eight partials, weak, six partials.

Mouthpiece No. 2, Unaltered

There were five strong partials, six medium partials, and four weak partials. The second and third partials were in the strong area. A slight format appeared in the region of the twelfth through the sixteenth partials. There was a rapid decrease in intensity beginning with the seventh partial. The first five partials were in the strong region.

Mouthpiece No. 2, After the First Filing

Only the third and fourth partials were in the strong area. The fifth partial was in the medium range, but was comparatively strong. The seventh partial was the next strongest partial. Most of the partials were in the medium range, but there were four in the weak range.

Mouthpiece No. 2, After the Second Filing

There were two partials in the strong area, four in the medium, and nine in the weak range. The third and the fifth partials were the strongest, with the fourth and sixth partials being the second strongest. All partials, except the second, were weaker than the partials in the other cases.

Comparisons and trends

All cases showed strong third, fourth, and fifth partials. The second mouthpiece, after the second filing, showed the most contrast when compared with the other cases. There was generally a gradual decrease in intensity levels in all cases after the third partial. The fourth partial was strong in both of the unaltered mouthpieces. The greatest contrast appeared between the spectrums of the unaltered mouthpieces and the second mouthpiece after the second filing. All but one partial was lower in intensity than the two unaltered mouthpieces.

Subject B, Note $\underline{b}^1$

Mouthpiece No. 1, Unaltered

The third and fourth partials were in the strong area. There were seven partials in the medium area and six partials in the weak range. The fourth and eighth partials were the next strongest with the eighth partial

being the strongest of all of the eighth partials of all of the cases. The eighth, ninth, tenth, and eleventh partials were of almost the same intensity.

Mouthpiece No. 1, After the First Filing

The fourth partial was the strongest partial in the strong area. The second, third, and fifth partials were of almost the same intensity. The eighth was unusually strong and showed up stronger than any partial in any of the cases. The eighth partial was even stronger than the third partial. After the tenth, the partials decreased in intensity. There were five partials in the medium area and six in the weak range.

Mouthpiece No. 2, Built Up

This case was unusual in that the fourth partial was the strongest of all the partials on this graph. The third partial was the second strongest. Within the first five partials, there was an increase in relative intensity when compared with the same partials in the other five cases. There were five partials in the medium range and five in the weak range. The first five partials were in the strong area.

Mouthpiece No. 2, Unaltered

The third partial was the strongest of the partials, and there were two partials in the weak area. The fourth and fifth partials were at the same intensity level. This

case showed the strongest upper partials, even though most of them were in the low-medium range. When compared with the first unaltered mouthpiece, this case showed a more complex spectral display, with stronger upper partials. The first five partials were in the strong area.

Mouthpiece No. 2, After the Second Filing

The third partial was the strongest and the fourth, fifth, and sixth were of about the same intensity. The ninth through the fifteenth partials were generally of the same intensity.

Comparisons and Trends

The most noticeable thing about this graph was the trend of the built-up mouthpiece to display stronger second, third, and especially fourth partials. The first mouthpiece, after the first filing, showed unusually strong eighth and ninth partials. Generally, all cases displayed a decrease in intensity after the fifth partial. The seventh partial was more characteristic of this last statement. The second mouthpiece, after the second filing, had the most gradual decrease in intensity until it leveled out at the ninth partial.

Subject C, Note *b*[1]

Mouthpiece No. 1, Unaltered

Partials two, three, four, and five were very strong. This case had more stronger partials than any of the other cases in this graph, even though eleven of the partials were in the medium area. Only the sixteenth partial was below minus forty decibels.

Mouthpiece No. 1, After the First Filing

The most noticeable aspect of this case was that the second partial, instead of the third partial, was the strongest. The fifth partial was the second strongest; and beginning with the eighth partial, each subsequent partial was weak. There was, however, a slight format region between the tenth and the sixteenth partials. There were nine weak partials, four medium, and two strong.

Mouthpiece No. 2, Built Up

The second and third partials were of almost the same intensity, but the third was slightly stronger than the second. The fifth partial was the next strongest. There was a gradual decrease in intensity from the sixth to the fourteenth partials. There was no sixteenth partial.

Mouthpiece No. 2, Unaltered

This case showed stronger third and sixth partials than any other case in this graph, even though there were eight partials in the weak range. Generally, this case appeared more closely equal in partial intensity than the other cases. The upper partials were strong, but the characteristic third and fifth partials were also strong.

Mouthpiece No. 2, After the First Filing

Thirteen partials appeared in the medium range. All partials except the second and sixteenth were in the medium area. Even the sixteenth partial was not very weak. Partials three, four, and five were strong and dropped in intensity with the sixth partial. The intensity of the remaining partials leveled off at this point.

Mouthpiece No. 2, After the Second Filing

The third, fourth, and fifth partials were in the strong area. The partial structure, in general, resembled the first unaltered mouthpiece. Four partials were in the weak area and eight were in the medium range. The first nine partials were of almost the same intensity as the same partials of the first unaltered mouthpiece.

Comparisons and trends

Four of the six cases had strong second partials. In two of the cases, the second partial was stronger than

the third partial. The partial structure of the first unaltered mouthpiece resembled that of the second mouthpiece, after the second filing. There was a general trend for the upper partials of the second mouthpiece, after the second filing, to be less intense than the first mouthpiece, unaltered. The first five partials were the strongest shown in all cases.

Subject A, Note *f*-sharp^2

Mouthpiece No. 1, Unaltered

All partials, except the second and fourth, were significantly stronger than the other partials in the remaining five cases. The third and fifth partials were the strongest. There were five partials in the strong area, nine in the medium, and one in the weak range. The tenth partial was unusually strong. After the tenth partial, the intensity level dropped significantly.

Mouthpiece No. 1, After the First Filing

The second and fourth partials were stronger than the third and fifth partials. The sixth, seventh, and eighth partials had the same intensity level. There were no other apparent trends. There were three partials in the strong area, five in the medium, and seven in the weak area.

Mouthpiece No. 2, Built Up

There were two partials in the weak range, six in the medium, and seven in the weak area. The second partial was the strongest of this case. The only trend that was apparent was that there was a general decrease in intensity beginning with the second partial.

Mouthpiece No. 2, Unaltered

All partials, except the second, showed a decrease in intensity. There were five strong partials, ten in the medium area, and none in the weak range. The second partial was the strongest, and the fifth was nearly the same intensity. There were no other consistent trends.

Mouthpiece No. 2, After the First Filing

The third partial was the strongest in this case. The fourth partial was the next strongest and the seventh partial was unusually strong. Other than the first unaltered mouthpiece, this case showed the strongest set of partials. The second and third partials were in the strong area, nine partials were in the medium area, and four in the weak range.

Mouthpiece No. 2, After the Second Filing

The second partial was the strongest of all of the partials on this graph. This case showed the most consistent decrease in intensity of partials beginning with the second partial. There were three partials in the

strong area, nine in the medium area, and one in the weak area. This case most resembled the spectral display of the first unaltered mouthpiece, except that this case showed a relatively weaker partial display.

Comparisons and trends

All second partials were in the strong area, except in the second mouthpiece, after the first filing. The most obvious and consistent trend was the dominance of the strength of the partials of the first unaltered mouthpiece over the other five cases. There were no other consistent trends.

Subject B, Note f-sharp²

Mouthpiece No. 1, Unaltered

The even-numbered partials were stronger than the odd-numbered ones through the sixth partial. After the sixth partial, this case had the strongest partials of any of the cases shown on the graph. There were three in the strong area, ten in the medium area, and two in the weak range.

Mouthpiece No. 1, After the First Filing

The first six partials were in the strong area, and the third through the sixth partials were of nearly the same intensity. There was a general decrease in intensity of partials beginning with the fifth partial.

Mouthpiece No. 2, Built Up

The second and sixth partials were the strongest in this case. There were no consistent trends in the spectral display other than a general decrease in intensity after the sixth partial. There were eight partials in the weak area, two in the medium, and five in the strong area.

Mouthpiece No. 2, Unaltered

From the first to the sixth partial there was a general increase in intensity of partials when compared with the first unaltered mouthpiece. Beginning with the seventh partial, the opposite was true when comparing the same two cases. There were five strong partials, one medium, and nine weak partials. All partials from the eighth on were in the weak area.

Mouthpiece No. 2, After the First Filing

There were more weak partials in this case than in the other five cases. There were four in the strong area, one in the medium, and ten in the weak range. The second partial was the strongest of all partials shown on the graph. The even-numbered partials were generally stronger than the odd-numbered ones.

Mouthpiece No. 2, After the Second Filing

The most consistent and obvious trend shown on the graph was the relative decrease in partial intensity of

each partial when this case was compared with the first unaltered mouthpiece.

Comparisons and trends

All cases showed the second and third partials in the strong area. The even-numbered partials were generally stronger than the odd-numbered ones. There was an obvious relative decrease in partial intensity of each partial when the second mouthpiece, after the second filing, was compared with the first unaltered mouthpiece.

Subject C, Note <u>f</u>-sharp^2

<u>Mouthpiece No. 1, Unaltered</u>

Five partials appeared in the strong area, nine in the medium, and one in the weak range. This case showed partials five, seven, nine, ten, eleven, twelve, thirteen, and fourteen to be far above any of the partials of the same number in the five other cases. This fact is noticeable in the graphs of all three subjects. All odd-numbered partials appeared stronger in this case than in the others. The third partial was the strongest.

<u>Mouthpiece No. 1, After the First Filing</u>

There was a dramatic gain in the number of partials that fell in the weak area. There were nine in this area, four in the medium, and two in the strong area. The second partial was the strongest and there was a trend toward the

even-numbered partials being stronger than the odd-numbered partials in this case.

Mouthpiece No. 2, Built Up

In the strong range four partials appeared, two appeared in the medium range, and nine in the weak range. All but three partials showed an increase in intensity when compared with the partials of the first mouthpiece, after the first filing. The second partial was the strongest partial, and the fourth and fifth partials were of almost the same intensity. The third partial was second strongest in intensity.

Mouthpiece No. 2, Unaltered

There was a noticeable increase in the number of weak partials. Beginning with the sixth partial, all of the partials were in the weak area. There was no similarity between the spectral display in this case and the first unaltered mouthpiece. The second partial was the strongest. The third and fourth partials were at approximately the same intensity level.

Mouthpiece No. 2, After the First Filing

The second partial was stronger in this case than any second partials in the other five cases. The third partial was the next strongest, and the fourth and fifth partials were at the same intensity level. The upper

partials were stronger in this case than in all cases, except the first unaltered mouthpiece. There were two partials in the strong area, seven in the medium, and five in the weak range.

Mouthpiece No. 2, After the Second Filing

This was the only case that showed a stronger third partial than the second. It also had the strongest fourth partial. When compared with the first unaltered mouthpiece, there was a definite decrease in intensity levels of all partials, except the second and fourth partials. Four partials were in the strong area, three in the medium, and eight in the weak area.

Comparisons and trends

The most striking aspect about this graph was the relative strength of all partials in the first unaltered mouthpiece when compared to the other five cases. The second mouthpiece that was built up seemed to increase in partial intensity when compared with the first mouthpiece, after the first filing. All cases showed the second and third partials in the strong area, and all but one case showed the second partial to dominate the spectral display. The second mouthpiece, after the second filing, showed a decrease in the intensity level of most partials when compared with the first unaltered mouthpiece. There were no similarities between the two unaltered mouthpieces.

Subject A, Note $\underline{b}^2$

Mouthpiece No. 1, Unaltered

The third partial of this case was the strongest of any of the other cases. This was also true of the fifth partial. This case was unusual in that the sixth, seventh, and eighth partials were in the strong area and gained in intensity instead of decreasing as seen in most of the other graphs. The tenth partial was unusually strong. There were nine partials in the strong area and six in the middle area.

Mouthpiece No. 1, After the First Filing

This case was the most unique of any case in this study. It had no partials in the medium or weak range. The second through the fifteenth partials were of the same intensity, with the exception of the fifth partial. The fifth partial was the same intensity as the second partial. The sixteenth partial was the weakest of the partials, but still had a relative intensity of minus eighteen decibels.

Mouthpiece No. 2, Built Up

Only the second partial appeared in the strong area in this case. Ten appeared in the medium area, and four appeared in the weak area. The third partial was weaker than any third partial of any other case

shown in this graph. The even-numbered partials were comparatively stronger than the odd-numbered ones.

Mouthpiece No. 2, Unaltered

The second partial was the strongest of the spectral display of this case. There was a dramatic drop in intensity between the second and third partials. This case had several of the weakest partials on the graph. This was true of the fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, and sixteenth partials. There were twelve partials in the weak area, two in the medium, and one in the strong area.

Mouthpiece No. 2, After the First Filing

This case had the greatest number of partials in the weak area. There were thirteen in the weak range, one in the medium, and one in the strong range. Only the second unaltered mouthpiece had weaker partials. From the fifth through the fifteenth partials, this case showed an increase in intensity when compared with the second unaltered mouthpiece.

Mouthpiece No. 2, After the Second Filing

There was a definite format from the fifth through the tenth partials and a definite decrease in intensity from the second through the sixth partials. The second partial was the strongest. There were no other trends.

Comparisons and trends

The first mouthpiece, after the first filing, was so radically different from any display in the study that it was presumed that there was a malfunction in the testing machinery. The second mouthpiece which was built up showed strong uneven numbered partials and had stronger upper partials than the second mouthpiece, after the second filing. All cases showed a strong second partial.

Subject B, Note $\underline{b}^2$

Mouthpiece No. 1, Unaltered

The second partial was the strongest partial. There was a sharp decrease in intensity so that by the fifth partial the intensity level had dropped to minus fifty-two decibels. This case had the greatest number of partials in the weak range and, beginning with the fifth partial, also had the weakest upper partials. There was one partial in the medium range (the third) and two in the strong area.

Mouthpiece No. 1, After the First Filing

There was a consistent decrease in the intensity of the partials beginning with the third through the seventh partial. The second and third partials were weaker than the first unaltered mouthpiece. The distribution of the number of partials in the ranges was the

same as the first unaltered mouthpiece. There were no other trends.

