

CONTROL OF THE ACOUSTICAL AND VISUAL  
CONCEPTS IN EDUCATION

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## TABLE OF CONTENTS

	Page
ABSTRACT . . . . .	iii
Chapter	
I. INTRODUCTION . . . . .	1
STATEMENT OF THE PROBLEM . . . . .	2
IMPORTANCE OF THE STUDY. . . . .	2
LIMITATIONS OF THE PROBLEM . . . . .	4
DEFINITION OF TERMS. . . . .	4
II. REVIEW OF THE LITERATURE. . . . .	7
III. DISCUSSION OF RESEARCH. . . . .	18
IV. SUMMARY AND CONCLUSION . . . . .	40
SUMMARY. . . . .	40
CONCLUSION . . . . .	44
V. RECOMMENDATIONS . . . . .	46
BIBLIOGRAPHY. . . . .	50
A. BOOKS . . . . .	51
B. PERIODICALS . . . . .	51
C. DISSERTATION ABSTRACTS . . . . .	52
APPENDIX A . . . . .	54
APPENDIX B . . . . .	57

APPENDIX C . . . . .	60
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APPENDIX D . . . . .	61
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## ABSTRACT

The purpose of this study had three general aims. First, in controlling the acoustical concepts in education, it was possible to show that auditory abilities and discrimination were enhanced because of better information transfer. Second, that visual discrimination and perception are key factors in the general subject of visual literacy. Third, the visual and auditory areas reinforce each other in many ways but work against each other in others.

This was a library research study. Current books, latest periodicals both in print and microfilmed, and Doctoral Abstracts were the chief sources in the chosen field. It was the desire of the writer to confine the results as being applied to normal school conditions, conditions that nearly all teachers would encounter in a normal teaching career.

It was found that auditory distractions of various kinds are detrimental to the learning process. One of these distractions, reverberation, is controlled by various construction and arrangement methods.

It was found that visual discrimination and visual perception were dependent upon the perceptual system of the individual. In the school room the proper amount and control of light will enhance the system.

The visual and the auditory areas reinforce each other in many ways but may work against each other. There is a tendency to favor one system over the other under certain conditions. Verbal coding may be supplemented or replaced by visual imagery. Effective visual design and presentation are functions of many interrelationships.

## CHAPTER I

### INTRODUCTION

One of the terms one reads about recently is "visual literacy". Some people are raising questions as to the actual meaning of the term. "Visual literacy" has become a catch-all phrase, with as many definitions as it has investigators. The term has been used to describe every conceivable aspect of comprehending the complex varieties of photographic subjects, art forms and drawings, actual forms of common subjects, and other objects that make possible the understanding of the everyday community. Most of the present research is concentrated on developing new visual stimuli and response situations which will minimize the present dependency upon verbal comprehension measures. Others are attempting to determine the degree of interaction between visual-verbal stimuli.

Verbal stimuli refers to sound and its application to communication and language. When children enter school, they speak the language of their communities. They are able to communicate with each other and their teachers and this is all through a sound medium. When learning to read and write, they must begin to learn a visible

symbol system for the language they speak. Also, as they continue, they will be learning symbol systems for mathematics, music, cartography, and all sciences; things that have made possible our civilization. In this context the concepts of literacy and symbolism are intermeshed in a combination of visual and verbal education.

There is a wealth of literature waiting to stimulate, tickle, caress, assail, comfort, and inspire the child's imagination, but only after learning to read will that imagination be liberated.

#### STATEMENT OF THE PROBLEM

This study had three general purposes. First, to show that by controlling the acoustical concepts in education, it is possible to enhance auditory abilities and auditory discrimination. Second, to show that visual discrimination and visual perception are key factors in the general subject of visual literacy. Third, to show that the visual and the auditory areas reinforce each other in many ways but may work against each other.

#### IMPORTANCE OF THE STUDY

The control of acoustics and visual concepts is a central purpose in all phases of education. The acoustical aspects are very closely related to the auditory abilities and auditory perception which greatly reinforce the input of information from visual channels. Today's child



is generally better informed visually and intellectually more skilled for two reasons. The first and probably most important would be the increased visual experiences that are provided; the second would be the methods of using the ears to enhance and enrich the inputs of the first.

Kingsbury pointed out the importance of communication in the classroom:

Any classroom with a teacher talking and a student listening (or vice versa) is a communication system. The three elements of this system are a source, a path, and a receiver. The source generates a signal which is transmitted along the path, with various distortions and losses, and is perceived by the receiver; and if communication is the goal, then hopefully it is received in a form and at a level adequate for recognition. This means there must be information available on the human voice, the transmission path (the room) and the human ear.<sup>1</sup>

Knirk in discussing acoustical and visual environments stated:

The importance of an appropriate visual environment for learning tasks cannot be overestimated. The visual environment affects a learner's ability to perceive visual stimuli and affects his mental attitude and thus performance.<sup>2</sup>

Many of the points that were discussed in this report were actually combinations of inputs of the two major perceptual systems, hearing and vision. The writer hoped to show the interdependence of the two systems and that sound presented in an equally effective manner will greatly enhance the visual sense.

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<sup>1</sup>H. F. Kingsbury, "Acoustics in a Changing Classroom," Educational Technology, 13:62-4, Mr '73

<sup>2</sup>Frederick G. Knirk, "Acoustical and Visual Environments Affect Learning," Audiovisual Instruction, 15:34-5, 0 '70

## LIMITATIONS OF THE PROBLEM

This was a library research study. A wide variety of sources were used with an emphasis on current literature. A large amount of this literature was from the Dissertation Abstracts from the period 1960 to 1974. In making the selections, an effort was made to limit the results to those of normal children or students; the studies regarding mentally impaired, auditorially impaired, or otherwise handicapped children was gathered but not included in this study. The writer attempted to restrict the data to normal school conditions; conditions that nearly all teachers would be expected to encounter in a normal teaching career.

## DEFINITION OF TERMS

Acoustics - the physics of sound.

Anechoic chamber - (or dead room) characterized by highly absorptive wedges or long pyramids mounted to the walls of the room to absorb all incident sound energy.

Array - to place in proper or desired order.

Concept - an idea of something formed by mentally combining all its characteristics or particulars.

Degree of Masking - for a given frequency, the decibel difference between background noises and the normal threshold of audibility.

Discrimination - the act of noting or observing a difference; distinguish accurately.

Echoing - sound that reaches a listener via two paths differing greatly in length produces an unpleasant fluttering effect.

Figure-Ground Perception - the ability to identify significant objects as distinct from a sometimes confusing moving background.

Grammar - the fundamental rules of any science, art, or subject.

Loudspeaker - an electroacoustic transducer which converts electrical energy to acoustical energy.

Masking - the shift of the threshold of hearing of the host sound due to the presence of the masking sound.

Microphone - an electroacoustic transducer which converts acoustical energy to electrical energy.

Noise, airborne - due to the fluctuations of air pressure about the mean atmospheric pressure.

Perception - a single unified awareness derived from sensory processes while a stimulus is present.

Reverberation - the persistence of sound in an enclosure as the result of continuous reflections of sound at the walls after the sound source has been turned off. It depends on the size and shape of the enclosure as well as the frequency of the sound.

Reverberation time - the time in seconds for the sound pressure

to decrease to ten to the minus six of its original value (or a sixty decibel drop) after the source is turned off.

Room flutter - occurs between a pair of parallel opposite walls that are smooth and highly reflective. The sound is reflected back and forth between the two to produce multiple echoes.

Sound articulation - the percentage of the total number of speech sounds correctly recorded and identified.

Speech - concerns the structure of the language and is characterized by the interpretative aspect, loudness, pitch, timbre, and tempo.

Pitch - the frequency of vibration of a pure tone.

Timbre - or tone quality may be described as the instantaneous cross section of the tone, i. e., in terms of the number, intensity, distribution and phase of the harmonics. Intensity of overtones can produce changes in timbre whose subjective behavior is much more complex than that of loudness or pitch.

Troffer - an inverted trough serving as a support and reflector for a fluorescent lighting unit.

## CHAPTER II

### REVIEW OF THE LITERATURE

Controlling visual and acoustical concepts to improve the learning environment is very important because it is estimated that over ninety percent of external knowledge enters by these two paths. In the following pages the writer will attempt to bring out many of the methods by which these two paths are used. As a result, educational methods using newly accepted practices are being put into effect.

The traditional view of the perceptual senses was that they were a system of passive receptors dormant until exposed to the particular kind of energy, mechanical force, or chemical substance to which the particular receptor responded. The modern view, due to research, is that some of the senses are active exploratory systems that seek out information from the environment and are highly selective in the information they pick up. These "senses" could better be described as perceptual systems.<sup>1</sup>

Goldstein made some interesting observations regarding perception:

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<sup>1</sup>Julian Hochberg, Perception, Englewood Cliffs, New Jersey, Prentice Hall, 1964

Perception involves a continuously active process of scanning, fixating, constructing scenes from parts of scenes, interpreting, and remembering. An observer who takes part in this active process can take in a large amount of information but the observer's capacity is limited by the constraints set by his perceptual apparatus. Our perceptual system demands that an object be fixated if it is to be seen in detail; thus, if the purpose of a presentation is to present detailed information, then time must be allowed for the observer to fixate every relevant image at least once. As manufacturers of multi-media equipment claim, projecting multiple images, may, in fact, present "the maximum amount of information in the minimum time." But we know there is no guarantee that all of this information will be processed and remembered by the observer unless adequate time is allowed for the requisite fixations. On the other hand, we know that once a picture receives only a few fixations it is very likely that the picture will be recognized later. The presentation should be slow enough to allow the necessary fixations, but, since our memory for pictures is excellent, overly long exposures are not necessary.<sup>2</sup>

For the purpose of this paper, most of the emphasis is placed on the active visual and auditory systems. While the eye is the primary organ of vision, the visual perceptual system includes a complex muscular arrangement that permits an optical search of the environment, somewhat like the use of a search light at night. Unlike vision, the reception of sound signals is not highly dependent upon the physical orientation of the receiver, although reception may be improved somewhat.<sup>3</sup>

The degree of success for people receiving audio information is much higher where reverberation is controlled. Reverberation has a

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<sup>2</sup>E. Bruce Goldstein, "The Perception of Multiple Images," Audiovisual Communications Review, 23:34-68, Summer '73.

