INFORMATION TO USERS

The most advanced technology has been used to photograph and reproduce this manuscript from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

U·M·I

University Microfilms International
A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
313/761-4700 800/521-0600

Effects of selected timbres, tasks, grade level, and gender on vocal pitch-matching accuracy of kindergarten through third-grade children

Tatem, Frank Leon, Jr., Ed.D.

The University of North Carolina at Greensboro, 1990

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

EFFECTS OF SELECTED TIMBRES, TASKS, GRADE LEVEL, AND GENDER ON VOCAL PITCH-MATCHING ACCURACY OF KINDERGARTEN THROUGH THIRD-GRADE CHILDREN

by

Frank L. Tatem, Jr.

A Dissertation Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Greensboro
1990

Approved by

Patricia E. Sink

Dissertation Adviser

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

Dissertation Adviser Patricia E. Sink

Committee Members James W.
Hilary Apfelstadt
Lois V. Edinger
Barbara B. Bair

March 22, 1990
Date of Acceptance by Committee

March 22, 1990
Date of Final Oral Examination

TATEM, FRANK L., JR., Ed.D. Effects of Selected Timbres, Tasks, Grade Level, and Gender on Vocal Pitch-Matching Accuracy of Kindergarten through Third-Grade Children. (1990) Directed by Dr. Patricia Sink. 168 pp.

The purpose of this study was to investigate effects of selected timbres, tasks, grade level, and gender on vocal pitch-matching accuracy of kindergarten through third-grade children. Five primary null hypotheses were tested to determine significant effects of these variables on vocal pitch-matching accuracy of kindergarten through third-grade children. Two secondary null hypotheses were tested to identify possible relationships of home musical environment (HME) and socioeconomic status (SES) to vocal pitch-matching accuracy (VPMA) of kindergarten through third-grade children.

A pitch-matching test was constructed and administered individually to 111 subjects. The test consisted of three subtests which required subjects to vocally match aurally presented single tones, melodic intervals, and tonal patterns. Six timbres were used as stimuli: oboe, piano, resonator bells, soprano voice, trumpet, and violin. Subjects' vocal pitch-matching responses were recorded individually and analyzed via Visi-Pitch, computer interface, and a Packard Bell IBM-compatible computer.

Results of the study demonstrated that timbre and task significantly affected children's VPMA ($p < .001$); that single-tone tasks significantly reduced children's VPMA (p < .001); that grade level and gender, independently functioning, did not significantly affect children's VPMA (p > .05); and that task, gender, and grade level interact, significantly affecting children's VPMA (p < .01). Children responded most accurately when a soprano voice served as the presentation stimulus and when there were two or more frequencies in the aurally presented stimuli. Subjects' responses were significantly less accurate when the presentation stimulus was resonator bells (p < .001). No significant relationship was observed between HME and VPMA or between SES and VPMA.

Acknowledgements

I would like to express my thanks to my wife, Sandra, who provided the emotional and financial support which made this work possible and to my children, Sherri, Brian, and Amy, for their patience and understanding during the years in which this work was in progress. Their sacrifices will always be remembered.

To Dr. Patricia E. Sink, my dissertation adviser, I extend my deep gratitude for her unflagging assistance, encouragement, and consistently professional advice throughout this project. I would like to thank the members of my committee, Dr. Apfelstadt, Mrs. Bair, Dr. Edinger, and Dr. Sherbon, for their concern, encouragement, and expertise which contributed so much to the quality of this project. Their ability to combine professional attitudes and human concern has made my experience both enjoyable and productive.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The Importance of Singing

For most children, singing is a natural and spontaneous form of musical expression beginning in infancy and developing rapidly during the early childhood years. Michel (1973) reports that the first year after birth is an important period in the musical development of human beings. He maintains that infants, from two to three months old, can distinguish between two timbres. By age six to seven months, according to Michel, a child is able to distinguish between two tones up to an interval of a minor third. Moog (1976) maintains that by two years of age every child of normal development is capable of singing. According to some researchers, infants even possess ablilties to match pitches (Wendrich, 1981; Ries, 1982; Fox, 1984) and imitate melodic contours and standard rhythms at very early ages (Gardner, Davidson, and McKernon, 1979). Miller (1986) states that young children participate in musical activities freely and spontaneously within their natural environment. The early development and spontaneous quality of children's singing abilities make singing a principal means for music educators to introduce musical concepts and develop singing skills of children in kindergarten through third grades.

Vocal Pitch-matching Activities

Vocal pitch-matching activities, sometimes referred to as "tone matching" activities, are frequently recommended as a part of elementary singing instruction (Gelineau, 1970; Nye and Nye, 1970; Swanson, 1980; Sims, Moore, and Kuhn, 1982; Hackett and Lindemann, 1988). These activities may consist of simple devices such as calling the roll on a descending minor third, chanting, echo singing, or learning a song by rote. Gould (1969) recommends echo singing as a means of developing the pitch-matching abilities of young children. Nye and Nye (1970) recommend tone-matching songs and games as an aid to developing a sense of pitch and assisting "uncertain" or "out-of-tune" singers. McDonald and Simons (1989) refer to pitch-matching or "pitch-imitation" as skills which are important to the process of learning songs. This investigation focuses on several factors which research indicates may affect children's vocal pitch-matching accuracy.

Factors Affecting Vocal Pitch-matching Accuracy

The teacher's voice is the instrument most frequently employed as an aural model for children's vocal pitch-matching activities. Music educators and researchers, however, often recommend the use of various fixed-pitch instruments such as piano, bells, and recorder for the purpose of:

1. providing starting pitches
2. demonstrating the melodic line of a song
3. assisting children with vocal pitch-matching deficiencies
4. assisting children who are unable to match pitches with the male voice (Raebeck and Wheeler, 1969; Gelineau, 1970; Nye and Nye, 1970; Hackett and Lindemann, 1988).

While most writers support the use of instruments as an aid to vocal pitch-matching, others express reservations concerning the effectiveness of this practice. Hoffer and Hoffer (1982) state that the use of instruments such as piano or bells is justified only if the teacher's singing voice is of "poor" quality. They further state that correct pitches are more difficult to locate with instrumental models and cite differences in timbre as one of the problems affecting childrens' performances with these instruments.

A review of the literature supports this concern and reveals that other factors such as task, grade level, and gender also affect children's vocal pitch-matching accuracy. Although not specifically associated with vocal pitch-matching accuracy, home musical environment and socio-economic status are reported in the literature as factors affecting a range of musical abilities including children's singing abilities.

Statement of the Problem

Musical instruments are often used in vocal pitch-matching activities to assist young children in the development of vocal pitch-matching accuracy. Previous researchers of vocal pitch-matching accuracy have included a variety of classroom instruments such as male and female voice; autoharp; pitch pipe; flutophone; soprano recorder, and a child's voice. Researchers generally report significant effects on children's vocal pitch-matching accuracy for soprano or female voice (Clegg, 1966; Hermanson, 1971; Sims, Moore, and Kuhn, 1982; Small and McCachern, 1983); violin (Petzold, 1966); child's voice (Green, 1987) and male voice in falsetto range (Montgomery, 1988).

For the female teacher with adequate vocal abilities, the task of choosing an appropriate timbre for classroom presentations is relatively simple. Swanson (1980) states that the female teacher has an advantage over the male teacher when vocally presenting song materials because the range of the child voice lies within the range of the female voice. Results of vocal pitch-matching studies contained in the literature support Swanson's statement. When comparing effects of soprano or female voice to effects of a variety of timbres, most music researchers agree that soprano voice timbre increases vocal pitch-matching accuracy.

For male teachers and teachers with inadequate singing voices, choosing an appropriate timbre for classroom presentations is a more difficult task. While most music researchers report a significant increase in accuracy for soprano or female voice, disparities among the various studies suggest that other timbres may be more effective than soprano voice. For example, Petzold (1966) reports greater vocal pitch-matching accuracy in response to violin than to soprano voice. Green (1987) reports subjects were significantly more accurate when responding to a child's voice than when responding to soprano voice.

The piano is often used to present vocal pitch-matching materials to young children; however, research indicates that piano may be a poor choice. Despite the prominence of piano in elementary music programs, researchers report less accuracy for responses to piano (Clegg, 1966; Petzold, 1966; Hermanson, 1971) than other timbres included in the studies.

Resonator bells are recommended frequently by authors of methods texts for pitch-matching activities (Raebeck and Wheeler, 1969; Nye and Nye, 1972); Swanson, 1980) and in elementary basal textbook series (e.g., Holt Music Series: Meske, Andress, Pauta, and Willman, 1988; World of Music: Palmer, Reilly, and Scott, 1988). A survey by this investigator of the Holt Music Series and the World of Music series shows that for kindergarten through grade three resonator bells are included in approximately 65 percent and 27 percent of the lessons, respectively. Nevertheless, evidence of effects of resonator bells on vocal pitch-matching accuracy is noticeably lacking in the literature. Additional research is needed to determine the effects of resonator-bell timbre on children's vocal pitch-matching accuracy.

The wide variety of timbres among orchestral instruments may include timbres which increase vocal pitch-matching accuracy; however, orchestral instruments have received little attention in previous studies investigating vocal pitch-matching accuracy. The previous lack of attention to orchestral instruments is no doubt due to a lack of practical application to classroom activities. Identifying potentially helpful timbres has been of minimal value to teachers who are unable to perform with the instruments. Today, however, with the aid of electronic keyboards and sampling devices, teachers possessing keyboard skills can employ instrumental timbres in classroom presentations.

Research studies also identify task as a factor affecting children's vocal pitch-matching accuracy. While most investigators agree that children experience greater difficulty with single tones than melodic patterns (Clegg, 1966; Jones, 1971; Gordon, 1980; Goetze, 1985), others assert that the number of tones comprising a pattern does not contribute to pattern difficulty. Sims, Moore, and Kuhn (1982) concluded that pitch-matching accuracy increased as pattern length decreased from five tones to one tone. Petzold (1966) agrees with Heinlein's (1929) position that the number of tones within a pattern is not a valid measure of item difficulty. Furthermore, little empirical evidence is available about the effects of specific characteristics of a task such as range, interval direction, and interval size on children's vocal pitch-matching accuracy. Additional research is needed to clarify effects of specific characteristics of task (i.e., pattern length, range, interval size, and interval direction) on vocal pitch-matching accuracy of young children.

The literature demonstrates that other variables such as grade level and gender also affect vocal pitch-matching accuracy (Drexler, 1938; Clegg, 1966; Petzold, 1966; Hermanson, 1971; Ramsey, 1981). Few investigations of vocal pitch-matching accuracy include these variables nor do they examine possible interaction effects of timbre, task, grade level, and gender on singing abilities. A review of the literature supports the need for additional research on effects of timbre, task, grade level, and gender on vocal pitch-matching accuracy.

Research also has shown that home musical environment (HME) and socio-economic status (SES) are contributing factors to developing a young child's singing abilities (Reynolds, 1960; Kirkpatrick, 1962; Moore, 1973; Shelton, 1965; and, Apfelstadt, 1984). Since these variables are examined infrequently in vocal pitch-matching studies, additional research is needed to determine the possible relationships among HME, SES, and vocal pitch-matching accuracy of children in kindergarten through third-grade. Furthermore, variations in investigator-developed questionnaires and research methods raise questions concerning the validity of previous results.

Purpose of the Study

The purpose of this study was to investigate effects of selected timbres, tasks, grade level, and gender on the vocal pitch-matching accuracy of kindergarten through third-grade children; and, to examine the possibility of interactions between the four main effects. Because of the possible influence of HME and SES on vocal pitch-matching accuracy, the relationship of these variables also was examined within the present study.

Definitions

The term "vocal pitch-matching accuracy" is defined as the mean frequency deviation of a subject's vocal pitch-matching response from the aurally-presented stimulus. Vocal pitch-matching accuracy at each level of a main effect variable is defined as the mean frequency deviation across all responses comprising a specific level of the variable. For example, a subject's vocal pitch-matching accuracy for soprano voice timbre is the mean frequency deviation of all Pitch-Matching Test (PMT) responses to soprano voice stimuli by a particular subject. Vocal pitch-matching accuracy for soprano voice timbre is the mean frequency deviation of all PMT responses by all subjects to soprano voice stimuli. Similarly, overall vocal pitch-matching accuracy is the grand mean frequency deviation of PMT responses across all timbres and tasks by a subject.

The terms "flat" and "sharp" are defined simply as direction of error. No attempt is made to determine the musical interval of flatness or sharpness. "Flat" indicates only that a subject sang below the stimulus; "sharp" indicates only that a subject sang above the stimulus.

Radocy and Boyle (1979) define timbre as "the tonal attribute that distinguishes sounds of identical pitch, loudness, and duration" (p. 53). Within the present study, the term "timbre" is defined specifically as the characteristic sound of a musical instrument which distinguishes it from other musical instruments. The definition of "musical instrument" includes the human voice.

Delimitations

Selection of subjects within the present study is delimited to children in kindergarten through third-grade. To participate in the study, subjects were required only to return a parent-signed permission slip and to complete the *Pitch Matching Test* used in this study. Task is delimited to vocal pitch-matching tasks containing no more than three tones to avoid possible effects of memory. Interval size is delimited to intervals no larger than the perfect fifth.

Although young children perform more accurately on smaller intervals such as seconds and thirds, the fifth plays an important role in establishing tonality which is important to this investigation. To avoid possible effects of training, each of the Pitch-Matching Test stimuli are delimited to a single presentation.

Value of the Study

Research indicates an early onset and rapid development of singing abilities during the early childhood years. The combination of these factors creates a relatively short period of time for optimum development of a young child's singing abilities. Much of this critical period of development has passed by the time a child enters kindergarten and becomes involved in a music education program. Much of the success of music education programs depends upon knowing which methods and procedures are most effective for teaching young children to sing at each grade level. The present study contributes to the literature on vocal pitch-matching accuracy in five specific areas.

First, this study provides additional evidence concerning effects of soprano voice, piano, and resonator-bell timbre on vocal pitch-matching accuracy. Results of the present study may serve to define more clearly the role of these popular classroom instruments in vocal pitch-matching instruction.

Second, this study provides evidence concerning effects of orchestral timbres specifically, violin, trumpet, and oboe, which receive little attention in previous investigations. The wide variety of timbre among orchestral instruments may contain timbres conducive to improving vocal pitch-matching accuracy. Results of the study also provide direction for future investigations of timbre effects.

Third, this study provides additional evidence concerning effects of tasks containing single tones, melodic intervals, and tonal patterns as well as specific characteristics of task such as range, interval size, and interval direction. Results of this study are important to understanding the contribution of these characteristics to children's vocal pitch-matching accuracy. Range, interval size, and interval direction are seldom examined in previous vocal pitch-matching investigations.

Fourth, this study provides additional evidence concerning the relationships among home musical environment, socioeconomic status, and vocal pitch-matching accuracy. Results of the study also provide direction for future research in this area.

Finally, provisions for accurate, objective measurement are included in the present study. With the exception of the study conducted by Hermanson (1971), measurements in previous studies are subjective relying on judgments by panels of "experts" (Petzold, 1966) or the investigator

(Clegg,1966; Sims, Moore, and Kuhn, 1982; and, Small and McCachern, 1983). In the Hermanson study, subjects' deviations from stimuli were calculated by means of a chromatic pitch stroboscope and rounded to the nearest 100 cents. Within the present study, subjects' deviations were analyzed using a Visi-Pitch (6087DS), a Visi-Pitch computer interface (6098), and a Packard-Bell (PB8810) IBM-compatible computer. Use of the Visi-Pitch in the present study provides more accurate measurement than the subjective measurements used in some previous studies or the chromatic pitch stroboscope used in the Hermanson study. Increased accuracy of measurements enhances the value of the present study. Furthermore, additional knowledge gained from the study may help music educators to select materials and methods which improve children's vocal pitch-matching accuracy. Increased vocal pitch-matching accuracy among young children improves individual singing abilities as well as the quality of group musical experiences, and may lead to more active participation in music during the later grades.

CHAPTER II

REVIEW OF THE LITERATURE

Factors Affecting Vocal Pitch-Matching Accuracy

Timbre

Early investigations of timbre were directed toward determining the physical components of this subjective musical characteristic. The most prominent early researcher was Helmholtz (1877) who concluded that the timbre of a musical sound is determined by the presence of a series of harmonics and the relative strengths of those harmonics. The term "harmonics" or "harmonic series" refers to the presence in a musical sound of a fundamental frequency and its integrally related multiple frequencies. The fundamental is usually the lowest frequency and of greatest intensity. Other harmonics in the series are usually of lesser intensity than the fundamental. The terms "tonal spectrum" and "waveform" are used to refer to the series of harmonics which give each instrument its characteristic sound.

Helmholtz's conclusion that timbre is determined by the tonal spectrum or waveform of a given instrument remains essentially true today. Investigations conducted by Helmholtz, however, were limited to the timbre of the "steady state" portion of musical sounds. The term "steady state" is a reference to the sustained portion of a musical sound which follows the "attack transient," or beginning of the sound. The "decay transient" of a musical sound occurs as the energy producing the steady state begins to dissipate. Subsequent research showed that perception of timbre was not limited to the waveform of a musical sound's steady state but also was affected by changes in attack and decay transients, intensity, vibrato, and even noise (Rasch and Plomp, 1982). Numerous researchers reported that alterations of attack and decay transients confused subjects who attempted to identify instrumental timbres (Stumpf, 1926; George, 1954; Berger, 1963; Schaeffer, 1966; and Strong and Clark, 1967). Research showed that in addition to waveform, temporal characteristics of musical sounds (e.g, attack and decay) also contributed to perception of timbre and were therefore important when considering effects of timbre on musical skills.

The literature contains several studies concerned specifically with the effect of timbre on vocal pitch-matching accuracy of young children. While studies vary considerably, researchers report an effect of timbre on children's vocal pitch-matching responses.

The earliest of these investigations were conducted by Clegg (1966) and Petzold (1966). Clegg investigated the accuracy of vocal pitch-matching responses of primary-aged school children (n = 796) selected from among male and female students in grades one, two, and three. Tones produced by male voice, female voice, piano, autoharp, pitch pipe, song bells, flutophone, and soprano recorder served as stimuli. Clegg found that pitch-matching accuracy was best when female voice was the stimulus. Although children performed less accurately with piano timbre than female voice, the investigator concluded that pitch-matching activities could be conducted effectively using a piano. Performances were increasingly less accurate with the timbres of autoharp, pitch pipe, male voice, recorder, flutophone, and song bells, respectively. The researcher reported that some children attempted to sing an octave higher when matching pitches with the timbres of song bells, flutophone, and recorder. Clegg attributed the difficulty to instrumental range and stated that these instruments have a range an octave above the child's singing range. Since similar transposition problems were observed by Petzold (1966) when flute timbre was presented in the octave above the child's singing range, the difficulties children experienced with song bells and flutophone timbre are most likely due to instrumental range. The same cannot be said for soprano recorder timbre since the range of the recorder is within the child's singing range.

Petzold (1966) studied the vocal responses of children in grades one through six to stimulus tones produced on piano, flute, soprano voice, and violin. The study was one of four one-year studies investigating melody, rhythm, harmony, and timbre. Results showed that children performed with greatest accuracy when matching violin tones. Children were less accurate when performing with soprano voice, piano, and flute, respectively. The author suggested that flute timbre may have inhibited accuracy since flute tones were presented in the octave above the children's singing range. Performances with flute tones were significantly ($p < .01$) less accurate than performances with either soprano voice or violin. Petzold indicated surprise that performances with piano and voice proved less accurate than those with violin since these two instruments were used most frequently in classroom music programs.

Hermanson (1971) conducted an investigation of simultaneous vocal pitch acuity of kindergarten and third-grade children ($n = 103$). "Simultaneous vocal pitch acuity" refers to the fact that pitch-matching occurs as the stimulus is being presented. Children were asked to sing along with four pre-recorded melodies presented by electronic oscillator, woman's voice, piano, and child's voice. The author reported that subjects' performances were significantly more accurate with female voice than with piano ($p < .01$). Response differences elicited between female voice and oscillator stimuli were found to be statistically significant ($p < .05$). No significant response differences were observed between a child's voice, oscillator, and piano. Although performances with female voice were more accurate than with the child's voice, differences were not found to be significant. Subjects performed least accurately with the piano.

Studies comparing effects of male and female voice on vocal pitch-matching accuracy were conducted by Sims, Moore, and Kuhn (1982) and by Small and McCachern (1983). Sims, Moore, and Kuhn selected two groups of five and six-year old children to participate in their study. Each group consisted of thirty subjects from each age level. A pitch-matching test of 20 patterns was administered to subjects twice, once with the female voice and again with the male voice. A significant ($p < .05$) increase in accuracy was observed for performances with the female voice stimulus.

A second study involving male and female voice was conducted by Small and McCachern (1983). The purpose of this study was to determine if first-grade children ($n = 55$) could match pitch more accurately with a male or female stimulus before and after a short practice period. A pretest was administered to all subjects. The investigators reported significant differences ($p < .05$) between performances in favor of the female model but stated that although subjects did experience more difficulty with the male model than with the female model, the expectation that male vocal modeling is more problematic than female vocal modeling for first-grade students may be unwarranted.

sample size (n = 44) and relatively small differences between grand means for male and female subjects were cited as reasons for their cautious interpretation of the finding.

Green (1987) investigated the effects of soprano voice, tenor voice, and a child's voice on vocal pitch-matching accuracy of first- through sixth-grade children (n = 282). The investigator reported a significant ($p < .05$) increase in vocal accuracy when the aural stimuli were presented via the child's voice. Subjects were increasingly less accurate when aural stimuli were presented via female voice and tenor voice, respectively.

In a recent study, Montgomery (1988) investigated the effectiveness of vocal modeling by a male teacher using the normal and falsetto vocal ranges. The investigator's subjects (n = 40) were two intact third-grade classes. At the outset of the study, both groups were pretested using a revised form of the Boardman Test of Vocal Accuracy (Boardman, 1964). Following the pretest, one group of subjects received twelve weeks of instruction during which the normal voice range was used as the vocal model. The second group received twelve weeks of instruction during which the falsetto voice range was used as the vocal model. Upon completion of the treatment period, a posttest was administered to both groups of subjects. Although the group receiving falsetto vocal modeling demonstrated greater accuracy, the investigator reported no significant differences in vocal accuracy as a result of the two methods of vocal instruction. A significant difference was observed among combined groups when falsetto modeling was used. Across all subjects, vocal accuracy was greater when patterns were modeled by falsetto than when modeled by the nonfalsetto male singing voice.

Task

The literature also contains studies identifying task as a factor affecting children's vocal pitch-matching accuracy. Jones (1971) reported that young children experienced greater difficulty with single tones than melodic patterns. Clegg (1966) reported that children were most successful when matching C4 (261.63 Hz), E4 (329.63 Hz) and the descending minor third G4 (392 Hz) to E4 (329.63 Hz). Gordon (1980) stated that children perform tonal patterns with greater accuracy than single tones. By contrast, Sims, Moore, and Kuhn (1982) concluded that pitch-matching accuracy significantly ($p < .05$) increased as pattern length decreased. Petzold (1966) agreed with Heinlein's (1929) position that the number of tones within a pattern is not a valid measure of item difficulty. Gordon (1971), however, stated that patterns with too many tones are difficult to remember, and therefore, pattern length is indicative of item difficulty. Results of previous investigations concerning task may be confounded by the complexity of tasks included in pitch-matching tests. A review of investigator-written pitch-matching tests revealed considerable variations with respect to specific characteristics of task, such as range, interval size, interval direction, and pattern length.

Hermanson's (1971) pitch-matching test contained four melodies each composed of four tones within a range of D4 to A4. The author recommended future research using shorter patterns and suggested limiting the number of tones per item to two. In the study conducted by Clegg (1966), test items contained from one to five tones. The author stated that children performed best when items contained no more than two tones. In both studies, however, effects of range, interval size, and interval direction were not investigated. The pitch-matching test by Sims, Moore, and Kuhn was comprised of items containing from one to six tones. The authors' pitch-matching test was not included in the report and effects of range, interval size, and interval direction were not a consideration of the study. Petzold's <u>45-Item Test</u> consisted of patterns containing from 3 to 7 tones within a range of Bb3 to Eb5. A wide variety of intervals were included in the patterns ranging from a minor second to a perfect octave. As in previous studies, effects of range, interval size, and interval direction were not a consideration in the study. An understanding of range, interval size, interval direction, and pattern length was essential to establishing content validity of the Pitch-Matching Test (PMT) for the present study.

Range

Early research reports contain conflicting results regarding the range of children's singing voices. Jersild and Bienstock (1934) and Froschel (1920) reported wide ranges while Paulson (1895) and Gutzman (1928) reported ranges considerably smaller. In a review of vocal range literature, Welch (1979) stated that discrepancies found in early research may have occurred because some researchers attempted to define the outer limits of children's singing voices. Other researchers, however, were interested in the quality of sound which could be produced comfortably by young children. Researchers generally defined the comfortable range for young children (ages 5-8) to be from A3 (220 Hz) or A#3 (233.08 Hz) to B4 (493.88 Hz) or C5 (523.25 Hz) (Cleall, 1970; Wilson, 1970; Joyner, 1971; Young, 1971; Hall, 1972; and, Plumridge, 1972). Comfortable singing ranges for five and six-year old children were smaller than those reported for older children varying from a major second to as much as a major third higher or lower. These variations, however, were small across research studies and researchers consistently reported combined comfortable singing ranges for boys and girls within the octave C4 (261.63 Hz) to C5 (523.25 Hz).

A review of vocal pitch-matching tests among related studies revealed that test items generally were limited to tones from the comfortable singing range previously defined (i.e., C4 (261.63 Hz) to C5 (523.25 Hz)). Nevertheless, results indicated that children continued to sing inaccurately in spite of this delimitation. As stated previously, Clegg (1966) concluded that children were most successful when matching C4 (261.63 Hz), E4 (329.63 Hz) and the descending minor third G4 (392 Hz) to E4 (329.63 Hz). The singing range used in the Clegg study was from C4 to C5. Hermanson (1971) reported that children tended to sing flat even though the singing range used in her study was from D4 to A4. Sims, Moore, and Kuhn (1982) reported excessive flatting tendencies among kindergarten and first-grade subjects. Test items included frequencies ranging from C4 to C5. According to the authors, flatting errors of one or more half-steps accounted for 64 percent of inaccurately sung pitches. A similar concern did not appear in the literature for sharping errors. In the study just cited, sharping errors accounted for only 23 percent of inaccurately sung pitches. The investigators suggested that future studies contain items "centered" in the child's comfortable range. These findings suggested that the comfortable singing range for children's voices may be lower than previously thought and perhaps "centered" around the tones D4 or E4.

Interval Size and Direction

The few researchers investigating melodic interval size demonstrated that children sang intervals within and of a perfect fourth and fifth most accurately (Jersild and Bienstock, 1934; Drexler, 1938; Clegg, 1966; Young, 1971; Ramsey, 1981). Vocal pitch-matching tests found in the related literature for this study contained primarily seconds and thirds and thus were generally consistent with research findings; however, previous pitch-matching tests also contained a number of wide intervals including the perfect octave.

Drexler (1938) stated that ascending seconds, fourths, and fifths were more difficult than descending intervals for children of kindergarten and nursery school age. A number of researchers reported that the descending minor third was among those intervals easiest to sing (Jones, 1971; Young, 1971; Moorhead and Pond, 1978; and, Sinor, 1984). Other researchers indicated little or no differences between performances of ascending and descending intervals (Jersild and Bienstock, 1934; Sinor, 1984). Jersild and Bienstock (1934) reported little difference between performances of ascending and descending intervals for children of ages two to ten.

Most vocal pitch-matching studies in the related literature provided no information regarding interval size or direction. As a result, little is known about the effect of interval size and direction on vocal pitch-matching accuracy. Additional research is needed to determine the role of interval size and direction on vocal pitch-matching accuracy of children in kindergarten through third-grade.

Grade Level

With few exceptions, research has shown that older children demonstrate more advanced musical abilities than younger children (Simons, 1986). A review of the literature demonstrated that this statement is also true for vocal pitch-matching accuracy. Drexler (1938) reported that older subjects sang more "tunefully" than younger subjects. The investigator studied the singing abilities of pre-school and kindergarten children. Hermanson (1971) reported significant differences ($p < .01$) in vocal pitch-matching accuracy between kindergarten and third-grade children. Ramsey (1981) reported an increase with age in the accuracy of perception of melodic rhythms, melodic contour, and melodic intervals for pre-school children, ages 3.5 to 5 years.

While investigators generally support an effect of grade level on vocal pitch-matching accuracy, results of some studies indicate contradictory results regarding differences between specific grade levels. Petzold's (1966) finding that significant differences ($p < .01$) in pitch-matching abilities appear between grades one and two and between grades one and three was inconsistent with results reported by Clegg (1966). Clegg reported nonsignificant increases in vocal pitch-matching abilities between grades one, two, and three. Sims, Moore, and Kuhn (1982) reported no significant differences in vocal pitch-matching accuracy between five- and six-year old subjects and suggested that five- and six-year old children may be at the same level of vocal development. Additional research is needed to determine if significant differences in vocal pitch-matching abilities exist between children in kindergarten through third-grade.

Gender

The literature contains evidence in support of an effect of gender on vocal pitch-matching abilities. Both Clegg (1966) and Petzold (1966) reported an effect of gender on vocal pitch-matching accuracy of young children. Petzold reported that girls' scores were consistently higher than boys' scores on all four timbre treatments used in his study. In a study conducted by Jordan-DeCarbo (1982), higher scores were reported for kindergarten girls than kindergarten boys on aural tests and singing tests. The investigator used Gordon's Primary Measures of Music Audiation and two author-constructed singing tests. Moore (1973) reported that five-year old girls performed better than boys on vocal pitch-matching accuracy.

Some music researchers reported conflicting results regarding gender effects. In a study conducted by Jersild and Bienstock (1934), the investigators reported inconclusive evidence of gender differences between boys and girls. Patrick (1978) reported no significant differences between auditory perception performing ability of first-grade girls and boys. Apfelstadt (1984) reported finding no significant differences between the performances of kindergarten girls and boys on tests of pitch discrimination and vocal accuracy. With the disparity of findings and preponderance of evidence supporting an effect of gender on vocal pitch-matching accuracy, additional research is needed to determine the influence of gender on vocal pitch-matching accuracy of children in kindergarten through third-grade.

Secondary Factors

Home Musical Environment

A musical home environment, according to several researchers, has a positive effect on creativity and musical responses of young children. Michel (1973) stated that:

> If those who are immediately concerned with the baby speak and sing to him, this will have a vital effect on the whole process [of learning to speak and sing] (p. 16).

Home musical environment was not a factor affecting vocal pitch-matching accuracy in vocal pitch-matching studies involving effects of timbre. Other studies, however, have shown that home musical environment does influence the musical development of young children. Musical training and out-of-school music experiences were found to be significant factors in the development of auditory perception (Petzold, 1969). Reynolds (1960), Kirkpatrick (1962), and Apfelstadt (1984) reported that participation in music, both in and out of the home, the presence of instruments in the home, and the mother's involvement in music with the child contributed to the development of singing abilities.

In the study conducted by Kirkpatrick (1962), the relationship between home musical environment and singing ability of pre-kindergarten children was investigated. Using information gathered via parent interviews, the investigator rated homes as "excellent to good," "good to fair," and "poor." Subjects' ($n = 116$) singing performances were recorded in their homes. Vocal accuracy was determined by means of a Stroboconn.

Subjects who performed with 90 percent pitch-matching accuracy were rated as "singers." Subjects who performed with 75 percent to 89 percent pitch-matching accuracy were rated as "partial singers." Subjects who performed with less than 75 percent pitch-matching accuracy were rated as "non-singers." Kirkpatrick reported significant relationships between singing abilities and home musical environment ($p < .005$). Significant increases in singing abilities ($p < .05$) also were reported for the following home musical situations including: (1) mothers who sang to and with their children; (2) direct parent aid in learning songs; (3) conversations in song; (4) family participation in singing and instrument playing; and, (5) parents with musical backgrounds.

Apfelstadt (1984) investigated the relationship between home musical environment and vocal accuracy. Parents were asked to complete an investigator-developed questionnaire containing questions pertaining to three areas of musical involvement: (1) parent/sibling involvement with music in and out of the home; (2) child's involvement with music in and out of the home; and, (3) types of musical equipment (including instruments) in the home. When pretest rote-song scores were compared with results from the questionnaires, the investigator found that homes with high and medium musical environment levels generally produced better singers. Where the home musical environment was low, "poor" singers were produced.

An investigation of the relationship between home environment and "awakened musicality" of pre-school children upon entering kindergarten was conducted by Reynolds (1960). "Awakened musicality," as defined by the author, is the ability to sing in a definite key with an awareness of melodic contour and rhythmic changes. Each child was asked to sing a familiar song which was tape recorded and subsequently evaluated by a panel of judges. The investigator reported that factors which contribute to the musical "awakening" of pre-school children included: (1) involvement of mother in singing, operating the phonograph, and playing piano for the child; (2) presence of quality children's records in the home; (3) attendance at concerts; (4) musically trained parents; (5) a home environment where musical expression is encouraged; and, (6) a piano and phonograph in the home.

Shelton (1965) investigated the relationships between home musical environment and musical responses of first-grade children. After two months of contact with the children, three elementary school music specialists were asked to indicate which students showed the most musical response and the least musical response. Criteria for teachers' evaluations included a child's ability to sing in tune; respond to rhythms as indicated by body movement and by playing instruments; respond to contrasting tempi and moods while listening to music; and, participate in musical activities with enjoyment and freedom. Eighteen "musical" and twelve "nonmusical" children were selected by this method. Parent interviews were conducted in the home by the researcher and homes were classified as "musical," "average," or "unmusical" on the basis of these interviews as well as other information obtained from kindergarten and church school teachers. The lack of information concerning the interview process and the classification of homes is cited by Greenberg (1969) as a weakness of the study.

Shelton reported significant differences between home musical environment and childrens' musical responses.

Brand (1985) conducted a study for the purpose of designing and validating an instrument for evaluating home musical environments. The first step in the process of constructing this instrument was the creation of a pool of 33 items related to a "nurturing" musical environment as identified in the literature. To establish content validity, a panel of four music educators selected 15 items which they felt best represented an outstanding home musical environment.

In its final form, the Homes questionnaire was distributed to 201 second-grade children who were instructed to have their parents complete and return the form. The investigator's conclusions were based on 157 forms which were returned. The author attributed the high reliability coefficient (.86) to careful selection and wording of test items during development of the instrument. Criterion-related validity was established by factor analysis which identified four significant factors in home musical environments: (1) parental attitude toward music involvement with child; (2) parental concert attendance; (3) parent/child ownership and use of record/tape player, records, tapes; and, (4) parent plays/played a musical instrument. Factors one, two, and three accounted for over 63 percent of total variance and were related significantly to the music teacher's perception of the child's home musical environment. Brand cautions that the results may have been influenced by the fact that subjects were chosen from predominately minority populations of lower or lower-middle class populations and limited to only second-grade students; that music teachers' evaluations of homes were subjective; and that 22 percent of the subjects did not return a completed instrument. These limitations notwithstanding, the author concluded that the instrument appeared to be both reliable and valid for purposes of assessing home musical environment.

Socioeconomic Status

Researchers investigating vocal pitch-matching abilities generally have not included socioeconomic status (SES) as a variable in their studies. Clegg (1966) included SES in her study; however, the sample was not stratified and control for SES was subjective in nature. In Clegg's study, the superintendent of schools was asked to select three schools thought to be representative of low, middle, and high SES levels. Since performances between the three schools did not differ appreciably, the investigator deemed that SES was not a factor.

There is evidence that SES may be a factor affecting the development of vocal accuracy. In a study conducted by Kirkpatrick (1962), SES was determined to be related to home musical environment. The investigator stated that "poor" musical environments produced no "singers" and the number of "poor" musical environments in homes with lower SES levels was significant ($p < .01$). Kirkpatrick defined "singers" as subjects who achieved a minimum of 90 percent pitch-matching accuracy.

Results of a study conducted by Petzold (1963) indicated that pitch-matching responses were more accurate for children from homes with high SES levels than children from homes with low SES levels. The author stratified the sample for the timbre study (1966) to control for SES but reported no findings regarding SES.

SES levels within the present study were based on six income levels used by the Bureau of the Census in a publication authored by Bruno (1988). Bruno stated that the use of broad income categories tends to reduce the incidence of nonreporting among families surveyed. Bruno's rationale was an important consideration in the present study. A more detailed request of parents regarding family finances may have increased the rate of nonreporting and resulted in a loss of SES data.

Statement of Hypotheses

The purpose of the present study was to examine effects of selected timbres, tasks, grade level, and gender on the vocal pitch-matching accuracy of children in kindergarten through grade three and to investigate the possibility of interactions between the four main effects. The following primary null hypotheses were tested:

1. There is no significant effect of timbre treatments on vocal pitch-matching accuracy of children in kindergarten through third-grade.
2. There is no significant effect of task on vocal pitch-matching accuracy of children in kindergarten through third-grade.
3. There is no significant effect of grade level on vocal pitch-matching accuracy of children in kindergarten through third-grade.
4. There is no significant effect of gender on vocal pitch-matching accuracy of children in kindergarten through third-grade.
5. There are no significant interaction effects of timbre treatment, task, grade level,and gender on vocal pitch-matching accuracy of children in kindergarten through third-grade.

In addition to the main effects of timbre, task, grade level, and gender, relationships among home musical environment (HME), socioeconomic status (SES), and vocal pitch-matching accuracy also were investigated. The following secondary null hypotheses were tested:

1. There is no significant relationship between <u>HOMES</u> scores and vocal pitch-matching accuracy of children in kindergarten through third-grade.
2. There is no significant relationship between SES and vocal pitch-matching accuracy of children in kindergarten through third grade.

