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Intensity and Frequency Analyses of a Sampling of Modern-Day Rhythm-Blues Music

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INTENSITY AND FREQUENCY ANALYSES OF A SAMPLING OF MODERN-DAY RHYTHM-BLUES MUSIC

(TITLE)

BY

Carol McDuffie Hamilton

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I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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ACKNOWLEDGMENT

The writer wishes to express her sincere appreciation to the band members of the "Artistics" who cooperated with and tolerated the author during data collection.

The writer is most grateful to Dr. James M. Flugrath, advisor for the paper, Dr. Wayne L. Thurman, Dr. Jerry Griffith, and Mr. Lynn E. Miner for their interest, judgment, patience, and encouragement. The author is also indebted to Dr. C. E. Strandberg for his assistance in producing illustrations for the paper.

Obviously, a study such as this is the product of many influences. To those mentioned previously, and others unnamed, goes much credit for the final product. Finally, the author is particularly grateful to her husband, Bill, for his patience and constant support.

C. F. H.

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CHAPTER I

INTRODUCTION

During the past two years, much interest has evolved concerning the effect of modern-day "live," "psychedelic" and "rhythm-blues" music on the human hearing mechanism. Whether or not the effect constitutes a potential health hazard has been questioned and debated but remains unresolved. There is a critical shortage of research concerning "live" musical situations which, in part, is responsible for the uncertainty. Too, the current disagreement regarding specific definition of "hazard", in terms of acceptable noise levels and time exposures, makes it difficult to formulate any valid statements concerning the possibility of damage risk. Although many criteria have been proposed (2, 6, 8, 9, 17, 19), they are not directly applicable to the question under study, since, again, little research has been published. Nevertheless, because of the present uniqueness, extreme popularity and enticement of "rhythm-blues" music among young people, it is quite appropriate to question the possibility of auditory damage resulting from exposure to high intensity levels.

Obviously, damage risk is remote if the members of the audience attend performances only occasionally, or

frequently for periods of short duration. It seems reasonable to assume that many young people may be classified in this category. However, there is a population that does attend dances frequently for long periods of time, namely, band members. Relatively little professional interest has been focused on this group. Professional band groups as well as popular local amateur groups perform regularly and, at times, may be scheduled from five to seven evenings per week with possibly more than one appearance per day. Moreover, these groups may play for years, and exposure time may approximate many hours a week. In addition, these same persons sometimes hold jobs in noisy work environments which add to the exposure time incurred during a given day or week. Therefore, to question the potential health hazard posed by music becomes quite feasible, especially in regard to musicians. This question is of particular importance to audiologists who share with physicians the responsibility of determining the degree to which a health hazard exists, if at all.

Before any reliable statements can be made concerning auditory damage risk, the characteristics of the musical situation must be described and studied. The following variables should be considered: a) categorical classification of the music for which criteria have been established, if possible, b) duration and consistency of exposure, c) intensity level, d) frequency distribution of intensity, e) time of exposure, or variations in intensity as a function of "MacLean's cocktail effect" (11), f) background noise,

g) consistency of amplifier gain within and between performances, h) placement of performers on stage, i) placement of loud-speakers, j) description and size of room, and k) type of song--instrumental or vocal. Each of these factors may be related to the damage risk phenomenon and must be described and perhaps controlled.

The purpose of this paper is to report a descriptive investigation of an extensive sample of "rhythm-blues" music produced by a local professional band. Because of the variables involved in regard to safe exposure levels and the fact that the data reported are based on one group playing one kind of music, no definite conclusions regarding aural damage resulting from exposure to the music can be made. However, the investigative procedure, the problems encountered, the method of analysis, and the data obtained may be helpful to future researchers in this area. While each of the variables mentioned earlier will be considered and fully described, principal emphasis will be placed on an analysis of the intensity, frequency, and time characteristics of the music samples.

CHAPTER II

REVIEW OF THE LITERATURE

Although research on noise measurement in industry, the military, business, and aircraft is voluminous and some is of long-standing, relatively little has been published concerning musical situations. Glorig (5), found intensity levels of musical groups ranging from 105-115 dB on the "A" weighting scale, the network of a sound level meter designed to pass high frequencies. Glorig also reported hearing tests in musicians showed a trend towards high frequency losses, which may be found in connection with noise over-exposure (15).

Pollock *et al.* (4), recently noted that the sound level of the music dropped below 90 dB only at a distance of forty feet outside the building in which it originated. The temporary losses of hearing acuity ranged from one and one-half to thirty-five dB in ten youngsters. All were described as having "ringing in their ears," which may be found in connection with noise-induced hearing loss (14). Inside the building, Pollock and his associates found the intensity level to be 120 dB in front of the bandstand. However, exact positioning of their measuring equipment was not specified. If these levels are "typical" of musical

situations, further investigation would seem warranted.

Related research has been done by Leggert and Northwood (10) who studied the noise level of eight parties. One purpose was to determine if the noise might constitute auditory damage risk for "habitual party goers." Their results indicated that the level was not high enough (80-85 dB) to warrant further study. However, of importance to the present study is the suggestion made by the authors that information should be obtained concerning the sound level as related to time, accumulation of guests, room characteristics, and attendance.

Sorensen (16) investigated the pressure ranges for musical symbols <u>ppp</u> to <u>fff</u> on the violin, clarinet, flute, and cornet. The results indicated that differences in sound levels of the individual instruments may be the product of room characteristics. As would be expected, the sound levels were highest in reverberant rooms and lowest in an anachoic chamber. The data suggest the need to specify room characteristics, if relevant, in future studies.

The previous review of the literature illustrates for the reader the lack of research in this area. In the present study, suggestions and implications from the previous studies will be considered, and some will be incorporated into the procedure. In addition, a frequency analysis of the music will be performed, which previously has not been done, to study the distribution of intensity. The following chapters will deal with procedure, analysis, and subjective

observations of the music sampling. Improvements in procedure will also be suggested and discussed.

CHAPTER III

PROCEDURE

Subjects and Situation

The musical group chosen for this study consisted of seven members (six male and one female). One male and female were solely vocalists. However, three of the remaining members often vocally participated in the musical presentations. This group was arbitrarily selected from a college dance schedule and was considered a local professional band, which had been in existence for approximately seven years. The band was categorized as "rhythm-blues" rather than "psychedelic"; that is, no stroboscopic lights, mechanical noise makers, or distorted amplification signals were regularly used by the group.

Explanations to the members included statements that the investigator wanted to measure the "loudness" of their music and was doing so for a "research paper." Assurances were made that no specific names would be printed and that the investigator's equipment would not interfere with their performance. They were requested to play "as usual" and at gain levels typically used during a performance. In the researcher's opinion, the band members were quite cooperative, and it was not felt that results were, in any way, distorted

because of their attitudes.

The band members performed on a stage with dimensions of sixteen by twenty feet. (Figure 1) Assuming one is facing the staging area, the drummer was positioned to the rear and at the center of the stage. One guitarist was to the left forward of the stage; one was to the right rear. Saxophone players were both to the right forward, while the vocalists stood between the saxophone players and guitarist. Loudspeakers connected with the public address system were each stationed forward and to the right and left of the staging area.

The dance was attended by 125-150 college students, seventy-five per cent of whom participated in the dancing in front of the stage. Spectators were generally positioned to the sides of the band and to the rear of the dancers. One of two entryways to the room was open during the entire performance; the other was ajar only during exiting of the audience.