Mouthpiece No. 2, Built Up

This case had an unusual number of strong upper partials. Beginning with the fourth partial, all but the seventh displayed partials that were stronger than the other five cases. The second partial was the strongest. The fifth through the fifteenth partials were generally equal in relative intensity levels. There were two partials in the strong area, twelve in the medium, and one in the weak area.

Mouthpiece No. 2, Unaltered

The second, third, and fourth partials were stronger in this case than in any of the other cases. Partials decreased in intensity until the sixth partial. From there through the sixteenth partial the even-numbered partials were stronger than the odd-numbered partials. There were no other consistent trends or patterns. There were two partials in the strong area, four in the medium, and nine in the weak range.

Mouthpiece No. 2, After the First Filing

Partial number five was stronger in this case than in any of the other cases. The second partial was the strongest partial in this case. Generally, the even-numbered upper partials were stronger than the odd-

numbered partials. There was a consistent decline in the intensity of the partials until the sixth partial. From the eighth partial there was a format area through the twelfth partial.

Mouthpiece No. 2, After the Second Filing

The most consistent trend was that the upper partials were very strong and second in intensity only to the second mouthpiece, which was built up. From the fourth partial through the sixteenth partial this case had stronger partials when compared with the first mouthpiece, after the first filing.

Comparisons and trends

All cases had very strong second partials and the intensity level declined rapidly after this partial. The second mouthpiece, which was built up, displayed comparatively strong upper partials. The upper partials of the second mouthpiece after the second filing were stronger when compared with the partials of the first mouthpiece, after the first filing.

Subject C, Note $\underline{b}^2$

Mouthpiece No. 1, After the First Filing

The second partial was stronger than the others shown for this case. The third partial was the next strongest and was the only other partial to be within the

strong range. This case had more partials in the weak area than any other case. There were twelve partials in the weak area, and one in the medium. Generally, each partial decreased in intensity until the eighth. At this point, there was a format area through the eleventh partial.

Mouthpiece No. 2, Built Up

The second and third partials were the strongest of the partials, and both partials were weaker than the previous case, but the remaining partials were all stronger than the previous case. From the seventh partial through the sixteenth, this case showed the strongest partials on the graph. There was one partial in the strong area, nine in the medium, and five in the weak range.

Mouthpiece No. 2, Unaltered

Partial number seven was unusually strong in this case. This was evident from the comparative intensity of the sixth and eighth partials. The second and third partials were weaker than the first unaltered mouthpiece, but all of the remaining partials were stronger. There were two partials in the strong area, three in the medium range, and ten in the weaker range.

Mouthpiece No. 2, After the First Filing

The second partial was the strongest of this case. The third partial was weaker than any third partial shown

on this graph. The upper partials were unusually strong, but not as strong as the second mouthpiece that was built up. There was one partial in the strong area, nine in the medium, and five in the weak area.

Mouthpiece No. 2, After the Second Filing

This case had the strongest second and third partials shown on the graph. There was a consistent decrease in partial intensity to the fifth partial and then another from the sixth to the ninth. All partials from the fourth through the twelfth were stronger than the first unaltered mouthpiece.

Comparisons and trends

All cases displayed a strong second partial. The second mouthpiece that was built up displayed the strongest upper partials. The upper partials of the second mouthpiece, after the second filing, were stronger than the first unaltered mouthpiece. The two unaltered mouthpieces displayed dissimilar spectrums

SUMMARY OF SPECTRAL ANALYSIS

The spectral display of partials differed for each note, but each note showed similar tendencies for the three subjects. For example, the low e showed the greatest number of strong partials. The third and fifth

partials were the strongest for any of the test notes. Partial intensity decreased gradually as the notes ascended. For instance, the partials for low e from the lowest number to the highest number decreased in intensity more gradually than for c^1. This was also true for each subsequent test note. Each subject showed a slightly different spectral display on each mouthpiece for each note.

Generally, the second partial became stronger as the fifth partial became weaker. This tendency began with b^1 and continued as the test notes ascended in frequency.

CHAPTER VI

INTONATION AND RESPONSE ANALYSIS

Mouthpiece No. 1, Unaltered

Subjects A, B, and C had no trouble playing the test notes in tune to a Stroboconn set at A-440 pitch on Mouthpiece No. 1, Unaltered, with the barrel joint pulled out one millimeter and the temperature remaining between 76° and 78° Fahrenheit. Response was satisfactory.

Mouthpiece No. 1, After the First Filing

Subject A found e to be four cents sharp, and c^1 to be four cents sharp on this mouthpiece, with the barrel joint pulled out two millimeters and the temperature at 78°F. With the exception of b^2, which was three cents sharp, the rest of the notes were in tune to A-440. Subject A reported that he was lipping down more than usual to get the notes in tune and in some cases he was not able to get any closer in tune than four cents. Subject A reported that this mouthpiece was exceedingly hard to blow and that the tone sounded very airy to him.

With the temperature at 76°F and the barrel joint pulled out one millimeter, Subject B had to lip down on a^1 and b^1. The amount of lipping was said to be about

four cents in order to play the test notes in tune. This subject reported that the mouthpiece was difficult to blow, and that the tone sounded stuffy to him.

Subject C found that e was five cents sharp with the barrel joint pulled out one millimeter and the temperature at 77°F. He stated that this mouthpiece was difficult to blow and that the tone sounded stuffy to him. This subject made the statement that he was starting to adjust to the needed lipping near the end of the test.

Mouthpiece No. 2, Built Up

Subject A found the following notes to be sharp: b^1, four cents; f-sharp^2, two cents; b^2, eight cents. The barrel joint was pulled out one and one-half millimeters, the middle joint was pulled out two-tenths of a millimeter, and the temperature was at 77°F. This subject stated that this mouthpiece was easier to blow, but was unstable on b^2.

Subject B found the following notes to be sharp: b^1, four cents; f-sharp^2, three cents; b^2 six cents. He found a^1 to be two cents flat. The response was said to be satisfactory, except that this subject said that he had to blow with greater force in order to achieve an eight-volt volume control. The barrel joint was pulled out one and one-half millimeters, the middle joint was pulled out two-tenths of a millimeter, and the temperature was at 77°F.

Subject C stated that b^1 was four cents sharp, f-sharp^2 was three cents sharp, and b^2 was four cents

sharp. The intonation of the other test notes was satisfactory. For this case, the temperature and joint adjustments were the same as for Subject B.

Mouthpiece No. 2, Unaltered

Subject A found the following notes sharp: $\underline{c}^1$, two cents; $\underline{b}^1$, five cents; $\underline{b}^2$, six cents. The barrel joint was pulled out one and one-half millimeters, the middle joint was pulled out two-tenths of a millimeter, and the temperature remained steady. Response of this mouthpiece was said to be satisfactory.

Subject B stated that $\underline{e}$ and $\underline{a}^1$ were flat by five cents and that $\underline{b}^2$ was sharp by four cents. Response was satisfactory with room temperature and the amount of adjustment of the barrel and middle joints being the same as for Subject A.

Subject C found notes $\underline{c}^1$ and $\underline{b}^1$ flat by two cents, and $\underline{b}^2$ sharp by three cents. Temperature and barrel and middle joint adjustments were the same for this case. This subject stated that this mouthpiece was easier to blow than the others tested so far.

Mouthpiece No. 2, After the First Filing

Subject A was two cents sharp on $\underline{a}^1$, $\underline{b}^1$, and twelve cents sharp on $\underline{b}^2$. Subject A was four cents flat on $\underline{e}$. The response was satisfactory with the barrel joint pulled out one and one-half millimeters and the middle joint pulled out two-tenths of a millimeter.

Subject B found the following notes to be flat: e, seven cents; c^1, four cents; a^1, seven cents; b^1, two cents; f-sharp^2, three cents. The last note, b^2 was twelve cents sharp. Subject B stated that he thought the sound was dull. The barrel joint was pulled out one millimeter and the temperature was at 76°F.

Subject C found the following notes to be flat: e, eight cents; c^1, four cents; b^1, three cents; f-sharp^2, two cents. The note b^2 was six cents sharp. Subject C stated that the tone was more stuffy than the built up mouthpiece and that the response was more sluggish. The adjustment of joints and the temperature was the same as the other two subjects for this case.

Mouthpiece No. 2, After the Second Filing

Subject A stated that the following notes were sharp: c^1, three cents; b^1, three cents; f-sharp^2, six cents; b^2, eight cents. The low e was three cents flat. The temperature was at 79°F. The mouthpiece was pulled out one and one-half millimeters. Subject A stated that this mouthpiece responded better in all registers and better than any of the previous cases tested.

Subject B was flat on the following notes: e, seven cents; c^1, three cents; and b^1, two cents. The b^2 was thirteen cents sharp. Temperature remained steady and the adjustment of the clarinet joints was the same as for

Subject A. The response was said to be better and the tone to be less stuffy.

Subject C was flat on e, four cents; c^1, three cents; a^1 three cents; and b^1, three cents. The note b^2 was three cents sharp. Temperature and joint adjustments were the same as for Subject A in this case. Subject C stated that this mouthpiece was very free-blowing and was not stuffy.

SUMMARY OF INTONATION AND RESPONSE ANALYSIS

The three subjects had no intonation problems with the first unaltered mouthpiece. The response was said to be satisfactory.

Each subject found that the first mouthpiece, after being filed once, responded poorly. They agreed that this mouthpiece was difficult to blow and all used the word "stuffy" to describe the response.

When the second mouthpiece was built up with bonding clay to the measurements given in Appendix A, the three subjects found that there was a general rise in pitch on b^1, f-sharp^2, and b^2. The three subjects did not agree on the response of this mouthpiece.

The second mouthpiece, listed as MP2U, presented problems for all three subjects. Each subject had intonation difficulties with different notes. The subjects agreed that the response was satisfactory.

The second alteration of the second mouthpiece, listed in Appendix A as MP2AFF, also presented intonation problems for the three subjects. Two of the subjects found the pitch to be lower, and one of the subjects found certain notes to be sharp. The subjects did not agree on the response of the mouthpiece at this point.

When the second mouthpiece was filed for the second time, MP2ASF, one subject had several sharp notes, and the other two subjects had several flat notes. The three subjects agreed that the response of this mouthpiece was improved and better than any tested to this point.

Altering the baffle of the clarinet mouthpiece did affect the test notes in terms of intonation and response. The effects were different for each individual. However, each subject had his own problem notes. These notes had similar tendencies in terms of intonation for each mouthpiece. Building up the mouthpiece with bonding clay to the measurements listed in Appendix A resulted in a generally raised pitch. Filing the baffle of the second mouthpiece, MP2ASF, to the measurements listed in Appendix C resulted in a free-blowing and responsive mouthpiece.

The testing equipment malfunctioned on Subject A, note $\underline{b}^2$ for Mouthpiece No. 1, After the First Filing, and for Subject B, note $\underline{b}^2$ on Mouthpiece No. 2, Built Up. This is shown on the graphs on pages 123 and 124.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

After analyzing partial spectrums of the three subjects involved in this study with the intent of discovering whether or not there were any trends that could be predicted, the following statements are presented in order to summarize the data developed herein.

The spectral display of partials differed for each note played, but each note showed similar tendencies for the three subjects. For example, low e showed the greatest number of strong partials for all three subjects. Also, partial intensity decreased gradually as the notes ascended. For instance, the partials for low e, from the lowest numbered to the highest numbered, decreased more gradually than for c^1.

Each alteration of the mouthpiece produced a slightly different spectral display for each subject. The most consistent trend was that the second mouthpiece, after the second filing, showed a decrease in the relative intensity of its partials when compared with the first unaltered mouthpiece.

The second mouthpiece, which was built up, generally showed stronger upper partials when comapred with the first

unaltered mouthpiece. The second mouthpiece, listed as MP2ASF, had more weaker partials when compared with the first unaltered mouthpiece. There were fewer intonation problems with the first unaltered mouthpiece than with the others.

The second mouthpiece, which was built up with bonding clay to the measurements given in Appendix A, was found to be generally sharper than the other cases.

The response of the first mouthpiece, listed as MP1AFF, was said to be extremely "stuffy" by the three subjects. Therefore, this mouthpiece was discarded.

The three subjects agreed that the response of the second mouthpiece, listed as MP2ASF, was better than any tested.

From these summarized findings certain conclusions can be drawn.

1. Two mouthpieces bearing the same manufacturer's number do not necessarily have precisely the same baffle measurements.

2. Altering the baffle of the clarinet did affect the test notes in terms of intonation and response, and the effects were different for each individual.

3. Each subject had certain notes that tended to be difficult to tune for each alteration. These problems

notes varied for each subject, but sometimes reoccurred as an intonation problem for more than one case.

4. The mouthpiece that was built up with bonding clay to the specifications listed in Appendix A under the code of MP2BU resulted in a generally raised pitch.

5. The third alteration to the second mouthpiece, which is listed in Appendix A as MP2ASF, resulted in a free-blowing and responsive mouthpiece.

6. There is not enough conclusive evidence to prove that there is a relationship between the partial spectrums of the clarinet tones used in this study and intonation problems that resulted.

From the evidence presented in this study, it is recommended that further investigation should be made concerning the response of a mouthpiece and the increase and decrease of the relative intensity of its partials. It is hoped that the knowledge gained in this experiment may be used in some measure as a guide for further study, and as an aid in the improvement of tone quality, intonation, and response of clarinet mouthpieces.