<sup>3</sup>Julian Hochberg, Perception, Englewood Cliffs, New Jersey, Prentice Hall, 1964

marked influence in the understanding of speech at various distance between persons. There has been a great change in construction techniques in recent years based on classroom results. Architects, planners, and administrators have had to pay close attention to acoustical requirements. New techniques for controlling noise have been incorporated, such as the use of constrained-layer damping to control structure borne noise resulting from mechanical vibrations, the planting of trees or shrubbery or construction of walls along streets for traffic noises, and the use of various porous materials for walls and floors to control reverberations within the classroom.<sup>4</sup>

Caffarella defined reverberation and absorption as follows:

The acoustical conditions in a room which contribute to ease in listening are controlled by two concepts in acoustical theory--absorption and reverberation. Absorption is the ability of a given material to take in sound. Reverberation is the length of time a sound can be heard. The proper combination of absorption and reverberation make it acoustically conducive to the activity planned for that room.<sup>5</sup>

Kingsbury warned against ambient noise in the classroom:

The two most important criteria over which architects, engineers and educators have control are the noise present in the unoccupied classroom and the amount and placement of acoustical absorption. Of these two, by far the most important is the unoccupied (ambient) noise level. While this ambient noise is the result of many noises, it is usually dominated by the noise from

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<sup>4</sup>Ralph Clifton Morgan, "Acoustical Considerations for the Administrator in school planning," Dissertation Abstracts, 31:114A, 1969

<sup>5</sup>E. P. Caffarella, "Acoustics of Educational Facilities," Audiovisual Instruction, 18:10-11, D '73

the heating and ventilating equipment, although in urban locations, a significant addition can be from exterior traffic noise.<sup>6</sup>

Rettinger outlined several guidelines for the architectural engineers.

The exploitation of audiovisual media cannot be successful until the architectural designer of the new learning spaces has been made aware of the engineering criteria of hearing, seating, sightlines, picture brightness, picture distortion, etc. The architect and acoustician thus become involved in technical discussions that, at first, might appear to be outside their domain. But sound and sight of the modern media are so intimately connected that it becomes desirable for both of these designers to consider some of the technical aspects of front-screen and rear-screen projection of film, television reception by monitor and by projected image, lecture presentation by recorded tape, etc., for the efficient presentation of these services.<sup>7</sup>

The necessity and value of acoustical design is also outlined by Rettinger:

The acoustic design of most rooms is part of the means but not the end of the architectural design of a building if we except such specialized structures as recording studios, reverberation chambers, and sound stages. Acoustics is a servant to architecture, along with lighting, ventilation, sanitation, heating, etc. Nevertheless, acoustic planning involves visualization in three dimensions in such a way that the resultant composition is both efficient acoustically and expressive esthetically. It requires, therefore, creative ability of a special kind for the fullest development of the art and science that architectural acoustics is.<sup>8</sup>

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<sup>6</sup>H. F. Kingsbury, "Acoustics in a Changing Classroom," Educational Technology, 13:62-4, Mr '73

<sup>7</sup>Michael Rettinger, Acoustics; Room Design and Noise Control, Chemical Pub. Co., 1968

<sup>8</sup>Ibid



School auditory distractions adversely affect reading for general meaning and have similar effects on the performance of students of varying levels of mental ability. Certain conditions must be imposed where students are helped to learn by controlling ambient sounds. It was found that video-audio control, using ear phones for the audio part was effective for technical and science students but not for the academic students. The longer the student used the apparatus during study, the greater his learning gain.<sup>9</sup>

Many of the physiological and psychological effects of noise were investigated by Seto. He noted:

Noise interferes with work, sleep, and recreation. It also causes strain and fatigue, loss of appetite and indigestion, irritation and headache. High intensity noise has adverse cumulative effect on human hearing mechanism, producing temporary or permanent deafness. Psychologically, noise adversely affects the output of workers, decreases their efficiency and increases their ability to error because of distraction from work. Noise from machines causes wear and damage to the machines.<sup>10</sup>

Rettinger pointed out that noise is often a social problem:

A social problem is one that concerns human relationships, and noise is not unlike alcohol, drug addiction, and poverty in that it can cause discord, tension, illness, deafness, and legal action. Noise is more wide-spread and insidious. Noise as a social cause of disease is probably being underestimated today, in the face of hearing losses that are becoming more numerous and

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<sup>9</sup>Paul Edward Sumter, "Learning experiment: effectiveness of controlling environmental distractions," Dissertation Abstracts, 31:2818A, 1969

<sup>10</sup>William W. Seto, Acoustics, New York, McGraw-Hill, 1971

starting at an earlier age.<sup>11</sup>

One of the problems of slow learners or disadvantaged children is the auditory language used by their teachers for communication. Teachers need intensive training in linguistic fundamentals, the stages of language development, and the characteristics of the language or dialects spoken in their classrooms in implementing available resources. Then they must be given freedom to manipulate these variables in the matching of instruction to the children.<sup>12</sup>

Seto defined the sounds of speech:

Speech sounds are complex audible acoustic waves that provide the listeners with numerous clues. Speech concerns the structure of language and is characterized by the interpretative aspect, loudness, pitch, timbre, and tempo. Intelligibility of speech is an indication of how well speech is recognized and understood. This depends on acoustic power delivered during the speech, speech characteristics, hearing ability, and ambient noises.<sup>13</sup>

Rettinger considered three speech factors that are important to communication:

To cut through the maze of minute findings, we shall consider only three principal speech factors:

Digit communicability - This is generally very high, even

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<sup>11</sup>Michael Rettinger, Acoustics; Room Design and Noise Control, New York, Chemical Pub. Co., 1968

<sup>12</sup>Paulette Marlowe Alexander, "The development of auditory skills in young children: An interdisciplinary view," Dissertation Abstracts, 34:157A, 1973

<sup>13</sup>William W. Seto, Acoustics, New York, McGraw-Hill, 1971

when the signal-to-noise is low. It is probably due to the exclusiveness of number sounds.

Sentence communicability - This also ranks high on the ladder of intelligibility, chiefly because much meaning can be extracted from context, association, interrelation, etc.

Word communicability - This is the lowest form of communication, and for a satisfactory score requires a high signal-to-noise ratio, good hearing acuity, absence of speech defects and accents, ample motivation, elevated speech level, short reverberation in the room and slow enunciation. Fifty percent word communicability of "articulation" is required for intelligent conversation or sentence communicability. The intelligibility of words increases markedly with the number of syllables per word, duo-syllable words being almost twice as easily understood as monosyllables.<sup>14</sup>

The eye searches the world without stopping. Shapes would be a kaleidoscopic chaos unless corrections were made constantly to bring various points of interest into clear focus. The visual system seems to consist of a short term store with a capacity for sufficient information to recognize two complex symbols and a long-term store of effective unlimited capacity.<sup>15</sup>

Visual stimulation and interaction with one's environment play extremely important roles in perceptual development while at the same time processing the organizing information play is equally as important. The effective design and presentation of visual objects were

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<sup>14</sup>Michael Rettinger, Acoustics; Room Design and Noise Control, Chemical Pub. Co., 1968

<sup>15</sup>Dean Wallace Hoover, "The effect of method of material presentation upon eye movements and comprehension," Dissertation Abstracts, 34:1483A, 1973

found to be functions of many relationships.<sup>16</sup>

Franzwa pointed out the importance of meaningfulness:

Meaningfulness of materials to learners may vary within any given audiovisual presentation. Picture detail may range from simple line drawings to complex photographic reproductions. Presentation mode may consist of either the presentation of pictorial materials alone or the addition of verbal materials, visually or aurally, to the pictorial presentation.<sup>17</sup>

There seems to be no difference between male and female subjects in being able to distinguish between kinds of pictures. The more complicated an image the less impact first impressions made upon the individual. Higher academic achievement seems to increase the degree of perception. It has been found that persons with greater discrimination between pictorial images will also tend to think they see differences between identical images. The making of critical decisions about pictorial images is more stable for the individual than is the sensitivity to the pictorial images.<sup>18</sup> When materials were matched to the student's reading level both the insufficient and irrelevant information inhibited the subjects, but when pictures were added to all

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<sup>16</sup>Gerald Franklin McVey, "An analysis, synthesis, and application of selected research findings to visual design and presentation by the visual specialist," Dissertation Abstracts, 31:5274A, 1969

<sup>17</sup>R. D. Franzwa, "Influence of meaningfulness, picture detail, and presentation mode on visual retention," Audiovisual Communications Review, 21:209-23, Summer '73

<sup>18</sup>Leslie Drews Stroebe, "Discrimination of pictorial stimulus attributes," Dissertation Abstracts, 35:273A, 1974

three types of information there were no significant difference between the mean performance of students.<sup>19</sup>

While many studies point out significant differences across cultures in susceptibility to several geometric or optical illusions, it should be brought out that the differences are not based on factors of race. They are for the most part differences in experience. To a great extent humans must learn to perceive. The basic process of perception is the same for all mankind. Only the contents differ and only because they reflect different perceptual inference habits.<sup>20</sup>

While investigating the relationship of auditory perception to primary grade reading abilities Lyness observed that good readers did not fail more than one auditory subtest, whereas poor readers failed at least three or four. This suggested that compensation for a single auditory weakness can be accomplished, but compensation for more becomes progressively harder as they increase in number. It can be seen that auditory perception plays an important role in learning to read. Assessing the child's auditory abilities is important to designing a remedial program specific to his needs.<sup>21</sup>

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<sup>19</sup>Kenneth A Polcyn, "Improving social studies communication: A study of intervening variables (noise) affecting written materials," Dissertation Abstracts, 34:669A, 1970