Band Instruments

Instruments included a baritone saxophone, a tenor saxophone, an electric bass guitar, a standard electric guitar, a tamborine, a cowbell, and a jazz drum set, consisting of a bass drum, floor tom, tom-tom, high-hat, cymbal, and snare drum. The musical signals from the electric bass guitar were amplified through a Fender System, which terminated in two twelve-inch loudspeakers. An Ampex Amplification System with a fifteen inch speaker was used with the standard electric

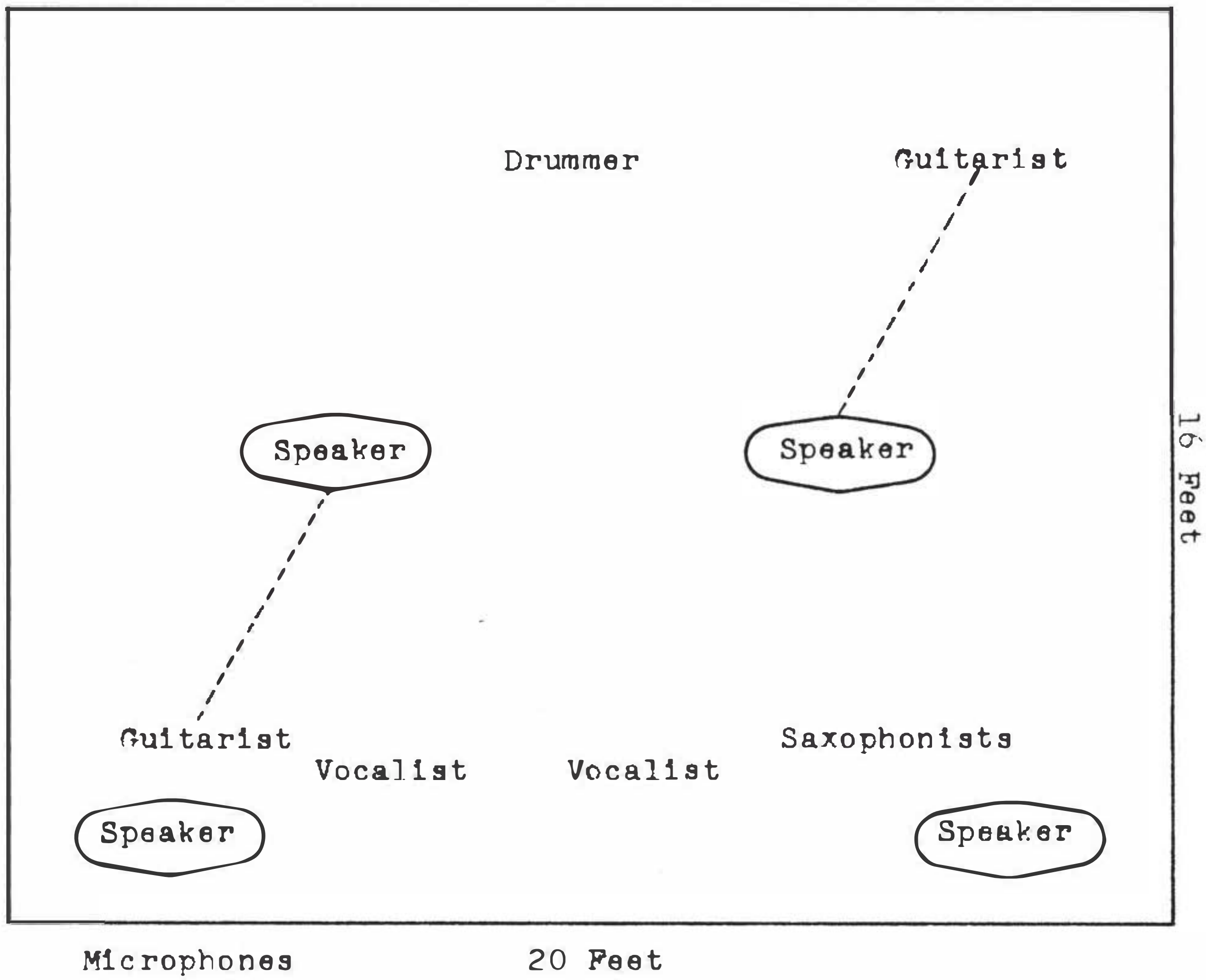


Figure 1. Schematic diagram showing positioning of band members, loudspeakers, and pick-up equipment.

guitar. In addition, two Atlas loudspeaker enclosures, each containing six six-inch speakers, were connected to the public address system.

Room Description

The data were collected during an evening performance at the Eastern Illinois University Union Ballroom. The ballroom dimensions were 47' 7" X 111' X 15' 10". (Figure 2) The ceiling of the room was an acoustical plaster composition in a semi-hardened state, which allowed greater sound absorption. The east and west walls of the room were pre-cast aggregate panels interlaced with eight-inch casement windows. Large panes of glass of single thickness and non-thermal pane formed the south wall of the room; the north wall was fashioned of two-inch stripped paneling finished in a smooth texture. The floor was constructed of nine inch by nine inch asphalt floor tile on concrete. Two entryways were located on the north wall approximately fifty feet apart. On the east and west ends of the north wall were storage cabinets behind two-inch hollow core wooden doors.

Method

Thirty minutes of uninterrupted music were tape recorded. This did not include pauses between songs or rest breaks for the band members. The samples were taken during the middle hour and one-half of a three-hour performance; this particular time segment was considered to be most representative of a typical dance situation. During the initial

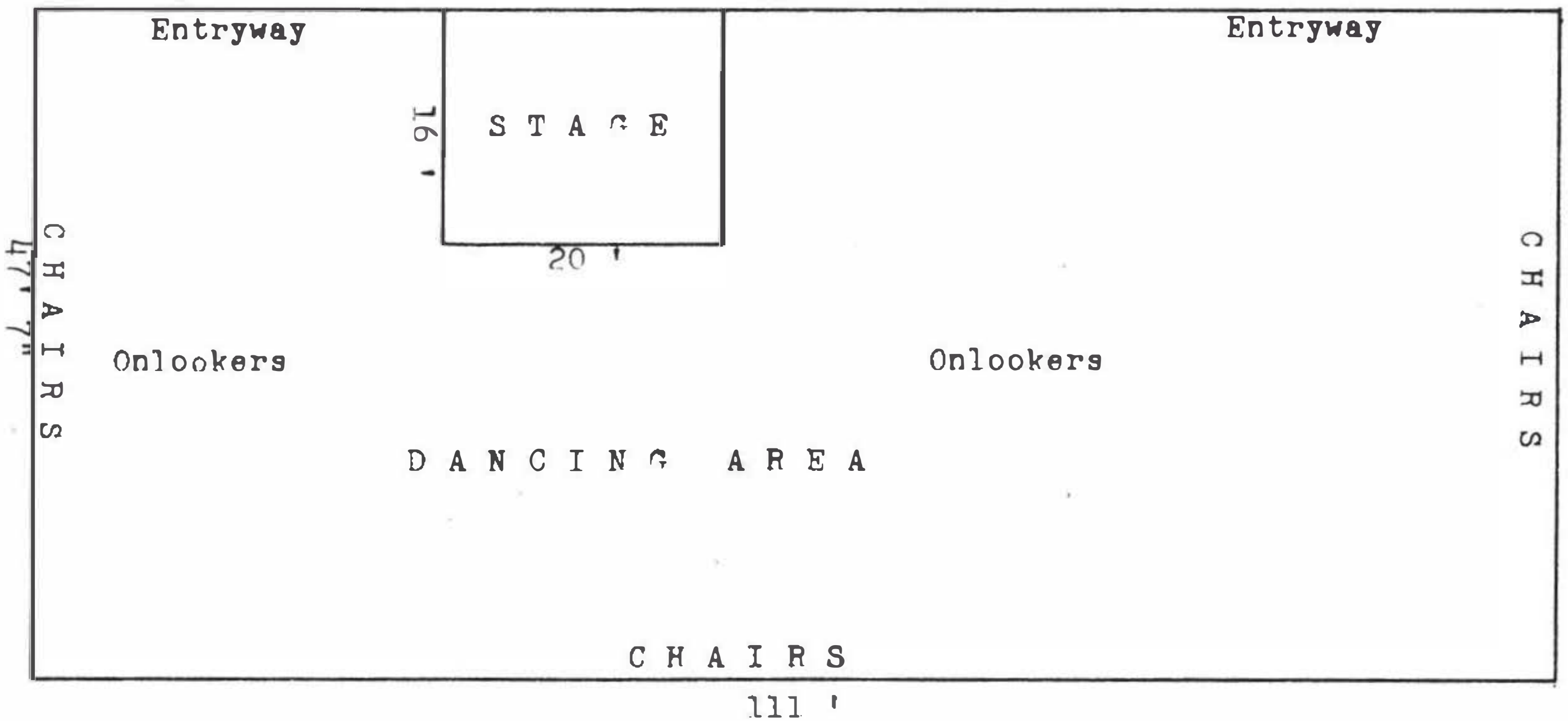


Figure 2. Diagram indicating the performance positioning of the dancers, onlookers, and the stage relative to the ballroom.

half-hour, most of the people were still arriving, and during the final half-hour, many had already gone from the dance. It was judged that data collection during this time would permit a sampling of peak intensity levels from all sources, including the crowd, reached during the dance.