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APPENDIX A

Baffle Measurements of Clarinet Mouthpieces

Mouthpiece Code	Horizontal Point 1 at Vertical Point 1
MP1U	.040
MP1AFF	.036
MP2BU	.054
MP2U	.039
MP2AFF	.038
MP2ASF	.036

Mouthpiece Code	Horizontal Point 2 at Vertical Point 1
MP1U	.075
MP1AFF	.035
MP2BU	.075
MP2U	.071
MP2AFF	.062
MP2ASF	.061

	Horizontal Point 3 at Vertical Point 1
MP1U	.087
MP1AFF	.063
MP2BU	.084
MP2U	.082
MP2AFF	.067
MP2ASF	.065

	Horizontal Point 4 at Vertical Point 1
MP1U	.101
MP1AFF	.099
MP2BU	.089
MP2U	.084
MP2AFF	.072
MP2ASF	.071

	Horizontal Point 5 at Vertical Point 1
MP1U	.105
MP1AFF	.090
MP2BU	.101
MP2U	.095
MP2AFF	.082
MP2ASF	.080

	Horizontal Point 6 at Vertical Point 1
MP1U	.137
MP1AFF	.100
MP2BU	.131
MP2U	.102
MP2AFF	.089
MP2ASF	.086

	Horizontal Point 1 at Vertical Point 2
MP1U	.068
MP1AFF	.038
MP2BU	.058
MP2U	.054
MP2AFF	.048
MP2ASF	.046

	Horizontal Point 1 at Vertical Point 2
MP1U	.077
MP1AFF	.052
MP2BU	.072
MP2U	.069
MP2AFF	.065
MP2ASF	.065

	Horizontal Point 3 at Vertical Point 2
MP1U	.089
MP1AFF	.054
MP2BU	.095
MP2U	.078
MP2AFF	.071
MP2ASF	.070

	Horizontal Point 4 at Vertical Point 2
MP1U	.097
MP1AFF	.076
MP2BU	.097
MP2U	.084
MP2AFF	.078
MP2ASF	.075

	Horizontal Point 5 at Vertical Point 2
MP1U	.111
MP1AFF	.087
MP2BU	.099
MP2U	.095
MP2AFF	.087
MP2ASF	.087

	Horizontal Point 6 at Vertical Point 2
MP1U	.107
MP1AFF	.089
MP2BU	.107
MP2U	.095
MP2AFF	.093
MP2ASF	.092

	Horizontal Point 1 at Vertical Point 3
MP1U	.067
MP1AFF	.043
MP2BU	.057
MP2U	.054
MP2AFF	.046
MP2ASF	.046

	Horizontal Point 2 at Vertical Point 3
MP1U	.081
MP1AFF	.056
MP2BU	.091
MP2U	.067
MP2AFF	.065
MP2ASF	.064

	Horizontal Point 3 at Vertical Point 3
MP1U	.091
MP1AFF	.067
MP2BU	.091
MP2U	.078
MP2AFF	.075
MP2ASF	.072

	Horizontal Point 4 at Vertical Point 3
MP1U	.103
MP1AFF	.079
MP2BU	.089
MP2U	.084
MP2AFF	.082
MP2ASF	.079

	Horizontal Point 5 at Vertical Point 3
MP1U	.092
MP1AFF	.103
MP2BU	.092
MP2U	.089
MP2AFF	.088
MP2ASF	.085

	Horizontal Point 6 at Vertical Point 3
MP1U	.107
MP1AFF	.100
MP2BU	.110
MP2U	.097
MP2AFF	.095
MP2ASF	.095

	Horizontal Point 1 at Vertical Point 4
MP1U	.068
MP1AFF	.047
MP2BU	.061
MP2U	.061
MP2AFF	.053
MP2ASF	.051

	Horizontal Point 2 at Vertical Point 4
MP1U	.083
MP1AFF	.058
MP2BU	.079
MP2U	.069
MP2AFF	.062
MP2ASF	.062

	Horizontal Point 3 at Vertical Point 4
MP1U	.093
MP1AFF	.678
MP2BU	.095
MP2U	.080
MP2AFF	.073
MP2ASF	.069

	Horizontal Point 4 at Vertical Point 4
MP1U	.098
MP1AFF	.081
MP2BU	.100
MP2U	.087
MP2AFF	.080
MP2ASF	.077

	Horizontal Point 5 at Vertical Point 4
MP1U	.106
MP1AFF	.095
MP2BU	.104
MP2U	.093
MP2AFF	.087
MP2ASF	.084

	Horizontal Point 6 at Vertical Point 4
MP1U	.105
MP1AFF	.096
MP2BU	.112
MP2U	.098
MP2AFF	.094
MP2ASF	.093

	Horizontal Point 1 at Vertical Point 5
MP1U	.068
MP1AFF	.049
MP2BU	.067
MP2U	.060
MP2AFF	.052
MP2ASF	.051

	Horizontal Point 2 at Vertical Point 5
MP1U	.081
MP1AFF	.061
MP2BU	.081
MP2U	.071
MP2AFF	.064
MP2ASF	.062

	Horizontal Point 3 at Vertical Point 5
MP1U	.090
MP1AFF	.069
MP2BU	.090
MP2U	.082
MP2AFF	.077
MP2ASF	.069

	Horizontal Point 4 at Vertical Point 5
MP1U	.095
MP1AFF	.083
MP2BU	.097
MP2U	.087
MP2AFF	.082
MP2ASF	.077

	Horizontal Point 5 at Vertical Point 5
MP1U	.106
MP1AFF	.088
MP2BU	.106
MP2U	.095
MP2AFF	.087
MP2ASF	.083

	Horizontal Point 6 at Vertical Point 5
MP1U	.108
MP1AFF	.101
MP2BU	.115
MP2U	.101
MP2AFF	.095
MP2ASF	.095

	Horizontal Point 1 at Vertical Point 6
MP1U	.065
MP1AFF	.049
MP2BU	.062
MP2U	.060
MP2AFF	.053
MP2ASF	.050

	Horizontal Point 2 at Vertical Point 6
MP1U	.078
MP1AFF	.060
MP2BU	.079
MP2U	.070
MP2AFF	.063
MP2ASF	.051

	Horizontal Point 3 at Vertical Point 6
MP1U	.089
MP1AFF	.071
MP2BU	.092
MP2U	.093
MP2AFF	.073
MP2ASF	.069

	Horizontal Point 4 at Vertical Point 6
MP1U	.093
MP1AFF	.081
MP2BU	.097
MP2U	.087
MP2AFF	.080
MP2ASF	.075

	Horizontal Point 5 at Vertical Point 6
MP1U	.099
MP1AFF	.08[illegible]
MP2BU	.091
MP2U	.090
MP2AFF	.08[illegible]
MP2ASF	.084

	Horizontal Point 6 at Vertical Point 6
MP1U	.104
MP1AFF	.099
MP2BU	.111
MP2U	.100
MP2AFF	.093
MP2ASF	.093

	Horizontal Point 1 at Vertical Point 7
MP1U	.062
MP1AFF	.046
MP2BU	.062
MP2U	.057
MP2AFF	.053
MP2ASF	.050

	Horizontal Point 2 at Vertical Point 7
MP1U	.077
MP1AFF	.059
MP2BU	.076
MP2U	.068
MP2AFF	.063
MP2ASF	.060

	Horizontal Point 3 at Vertical Point 7
MP1U	.087
MP1AFF	.067
MP2BU	.085
MP2U	.078
MP2AFF	.072
MP2ASF	.065

	Horizontal Point 4 at Vertical Point 7
MP1U	.089
MP1AFF	.085
MP2BU	.093
MP2U	.084
MP2AFF	.080
MP2ASF	.073

	Horizontal Point 5 at Vertical Point 7
MP1U	.097
MP1AFF	.086
MP2BU	.098
MP2U	.086
MP2AFF	.084
MP2ASF	.076

	Horizontal Point 6 at Vertical Point 7
MP1U	.100
MP1AFF	.095
MP2BU	.108
MP2U	.093
MP2AFF	.091
MP2ASF	.075

	Horizontal Point 1 at Vertical Point 8
MP1U	.056
MP1AFF	.044
MP2BU	.059
MP2U	.058
MP2AFF	.049
MP2ASF	.049

	Horizontal Point 2 at Vertical Point 8
MP1U	.094
MP1AFF	.052
MP2BU	.072
MP2U	.063
MP2AFF	.059
MP2ASF	.051

	Horizontal Point 3 at Vertical Point 8
MP1U	.077
MP1AFF	.063
MP2BU	.083
MP2U	.072
MP2AFF	.065
MP2ASF	.064

	Horizontal Point 4 at Vertical Point 8
MP1U	.084
MP1AFF	.072
MP2BU	.087
MP2U	.076
MP2AFF	.072
MP2ASF	.069

	Horizontal Point 5 at Vertical Point 8
MP1U	.089
MP1AFF	.082
MP2BU	.101
MP2U	.083
MP2AFF	.081
MP2ASF	.080

	Horizontal Point 6 at Vertical Point 8
MP1U	.094
MP1AFF	.091
MP2BU	.104
MP2U	.089
MP2AFF	.087
MP2ASF	.086

	Horizontal Point 1 at Vertical Point 9
MP1U	.052
MP1AFF	.034
MP2BU	.056
MP2U	.047
MP2AFF	.041
MP2ASF	.040

	Horizontal Point 2 at Vertical Point 9
MP1U	.064
MP1AFF	.045
MP2BU	.066
MP2U	.061
MP2AFF	.052
MP2ASF	.050

	Horizontal Point 3 at Vertical Point 9
MP1U	.070
MP1AFF	.054
MP2BU	.074
MP2U	.067
MP2AFF	.059
MP2ASF	.056

	Horizontal Point 4 at Vertical Point 9
MP1U	.078
MP1AFF	.065
MP2BU	.083
MP2U	.071
MP2AFF	.065
MP2ASF	.060

	Horizontal Point 5 at Vertical Point 9
MP1U	.087
MP1AFF	.075
MP2BU	.090
MP2U	.079
MP2AFF	.075
MP2ASF	.075

	Horizontal Point 6 at Vertical Point 9
MP1U	.088
MP1AFF	.083
MP2BU	.094
MP2U	.084
MP2AFF	.080
MP2ASF	.080

	Horizontal Point 1 at Vertical Point 10
MP1U	.047
MP1AFF	.037
MP2BU	.047
MP2U	.044
MP2AFF	.038
MP2ASF	.038

	Horizontal Point 2 at Vertical Point 10
MP1U	.046
MP1AFF	.043
MP2BU	.056
MP2U	.053
MP2AFF	.049
MP2ASF	.049

	Horizontal Point 3 at Vertical Point 10
MP1U	.066
MP1AFF	.052
MP2BU	.067
MP2U	.064
MP2AFF	.059
MP2ASF	.059

	Horizontal Point 4 at Vertical Point 10
MP1U	.072
MP1AFF	.061
MP2BU	.076
MP2U	.070
MP2AFF	.063
MP2ASF	.061

	Horizontal Point 5 at Vertical Point 10
MP1U	.087
MP1AFF	.071
MP2BU	.079
MP2U	.074
MP2AFF	.069
MP2ASF	.068

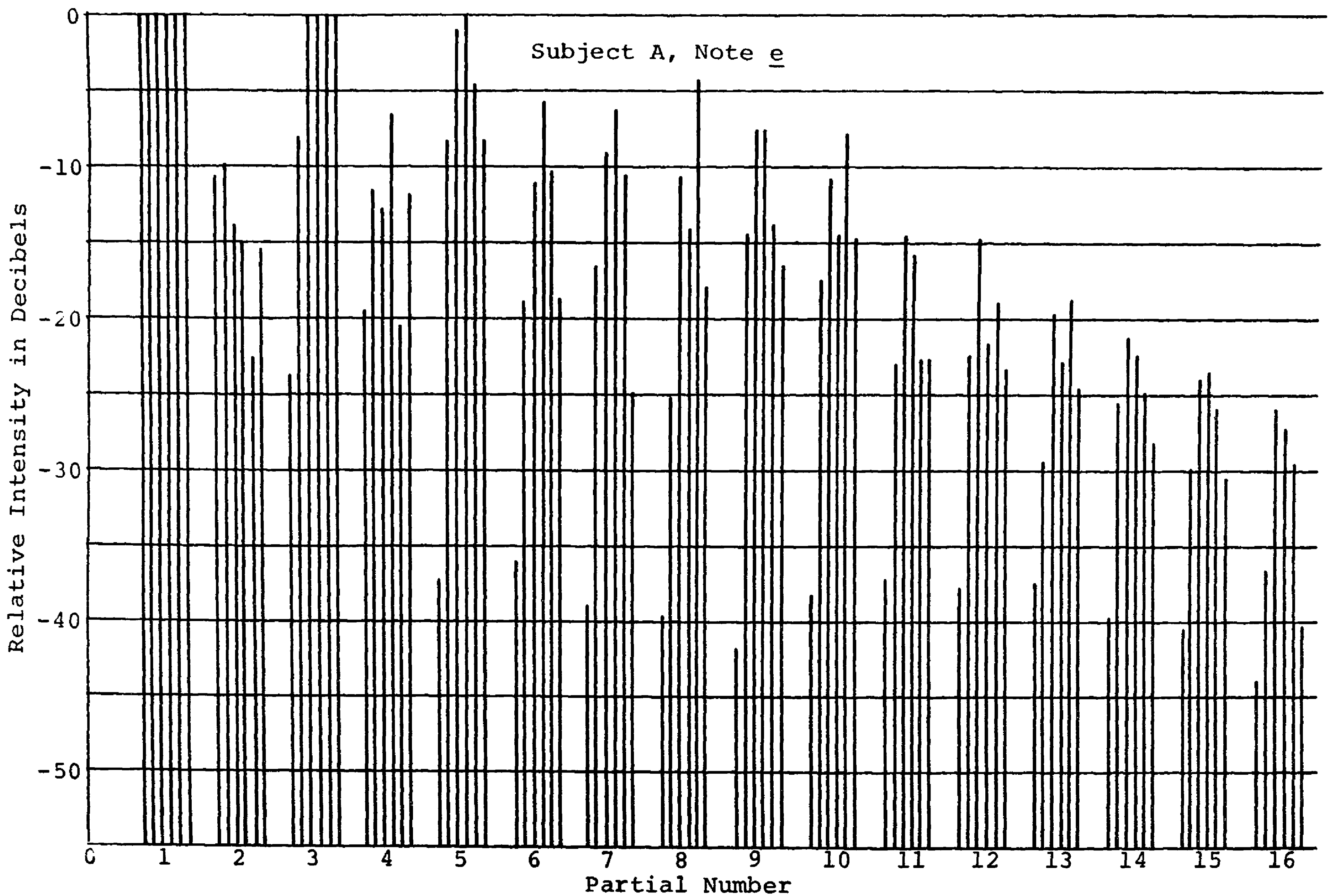
	Horizontal Point 6 at Vertical Point 10
MP1U	.089
MP1AFF	.079
MP2BU	.083
MP2U	.079
MP2AFF	.075
MP2ASF	.075