<sup>20</sup>Verle Leon Mickish, "The relationship of viewing skills and visual perception," Dissertation Abstracts, 31:2793A, 1970

<sup>21</sup>Sandra L. Lyness, "The relationship of auditory perception to primary grade reading abilities," Dissertation Abstracts, 28:3028A, 1967

In the testing of middle-class second graders it has been found that one half seem to prefer either an auditory or visual relationship in memory for letter sequences and the most efficient way of learning to spell a word. Difficulty of material did not seem to relate to the superiority of either channel of presentation of verbal materials.<sup>22</sup>

Where materials were quite difficult it has been found that the listening path was less effective than the visual path. High ability students were able to understand verbal material much better than lower ability students.<sup>23</sup>

Items presented visually were recognized more accurately than those presented verbally. Students requested to learn images of selected items had higher recognition results than those requested to learn the items verbally. It is possible that verbal coding may be supplemented or replaced by visual coding when memory for more than a few seconds is required. Encoding factors rather than perceptual factors would cause differences which arise in memory and possible problem solving.<sup>24</sup>

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<sup>22</sup>Theodore Kobs, "The relationship between second graders' auditory/visual memory span for random letter sequences and auditory/visual methods of learning to spell," Dissertation Abstracts, 33:2818A, 1972

<sup>23</sup>Stanton Phillip Thalberg, "An experimental investigation of the relative efficiency of the auditory and visual modes of presentation of verbal material," Dissertation Abstracts, 25:1017, 1964

<sup>24</sup>Robert Thomas Jones, "The effect of multi-channel audio stimuli on learning efficiency," Dissertation Abstracts, 31:226A, 1969

As the number of presentation channels increases, the amount of learning decreases. Materials learned under several channels seem to be very resistant to forgetting. It was found that information processing tends to be confined to one cluster at a time.<sup>25</sup>

## CHAPTER III

### DISCUSSION OF RESEARCH

A goal for all school lighting is to allow students and instructors to see comfortably and efficiently, and without undue distraction. Although proper school lighting has been a concern for years, still it often happens that too little attention is paid to the requirements of proper lighting during early planning stages. Too frequently the lighting layout is postponed until all other design problems are solved, instead of considering illumination as a basic ingredient of design. When the question of lighting is belatedly considered, it is frequently found that some of the proper locations for lighting fixtures have been pre-empted by a structural member or a ventilating duct, and the quality of illumination must be compromised.

The provision of proper lighting is of special importance in learning spaces intended for the optimum use of media; it is the type and quality of lighting during the viewing of images that is important. There is a wealth of available information about proper lighting for conventional learning tasks, but much less is known about proper lighting for image viewing.



In typical classroom situations, illumination is provided by a combination of natural and artificial sources, and often daylight is a major contributor. For ideal projection conditions, though, daylight is often a disturbing factor to be controlled or eliminated. Many of the smaller spaces in which images are projected will have windows, and where they provide too much ambient light on the screen, they will have to be shaded. In the larger spaces intended for the use of projected media, there should preferably be no windows. Artificial lighting can readily be controlled, and in proper amounts is essential to proper viewing conditions. Therefore, the following will deal primarily with illumination provided by artificial means.

In the design of interior spaces particularly, artificial lighting should be considered as one of the essential "tools" of architectural design; it may contribute as much as the choice of materials, finishes, or even the room shape itself.

The four basic functions of lighting are to provide: 1) visibility, as influenced by the amount, distribution, color, and control provided; 2) comfort, as determined by the absence of glare and eye strain; 3) atmosphere, as provided by the psychological reactions produced; 4) composition, as seen in its effects upon the architectural surroundings. Proper lighting of the learning spaces should be designed to fulfill all of these conditions.

Optimum conditions for the viewing of projected media impose

two basic requirements in respect to room lighting: 1) The provision of appropriate levels and quality of illumination concurrently on the screen, the desk surfaces and the surroundings; 2) The proper means and timing of lighting controls.

The typical conventional classroom is deficient on both counts. Usually darkening of the room necessitates lowering the window shades, or placing special blinds, then turning off the lights, and the light switch seldom is located convenient to the projector. Then there is insufficient light for note taking, and if the presentation is lengthy, drowsiness overtakes many of the viewers.

In the main, it is the brightness of surfaces, and especially the relative brightnesses (brightness ratio) of various surfaces within the field of vision, that are of primary concern. It's important to realize that, contrary to a common concept, brightness does not vary with large areas; "contrast", a term with a similar meaning, refers to the relative brightness of small adjacent areas, such as printed characters and their background.

The essential requirements of good lighting for optimum viewing of projected images follow. During the projection of images on a screen, the student's tablet (or writing) surface should be adequately lighted to facilitate taking notes. It should have as nearly as possible the same brightness as the average brightness of the projected image. The light falling on the tablet surface should not produce shadows.

The seated student should not be aware of room light sources within his normal line of vision. The brightness of other visual task surfaces, such as chalkboards and displays, when in use, should be about the same as that of the projected image. When not in use, their surface brightness should be lower, to blend inconspicuously with the general background. Other surfaces within the viewer's vision, including chalkboards and display areas not in use, should be less bright, but their brightness should not be less than one tenth of the average screen brightness.

When no projection of images is taking place, the general level of room lighting should be consistent with typical classroom lighting. In the large rooms, supplementary local lighting should be provided on chalkboards, display surfaces, demonstration areas, and the instructor himself, as may be required. Projection screens not in use should be inconspicuous.

Lighting of pre-set levels should be controlled by the instructor, or "tied in" with projection equipment. In the interest of economy, these lighting conditions should be achieved without the use of elaborate and expensive dimmer devices, custom fixtures or other costly equipment.

In short, the goal in order to minimize eyestrain is the achievement of proper relationships between the brightness of the screen image and other task surfaces and surrounding surfaces within the viewer's field of vision. This is somewhat complicated by the fact that the reference brightness value--the average screen brightness--is not

constant. (See Appendix A) With any projected media, it depends on number of variable factors such as the lumen output of the projector, the type of screen used, and the nature of the projected material. Also, the characteristic average brightness of screen image produced by various media differ even more significantly. It would be highly impractical to attempt to accommodate all of these varying brightness levels. But it is advisable to provide several levels of room lighting which are consistent with, and keyed to, the medium being used.

In providing appropriate surface brightnesses, the choice of colors and textures is most important consideration. The writing surfaces (desk or counter top) should be neither glossy white, producing glare, nor a dark color, contrasting with the writing paper, but should have a light-colored matte finish with a light reflection value of fifty or sixty percent. The floor, ceiling and walls may be generally light colored, but near the projection screens, they may be darker to minimize the amount of light they reflect on the screens. Chalkboards should have low reflectance to provide good contrast for chalk. The use of bright metal trim anywhere in the room is distracting and objectionable, and should by all means be avoided.

Appropriate lighting levels should be predetermined and preset, and the instructor's control should extend only to the selection of sequence and duration. It is recommended that when a lectern is used, as in the larger spaces, the lighting circuits be so arranged that they are controlled by the same switches which operate the projectors, so that the

switch activating the projector also automatically reduces the level of room lighting, and the switch turning it off automatically raises the room lighting to its normal level. In the smaller rooms lighting will be controlled by simple wall switches, or may be part of the controls built into media modules.

The lighting requirements become more critical, and consequently the lighting system becomes more complex, as the size of the learning space increases. In the smaller rooms, conventional ceiling light sources are generally satisfactory for providing two levels and sufficient background lighting of wall and ceiling surfaces is usually provided by "spill" from these sources. In the larger rooms, though, it is usually advisable to provide supplementary special "wash" lighting on the wall areas to bring their brightness up to the proper level in respect to the screen brightness.

For larger spaces two basic types of systems are possible. System A uses incandescent recessed downlight located in the ceiling over the seating area, with auxiliary lighting of the side walls by means of a continuous band of lamps mounted on the wall behind an opaque fascia strip. The whole system is controlled at predetermined levels by means of dimmers. System B consists of recessed fluorescent troffers placed in continuous rows across the ceiling paralleling the seating rows, with a directional forty five degree cut-off, parabolic reflector grid located below the luminaires and flush with the ceiling.

Another line of single-lamp troffers with similar reflector grids is placed in the ceiling along each side wall to provide wash lighting on the walls. This system does not require dimmer controls; instead several lighting levels can be provided by circuitry and switching. In both systems, accent lighting of the display surfaces, chalkboards, demonstration area and instructor's station can be provided by units from the instructor's station by automatic switching tied-in with the projector controls.

Naturally there are modifications and combinations of these two systems that would perform satisfactorily. The choice must be made by weighing factors such as initial and operating costs, maintenance costs, reliability, operating noise, and quality of desired light.

Architectural acoustics has long been a matter of concern in concert halls and large auditoriums, but only recently has good acoustics in nearly all types of buildings become a concern. With the rising noise level of our modern environment, there is increasing concern with noise control problems, and now acoustical requirements are even being introduced into building codes.

Good acoustics are important in school buildings. Education depends on communication; good hearing conditions are just as essential as good lighting, and both must be carefully considered early in the planning stage. The growing interest in school building acoustics has led to many special studies and investigations. Two developments in

particular have prompted this concern; the introduction of open planning and the increasing use of electronic media in teaching. Both of these developments are highly significant, and both complicate the "noise problem". Unfortunately, as they affect acoustics, they are basically incompatible.

There are two objectives of acoustics. 1. Good conditions for hearing must be provided wherever desired. 2. The elimination, as far as possible, of unwanted sound or noise must be accomplished. Both are important in school design, but not necessarily of equal importance in all spaces. This depends upon the intended function of the space.