CHAPTER III

METHODS AND PROCEDURES

Selection of Subjects

The study was conducted in a rural North Carolina public school using a randomly selected sample of children in kindergarten through grade three (n = 111). To achieve randomization, a numbered listing of subjects was prepared for each grade level. Subjects were selected from the listings using a random number table (Glass & Hopkins, 1984). The sample was composed of 12 male and 13 female kindergarten subjects; 12 male and 16 female first-grade subjects; 15 male and 14 female second-grade subjects; and 11 male and 18 female third-grade subjects. A copy of the letter requesting permission to conduct the study is presented in Appendix A.

Prior to testing, an information packet was sent to the parents of each subject. The information packet contained the following items:

1) Letter to parents explaining the study
2) Parental permission form
3) Home musical environment questionnaire
4) Instructions for completing the permission form and questionnaire.

Subjects were required to return the signed permission forms before being allowed to participate in the study. A copy of the letter to parents is presented in Appendix B.

Data Collection Materials

Pitch-Matching Test

Selection of Timbres

Timbres investigated in this study were soprano voice, piano, resonator bells, violin, trumpet, and oboe representing both traditional classroom instruments and orchestral instruments. Disparities in the literature concerning effects of piano and soprano voice on vocal pitch-matching accuracy as well as the prominence of these two instruments in elementary music programs suggested that additional investigation of these timbres was needed (Clegg, 1966; Petzold, 1966; Hermanson, 1971; Green, 1985). A review of vocal pitch-matching studies revealed a scarcity of information regarding effects of orchestral instruments and resonator bells on vocal pitch-matching accuracy (Petzold 1966; Clegg, 1966).

Construction of the PMT

The Pitch-Matching Test (PMT) was comprised of three subtests each representing a different pitch-matching task. The range for all test items was delimited to the C major diatonic scale (C4-C5) since research suggests that the comfortable range for young children lies within the C4 to

C5 octave (Wilson, 1970; Cleall, 1970; Joyner, 1971; Plumridge, 1972; Hall, 1972; Sims, Moore, and Kuhn, 1981). Interval classifications included in the PMT were major and minor second, major and minor third, perfect fourth, and perfect fifth. The decision to include intervals no larger than the perfect fifth was based on studies which demonstrated that children sang intervals within and of a perfect fourth and fifth most accurately (Jersild and Bienstock, 1934; Drexler, 1938; Clegg, 1966; Jones, 1971; Young, 1971; Ramsey, 1981), and on the need to compare subjects' performances of these intervals within tonal patterns.

The number of tones per item to be used in the present investigation was delimited to three. This permitted the inclusion of three pitch-matching tasks and is consistent with recommendations of previous researchers (Sims, Moore, and Kuhn, 1982; Gordon, 1971; Gordon, 1980; Hermanson, 1971; Clegg, 1966). The manner in which the PMT was constructed permitted analysis of task by range, interval size and direction, and test item length.

The first subtest, the Single Tone (ST) subtest, contained the eight tones of the diatonic C major scale. The ST subtest was constructed according to the following procedure. First, tones in the C major scale were divided into lower (C4 (261.63 Hz) - F4 (349.23 Hz)) and upper (G4 (392 Hz) - C5 [523.26 Hz)) ranges. Second, tones were sequenced randomly within each range to provide a different order of presentation for each of the six timbre treatments (see Appendix C).

The second subtest, the Melodic Interval (MI) subtest, contained six melodic intervals within the range of C4 to G4. Each melodic interval was presented in both ascending and descending forms for each interval class creating a total of twelve intervals. A different order of presentation was created for each of the six timbre treatments.

The third subtest, the Tonal Pattern (TP) subtest, contained five pairs of tonal patterns in the key of C major within the range of C4 to G4. Each tonal pattern consisted of three tones. The five pairs of tonal patterns represented movement by step, half-step, skip, leap, and skip-leap combination. A "pair" contained one tonal pattern presented in both ascending and descending forms. For example, the first tonal pattern began on the tonic (C4) and ascended. The second tonal pattern began on the last note of the first tonal pattern and descended to the tonic. A different ordering of the five pairs of tonal patterns was created for each of the six timbre treatments.

Reliability and Validity of the PMT

Reliability of the PMT was determined by using the Kuder-Richardson coefficient alpha which is designed to test reliability of tests with items that have variable points (Boyle and Radocy, 1987). Because of the inverse relationship between mean frequency deviations and vocal pitch-matching accuracy, mean frequency deviations were inappropriate for use in the Kuder-Richardson coefficient alpha formula. Use of mean frequency deviations represented a zero-based measurement where "zero" indicated perfect vocal pitch-matching accuracy. Hence, an increase in mean frequency deviations reflected a decrease in vocal pitch-matching accuracy. A positive measure of vocal pitch-matching accuracy was needed for use in the Kuder-Richardson formula. Therefore, scores were totaled for each stimulus frequency to show the number of correct responses associated with each stimulus. A higher score reflected an increase in vocal pitch-matching accuracy. The reliability of the PMT was determined to be .97. Upon completion of a review of research on measurement of primary-aged children's vocal pitch-matching abilities, the PMT was designed to meet the objectives of the study and according to research findings. The investigator concluded that the PMT contained content validity and was highly reliable.

Creation of Audio Tapes

A master recording, containing the six PMT timbre treatments, was created in a professional recording studio. Each item in the ST and MI subtests was recorded at a tempo of 60 beats per minute (bpm). Each item in the TP subtest was recorded at a tempo of 120 bpm. A faster tempo was used in the TP subtest to control for possible memory effects due to increased pattern length. Also, the investigator observed that previous studies (Petzold, 1966; Taylor, 1976) including three or more tones per pattern were administered at a tempo of 120 bpm. An electronic metronome was used to ensure that the tempo remained constant. All tones for violin, oboe, trumpet, and soprano voice timbre treatments were produced acoustically by graduate students and members of the School of Music faculty at the University of North Carolina at Greensboro. Tones for resonator bells and piano timbre treatments were produced acoustically by the investigator. The master tape was recorded on Ampex 456 magnetic tape at a speed of 15 i.p.s. using an Otari 50/50 reel-to-reel tape recorder and two Electrovoice (RE-20) microphones. To avoid an ordering effect on vocal pitch-matching accuracy, six different orders of the PMT stimuli were prepared and recorded on the master tape as indicated in Figure 1. The letters (i.e., S P R V T O) used in Figure 1 are abbreviations for the timbres soprano voice, piano, resonator bells, violin, trumpet, and oboe. A cassette tape for each PMT order was then created from the master tape

PMT	ST	MI	TP
1	S P R V T O	S P R V T O	S P R V T O
2	P V O S R T	P V O S R T	P V O S R T
3	R O T P S V	R O T P S V	R O T P S V
4	V S P T O R	V S P T O R	V S P T O R
5	T R S O V P	T R S O V P	T R S O V P
6	O T V R P S	O T V R P S	O T V R P S

Fig. 1: Order of PMT Stimuli

using TDK-SA(X) high bias magnetic cassette tapes. The purpose of using cassette tapes was to present subjects with the musical stimuli during the testing phase of the study. The cassette format provided flexibility and conserved time during the administration of the six different orders of the PMT by permitting direct access to the preassigned PMT order for each subject. Use of reel-to-reel tape would have required winding or rewinding to present the appropriate PMT order when subjects were absent from testing.

Home Musical Environment Questionnaire

The Home Musical Environment Scale (HOMES) was used to evaluate the home musical environment (HME) of subjects participating in this study. Unlike most data collection instruments for HME, information on reliability and validity was available for the HOMES data collection instrument (Brand, 1985). A reliability coefficient of .86 was reported by the author and factor analysis was used to establish criterion-related validity. In addition to providing HME data, parents were requested to indicate gross income ranges for purposes of socioeconomic status (SES) classification. Six SES classifications (see Figure 2) were used with income ranges corresponding to family income levels used by the Bureau of the Census (Bruno, 1988). Parents were asked to check the income range representing their gross family income. Ninety-four percent of subjects' parents provided this information. A copy of the complete questionnaire is presented in Appendix D.

Very Low	(VL)	Less than $10,000
Low	(L)	$10,000 - $19,999
Low-Middle	(LM)	$20,000 - $29,999
Middle	(M)	$30,000 - $39,999
Upper-Middle	(UM)	$40,000 - $49,999
High	(H)	$50,000 and Above

Fig. 2: Family Income and SES Levels

Collection of Data

Pilot Study

A pilot study was conducted to determine the validity and reliability of the study's methods and procedures. During this phase of the study, equipment and facilities were evaluated to ensure proper testing conditions; to ensure appropriate intensity levels; and to determine time required for PMT administration. Data from the pilot study were analyzed to determine if changes were needed in the study. Appropriate changes in the study were made as indicated by the analysis. These changes are discussed in this chapter in conjunction with the appropriate topics.

PMT Administration

The PMT was administered individually to each subject during a single testing session. The decision to administer the tests in one session was based on pilot study results which indicated that subjects appeared to be confused by the alternating arrangement of the three subtests used in the pilot study. During the pilot study, stimuli were presented in two nine-minute sessions (see Figure 3). Under this arrangement, three timbre treatments were presented during each session and subjects were required to complete all levels of task before proceeding to the next timbre treatment. Pilot study results suggested that subjects may benefit if stimuli were arranged by task and presented in a single session (see Figure 4). This arrangement required a testing session of eighteen minutes including instructions and a short demonstration and practice section. The alternating arrangement of tasks used in the pilot study affected some students adversely by requiring them to continually change tasks while at the same time being presented a different timbre. Although duration of the

Session One	
Timbre	Task
S	ST/MI/TP
P	ST/MI/TP
R	ST/MI/TP

Session Two	
Timbre	Task
V	ST/MI/TP
T	ST/MI/TP
O	ST/MI/TP

Fig. 3: Two-Session Format

Task	Timbre
Single Tone	S/P/R/V/T/O
Melodic Interval	S/P/R/V/T/O
Tonal Pattern	S/P/R/V/T/O

Fig. 4: One-Session Format

testing session was longer than desirable, the change was necessary to avoid confounding any potential effect of task. A detailed presentation of the one-session format including the investigator's script is presented in Appendix E.

A testing schedule was developed in conjunction with the principal and teachers of the school to minimize disruption of the school day. The testing phase of the study was conducted during the morning between the hours of 8:30 and 11:30 and in the afternoon between 12:30 and 1:30. Testing was conducted in a small room located near kindergarten, first grade, and second grade subjects. Upon examination, the room appeared to be reasonably free of extraneous noise. Prior to testing, each subject was assigned an identification number which was used throughout the study. A brief demonstration and practice period preceded the testing session for each subject. During this time, subjects were provided instructions and permitted to practice each task before proceeding with the test. During testing, access to the testing site was limited to the investigator and the subject being tested.

At the beginning of each test session, the subject's identification number was announced by the instructor and recorded on the subject's response tape. Each test item was presented once followed by silence equal to the duration of the item. Stimuli were limited to a single presentation to ensure that training was not a factor should effects exist for any of the four main variables. To ensure an even distribution of the six PMT orders across all subjects, subjects were preassigned a PMT order within their respective grade levels. As a result, repeated treatment sequences occurred with every seventh subject within each grade level.

Playback of the stimuli was provided via a Teac Syncaset Model 124 cassette tape recorder, a Scott Model RS30 stereo amplifier, and two Sansui S42-U three-way speakers. Subjects' responses were recorded via a Teac Syncaset Model 124 cassette tape recorder and a Shure SX-12 condenser microphone on chromium-oxide cassette audio tapes. Subjects were instructed to sing on "doo" during the period of silence following each item. The instructions directed subjects to sing in an echo style as soon as the music stopped. Both stimuli and responses were recorded on the response tapes.

Analysis of Data

Visi-Pitch Analysis

Upon completion of the testing phase, subjects' taped responses were analyzed using a Visi-Pitch and a Packard-Bell (PB8810) IBM-compatible computer. The Visi-Pitch is most frequently used in clinical speech applications for speech and vocal therapy. It is also an excellent means of analyzing singing responses and has been used in a previous study conducted by Goetze (1985). The Visi-Pitch equipment used in the present study included a Visi-Pitch (6087DS); a Visi-Pitch computer interface (6098) with cable; a microphone (trigger style); two diskettes (backup diskette included); documentation manuals and a training videotape. A diagram of the equipment used in the Visi-Pitch analysis is presented in Figure 5.

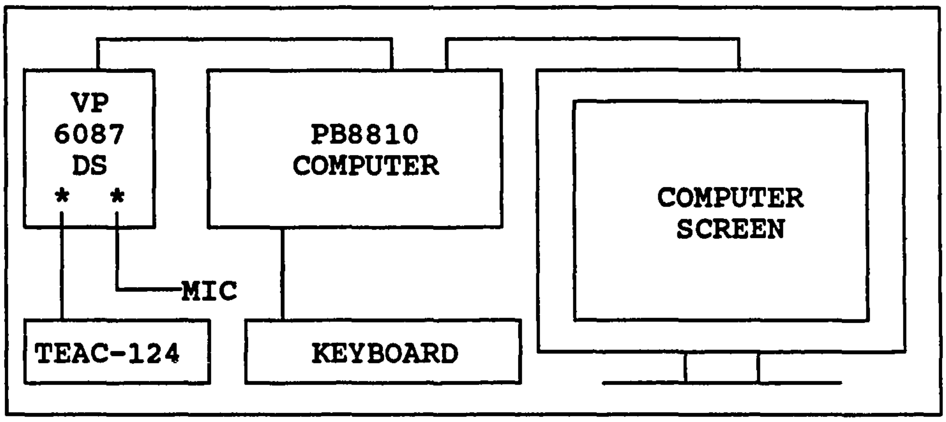


Fig. 5: Visi-Pitch Analysis Equipment

To assemble the Visi-Pitch, the investigator removed the computer cover and installed the interface board in one of the computer's expansion slots. After replacing the computer cover, the interface cable was used to connect the Visi-Pitch interface to the Visi-Pitch (6087DS). The microphone plug was inserted into the microphone input located on the front of the Visi-Pitch (6087DS). The Teac Syncaset Model 124 cassette tape recorder used to record subjects' responses was connected via audio cable to the auxiliary input also located on the front of Visi-Pitch

(6087DS). Although responses were input via audio cable, the microphone was needed to "trigger" the start of each response or series of responses to be analyzed. Finally, the Visi-Pitch software program was installed on the IBM-compatible Packard-Bell computer (PB8810). To begin the analysis, an audio cassette containing a subject's vocal pitch-matching responses was placed into the cassette tape recorder and cued for playback using the "pause" feature on the cassette recorder. To load a response into the Visi-Pitch, the investigator released the "pause" button and depressed the microphone trigger simultaneously. As the response played, the computer screen displayed a "trace" or line drawing of the frequencies comprising the response. After loading a response, the investigator used the computer's arrow keys to move the left and right vertical cursor bars to the beginning and ending of the response, respectively. The frequency at each cursor bar was displayed on the computer screen beside the words "LEFT" and "RIGHT." Using the software main menu, the investigator accessed the statistical portion of the program to compute and display the fundamental frequency of the response. The fundamental frequency was then recorded on the subject's response data collection form. The procedure was repeated for each response and for each PMT stimulus. A sample response data collection form is provided in Appendix F.

Additional information pertaining to the Visi-Pitch is presented in Appendix G.

To standardize the analysis procedure and ensure a consistent analysis across all responses and stimuli, the investigator practiced several hours before beginning the analysis. In addition to becoming more familiar with the Visi-Pitch, the practice period provided the investigator with important information concerning subjects' responses. For example, some subjects produced very soft, breathy responses. The weak signal created by these responses sometimes required an increase in the output level to the Visi-Pitch. Subjects would often slide up or down following the attack or decay transients of the tone before reaching and sustaining a pitch level. In some instances, a subject's pitch would fluctuate noticeably during the steady-state portion of the tone. Some responses were of extremely short duration. To avoid introducing subjective judgments into the analysis, the investigator analyzed the entire response making no allowances for any of the response variants cited above.

Upon completion of the analysis, frequencies recorded on each subject's data collection form were placed in a computer file. Fundamental frequencies for each PMT stimulus were placed in a second computer file. Each subject's response file was paired with the PMT stimuli file using a Digital Equipment Corporation Vax computer.

Preparation of Data File

Using Biomedical Data Processing (BMDP) statistical software program 1D (Dixon, Brown, Engelman, Hill & Jennrich, 1988), subjects' frequency deviations from PMT stimuli were computed for each stimulus-response pair by subtracting the response from the stimulus. If the resulting deviation was positive, the response was defined as "flat" and coded "F." If the resulting deviation was negative, the response was defined as sharp and coded "S." When a response exactly matched the stimulus frequency, a response was defined as "perfect" and coded "P." Inaccurate responses also were tested to determine if a subject responded in the octave above or below the stimulus or completely exceeded the test range (C4 to C5). When a subject's response note (e.g., C4, D4) matched the stimulus note in the octave above or below the stimulus, the response was defined as an octave response and coded "1." If a subject's response exceeded the test range (i.e. either above C5 or below C4), the response was defined as "out-of-range" and coded "0." The various response types were created as a means of describing subjects' vocal pitch-matching data in musical terms.

Mean frequency deviations were computed for each subject and for each level of the main effect variables. For items containing multiple responses, mean frequency deviations were computed using total deviation for all frequencies within the item. Similarly, total deviation was used to compute mean frequency deviations for each level of a main effect variable. Finally, the HOMES questionnaire was scored and results entered into the data file along with subject's age, grade level, gender, and SES codes indicating gross income ranges.

Research Design and Analysis of PMT Data

Data were analyzed via a 2 (gender) X 4 (grade) X 3 (task) X 6 (timbre) factorial analysis of variance with repeated measures as a mixed design. To analyze subject and stimulus variable effects and possible interactions, the investigator employed a four-way ANOVA as a mixed-design model (i.e., A X B (C X S) (D X S)). Two variables (gender and grade) served as independent or between-subject factors, and two variables (task and timbre) served as repeated or within-subject factors. Because each subject received the same conditions across all PMT stimuli (i.e., timbre and task treatments), it was necessary to use a repeated measures analysis to determine effects of timbre and task treatments on subjects' pitch-matching responses. Keppel (1973) reviewed the advantages and disadvantages of factorial analyses with repeated measures in educational research.

One disadvantage is the possibility of a "carry-over-effect" functioning as a confounding factor; and thereby, affecting subjects' responses (or the accuracy of data).

Due to repetition of stimuli, subjects may improve as they progress through an experiment. In the current study, the investigator sought to reduce confounding, "carry-over-effects" by ordering the stimuli at three levels. First, a different ordering of PMT test items was created for each of the six timbre treatments. Second, the six timbre treatments were arranged in six different orders and designated as PMT 1 through PMT 6. Third, the six PMT orders were rotated among subjects within each grade level.

The primary advantage of designing an experiment using repeated measures is that the design controls for individual differences among subjects across treatments. Because subjects received each treatment condition associated with the repeated measures (i.e., timbre and task), it was possible to observe individual differences between treatments. Keppel maintains that analyses using repeated measures analysis do not guarantee that all variance is attributable to treatment conditions alone; however, the extent of error should be less for a repeated measures design than for a non-repeated measures design using independent-subject groups for treatment conditions. Additionally, analyzing data collected via repeated measures with between-subjects analysis procedures may result in a type-I error (i.e. rejecting a null hypothesis when it is true).

Perhaps more importantly, using a mixed design makes it possible to observe commonalities among subjects within treatment conditions. When studying effects of stimulus variations, such as variations which occur in musical patterns, using different subject groups for each treatment condition would be impractical and limit generalizability of the findings. A between-subjects design would not employ repeated measures; however, it would introduce confounding variables, such as test-condition variations across the exceedingly large sample of subjects necessary to meet design requirements. The design of the current study necessitated the use of ANOVA procedures for repeated and independent measures. These procedures differentially controlled for variance differences resulting from between-subject (gender and grade) and within-subject (timbre and task) variables.

Statistical Procedures

ANOVA and Post Hoc Tests

To perform the aforementioned data analysis, mean frequency deviations for timbre, task, gender, and grade level were analyzed via Biomedical Data Processing (BMDP) statistical software program 2V designed for analysis of variance with repeated measures (Dixon, Brown, Engelman, Hill & Jennrich, 1988). Posthoc mean comparison *t*-tests were performed for any interaction effects found to be significant. Posthoc tests enabled the investigator to clarify interactions by examining simple effects for each main effect across all variables.

Pearson Correlations

Pearson product-moment correlations were performed on HOMES scores and vocal pitch-matching data to determine the possible relationship between home musical environment and vocal pitch-matching accuracy. Pearson product-moment correlations were performed also on SES levels and vocal pitch-matching data to determine the possible relationship between SES and vocal pitch-matching accuracy.

Descriptive Statistics

Descriptive statistics procedures including mean, standard deviation, standard error of the mean, frequency, and range were performed on the data via BMDP statistical software program 1D (Dixon et al, 1988). Multiway frequency tables for flat-sharp data and other frequency related data were compiled using BMDP statistical software program 4F (Dixon et al, 1988).

CHAPTER IV

ANALYSIS AND RESULTS

The purpose of the present study was to examine effects of selected timbres, tasks, grade level, and gender on the vocal pitch-matching accuracy of children in kindergarten through grade three. The possibility of interactions between the four main effects also was examined. Statistical procedures, specifically analysis of variance, post hoc analysis via t-tests, Pearson product-moment correlations, and descriptive statistics were used to test the null hypotheses and analyze the data. Results of the study are presented in three sections each related to a specific statistical treatment and the associated null hypotheses. Section one contains results of the analysis of variance and a discussion of significant and non-significant comparisons for each of the main effects. Section two contains results of Pearson correlations testing relationships among home musical environment and vocal pitch-matching accuracy and between socioieconomic status and vocal pitch-matching accuracy. Results of descriptive statistics procedures are presented in section three.

Analysis of Variance

Data were analyzed statistically via a 6 (timbres) X 3 (tasks) X 4 (grade levels) X 2 (genders) factorial analysis of variance with repeated measures as a mixed design (Keppel, 1973). The procedure was accomplished via Biomedical Data Processing (BMDP) program 2V (Dixon, Brown, Engelman, Hill & Jennrich, 1988). Results of the analysis of variance are summarized in Table 1.

Table 1
Analysis of Variance Summary

Source	SS	df	MS	F
Total	8179548.892	1	_____	_____
Grade (Grd)	60931.956	3	20310.652	1.41
Gender (Gen)	9499.774	1	9499.774	0.66
Grd X Gen		3	2077.959	0.14
Error		103	14405.039	_____
Timbre (Tim)	138155.573	5	27631.115	27.02*
Tim X Grd	2267.927	15	155.195	0.15
Tim X Gen	1854.111	5	270.822	0.36
Tim X Grd X Gen	18243.264	15	1216.218	1.19
Error	526708.555	515	1022.735	_____
Task (Tsk)	1350182.587	2	675091.294	225.12*
Tsk X Grd	6755.634	6	1125.939	0.38
Tsk X Gen	4429.069	2	2214.535	0.74
Tsk X Grd X Gen	63462.080	6	10577.013	3.53**
Error	617740.662	206	2998.741	_____
Tim X Tsk	14338.595	10	1433.860	4.20*
Tim X Tsk X Grd	11911.595	30	397.053	1.16
Tim X Tsk X Gen	2756.085	10	275.609	0.81
Tim X Tsk X Grd X Gen	7443.701	30	248.123	0.73
Error	351697.548	1030	341.454	_____

* p < .001   ** p < .01

To begin the analysis, mean frequency deviations were computed for individual subject's responses at each level of the timbre and task variables. Results were matched with subject's data for grade, gender, HME, and SES variables and entered into a computer file. Individual subjects' means were then computed for each level of the timbre and task variables and the five major null hypotheses were tested.

Hypothesis One: Timbre

The investigator hypothesized that there is no significant effect of timbre treatments on vocal pitch-matching accuracy of children in kindergarten through third grade. Results of the analysis of variance performed on the vocal pitch-matching data demonstrated that timbre significantly affected subject's vocal pitch-matching accuracy ($p < .001$). Thus, the null hypothesis was rejected.

Results of post hoc *t*-tests, summarized in Table 2, demonstrated that vocal pitch-matching accuracy was significantly greater when children performed with soprano voice ($p < .001$) than with any other timbre treatment. Results were consistent with previous studies in which greatest accuracy was associated with female voice (Clegg, 1966; Hermanson, 1971; Sims, Moore, and Kuhn, 1982; Small and McCachern, 1983). Previous studies compared soprano voice to male voice, piano, child's voice, electronic oscillator, song bells, flutophone, recorder, autoharp, pitchpipe, flute, and violin. In all comparisons, except violin, subjects demonstrated significantly greater accuracy when soprano voice served as the aural model ($p < .05$).

Table 2
Mean Frequency Deviations and t-values by Timbre

Mean	Timbre	T	V	O	P	R
50.80	S	-8.45*	-8.95*	8.09*	8.65*	8.09*
63.95	T	----	-0.21	0.27	1.00	4.42*
64.20	V	----	----	0.01	1.00	4.39*
64.21	O	----	----	----	-0.83	-4.34*
65.34	P	----	----	----	----	-3.83*
80.51	R	----	----	----	----	----

* $p < .001$

In the present study, no significant differences were observed between mean frequency deviations for violin, trumpet, oboe, and piano. Results demonstrated a slight advantage associated with trumpet timbre and a slight disadvantage associated with piano timbre. The relatively low position of piano in relation to the other timbres is consistent with previous research (Petzold, 1966; Hermanson, 1971). In view of the small differences, the four timbres appeared to be effective aural models for vocal pitch-matching activities.

Subject's responses were least accurate when resonator bells served as the PMT stimuli ($p < .001$). When resonator bells served as stimuli, subjects frequently attempted to match pitches an octave higher than the stimuli. Resonator bells were included in this investigation based upon the assumption that the range for the bells was from C4 (261.63) to C5 (523.25). In manufacturer's literature and discussions with the bell manufacturer's representative, the bells were described as a two-octave set with a range of C-C'' with the lowest frequency being middle C. Visi-Pitch analysis, however, showed that the fundamental frequencies of resonator-bell stimuli were physically an octave higher than assumed and advertised. Spectrum analyses confirmed the Visi-Pitch readings and revealed the presence of only two harmonics for most of the stimuli. These two factors may explain subjects difficulties with the resonator bells.

Since the resonator-bell stimuli were presented in the octave above the subject's range, it was not surprising that many subjects experienced difficulty when responding to the resonator bells. Similar results were reported in previous studies where tonal stimuli were presented in the octave above a child's range (Petzold, 1966; Clegg, 1966).

A lack of periodicity resulting from short decay transients also may have contributed to subject's difficulties with resonator bells. Radocy and Boyle (1979) defined periodicity as the rate at which a sound wave repeats itself and state that periodicity is very important to pitch perception (pp. 20-23). The authors explained that waveform repetitions are detected by a process called "fundamental tracking" which results in "periodicity pitch." The analysis of harmonic spectra of resonator-bell stimuli revealed short decay transients for most resonator-bell stimuli which may have prevented sufficient waveform repetition for proper tracking of the fundamental. The presence of weak second harmonics for most resonator-bell stimuli and missing third harmonics for all resonator-bell stimuli further explains subjects' difficulties matching resonator-bell stimuli. Results of the analysis of harmonic spectra are presented in Appendix H.

Because resonator bells are used frequently in the classroom with the expectation that children will respond within the middle octave range, the bells were retained in the study (Nye and Nye, 1970; Hoffer and Hoffer, 1987; Hackett and Lindemann, 1988). To make results more relevant to classroom application, mean frequency deviations for resonator-bell responses were computed using frequencies from the middle octave (C4 to C5). Computing mean frequency deviations using frequencies in the octave C5 to C6 would serve only to exaggerate an already significant effect and would not properly represent the manner in which the instrument is used in the classroom. As may be noted in Table 2, resonator bells evoked a mean frequency deviation of 80.51 Hz which was significantly different than the other timbral stimuli ($p < .001$).

Hypothesis Two: Task

The investigator hypothesized that there is no significant effect of task on vocal pitch-matching accuracy of children in kindergarten through third-grade. Results of the analysis of variance demonstrated that task significantly affected children's vocal pitch-matching accuracy ($p < .001$). Therefore, the null hypothesis was rejected.

Results of post hoc *t*-tests, summarized in Table 3, demonstrated that vocal pitch-matching accuracy was significantly greater for tonal patterns and melodic intervals than for single tones ($p < .001$). Results were consistent across all timbre treatments. Differences between melodic intervals and tonal patterns approached significance ($p = .054$).

Table 3
Mean Frequency Deviations and *t*-values by Task

Mean	Task	MI	TP
101.71	ST	15.42*	14.93*
47.62	MI	----	1.95
45.18	TP	----	----

* $p < .001$

Specific Tasks Within Subtests

Within each subtest of the PMT, specific tasks were included reflecting singing tasks required while performing vocal pitch-matching activities. Table 4 presents mean frequency deviations for specific tasks in rank order for each subtest within the PMT.

Table 4
Mean Frequency Deviations: Specific Tasks by Subtest

Task	Item	A/D	MFD	Specific Task
ST	1	N	43.323	C4/Initial Pitch
	2	N	48.601	D4/Initial Pitch
	3	N	61.913	E4/Initial Pitch
	4	N	68.383	F4/Initial Pitch
	5	N	100.833	G4/Initial Pitch
	6	N	132.752	A4/Initial Pitch
	7	N	166.767	B4/Initial Pitch
	8	N	191.091	C5/Initial Pitch
MI	1	D	37.710	D4 to C4/Major 2nd
	1	A	39.799	C4 to D4/Major 2nd
	3	D	40.363	E4 to C4/Major 3rd
	3	A	41.397	C4 to E4/Major 3rd
	4	A	43.698	D4 to F4/minor 3rd
	4	D	44.003	F4 to D4/minor 3rd
	2	A	50.955	E4 to F4/minor 2nd
	2	D	51.968	F4 to E4/minor 2nd
	5	A	53.608	D4 to G4/Perfect 4th
	6	A	54.761	C4 to G4/Perfect 5th
	5	D	56.016	G4 to D4/Perfect 4th
	6	D	57.568	G4 to C4/Perfect 5th
TP	1	A	35.041	C4/D4/E4 Step
	1	D	35.655	E4/D4/C4 Step
	5	D	36.139	D4/Db/C4 Half-Step
	5	A	37.903	C4/C#/D4 Half-Step
	4	A	46.901	C4/G4/E4 Leap/Skip
	2	A	49.142	C4/E4/G4 Skip
	2	D	50.043	G4/E4/C4 Skip
	3	A	50.911	C4/G4/G4 Leap/Repeat
	4	D	53.663	E4/G4/C4 Skip/Leap
	3	D	56.411	G4/G4/C4 Repeat/Leap

* A/D = Ascending/Descending N = Not Applicable

The Single Tone (ST) subtest was comprised of the diatonic tones of the C major scale presented in random order. The investigator attempted to simulate starting pitches presented without establishing a tonality. The Melodic Interval (MI) subtest consisted of six intervals presented in ascending and descending forms representing intervals ranging from a minor second to a perfect fifth. The Tonal Pattern (TP) subtest consisted of five tonal patterns representing movement by: (1) step; (2) half-step; (3) skip; (4) leap-skip; and (5) leap-repeat. To further investigate the effects of task, mean frequency deviations were computed for specific tasks within each task level and post hoc *t*-tests performed on the results.

ST Subtest. As in previous studies, range for the present study was limited to that which music researchers have defined as the "comfortable range," that is C4 to C5 (Cleall, 1970; Wilson, 1970; Hermanson, 1971; Hall, 1972; Sims et al, 1982). Nevertheless, as stimulus frequency increased, a corresponding increase in mean frequency deviations was observed. A Pearson product-moment correlation was performed on stimulus frequency and mean frequency deviations for ST performances. The resulting coefficient of .99 indicated a strong relationship between mean frequency deviations and stimulus frequency, indicating that increased stimulus frequency resulted in increased mean frequency deviations. Results of post hoc *t*-tests revealed a significant increase in mean frequency deviations for C4 to D4 ($p < .05$). Greater significance was observed for each increase in stimulus frequency above D4 ($p < .001$) indicating that range was a factor contributing to poor ST performances. Results are presented in Table 5.

Table 5
Mean Frequency Deviations: Stimulus Frequencies by Task

Stim. Freq.	Single Tone	Melodic Interval	Tonal Pattern
C5	191.09	N	N
B4	166.77	N	N
A4	132.75	N	N
G4	100.83	72.94	65.61
F4	68.38	52.62	N
E4	61.91	47.82	44.55
D4	48.60	38.48	36.25
C#4	N	N	36.82
C4	43.32	36.60	34.38

N = frequency not included in task

Additionally, a difference of 32.5 Hz between F4 and G4 appeared to divide single-tone tasks into two groups: (1) lower frequencies with small frequency deviations, and (2) higher frequencies with large frequency deviations. This categorization suggested that subjects experienced greater difficulty when singing pitches above F4. Mean frequency deviations for single tones C4 to F4 increased by an average of 8.3 Hz. Mean frequency deviations for single tones G4 to C5 increased by an average of 30 Hz. The large difference in mean frequency deviations between F4 and G4 and subsequent stimuli suggested that subjects' perhaps were unable to use head voice when attempting to sing frequencies above F4.

Finally, a lack of tonality appeared to be a second factor contributing to subjects' difficulties with single tone tasks. Subjects performed significantly more accurately on MI and TP tasks than on ST tasks regardless of grade level or gender ($p < .001$). Subjects were most accurate when performing TP tasks.

MI Subtest. Mean frequency deviations for MI tasks demonstrated that small intervals (e.g., seconds and thirds) tended to produce greater vocal pitch-matching accuracy than large intervals (e.g., perfect fourths and fifths). Differences in mean frequency deviations between ascending and descending forms of like intervals were small ranging from .3 Hz (minor thirds) to 2.8 Hz (perfect fifths). Results of post hoc t-tests revealed a significant increase ($p < .001$) in mean frequency deviations associated with each increase in stimulus frequency above D4 (see Table 5). The investigator observed that as mean frequency deviations for stimulus frequencies increased, successive pairs of melodic intervals (i.e. major seconds, major thirds, minor thirds, minor seconds) generally contained the next highest stimulus frequency indicating that range contributed to childrens' difficulties with melodic intervals (see Table 4). Significant differences were observed between descending minor thirds and ascending perfect fourths ($p < .001$); ascending minor seconds and ascending perfect fourths ($p < .05$); and ascending minor seconds and perfect fifths ($p < .05$). The presence of G4 in perfect fourths and fifths, however, is a confounding factor since G4 was associated with a significant increase in mean frequency deviations ($p < .001$) within melodic interval tasks. Therefore, significance is most likely due to the presence of G4 and not interval size or direction.

Curiously, descending minor thirds, often reported as less difficult than other intervals (Jones, 1971; Sinor, 1984; Young, 1971), produced significantly less accurate responses than descending major thirds or ascending and descending major seconds ($p < .05$). Although not significant, descending minor thirds were less accurate than ascending minor thirds or ascending and descending major thirds. Descending minor thirds produced significantly more accurate vocal pitch-matching responses than ascending minor seconds ($p < .001$).

Major intervals produced more accuracy than minor intervals, however, no significant differences were observed. Performances of ascending perfect fourths and fifths were more accurate than descending perfect fourths and fifths. Minor seconds produced significantly less accurate responses than major seconds or major and minor thirds ($p < .001$). No significant differences were observed between ascending and descending forms of intervals.

TP Subtest. Among specific TP tasks, performances involving movement by steps (major second) resulted in highest vocal pitch-matching accuracy. Major seconds also resulted in most accuracy when performed as melodic intervals. Movement by half-steps (minor second) produced the second highest vocal pitch-matching accuracy differing from movement by steps by 2.9 Hz. Less accuracy resulted when minor seconds were performed as melodic intervals suggesting that tonality contributed to greater accuracy. Performances of ascending patterns were slightly more accurate than descending patterns. Performances of patterns involving perfect fifths were generally less accurate than those involving intervals of a second or third. There was some evidence to indicate that subjects experienced more difficulty with tasks which did not begin on the tonic (C4). For example, performances of the ascending leap-skip (C4/G4/E4) were significantly more accurate ($p < .01$) than performances of the descending skip-leap (E4/G4/C4) which required that subjects begin on E4. Also, performances of the ascending leap-repeat (C4/G4/G4) were significantly more accurate ($p < .001$) than performances for the descending repeat-leap (G4/G4/C4) which required that subjects begin on G4.

Results of post hoc t-tests performed on stimulus frequencies revealed a significant increase in mean frequency deviations associated with an increase in stimulus frequency from D4 to E4 ($p < .05$) and from E4 to G4 ($p < .01$) (see Table 5). In the Tonal Pattern subtest, no significant differences were observed between C4, C#4, and D4 across timbres. As shown in Table 4, tonal patterns containing G4 resulted in significantly higher ($p < .05$) mean frequency deviations than those without G4. As previously stated, ascending leap/repeat patterns (C4/G4/G4) were sung more accurately than descending repeat/leap patterns (G4/G4/C4). Ascending leap/skip patterns (C4/G4 /E4) were sung more accurately than descending skip/leap patterns (E4/G4/C4). Since both patterns contained G4, the differences appeared to be due to the fact that the descending patterns did not begin on the tonic. Descending half-steps were sung more accurately than ascending half-steps ($p < .001$). Performances of ascending and descending forms of patterns representing movement by step and skip were not significantly different. The presence of G4 in patterns representing movement by skip, leap/repeat, and skip/leap confounds any conclusions regarding the effect of interval size and pattern complexity on difficulty of tonal-pattern tasks.