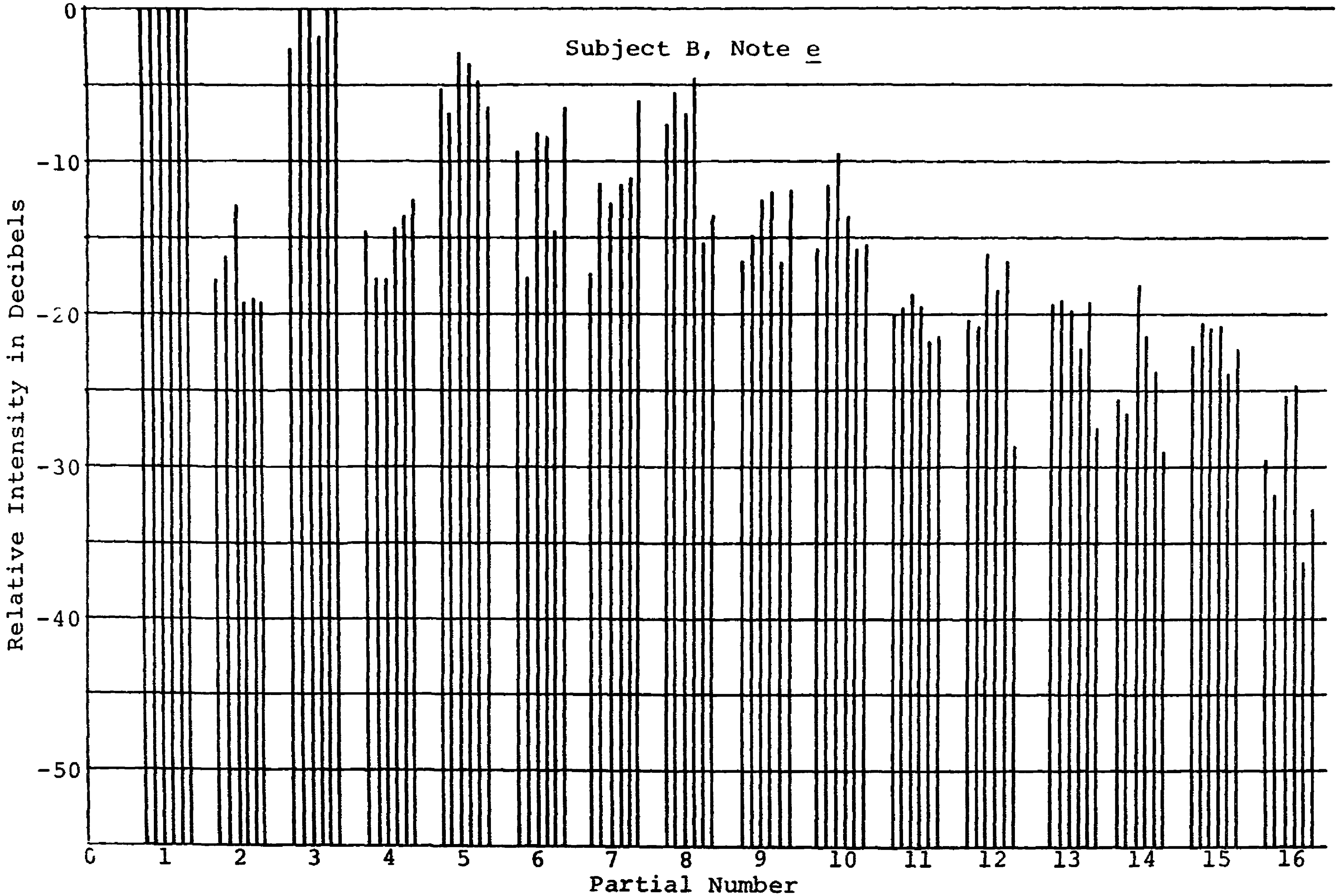
APPENDIX B

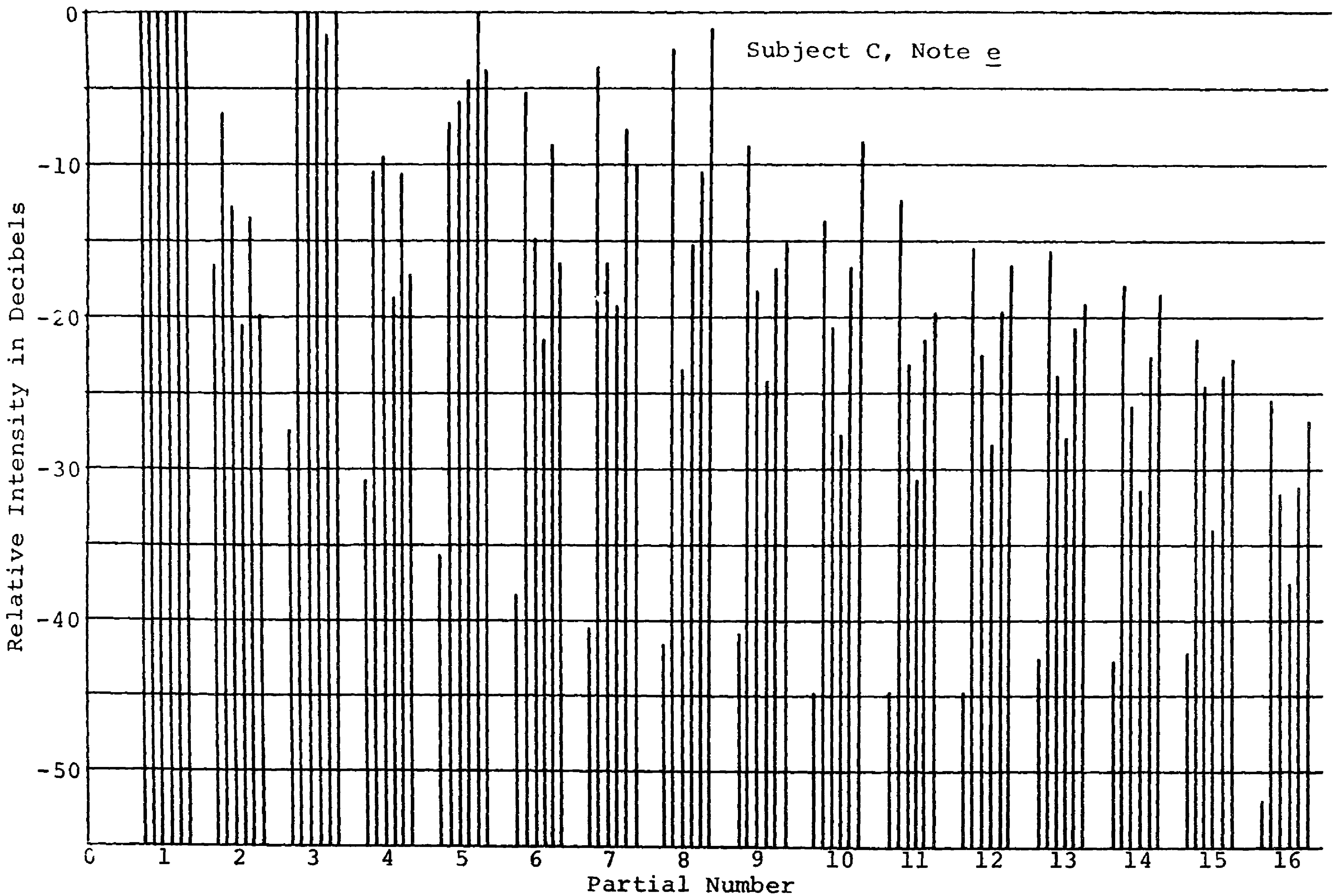
Graphs Showing Comparisons of Partial Spectrums Before and After Alterations

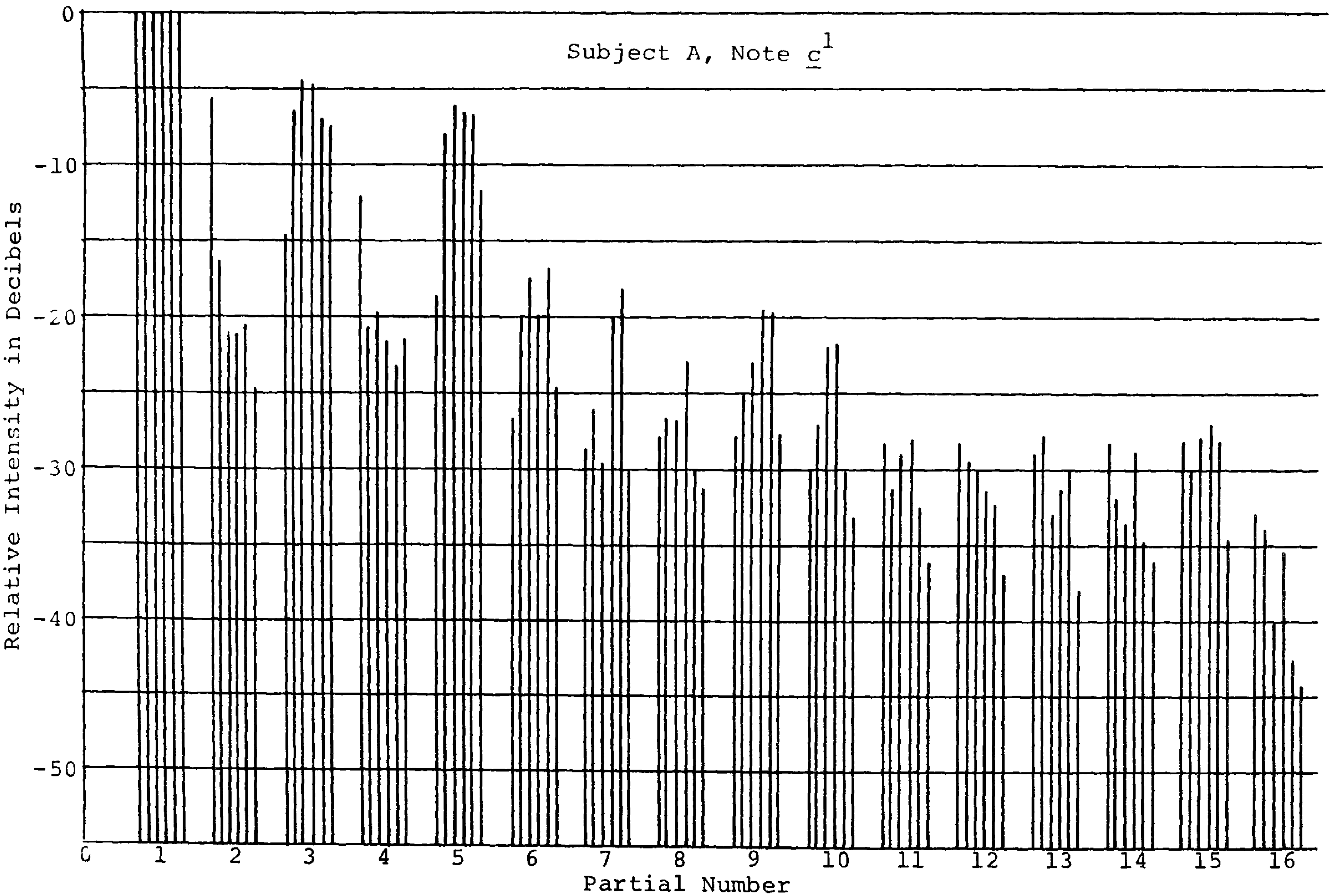
Each graph shows the sixteen partials of one subject playing one test note before and after each alteration. Each line above each partial represents a different case. The first partial represents the fundamental. The cases are in order from left to right and are as follows:

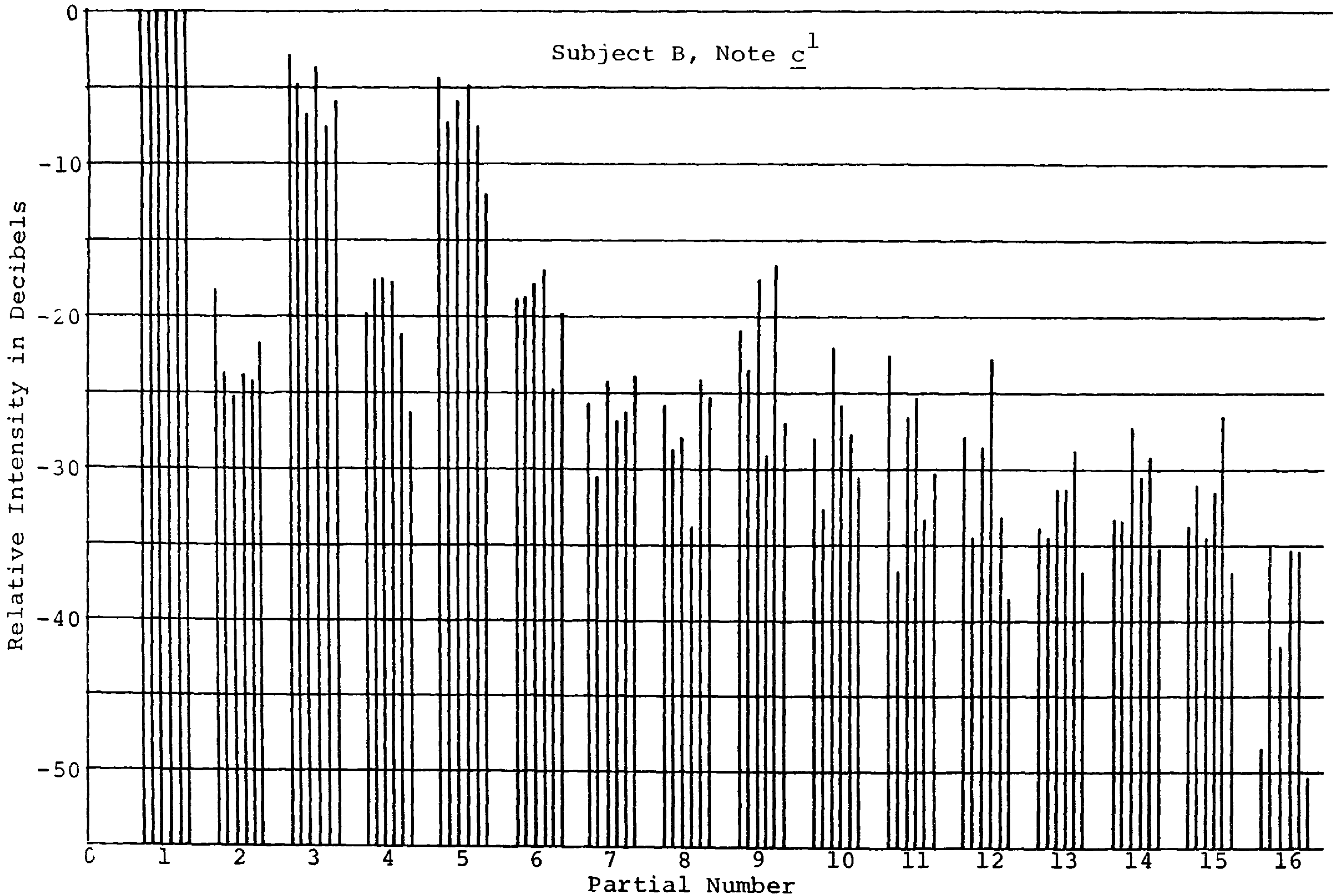
Mouthpiece No. 1, Unaltered
Mouthpiece No. 1, After the First Filing
Mouthpiece No. 2, Built Up
Mouthpiece No. 2, Unaltered
Mouthpiece No. 2, After the First Filing
Mouthpiece No. 2, After the Second Filing

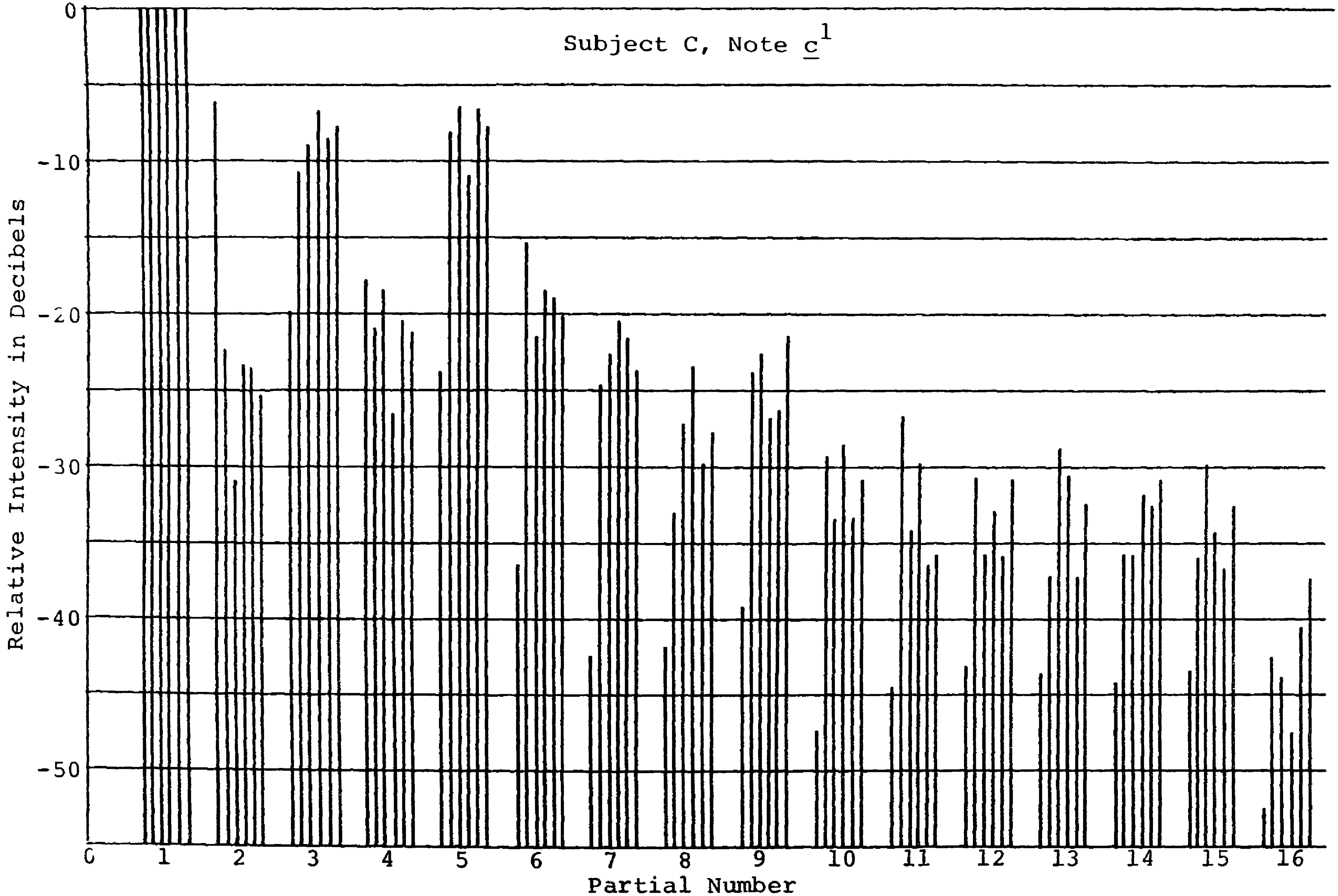

Subject A, Note e
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
Partial Number
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

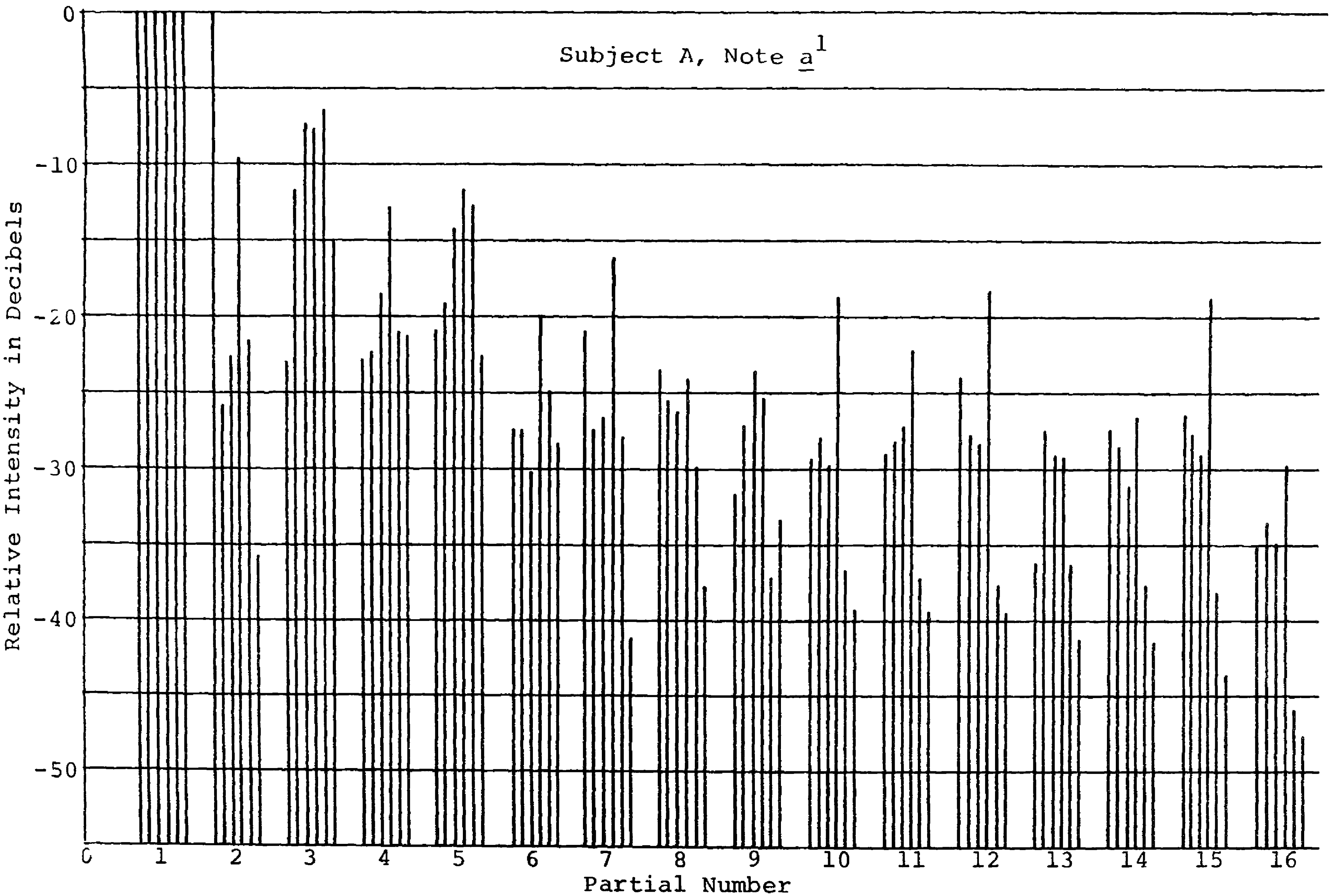

Subject B, Note e
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number

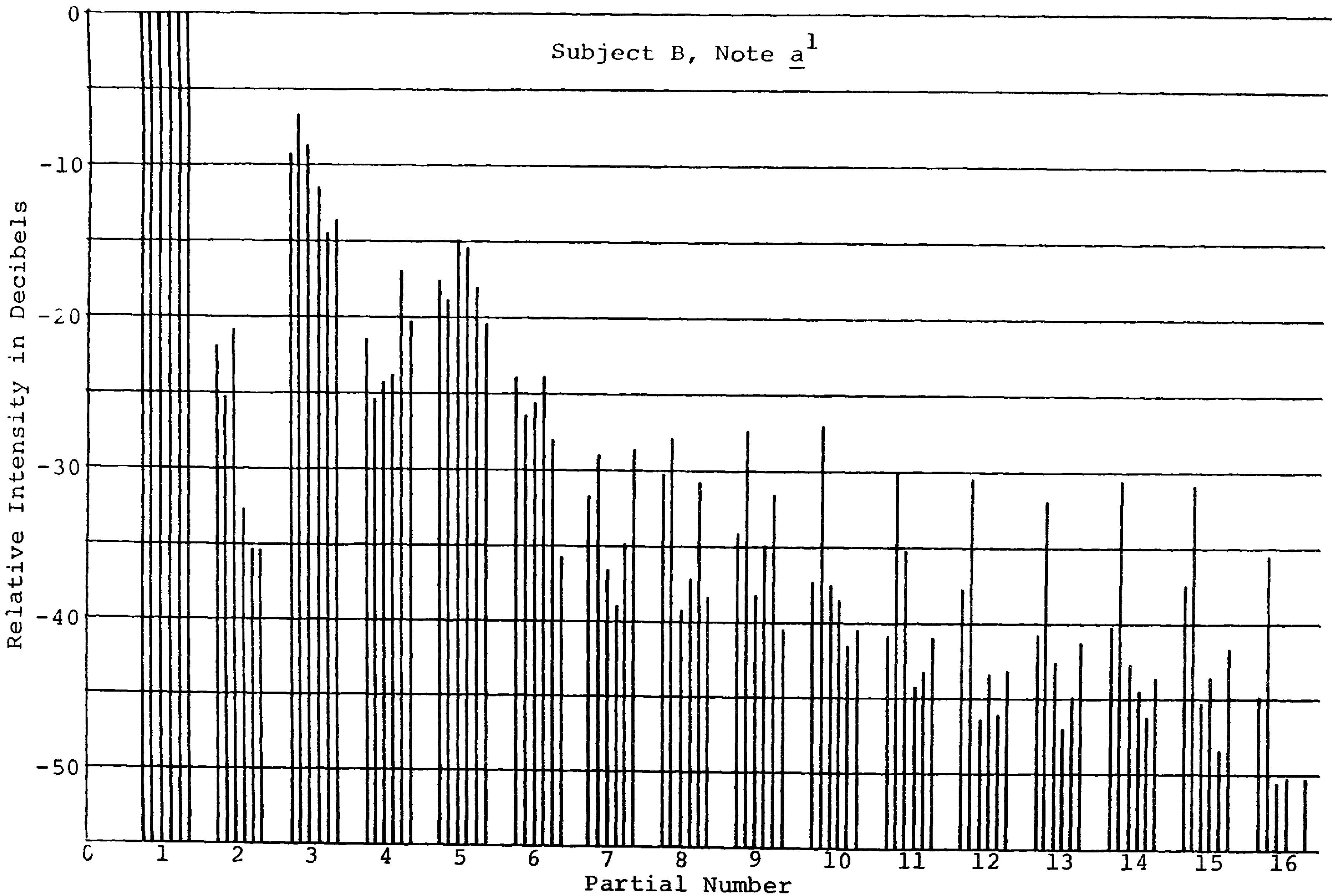

Subject C, Note e
0
-10
-20
-30
-40
-50
Relative Intensity in Decibels
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number


Subject A, Note c[1]
0
-10
-20
-30
-40
-50
Relative Intensity in Decibels
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number