Before obtaining data with this particular band, the investigator had undergone a "practice session" with another band during a similar dance in the same room. This was done in order to determine the most accurate procedures and to study problems involved, as well as to ensure that the method was well-understood. It was found that synchronization of equipment would present somewhat of a problem and that constant observation of graphic level recordings was necessary.

Description of Equipment

In order to obtain a continuous reading of intensity, a Model 1551-C General Radio Company Sound Level Meter (SLM) was connected to a Model 1521-A General Radio Company Graphic Level Recorder (GLR) with a 40 dB potentiometer. An adaptor cable assembly joined the output jack of the sound level meter with the recorder input terminals. The piezoelectric ceramic microphone (Type 1560-P3) on the sound level meter was nondirectional. The meter batteries switch was set on "Fast" in order to obtain a more accurate read-out of the level recorder, and the "C" weighting network was selected because of its relatively flat frequency response from 20 to 20,000 Hz. The attenuator switch on the SLM was varied to prevent over-driving the meter as the music changed

intensity. All baseline changes were indicated.

Intensity versus time measurements were plotted with the graphic level recorder described above. To ensure optimum response, a twenty inches per second writing speed was chosen. Paper speed was twenty-five inches per minute or one-hundred divisions per minute on the chart paper. The paper had a linear time base with one division equalling 1/4 inch, and was specified as a function of time. (Part No. 1521-9528) The input attenuator switch was on zero attenuation at all times.

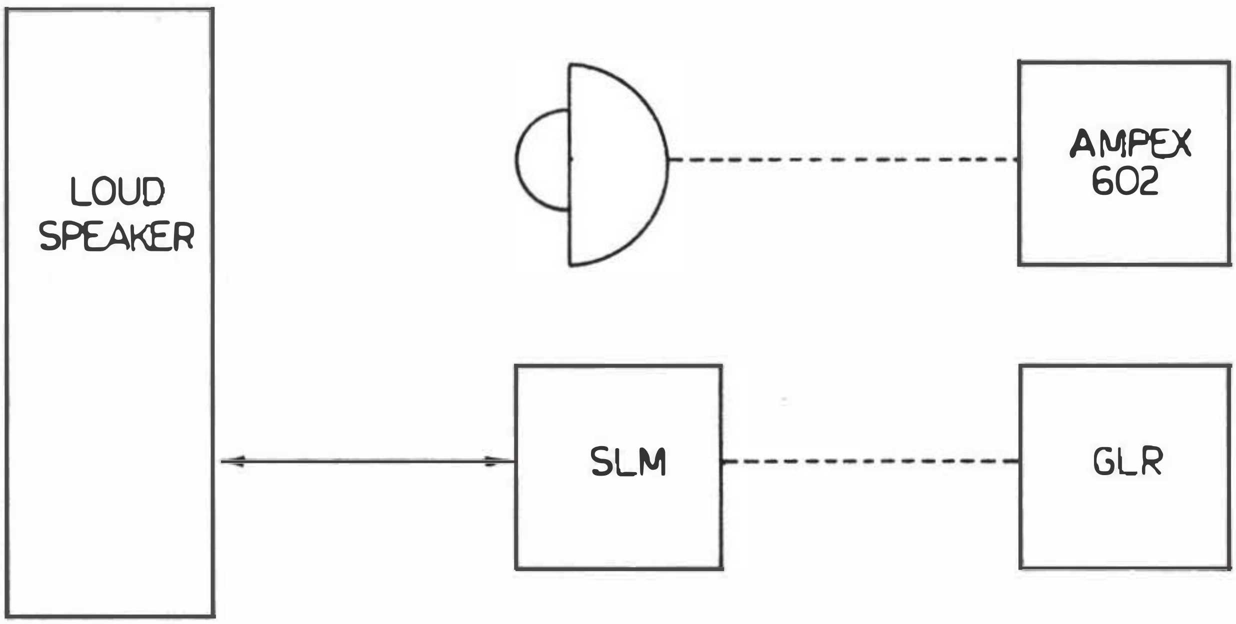
Before and after transportation to the sound field, the SLM batteries were checked according to the operating manual (13). Upon arrival in the testing environment, the sound level meter and graphic level recorder were calibrated according to the instructions in the manual (12).

In addition to the graphic record, a tape recording was made with an Astatic Model 77 Dynamic Cardioid Microphone that fed into a Model 602 Ampex Magnetic Tape Recorder. The frequency response range of the directional microphone was from 30 to 15000 Hz with slight emphasis (+3 dB) at 5000 Hz. Recordings were made at a tape speed of 7 1/2 ips. At this speed, the frequency response of the Ampex 602 was +2, -4 dB from 40 to 15,000 Hz. Data were stored on Scotch Brand Recording Tape, Number 111. The recording level was visually monitored before actual recording began to guard against distortion. The record level was held constant by adjusting the microphone record level switch and maintaining this

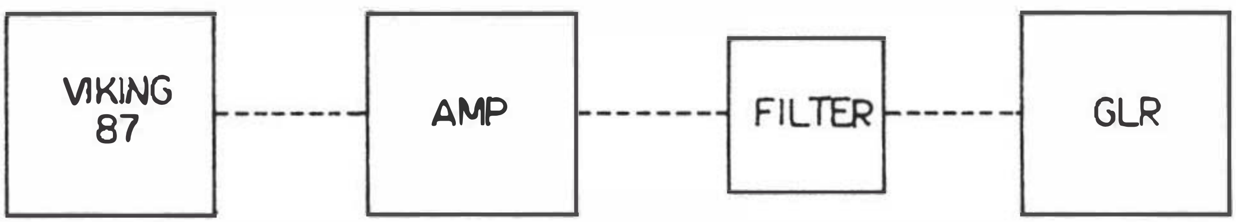
position throughout the entire recording session.

The SLM, microphone, and GLR were placed on a stand level with the loudspeaker on the left front of the stage. These instruments rested on rubber sheeting. Both microphones were twelve inches from the loudspeaker, and the Astatic was placed at a 90-degree angle to it. (Figure 3a) This distance was chosen to prevent the "baffle" effect caused by the movement of dancers between pick-up equipment and the loudspeaker. The particular loudspeaker was chosen because of availability of electrical outlets close to it, and because of its accessibility. The GLR was at a lower level of the stand since it was unnecessary for it to be in close proximity to the microphone. The tape recorder was positioned upright to the left of the stage and was closely monitored by an assistant to ensure that all switches were not disturbed. All instruments were turned on before the beginning of a song and remained functioning during breaks between songs so that they would remain synchronized. This was also done to identify the beginnings and endings of songs on both the level recorder and tape recorder. Therefore, both the tape recorder and the GLR received the same input signals simultaneously. A stop watch indicated elapsed time during each song so that estimates could be made regarding total record time.