Results of the data analysis demonstrated that problems associated with range and the lack of tonality contributed to subjects' difficulties with single-tone tasks. Problems associated with range also may have contributed to subjects' difficulties with melodic-interval and tonal-pattern tasks confounding results concerning interval size and direction.

Hypothesis Three: Grade Level

The investigator hypothesized that there is no significant effect of grade level on vocal pitch-matching accuracy of children in kindergarten through third grade. Significant main effects were not found for grade level (p = .24); therefore, the null hypotheses was retained. Mean frequency deviations grouped by grade level and task are summarized in Table 6.

Table 6
Mean Frequency Deviations: Task by Grade Level

PMT Task	Kindergarten	First Grade	Second Grade	Third Grade
ST	108.92	93.62	104.56	100.45
MI	53.90	44.39	51.17	41.79
TP	54.14	38.35	48.61	40.60
All	73.32	58.79	68.11	60.94

In the present study, kindergarten, second-, and third-grade subjects demonstrated progressively lower mean frequency deviations for each level of task. Second-grade subjects were less accurate than first-grade and third-grade subjects for melodic intervals and tonal patterns. First-grade subjects were the most accurate grade level for single tones and tonal patterns. Across all levels of task, first-grade subjects were the most accurate grade level. Because of the exceptional performance by first-grade subjects, an increase in vocal pitch-matching accuracy with grade level was not observed. Results did not confirm most research which supports effects of grade level or age on musical abilities of young children (Boardman, 1964; Duell and Anderson, 1967; Clegg, 1966; Hermanson, 1971; Young, 1971; Simons, 1986).

Hypothesis Four: Gender

The investigator hypothesized that there is no significant effect of gender on vocal pitch-matching accuracy of children in kindergarten through third-grade. Significant main effects were not found for gender (p = .42); therefore, the null hypothesis was retained. Mean frequency deviations by task, grade level, and gender are presented in Table 7.

Table 7
Mean Frequency Deviations:
Task by Grade Level and Gender Groupings

PMT Task	Kindergarten	First Grade	Second Grade	Third Grade	All Grades
S T	90.96(M) 125.51(F)	96.81(M) 91.23(F)	100.64(M) 108.75(F)	102.44(M) 99.23(F)	97.71(M) 106.18(F)
M I	58.48(M) 49.67(F)	42.11(M) 46.10(F)	50.13(M) 52.29(F)	31.37(M) 48.15(F)	45.52(M) 49.05(F)
T P	61.66(M) 47.20(F)	38.10(M) 38.54(F)	46.82(M) 50.53(F)	31.11(M) 46.40(F)	44.42(M) 45.67(F)
ALL TASKS	70.37(M) 74.13(F)	59.01(M) 58.62(F)	65.86(M) 70.52(F)	54.97(M) 64.59(F)	62.55(M) 66.97(F)
	72.3 (G)	58.8 (G)	68.1 (G)	59.8 (G)	64.8(GM)

* Indications of gender appear in parentheses.
(G) = Grade level means (GM) = Grand mean

The present study confirmed findings by Patrick (1978) and Apfelstadt (1984) who reported no significant effects of gender on young children's pitch-matching abilities. Additionally, numerous researchers have asserted that females perform more accurately than males across various musical behaviors (Clegg, 1966; Petzold, 1966; Moore, 1973; Jordan-DeCarbo, 1982; Miller, 1986). In the current study, males' vocal pitch-matching responses, across all tasks, were more accurate than females at each grade level except for first-grade subjects. Across all grade levels, males were more accurate than females at each level of task and across all PMT responses. The only significant difference was between kindergarten males and females ($p < .05$) for performances of single-tone tasks. The ability of males to perform single-tone tasks decreased with age.

Hypothesis 5: Interactions

The investigator hypothesized that there are no significant interaction effects of timbre, task, grade level, and gender on vocal pitch-matching accuracy of children in kindergarten through third-grade. The analysis of variance revealed a significant interaction effect between timbre and task ($p < .001$) and between task, grade level, and gender ($p < .01$). Therefore, the null hypothesis was rejected.

Timbre and Task

At the single-tone level of task, responses to soprano voice were significantly more accurate ($p < .001$) than responses to all other timbres. Responses to resonator bell stimuli were significantly less accurate ($p < .001$) than resonses to all other timbres. When trumpet, violin, oboe, and piano served as stimuli, mean frequency deviations were not significantly different. The most noticeable difference was observed between performances of trumpet and violin which approached significance ($p = .08$). Although not significant, differences associated with the trumpet merit additional research.

At the melodic-interval level of task, responses to soprano voice were significantly more accurate ($p < .001$) than responses to all other timbres. Responses to resonator bells were significantly less accurate ($p < .001$) than responses to all other timbres. Significant differences also were observed between violin and piano ($p < .05$). Differences between trumpet, oboe, and piano were not significant nor were differences between violin, trumpet, and oboe.

At the tonal-pattern level of task, responses to soprano voice were significantly more accurate ($p < .001$) than responses to all other timbres. As with previous tasks, responses to resonator bell stimuli were significantly less accurate ($p < .001$) than responses to soprano voice stimuli. Lower significance levels resulted when responses to resonator bell stimuli were compared to responses to oboe, violin, trumpet, and piano stimuli.

Results of post hoc t-tests demonstrated significant differences between resonator bells and oboe; resonator bells and violin; and resonator bells and piano (p < .01). Response differences between resonator bells and trumpet were also significant (p < .05) as were response differences between oboe and trumpet (p < .01). No significant differences were observed between violin, piano, and trumpet or between oboe, violin, and piano.

Results of post hoc t-tests, summarized in Table 8, demonstrated that the timbres of trumpet, violin, and oboe

Table 8
Order of Mean Frequency Deviations for Timbre Treatments (Least to Greatest) at Each Level of Task

Single Tone					
Soprano Voice	Trumpet	Oboe	Piano	Violin	Resonator Bells
Melodic Interval					
Soprano Voice	Violin	Trumpet	Oboe	Piano	Resonator Bells
Tonal Pattern					
Soprano Voice	Oboe	Violin	Piano	Trumpet	Resonator Bells

t-test comparisons of means not significantly different at .05 level are underscored.

were effective aural models for vocal pitch-matching activities and warrant additional study. For male teachers or teachers with inadequate singing abilities, results indicated that these timbres may serve well as aural models for vocal pitch-matching activities. Lower levels of significance associated with responses to resonator bell stimuli at the tonal-pattern task level suggest that tonality was effective in reducing error despite the difficulties associated with resonator-bell timbre.

Task, Grade Level, and Gender

To further analyze the interaction between task, grade level, and gender, post hoc *t*-tests were performed on means for all combinations of grade level and gender at each level of task. Results indicated that single tone tasks were primarily responsible for the interaction between task, grade level, and gender. The investigator observed that mean frequency deviations associated with the frequencies of A4 (440 Hz), B4 (493.88 Hz), and C5 (523.25 Hz) were contributing disproportionately to the variance for single-tone tasks. To determine the extent to which these frequencies were affecting significance levels for the main effects, mean frequency deviations for A4, B4, and C5 were collapsed and a second ANOVA was performed on the data.

Results demonstrated that mean frequency deviations for single-tone tasks remained significantly higher than those for melodic-interval and tonal-pattern tasks indicating significantly less accuracy for single-tone tasks ($p < .001$). Mean frequency deviations used in the two ANOVAs are contrasted in Table 9. The smaller means associated with

ANOVA 2 reflect the elimination of response data for A4, B4, and C5. Unlike the first ANOVA, no significant interaction between task, grade level, and gender resulted from the second ANOVA (p = .20).

Table 9
Comparison of Mean Frequency Deviations
for Single-Tone Tasks by Timbre

ANOVA	S	T	O	P	V	R	ALL TIMBRES
1	82.23	98.49	100.67	102.48	103.11	123.28	101.71
2	51.15	60.73	61.74	63.59	61.57	88.29	64.51
DIFF	31.08	37.76	38.93	38.89	41.54	34.99	37.20
%DIFF	37.80	38.30	38.70	38.00	40.30	28.40	36.60

Furthermore, no change in significance level was observed for either soprano voice or resonator-bell timbre treatments. A slightly different ordering was observed for oboe, trumpet, piano, and violin with violin showing the greatest percentage of change. Having identified the level of task responsible for the interaction, analysis of the original data file was resumed to determine the grade-gender group and timbre(s) associated with the interaction. Since the greatest change occurred for performances of violin single-tone tasks, R-square coefficients were computed for timbre treatments at each level of task. R-square coefficients indicated that 10.4 percent of total variance was associated with violin single-tone performances. A significant interaction between grade and gender also occurred ($p < .05$) for this timbre-task combination. Additionally, R-square coefficients indicated that single-tone performances with piano stimuli accounted for 8.5 percent of total variance with no significant interaction between grade level and gender ($p = .09$).

A review of mean frequency deviations for grade-gender groupings revealed that for violin single-tone performances, kindergarten females and first-grade females produced the highest mean frequency deviations, 130.46 Hz and 88.29 Hz respectively. Kindergarten females and second-grade females had the highest mean frequency deviations for piano single-tone performances, 128.06 Hz and 115.76 Hz respectively. Based on these results, the investigator concluded that the interaction between task, grade level, and gender was primarily the result of greater mean frequency deviations of responses by kindergarten, first-grade, and second-grade females to violin and piano single-tone stimuli. Furthermore, the interaction was directly attributable to the frequencies of A4, B4, and C5 found only in single-tone tasks.

Results of grade-gender comparisons, presented in Table 10, showed that kindergarten males performed single-tone tasks significantly more accurately than did kindergarten females; this was the only significant within-grade comparison (p < .05). First-grade and third-grade females performed single-tone tasks significantly more accurately than did kindergarten females (p < .05); and, first-grade males were significantly more accurate than kindergarten females (p < .05) on single-tone tasks. No significant differences were observed between second-grade females and other grade-gender groupings for single-tone tasks.

Table 10
Mean Frequency Deviations:
Single-Tone Tasks by Grade Level and Gender Groupings

Single-Tone Tasks									
GRDGEN	MEAN	KM	KF	FM	FF	SM	SF	TM	TF
KM	90.96								
KF	125.51	*		**	**	+		+	**
FM	96.81								
FF	91.23								
SM	100.64								
SF	108.75								
TM	102.44								
TF	99.23								

* p <.01 ** p <.05
\+ approached significance (p = .06)

Although significance was directly attributable to performances of single-tone tasks, performances of melodic-interval stimuli and tonal-pattern stimuli also contributed to the interaction effect. R-square coefficients showed that performances of tonal patterns with resonator-bell stimuli accounted for 11.7 percent of total variance. Grade-gender interaction for this timbre-task combination was near significance (p = .067). Since kindergarten males had the highest mean frequency deviation for this timbre-task combination, *t*-tests were performed to determine the source of variance. Results demonstrated that kindergarten males were significantly less accurate (p < .05) than first-grade males, first-grade females, and third-grade males for performances of tonal patterns with resonator bells. Across all timbres, third-grade males performed significantly more accurately than kindergarten females (p < .05) for melodic-interval tasks; and, mean differences between third-grade males and kindergarten males approached significance (p < .06) for both melodic-interval tasks and tonal-pattern tasks. Results are presented in Table 11 and Table 12.

Table 11
Mean Frequency Deviations:
Melodic-Interval Tasks by Grade Level and
Gender Groupings

Melodic-Interval Tasks									
GRDGEN	MEAN	KM	KF	FM	FF	SM	SF	TM	TF
KM	58.48							+	
KF	49.67							**	
FM	42.11								
FF	46.10								
SM	50.13								
SF	52.29								
TM	31.37								
TF	48.15								

** p <.05
+ approached significance (p = .06)

Table 12
Mean Frequency Deviations:
Tonal-Pattern Tasks by Grade Level and Gender Groupings

Tonal-Pattern Tasks									
GRDGEN	MEAN	KM	KF	FM	FF	SM	SF	TM	TF
KM	61.66							+	
KF	47.20								
FM	38.10								
FF	38.54								
SM	46.82								
SF	50.53								
TM	31.11								
TF	46.40								

+ approached significance (p = .06)

Summary of ANOVA and Post Hoc Tests

Results of the analysis of variance performed on vocal pitch-matching data demonstrated that timbre and task significantly affected subjects' vocal pitch-matching accuracy (p < 001). Post hoc t-tests revealed that subjects were significantly more accurate (p < .001) when responding to soprano voice and significantly less accurate (p < .001) when responding to resonator bells than all other timbres. No significant differences were observed between performances of single-tone tasks with piano, violin, trumpet, and oboe timbres which clustered between soprano voice and resonator bells. Subjects' vocal pitch-matching accuracy was significantly greater for melodic-interval and tonal-pattern tasks (p < .001) than for single-tone tasks. Results also demonstrated a significant interaction between timbre and task

($p < .001$). For each level of task, soprano voice and resonator bells were the most and least effective timbres, respectively. Considering only the timbres of piano, violin, trumpet, and oboe, subjects' performances of single tones were more accurate when trumpet was the stimulus timbre. Performances of melodic intervals were more accurate when violin was the stimulus timbre and performances of tonal patterns were more accurate when oboe served as the stimulus. Significant differences were observed between performances of melodic intervals with violin and piano ($p < .05$). Performances of tonal patterns with oboe and trumpet were also significant ($p < .05$).

Grade level and gender, independently functioning, did not significantly affect vocal pitch-matching accuracy. A significant interaction, however, was observed between task, grade level, and gender ($p < .01$). Post hoc t-tests revealed that the interaction was primarily attributable to single-tone tasks, specifically responses of kindergarten and first-grade females to violin stimuli and responses of kindergarten and second-grade females to piano stimuli employing the frequencies of A4, B4, and C5.

Pearson Correlations

Because home musical environment and socioeconomic status were reported in the literature as factors affecting children's musical skills, they were included in the investigation to control for possible effects. The investigator tested the following secondary null hypotheses concerning home musical environment (HME) and socioeconomic status (SES):

1) There is no significant relationship between <u>HOMES</u> scores and vocal pitch-matching accuracy of children in kindergarten through third-grade.

2) There is no significant relationship between SES and vocal pitch-matching accuracy of children in kindergarten through third-grade.

The analysis failed to produce significant correlations between HME and vocal pitch-matching accuracy or between SES and vocal pitch-matching accuracy. Thus, the secondary null hypotheses were retained.

Data were collected via the <u>HOMES</u> questionnaire and parent survey forms issued at the beginning of the study. Ninety-eight percent of subjects returned the questionnaire and survey form. Ninety-four percent provided the requested SES information. To determine their relationship to vocal pitch-matching accuracy, Pearson product-moment correlations were performed on HME, SES, and vocal pitch-matching data. Three significant correlations resulted from these procedures. In each instance, a significant relationship was observed between the HME and SES variables.

First, correlations performed across all subjects yielded a significant correlation between HME and SES

(0.29, p < .01). Table 13 summarizes the results of this procedure. Mean frequency deviations across all responses were used as the measure of vocal pitch-matching accuracy (VPMA).

Table 13
Correlation Matrix: All Subjects

	HME	SES	GRD	VPMA
HME	1.00			
SES	.29**	1.00		
GRD	-.12	-.02	1.00	
VPMA	-.05	.04	-.09	1.00

** p < .01

Second, correlations performed for each grade level resulted in a significant correlation between HME and SES for third-grade subjects. Non-significant correlations resulted from all other comparisons. Table 14 summarizes the results of this procedure.

Table 14
Correlation Matrix: Grade Level

	GRADE	HME	SES	VPMA
SES	K	.34	1.00	
	F	.05	1.00	
	S	.15	1.00	
	T	.51**	1.00	
VPMA	K	-.31	.27	1.00
	F	-.15	.06	1.00
	S	-.06	-----	1.00
	T	-.21	-.10	1.00

** p <.01

Third, comparisons among female subjects resulted in a significant correlation between HME and SES (.35, p <.01). Non-significant correlations were observed for comparisons among male subjects as well as between male and female subjects. Results are summarized in Table 15.

Table 15
Correlation Matrix: Gender

	GENDER	HME	SES	VPMA
SES	M	.22	1.00	
	F	.35**	1.00	
VPMA	M	-.21	-.18	1.00
	F	.09	.21	1.00

** p <.01

Significant correlations between HME and SES were consistent with Kirkpatrick (1962) who found the number of "poor" musical environments in homes with lower SES levels to be significant (p < .01). The lack of significance between HME and vocal pitch-matching accuracy may be attributable to the fact that only two items on the HME questionnaire directly addressed the child's singing abilities. Therefore, the investigator cannot conclude that HME is not a factor affecting children's vocal pitch-matching abilities.

Descriptive Statistics

Descriptive statistics, including range, mean, standard deviation, standard error of the mean, range, and multi-way frequency and percentage tables, were performed on subjects' vocal pitch-matching data. Biomedical Data Processing (BMDP) statistical software program 1D was used to obtain descriptive statistics; program 4F was used to produce multiway frequency and percentage tables (Dixon, Brown, Engelman, Hill, and Jennrich, 1988).

Subjects (n = 111) performed a total of 41103 responses. Missing responses accounted for only .5 percent of the 41292 possible responses. The mean age for grade level revealed a difference of approximately one-year between each grade level. The mean Home Musical Environment Scale (HOMES) score for the sample was 30.7 points out of a possible score of 44 points. Home musical environment scores varied by only 1.5 points across all grade levels. The mean socioeconomic status level was 3 (Low-Middle) indicating that the average annual salary for families represented in the sample ranged from $20,000 to $30,000. A summary of descriptive statistics for age, home musical environment (HME), socioeconomic status (SES), and vocal pitch-matching accuracy (VPMA) is presented in Table 16.

Subjects' vocal pitch-matching responses were analyzed via Visi-Pitch to determine fundamental frequencies and paired with appropriate stimuli. Frequency deviations were computed by subtracting the response frequency from the stimulus frequency. Mean frequency deviations, reflecting subjects' vocal pitch-matching accuracy, were calculated

Table 16
Descriptive Statistics

Variable	Grouping Grd/Gen	Total Freq.	Mean	Std. Dev.	St.Err of Mean	Range
AGE	All Subjects	111	7.0	1.268	0.1204	5
	Kindergarten	25	5.3	0.476	0.0956	1
	First-Grade	28	6.6	0.497	0.0940	1
	Second-Grade	29	7.5	0.572	0.1063	2
	Third-Grade	29	8.5	0.634	0.1177	2
	Male	50	7.0	1.204	0.1702	4
	Female	61	7.1	1.328	0.1700	5
HME	All Subjects	109	30.7	6.383	0.6114	33
	Kindergarten	25	32.1	6.254	1.2508	21
	First-Grade	27	30.9	5.399	1.0390	20
	Second-Grade	29	29.4	6.967	1.2937	32
	Third-Grade	28	30.4	6.784	1.2821	30
	Male	50	30.5	6.544	0.9255	32
	Female	59	30.8	6.295	0.8195	25
SES	All Subjects	103	3.2	1.454	0.1432	5
	Kindergarten	23	3.3	1.453	0.3029	5
	First-Grade	26	3.3	1.564	0.3066	5
	Second-Grade	28	2.8	1.278	0.2415	5
	Third-Grade	26	3.3	1.543	0.3027	5
	Male	49	3.0	1.443	0.2062	5
	Female	54	3.3	1.462	0.1989	5
VPMA	All Subjects	111	64.8	28.04	2.6614	147.4
	Kindergarten	25	72.3	24.32	4.8637	127.1
	First-Grade	28	58.8	26.29	4.9685	91.3
	Second-Grade	29	68.1	32.44	6.0247	145.3
	Third-Grade	29	59.8	27.37	5.0828	118.8
	Male	50	62.6	27.24	3.8515	146.7
	Female	61	67.0	28.81	3.6887	146.0

across all variables and variable combinations. The grand mean frequency deviation, representing overall vocal pitch-matching accuracy, was 64.8 Hz with a standard deviation of 28 Hz and a standard error of mean of 2.66 Hz. Grand mean results demonstrated that kindergarten subjects performed with least accuracy while first-grade subjects performed with greatest accuracy. Although differences were small, males were more accurate than females across all responses.

Response data also were examined to determine if responses were performed: (1) flat or sharp; (2) within given ranges of error for the stimuli; (3) above or below the range of frequencies included in the PMT (C4 (261.63 Hz) to C5 (523.25 Hz)); or (4) above the PMT range but specifically an octave above or below the stimuli. A detailed account of all PMT responses is presented in Table 17.

Table 17
Summary of Subjects' Responses

41292	total possible responses	% of Total Responses
189	responses were missing	
41103	total responses	
24866	responses were flat	60.5%
16170	responses were sharp	39.3%
67	responses were perfect	.2%
41103		100.0%
9854	responses were accurate	23.9%
31249	responses were inaccurate	76.1%
41103		100.0%
33852	responses within C4-C5	82.4%
526	above C5	1.2%
6725	below C4	16.4%
41103		100.0%
203	responses an octave below stimulus	.5%
122	responses an octave above stimulus	.3%

Flat and Sharp Responses

Each response was tested to determine if a response was flat, sharp, or perfect. Responses with frequency deviations below the stimulus frequency were defined as "flat" and coded "F"; responses with frequency deviations above the stimulus frequency were defined as "sharp" and coded "S." When a response frequency exactly matched the stimulus frequency, a response was defined as "perfect" and coded "P." Data for flat, sharp, and perfect responses were compiled via multiway frequency tables using BMDP statistical software program 4F (Dixon et al, 1988). As shown in Table 17, subjects sang flat over 60 percent of the time. Sixty-seven (67) responses were determined to be perfect.

The extensive flatting observed in this study was consistent with reports of flatting in previous studies (Hermanson, 1971; Sims, Moore, and Kuhn, 1982). For each of the main effects, percentages of flat responses seldom dropped below 50 percent of total responses. The following sections present the results of flat-sharp data across all responses for each of the main effect variables. Within the present study, only the frequency of flat and sharp responses was observed. No attempt was made to determine the interval of flatting or sharping. Therefore, the terms "flat" and "sharp" indicate a tendency to sing below or above the stimuli respectively. In the discussions of flatting and sharping which follow, the resonator-bell timbre is omitted since many subjects attempted to sing in the octave above the test range. Resonator-bell responses are discussed in detail in the section concerning the timbre main effect.

Timbre and Task

Across all tasks, the percentage of flat responses for each timbre treatment was generally high with small differences between each treatment. Results indicated that timbres of orchestral instruments were effective in reducing the percentage of flat responses. The timbres of oboe, violin, and trumpet produced fewer flat responses than did soprano voice and piano. These results were unexpected for two reasons. First, subjects were most familiar with piano and soprano voice timbres as a result of participating in school, church, and home musical experiences. Second, mean frequency deviations for soprano voice were significantly lower than other timbres in the study ($p < .001$).

When subjects performed single-tone tasks, results showed that soprano voice timbre elicited the lowest percentage of flat responses followed by trumpet, oboe, violin, and piano respectively. The percentage of flat responses ranged from 75.2 percent of all PMT responses (soprano voice) to 78.8 percent (piano). Across all timbres, the percentage of flat responses was higher for single-tone tasks (76%) than for either melodic-interval (59.4%) or tonal-pattern tasks (56.9%).

When subjects performed melodic-interval tasks, oboe timbre elicited the lowest percentage of flat responses followed by violin, trumpet, soprano voice, and piano, respectively. No difference was observed between trumpet and soprano voice. Across all timbres, a mean difference of 16.1 percent was observed between the percentage of flat responses for melodic-interval tasks (59.4%) and the percentage of flat responses for single-tone tasks (76%).

When subjects performed tonal-pattern tasks, violin timbre elicited the lowest percentage of flat responses followed by trumpet, oboe, soprano voice, and piano respectively. Results are summarized in Table 18.

Table 18
Percentage of Flat and Sharp Responses by Timbre and Task

TIMBRE	%	ST	MI	TP	TOTAL
OBOE	F S	77.4 22.6	58.9 41.1	57.1 42.9	60.4 39.6
PIANO	F S	78.8 21.2	63.1 36.9	60.2 39.8	63.4 36.6
RBELLS	F S	69.2 30.8	50.1 49.9	52.8 47.2	55.9 44.1
SOPRANO VOICE	F S	75.2 24.8	61.6 38.4	59.8 40.2	62.5 37.5
TRUMPET	F S	76.7 23.3	61.6 38.4	56.1 43.9	60.7 39.3
VIOLIN	F S	78.6 21.3	60.8 39.2	55.5 44.5	60.6 39.4
ALL TIMBRES	F S	76.0 24.0	59.4 40.6	56.9 43.1	60.6 39.4

F/S= Flat/Sharp

The slightly lower percentages of flat responses associated with oboe, trumpet, and violin for tonal patterns, and across all tasks suggested that these timbres may serve to reduce flat pitch-matching responses, and therefore, should be included in future research. Across all timbres, flatting associated with tonal-pattern tasks decreased by a mean difference of 19.6 percent as compared to single-tone performances. The improvement in flatting observed for melodic intervals and tonal patterns may be attributable to the presence of more than one pitch in the melodic-interval stimuli and tonality established in the tonal-pattern subtest. Performances of tonal patterns resulted in the least amount of flatting.

Grade Level and Gender

All grade-gender groups had a high percentage of flatting for single tone tasks with a range of 65.6 percent for kindergarten males to 87.2 percent for kindergarten females. For kindergarten males, however, the percentage of sharp responses increased for performances with melodic intervals and tonal patterns. For melodic-interval tasks, the percentage of flat responses ranged from 42.5 percent for kindergarten males to 73.2 percent for third-grade males. For tonal pattern tasks, kindergarten males had the lowest percentage of flat responses (37.7%) while third-grade males had the highest percentage (67.3%).

Kindergarten males were the only group to perform more sharp responses than flat responses across all tasks and timbre treatments. By contrast, the percentage of flat responses increased from 43.1 percent for kindergarten males to 71.5 percent for third-grade males representing a difference of 28.4 percent. Results are presented in Table 19.

Table 19
Percentage of Flat and Sharp Responses
by Task, Grade Level, and Gender

GRADE	GEN	%	ST	MI	TP	TOTAL
KINDERGARTEN	M	F	65.6	42.5	37.7	43.1
		S	34.4	57.5	62.3	56.9
	F	F	87.2	66.5	57.0	64.6
		S	12.8	33.5	43.0	35.5
FIRST GRADE	M	F	73.4	60.0	59.8	61.6
		S	26.6	40.0	40.2	38.4
	F	F	70.6	62.8	59.1	62.0
		S	29.4	37.2	40.9	38.0
SECOND GRADE	M	F	76.3	55.7	53.6	57.3
		S	23.7	44.3	46.4	42.7
	F	F	80.4	63.5	64.1	65.9
		S	19.6	36.5	35.9	34.1
THIRD GRADE	M	F	82.2	73.2	67.3	71.5
		S	17.8	26.8	32.7	28.5
	F	F	72.7	58.4	56.7	59.4
		S	27.3	41.6	43.3	40.6

As shown in Table 19, flatting among males also increased with grade level for single-tone tasks. Across all tasks, results demonstrated that third-grade males tended to sing flat more often than males at all other grade levels. Conversely, third-grade females tended to sing fewer flat responses than females at all other grade levels. With the exception of third-grade subjects, males performed fewer flat responses across all tasks than females.

Similarly, across all timbres, males produced fewer flat responses than did females. Table 20 summarizes these results.

Table 20
Percentage of Flat and Sharp Responses
by Timbre and Gender

GENDER	MALE		FEMALE	
TIMBRE	%F	%S	%F	%S
OBOE	57.8	42.2	63.1	36.9
PIANO	61.9	38.1	65.5	34.5
RBELLS	53.8	46.2	58.4	41.6
S.VOICE	61.6	38.4	63.4	36.6
TRUMPET	57.9	42.1	63.8	36.2
VIOLIN	57.4	42.6	63.6	36.4
TOTALS	58.4	41.6	63.0	37.0

As shown in Table 21, when grade and task were studied, first-grade subjects had fewer flat responses for single-tone tasks; however, the percentage of flat responses remained high with only small differences between grade

Table 21
Percentage of Flat and Sharp Responses
by Grade Level and Task

GRADE	%	ST	MI	TP	TOTAL
KINDERGARTEN	F	76.4	54.5	47.4	53.8
	S	23.6	45.5	52.7	46.2
FIRST GRADE	F	72.0	61.4	59.5	61.8
	S	28.0	38.6	40.5	38.2
SECOND GRADE	F	78.4	59.6	58.9	61.6
	S	21.6	40.4	41.1	38.4
THIRD GRADE	F	77.5	65.8	62.0	65.5
	S	22.5	34.2	38.0	34.5

levels. Kindergarten subjects had the lowest percentage of flatting for melodic-interval and tonal-pattern tasks, while third-grade subjects had the highest percentage of flatting for these tasks. Across all tasks, kindergarten subjects had the lowest percentage of flat responses.

Accurate Vocal Pitch-matching Responses

Response data were tested to determine if subjects' responses were accurate or inaccurate. This was accomplished by establishing cut-off points for each of the PMT stimuli. Cut-off points were determined by averaging the difference between adjacent half-steps within the range of the PMT (Figure 6). If a response was between the cut-off points established for the stimulus, the response was deemed accurate and a "score" of one point was awarded to the subject. Scores were totaled for each stimulus frequency

Stimulus Frequency	Lower Range	Upper Range
C5	508.6	538.8
B4	480.4	508.5
A#4	453.5	480.3
A4	428.0	453.4
G#4	404.0	427.9
G4	382.3	403.9
F#4	359.9	382.2
F4	339.4	359.8
E4	320.7	339.3
D#4	302.7	320.6
D4	285.7	302.6
C#4	269.7	285.6
C4	254.4	269.6

Fig. 6: Cut-Off Points

to show the number of correct responses associated with each stimulus. Consequently, a higher score reflected an increase in vocal pitch-matching accuracy. Calculating accurate response scores was an important step in determining the reliability of the PMT.

Responses Below C4 and Above C5

Among the total of 41103 responses there were 6725 responses below C4 (16.3%) and 526 (1.3%) responses above C5. These responses exceeded the test range of the PMT (C4 - C5) and were labeled as "out-of-range" responses. "Out-of-range" responses accounted for 17.6 percent of total responses. As shown in Table 22, when the stimulus was C#4, subjects performed "out-of-range" responses 11.9 percent of the time. When the stimulus was A4, the percentage of "out-of-range" responses increased to 30.6 percent of the time. The three frequencies having the highest percentages

Table 22
"Out-of-Range" Responses by Stimulus Frequency

Stimulus Frequency	Stimulus Count	Out-of-Range Responses	%of Stimuli
C#4	1332	158	11.9
G4	8658	1184	13.7
E4	7326	1070	14.6
D4	7326	1206	16.5
F4	3330	569	17.1
C4	11322	2467	21.8
C5	666	196	29.4
B4	666	197	29.5
A4	666	204	30.6
TOTALS	41292	7251	17.6

of "out-of-range" responses were A4, B4, and C5. These frequencies also had the lowest percentage of accurate responses.

Responses an Octave Above or Below Stimuli

Some "out-of-range" responses represented performances of the stimulus at the octave above or below that presented to subjects. Table 23 presents the distribution of "octave" responses for each of the stimulus frequencies. Some subjects responded to C4 or C5 by singing an octave above or below respectively. The percentage of responses at the octave above is .3 percent of total responses. Six subjects accounted for 105 (86%) of the 122 responses at the octave above. Of the six, two were kindergarten subjects who contributed 51 (41.8%) of responses at the octave above. The percentage of responses at the octave below is .5

Table 23
Responses an Octave Above or Below Stimulus

STIMULUS FREQUENCY	COUNT BELOW	COUNT ABOVE
C5	74	0
B4	62	0
A4	29	0
G4	34	4
E4	0	13
F4	4	9
D4	0	21
C#4	0	4
C4	0	71
TOTALS	203	122

percent of total responses yielding a total of .8 percent for both conditions.

Summary of Descriptive Statistics

Results of descriptive statistics demonstrated that 60.5 percent of subjects' responses were performed flat (i.e., below the stimulus frequency). The timbres of oboe, trumpet, and violin produced fewer flat responses across all timbres than traditional classroom instruments of soprano voice, piano, and resonator bells. Soprano voice produced fewest flat responses for single-tone tasks, oboe produced fewest flat responses for melodic-interval tasks, and violin produced fewest flat responses for tonal-pattern tasks. Performances of tonal patterns resulted in the least amount of flatting. Kindergarten males were the only group to perform more sharp responses than flat responses across all tasks. Third-grade males had the highest percentage of flat responses across all tasks. "Out-of-range" responses accounted for 17.6 percent of all responses 16.3 percent of which were below the test range (C4 to C5). Responses judged to be an octave above or below the stimulus accounted for .8 percent of all responses. Subjects produced only 67 perfect responses.

CHAPTER V

SUMMARY AND CONCLUSIONS

Singing is a principal means for music educators to introduce concepts and skills to children in kindergarten through third-grade. There is, however, a noticeable lack of research on singing skills as a function of timbre, task, grade level, and gender. The purpose of this study was to investigate effects of selected timbres, tasks, grade level, and gender on vocal pitch-matching accuracy of kindergarten through third-grade children. Five primary null hypotheses were tested to determine the significant effects of these variables on kindergarten through third-grade children. Two secondary null hypotheses were tested to determine the relationships among home musical environment (HME), socioeconomic status (SES), and vocal pitch-matching accuracy of kindergarten through third-grade children.

A Pitch-Matching Test (PMT) was constructed and administered individually to 111 subjects in kindergarten through third-grade. The PMT was designed to contain content validity based upon a review of research findings regarding primary-aged children's vocal pitch-matching accuracy. The reliability of the PMT was .97 as determined by the Kuder-Richardson coefficient-alpha method for determining the reliability of tests containing items with variable quantities (Boyle and Radocy, 1987). The test consisted of three subtests which required subjects to vocally match aurally presented single tones, melodic intervals, and tonal patterns. Six timbres were used to administer the subtests: oboe, piano, resonator-bells, soprano voice, trumpet, and violin. The frequencies of subtest one ranged from C4 (261.63 Hz) to C5 (523.26 Hz), and of subtests two and three from C4 (261.63 Hz) to G4 (392 Hz). Subject's vocal pitch-matching responses and PMT stimuli were recorded individually and analyzed via Visi-Pitch, computer interface, and Packard Bell IBM-compatible computer. Fundamental frequencies provided by the Visi-Pitch were accurate within .1 Hz. Subjects' mean frequency deviations from the fundamental frequencies of the PMT stimuli were computed and data were analyzed statistically via a 6 (timbres) X 3 (tasks) X 4 (grade levels) X 2 (genders) factorial analysis of variance with repeated measures as a mixed design (Keppel, 1973).

Results of the study demonstrated that: (1) timbre and task, independently functioning, significantly affected vocal pitch-matching accuracy of kindergarten through third-grade children ($p < .001$); (2) tasks involving single tones significantly reduced children's abilities to match pitch ($p < .001$); (3) gender and grade level, independently functioning, did not significantly ($p > .05$) affect children's vocal pitch-matching accuracy; (4) task, grade level, and gender interact, significantly affecting children's vocal pitch-matching accuracy ($p < .01$); (5) abilities to sing melodic intervals and tonal patterns increased with age; and (6) among males, the ability to match single-tone tasks diminished with age.

The study showed that all children most accurately responded when there were two or more frequencies in the aurally presented stimuli, and when soprano voice was the presentation medium. Furthermore, subjects' responses were significantly less accurate when the presentation medium was resonator bells ($p < .001$). Results demonstrated that the timbres of oboe, violin, trumpet, and piano were not significantly different and may be used as effective alternative timbres for male teachers or teachers with inadequate singing voices. Further research is needed to confirm this hypothesis.

Timbre treatments had little effect upon the percentage of flat or sharp responses; however, subjects tended to sing flat less often when responding to orchestral timbres than with piano or soprano voice. Subjects performed fewest flat responses when performing tonal patterns. Kindergarten, first-grade, and second-grade males performed fewer flat responses at each level of task than females. Across all responses, subjects sang flat over 60 percent of the time.

HME and SES were found to be related significantly across all subjects ($p < .01$). Specifically, a significant relationship between HME and SES also was found for female subjects ($p < .01$) and third-grade subjects ($p < .01$); but, not for male, first-grade or second-grade subjects. No significant relationship was observed between HME and vocal pitch-matching accuracy ($p = .63$) or between SES and vocal pitch-matching accuracy ($p = .67$).

Implications for Music Education

Timbre

As in previous studies (Clegg, 1966; Hermanson, 1971; Small and McCachern, 1982; and Sims, Moore, and Kuhn, 1983), results of the present study demonstrated that soprano voice was superior as an aural model for vocal pitch-matching experiences with young children. Mean frequency deviations for performances with soprano voice timbre were significantly lower than performances with other timbres ($p < .001$) regardless of the task involved. Greater familiarity with soprano voice timbre than with other timbres must be considered a confounding factor when attributing increased accuracy to soprano voice stimuli. Nevertheless, results seem to support the assertion by Swanson (1980) that female teachers have an advantage when presenting aural stimuli to young children. Prior to the invention of electronic synthesizers, no challenge could be made to this assertion; however, for male teachers or teachers who are inadequate singers, it is possible to digitally sample a soprano voice and use an electronic keyboard and sampler to present aural materials to young children. Similarly, an electronic keyboard could be used to present aural materials with trumpet, violin, or oboe timbre employing either preset or digitally sampled timbres. Results of the present study demonstrated that these timbres may be effective as alternative timbres to soprano voice. Clegg (1966) found no significant differences between female voice and piano. She concluded that piano timbre may be used for effective vocal pitch-matching. In Hermanson's (1971) study, responses to piano timbre were significantly less accurate than responses to female voice ($p < .05$); and, in Petzold's (1966) study, differences between responses to violin and piano timbre approached the .05 level of significance in favor of the violin. Within the present study, responses to piano were significantly less accurate ($p < .001$) than responses to soprano voice. Additionally, for melodic-interval tasks, responses to violin timbre were significantly more accurate ($p < .05$) than responses to piano timbre. Although nonsignificant, responses to trumpet and oboe timbre were more accurate for single-tone tasks and tonal-pattern tasks, respectively, than piano. Results of the present study and other studies support the conclusion that use of piano timbre is not warranted when other timbres are available.