Hearing conditions within a room or space depend upon the size and shape of the room, the location and volume of sound, and the disposition of sound-absorbing and sound-reflecting surfaces within the room. The sound heard at any point within confined space consists of direct sound from the sound source, plus an infinite sequence of sound reflections from surrounding surfaces. The sound level of these reflections--the reverberant sound--depends upon whether the surroundings--the walls, floor, ceiling and furnishings--absorb or reflect the sound. Good hearing conditions are achieved by the control of sound reflection and absorption, and this, in turn, involves several basic requirements:

1. The reinforcement, as necessary, of the sound source by reflective surfaces.

2. The avoidance of long-delayed reflections from remote hard surfaces.

3. The elimination of inter-reflections (flutter) between parallel hard surfaces.

4. The control of the persistence of sound (reverberation).

5. The control of background noise within the room.

Good hearing conditions are obviously essential in all spaces where the learning process requires listening. Listening is essential in learning rooms of all sizes, from the small conference rooms to large auditoria, but good hearing conditions are seldom a problem to achieve in smaller spaces. As the size of the space increases, so also does the importance of acoustical design, and the proper planning of large spaces may require the assistance of acoustical experts.

Surface treatments and finishes in small rooms have relatively little effect on hearing conditions. In the medium group spaces accommodating up to sixty persons, it will generally suffice to provide a peripheral area of absorptive material on all sides of the room except that occupied by the instructor. A major part of the ceiling area should be hard and reflective to reinforce the instructor's voice or other sound sources.

In the larger group spaces, the disposition of reflective and absorptive surfaces, including the shape of the room itself, becomes increasingly important as the room dimensions and the distance sound must travel become larger. The objective should always be to so



dispose these materials within the room that occupants do not receive perceptibly delayed repetitions of a sound. If the surfaces lining the room are hard, and therefore sound-reflective, sound waves are bounced back and forth many times before they die out, and a long "reverberation period" results. When large areas of porous, and therefore sound-absorbant material such as carpet, upholsterd furniture or special acoustical "blankets" are introduced, the reflective energy is greatly reduced. Sound is largely absorbed and dies away quickly; the reverberation period is greatly reduced.

The acoustical factors have important design implications. They dictate that surfaces relatively close to the sound source should be relative to amplify and disperse the sound, while surfaces behind the audience, facing the sound source, should be absorptive to minimize reflection and reverberation. The provision, in effect, of an inclined "sounding board" surface over the instructor's area is essential, and may often be provided by the conformation of the ceiling itself. As a rule, other ceiling surfaces, too, should be reflective, flat planes. Curved surfaces, particularly domes, should be avoided, because they focus, rather than disperse sound. Non-parallel side walls, converging in the direction of the sound source, are preferred, because they improve the dispersion of sound and tend to reduce the reverberation period.

As the room size increases, the conformation of the floor area becomes important for acoustical reasons as well as for viewing. Sloped or stepped floors in the larger spaces improve the general hearing

conditions, because sound from the front of the room is better dispersed to all members of the audience. It's important to remember that good sight lines mean good "hearing lines."

Under normal conditions, amplification systems should not be necessary in most of the facilities if the recommendations as to room shape and acoustical treatment are followed. Exceptions will occur in the large rooms where it may be advisable to provide means of reinforcing live speech because of the likely limitations of some speakers. In all of the learning spaces, though, electronically reproduced sounds will be used in facilities should be provided for their distribution. With a built-in sound system being required anyway, it may be desirable in the larger rooms to design it to be used also for amplification and distribution of live sounds. In all cases, there should be only one sound system in any learning space, and it should be capable of accommodating interchangeably all needs--sound tracks on films, audio tapes, radio, television audio, intercom announcements, and when desired, sounds picked up by room microphone.

For the larger rooms there should be, 1) distributed, low level systems, with speakers located at various points in the ceiling, and 2) central, high level systems, with a single speaker (or battery of speakers) located at a point above the instructional area and directed at the center of the audience. The selection will depend on the size and functions of the space.

A minimum requirement of any sound system is that it have sufficient reproductive quality for full intelligibility. In most of the rooms music will frequently be reproduced, and in certain rooms this may be the chief function of the system. The tonal quality of the system then becomes of prime importance. It's essential in all cases, too, that uniform volume be provided throughout the listening area with no feedback. When used to amplify live speech, it's important that the amplified sound seems to be coming from the same source as the direct live sound.

For reasons previously indicated, the problems of sound isolation between spaces are probably more urgent--and more difficult--in today's schools than are those related to the direction of sound originating within the listening area itself. (See Appendix B) The expanding use of reproduced sounds calls for improved sound barriers, while at the same time the search for spatial freedom and flexibility encourages the elimination of substantial space dividers. Unfortunately, the invisible sound barrier is yet to be invented and some logical compromise solution is necessary.

Three principal factors determine the "quietness" of an enclosed space in respect to air-borne sounds: 1) the level of sound (noise) in adjacent spaces; 2) the sound insulation quality of the intervening space enclosure; 3) the level of background noise within the space itself. It is the relationship of these factors that determine the degree of acoustical comfort experienced in a room. For many years the importance of

the sound insulating value (or transmission loss) of walls and floors has been recognized. It's only recently that the significance of background noise has received much attention.

Sound isolation from outside sources can be provided either by distance or by enclosure. Within a building sound isolation must be provided by floors and partitions, and it's in the construction of partitions that most problems of isolating air-borne sounds arise. When sound waves strike a boundary separating two media, some of the incident energy is reflected from the surface and the remaining energy is transmitted into the second medium. Some of this energy is eventually converted by various processes into heat energy and is said to have been absorbed by that medium. Although all materials do absorb some incident sound, the term "acoustical material" has been primarily applied to those materials which have been produced for the specific purpose of providing high values of absorption. The major uses of acoustical materials are almost invariably found to include the reduction of reverberant sound pressure levels and the reduction of reverberation time in enclosures.

Since about 1965, the use and variety of available specialized acoustical materials has greatly increased. This has been due mainly to both increased technology and public awareness and concern about noise in everyday life. In turn, this has led many public bodies and commercial public service operations to realize the benefits of providing good acoustical conditions for their clients. The architect and

acoustical engineer now have a wide choice of sound-absorbing materials which not only provide the desired acoustical properties, but also offer an extremely wide variety of colors, shapes, sizes, light reflectivities, fire ratings, and methods of attachment--to say nothing of the costs of purchase, installation, and upkeep.

Although a wide range of sound-absorbing materials exist which provide absorption properties dependent upon frequency, composition, thickness, surface finish, and method of mounting, they can be divided into five major classifications.

Porous sound absorbers constitute the first group. Porous materials are characterized by the fact that the nature of their surfaces is such that sound energy is able to enter the materials by a multitude of small holes or openings. They consist of a series of tunnel-like pores and openings which are formed by interstices in material fibers, or by foamed products. (Usually the more open and connecting these passages are, the larger the values of the sound-absorbing efficiency of the material.) When a porous material is exposed to incident sound waves, the air molecules at the surface of the material and within the pores of the material are forced to vibrate and in doing so lose some of their original energy. This is because part of the energy is converted into heat due to frictional and viscous losses of air molecules at the walls of the interior pores and tunnels within the material. At low frequencies these changes are isothermal, while at high frequencies they are adiabatic. In fibrous materials, much of the energy can also

be absorbed by scattering from the fibers and by the vibration caused in the individual fibers. The amount of incident energy absorbed is usually strongly dependent upon (a) frequency, (b) thickness, and (c) methods of mounting. These should always be considered in the choice of a particular material. (See Appendix C)

Panel or membrane absorbers are the second classification group. When a sound source is turned on in a room, a complex pattern of room mode is set up, each having its own characteristic frequency. These room modes are able, in turn, to couple acoustically with structures in the room, or even the boundaries of the room, in such a way that acoustic power can be fed from the room modes to other structural modes in, for example, a panel hung in the room.

The evidence shows that resonant panels can be very efficient absorbers. In addition, their nonperforated surfaces are durable and can be painted with no effect on their acoustical properties. It is important that this type of sound absorber be recognized, as such, in the design of an auditorium. Failure to do so, or to underestimate its effect, will lead to excessive low frequency absorption, and the room will have a relatively short reverberation time. The room will then be considered to be acoustically unbalanced and will lack warmth. Typical panel absorbers found in auditoria include; gypsum board partitions, wood paneling, windows, wood floors, suspended ceilings, ceiling reflectors, and wood platforms.

Helmholtz resonator absorbers, the third classification group, consist of an acoustic cavity contained by rigid walls and connected to the outside by a small opening called the neck. Incident sound causes air molecules to vibrate back and forth in the neck section of the resonator like a vibrating mass while the air in the cavity behaves like a spring. Such an acoustic mass spring system has a particular frequency at which it becomes resonant. At this frequency, energy losses in the system due to frictional and viscous forces acting on the air molecules in and close to the neck become maximum, and so the absorption characteristics also peak at that frequency. Usually there will be only a very small amount of damping in the system, and hence the resonance peak is usually very sharp and narrow, falling off very quickly on each side of the resonance frequency.

Although Helmholtz type resonators could be built for any frequency, their size is such that they are used mainly for low frequencies in the region fifty to four hundred Hertz. Because of their sharp resonance peaks, undamped resonator absorbers have particularly selective absorption characteristics. Therefore, they are used primarily in situations where a particularly long reverberation time is observed at one frequency.

Acoustical spray-on materials, the fourth classification group, consist of a range of materials formed from mineral or synthetic organic fibers mixed with a binding agent to hold the fibrous content together in

a porous manner and also to act as an adhesive. During the spraying application the fibrous material is mixed with a binding agent and water to produce a soft lightweight material of coarse surface texture with high sound-absorbing characteristics. Due to the nature of the binding agent used, the material may be easily applied directly to a wide number of surface types including wood, concrete, metal lath, steel, and galvanized metal. When sprayed onto a solid backing, this type of spray-on material usually exhibits good mid and high frequency absorption and, when applied to, for example metal lath with an air space behind it, the material then also exhibits good low frequency absorption. The absorption values increase with greater depth of application, especially at low frequencies.

Acoustical plaster is the fifth and last of the classification groups. The application is made either to a plaster base or to concrete, and must have a solid backing. Because of this, acoustical plasters have poor low frequency absorption characteristics (also due to the thickness of application which rarely exceeds one half inch).