The attenuator switch on the SLM, which indicated baseline, was adjusted when necessary due to a change in the input signal caused by the music. The chart paper on



a)



b)

Figure 3. Block diagram of the recording equipment used in the sound field (a), and equipment set-up for analysis in the sound conditioned room (b).

the GLR was also monitored by the investigator during recording to ensure correct paper movement, accurate tracings, and to avoid pen-pegging. Those tracings which were questionable due to pen pegging and/or paper wadding were not used, and all recording was halted. Recording was begun again during a break between songs to ensure that both recorders stored the same information. Song titles were written on the paper as a check for coordinating the two recorders' information; beginnings and endings of songs were marked for identification. All the songs that were analyzed were vocal.

Analysis of Data

The stored information was returned to an audiometric control room for analysis. The tape recording was played back on a Viking 87 Tape Transport at 7 1/2 ips, which had a playback frequency response of 25 to 20,000 Hz (±3 dB) at this speed. The system was built into a Model 15C Beltone Audiometer which was used as an amplification system for the original recording. Prior to the frequency analysis, the original tape was timed at 41 minutes, 9 seconds. (Table 1) Four of the original songs were deleted resulting in eleven songs for final analysis, five of which were sung by the female vocalist and six by the male. The eleven remaining songs were timed at 30 minutes and 35 seconds and were used for the final analysis.

Frequency analyses were performed with the Allison Model 25 Filter installed in a Beltone Model 15C Audiometer. The audiometer was connected with the GLR from a monitor

TABLE 1.

TAPE NUMBER, SONG NUMBER, VOCALIST, AND TIMING OF EACH RECORDED SONG

Tape No.	Song No.	Vocalist	Length Minutes-Seconds
1	1	Male	2-19
1	2	Male	2-39
1	3	Female	3-02
1	4	Female	2-38
1	5	Deleted	Deleted
1	6	Deleted	Deleted
1	7	Male	2-53
1	8	Female	3-22
1	9	Deleted	Deleted
2	10	Deleted	Deleted
2	11	Male	3-58
2	12	Male	2-34
2	13	Female	2-20
2	14	Male	2-33
2	15	Female	2-17
TOTALS		5 F, 6 M	30-35

jack into the input terminals of the recorder. (Figure 3b, p. 15) Speakers and earphones to the audiometer were disconnected so that the recording went through only the filter, audiometer, and GLR. The filter's insertion loss in the passband was calculated to be 1 dB.

After splicing the tape in order to delete the four unneeded songs, the researcher played the recording, unfiltered, on the Viking recorder through the audiometer into the GLR. This was done to ensure that the original graphic recording matched the form of the tape recording read-out taken in the sound field.

Thirty seconds of a 1000 Hz signal were added to the beginning of the magnetic tape to facilitate analysis. With the Astatic microphone placed in front of and level with a loudspeaker in an audiometric sound room, together with an H. H. Scott 450 Sound Level Meter, the tonal signal was adjusted to 100 dB sound pressure level. This was monitored with the SLM placed next to and at the same level with the Astatic microphone. The signal was then recorded on unused Scotch Brand Magnetic Tape, Number 111, on the original Ampex tape recorder and was spliced on the original tape recording.

The musical recording was filtered eight times, each with a different octave bandpass. The octave-bands were: 75-150, 150-300, 300-600, 600-1200, 1200-2400, 2400-4800, 4800-9600, 9600-19200 Hz. Graphic level recording traces were thus available for the thirty minutes of music for each of the eight bands. Thirty minutes of the unfiltered

version taken upon return from the sound field were also available.

Since the intensity levels of the original unfiltered version were already-known--the baseline was marked on the chart paper during collection--the pure tone was adjusted mechanically through the attenuator dial on the audiometer (Chan 2) until it showed on the chart paper at the proper point. By counting divisions from the established baseline, the level of the calibration pure tone could be determined. It was found to be 129 dB plus the filter's insertion loss of 1 dB added. From this point, each octave-band analysis baseline could be determined by subtracting the number of divisions from the signal tracing to the baseline. Before each analysis, the pure tone was positioned on the paper such that both musical tracing and pure tone could be seen. As the signal was being positioned, the filter was not functioning. Positioning of the signal was of importance to ensure that the writing pen did not peg on either the base or upper limits of the paper. After the signal was recorded for each of the eight octave-bands, the filter was turned on, and the filtered results were traced on the chart paper relative to the pure tone tracing. This procedure was continued throughout the eight band analyses.

All graphic recording was monitored acoustically through the audiometer monitoring system and visually by observation of the chart paper. The attenuator dial of Chan 2 of the audiometer was kept constant through each of the

eight filtered segments. Writing speed, paper speed, and input attenuation were the same as in the original recording taken in the sound field.

Each filtered version was then analyzed for intensity level. One hundred equally-spaced readings were taken every thirtieth division of the octave-band reading for each of the eight half-hour graphs. A total of 500 readings resulted for the entire spectrum analysis. In terms of time, every thirtieth division corresponded to a reading taken from a sound level meter every eighteen seconds during the one-half hour of continuous music.

Finally, the tape recording was visually monitored with a Tektronix Type 565 Cathode Ray Oscilloscope, Type 2A60 Plug In. The Viking transport reproduced the recording through the audiometer to the oscilloscope. Peak-clipping, as defined by Beam (1), was apparent in a short section of only one of the eleven songs analyzed and was not considered to be influential in the final results.

CHAPTER IV

RESULTS AND DISCUSSION

The intensity readings of each of the eight filtered segments obtained during the frequency analysis were analyzed and means, standard deviations, and variances computed. The original recording taken in the sound field and the unfiltered version were compared statistically by means of a "Student" *t*-test to determine the significance of the difference between mean intensity levels. These measures then served as methods of comparison among the octave-bands.

This chapter will be concerned with the presentation of these data, the statistical analyses of the data, and a discussion of the results.

A "Student" *t*-test, as described by Ferguson (3), was employed to test the difference between the means of the intensity levels taken for the unfiltered and the original versions. An analysis of variance was applied to determine the overall, between and within groups variance of the intensity levels among the five bandwidths. Interpretations of the data based on inspection of graphic displays are also presented.

Results of the Original and Unfiltered Tapes

Examination of the unfiltered data taken upon return from the sound field revealed a GLR tracing which was slightly

different in form and pen sweep from the original version. Identical points in time disagreed in intensity level, and time-varying points differed in pen sweep. (Examples of the read-outs may be seen in Appendix B). This may have been due to one or a combination of the following: 1) incongruity in microphone frequency response characteristics, 2) differences in the record and playback characteristics of the two tape recorders, and 3) differences in directional and nondirectional microphone characteristics. Because of these differences, the following analysis was made.

One-hundred intensity readings from each of the two versions were taken. The original version (sound field) yielded a mean of 119.460 dB and a standard deviation of 4.774 dB; the unfiltered version resulted in a mean of 120.250 dB and a standard deviation of 5.857 dB. However, a statistical _t_-test indicated no significant difference between the two. The results are presented in Table 2. Therefore, it was assumed that the tape recording could be played back on the Viking transport without its affecting the GLR intensity tracings differently from the Ampex and that the two recordings were comparable. It should be realized that the Ampex would have been utilized for playback had it not been necessary to have an amplifier between the recorder and GLR. For practical reasons, the Viking was chosen since it was built directly into the audiometer and amplification system.

TABLE 2.

SUMMARY OF t-TEST FOR TESTING THE SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS FOR THE UNFILTERED VERSION AND THE ORIGINAL RECORDING

Analysis	Original (Sound Field)	Unfiltered (Sound Room)
No. of Raw Scores	100	100
Mean	119.460	120.250
Standard Deviation	4.774	5.857
Sum of Values	11946.000	12025.000
Sum of Squared Values	1429348.000	1449437.000

t-score - .995*

* Not Significant at the .05 Level.