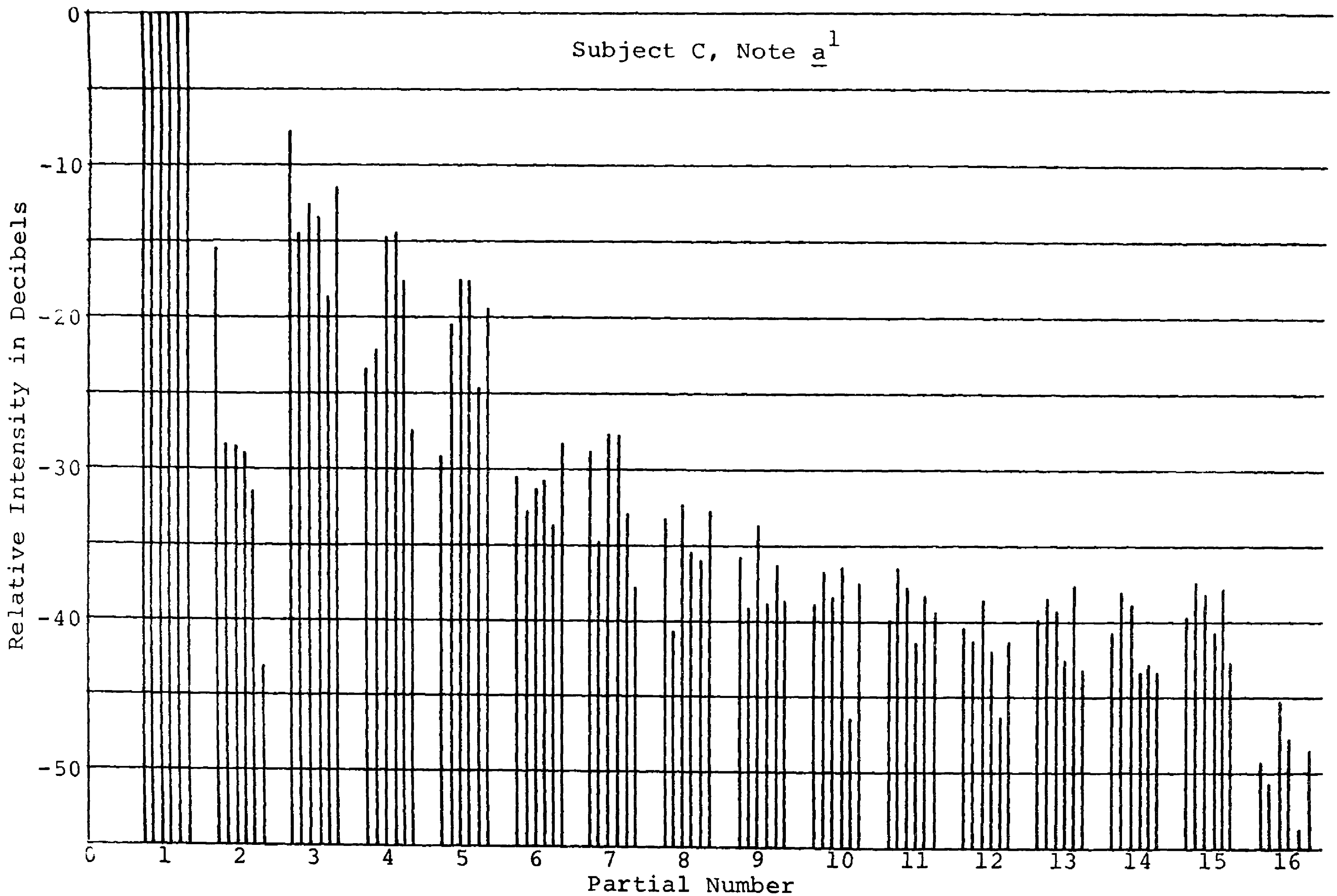

Subject B, Note c[1]
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
Partial Number
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