To be totally effective, any sound barrier must be air-tight. Even the smallest opening, such as open points or cracks, electrical outlet boxes back to back, or keyholes, will greatly reduce the sound-isolating value of a partition. All openings are sound leaks, and have even more significance, relatively, than leaks in waterproofing. A hole



of only one square inch in one hundred square feet of wall having a forty decibel transmission loss rating will "leak" as much sound as all the rest of the wall.

It is because of a combination of deficiencies--light mass, stiffness and most importantly, numerous leaks--that until recently most reasonable priced flexible or folding partitions have been relatively ineffective as sound barriers. In the past several years this situation has improved. Some manufacturers have developed new products which are better designed and engineered with careful attention to a better choice of materials and thorough edge sealing, resulting in greatly improved acoustical performance.

In some of the newer schools, open planning has been used extensively with no full partitions separating classrooms or corridors. Proponents of such planning claim that the liberal use of carpeting, acoustical surfacing and baffles, can overcome noise problems. Studies have been made to evaluate this approach to school planning, emphasizing its psychological advantages and attempting to rationalize its acoustical disadvantages. Significantly, although the majority of teachers interviewed appear to find the spaces generally quite acceptable, many of them stated that the use of television or record playing in adjoining areas is distracting.

The omission of full and substantial partitions between learning spaces limits the proper and effective use of electronic media.

Open planning of this type (without full partitions) may be acceptable for some teaching--learning situations, particularly among young children, where a high level of background noise can be tolerated. It cannot be recommended where electronic media are to be regularly used, unless headsets or low volume speakers are employed. The minimum acceptable sound barrier between spaces planned for the regular use of electronic media should have a transmission loss of not less than forty decibels.

Background noise level within the learning space itself must also be reduced below objectionable levels. The more commonly disturbing sources are mechanical ventilation equipment and projection equipment. An enclosure should be provided for all projectors to minimize their noise. In smaller rooms, such enclosures may be simply boxes or "media modules" containing the equipment. Interior surfaces of these enclosures should be lined with sound absorbent material.

In the larger rooms, front projection equipment should be housed in permanent "soundproof" projection booths. Projection should be through a glazed panel, rather than open ports, and the glazing should be heavy plate glass set in resilient gasketing. Rear projection spaces for the large rooms must also be carefully designed to confine equipment noises. The projection screen will be vulnerable to sound leakage. If a rigid screen is used, it should be set in

resilient mountings. The typical flexible screen has inadequate value as a sound barrier, and should be backed up with a plate glass panel sealed with a resilient compound or gasket. Both types of projection areas should contain sound absorbent material, and any doors connecting it with the learning space should be of solid construction and gasketed.

Another acoustic problem arises in an audiovisual lecture room when a number of black and white or color television monitors are suspended from the ceiling for viewing by several student groups. In such a set-up it becomes important that the reproduced sound from any one of the sets does not destructively interfere with the sound from any other set or number of sets, and vice versa. The answer lies in carefully orienting each television set and installing sufficient sound-absorbent material on the walls, and floor of the enclosure to reduce the magnitude of the first reflections. (See Appendix D)

Few lecturers are able to speak sufficiently loudly in enclosures of more than fifty thousand cubic feet in volume to produce in the rear sections sound pressure levels of sixty decibels or more--comfortable listening levels. Many cannot even generate sufficient sound power in smaller enclosures unless the room is on the live side, with windows closed, and the ventilating or air-conditioning system operating at a low level. When film or television projectors with noisy cooling fans are in operation in the same room, the un-reinforced speech of the

lecturer frequently is even less well understood. Hence audiovisual enclosures with volumes larger than ten thousand cubic feet should have facilities for amplifying the lecturer's voice.

The position of the sound reinforcement loudspeakers should be above the lecturer, and preferably slightly ahead of him toward the audience, to avoid acoustic feed-back between the loudspeakers and his (preferentially directional) microphone.

If today's education is to become tomorrow's means for survival, it is important to examine school building plans carefully from a combined acoustic-psychologic point of view. While air-conditioning is definitely a necessity in our metropolitan school systems, it does not follow that all windows may be eliminated, particularly for elementary classrooms with their impressionable charges. Even small double-pane windows, to let in some sunlight and to permit an occasional look outside, appear desirable in such enclosures. There are other significant factors, such as shape of room (preferably square), size of room (ten thousand cubic feet), coloring, and others, which deserve consideration along with the acoustics of the room to provide suitable learning spaces.

The study of noise and acoustics in education can be extended to a study of the noise conditions encountered by children in their home lives. These conditions have a significant effect upon the learning abilities of the children. We can forget about the lullaby of Broadway. The

city's noise does not soothe. Children who live in it develop trouble in discriminating between similar words. If this happens, their ability to read is also affected. In many of our cities there are apartment houses and homes that are surrounded by traffic-choked streets. The din of diesel trucks, sirens, the screech of brakes and the roar of motorcycles make up the daily diet of noise. Most of the thousands of people in hundreds of cities learn to tolerate the noise and some may even become insensitive to it. But the cost of this tolerance is high.

Where children live in multi-story apartment buildings, it has been found that those who live on the higher floors are not affected as much by noise. Investigations have found a significant relationship between floor level and auditory discrimination, scores in word knowledge, reading comprehensions, and reading total in children who have lived in apartment buildings for more than four years. These findings suggest that length of exposure and intensity of noise were important in determining the ability to discriminate between sounds and reading achievement. There is the suspicion that the reading deficit is largely a function of poor auditory discrimination. In any case, it can be said that both auditory discrimination and reading achievement are related to the intensity of the noise and the length of exposure to it.

## CHAPTER IV

### SUMMARY AND CONCLUSION

#### SUMMARY

This paper was designed to bring out various ways in which the control of the visual and acoustic concepts influence the environment of education. It must be remembered that in the case of all of these elements the first thing that must take place is the presentation of any material so that the perception systems of the human will begin to operate.

Attention is the prime factor in perception of educational materials. They must be presented in various manners so that perception can take place. The several factors that influence the effectiveness of presentation practices are the ability level of the students, difficulty of the material, preference of sensory mode (visual or auditory), speaking rate, noise stress, effective visual design, and presentation practices.

It seems that the higher the ability of the students the higher the degree of perception possessed by these students. In all cases it seems that as the difficulty of the material increases the speed of

perception slows down. People vary in how they use their visual and auditory modes. Some prefer use of the visual mode, some prefer use of the auditory mode, and about one half do not have very much preference between the two.

There are many kinds of visual designs, some of which are used to conceal, and some of which are used to accentuate. In this discussion the emphasis is placed on the type of design that will be effective in an educational situation, one which will make sense to the perception system being used. This of course is not a simple task because effective visual design and presentation are functions of many relationships.

Where two clusters of information are used for information processing, it was found that processing proceeded on one cluster at a time. The consequences of perceptual factors for performance in a concept identification task, such things as size, color, and shape of the stimuli among which must be chosen from trial to trial. When using clusters of information which are unlike each other it was found that consecutive hypotheses tend to be selected first from one and then the other. It was also determined that presenting eight stimulus dimensions in two clusters tends to direct many aspects of information processing to one cluster at a time.

Processing of visual images works much better when the images are of a larger size. Images of a smaller size take longer to process.

Complex images will be processed in a much less complete way and take longer. As images are constructed but the process consumes more time, the larger the image, the more time required.

Discrimination errors and response latencies are significantly dependent on grammatical structure, grammatical structure was found to be only a partial explanation, however, and additional factors obviously influence visual processing to a considerable extent.

A serial position effect was also found and indicates that the earliest items on a visual list are least remembered. This is the reverse of the serial position effect found for auditory-verbal data and strengthens the hypothesis that two distinct systems are involved.

When memory for more than a few seconds is required for arrays of letters, patterns of geometric shapes, sequences of binary digits, and abstract line drawings, it is conceivable that verbal coding may be supplemented or replaced by another form of storage--visual imagery. It has been found that paired-associate learning of concrete nouns can be greatly enhanced by the use of imagery which links the objects named by the nouns. Items presented visually were recognized more accurately than items presented verbally. When instructed to form images of the study items, the students had higher recognition scores than those instructed to encode verbally. Recognition memory is enhanced when imagery of the items is employed.

Speech intelligibility is significantly influenced by variations



in reverberation time, speech-to-noise ratio, and speaker-to-listener distance. Listener performance will be the highest under anechoic conditions and will decrease as reverberation time is increased. As distance increases from six to twelve feet the interaction of reverberation, noise, and distance caused reductions in speech intelligibility far beyond the independent effects of those factors.

Methods of reducing the noise inherent in the air ducts of heating or air conditioning systems and comparison of materials to be used as floor covering are some problems considered when architects, planners, and school administrators confer when planning new school plants or consider when remodeling or planning to correct unfavorable acoustic conditions.

While viewing art symbols there was altered relationships between reading efficiency and eye movement, decreased vergence of ocular excursion and span of recognition, and increased fixations and duration of fixation also increased duration of fixation while viewing straight line drawings.

In the ability to identify pictorial images there is no difference between deaf or hearing persons or between male or females. In the perception of pictorial images most of the major development takes place below the eighth grade level. In the perception of pictorial image attributes, which are such things as lightness, hue, saturation, size, shape, sharpness, arrangement, boundary, and noise, the following

three things may be observed: one, there is a positive relationship in academic achievement; two, taking conventional art and photography courses makes no significant improvement; and three, there is a decrease as the number of attribute variables increase.

## CONCLUSION

There are three general aims in this study. One aim is that in controlling the acoustical concepts in education, it is possible to show how the areas of auditory abilities and auditory discrimination are greatly enhanced because of the much better information transfer process depending on the proper intelligibility of the spoken word. Two, to show that visual discrimination and visual perception are key factors in the general subject of visual literacy, and three, to show that the visual and the auditory areas reinforce each other in many ways but can work against each other.