Analysis of the Eight Octave-Bands

Ideally, every thirtieth division on the graph paper for each of the eight filtered octave-bands should have represented the exact same point in time, and, therefore, the mean intensities would have summated to equal the overall intensity of 120.250 dB. However, due to slight variations in paper speed and/or tape speed inherent in the equipment, these points did not occur at the same time. Further, tracings which were between divisions were taken as whole divisions, according to the direction of the pen sweep, which introduced a small but consistent error. Nevertheless, addition of means in octave-bands summated to approximate the overall mean intensity.

Analyses of the eight octave-bands resulted in five which contained intensity above 80 dB. These bands included frequencies from 150 to 4800 Hz. The octave-bands of 75-150, 4800-9600, and 9600-19,200 Hz contained negligible or no intensity. Furthermore, it would have been impossible to have found intensity above 15,000 Hz in the 9600-19,200 Hz band since the frequency response characteristics of the Astatic were limited in this area. Readings in each octave-band were then analyzed for mean intensity level and standard deviation. Table 3 summarizes the results obtained for these five filtered segments of the original; Figure 4 provides a graphic display of intensity variance among the bands.

Inspection of Table 3 reveals that the smallest difference between any two means was approximately 3 dB and

TABLE 3.

SUMMARY OF MEAN AND STANDARD DEVIATION ANALYSIS OF ONE HUNDRED INTENSITY READINGS IN EACH OF FIVE OCTAVE-BANDS

Octave	N	Mean (dB)	S.D.	Sum of Values	Sum of Squared Values
150-300	100	96.130	4.837	9613.00	926437.0
300-600	100	110.230	6.459	11023.00	1219237.0
600-1200	100	114.500	7.810	11450.00	1317124.0
1200-2400	100	107.900	8.059	10790.00	1170736.0
2400-4800	100	102.110	6.735	10211.00	1047249.0

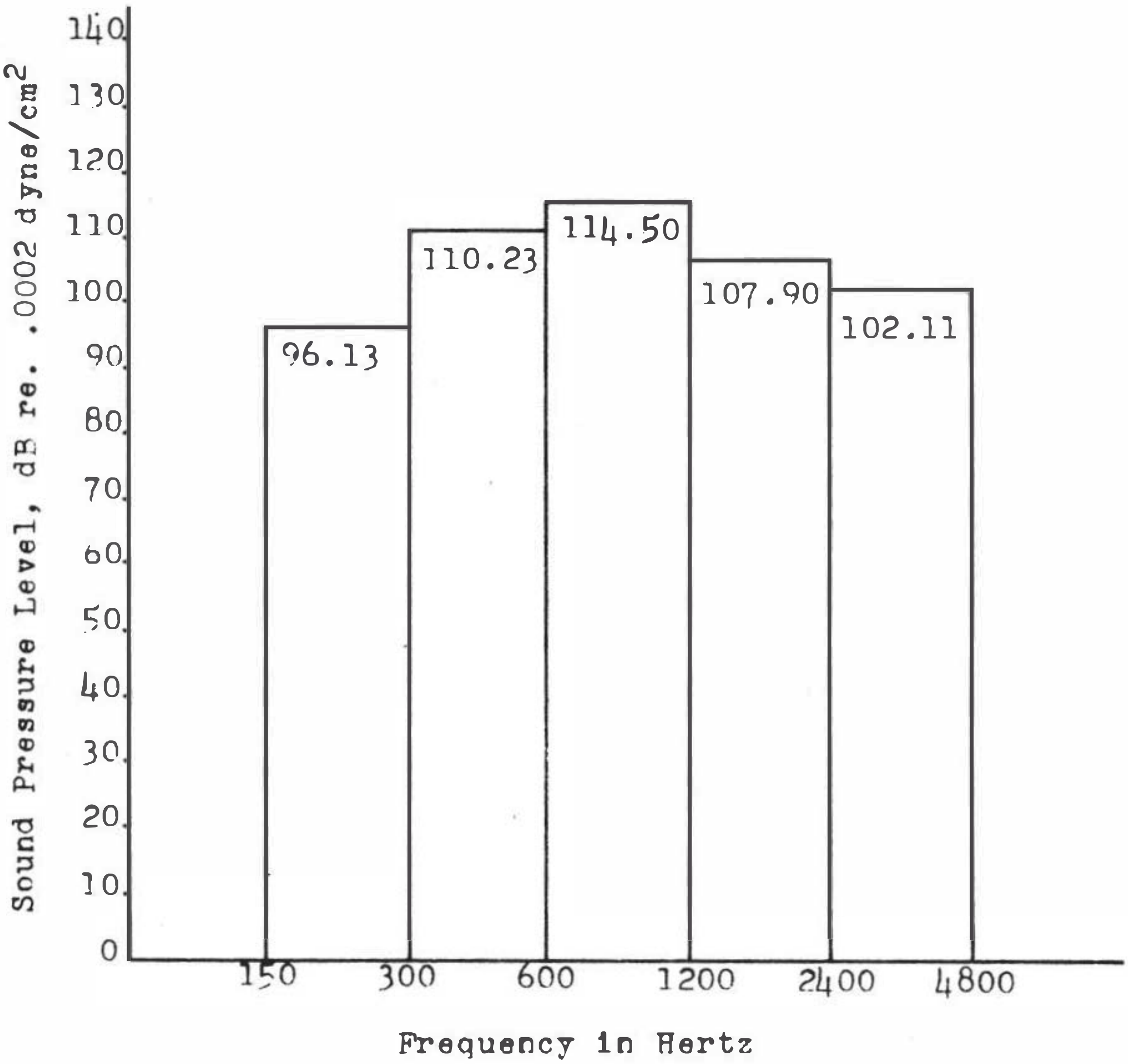


Figure 4. Graphic presentation of the mean intensity level in each of the five octave-bands from 150-4800 Hz. The mean intensity levels for each band is inserted near the top of each octave-band area for clarity.

that the largest difference was 18 dB. Also noteworthy are the relatively small standard deviations found for each of the octave-bands, the lowest being 4.837 dB for 150-300 Hz, and the highest being 8.059 dB for 1200-2400 Hz. The values suggested that the music was generally stable in intensity level throughout the performance and would seem important because it supported the classification of music as steady sound. Kryter *et al.*, (9, p. 452) describe steady sound and noise as follows:

> . . . sound that remains steady over at least several seconds as would be required for measurement of overall level with a typical sound-level meter. By "noise" is meant that the spectrum of the sound is complex, i.e., does not consist of merely a single or even several pure tones. This definition allows for intermittent exposures to steady sound, but is intended to exclude short bursts of sound that reach a maximum and sound-pressure level and then decline in level within less than 1 or 2 seconds.

The preceding definition is especially appropriate since it defines the term "noise" in contrast to Harris' (7) definition of noise as "unwanted sound". Obviously, there is a population of young people for whom the latter definition does not hold, even though the effects of music might be similar to those of noise. Nevertheless, of importance in this study was whether the band members "break" between songs to discuss the next presentation, or if they had a definite schedule of songs which permitted them to go from the end of one directly into the beginning of another. These pauses should be recognized and analyzed since they might be related to recovery of temporary threshold shift. Differences in bands in terms of pauses between songs might

result in differences of aural insult risk. In this study, the members did utilize a break between songs for discussion of following presentations. There is extensive literature on damage risk criteria for steady-state and intermittent noise (2, 6, 8, 9, 17, 19). However, since disagreements do exist concerning safe exposure limits, the results of the present intensity analyses were not interpreted in relation to these criteria.