Results of the present study also demonstrated that vocal pitch-matching responses to resonator bells were significantly less accurate ($p < .001$) than other timbres in the study. Performances of single tones with resonator bells demonstrated that resonator bells should not be used to present starting pitches without first establishing the tonality of the song to be sung. Although performances with resonator bells improved for melodic-interval and tonal-pattern tasks, performances with resonator bells were clearly inferior to performances with other timbres across all levels of task. On the basis of this study and previous studies (Clegg, 1966; Petzold, 1966), use of resonator bells pitched in the octave above the child's range cannot be recommended for vocal pitch-matching activities.

Task

Results showed that children, regardless of grade or gender, performed significantly ($p < .001$) less accurately when attempting single-tone tasks than when attempting melodic-interval and tonal-pattern tasks. The study demonstrated the importance of establishing a tonality for aurally presented materials and supports those who assert that tonal patterns are more appropriate for vocal pitch-matching activities than single tones (Smith, 1970; Jones, 1971; Gordon, 1978).

Some practical suggestions emerged from the results of subject's performances across the three tasks. First, range appeared to be a factor inhibiting children's vocal pitch-matching accuracy of single-tone performances. Children in the present study produced more correct responses to stimulus frequencies ranging from C4 to F4 than for stimulus frequencies ranging from G4 to C5. Results of post hoc t-tests revealed a significant increase in mean frequency deviations ($p < .05$) between C4 and D4. Significance was greater for each increase in stimulus frequency above D4 ($p < .01$). Additionally, children produced more responses on B3, C4, and D4 than other pitches, regardless of task, demonstrating that low tones were produced more readily. Results suggest that vocal materials should be limited to a low frequency range initially, perhaps B3 or Bb3 to F4, to ensure that as many children as possible participate in an activity. F4 is suggested as the highest practical frequency because pitches above F4 were associated with much larger mean frequency deviations at each level of task. These results also suggest that the practice of singing descending patterns to develop head voice may exclude many children who are unable to begin in a higher singing range.

Second, children must be prepared adequately before beginning a song or vocal pitch-matching activity. Within the present study, children were required to make spontaneous responses. A brief demonstration and practice session at the beginning of each subtest was the only preparation the children received. In the classroom, repetition and practice of starting pitches may help to ensure that as many children as possible are able to begin the song on the correct pitch. Furthermore, single tones were presented randomly without reference to an established tonality. Children's performances were significantly more accurate when performing the same frequencies within melodic-interval and tonal-pattern tasks. Results suggest that starting pitches should be presented within an established tonality accompanied by either the tonic chord or part of the melody to be sung.

Third, results showed that tonal patterns not starting on the tonic are generally more difficult to perform than tonal patterns beginning on the tonic pitch. Although results were confounded by the presence of G4 in some tonal patterns, results suggest that care should be taken when performing patterns not beginning on the tonic. (i.e., if a tonic pitch is established).

Grade Level and Gender

No significant effects were found for either grade level or gender as independently functioning variables; however, males demonstrated greater accuracy than females at each grade level with the exception of the first-grade. Kindergarten males were significantly more accurate ($p < .05$) than kindergarten females when performing single-tone tasks; and, across all grades and tasks, males demonstrated greater accuracy than females. These results were surprising since many researchers report that females perform more accurately than males across various musical tasks including vocal pitch-matching tasks (Clegg, 1966; Petzold, 1966; Moore, 1973; Miller, 1986; Jordan-DeCarbo, 1982). Results indicate that males should be expected to perform as accurately as females during vocal pitch-matching activities without requiring special attention in the instructional program.

Results of the study demonstrated some improvement in vocal pitch-matching accuracy among older students. Kindergarten, first-grade, and third-grade children demonstrated progressively lower mean frequency deviations for each task level. For performances of melodic intervals and tonal patterns, second-graders responded with higher mean frequency deviations than first-grade and third-grade children. Among males, the ability to perform single-tone tasks decreased with age. Results were not consistent with numerous studies in the literature which support effects of grade level on the musical abilities of young children (Boardman, 1964; Clegg, 1966; Duell and Anderson, 1967; Hermanson, 1971; Sims, Moore, and Kuhn, 1982). Nevertheless, results of the study support the conclusion that older children respond to vocal pitch-matching materials more accurately than younger children.

Suggestions for Future Research

While the present study addressed several important concerns relevant to vocal pitch-matching accuracy, results of the study prompted additional concerns which require further investigation. The following research studies are recommended to further investigate issues unresolved by the current study.

A replication of this study is needed to determine if vocal pitch-matching accuracy can be evoked with children in kindergarten through third-grade using digitally sampled and electronically produced timbres. Because soprano voice elicited significantly greater accuracy ($p < .001$) than other timbres in the present study, a digitally sampled soprano voice should be included in a replication of this study. If digitally sampled soprano voice can be shown to be effective, male teachers and teachers with inadequate singing voices may be able to conduct vocal pitch-matching activities more effectively than would be possible using their voices or other timbres.

Although associated with significant ($p < .001$) inaccuracy, resonator bells also should be included in a replication of this study. Because resonator bells are widely recommended as a part of classroom music programs and are relatively inexpensive to obtain, use of these instruments will continue. Additional research is needed to confirm results of the present study and to determine if continued use of resonator bells during vocal pitch-matching experiences is warranted. Results of this study suggest that use of resonator bells pitched in the octave above the child's range does not facilitate vocal pitch-matching accuracy.

Further research is needed to determine effects of sampled and electronically produced oboe, trumpet, and violin timbres on vocal pitch-matching accuracy. Since these timbres are preset on many electronic keyboards, research should be conducted initially using preset timbres found in less expensive keyboards. These instruments are more readily available to teachers than the more expensive electronic keyboards with microphone sampling capabilities. Consequently, research results may be more immediately applicable to classroom teaching.

While soprano voice is clearly superior as an aural model for young children, there is a natural advantage to soprano voice timbre because it is the timbre with which children are most familiar. Results of this study demonstrated that trumpet, violin, and oboe timbre, although much less familiar to children, were effective aural models during vocal pitch-matching experiences. Additional research is needed to understand effects of training with trumpet, oboe, and violin timbres on children's vocal pitch-matching accuracy. Future research may include a control group using soprano voice and one group of subjects for trumpet, oboe, and violin. Only children in trumpet, oboe, and violin groups receive training and all groups are pretested and posttested using their respective timbres.

The purpose of the study is to determine if significant differences between soprano voice, trumpet, oboe, and violin timbre result following a training period to familiarize children with the less familiar timbres of trumpet, oboe, and violin.

A need exists for development and testing of a home musical environment questionnaire more sensitive to vocal performance activities. The new questionnaire should emphasize a child's participation in pitch-related activities, specifically, participation in singing activities at home, school, and church. Relevant factors identified in the original Home Musical Environment Scale (HOMES) (Brand, 1985) questionnaire should be included.

Finally, further research is needed to determine the effects of range, interval size, interval direction, and pattern difficulty on tasks involving two and three tones. Results associated with large intervals (e.g., P4 and P5) and tonal pattern difficulty in the present study were confounded by the presence of G4 which was associated with high mean frequency deviations. A second version of the melodic interval and tonal pattern subtests should be developed in which the range for perfect fourths and perfect fifths is delimited to B3 or Bb3 to F4. This change to the PMT would enable investigators to determine which factors are contributing to children's difficulties with specific tasks, excluding upper-range frequencies which confounded results of this study.

Studies examining effects of digitally sampled and electronically produced timbres and training with selected timbres are needed to determine effective alternative timbres for male teachers and teachers with inadequate singing voices. These studies, as well as research on effects of range, interval size, and direction on singing task difficulty; home musical environment; and effects of perceptual skills on vocal pitch-matching accuracy should yield information relevant to selecting appropriate instructional materials and methods for primary-aged children.

BIBLIOGRAPHY

Apfelstadt, H. (1984). Effects of melodic perception instruction on pitch discrimination and vocal accuracy of kindergarten children. Journal of Research in Music Education, 32(1), 15-24.

Berger, K. W. (1963). Some factors in the recognition of timbre. Journal of the Acoustical Society of America, 36, 1888-1891.

Boardman, E. L. (1964). An investigation of the effect of preschool training on the development of vocal accuracy in young children. (Doctoral dissertation, University of Illinois). Dissertation Abstracts International, 25, 1, 1245.

Boyle, J. D., and Radocy, R. E. (1987). Measurement and evaluation of musical behaviors. New York: Schirmer.

Brand, M. (1985). Development and validation of the Home Musical Environment Scale for use at the early elementary level. Psychology of Music, 13,(1) 40-48.

Bruno, Rosalind R. (1988). School Enrollment-Social and Economic Characteristics of Students: October 1986 (U. S. Department of Commerce, Bureau of the Census, Series P-20, No.429). Washington D. C.: Bureau of the Census.

Cleall, C. (1970). Voice Production in Choral Technique, London:Novella.

Clegg, B. W. (1966). A comparative study of primary grade children's ability to match tones. (Master's thesis, Brigham Young University, 1966).

Dixon, W. J., Brown, M. B., Engelman, L., Hill, M. A., and Jennrich, R. I. (1988). BMDP statistical software manual. California: University of California.

Drexler, E. N. (1938). A study of the development of the ability to carry a melody at the pre-school level. Child Development, 9, 319-332.

Duell, O. and Anderson, R. (1967). Pitch discrimination among primary school children. Journal of Educational Psychology, 58, 315-318.

Fox, D. B. (1984). The pitch range and contour of infant vocalizations. Paper presented at MENC Convention, Chicago.

Froschels, E. (1920). Untersuchungen uber die Kinderstimme. Zentralb.f.Physiol, 34. In Schoen, (1940). Psycology of Music (pp. 477-484). New York: Roland Press.

Gardner, H., Davidson, L., and McKernon, P. (1979). The acquisition of song: A developmental approach. National symposium on the applications of psychology to the teaching and learning of music. Reston, Virginia: Music Educators National Conference.

Gelineau, R. Phyllis (1970). Experiences in Music. McGraw-Hill, Inc.

George, W. H. (1954). A sound reversal technique applied to the study of tone quality. Acustica, 4, 224-225.

Goetze, Mary (1985). Factors affecting accuracy in children's singing. (Doctoral dissertation, University of Colorado). Dissertation Abstracts International, 46, 10, 2955.

Gordon, E. (1971). The Psychology of Music Teaching. New Jersey: Prentice-Hall.

Gordon, E. (1980). Learning sequences in Music: Skill, content, and patterns. Chicago: GIA Publications, Inc.

Gordon, E. (1986). Primary Measures of Music Audiation. Chicago: GIA Publications, Inc.

Green, G. A. (1987). The effect of vocal modeling on pitch-matching accuracy of children in grades one through six. (Doctoral dissertation, The Louisiana State University and Agricultural and Mechanical College. University Microfilm No. 8719365).

Greenberg, M. A. (1969). Critique of the influence of home musical environment upon musical response of first-grade children. Council for Research in Music Education, 17, 55-60.

Gould, A. O. (1969). Developing specialized programs for singing in the elementary school. Council for Research in Music Education, 17, 9-22.

Gutzman, H. (1928). Physiologie der Stimme und Sprache, Braunschweig. In Fieldhouse, A.E. (1937). A study of backwardness in singing among school-children. (Doctoral dissertation, London University).

Hackett, Patricia and Lindemann, Carolynn A. (1988). The Musical Classroom: Backgrounds, Models, and Skills for Elementary Teaching. Prentice-Hall, Inc.

Hall, K. J. (1972). An investigation of the vocal range of junior schoolchildren. (Doctoral dissertation, Froebel Institute, London).

Heinlein, Christian P. (1928). Brief discussion of the nature and function of melodic configuration in tonal memory, with critical reference to the Seashore Tonal Memory Test. Journal of Genetic Psychology, 35, 45-61.

Helmholtz, H.L.F. von (1877). On the Sensations of Tone as a Physiological Basis for the Theory of Music (4th ed.). Trans. A. J. Ellis. New York: Dover, 1954.

Hermanson, L. W. (1971). An investigation of the effects of timbre on simultaneous vocal pitch acuity of young children (Doctoral dissertation, Columbia University, 1971). Dissertation Abstracts International, 32, 3558-A.

Hoffer, C. R. and Hoffer, M. L. (1982). Teaching Music in the Elementary Classroom. New York: Harcourt-Brace-Jovanovich.

Jersild, A. T. and Bienstock, S. F. (1934). A study of the development of children's ability to sing. Journal of Educational Psychology, 25, 7, 481-503.

Jones, M. (1971). A pilot study in the use of a vertically-arranged keyboard instrument with the uncertain singer. Journal of Research in Music Education, 19(summer), 183-194.

Jordan-Decarbo, J. (1982). Same-different discrimination techniques, readiness training, pattern treatment, and sex on aural discrimination and singing of tonal patterns by kindergartners. Journal of Research in Music Education, 30(4), 237-246.

Joyner, D. R. (1971). Pitch discrimination and tonal memory and their association with singing and the larynx. (M. Phil. thesis, Reading).

Keppel, G. (1973). Design and Analysis: A Researcher's Handbook. New Jersey: Prentice-Hall.

Kirkpatrick, W. C. (1962). Relationships between the singing ability of pre-kindergarten children and their home musical environment. (Doctoral dissertation, University of Southern California, 1962.) Dissertation Abstracts International, 23, 886.

McDonald, Dorothy T. and Simons, Gene M. (1989). Musical Growth and Development. Schirmer Books.

Meske, E. B., Andress, B., Pautz, M. P., and Willman, F. (1988). Holt Music Series. New York: Holt, Rinehart, and Winston.

Michel, P. (1973). Psycology of Music, 11(2), 14-20.

Miller, L. B. (1986). A description of children's musical behaviors: naturalistic. Council for Research in Music Education, 87, 1-16.

Montgomery, Timothy D. (1988). Study of the Association Between Two Means of Vocal Modeling by a Male Music Teacher and Third-Grade Student's Vocal Accuracy in Singing Pitch Patterns. (Doctoral dissertation, The University of North Carolina at Greensboro, 1988). Dissertation Abstracts International, 49, 8, 2142-A.

Moog, H. (1976). The development of musical experience in children of pre-school age. Psychology of Music, 4(2), 38-45.

Moorhead, G. E. and Pond, D. Music of young children (fifth printing), Santa Barbara, California: Pillsbury Foundation for Advancement of Music Education, 1978.

Moore, D. L. (1973). A study of pitch and rhythm responses of 5-year-old children in relation to their early musical experiences. (Doctoral dissertation, Florida State University). Dissertation Abstracts International, 34, 6689A-6690A.

Nye, R. V. and Nye, V. T. (1970). Music in the Elementary School (3rd ed.). Englewood Cliffs: Prentice-Hall.

Patrick, L. R. (1978). An investigation of the pitch-matching abilities of first-grade children. (Doctoral dissertation, Michigan State University). Dissertation Abstracts International, 40, 531-A.

Palmer, M., Reilly, M. L., and Scott, C. R. (1988). World of Music. New Jersey: Silver Burdett-Ginn.

Paulsen, E. (1895). In Revesz (1953), Introduction to the Psychology of Music (p. 50). London: Longmans.

Petzold, R. G. (1966). Auditory Perception of Musical Sounds by Children in the First Six Grades. Wisconsin: University of Wisconsin, Cooperative Research Project 1051, (ERIC ED 010-297).

Petzold, R. G. (1969). Auditory Perception by Children, Journal of Research in Music Education, 17, 82-87.

Plumridge, J. M. (1972). The range and pitch levels of children's voices, in relation to published material for children's voices. (Diss. Dip. Adv. Study of Ed., Reading).

Radocy, R. E. and Boyle, J. D. (1979). Psychological Foundations of Musical Behavior. Springfield, Illinois: Charles C. Thomas.

Raebeck, L. and Wheeler, L. (1969). New Approaches to Music in the Elementary School (2nd ed.). Dubuque: Wm. C. Brown.

Ramsey, J. H. (1981). An investigation of the effects of age, singing ability, and experience with pitched instruments on the melodic perception of preschool children. (Doctoral dissertation, The University of Iowa). Dissertation Abstracts International, 42, 7, 3053-A.

Rasch, R. A. and Plomp, R. (1982). The perception of musical tones. In D. Deutsch (Ed.) (1982), The Psychology of Music (pp. 1-24). New York: Academic Press/Harcourt-Brace-Jovanovich.

Reynolds, G. E. (1960). Environmental sources of musical awakening in preschool children. Dissertation Abstracts International, 21, 1214-1215.

Ries, Nevaida Layton Lee (1982). An Analysis of the Characteristics of Infant-Child Singing Expressions. (Doctoral dissertation Arizona State University. University Microfilms No. 8223568).

Schaeffer, P. (1966). Traite des objets musicaux. Paris: Ed. du Seuil.

Shelton, J. S. (1965). The influence of home musical environment upon musical response of first-grade children. Dissertation Abstracts International, 26, 12, 7361.

Sims, W. L., Moore, R. S., and Kuhn, T. L. (1982). Effects of female and male vocal stimuli, tonal pattern length, and age on vocal pitch-matching abilities of young children from England and the United States. Psycology of Music [Special issue], 104-108.

Sinor, E. (1984). The singing of selected tonal patterns by preschool children. Dissertation Abstracts International, 45, 3299-A.

Simons, G. (1986). Early childhood musical development: A survey of selected research. Council for Research in Music Education, 86, 36-52.

Small, A. R. and McCachern, F. L. (1983). The effect of male and female modeling on pitch-matching accuracy of first-grade children. Journal of Research in Music Education, 31(3), 227-233.

Smith, R. B. (1970). Music in childhood education. New York: Ronald Press Co.

Strong, W. and Clark, M. Jr. (1967). Perturbations of synthetic orchestral wind instrument tones. Journal of the Acoustical Society of America, 41, 39-52.

Stumpf, C. (1926). Die sprachlante. Berlin and New York: Springer-Verlag.

Swanson, B. R. (1980). Music in the Education of Children (4th ed.). Belmont: Wadsworth, Inc.

Taylor, J. A. (1976). Perception of tonality in short melodies. Journal of Research in Music Education, 24, 197-208.

Welch, G. F. (1979). Vocal range and poor pitch singing. Psychology of Music, 7, 13-31.

Wendrich, K. (1981). Pitch imitation in infancy and early childhood: Observations and implications. Dissertation Abstracts International, 42, 5019-A.

Wilson, D. S. (1970). A study of the child voice from six to twelve. (Doctoral dissertation, University of Oregon). Dissertation Abstracts International, 31, 5453A-5454A.

Young, W. T. (1971). An investigation of the singing abilities of kindergarten and first-grade children in East Texas. Washington, D.C.:Research in Education (ERIC), Department of Health, Education and Welfare, Office of Education.

APPENDIX A

PERMISSION TO CONDUCT STUDY

Dr. ________________________
Superintendent
______ County Public Schools
______________________ N.C.

Dear Dr. ________ :

I am writing to request permission to conduct a study in music education with children in grades K-3 in _____________ County Public Schools during the fall of 19--. The proposal for the study has been completed and submitted to my committee for approval. Dr. __________ (school principal) has indicated a willingness to consider my request to conduct the study at ___________ Elementary pending approval by your office and the ________ County School Board. A copy of the proposal is enclosed which should fully explain the study; however, if you have any questions, please let me know. Please accept my thanks for considering this request. I look forward to hearing from you at your earliest convenience.

Sincerely,

Frank L. Tatem, Jr.

APPENDIX B

PARENTAL LETTER AND CONSENT FORM

TO: Parents of children in grades K-3

FROM: Dr. ______________, Principal

Mr. Frank Tatem, a doctoral student from the School of Music at UNCG, has been granted permission to conduct a study in music education at ____________ Elementary School. The study is being conducted to determine if children sing more accurately with certain instruments than with others. Children who participate in the study will be asked to listen to short musical patterns and "echo sing" what they hear. The study will benefit music teachers and the children they teach by providing information about musical instruments used in the teaching of singing. Your child has been selected to participate in the study and we hope you will permit your child to be a part of the study. Please sign the form below and have your child return it to his/her teacher tomorrow. Also, please complete the enclosed questionnaire and return it with the permission slip. Keep the top portion of the letter for future reference. Your willingness to help is greatly appreciated. If you have any questions concerning the study you may contact Mr. Tatem at (phone number) and he will be happy to help.

____

Principal's Signature

CUT ON DOTTED LINE

RETURN THIS SECTION

I hereby give my permission for __________ to participate in the music education study being conducted at ____________ Elementary School.

____

Parent's Signature

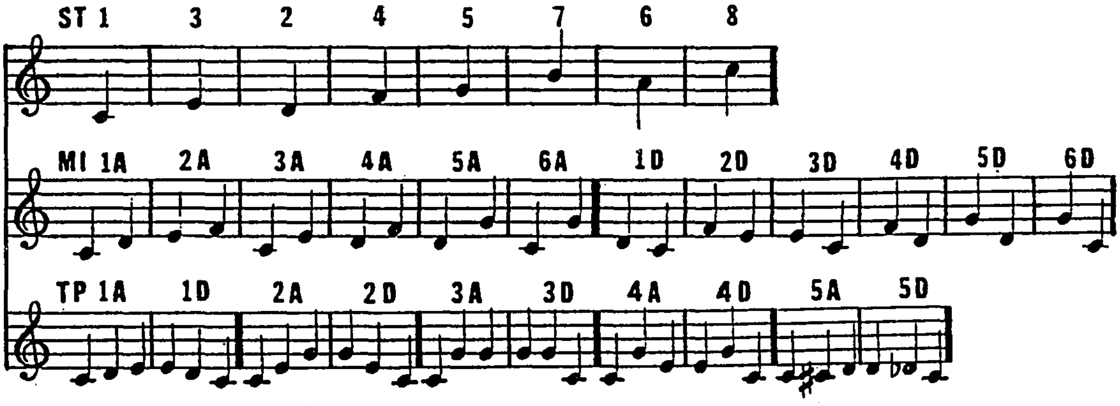
____

Date

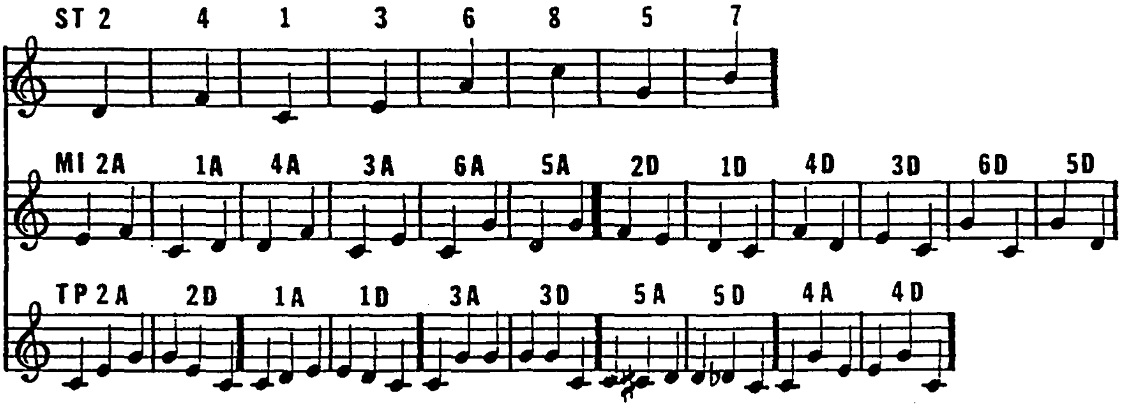
APPENDIX C

PMT TIMBRE TREATMENTS

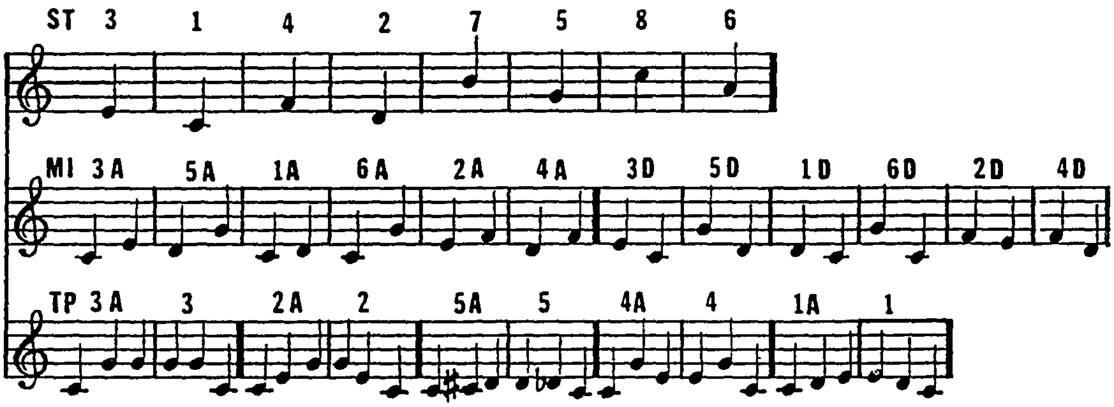
SOPRANO VOICE



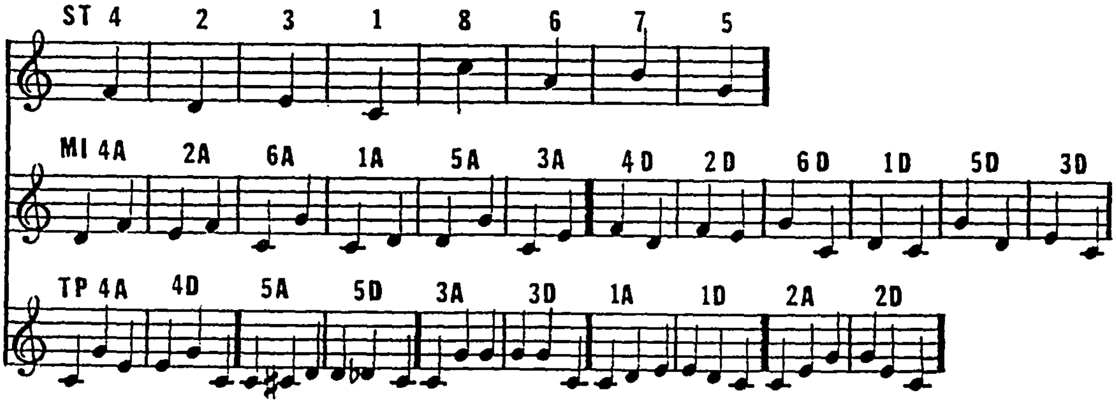
PIANO



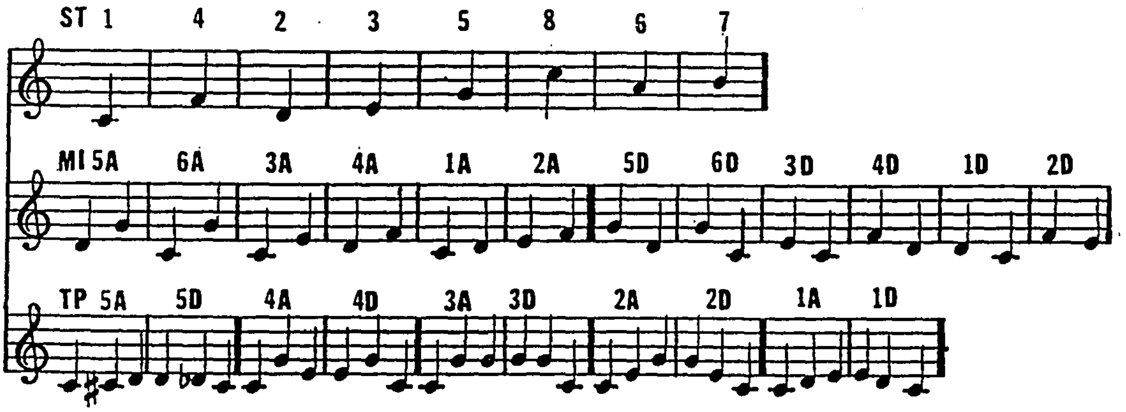
RESONATOR BELLS



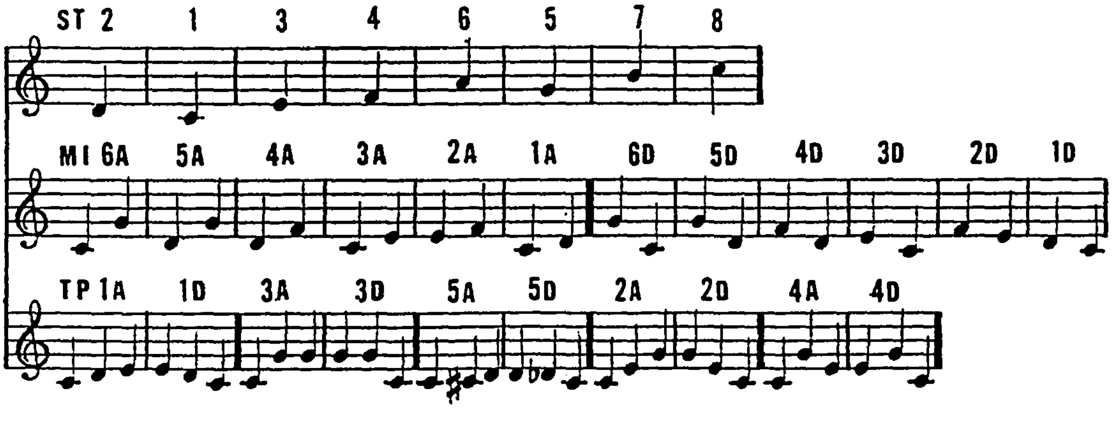
VIOLIN



TRUMPET



OBOE



APPENDIX D

HOMES QUESTIONNAIRE

Home Musical Environmental Scale
*(Item scores enclosed in parentheses)

A. PLEASE ANSWER THE FOLLOWING QUESTIONS (CIRCLE ONE)

1. Do you play or have you ever played a musical instrument?

YES(1) or NO(0)

2. Does your child play a musical instrument?

YES(1) or NO(0)

3. How many records of tapes have you purchased during the past year?

0-3(1) 4-7(2) 8-15(3) 16-20(4) 21 or more(5)

4. Is you child required to ask permission before playing records or tapes.

YES(0) or NO(1)

5. Does your child have his/her own record or tape player?

YES(1) or NO(0)

6. Have you sung or played in a musical group such as a church or temple choir or community band?

YES(1) or NO(0)

B. RATE THE EXTENT TO WHICH YOU HAVE DONE THE FOLLOWING: <u>CIRCLE ONE</u> (Number circled = Item score)

	<u>LOW</u> ......<u>HIGH</u>				
1. Provided children's records for your child	1	2	3	4	5
2. Helped your child learn songs	1	2	3	4	5
3. Provided toy musical instruments	1	2	3	4	5
4. Provided toys that make sounds or music	1	2	3	4	5
5. Sung with your child	1	2	3	4	5
6. Sung to your child	1	2	3	4	5

C. WHICH OF THE FOLLOWING DESCRIBES YOUR OVERALL ATTITUDE TOWARD MUSIC IN YOUR CHILD'S LIFE? (CIRCLE ONE PHRASE) (Number circled = Item score)

1	2	3	4
Music is not important	Other school subjects are more important	Music is important for my child	Music is an essential part of my child's life

D. CHILD'S PERSONAL DATA
Your answers will be kept in strictest confidence and will not be published in any form.

1. NAME ________________________ AGE:_____ GRADE: _____

2. Please list the names of brothers and/or sisters of this child who are participating in this study.

BROTHERS SISTERS

NAME:_________ AGE:__ GRD:__ NAME:_________ AGE:__ GRD:__

NAME:_________ AGE:__ GRD:__ NAME:_________ AGE:__ GRD:__

3. Please indicate your salary range by checking the amount in the blank provided below. If your spouse is employed include his/her salary in your response. Your answer to this question is very important to the study. This information will be kept in strictest confidence.

Please check one: (* SES levels are in parentheses)

$ Under $10,000 ____ (1)

$10,000. - $19,000 ____ (2)

$20,000 - $29,999 ____ (3)

$30,000 - $39,999 ____ (4)

$40,000 - $49,000 ____ (5)

$50,000 - Above ____ (6)

<u>HOMES</u> SCORE: _______ SES CODE: ______ SUBJECT ID.# _____

*Scoring Information and SES codes ommited on original form

APPENDIX E

PMT ADMINISTRATION

PMT ADMINISTRATION

Preliminary Remarks

1. Administrator greets each child using first name.
2. Child is seated.
3. Administrator starts response tape recorder and records child's identification number.
4. Administrator starts stimuli tape player to begin introductory remarks.

Administrator: "Thank you for coming. In a few moments, we are going to listen to a tape recording and play an echo game. Some of the musical examples on the tape have only one sound while others have two or three sounds. Each musical example is followed by silence to give you time to sing what you have heard. Let's listen to the tape and do a few practice examples.

PMT Demonstration and Practice

Single Tones

Administrator: "First, you will hear musical examples with only one musical sound. Listen very closely. As soon as the music stops, sing the sound you have heard on "doo." This is how you will do it."

Demonstration stimulus . . . .
(Tape plays stimulus)

Demonstration response . . . .
(Administrator sings)

(Blank tape-2 seconds)

Administrator: "Now it's your turn. Listen very closely."

First practice stimulus . . . .
(Blank tape for subject's response)

Second practice stimulus . . . .
(Blank tape for subject's response)

End of ST Demo and practice

Administrator: "We will now hear six different musical instruments. The voice on the tape will tell you how many sounds you will hear. Remember to sing just as soon as the music stops. "Are there any questions?" (Stop tape if there are questions.) "Let's begin."

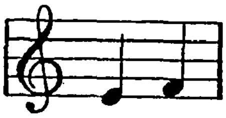
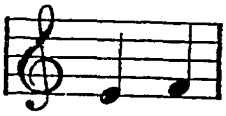
Administrator: "One sound." (Repeated for each timbre.)

ST-SUBTESTS (O)boe (P)iano (R)esonator bells
(S)oprano (T)rumpet (V)iolin

(See <u>APPENDIX C: PMT Timbre Treatments</u> for test items.)

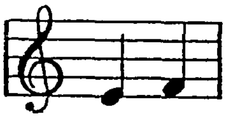
Melodic Intervals

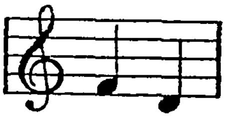
Administrator: "Next you will hear musical examples with two musical sounds. Listen very closely. As soon as the music stops, sing the sounds you have heard on "doo." This is how you will do it."

Demonstration stimulus . . . .
(Tape plays stimulus)

Demonstration response . . . .
(Administrator sings)

(Blank tape-2 seconds)

Administrator: "Now it's your turn. Listen very closely."

First practice stimulus . . . .
(Blank tape for subject's response)



Second practice stimulus . . . .
(Blank tape for subject's response)

End of MI Demo and practice ....

Administrator: "We will now hear six different musical instruments. The voice on the tape will tell you how many sounds you will hear. Remember to sing just as soon as the music stops. "Are there any questions?" (Stop tape if there are questions.) "Let's begin."

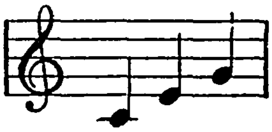
Administrator: "Two sounds" (Repeated for each timbre)

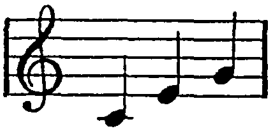
MI-SUBTESTS (O)boe (P)iano (R)esonator bells
(S)oprano (T)rumpet (V)iolin

(See APPENDIX C: PMT Timbre Treatments for test items.)

Tonal Patterns

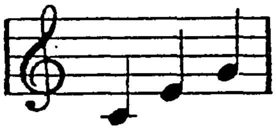
Administrator: "Next you will hear musical examples with three musical sounds. Listen very closely. As soon as the music stops, sing the sounds you have heard on "doo." This is how you will do it."

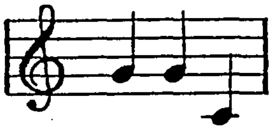
Demonstration stimulus . . . .
(Tape plays stimulus)

Demonstration response . . . .
(Administrator sings)



(Blank tape-2 seconds)

Administrator: "Now it's your turn. Listen very closely."

First practice stimulus . . . .
(Blank tape for subject's response)

Second practice stimulus . . . .
(Blank tape for subject's response)



End of TP Demo and practice

Administrator: "We will now hear six different musical instruments. The voice on the tape will tell you how many sounds you will hear. Remember to sing just as soon as the music stops. "Are there any questions?" (Stop tape if there are questions.) "Let's begin."

Administrator: "Three sounds." (Repeated for each timbre.)

TP-SUBTESTS (O)boe (P)iano (R)esonator bells
(S)oprano (T)rumpet (V)iolin

(See APPENDIX C: PMT Timbre Treatments for test items.)