It was found that speech intelligibility was influenced by such things as reverberation time, speech-to-noise ratio, and speaker-to-listener distance. Most of these conditions are influenced by the way the school facilities have been constructed, especially that of reverberation time. Proper methods of construction, proper kinds of materials used in the construction process, and proper arrangement of school rooms will do much toward improving the situations.

It was found that visual discrimination and visual perception

are dependent upon the perception system of the individual. Light in its various forms is the key to visual attention. Processing of visual images works much better when the images are of a larger size. Complex images will be processed in a much less complete way and take longer. A picture grammar provides a reasonable first approximation to a theory of visual processing.

The visual and the auditory areas reinforce each other in many ways but can work against each other. People vary in how they use their visual and auditory sensory modes. Verbal coding may be supplemented or replaced by visual imagery. Items presented visually were recognized more accurately than items presented verbally. Recognition memory is enhanced when imagery of the items is employed. Effective visual design and presentation are functions of many interrelationships.

## CHAPTER V

### RECOMMENDATIONS

Adequate attention must be paid to the requirements of proper lighting during early planning stages of building a new building. The type and quality of lighting is important during viewing of images. In small rooms where windows are located, shading is necessary to control ambient daylight during use of projected images. In larger rooms intended for projected media there should be no windows. Here artificial lighting can be controlled to provide proper amounts.

In most installations, fluorescent lighting is desired for any time that screen projections are not being used. Because Fluorescent lamps must have full rated voltage in order to operate, either another circuit equipped with dimmer switches for incandescent lamps or another circuit with very dim lamps to supply a preset light level could be used for screen projection periods.

The proper relationship between the brightness of the screen image and other task surfaces and surrounding surfaces within the viewer's field of vision is necessary to minimize eyestrain. The desk surfaces should have a light-colored matte finish with a light reflection value of fifty or sixty percent. The use of bright metal trim

anywhere in the room is distracting and objectionable.

The light circuits and projector circuits should be arranged so that they can be controlled from one location favorable to the instructor. In larger rooms it is usually advisable to provide supplementary special "wash" lighting on the wall areas to bring their brightness up to the proper level in respect to the screen brightness.

Good listening conditions are achieved by the control of sound reflection and absorption by: one, the avoidance of long-delayed reflections from remote hard surfaces; two, the elimination of flutter between parallel hard surfaces; three, control of reverberation; four, reinforcement of the sound sources by reflective surfaces; and five, control of background noise within the room.

Surfaces relatively close to the sound source should be relative to amplify and disperse the sound, while surfaces behind the audience, facing the sound source, should be absorptive to minimize reflections and reverberation. Nonparallel side walls, converging in the direction of the sound source, are preferred, because they improve the dispersion of sound and tend to reduce the reverberation period. Sloped or stepped floors in the larger spaces improve the general hearing conditions, because sound from the front of the room is better dispersed to all members of the audience.

There should be only one sound system in any learning space and it should be capable of accommodating interchangeably all needs--

sound tracks on film, audio tapes, radio, television audio, intercom announcements, and sounds picked up by room microphone. A minimum requirement of any sound system is that it have sufficient reproduction quality for full intelligibility.

There are five recommendations for rooms which are to be used for either speech or music reception or both: One, adequate loudness--the sound arriving at the listeners must be of sufficient intensity so that they can hear, understand, and appreciate the sound; two, uniform sound distribution--each member of the audience should be subjected to the same sound intensity independent of seating location. This requirement eliminates so-called hot and dead spots in the room; three, optimum reverberation. In order to understand speech fully, each component of the speech must be heard by the listener. If the room has a long reverberation time, then the speech components overlap and a loss of intelligibility results. Similarly for music enjoyment and appreciation, a certain amount of reverberation is required in order to obtain the quality and blend of the music; four, freedom from acoustical defects--many physical characteristics of listening rooms have a direct adverse effect on the quality of the sound received by the listener. These are generally known as acoustical defects and include: resonance, distortion, flutter echoes, long delayed reflections, focusing, and acoustical shadows; five, freedom from excessive background noise. It is clearly important that the sound received by a listener should not be

mixed with detectable exterior or interior unwanted noises. Such sounds may completely ruin what may otherwise be a room with excellent acoustics by distracting the listener's attention and by masking the wanted sound to produce lower intelligibility of speech and poor subjective reception of music.

Within a building sound isolation must be provided by floors and partitions. The sound-insulating properties of a barrier are determined largely by the mass and inertia of the barrier material. To be totally effective, any sound barrier must be air-tight. The liberal use of carpeting, acoustical surfacing and baffles can overcome noise problems in the new open planning schools. The minimum acceptable sound barrier between spaces planned for the regular use of electronic media should have a transmission loss of not less than forty decibels.

In the larger rooms, front projection equipment should be housed in permanent "soundproof" projection booths. Television monitor sets should be carefully oriented to prevent destructive interference of sound between sets. Audiovisual enclosures with volumes larger than ten thousand cubic feet should have facilities for amplifying the lecturer's voice.

The importance of the proper use of light and sound to the media specialist as well as to all other educators is growing at a fast pace. Students will be able to benefit from the resulting educational improvement. There are many unanswered problems in the visual and auditory areas that require future investigation.

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## APPENDIX A

# SCREEN SIZE CHART

## 8 mm MOVIES—Sound and Silent

Lens Focal Length	SCREEN WIDTH												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
3/4"	11'	14'	18'	22'	25'	31'	35'	39'	44'	52'	61'	70'	79'
1"	15'	19'	24'	29'	34'	41'	46'	52'	58'	70'	81'	93'	105'
1 1/2"	22'	29'	36'	44'	53'	61'	70'	78'	87'	104'	122'	139'	151'

## 16 mm MOVIES—Sound and Silent

Lens Focal Length	SCREEN WIDTH												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
1"	7'	9'	11'	13'	15'	18'	21'	24'	26'	32'	37'	42'	47'
1 1/2"	10'	13'	17'	20'	23'	28'	32'	36'	40'	48'	56'	64'	72'
2"	13'	18'	22'	26'	31'	37'	42'	47'	53'	63'	74'	84'	95'
2 1/2"	16'	22'	27'	33'	38'	46'	53'	59'	66'	79'	92'	105'	119'
3"	20'	26'	33'	40'	46'	55'	63'	71'	79'	95'	110'	126'	142'
3 1/2"	23'	31'	38'	45'	54'	64'	74'	83'	92'	110'	128'	147'	165'
4"	28'	35'	44'	53'	61'	73'	84'	95'	105'	122'	147'	169'	190'

## 3 1/2" x 4" SLIDES (LANTERN) MAXIMUM APERTURE 3" x 3"

Lens Focal Length	SCREEN SIZE						
	50"	60"	70"	84"	8'	9'	10'
6"	8'	12'	14'	16'	18'	20'	20'
9"	13'	15'	18'	21'	24'	27'	30'
12"	17'	20'	23'	28'	32'	36'	40'
16"	22'	27'	31'	37'	43'	48'	53'
20"	28'	33'	39'	47'	53'	60'	67'
24"	33'	40'	47'	56'	64'	72'	80'

## OPAQUE PROJECTION MAXIMUM APERTURE 10" x 10"

Lens Focal Length	SCREEN SIZE				
	50"	60"	70"	84"	8'
18"	9'	10'	12'	13'	16'
20"	10'	12'	13'	16'	17'
22"	11'	13'	15'	17'	19'
26"	13'	15'	17'	20'	23'

## OVERHEAD PROJECTION

Aperture Size	SCREEN SIZE				
	50"	60"	70"	84"	8'
7"	7'	9 1/2'	12'	15'	17'
9"	6 1/2'	9'	10'	12'	15'
10"	6'	7 1/2'	9'	11'	12'

## 35 mm FILM STRIPS SINGLE FRAME IMAGE—17.5 mm x 23 mm (.692" x .908") MAXIMUM APERTURE .908" x .908"

Lens Focal Length	SCREEN SIZE												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
3"	8'	11'	14'	17'	19'	23'	27'	30'	33'	40'	47'	53'	60'
4"	11'	15'	19'	22'	26'	31'	36'	40'	44'	53'	62'	71'	80'
5"	14'	19'	23'	28'	32'	39'	44'	50'	56'	68'	73'	89'	100'
6"	17'	22'	28'	33'	39'	47'	53'	60'	67'	80'	93'	107'	120'
7"	19'	26'	32'	39'	45'	55'	62'	70'	78'	94'	109'	125'	140'
8"	22'	29'	37'	45'	52'	62'	71'	80'	89'	107'	125'	142'	160'

## 2" x 2" SLIDES—35 mm DOUBLE FRAME IMAGE—23 mm x 34 mm (.908" x 1.34") MAXIMUM APERTURE 1.34" x 1.34"

Lens Focal Length	SCREEN SIZE												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
3"	6'	7'	9'	11'	13'	16'	18'	20'	22'	27'	31'	38'	40'
4"	7'	10'	12'	15'	17'	21'	24'	27'	30'	38'	42'	48'	54'
5"	9'	12'	16'	19'	22'	26'	30'	34'	37'	45'	52'	60'	67'
6"	11'	15'	19'	22'	26'	31'	36'	40'	45'	54'	63'	72'	80'
7"	13'	17'	22'	26'	30'	37'	42'	47'	52'	63'	73'	84'	94'
8"	15'	20'	25'	30'	35'	42'	48'	54'	60'	72'	84'	95'	107'