Results of Analysis of Variance

An analysis of variance was employed to determine the significant sources of variance for the five octave-bands. The results are presented in Table 4. It can be seen from inspection of the table that there is less than one chance in 100 that the disparity between the calculated variances is due to chance for all comparisons excepting 300-600 and 1200-2400 Hz. For this source of comparison, the probability is less than five chances in 100 that the difference is due to chance. Thus, it would seem that if one were to survey intensity levels for a spectrum analysis, each of these octave bands would be important and should be analyzed. It would be of importance to know intensity occurring within a band if any statements were to be made regarding aural damage risk.

General Discussion

It is quite important for the reader to understand that results of this study are not to be generalized to other

TABLE 4.

SUMMARY OF BETWEEN AND WITHIN GROUP ANALYSIS OF VARIANCE AMONG THE FIVE OCTAVE-BANDS

Source	df	Sum of Squares	Mean Squares	F Ratio
150-300 300-600	199	16451.52	82.671	302.290 *
150-300 600-1200	199	25311.155	127.192	395.909 *
150-300 1200-2400	199	15760.955	79.201	155.243 *
150-300 2400-4800	199	8731.120	43.875	50.990 *
300-600 600-1200	199	11182.355	56.193	17.575 *
300-600 1200-2400	199	10938.155	54.966	5.039 **
300-600 2400-4800	199	12072.220	60.664	74.383 *
600-1200 1200-2400	199	14772.000	74.231	34.242 *
600-1200 2400-4800	199	18378.395	92.354	141.999 *
1200-2400 2400-4800	199	12774.995	64.196	29.903 *
-ALL-	499	44323.862	88.825	107.601 *

* An F of 6.81; 1 and 200 df is required at 1% level.
** An F of 3.91; 1 and 200 df is required at 5% level.

musical groups. Too many of the previously discussed variables are uncontrolled. For example, number and type of band instruments, room characteristics, background noise level, method of presentation, type of musical presentation, break time, etc., all interact and are unique to this study.

Similarly, the reader should avoid assuming that because a mean intensity was highest in a particular frequency band, that this is the band of greatest importance. This is not necessarily a correct assumption because the hearing mechanism responds differently to the same absolute level in different octave-bands. For example, even though the highest mean intensity may be found in bandwidth X, the ear may be able to tolerate this intensity with little effect; however, a lower level in bandwidth Y may be potentially more hazardous than that found in X.

Thus, the graphic illustration of mean intensity levels should be studied according to specific distribution among bandwidths. For the five octave-bands, it is noteworthy that all mean intensities were above 95 dB SPL which is the exposure limit beyond which ear protection is required according to Ward *et al.* (19). Finally, the time characteristics are important insofar as breaks occurring between songs permit a recovery period if the ear is being exposed to too high levels. Length of the breaks varies and, as pointed out earlier, may not occur. Recovery time for the ear must be a controlled variable in research of this type.

This chapter has presented the results of the intensity

and frequency analyses in terms of statistics, subjective observation, and graphical and tabular presentations. The following chapter will provide a summary of the study and suggestions for future research and researchers.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study was designed to investigate the intensity and frequency composition of a sample of modern-day "rhythm-blues" music. The descriptive investigation was done during an actual performance of a local professional seven member musical group at a college dance. The research was also done to determine procedure, problems, and methods of analysis for future reference.

Two microphones were placed twelve inches from a loudspeaker; one fed a magnetic tape recorder which stored thirty minutes of continuous music. The other fed into a sound level meter connected to a graphic level recorder which provided a graphic representation of intensity levels. In addition, background noise caused by reverberation and audience noise was also recorded, which, in final form, yielded information concerning the actual intensity occurring at that point in the particular situation.

The data were returned to a sound conditioned room for analysis and played back from a tape transport through an amplifier and filter to a graphic level recorder. Eleven songs were each filtered in octave-band steps, which resulted in one hundred intensity readings from each of the five

octave-bands. Statistical analyses of these data were carried out by means of analysis of variance, arithmetic means, standard deviations, and a "Student" *t*-test. In addition, graphic and tabular displays of the data were utilized in the interpretation of the results.

Also included in the study was a description of the musical instruments, musical group, room characteristics, and performance.

The results of the statistical analyses and interpretation of the graphic displays support the following:

1) Significant frequency composition ranged from 150 Hz to 4800 Hz. Negligible intensity existed below and above these limits.
2) For this particular musical group in this specific setting, a mean overall intensity of 120.25 dB (re. .0002 dynes/sq.cm.) with a standard deviation of 5.86 dB was found.
3) Mean intensity level in each of the five octave-bands was significantly different from all others at at least the .05 level of confidence.
4) Standard deviations were relatively small for each octave-band which may indicate a categorization of the music as steady sound.
5) The frequency band from 600-1200 Hz contained the greatest amount of intensity (114.5 dB) and 150-300 Hz contained the least amount (96.1 dB).

During the course of this study, several considerations were suggested as to procedure and analysis:

1) Magnetic tape recording of a known pure tone intensity previous to and following the actual collection of data would facilitate analysis, alleviate data gathering, and offer protection from intensity exposure to the investigator. This could be done by placing a pure tone of at least 110 dB at the beginning of the tape, taping all dials in the exact position of signal recording and collecting data. Without adjusting the dials, a repetition of the pure tone recording at the end of the tape would ensure that dials had not been disturbed.

2) The data should be filtered, but not the pure tone, through an octave-band filter into a graphic level recorder. The intensity levels could then be determined relative to the pure tone tracing.

3) In order to obtain a more accurate analysis, microphones of the same model should be placed at points which would allow pick-up of more instrumentation and vocalists' output.

4) If the study were to be one of hearing damage risk, collection should be done at ear level within the actual area of dancing of the audience.

5) The situation should be fully described as to room characteristics, type of instrumentation, pick-up equipment, and musical presentation.

Several possibilities for future research have presented

themselves during the investigation. Some of these are:

1) A survey of hearing loss incidence in the population of musicians performing in modern-day musical groups. In addition, a study of average length of exposure time on a mass scale, which could be done through daily records kept by the musicians.
2) Further study of intensity levels reached during "live" performances by these bands. This should be done on a large population to allow generalization.
3) Concurrent with number two, frequency analyses of the output of the music to study intensity distribution should be done.
4) Studies relating results of the above to some type of damage risk criterion to estimate period of safe exposure and possible protective steps.
5) Studies of intensity and frequency, as was done in the present study, with the addition of analyzing time pauses between songs for auditory recovery. This may be of importance in relation to recovery period of temporary threshold shift, as defined by Ward (18).
6) Longitudinal study of a mass number of musicians from the beginning of their careers with reference audiograms and regular hearing evaluations kept.

Certain limitations of this study should be recognized:

1) Generalization of conclusions and implications to other musical groups should be avoided, since only one band was described and investigated.
2) Because of the limits stated in number one, it would be unwise to adapt conclusions to any damage risk criteria.
3) The method of collecting data could be improved, thus providing more accurate results.

Finally, the upsurge of interest concerning modern-day musical groups and aural damage possibility would seem to be warranted. Perhaps through this interest, future research studies will be initiated which, hopefully, will dispel or support the notion of auditory damage risk resulting from exposure to musical intensity levels.