APPENDIX F

RESPONSE DATA COLLECTION FORM

RESPONSE DATA ID#: _____ TAPE#: ____ SIDE#: ____ PAGE 1

ST SUBTESTS:

O: 2 ____ 1____ 3____ 4____ 6____ 5____ 7____ 8____

P: 2 ____ 4____ 1____ 3____ 6____ 8____ 5____ 7____

R: 3 ____ 1____ 4____ 2____ 7____ 5____ 8____ 6____

S: 1 ____ 3____ 2____ 4____ 5____ 7____ 6____ 8____

T: 1 ____ 4____ 2____ 3____ 5____ 8____ 6____ 7____

U: 4 ____ 2____ 3____ 1____ 8____ 6____ 7____ 5____

MI SUBTESTS:

O:19[C]___ 20[G]___ 17[D]___ 18[G]___ 15[D]___ 16[F]___ 13[G]___ 14[C]___

11[E]___ 12[F]___ 09[C]___ 10[D]___ 31[G]___ 32[C]___ 29[G]___ 30[D]___

27[F]___ 28[D]___ 25[E]___ 26[C]___ 23[F]___ 24[E]___ 21[D]___ 22[C]___

P:11[E]___ 12[F]___ 09[C]___ 10[D]___ 15[D]___ 16[F]___ 13[G]___ 14[C]___

19[C]___ 20[G]___ 17[D]___ 18[G]___ 23[F]___ 24[E]___ 21[D]___ 22[C]___

27[F]___ 28[D]___ 25[E]___ 26[C]___ 31[G]___ 32[C]___ 29[G]___ 30[D]___

R:13[G]___ 14[C]___ 17[D]___ 18[G]___ 09[C]___ 10[D]___ 19[C]___ 20[G]___

11[E]___ 12[F]___ 15[D]___ 16[F]___ 25[E]___ 26[C]___ 29[G]___ 30[D]___

21[D]___ 22[C]___ 31[G]___ 32[C]___ 23[F]___ 24[E]___ 27[F]___ 28[D]___

S: 9[C]___ 10[D]___ 11[E]___ 12[F]___ 13[G]___ 14[C]___ 15[D]___ 16[F]___

17[D]___ 18[G]___ 19[C]___ 20[G]___ 21[D]___ 22[C]___ 23[F]___ 24[E]___

25[E]___ 26[C]___ 27[F]___ 28[D]___ 29[G]___ 30[D]___ 31[G]___ 32[C]___

T:17[D]___ 18[G]___ 19[C]___ 20[G]___ 13[G]___ 14[C]___ 15[D]___ 16[F]___

09[C]___ 10[D]___ 11[E]___ 12[F]___ 29[G]___ 30[D]___ 31[G]___ 32[C]___

25[E]___ 26[C]___ 27[F]___ 28[D]___ 21[D]___ 22[C]___ 23[F]___ 24[E]___

U:15[D]___ 16[F]___ 11[E]___ 12[F]___ 19[C]___ 20[G]___ 09[C]___ 10[D]___

17[D]___ 18[G]___ 13[G]___ 14[C]___ 27[F]___ 28[D]___ 23[F]___ 24[E]___

31[G]___ 32[C]___ 21[D]___ 22[C]___ 29[G]___ 30[D]___ 25[E]___ 26[C]___

RESPONSE DATA ID#: _____ TAPE#: ____ SIDE#: _____ PAGE 2

TP SUBTESTS:

O:	33[C] _____	34[D] _____	35[E] _____	36[E] _____	37[D] _____	38[C] _____	[1A/1D]
	45[C] _____	46[G] _____	47[G] _____	48[G] _____	49[G] _____	50[C] _____	[3A/3D]
	57[C] _____	58[#] _____	59[D] _____	60[D] _____	61[#] _____	62[C] _____	[5A/5D]
	39[C] _____	40[E] _____	41[G] _____	42[G] _____	43[E] _____	44[C] _____	[2A/2D]
	51[C] _____	52[G] _____	53[E] _____	54[E] _____	55[G] _____	56[C] _____	[4A/4D]
P:	39[C] _____	40[E] _____	41[G] _____	42[G] _____	43[E] _____	44[C] _____	[2A/2D]
	33[C] _____	34[D] _____	35[E] _____	36[E] _____	37[D] _____	38[C] _____	[1A/1D]
	45[C] _____	46[G] _____	47[G] _____	48[G] _____	49[G] _____	50[C] _____	[3A/3D]
	57[C] _____	58[#] _____	59[D] _____	60[D] _____	61[#] _____	62[C] _____	[5A/5D]
	51[C] _____	52[G] _____	53[E] _____	54[E] _____	55[G] _____	56[C] _____	[4A/4D]
R:	45[C] _____	46[G] _____	47[G] _____	48[G] _____	49[G] _____	50[C] _____	[3A/3D]
	39[C] _____	40[E] _____	41[G] _____	42[G] _____	43[E] _____	44[C] _____	[2A/2D]
	57[C] _____	58[#] _____	59[D] _____	60[D] _____	61[#] _____	62[C] _____	[5A/5D]
	51[C] _____	52[G] _____	53[E] _____	54[E] _____	55[G] _____	56[C] _____	[4A/4D]
	33[C] _____	34[D] _____	35[E] _____	36[E] _____	37[D] _____	38[C] _____	[1A/1D]
S:	33[C] _____	34[D] _____	35[E] _____	36[E] _____	37[D] _____	38[C] _____	[1A/1D]
	39[C] _____	40[E] _____	41[G] _____	42[G] _____	43[E] _____	44[C] _____	[2A/2D]
	45[C] _____	46[G] _____	47[G] _____	48[G] _____	49[G] _____	50[C] _____	[3A/3D]
	51[C] _____	52[G] _____	53[E] _____	54[E] _____	55[G] _____	56[C] _____	[4A/4D]
	57[C] _____	58[#] _____	59[D] _____	60[D] _____	61[#] _____	62[C] _____	[5A/5D]
T:	57[C] _____	58[#] _____	59[D] _____	60[D] _____	61[#] _____	62[C] _____	[5A/5D]
	51[C] _____	52[G] _____	53[E] _____	54[E] _____	55[G] _____	56[C] _____	[4A/4D]
	45[C] _____	46[G] _____	47[G] _____	48[G] _____	49[G] _____	50[C] _____	[3A/3D]
	39[C] _____	40[E] _____	41[G] _____	42[G] _____	43[E] _____	44[C] _____	[2A/2D]
	33[C] _____	34[D] _____	35[E] _____	36[E] _____	37[D] _____	38[C] _____	[1A/1D]
U:	51[C] _____	52[G] _____	53[E] _____	54[E] _____	55[G] _____	56[C] _____	[4A/4D]
	57[C] _____	58[#] _____	59[D] _____	60[D] _____	61[#] _____	62[C] _____	[5A/5D]
	45[C] _____	46[G] _____	47[G] _____	48[G] _____	49[G] _____	50[C] _____	[3A/3D]
	33[C] _____	34[D] _____	35[E] _____	36[E] _____	37[D] _____	38[C] _____	[1A/1D]
	39[C] _____	40[E] _____	41[G] _____	42[G] _____	43[E] _____	44[C] _____	[2A/2D]

APPENDIX G

VISI-PITCH INFORMATION

Summary of Equipment

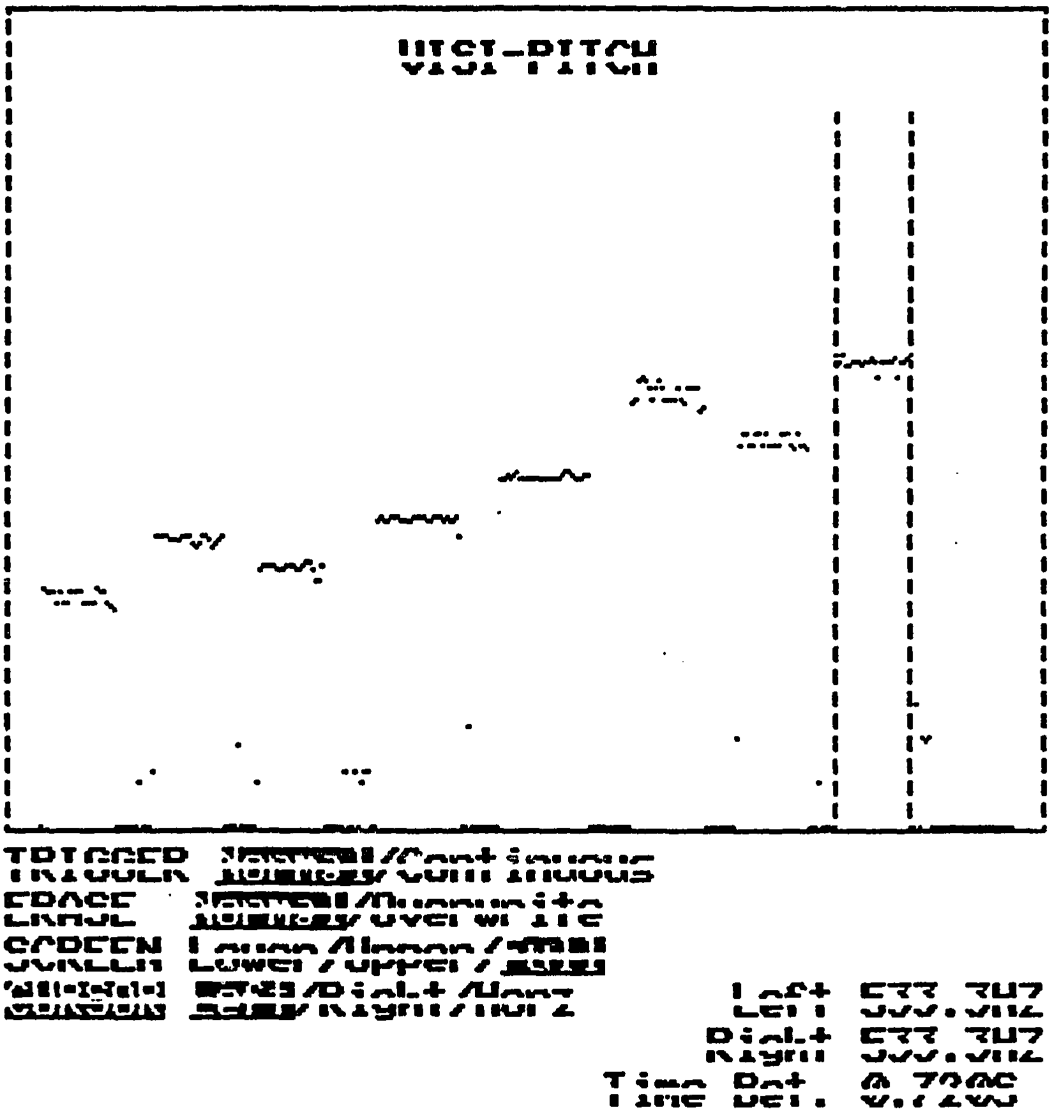
Visi-Pitch 6087DS
Visi-Pitch 6098 IBM interface with cable
Microphone with trigger
Two software disks (1 backup included)
Documentation manuals and training videotape

Audio cable- RCA to mini-phone plug for cassette recorder input (user provided)

Manufacturer:
Key Elemetrics Corp.
12 Maple Avenue
Pine Brook, N.J. 07058-9797
(201) 227-2000

Sample Analysis Screen

Soprano Voice-C5



VISI-PITCH

TRIGGER Manual/Continuous

ERASE Manual/Overwrite

SCREEN Lower/Upper/Both

CURSOR Left/Right/Horz

Left 533.3Hz

Right 533.3Hz

Time Del. 0.720S

Sample Statistics Screens

Screen 1:

```
   STATISTICS        COL 1| COL 2 |CHANGE

Time Bet. Cursors    0.720|------ |------- S

Average F0           526.8|------ |------- HZ
Extended Avg. F0     -----|------ |------- HZ
Std. Deviation F0      5.8|------ |------- HZ
Average DB           -----|------ |------- DB

Perturbation         0.479|------ |-------  %

Maximum F0           539.1|------ |------- HZ
Minimum F0           516.8|------ |------- HZ
F0 Range              22.3|------ |------- HZ

F0 at Left Cursor    533.3|------ |------- HZ
F0 at Right Crsr.    533.3|------ |------- HZ
DB at Left Cursor    -----|------ |------- HZ
DB at Right Crsr.    -----|------ |------- HZ
                     Col 1 = Current
                     Col 2 = Previous
Next Set of Statistics will be in Col 1
(Spacebar) For Page 2
(P) To Print Screen <  For Main Options
```

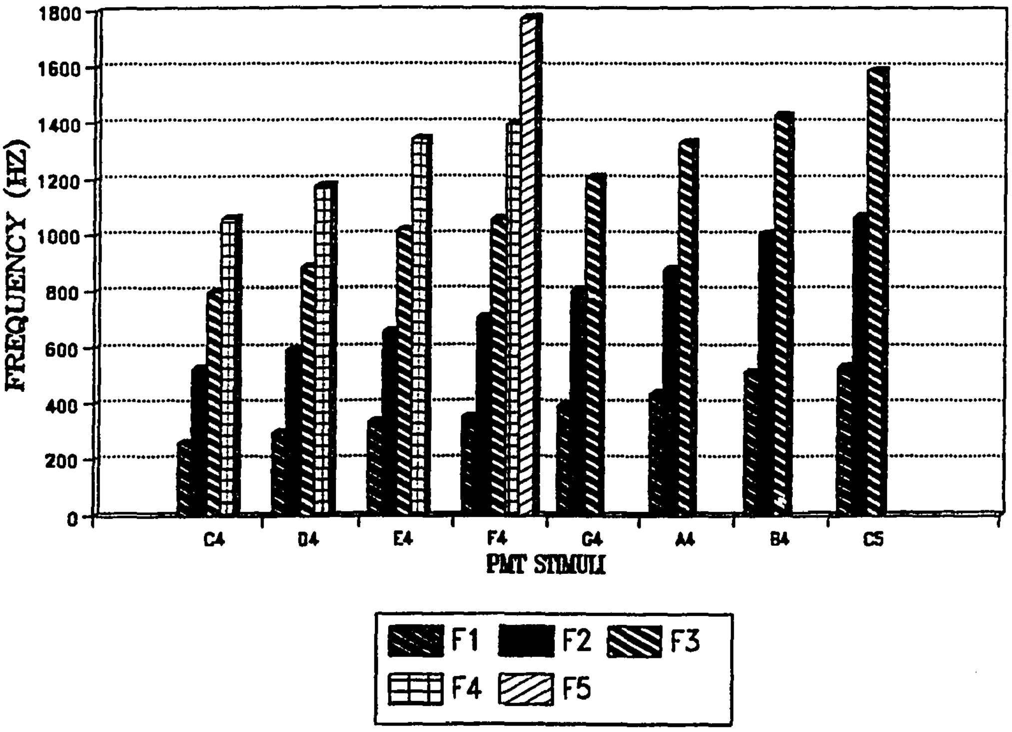
Screen 2:

```
   STATISTICS        COL 1| COL 2 |CHANGE

Percent Voiced       0.720|------ |------  %
Percent Unvoiced       0.0|------ |------  %
Percent Pause         3.05|------ |------  %

Value at Horz A      -----|------ |------
Value at Horz B      -----|------ |------

% Above Horz         -----|------ |------  %
% Below Horz         -----|------ |------  %
% Bet. Horz A&B      -----|------ |------  %

F0 Curve Match       -----|       |------- %
Match Sensitivity        5|      5|     0

                     Col 1 = Current
                     Col 2 = Previous
Next Set of Statistics will be in Col 1
(Spacebar) For Page 1
(P) To Print Screen <  For Main Options
```

APPENDIX H

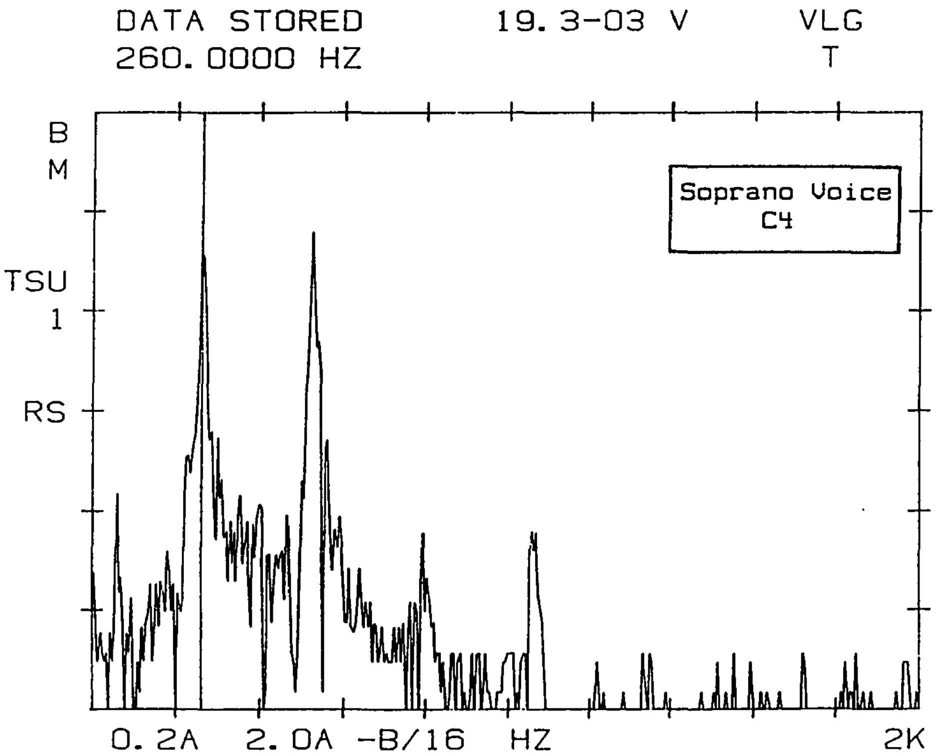
ANALYSIS OF HARMONIC SPECTRA

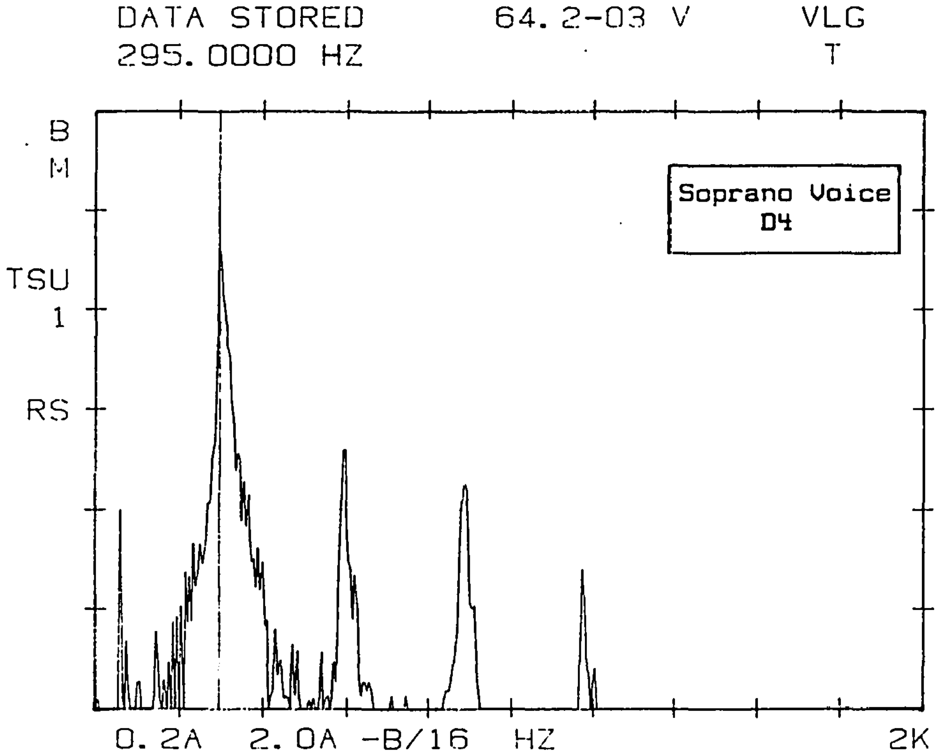
ANALYSIS OF HARMONIC SPECTRA
SOPRANO VOICE

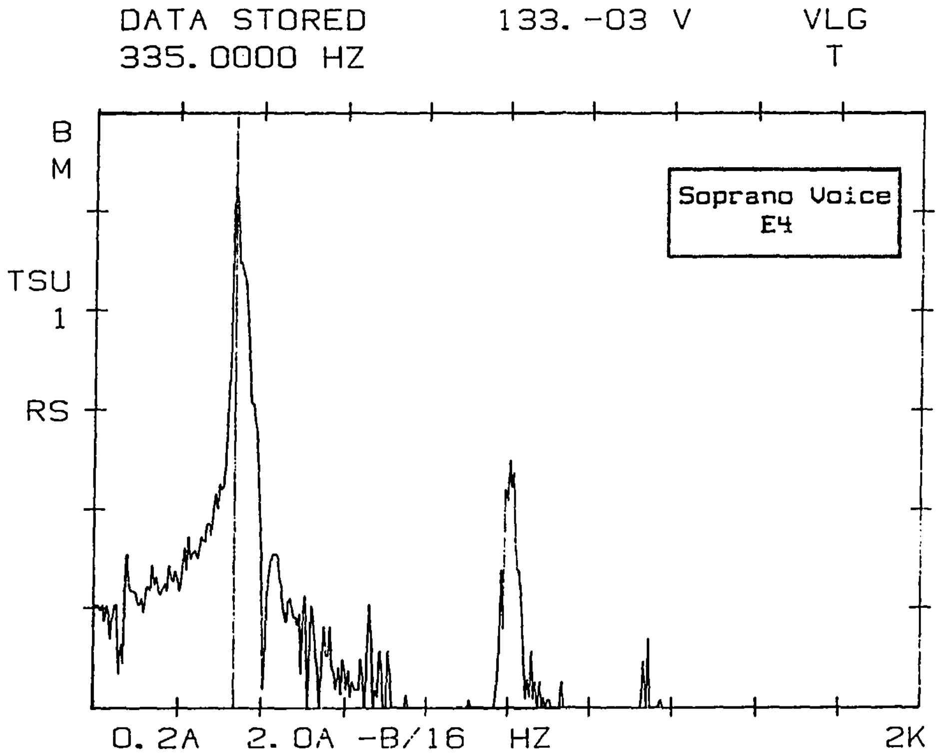


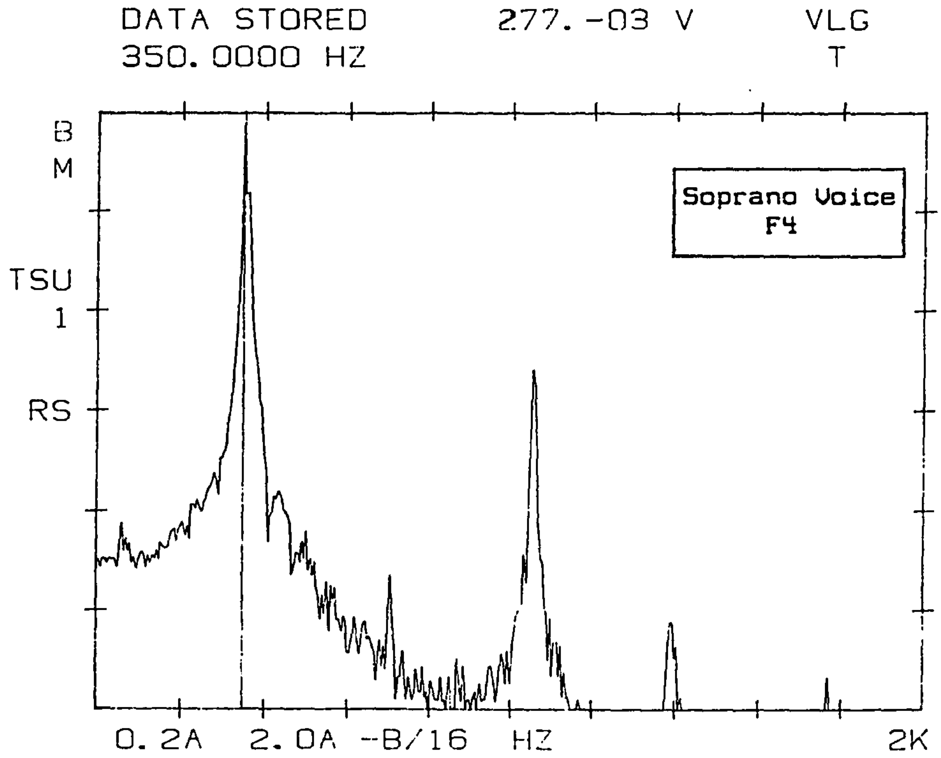
ANALYSIS OF HARMONIC SPECTRA
SOPRANO VOICE

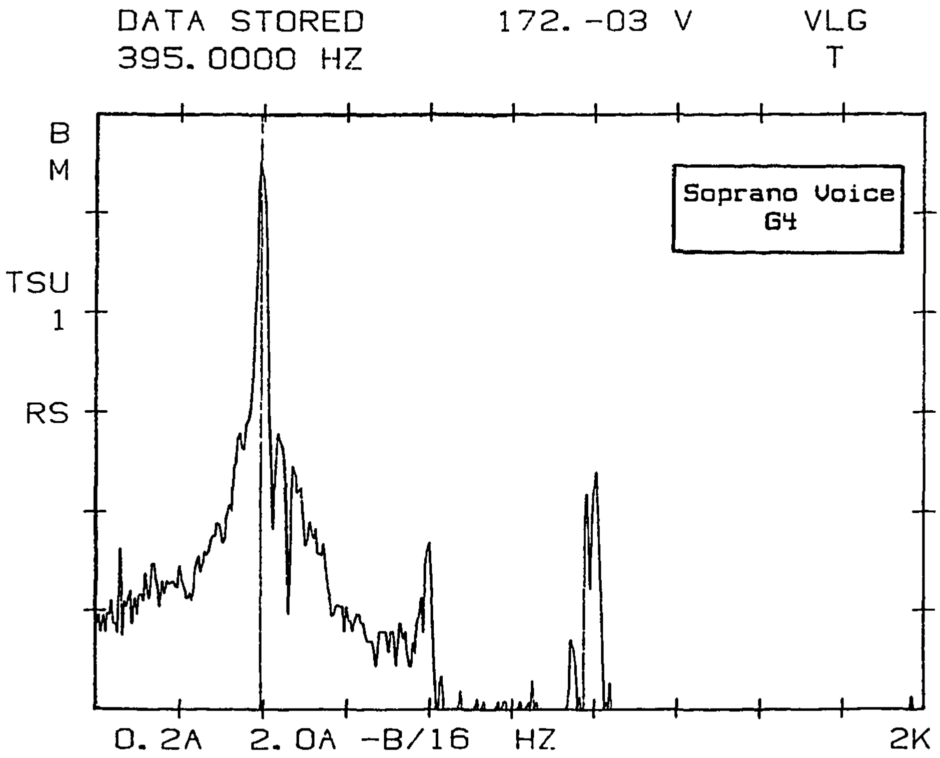
NOTE	STDHZ	F1	AMP/MV	F2	AMP/MV	F3	AMP/MV	F4	AMP/MV	F5	AMP/MV
C4	261.6	260	20.10	525	24.40	795	0.74	1060	0.78		
D4	293.7	295	65.10	590	6.65	885	4.24	1175	1.51		
E4	329.6	335	134.10	660	1.05	1015	5.07	1345	0.69		
F4	349.2	350	273.00	705	1.77	1055	15.70	1395	0.95	1770	0.43
G4	392.0	395	168.00	800	2.33	1205	4.99				
A4	440.0	440	111.00	880	11.10	1330	2.92				
B4	493.9	510	164.00	1005	15.80	1425	3.09				
C5	523.3	530	164.00	1065	19.20	1585	1.66				

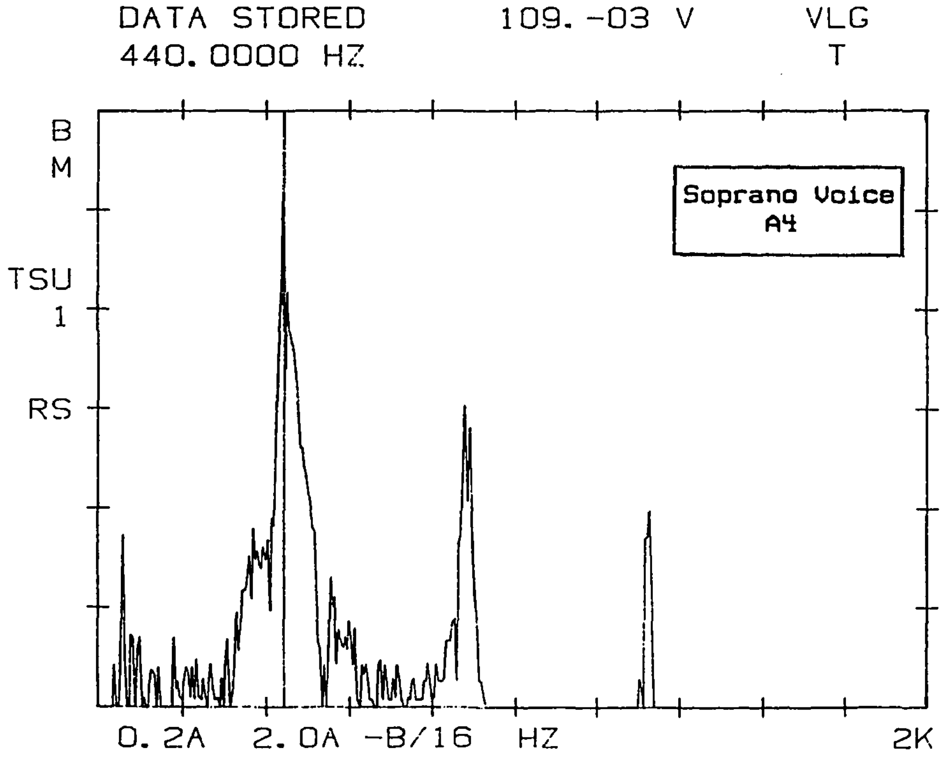

DATA STORED
260. 0000 HZ
19. 3-03 V
VLG
T
B
M
TSU
1
RS
Soprano Voice
C4
0. 2A
2. 0A
-B/16
HZ
2K

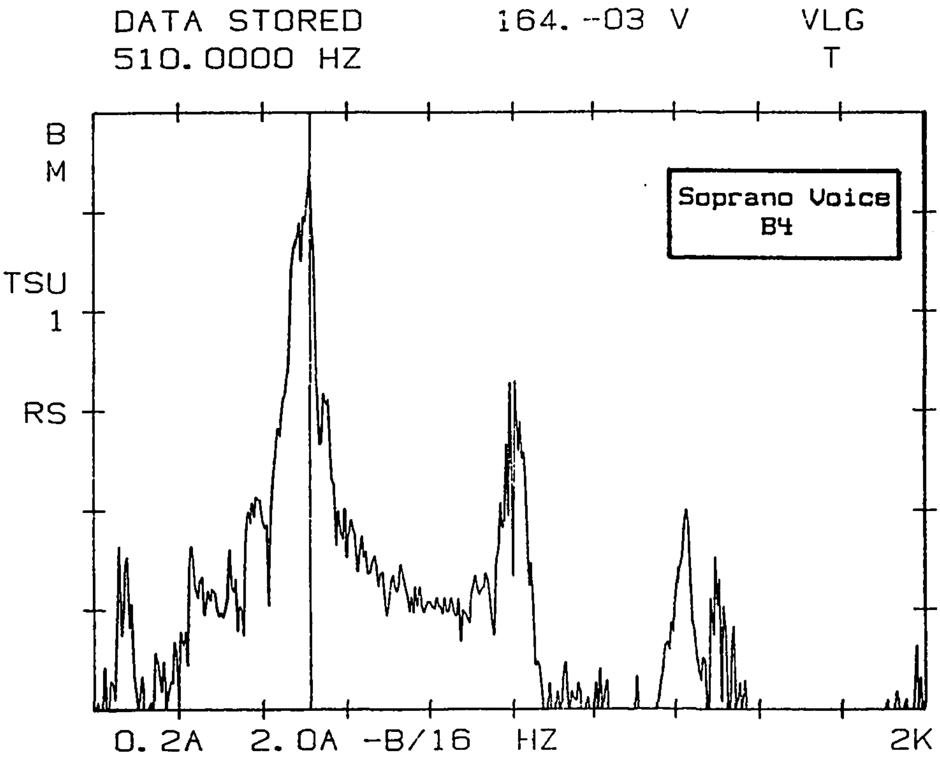

DATA STORED
295. 0000 HZ
64. 2-03 V
VLG
T
B
M
TSU
1
RS
Soprano Voice
D4
0. 2A
2. 0A
-B/16
HZ
2K

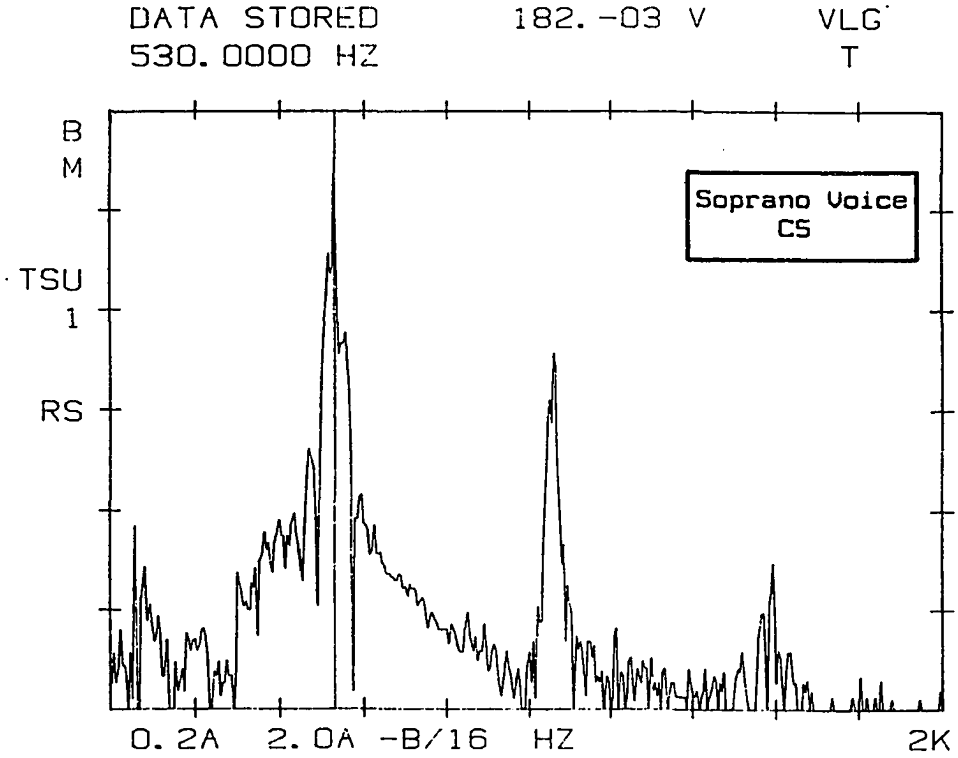

DATA STORED
335.0000 HZ
133.-03 V
VLG
T
B
M
TSU
1
RS
Soprano Voice
E4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
350.0000 HZ
277.-03 V
VLG
T
B
M
TSU
1
RS
Soprano Voice
F4
0.2A
2.0A
-B/16
HZ
2K

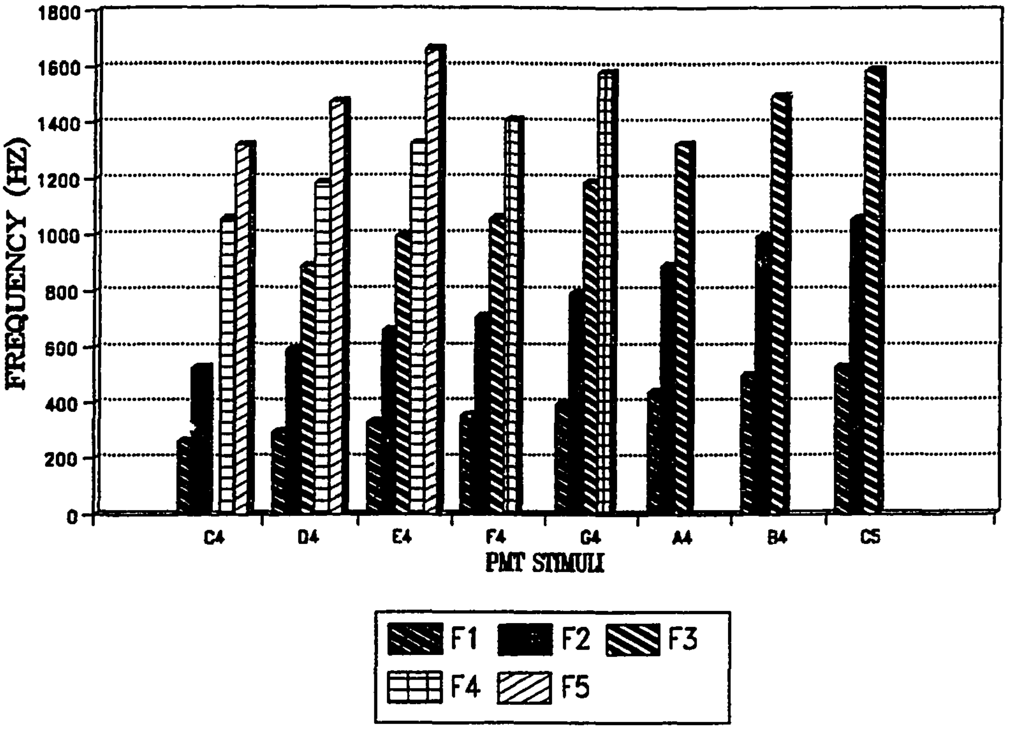

DATA STORED
395.0000 HZ
172.-03 V
VLG
T
B
M
TSU
1
RS
Soprano Voice
G4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
440.0000 HZ
109.-03 V
VLG
T
B
M
TSU
1
RS
Soprano Voice
A4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
164.-03 V
VLG
510.0000 HZ
T
B
M
TSU
1
RS
Soprano Voice
B4
0. 2A
2. 0A
-B/16
HZ
2K