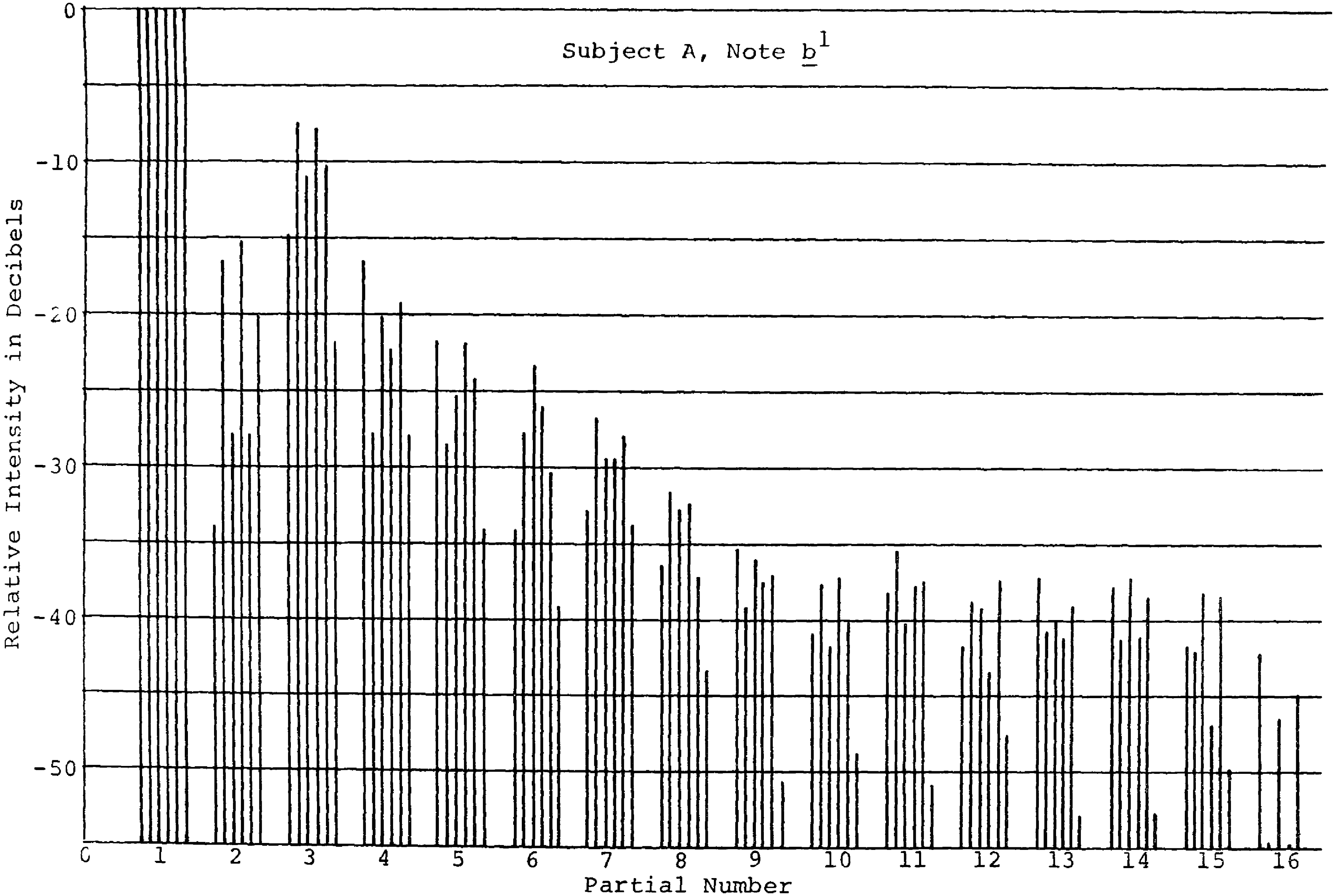

Subject C, Note c[1]
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number

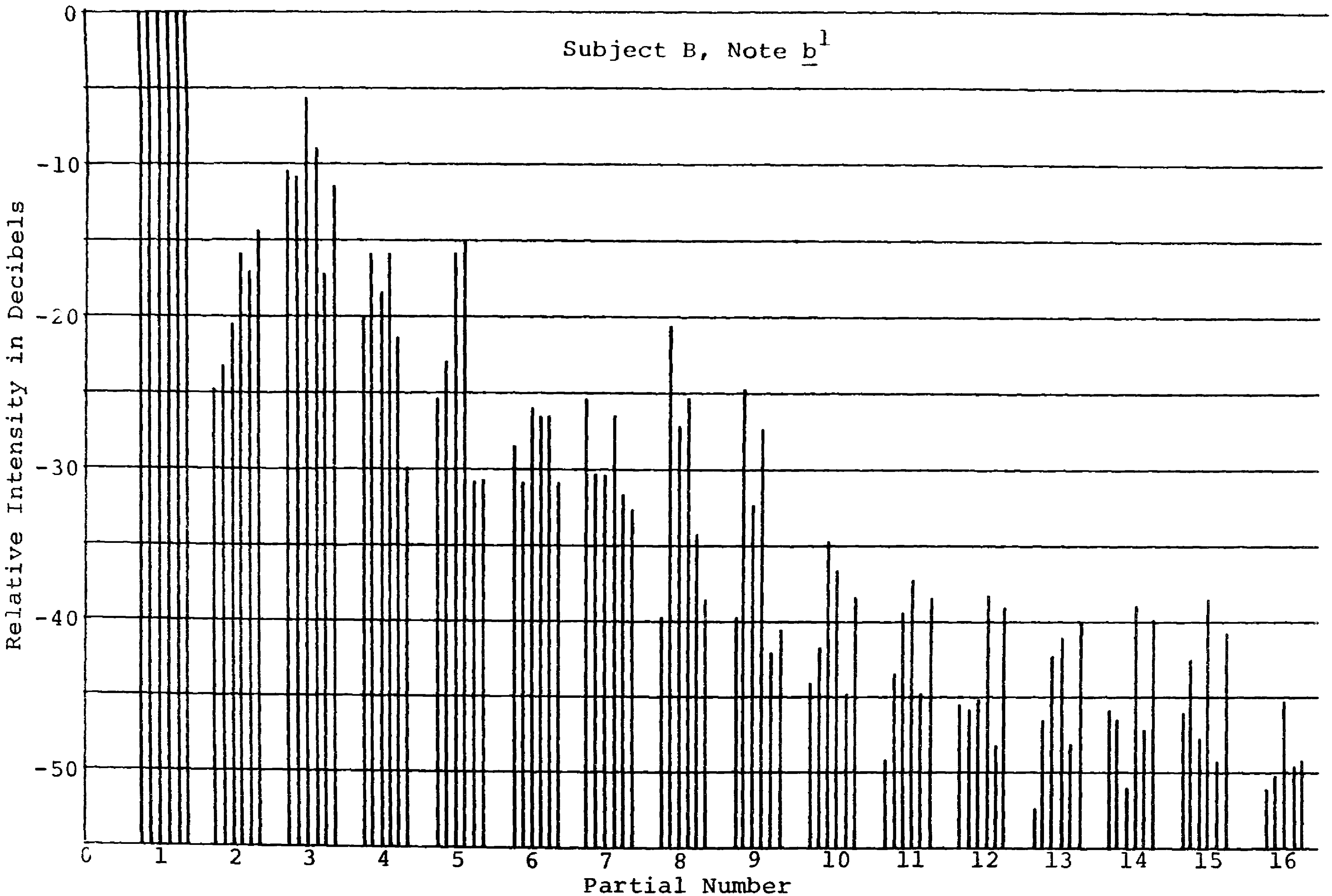

Subject A, Note a[1]
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number

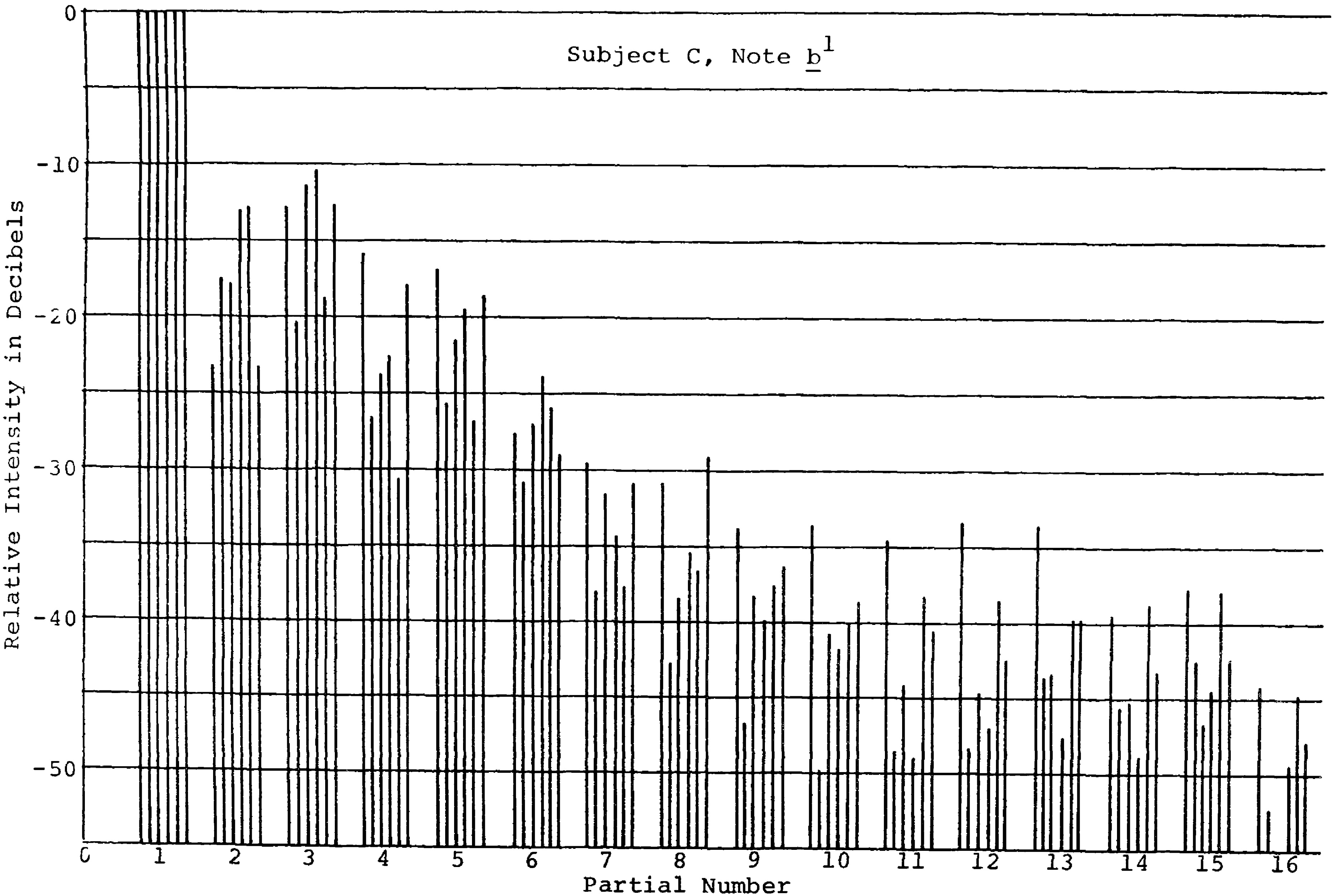


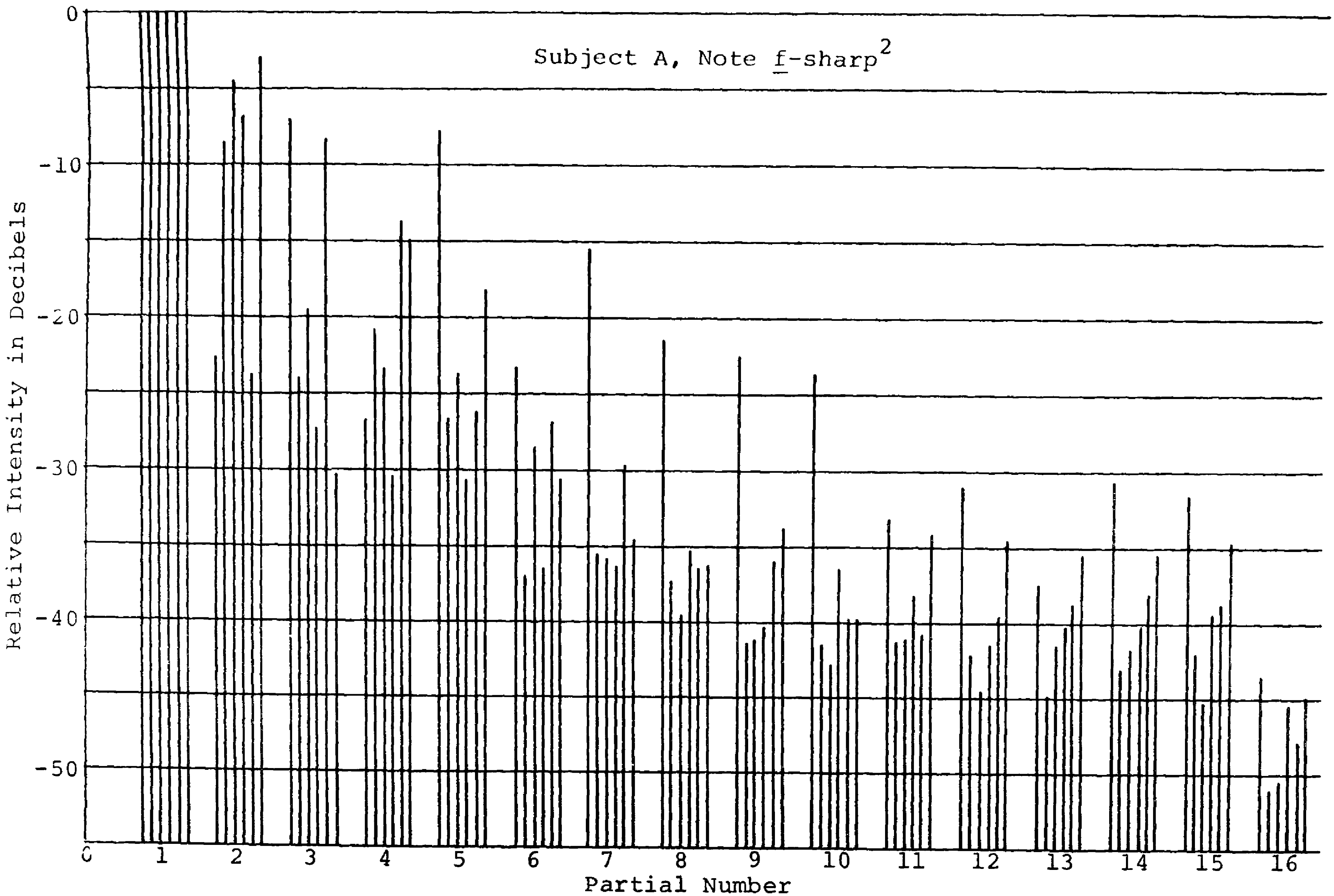
Subject B, Note a1
0
-10
-20
-30
-40
-50
Relative Intensity in Decibels
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number


Subject C, Note a[1]
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
Partial Number
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

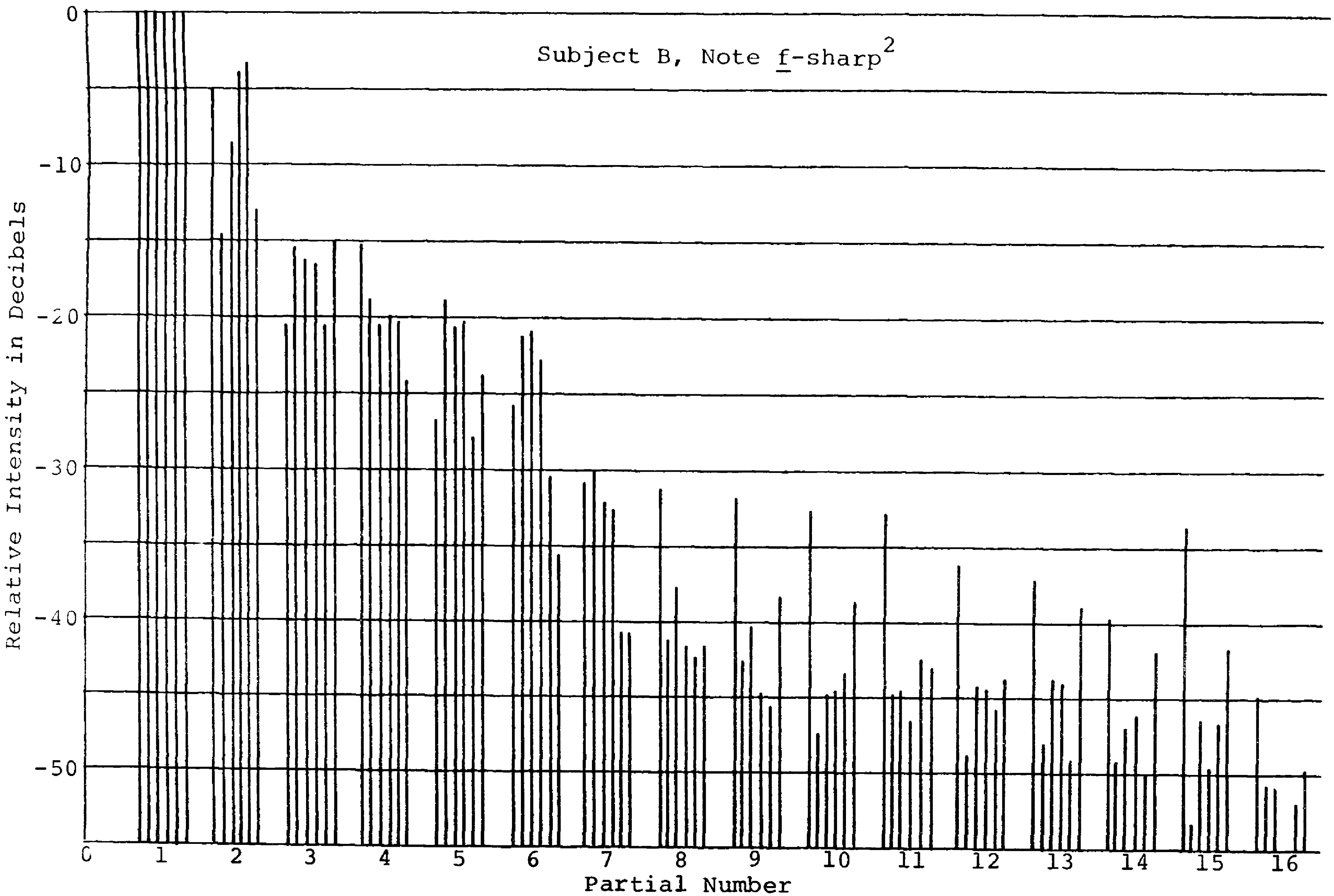

Subject A, Note b[1]
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
Partial Number
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