APPENDIX A

INTENSITY READINGS AND RESULTS OF STATISTICAL ANALYSES OF OCTAVE-BANDS, 150 TO 4800 Hz

TABLE 5.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY READINGS OF ORIGINAL VERSION TAKEN IN SOUND FIELD

Mean: 119.460 dB
Standard Deviation: 4.774 dB
Sum of Values: 11946.000
Sum of Squared Values: 1429348.000
Number: 100

+1 STD.DEV.	0 STD.DEV.		-1 STD.DEV.	-2 STD.DEV.
127	124	120	114	106
126	124	120	114	104
126	124	120	113	
126	124	120	113	
126	123	120	113	
126	123	120	113	
125	123	120	113	
125	123	119	113	
125	123	119	112	
125	123	119	112	
125	123	119	112	
125	123	119	112	
125	122	119	111	
125	122	119	110	
125	122	118	110	
125	122	118		
125	122	118		
	122	118		
	122	118		
	122	118		
	122	118		
	122	117		
	121	117		
	121	117		
	121	117		
	121	116		
	121	115		
	121	115		
	121	115		
	121	115		
	121	115		
	121	115		
	121	115		

TABLE 6.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY READINGS OF UNFILTERED VERSION TAKEN IN SOUND ROOM

Mean: 120.250 dB
Standard Deviation: 5.857 dB
Sum of Values: 12025.000
Sum of Squared Values: 1449437.000
Number: 100

+1 STD.DEV.	0 STD.DEV.		-1 STD.DEV.	-2 STD.DEV.
129	126	122	114	108
129	126	122	114	108
129	126	121	113	103
128	126	121	113	101
128	126	121	113	
128	126	121	113	
128	125	121	112	
128	125	121	112	
128	125	121	112	
127	125	121	112	
127	125	120	112	
127	125	120	111	
	124	120	109	
	124	119		
	124	119		
	124	119		
	124	119		
	124	118		
	124	118		
	124	117		
	124	117		
	124	117		
	124	117		
	124	117		
	124	117		
	124	117		
	123	116		
	123	116		
	123	116		
	123	116		
	123	115		
	122	115		
	122	115		
	122	115		
	122	115		
	122			

TABLE 7.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY LEVELS FOR 150-300 HZ OCTAVE-BAND

Mean: 96.130 dB
Standard Deviation: 4.837 dB
Sum of Values: 9613.000
Sum of Squared Values: 926437.0

+2 STD.DEV. +1 STD.DEV. 0 STD.DEV. -1 STD.DEV. -2 STD.DEV.

108	105	100	96	91	86
106	105	100	96	91	86
106	103	100	96	91	84
	103	100	96	90	
	103	100	96	90	
	103	100	95	90	
	103	100	95	90	
	102	100	95	90	
	102	100	95	89	
	102	99	95	89	
	102	99	95	89	
	101	99	95	89	
	101	99	95	89	
		99	95	88	
		99	95	87	
		99	95		
		99	95		
		98	95		
		98	95		
		98	94		
		98	94		
		98	94		
		98	94		
		98	94		
		97	93		
		97	93		
		97	93		
		97	92		
		97	92		
		97	92		
		96	92		
		96	92		
		96	92		

TABLE 8.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY LEVELS FOR 300-600 HZ OCTAVE-BAND

Mean: 110.230 dB
Standard Deviation: 6.459 dB
Sum of Values: 11023.00
Sum of Squared Values: 1219237.0

+2 STD.DEV.	+1 STD.DEV.	0 STD.DEV.		-1 STD.DEV.	-2 STD.DEV.
124	121	116	111	103	95
124	121	116	111	103	95
	121	116	111	102	95
	120	116	111	102	
	120	116	111	102	
	120	115	110	101	
	119	115	110	101	
	119	115	110	101	
	118	115	110	100	
	117	115	110	100	
	117	114	109	99	
	117	114	109	99	
	117	114	109	99	
	117	114	109		
		114	109		
		114	109		
		113	108		
		113	108		
		113	107		
		113	107		
		113	106		
		112	106		
		112	106		
		112	106		
		112	106		
		112	105		
		112	105		
		112	105		
		112	105		
		111	104		
		111	104		
		111	104		
		111	104		
		111	104		

TABLE 9.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY LEVELS FOR 600-1200 HZ OCTAVE-BAND

Mean: 114.500 dB
Standard Deviation: 7.810 dB
Sum of Values: 11450.0
Sum of Squared Values: 1317124.0

+1 STD.DEV.	0 STD.DEV.		-1 STD.DEV.	-2 STD.DEV.
130	122	113	106	98
129	122	113	106	
128	121	113	106	
128	121	113	105	
127	121	113	105	
126	120	113	105	
126	120	112	105	
126	120	112	105	
126	120	112	105	
125	120	112	103	
125	120	112	103	
125	120	111	102	
125	119	111	102	
125	119	111	100	
124	119	110	99	
124	119	110	99	
123	118	110		
123	118	110		
123	118	110		
	118	110		
	117	109		
	117	109		
	117	108		
	116	108		
	116	108		
	116	108		
	116	108		
	115	108		
	115	107		
	115	107		
	114	107		
	114	107		

TABLE 10.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY LEVELS FOR 1200-2400 HZ OCTAVE-BAND

Mean: 107.900 dB
Standard Deviation: 8.059 dB
Sum of Values: 10790.0
Sum of Squared Values: 1170736.0

+1 STD.DEV.	0 STD.DEV.		-1 STD.DEV.	-2 STD.DEV.
124	115	109	98	91
121	115	108	98	91
121	115	108	98	90
120	115	108	97	90
120	114	108	97	90
119	114	108	96	
119	114	107	96	
119	114	107	95	
119	113	107	95	
118	113	107	94	
117	113	107	94	
117	113	107	93	
117	113	106		
117	113	106		
117	113	106		
116	113	106		
	113	106		
	113	105		
	112	105		
	112	105		
	112	105		
	112	104		
	112	104		
	112	104		
	111	104		
	111	104		
	111	102		
	111	102		
	110	102		
	110	101		
	109	100		
	109	100		
	109	100		
	109			

TABLE 11.

MEAN, STANDARD DEVIATION, AND RAW INTENSITY LEVELS FOR
2400-4800 HZ OCTAVE-BAND

Mean: 102.110 dB
Standard Deviation: 6.785 dB
Sum of Values: 10211.00
Sum of Squared Values: 1047249.0

+2 STD.DEV.	+1 STD.DEV.	0 STD.DEV.		-1 STD.DEV.
116	114	108	103	95
116	113	108	103	94
	113	108	103	94
	111	107	103	94
	111	107	103	93
	111	107	102	93
	110	107	102	92
	110	107	102	92
	110	107	102	91
	110	107	102	90
	110	107	102	90
	109	107	102	90
	109	106	102	90
	109	106	101	90
	109	106	100	90
		106	100	90
		106	100	90
		106	99	90
		106	99	90
		106	99	
		105	98	
		105	98	
		105	97	
		105	97	
		105	97	
		105	97	
		105	97	
		104	97	
		104	97	
		104	96	
		104	96	
		104	96	

TABLE 12.