## SUPER SLIDES

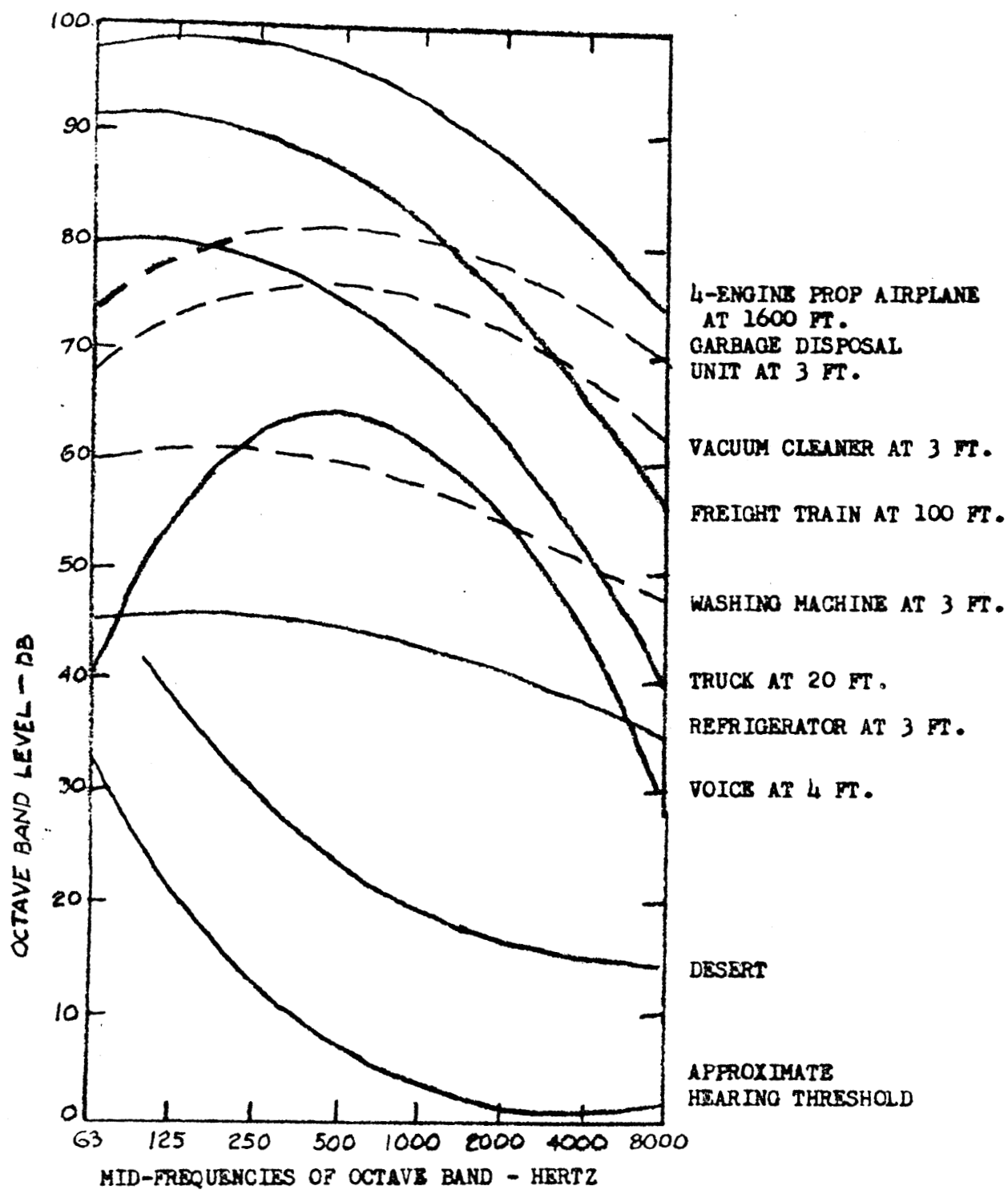
Lens Focal Length	SCREEN WIDTH												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
3"	5'	7'	8'	10'	12'	14'	16'	18'	20'	24'	28'	32'	36'
4"	7'	9'	12'	14'	16'	19'	22'	25'	28'	33'	39'	44'	50'
5"	8'	11'	14'	17'	19'	23'	27'	30'	33'	40'	47'	53'	59'
6"	10'	13'	17'	20'	23'	28'	32'	36'	40'	48'	56'	64'	72'
7"	11'	15'	18'	22'	27'	31'	37'	43'	49'	53'	64'	75'	85'
8"	13'	17'	22'	27'	31'	37'	43'	48'	53'	64'	75'	85'	98'

## 2 1/4" x 2 1/4" SLIDES MAXIMUM APERTURE 2 1/4" x 2 1/4"

Lens Focal Length	SCREEN SIZE												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
5"	6'	8'	10'	12'	14'	16'	19'	21'	23'	28'	33'	37'	42'
6"	7'	9'	12'	14'	16'	19'	22'	25'	28'	33'	39'	44'	50'
7"	8'	11'	14'	16'	19'	23'	26'	29'	33'	39'	46'	52'	59'
9"	11'	14'	17'	21'	24'	29'	33'	38'	42'	50'	58'	66'	75'

## 2 1/4" x 3 1/4" SLIDES MAXIMUM APERTURE 2 1/4" x 2 1/4"

Lens Focal Length	SCREEN SIZE												
	30"	40"	50"	60"	70"	84"	8'	9'	10'	12'	14'	16'	18'
6"	5'	7'	9'	10'	12'	15'	17'	19'	21'	25'	29'	33'	37'
9"	8'	10'	13'	16'	18'	22'	25'	28'	31'	37'	44'	50'	58'
12"	10'	14'	17'	21'	24'	29'	33'	38'	42'	50'	58'	67'	75'
16"	14'	19'	23'	28'	32'	39'	44'	50'	56'	66'	78'	89'	100'
20"	17'	23'	29'	35'	40'	49'	56'	63'	69'	83'	97'	111'	125'
24"	21'	28'	35'	42'	48'	58'	67'	75'	83'	100'	116'	133'	150'



OCTAVE-BAND-LEVEL SPECTRA OF VARIOUS NOISE SOURCES

## APPENDIX B

## NOISE COMPARISONS ON A DECIBEL CHART

## STANDARD NOISE LEVELS

## NOISE LEVELS IN INDOOR SPORTS SPACES

COMMON SOUND	RATING	DECIBELS	AVERAGE RATING	PEAK RATING
		120		
Thunder Nearby riveter	Deafening	110		
		100		Rackquetball
Noisy factory Unmuffled truck	Very loud	90	Handball Rackquetball courts	Diving Volleyball
		80	New Gym. pool	Swimming
Noisy office Average factory	Loud	70	Smith gym	
		60	Smith pool Bohler pool	Tennis
Noisy home Average office	Moderate	50	Fieldhouse	
		40		
Quiet home Auditorium	Faint	30		
		20		
Whisper Rustling leaves	Very faint	10		