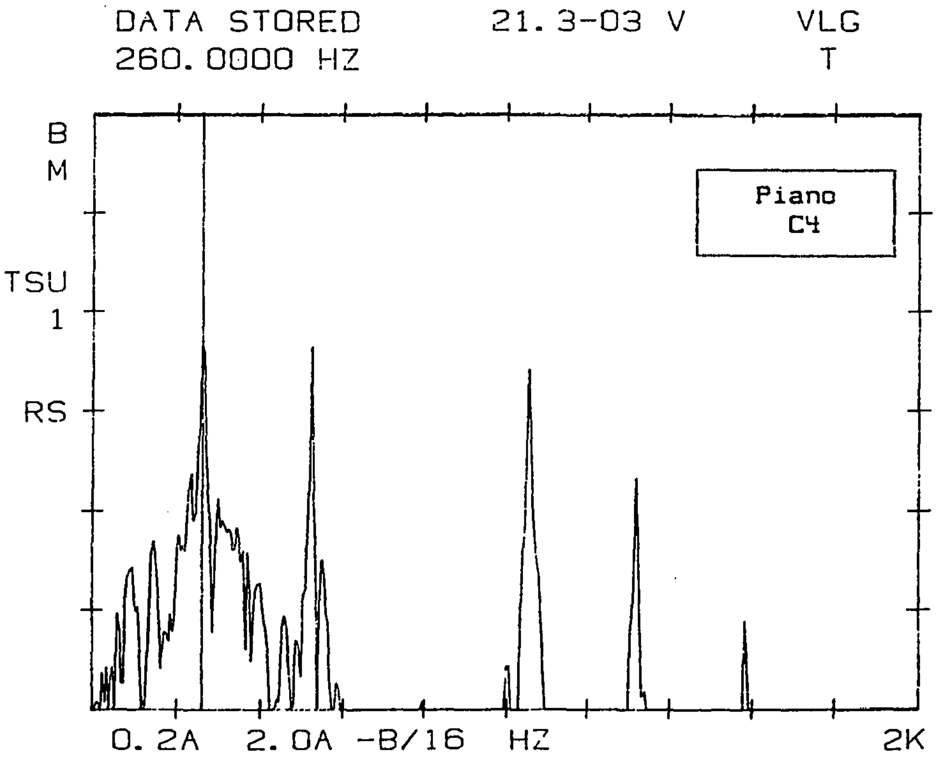

DATA STORED
182.-03 V
VLG
530.0000 HZ
T
B
M
TSU
1
RS
Soprano Voice
C5
0. 2A
2. 0A
-B/16
HZ
2K

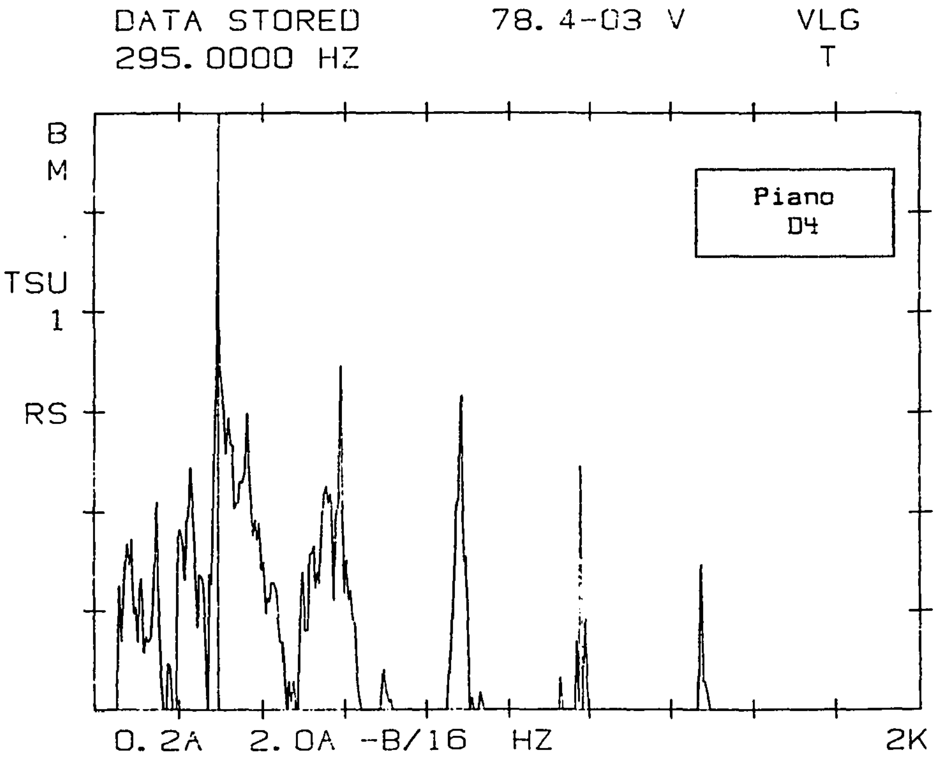
ANALYSIS OF HARMONIC SPECTRA
PIANO

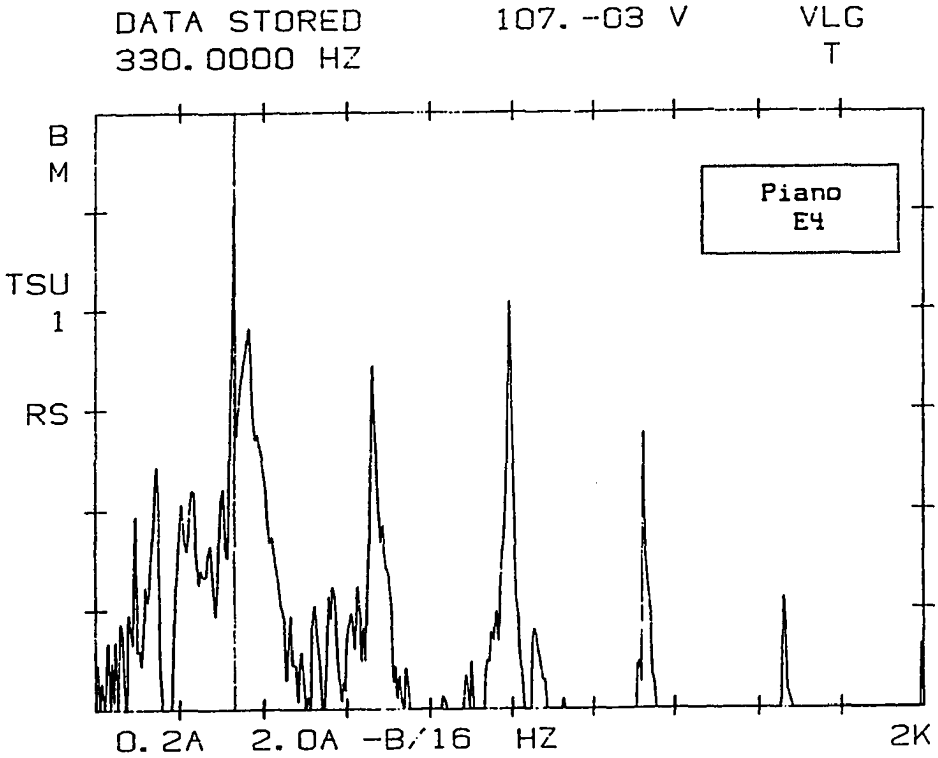


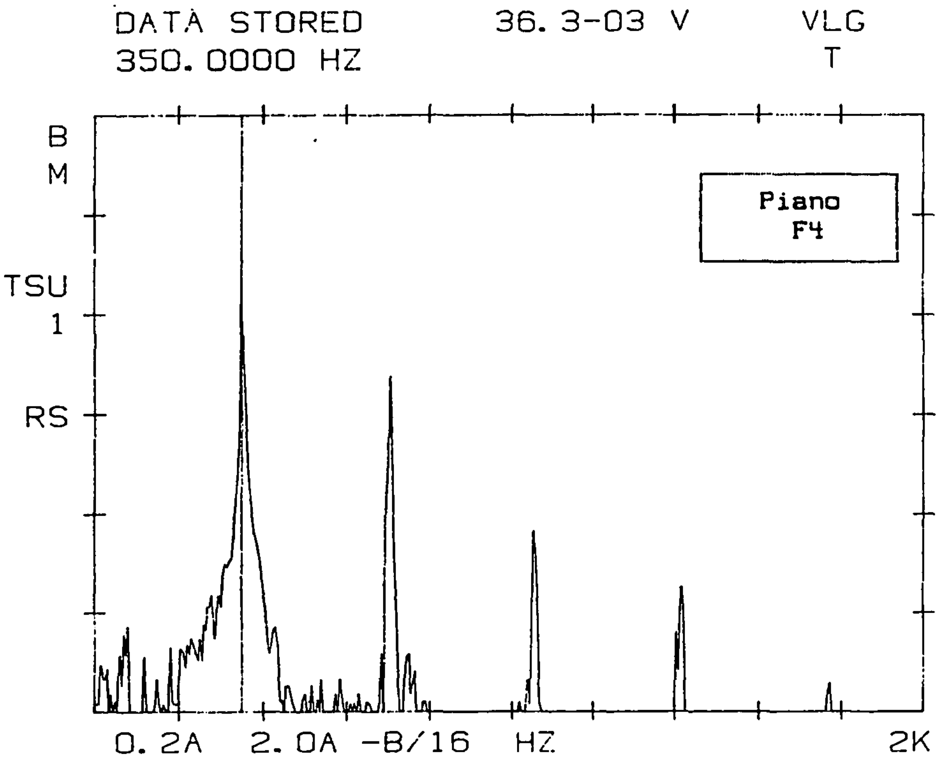
ANALYSIS OF HARMONIC SPECTRA
PIANO

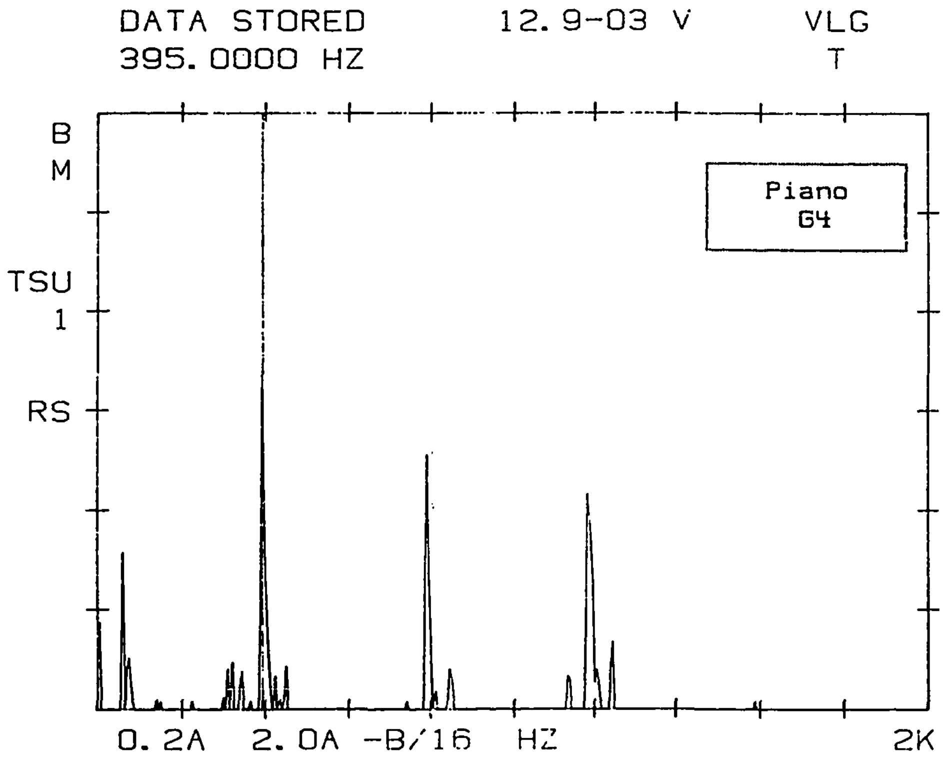
NOTE	STDHZ	F1	AMP/MV	F2	AMP/MV	F3	AMP/MV	F4	AMP/MV	F5	AMP/MV
C4	261.6	260	21.30	525	21.50			1055	16.50	1320	4.68
D4	293.7	295	28.20	590	17.00	885	11.80	1180	5.39	1475	1.93
E4	329.6	330	109.00	660	17.90	995	31.20	1325	8.18	1660	0.81
F4	349.2	350	118.00	705	8.19	1055	8.24	1410	2.15		
G4	392.0	395	36.40	790	9.44	1185	3.22	1580	0.66		
A4	440.0	440	49.80	885	11.70	1325	3.01				
B4	493.9	495	120.00	995	27.90	1495	3.43				
C5	523.3	525	55.30	1055	5.56	1585	1.80				

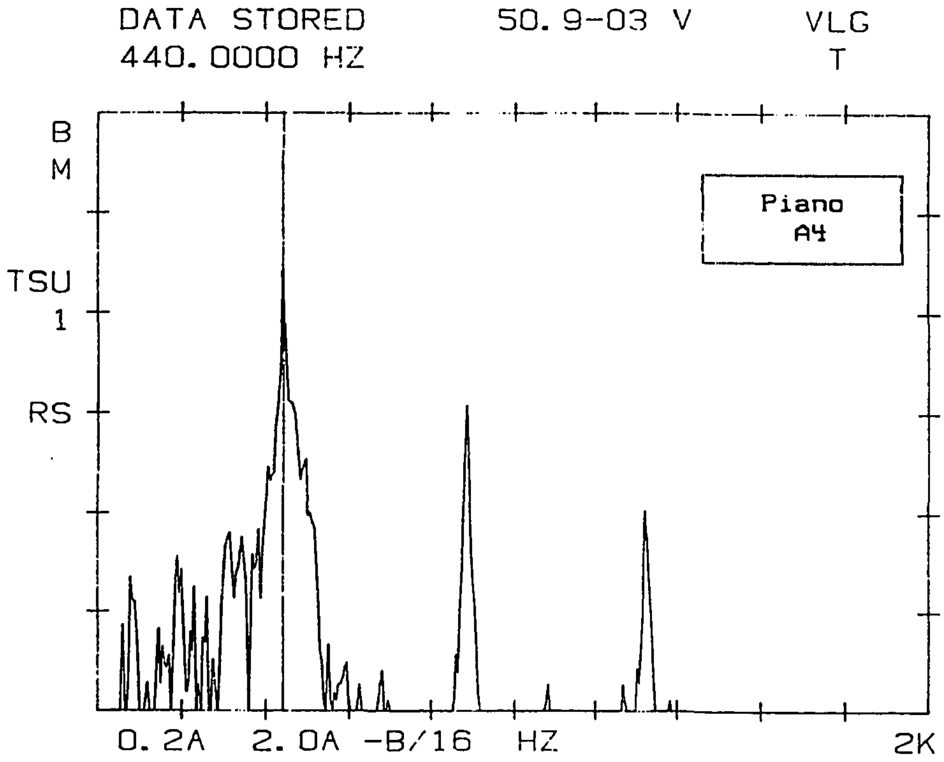

DATA STORED
21.3-03 V
VLG
260.0000 HZ
T
B
M
TSU
1
RS
Piano
C4
0.2A
2.0A
-B/16
HZ
2K

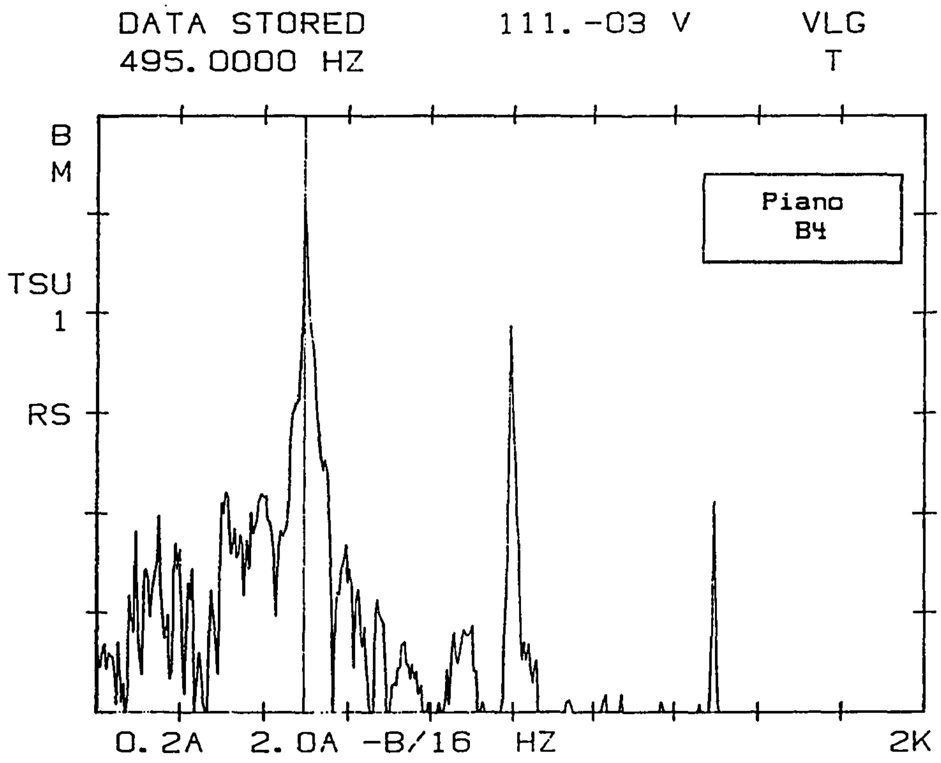

DATA STORED
78.4-03 V
VLG
295.0000 HZ
T
B
M
TSU
1
RS
Piano
D4
0.2A
2.0A
-B/16
HZ
2K

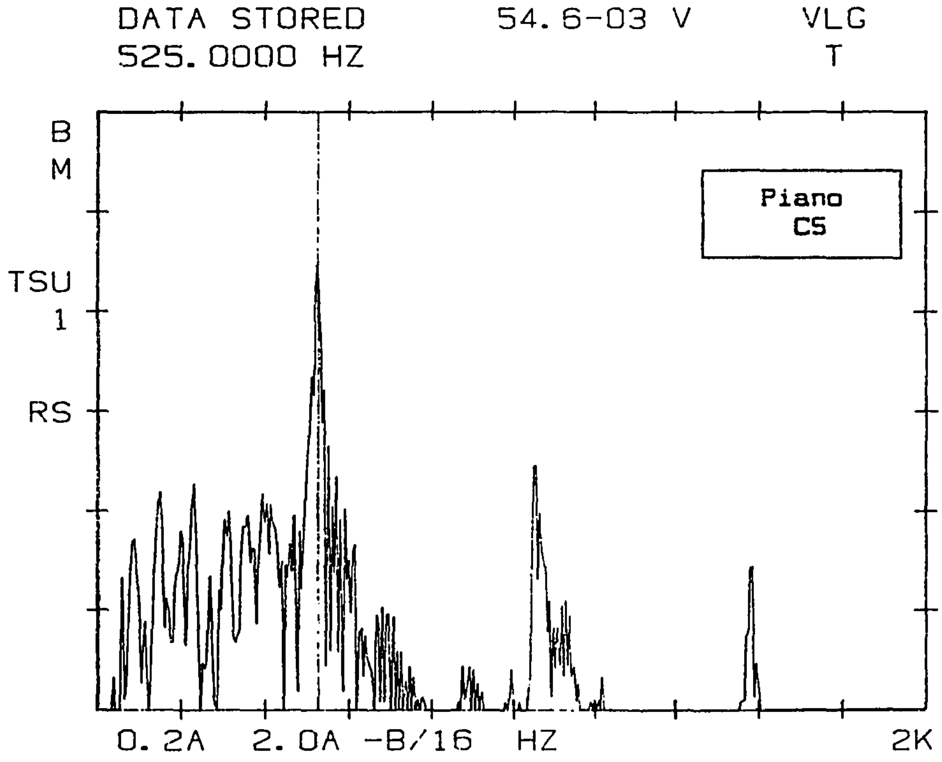

DATA STORED
330.0000 HZ
107.-03 V
VLG
T
B
M
TSU
1
RS
Piano
E4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
350.0000 HZ
36.3-03 V
VLG
T
B
M
TSU
1
RS
Piano
F4
0.2A
2.0A
-B/16
HZ
2K

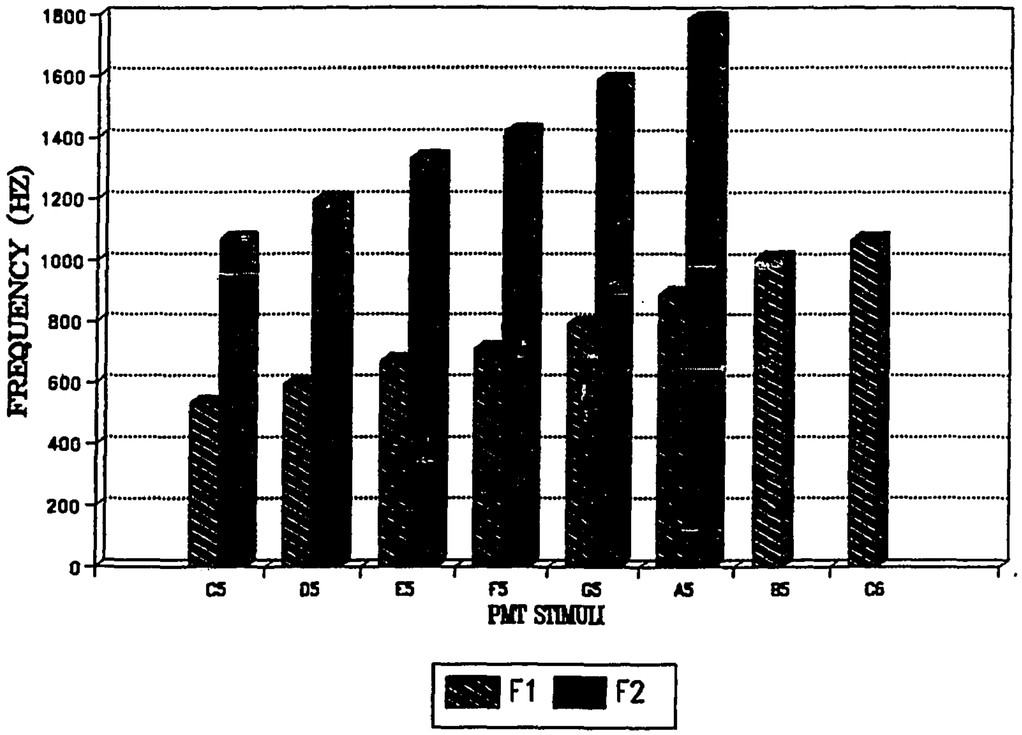

DATA STORED
12.9-03 V
VLG
395.0000 HZ
T
B
M
TSU
1
RS
Piano
G4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
50.9-03 V
VLG
440.0000 HZ
T
B
M
TSU
1
RS
Piano
A4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
495.0000 HZ
111.-03 V
VLG
T
B
M
TSU
1
RS
Piano
B4
0.2A 2.0A -B/16 HZ
2K

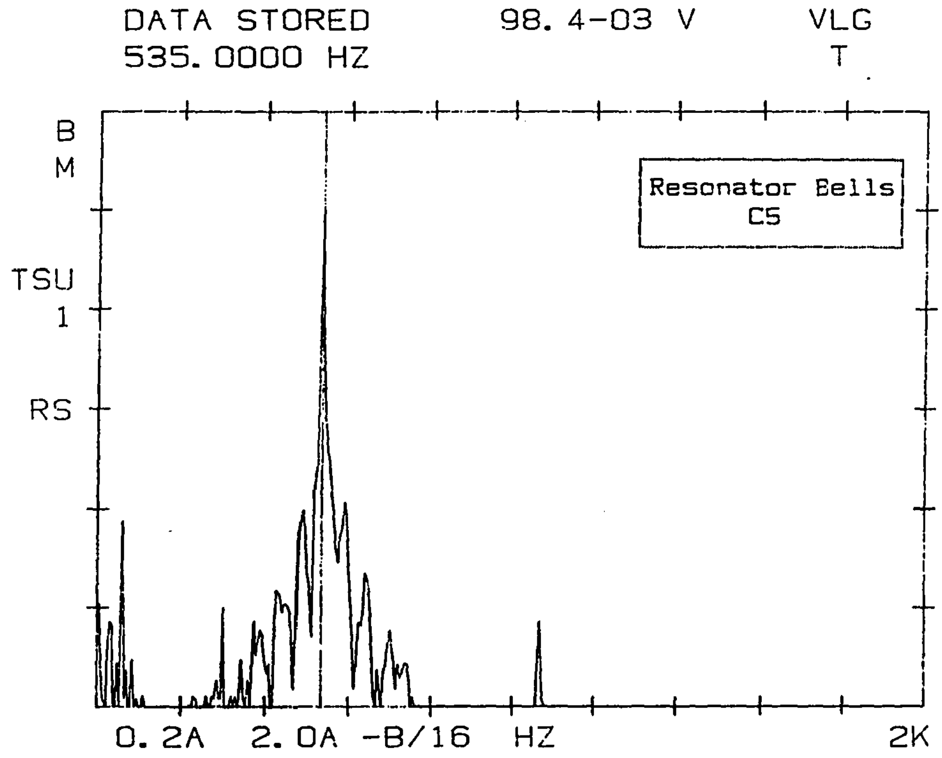

DATA STORED
525.0000 HZ
54.6-03 V
VLG
T
B
M
TSU
1
RS
Piano
C5
0.2A 2.0A -B/16 HZ
2K

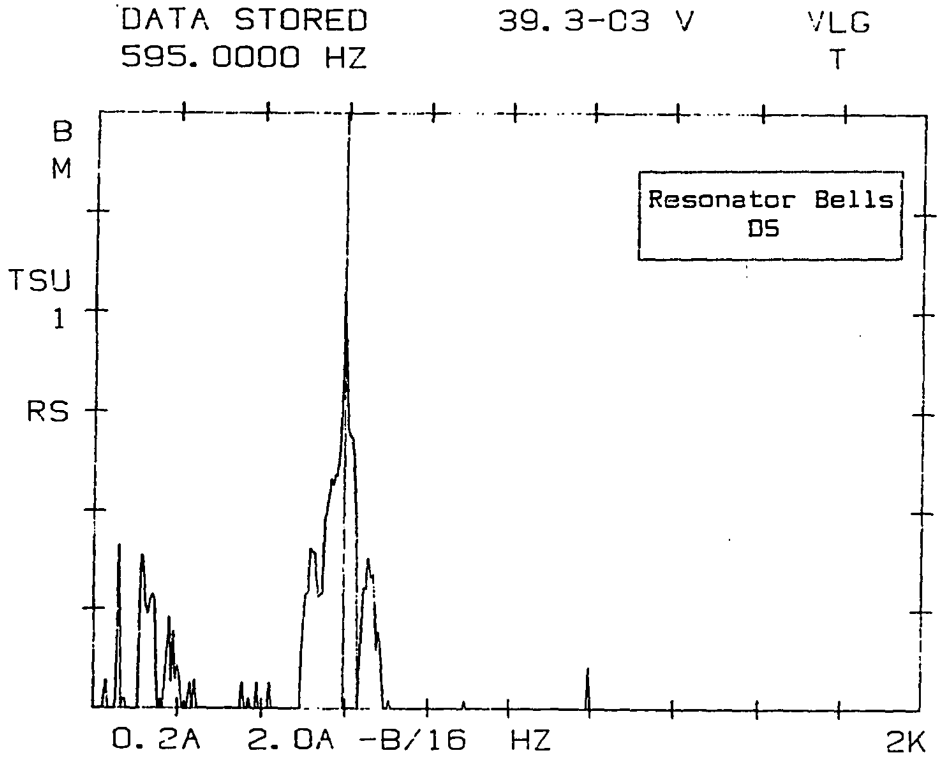
ANALYSIS OF HARMONIC SPECTRA
RESONATOR BELLS

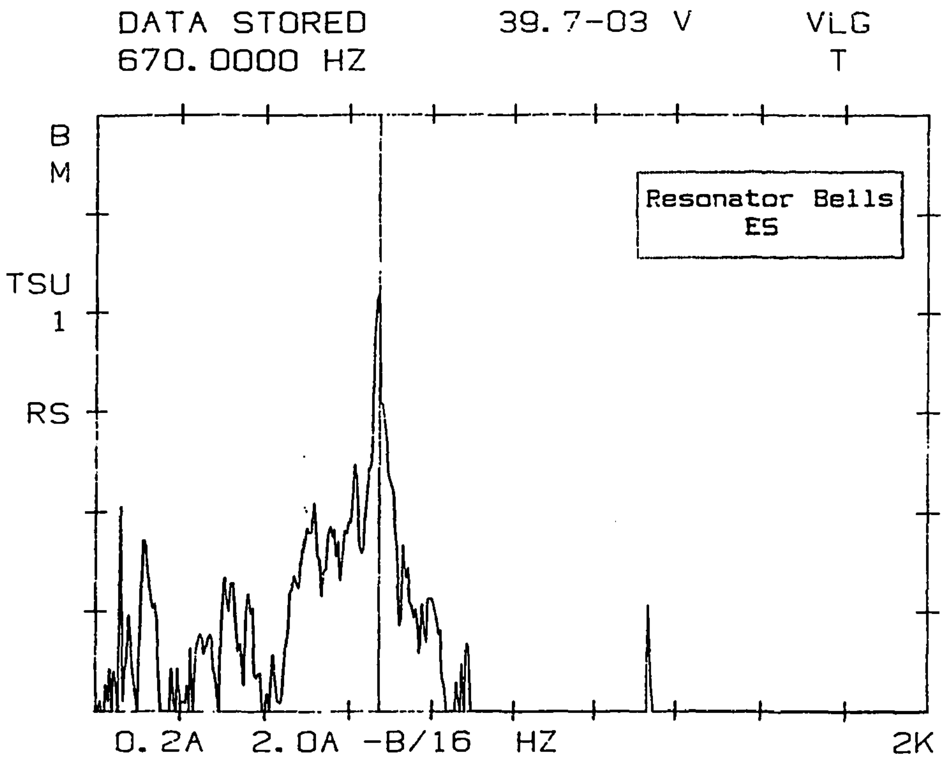


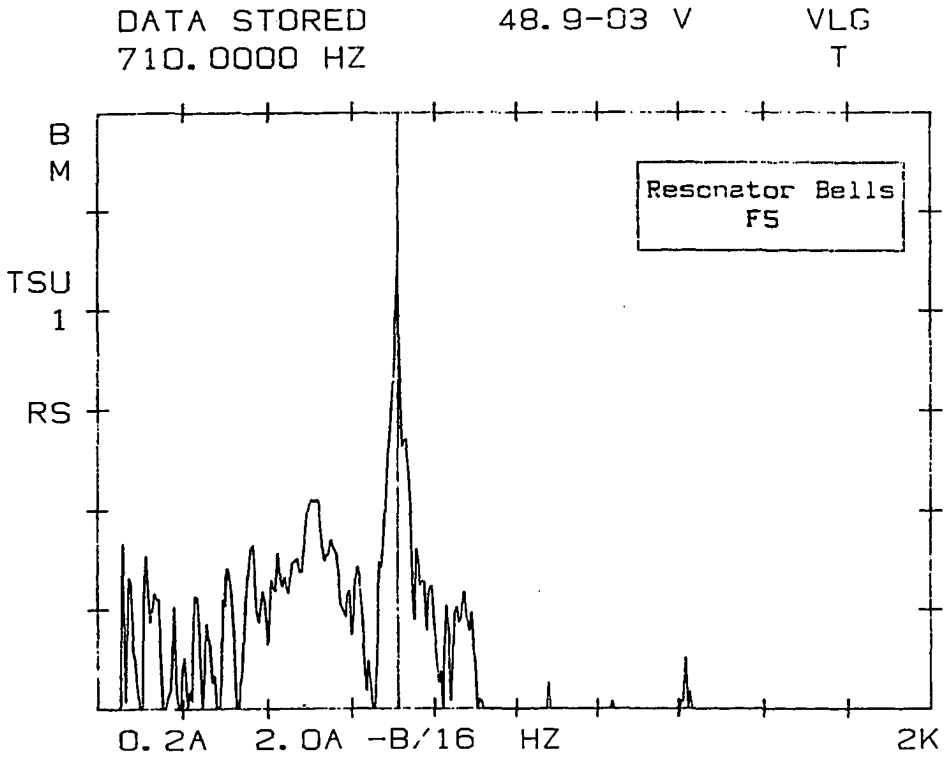
ANALYSIS OF HARMONIC SPECTRA
RESONATOR BELLS

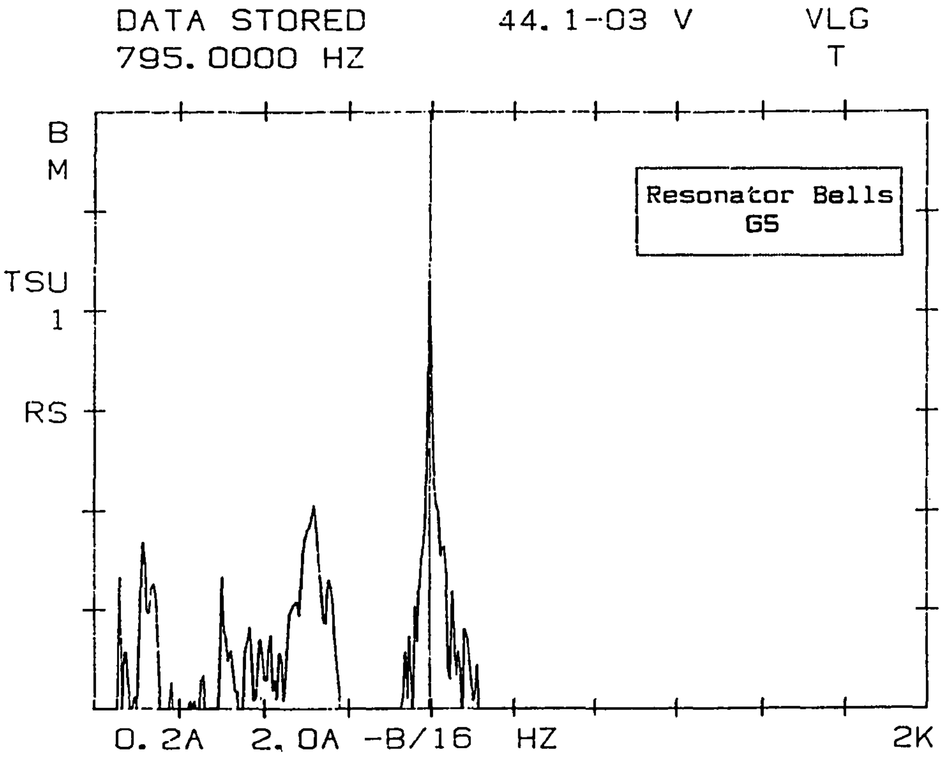
NOTE	STDHZ	F1	AMP/MV	F2	AMP/MV
C5	523.3	535	109.00	1070	1.46
D5	587.3	595	35.00	1195	0.60
E5	659.3	670	41.10	1335	1.01
F5	698.5	710	56.80	1420	0.43
G5	784.0	795	46.20	1590	0.31
A5	880.0	890	61.30	1785	0.46
B5	987.8	1005	55.00		
C6	1046.5	1065	59.60		

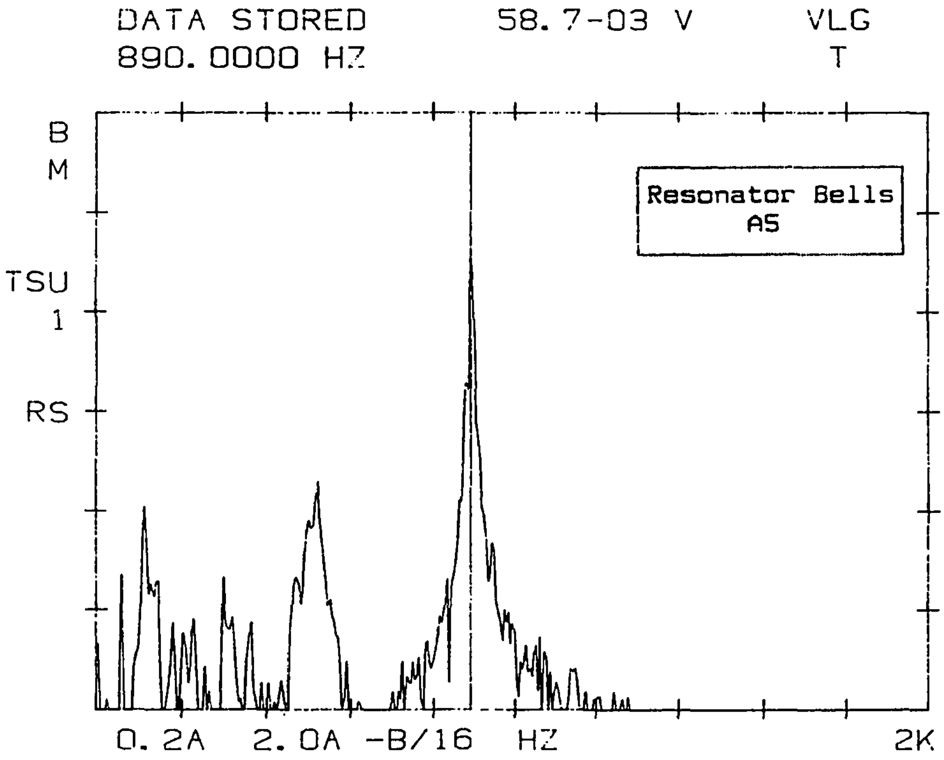

DATA STORED
535.0000 HZ
98.4-03 V
VLG
T
B
M
TSU
1
RS
Resonator Bells
C5
0.2A
2.0A
-B/16
HZ
2K