ANALYSIS OF VARIANCE OF 150-4800 HERTZ

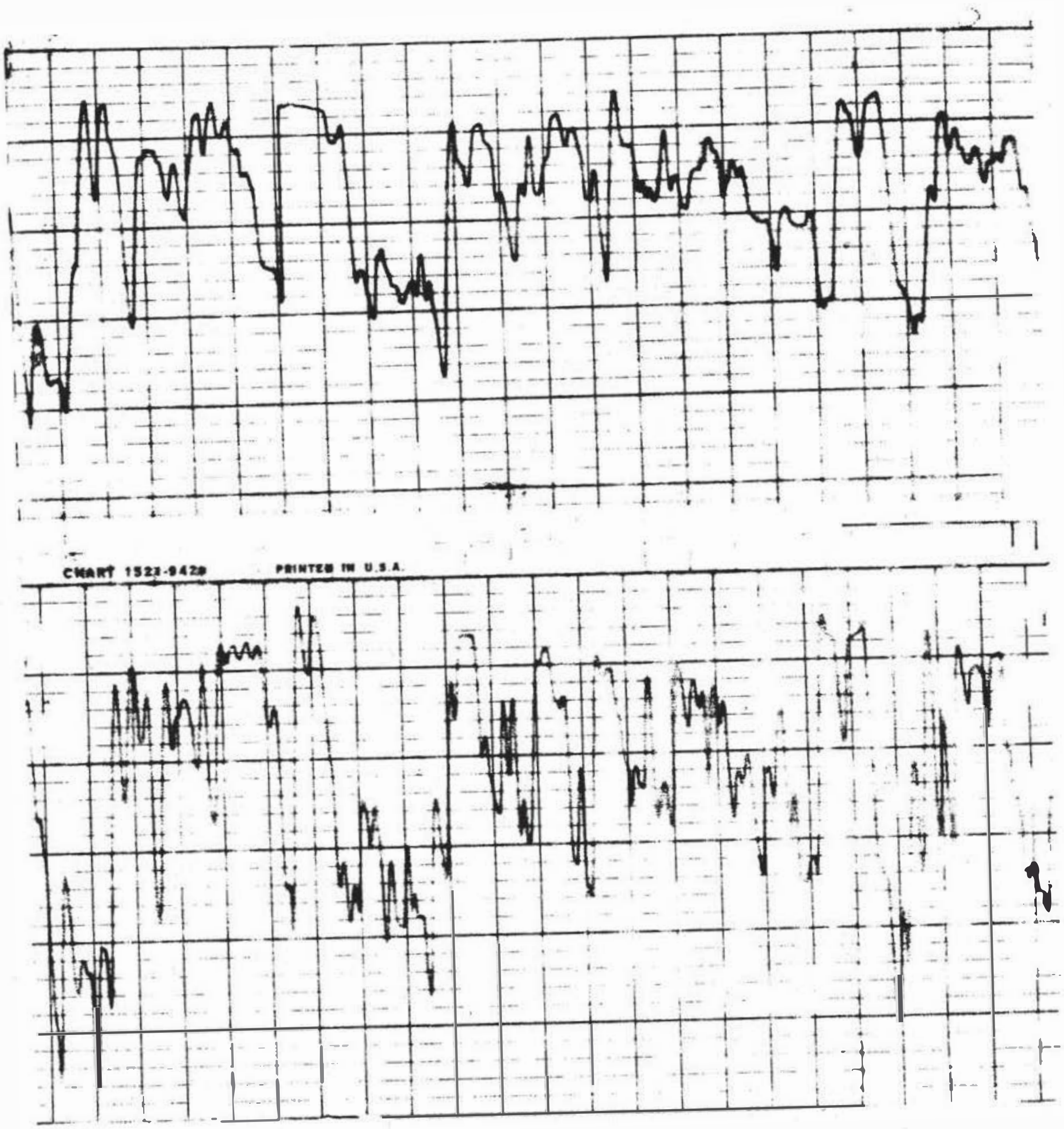
Octave Comparison	Source of Variation	Sum of Squares	df		Mean Squares
150-300 / 300-600	Between	9940.500	1		9940.500
	Within	6511.020	198		32.884
	TOTALS	16451.520	199		82.671
				F RATIO	302.290
150-300 / 600-1200	Between	16872.845	1		16872.845
	Within	8438.310	198		42.618
	TOTALS	25311.155	199		127.192
				F RATIO	395.909
150-300 / 1200-2400	Between	6926.645	1		6926.645
	Within	8834.310	198		44.618
	TOTALS	15760.955	199		79.201
				F RATIO	155.243
300-600 / 600-1200	Between	911.645	1		911.645
	Within	10270.710	198		51.872
	TOTALS	11182.355	199		56.193
				F RATIO	17.575
300-600 / 1200-2400	Between	271.445	1		271.445
	Within	10666.710	198		53.872
	TOTALS	10938.155	199		54.966
				F RATIO	5.039
300-600 / 2400-4800	Between	3296.720	1		3296.720
	Within	8775.500	198		44.321
	TOTALS	12072.220	199		60.664
				F RATIO	74.383
600-1200 / 1200-2400	Between	2178.000	1		2178.000
	Within	12594.000	198		63.606
	TOTALS	14772.000	199		74.231
				F RATIO	34.242
600-1200 / 2400-4800	Between	7675.605	1		7675.605
	Within	10702.790	198		54.054
	TOTALS	18378.395	199		92.354
				F RATIO	141.999
1200-2400 / 2400-4800	Between	1676.205	1		1676.205
	Within	11098.790	198		56.054
	TOTALS	12774.995	199		64.196
				F RATIO	29.903

TABLE 12. -- Continued

Octave Comparison	Source of Variation	Sum of Squares	df	Mean Squares
-ALL-	Between	20615.052	4	5153.763
	Within	23708.810	495	47.897
	TOTALS	44323.862	499	88.825
			F RATIO	107.601

APPENDIX B

SAMPLES OF GRAPHIC TRACINGS FOR ORIGINAL AND UNFILTERED VERSIONS



a)

b)

Figure 5. Examples of GLR tracing of the original version (a) taken in the sound field and the unfiltered version taken in the sound room (b).

BIBLIOGRAPHY

1. Beam, Robert E. (ed.), A Dictionary of Electronic Terms, Allied Radio, Chicago, 1967, 13.

2. Botsford, James H., "A Simple Method for Identifying Acceptable Noise Exposures," Journal of the Acoustical Society of A erica, 42, 1967, 810-819.

3. Ferguson, George A., Statistical Analysis in Psychology and Education, McGraw-Hill Book Company, Inc., New York, 1959, 125-126.

4. "Find Big Beat Is Bad Scene For U. S. Teens," Chicago Daily Tribune, January 13, 1968.

5. Glorig, Aram, Personal Communication, 1968.

6. Glorig, Aram, W. Dixon Ward, and J. Nixon, "Damage Risk Criteria and Noise Induced Hearing Loss," Archives of Otolaryngology, 74, 1961, 413-423. (Also In The Control of Noise, NPS Symp., 12, Her Majesty's Stationary Office London, 1962, Paper No. E-2).

7. Harris, Cyril, Handbook of Noise Measurement, McGraw-Hill Book Company, New York, 1967, 1-1.

8. Jones, Allen R., and F. W. Church, "A Criterion for Evaluation of Noise Exposures," Reprint from American Industrial Hygiene Association Journal, 21, 1960, 481-485.

9. Kryter, K. D., W. Dixon Ward, Ja es D. Miller, and Donald Eldredge, "Hazardous Exposure to Intermittent and Steady-State Noise," Journal of the Acoustical Society of America, 39, 1966, 451-464.

10. Leggert, R. F., and T. D. Northwood, "Noise Surveys of Cocktail Parties," Journal of the Acoustical Society of America, 32, 1960, 16-18.

11. MacLean, William R., "On the Acoustics of Cocktail Parties," Journal of the Acoustical Society of America, 31, 1959, 79-80.

12. Operating Manual, Type 1521-A Graphic Level Recorder, General Radio Company, West Concord, Massachusetts, Form 1521-0110-E, October, 1963, 23.

13. Operating Manual, Type 1551-C Sound Level Meter, General Radio Company, West Concord, Massachusetts, Form 1551-0110-0, January, 1964, 3-4.

14. Rieber, R. W., and R. S. Brubaker (eds.), Speech Pathology, J. B. Lippincott Company, Philadelphia, 1966, 198.

15. Silverman, S. Richard, and Halowell Davis, Hearing and Deafness, Holt, Rinehart, and Winston, Inc., New York, 1963.

16. Sorensen, Neil, "Pressure Level Ranges of Various Musical Instruments and the Effects of Different Rooms on These Instruments," Journal of the Acoustical Society of America, 26, 1954, 933.

17. von Gierke, Henry E., "On Noise and Vibration Exposure Criteria," Archives of Environmental Health, 11, 1965, 327-339.

18. Ward, W. Dixon, "Auditory Fatigue and Masking," in Modern Developments in Audiology, Academic Press, New York, 1963, 253.

19. Ward, W. Dixon, Aram Glorig, and Diane Sklar, "TTS From Octave-Band Noise: Applications to Damage Risk Criteria," Journal of the Acoustical Society of America, 31, 1959, 522-528.