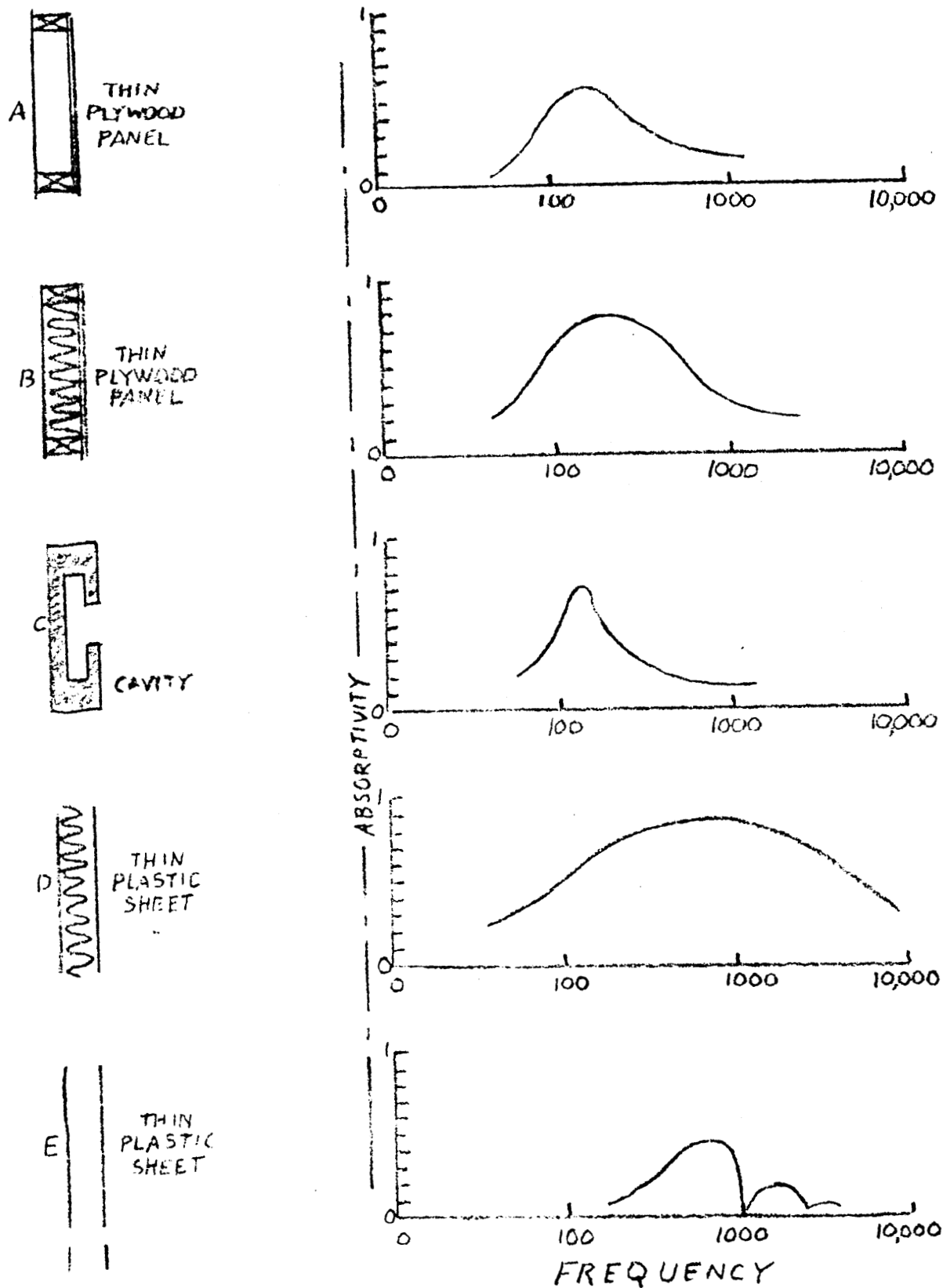
## REVERBERATION COMPARISONS

## STANDARD SPACES

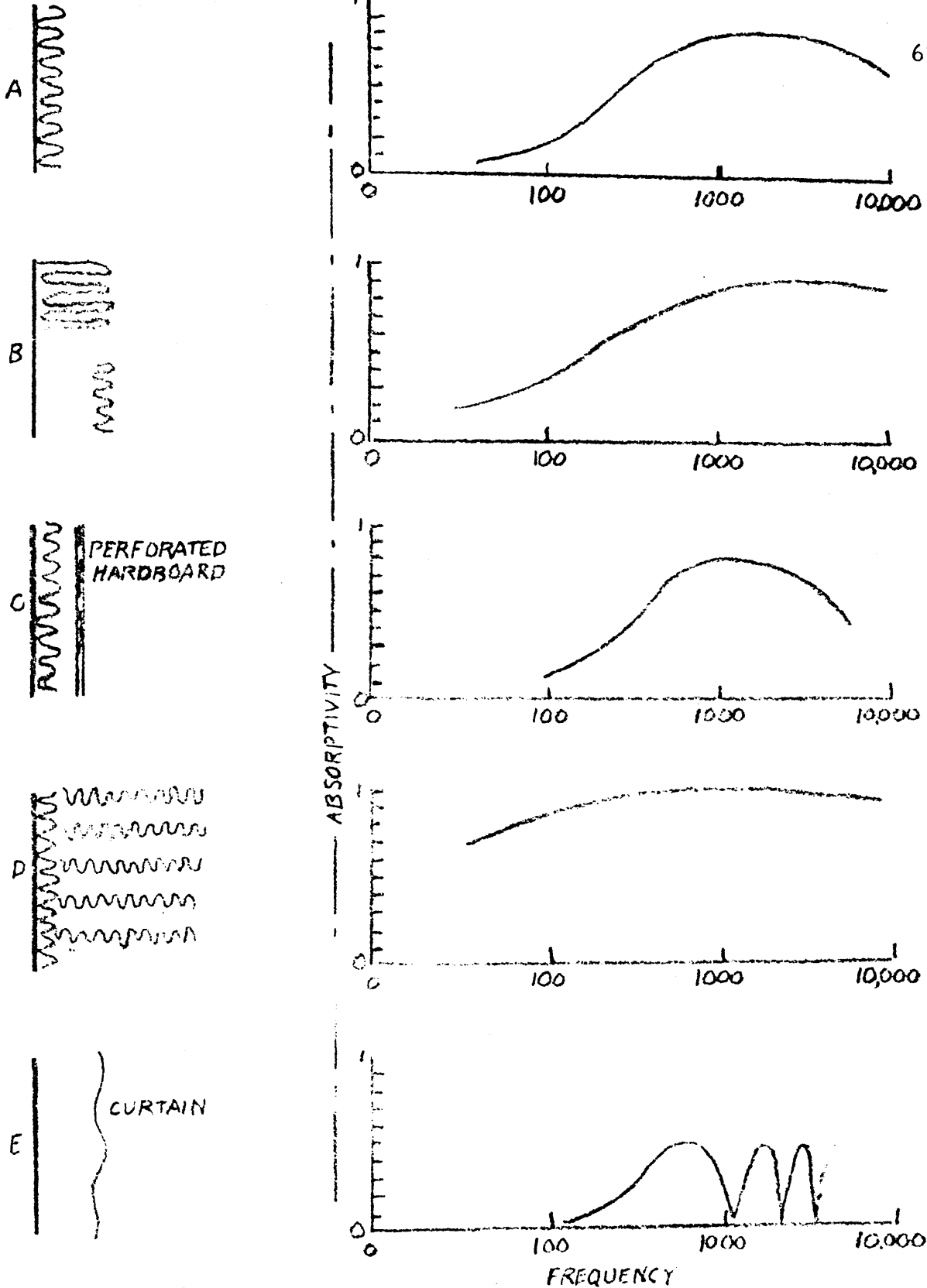
## INDOOR SPORTS SPACES

OPTIMUM REVERBERATION AT 500 Hz	REVERBERATION TIME, SECONDS	SPORTS SPACES REVERBERATION TIMES AT 500 Hz
	8.0	Fieldhouse
	7.0	Smith gymnasium
	6.0	
	5.0	
	4.0	New gym pool Handball/racquetball courts
Organ music	3.0	New gym gym
Choirs		
Symphonies		
Recital	2.0	Smith pool Bohler pool
Opera	1.0	
High school auditoriums		
Lecture rooms		
Playhouses		
Elementary classrooms		
Broadcast studios		

## APPENDIX C



ABSORPTION CHARACTERISTICS OF NONPOROUS MATERIALS



ABSORPTION CHARACTERISTICS OF POROUS MATERIALS

## APPENDIX D

## FRONT-SCREEN PROJECTION

### Advantages

- 1) Wide variety of screens available
- 2) Conventional audio equipment
- 3) Smaller projection angle tends to produce less image distortion

### Disadvantages

- 1) Tolerate less ambient light in viewing areas
- 2) Noisy when projector is located in viewing area
- 3) Produces heat in viewing area when projector located therein

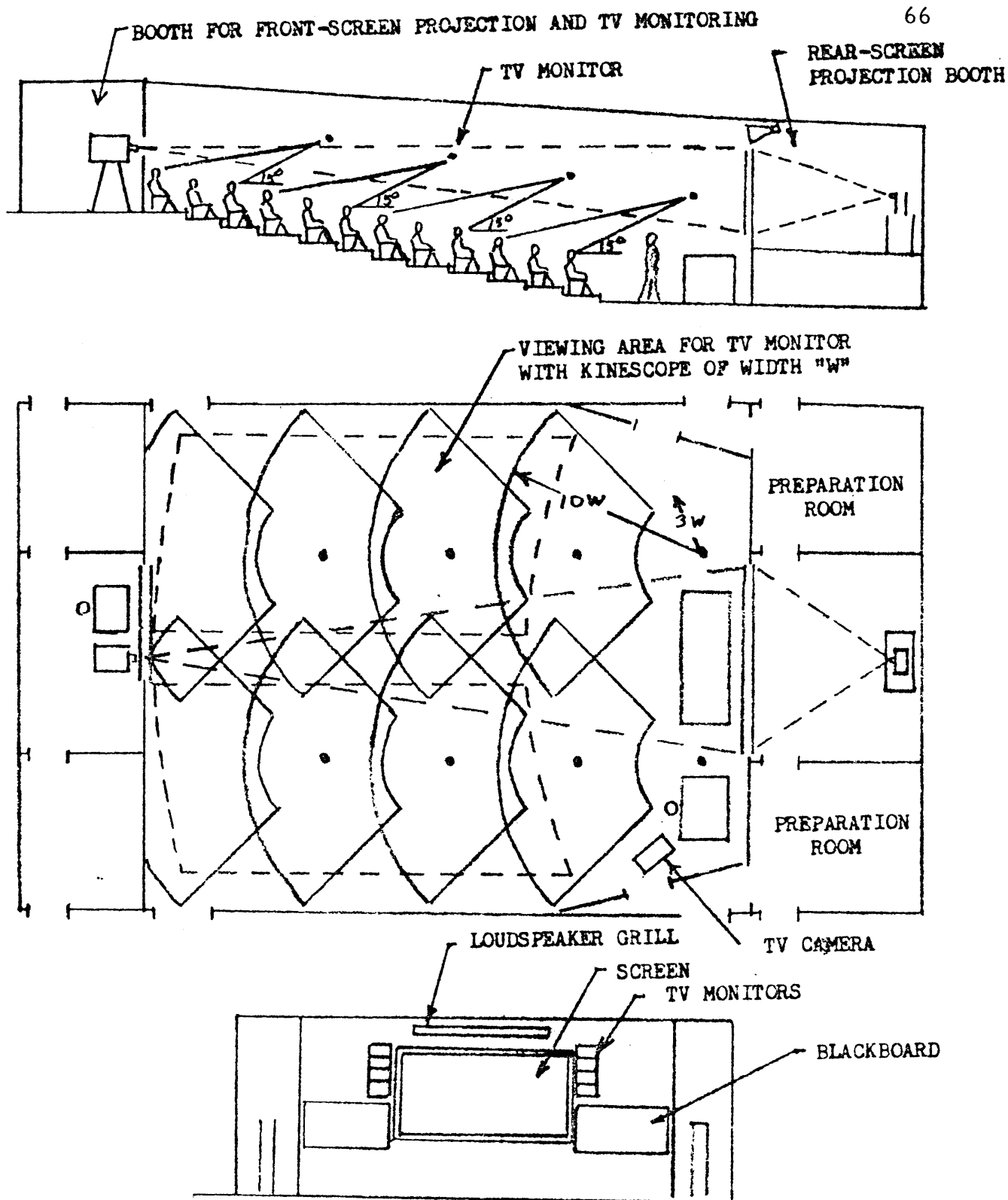
## REAR-SCREEN PROJECTION

### Advantages

- 1) Higher ambient lighting level permissible in viewing areas
- 2) Less audible projector noise in viewing area if screen is made  
a solid window
- 3) Instructor before screen does not cast shadow on it

### Disadvantages

- 1) Larger projection angle tends to produce image distortion
- 2) Lighting in projection room must be kept low, encumbering manual  
operations therein
- 3) Less readily available audio equipment
- 4) Less contrast due to light-scattering in screen material



UNIVERSITY LECTURE ROOM (UNIVERSITY OF CALIFORNIA, LA JOLLA, R. E. ALEXANDER, ARCHITECT), EMPLOYING COLOR TV MONITORS ON CEILING, REAR AND FRONT-SCREEN PROJECTION, AND SOUND REINFORCEMENT SYSTEM