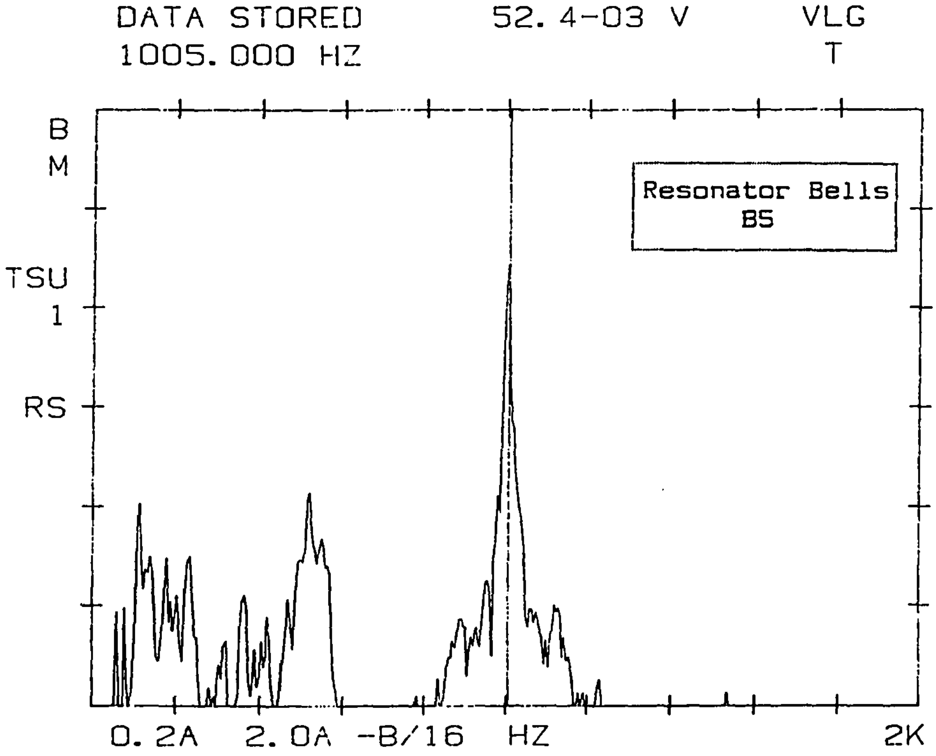

DATA STORED
595.0000 HZ
39.3-03 V
VLG
T
B
M
TSU
1
RS
Resonator Bells
D5
0.2A
2.0A
-B/16
HZ
2K

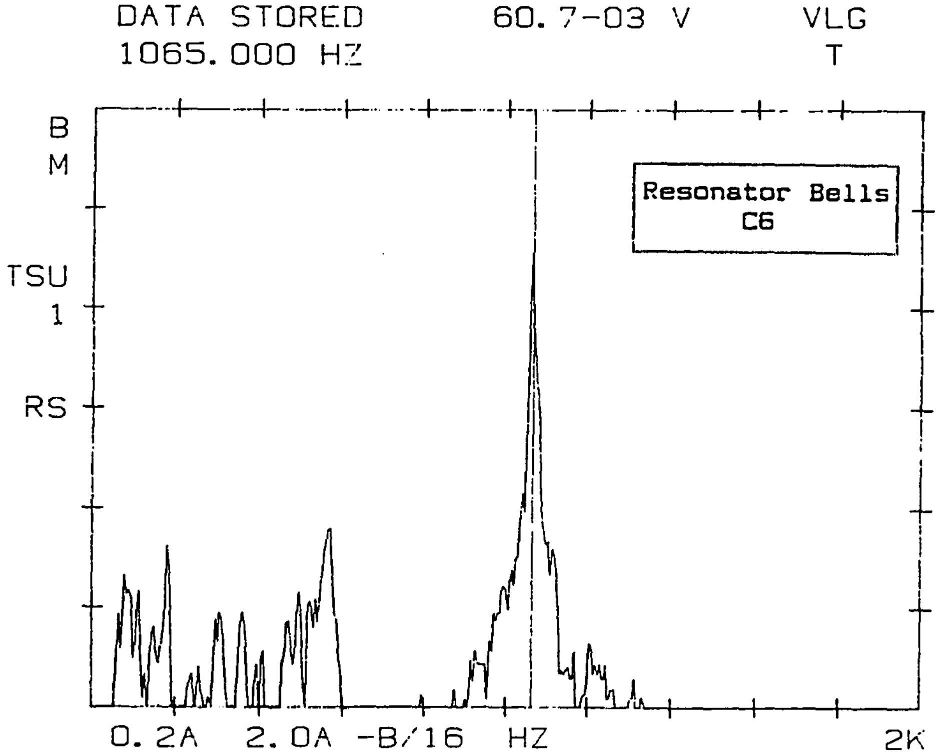

DATA STORED
670.0000 HZ
39.7-03 V
VLG
T
B
M
TSU
1
RS
Resonator Bells
E5
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
710.0000 HZ
48.9-03 V
VLG
T
B
M
TSU
1
RS
Resonator Bells
F5
0.2A
2.0A
-B/16
HZ
2K

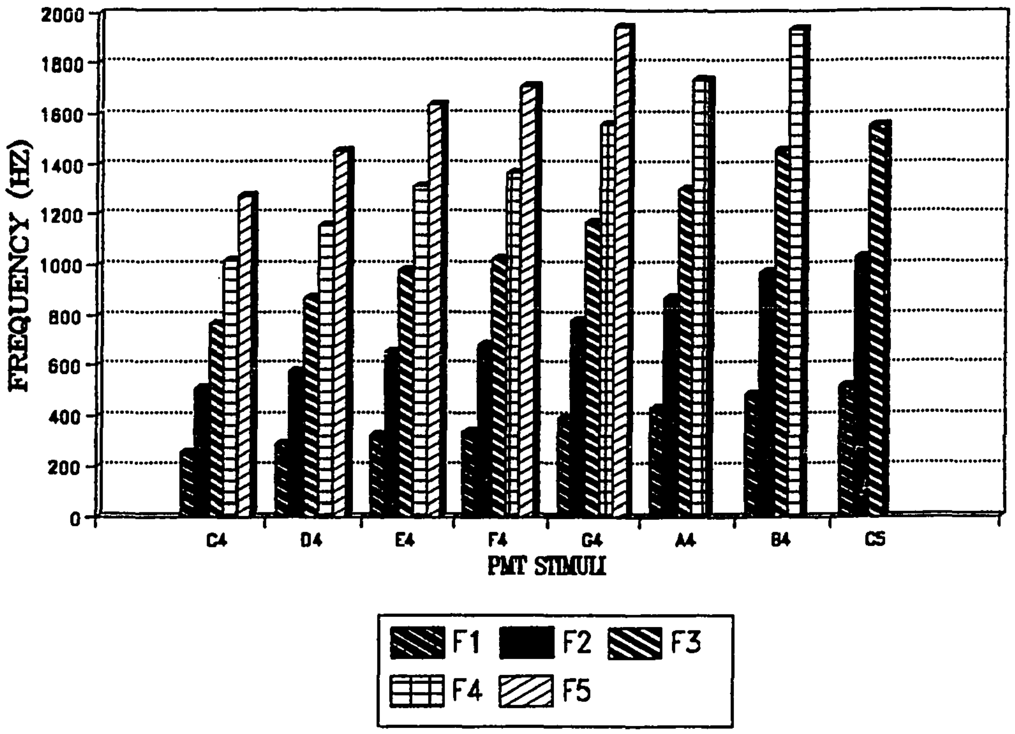

DATA STORED
44.1-03 V
VLG
795.0000 HZ
T
B
M
TSU
1
RS
Resonator Bells
G5
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
58.7-03 V
VLG
890.0000 HZ
T
B
M
TSU
1
RS
Resonator Bells
A5
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
52.4-03 V
VLG
1005.000 HZ
T
B
M
TSU
1
RS
Resonator Bells
B5
0.2A
2.0A
-B/16
HZ
2K

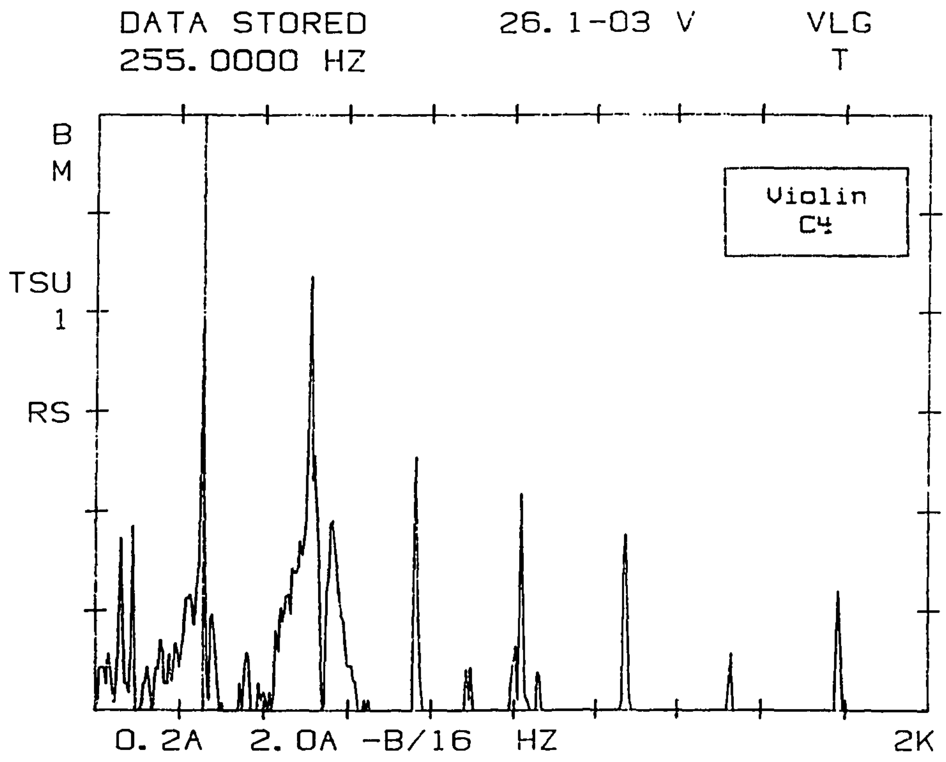

DATA STORED
60.7-03 V
VLG
1065.000 HZ
T
B
M
TSU
1
RS
Resonator Bells
C6
0.2A
2.0A
-B/16
HZ
2K

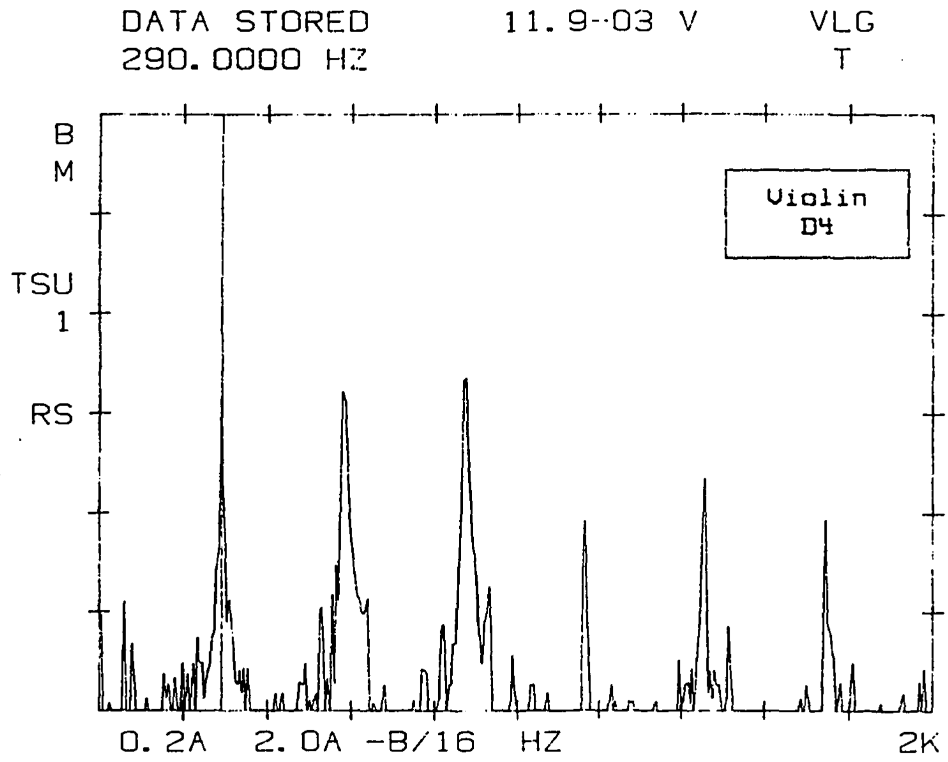
ANALYSIS OF HARMONIC SPECTRA
VIOLIN

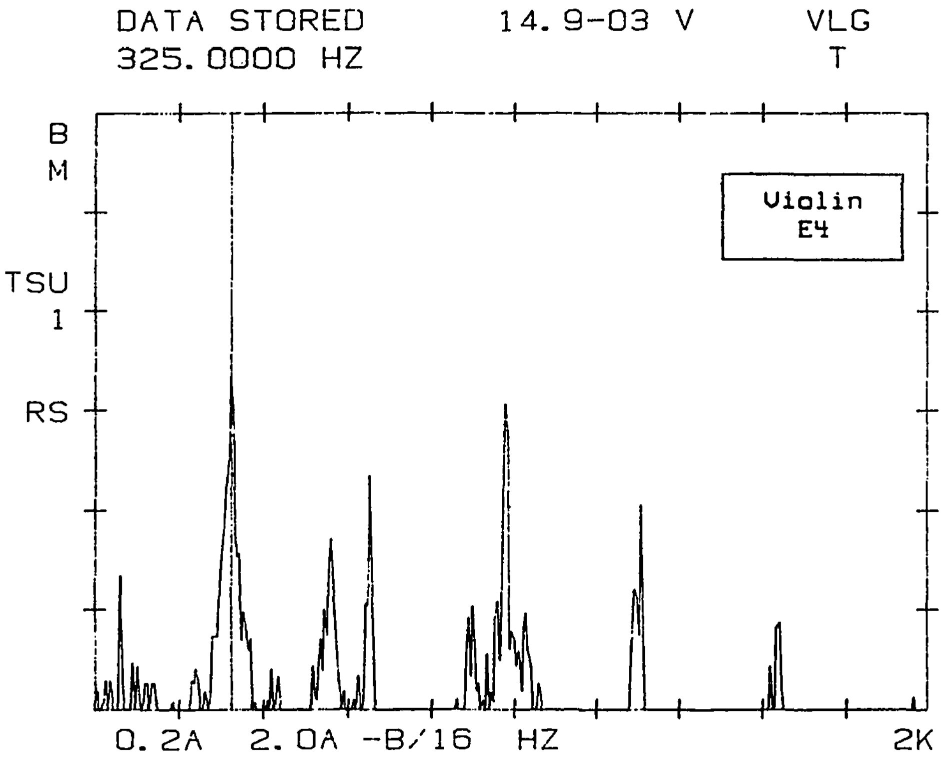


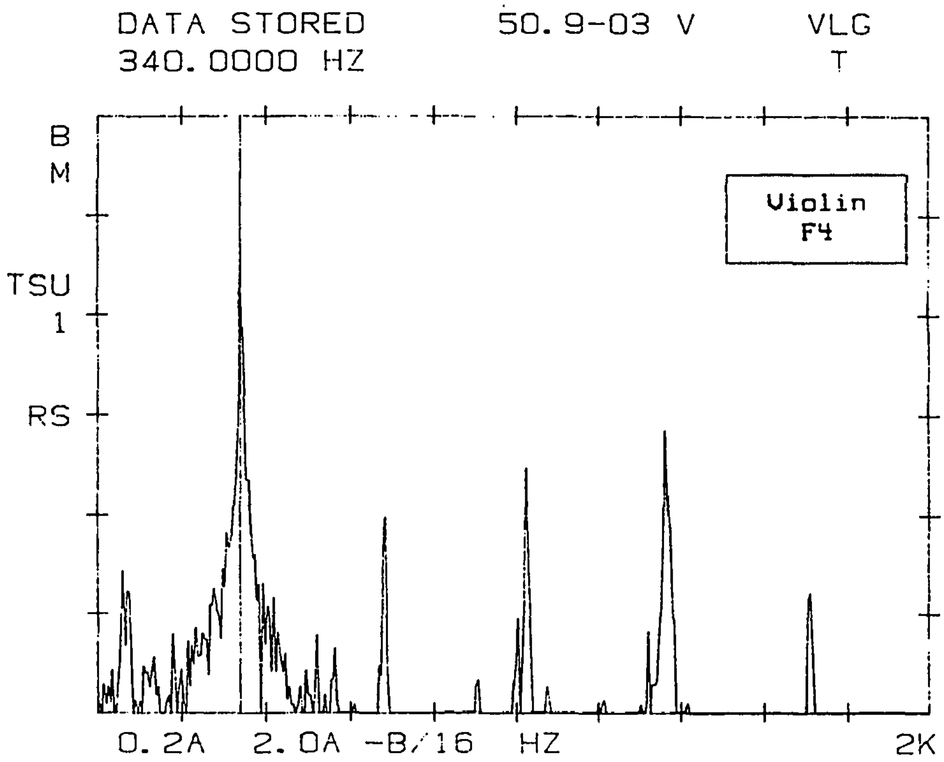
ANALYSIS OF HARMONIC SPECTRA
VIOLIN

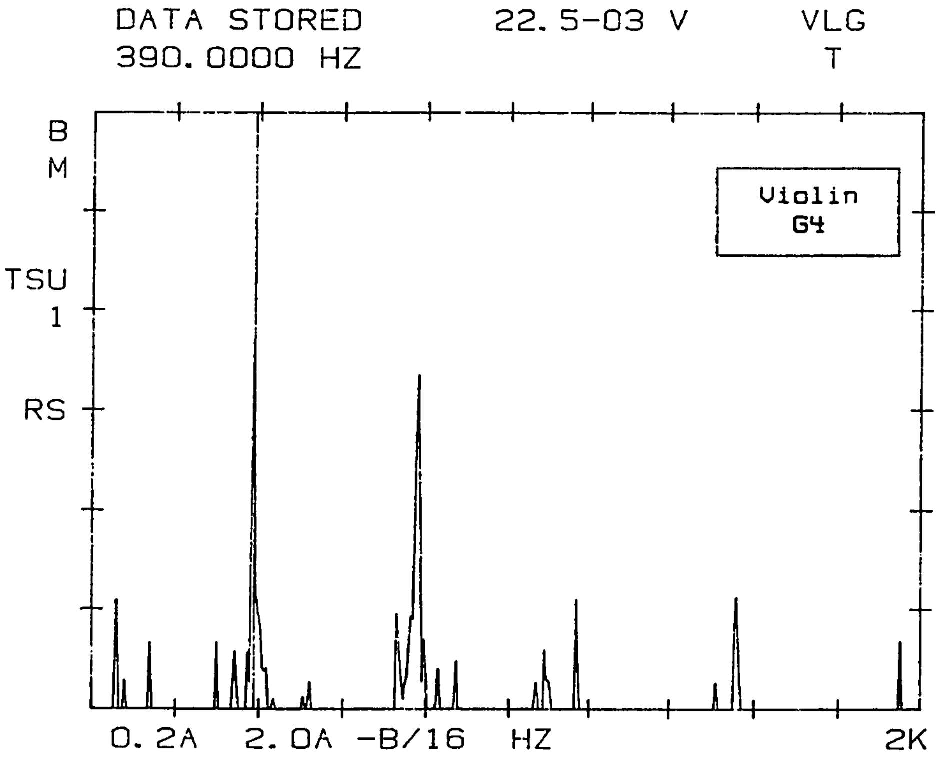
NOTE	STDHZ	F1	AMP/MV	F2	AMP/MV	F3	AMP/MV	F4	AMP/MV	F5	AMP/MV
C4	261.6	255	26.50	510	48.70	765	5.99	1020	3.93	1275	2.54
D4	293.7	290	13.10	580	17.80	870	20.20	1160	3.29	1450	5.14
E4	329.6	325	15.40	655	4.78	980	11.50	1310	3.35	1640	0.95
F4	349.2	340	50.00	685	3.02	1025	5.36	1365	7.94	1710	1.23
G4	392.0	390	22.20	780	13.60	1170	8.17	1555	1.12	1945	0.69
A4	440.0	435	43.70	870	26.30	1300	2.32	1740	6.54		
B4	493.9	485	49.10	970	11.10	1455	6.12	1940	1.32		
C5	523.3	520	65.60	1035	24.30	1555	1.25				

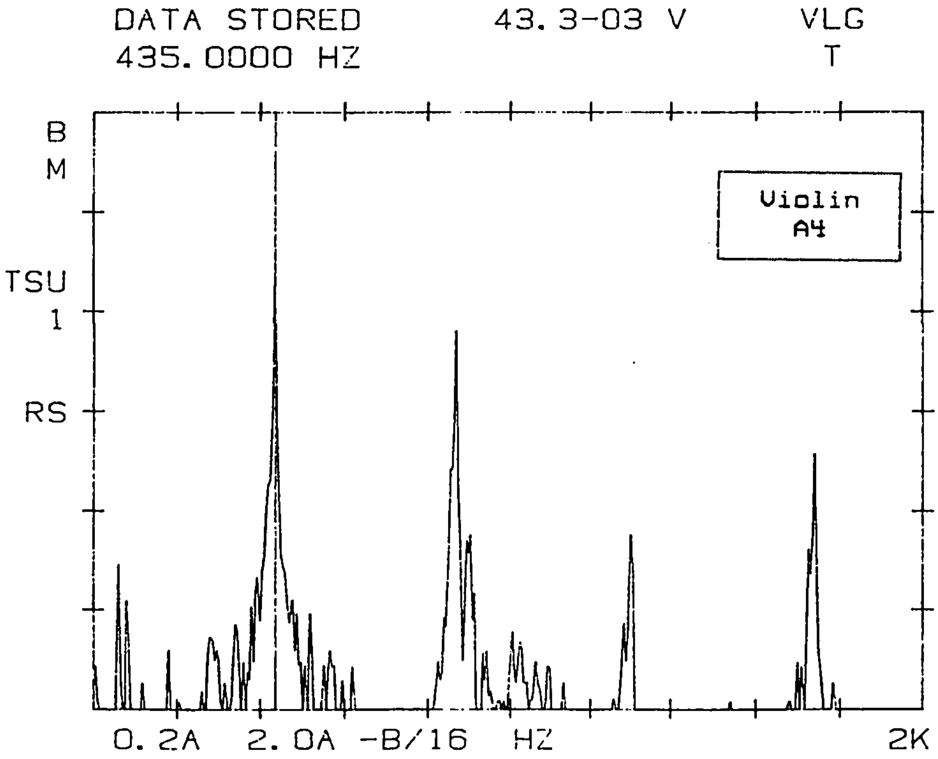

DATA STORED
255.0000 HZ
26.1-03 V
VLG
T
B
M
TSU
1
RS
Violin
C4
0.2A
2.0A
-B/16
HZ
2K

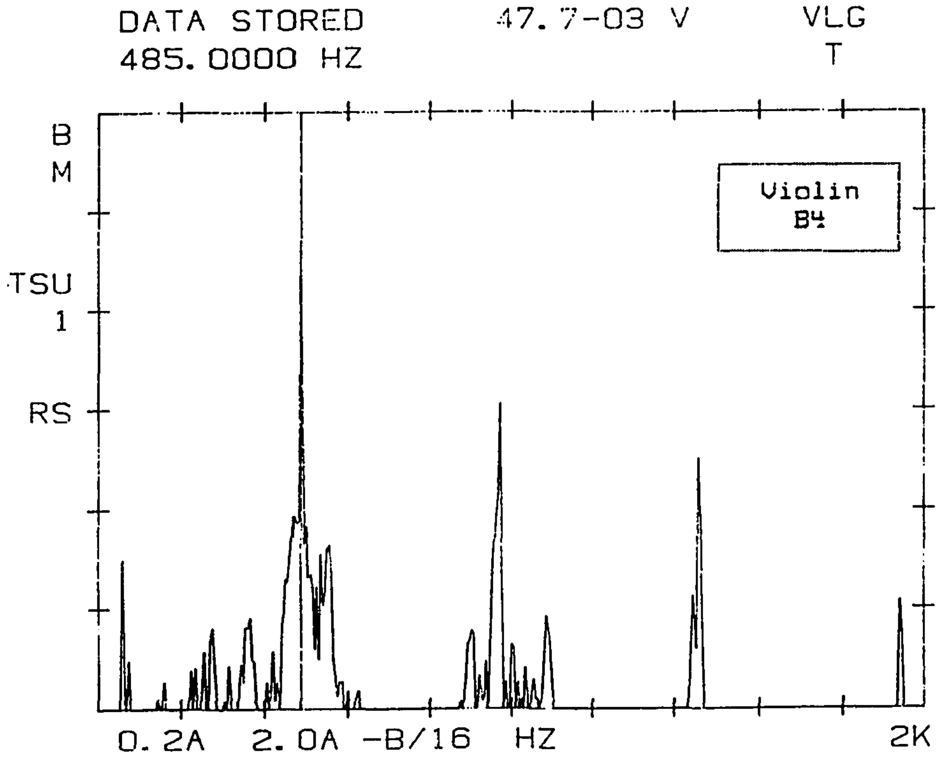

DATA STORED
290.0000 HZ
11.9-03 V
VLG
T
B
M
TSU
1
RS
Violin
D4
0.2A
2.0A
-B/16
HZ
2K

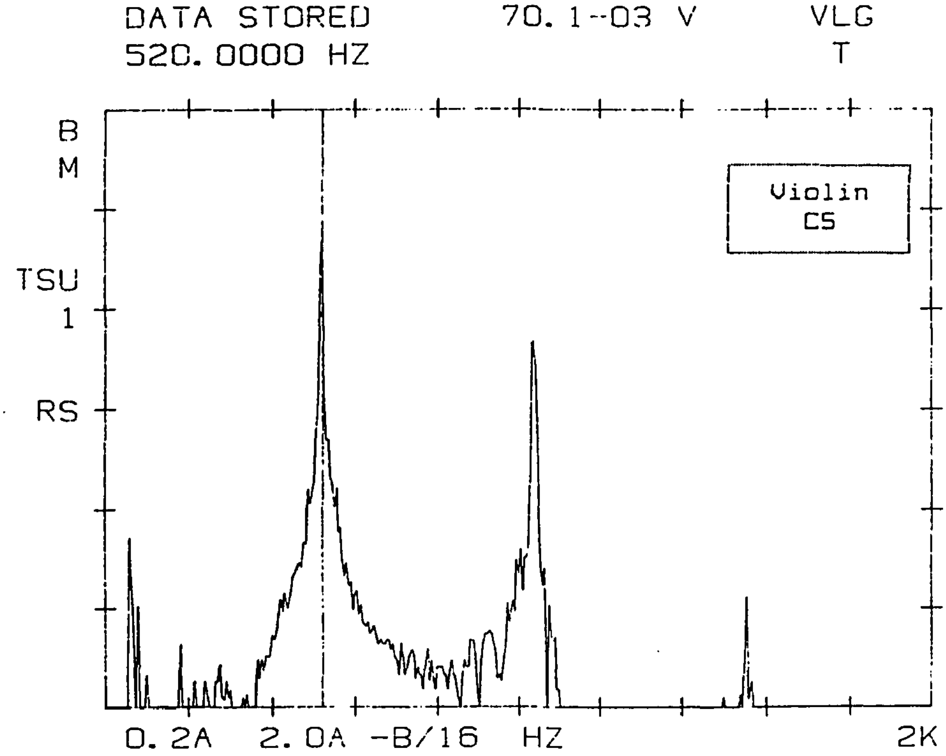

DATA STORED
325.0000 HZ
14.9-03 V
VLG
T
B
M
TSU
1
RS
Violin
E4
0.2A
2.0A -B/16
HZ
2K


DATA STORED
340.0000 HZ
50.9-03 V
VLG
T
B
M
TSU
1
RS
Violin
F4
0.2A
2.0A -B/16
HZ
2K

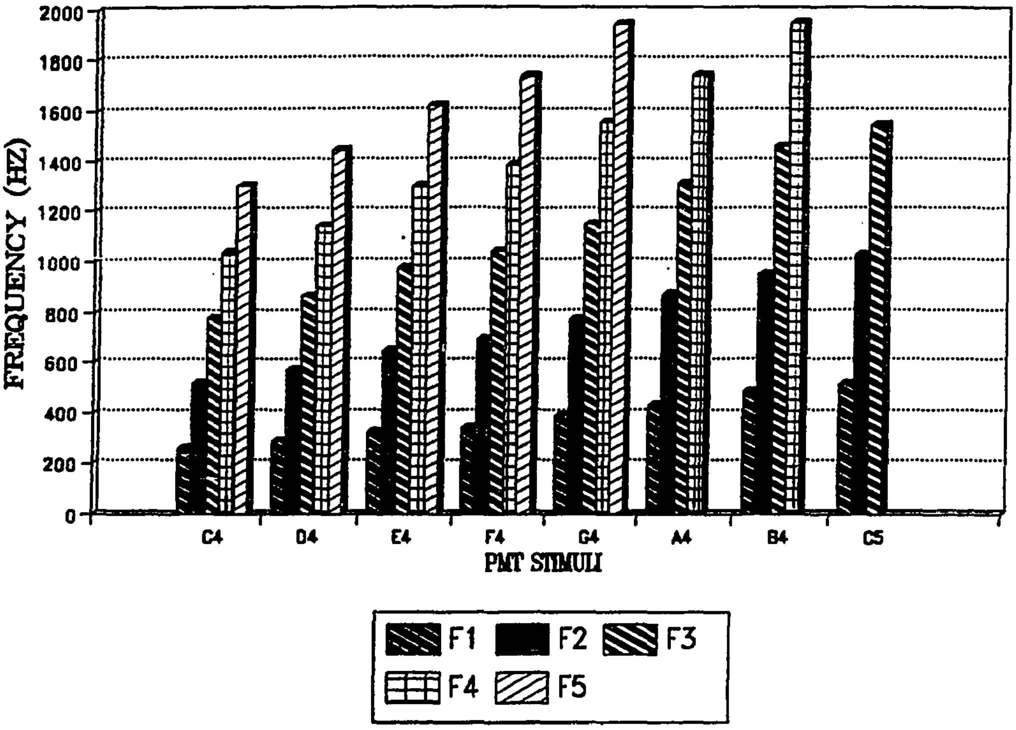

DATA STORED
390.0000 HZ
22.5-03 V
VLG
T
B
M
TSU
1
RS
Violin
G4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
435.0000 HZ
43.3-03 V
VLG
T
B
M
TSU
1
RS
Violin
A4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
485.0000 HZ
47.7-03 V
VLG
T
BM
TSU
1
RS
Violin
B4
0.2A
2.0A
-B/16
HZ
2K