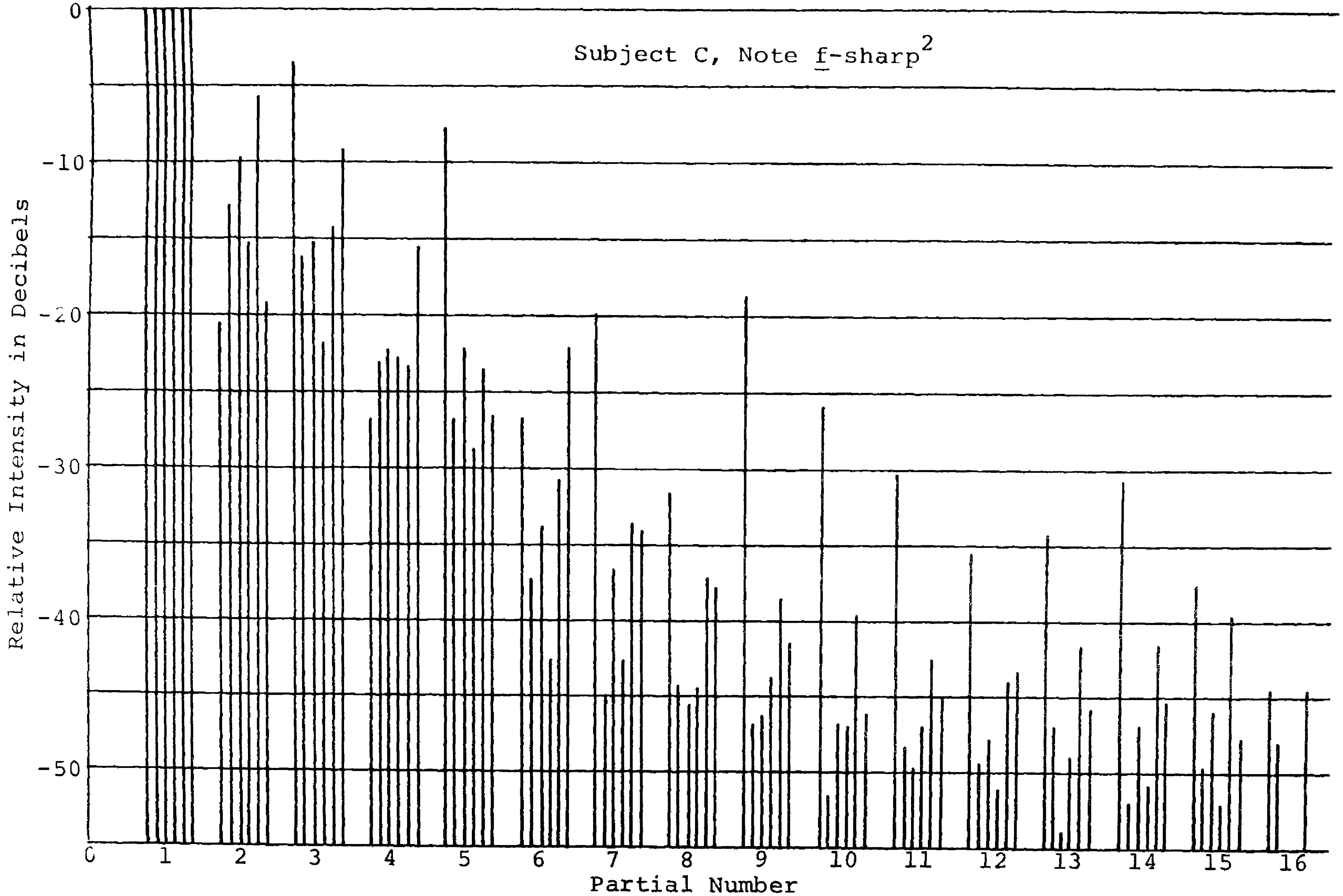

Subject B, Note b¹
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number

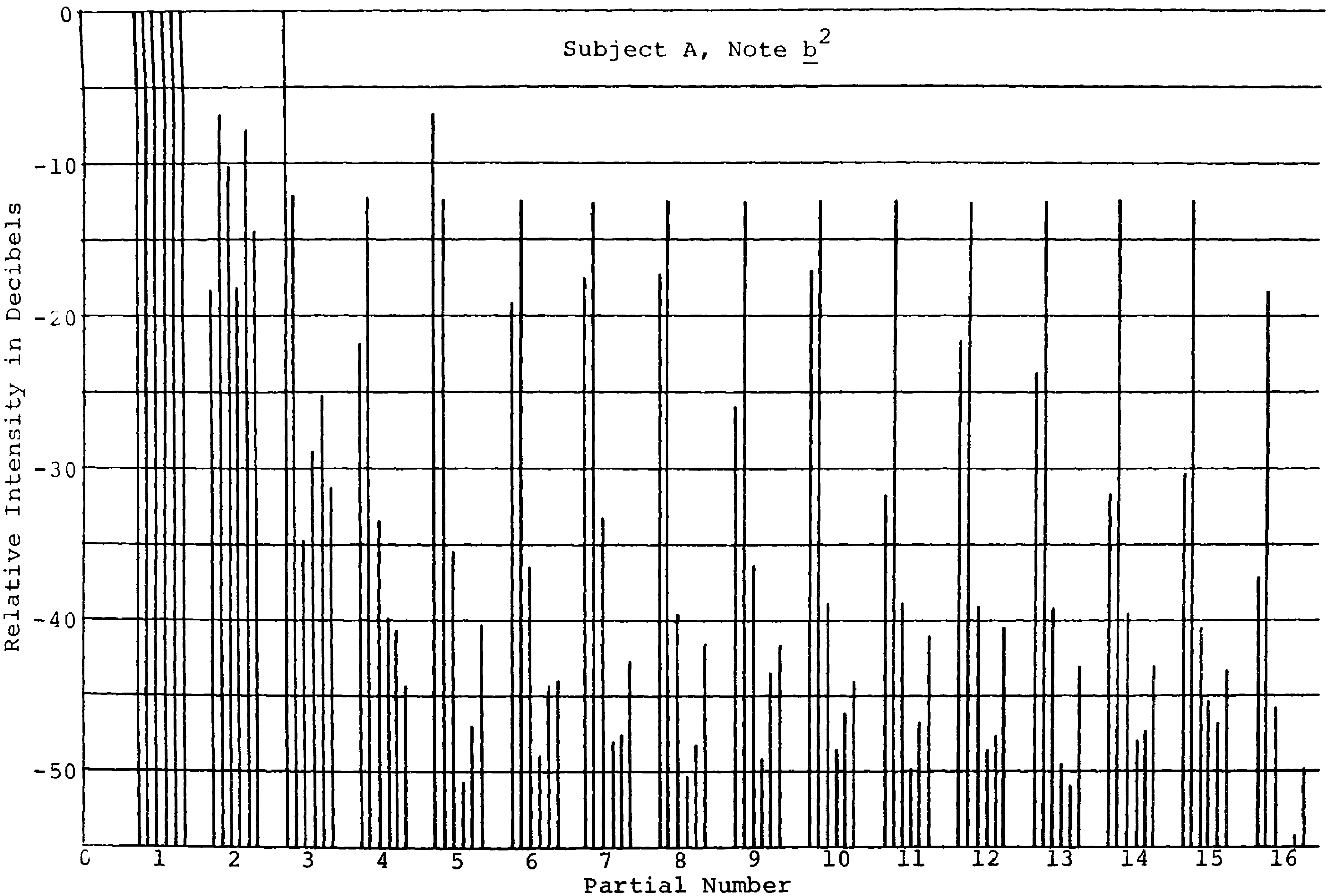

Subject C, Note b1
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
Partial Number
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

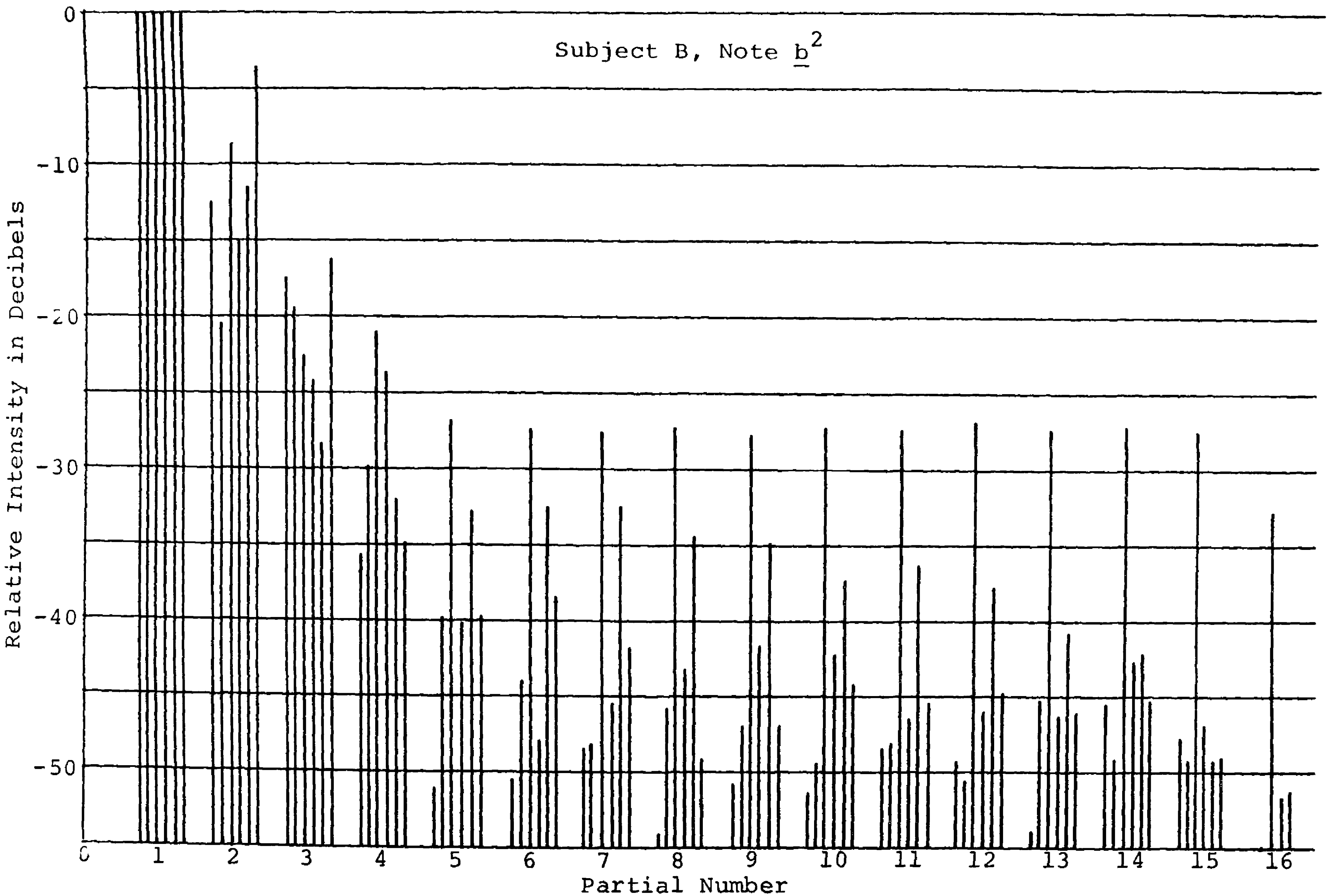


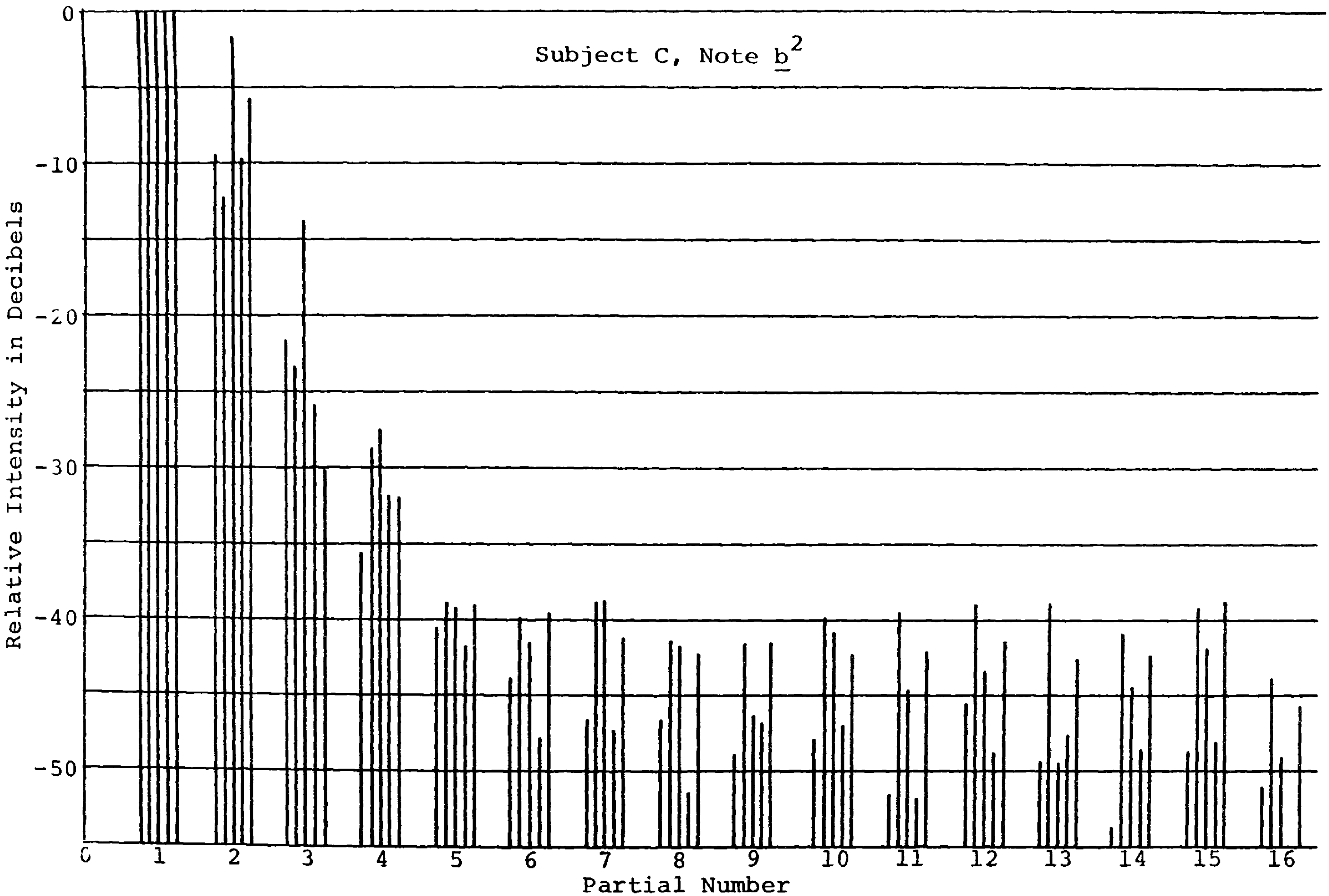
Subject A, Note f-sharp²
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number


Subject B, Note f-sharp^2
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number


Subject C, Note f-sharp²
0
-10
-20
-30
-40
-50
Relative Intensity in Decibels
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number


Subject A, Note b^2
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number


Subject B, Note b²
Relative Intensity in Decibels
0
-10
-20
-30
-40
-50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number



Subject C, Note b^2
0
-10
-20
-30
-40
-50
Relative Intensity in Decibels
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Partial Number

APPENDIX C

Intonation Differences Before and After Alterations

Subject A

Note	Mouthpiece No. 1 Unaltered		Mouthpiece No. 1 After Second Filing		Mouthpiece No. 2 Built Up	
	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat
e	0	0	+4	0	0	0
c^1	0	0	+4	0	0	0
a^1	0	0	0	0	0	0
b^1	0	0	0	0	+4	0
$f\#^2$	0	0	0	0	+2	0
b^2	0	0	+3	0	+8	0

Note	Mouthpiece No. 2 Unaltered		Mouthpiece No. 2 After First Filing		Mouthpiece No. 2 After Second Filing	
	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat	Cents Sharp	Cents Sharp
e	0	0	0	0	0	-3
c^1	+2	0	0	0	+3	0
a^1	0	0	+2	0	0	0
b^1	+5	0	+2	0	+3	0
$f\#^2$	0	0	0	0	+2	0
b^2	+6	0	+12	0	+8	0

Intonation Differences Before and After Alterations

Subject B

Note	Mouthpiece No. 1 Unaltered		Mouthpiece No. 1 After Second Filing		Mouthpiece No. 2 Built Up	
	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat
e	0	0	0	0	0	0
c^1	0	0	0	0	0	0
a^1	+1	0	+4	0	0	-2
b^1	0	0	+4	0	+4	0
$f\#^2$	0	0	0	0	+3	0
b^2	0	0	0	0	+6	0
Note	Mouthpiece No. 2 Unaltered		Mouthpiece No. 2 After First Filing		Mouthpiece No. 2 After Second Filing	
	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat	Cents Sharp	Cents Flat
e	0	-5	0	-7	0	-7
c^1	0	0	0	-4	0	-3
a^1	0	-5	0	-7	0	0
b^1	0	0	0	-2	0	-2
$f\#^2$	0	0	0	0	0	0
b^2	0	+4	12	0	+13	0

Intonation Differences Before and After Alterations

Subject C

Note	Mouthpiece No. 1 Unaltered Cents Sharp	Cents Flat	Mouthpiece No. 1 After Second Filing Cents Sharp	Cents Flat	Mouthpiece No. 2 Built Up Cents Sharp	Cents Flat
e	0	0	+5	0	0	0
c^1	0	0	0	0	0	0
a^1	0	0	0	0	0	0
b^1	0	0	0	0	+4	0
$f\#^2$	0	0	0	0	+3	0
b^2	0	0	0	0	+4	0

Note	Mouthpiece No. 2 Unaltered Cents Sharp	Cents Flat	Mouthpiece No. 2 After First Filing Cents Sharp	Cents Flat	Mouthpiece No. 2 Built Up Cents Sharp	Cents Flat
e	0	0	0	-8	0	-4
c^1	0	-2	0	-4	0	-3
a^1	0	0	0	0	0	0
b^1	0	-2	0	-3	0	0
$f\#^2$	0	0	0	-2	0	0
b^2	0	+3	+6	0	+3	0

VITA

Edmund Walter Winston was born on April 29, 1936, in New Orleans, Louisiana, where he attended Warren Easton High School. From Louisiana State University he received his Bachelor of Music Education degree in 1963 and his Master of Music degree in 1969. He married the former Faith Phillips of Baton Rouge, and they have one son, Edmund, III.

Mr. Winston formerly taught in the secondary public schools of Louisiana before accepting faculty positions at Campbell College in North Carolina and Clemson University in South Carolina. He is presently Assistant Professor of Music at Louisiana Tech University.

EXAMINATION AND THESIS REPORT

Candidate: Edmund Walter Winston

Major Field: Music

Title of Thesis: A Study of Alterations to the Baffle of the Clarinet Mouthpiece and How They Affect Tone Quality, Intonation, and Response

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

April 22, 1976