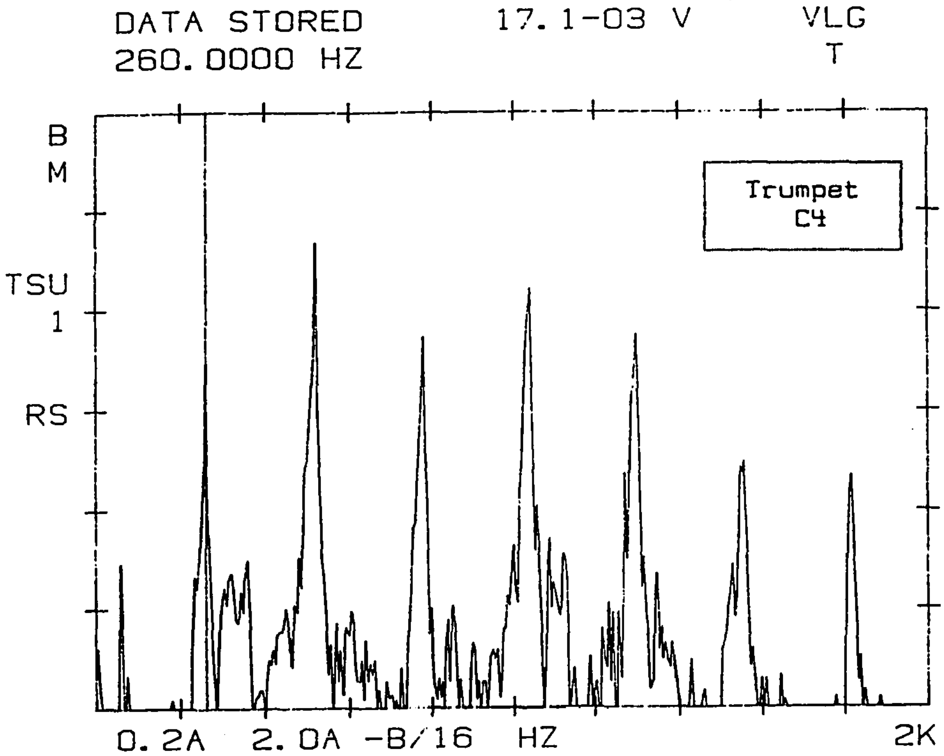

DATA STORED
520.0000 HZ
70.1-03 V
VLG
T
BM
TSU
1
RS
Violin
C5
0.2A
2.0A
-B/16
HZ
2K

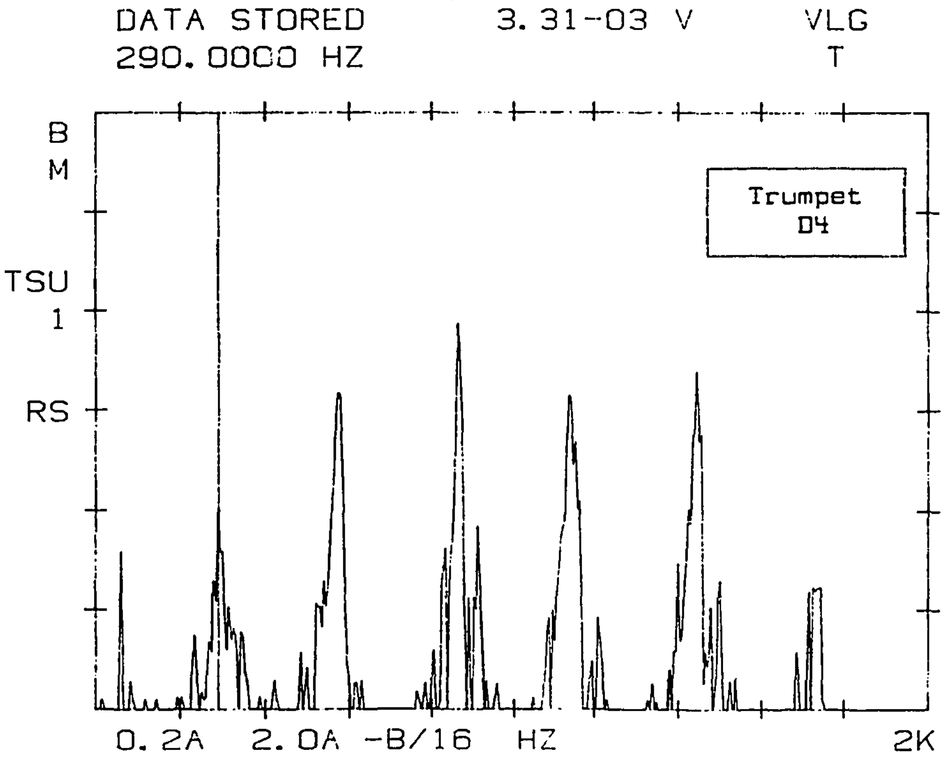
ANALYSIS OF HARMONIC SPECTRA
TRUMPET

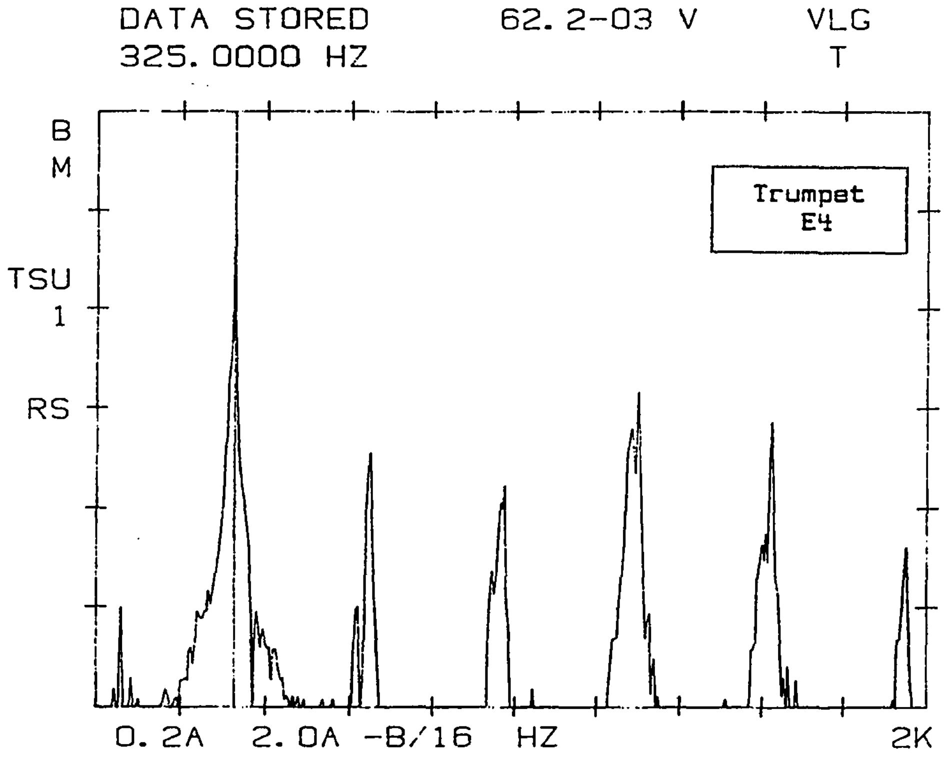


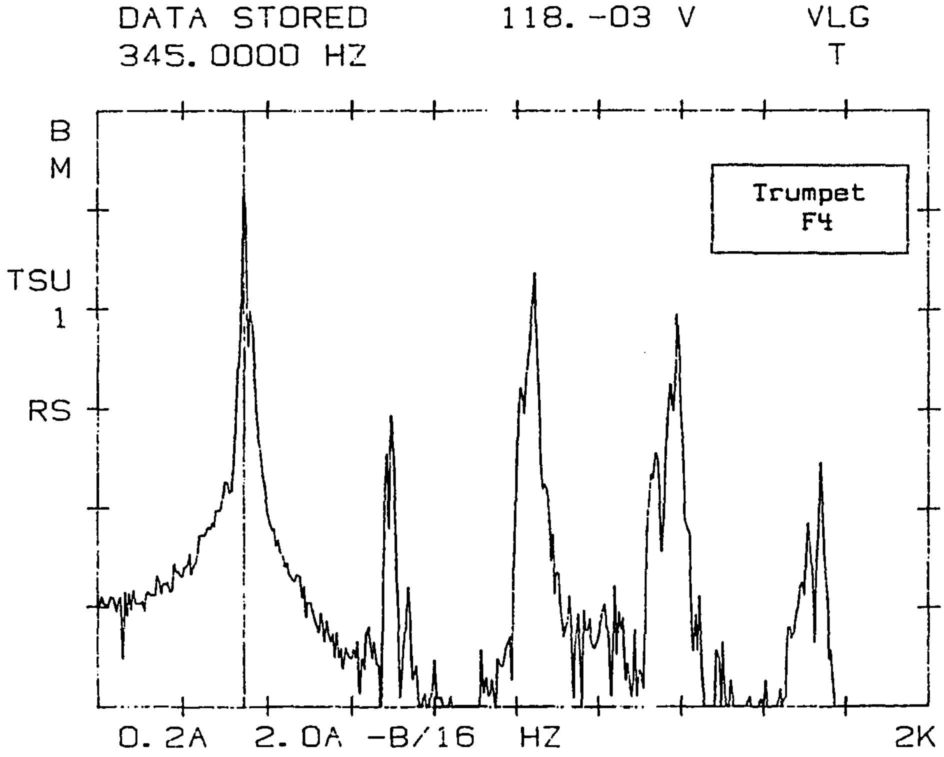
ANALYSIS OF HARMONIC SPECTRA
TRUMPET

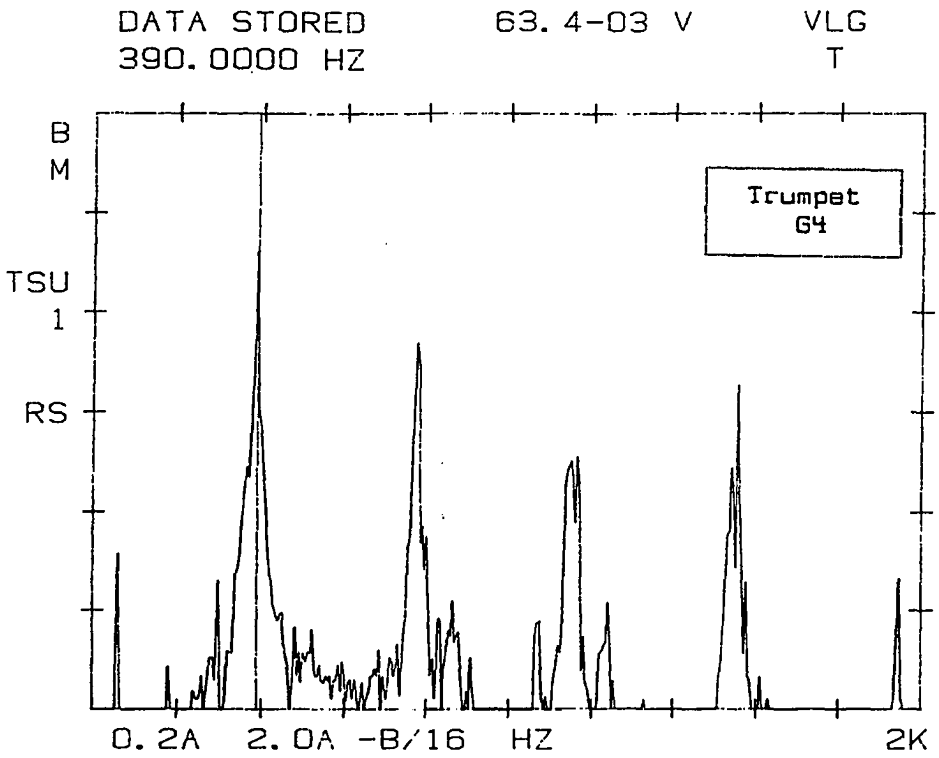
NOTE	STDHZ	F1	AMP/MV	F2	AMP/MV	F3	AMP/MV	F4	AMP/MV	F5	AMP/MV
C4	261.6	260	17.30	520	71.20	780	24.80	1040	44.70	1300	26.60
D4	293.7	290	3.28	575	13.80	865	30.00	1145	13.30	1445	14.50
E4	329.6	325	63.00	650	6.25	975	3.88	1300	12.20	1625	9.02
F4	349.2	345	123.00	695	9.46	1045	47.80	1390	32.10	1740	5.65
G4	392.0	390	64.70	775	21.40	1150	5.81	1555	13.80	1945	1.40
A4	440.0	435	27.50	870	40.00	1310	21.30	1745	6.92		
B4	493.9	485	44.00	950	6.90	1460	24.60	1950	4.48		
C5	523.3	515	67.10	1030	22.90	1545	20.90				

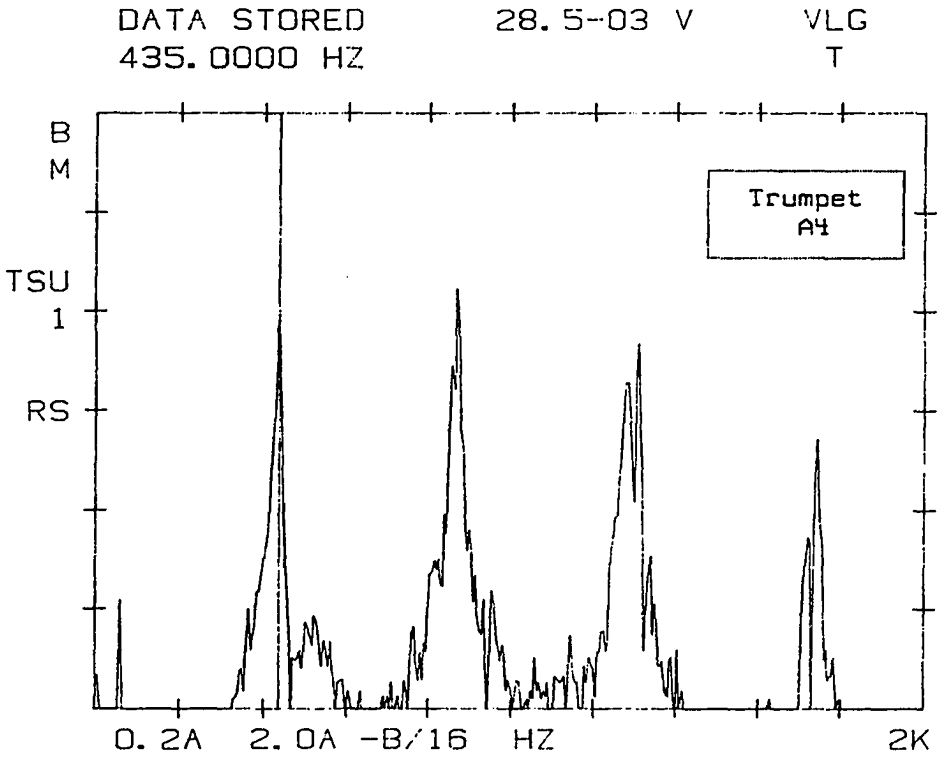

DATA STORED
260.0000 HZ
17.1-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
C4
0.2A 2.0A -B/16 HZ
2K

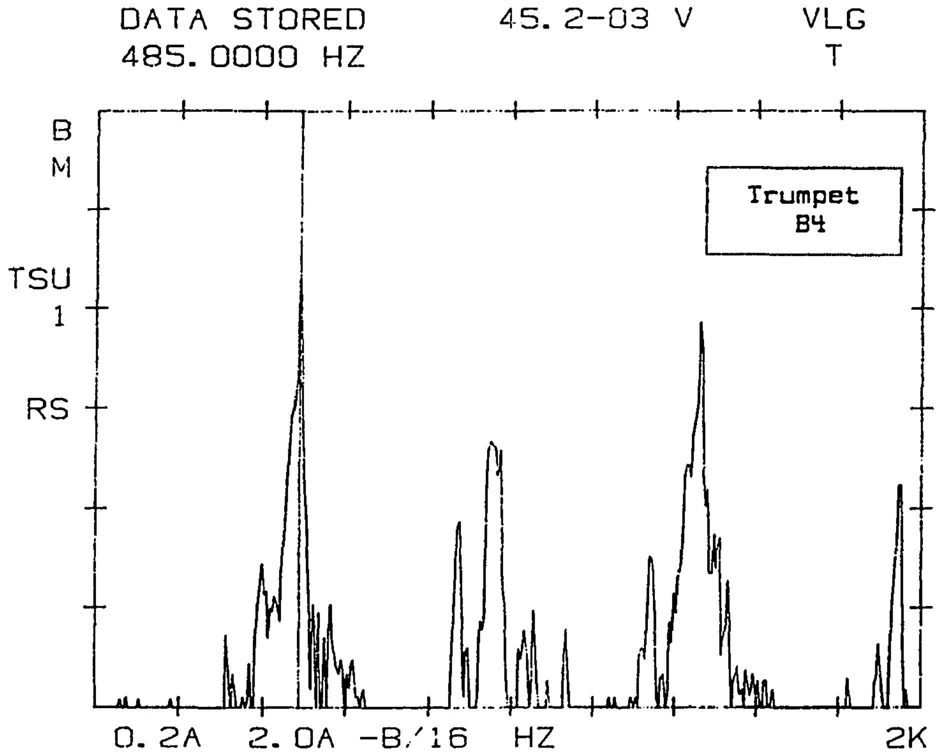

DATA STORED
290.0000 HZ
3.31-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
D4
0.2A 2.0A -B/16 HZ
2K

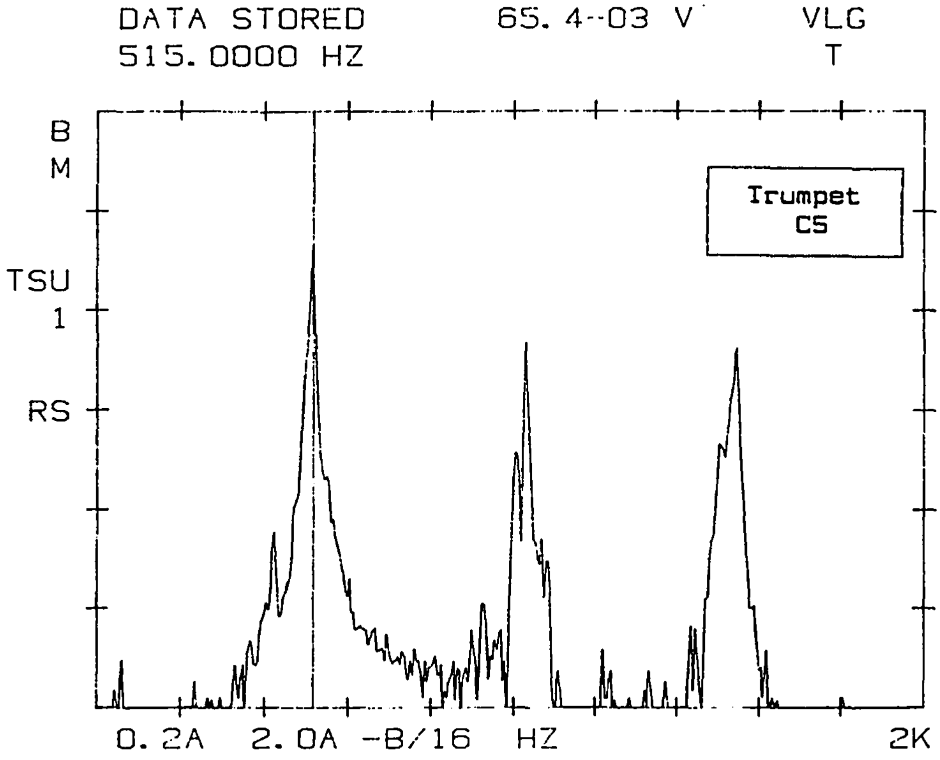

DATA STORED
325.0000 HZ
62.2-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
E4
0.2A 2.0A -B/16 HZ
2K


DATA STORED
345.0000 HZ
118.-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
F4
0.2A 2.0A -B/16 HZ
2K

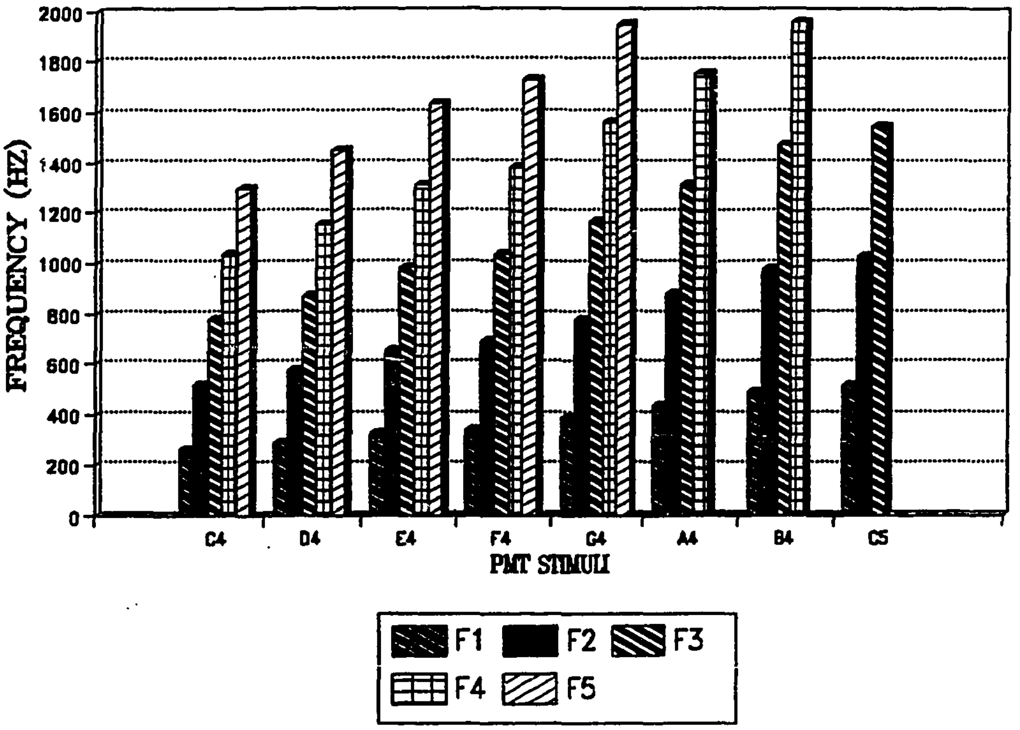

DATA STORED
390.0000 HZ
63.4-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
G4
0.2A 2.0A -B/16 HZ
2K


DATA STORED
435.0000 HZ
28.5-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
A4
0.2A 2.0A -B/16 HZ
2K


DATA STORED
485. 0000 HZ
45. 2-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
B4
0. 2A
2. 0A
-B/16
HZ
2K

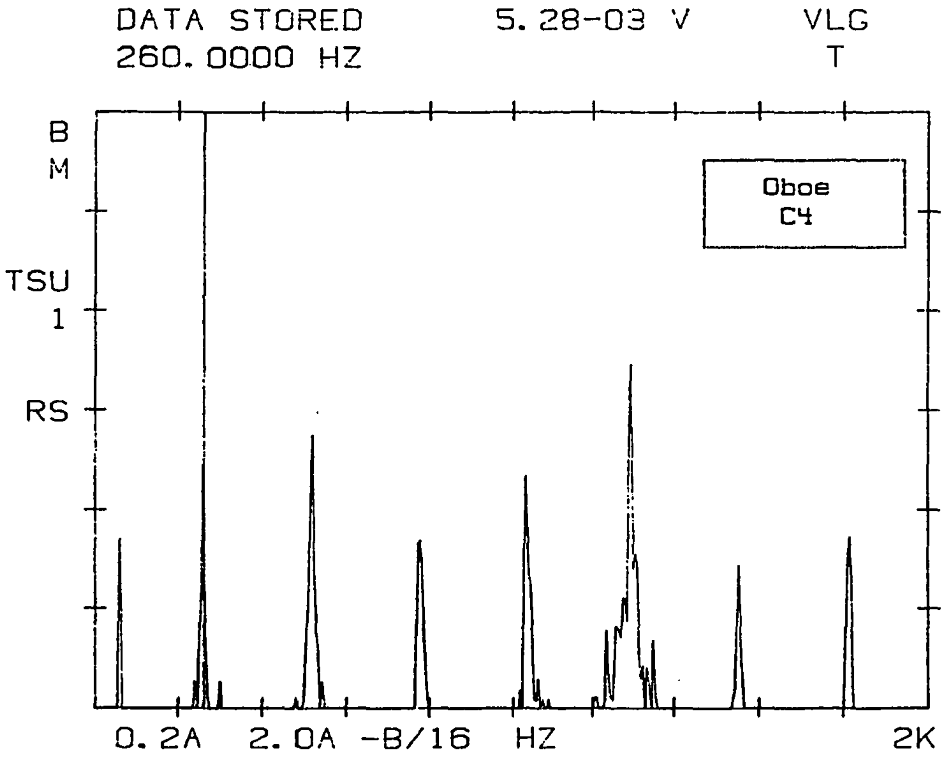

DATA STORED
515. 0000 HZ
65. 4-03 V
VLG
T
B
M
TSU
1
RS
Trumpet
C5
0. 2A
2. 0A
-B/16
HZ
2K

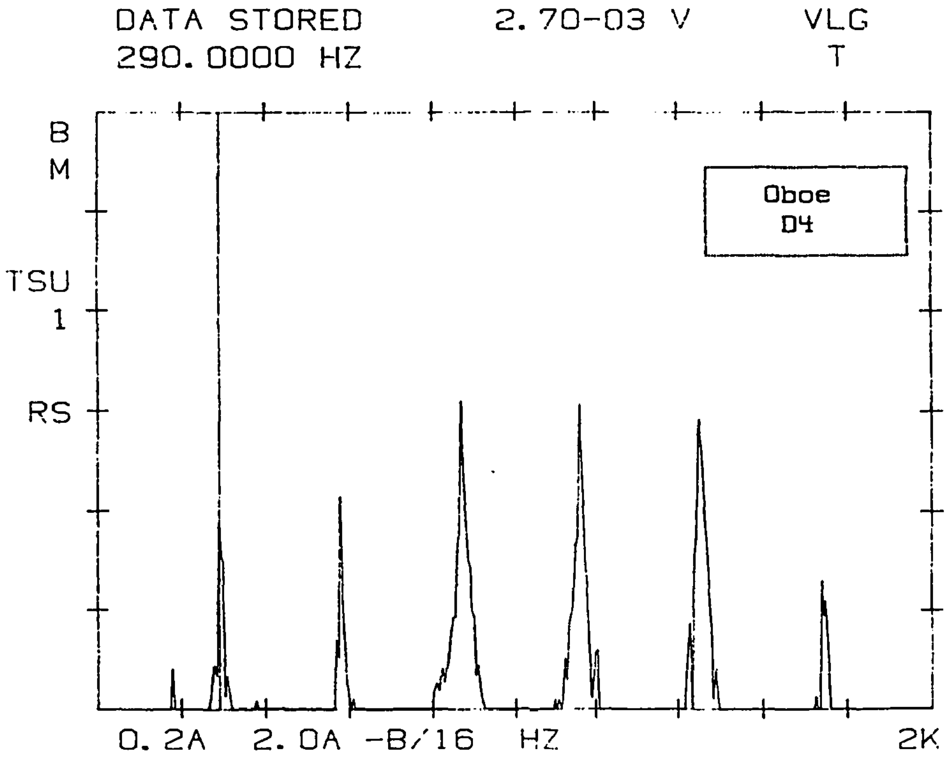
ANALYSIS OF HARMONIC SPECTRA
OBOE

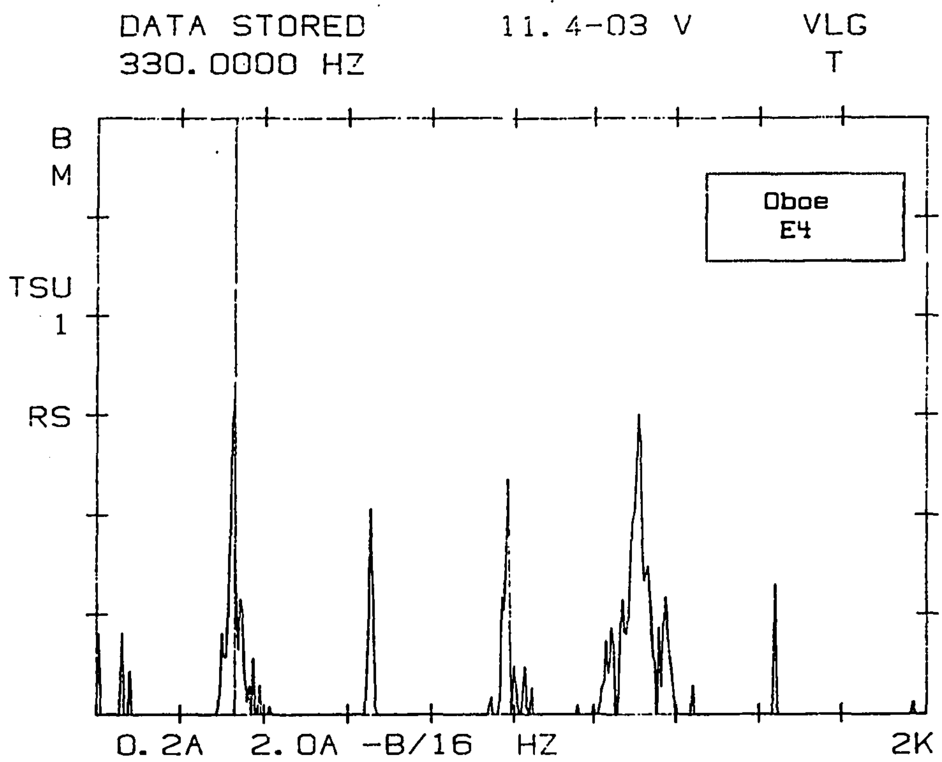


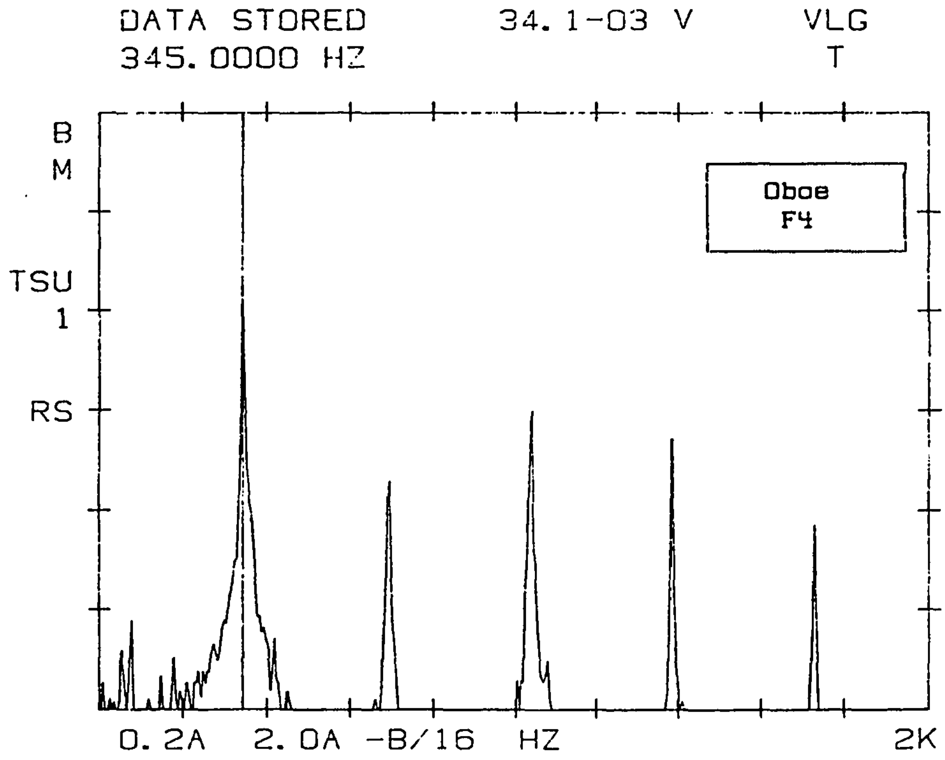
ANALYSIS OF HARMONIC SPECTRA
OBOE

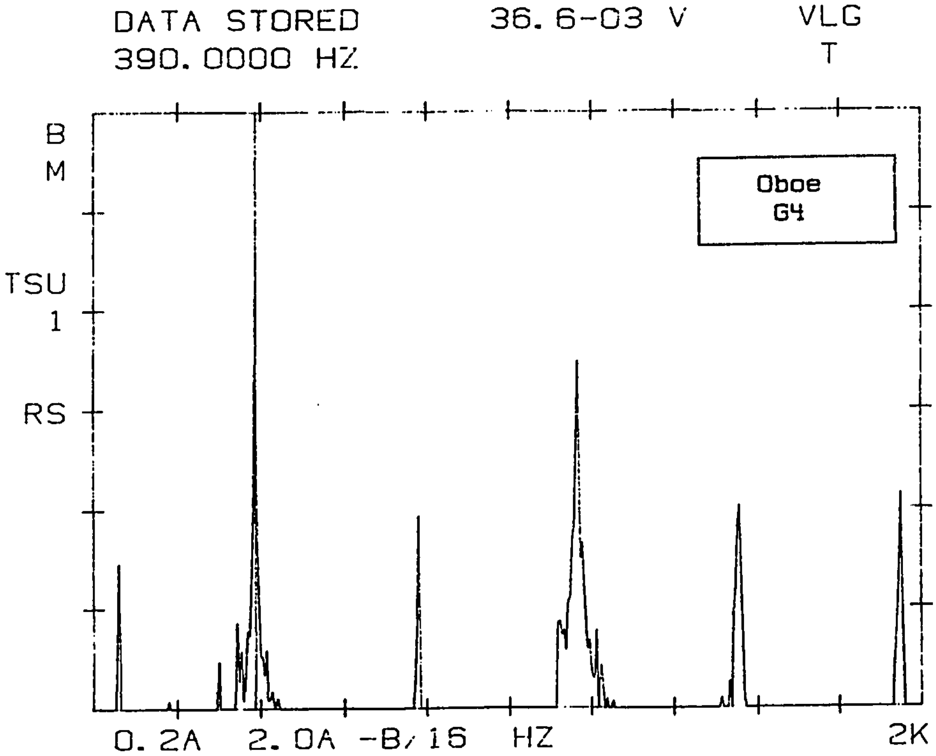
NOTE	STDHZ	F1	AMP/MV	F2	AMP/MV	F3	AMP/MV	F4	AMP/MV	F5	AMP/MV
C4	261.6	260	5.58	520	8.13	780	2.69	1040	3.71	1295	11.00
D4	293.7	290	2.78	580	3.72	870	11.30	1160	10.80	1450	9.15
E4	329.6	330	10.70	655	3.73	985	4.23	1310	12.80	1640	1.39
F4	349.2	345	34.60	695	3.97	1040	9.01	1385	6.92	1730	2.58
G4	392.0	390	36.30	780	3.04	1170	17.30	1560	3.40	1950	3.74
A4	440.0	440	9.74	880	5.34	1315	2.95	1755	4.43		
B4	493.9	490	10.50	980	1.17	1470	14.70	1960	1.61		
C5	523.3	515	25.90	1030	5.02	1545	8.92				

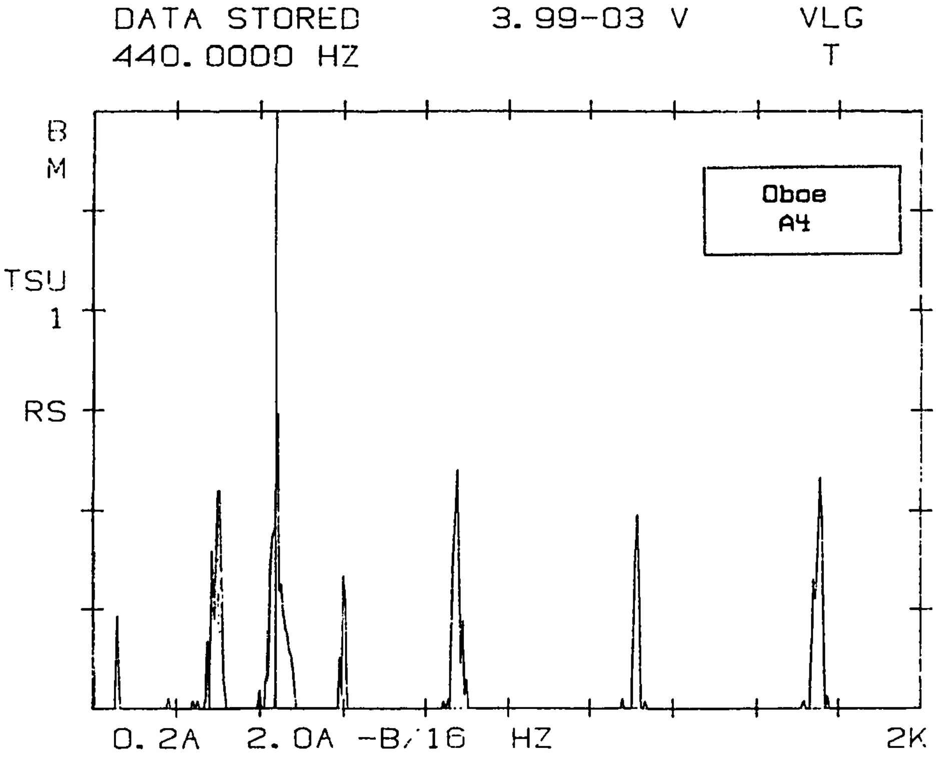

DATA STORED
260.0000 HZ
5.28-03 V
VLG
T
BM
TSU 1
RS
Oboe
C4
0.2A
2.0A
-B/16
HZ
2K

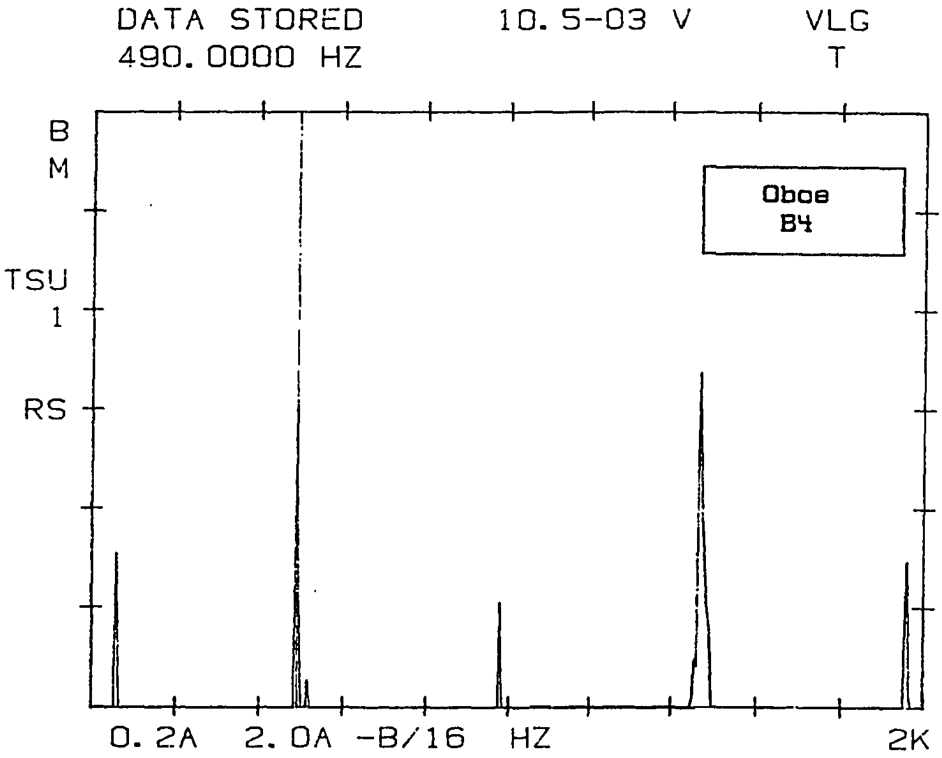

DATA STORED
290.0000 HZ
2.70-03 V
VLG
T
BM
TSU 1
RS
Oboe
D4
0.2A
2.0A
-B/16
HZ
2K

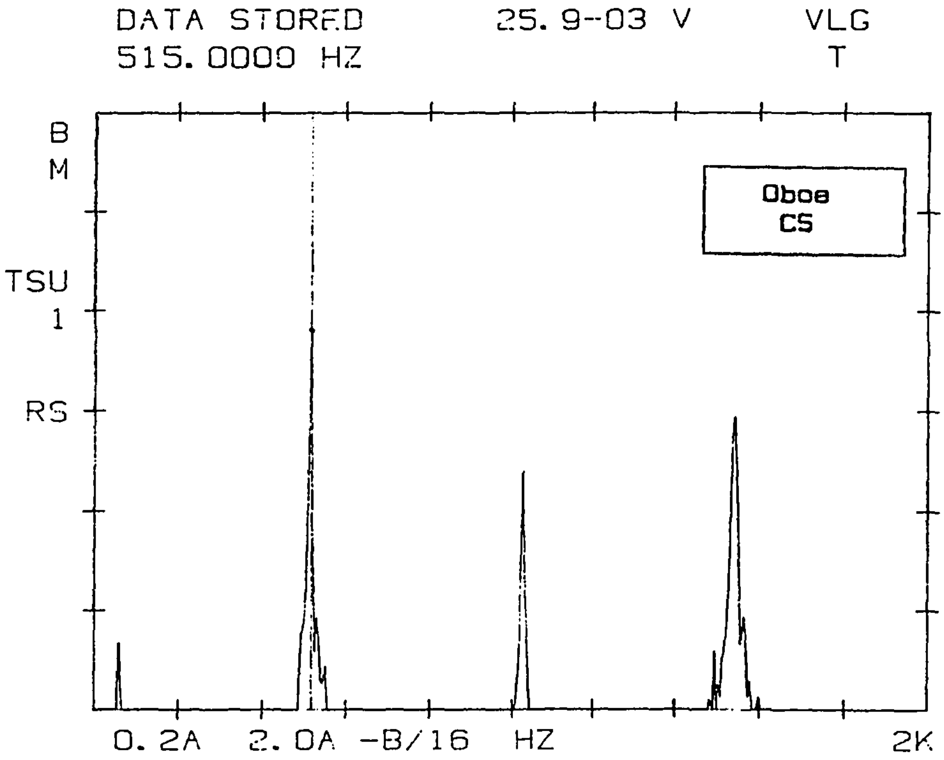

DATA STORED
11.4-03 V
VLG
330.0000 HZ
T
B
M
TSU
1
RS
Oboe
E4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
34.1-03 V
VLG
345.0000 HZ
T
B
M
TSU
1
RS
Oboe
F4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
390.0000 HZ
36.6-03 V
VLG
T
B
M
TSU
1
RS
Oboe
G4
0.2A
2.0A -B/16
HZ
2K


DATA STORED
440.0000 HZ
3.99-03 V
VLG
T
B
M
TSU
1
RS
Oboe
A4
0.2A
2.0A -B/16
HZ
2K


DATA STORED
490.0000 HZ
10.5-03 V
VLG
T
B
M
TSU
1
RS
Oboe
B4
0.2A
2.0A
-B/16
HZ
2K


DATA STORED
515.0000 HZ
25.9-03 V
VLG
T
B
M
TSU
1
RS
Oboe
C5
0.2A
2.0A
-B/16
HZ
2K