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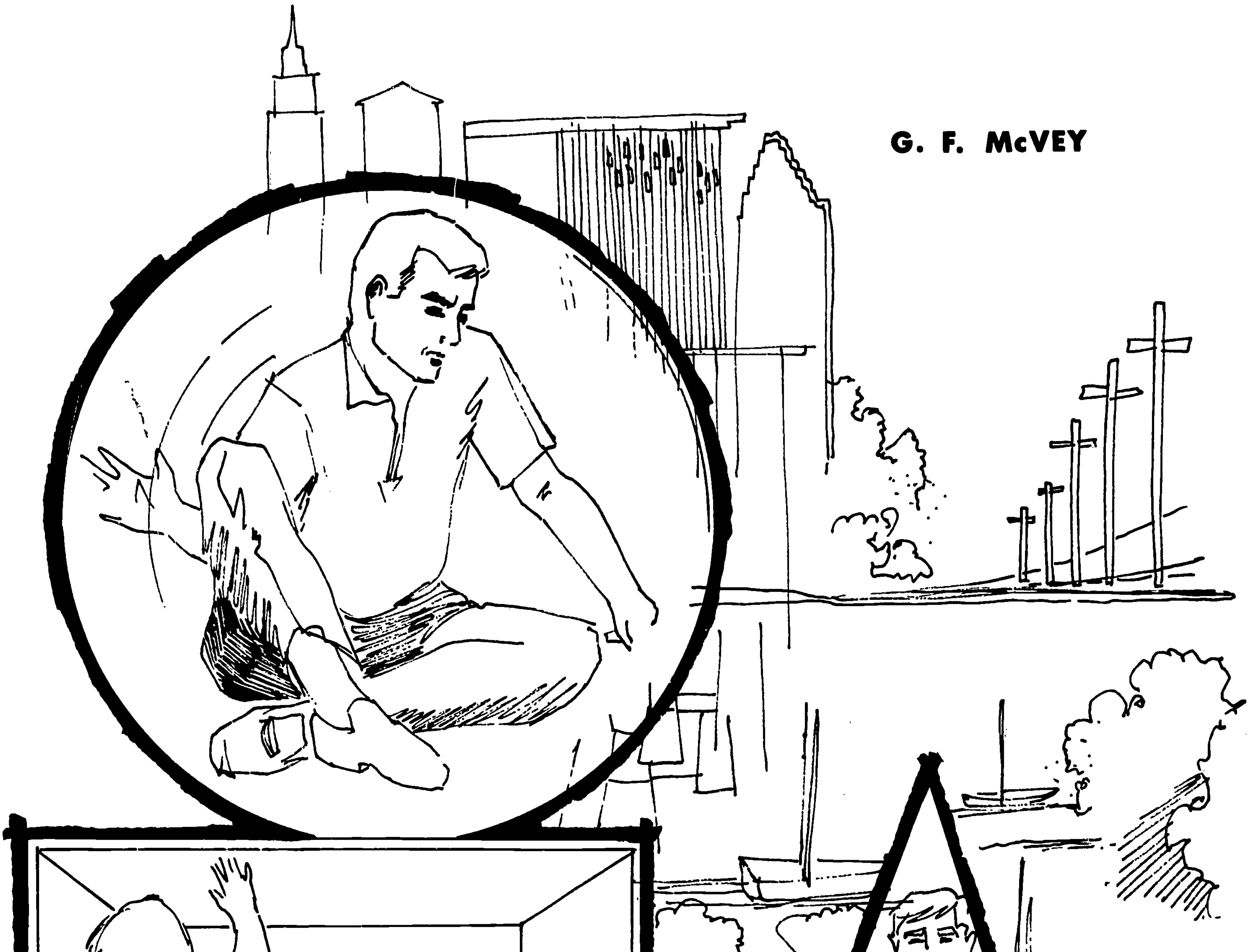
Various factors of the classroom environment that can contribute to a more complete learning atmosphere are explored. The author presents a review of certain research findings that may serve as guidelines in the development of an environmentally coordinated classroom. The importance of providing a classroom which promotes a multisensory approach to instruction is suggested. Among those factors discussed are--(1) visual scanning, (2) the visual field, (3) color, (4) lighting, and (5) seating. Also included are separate sections concerning guidelines for the design of integrated acoustical and thermal environments. In conclusion it is urged that the schoolhouse should provide its occupants with stimuli which are diverse yet within permissible parameters of a coordinated classroom. Administrators, teachers, and in particular, designers, should acquaint themselves with the results of environmental research in order to produce this integration. (RH)

G. F. McVEY



Environment for Learning

THE APPLICATION OF SELECTED RESEARCH TO CLASSROOM DESIGN AND UTILIZATION

This monograph served as the text for an illustrated lecture by the author to the members of D. A. V. I. at their national convention in Portland, Oregon, April 29, 1969

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Today there is great interest focused on the study of the interaction between man and his environment, and justifiably so because man is, to a large degree, a product of his environment. Environmental research, however, is immersed in so much ambiguity and complexity that one psychologist recently referred to it as "the messiest kind around" and "a bucket of worms." Although we accept this as a cautionary note, those of us concerned with the design of better schools--from architects to teachers--must continue to look to the results of environmental studies in order to promote the physiological and psychological well-being of the human organism.

An exploration of the various ramifications of the classroom environment as it contributes to a learning atmosphere requires a close look at the way the human physiology reacts to its physical "surround" through sensory motor receptors such as the exteroceptors (eyes. ears, fingers, tongue, nose) and the proprioceptors (such as the muscles, joints, tendons). Next it would be well to review research findings that may serve as guidelines in the development of an environmentally coordinated classroom.

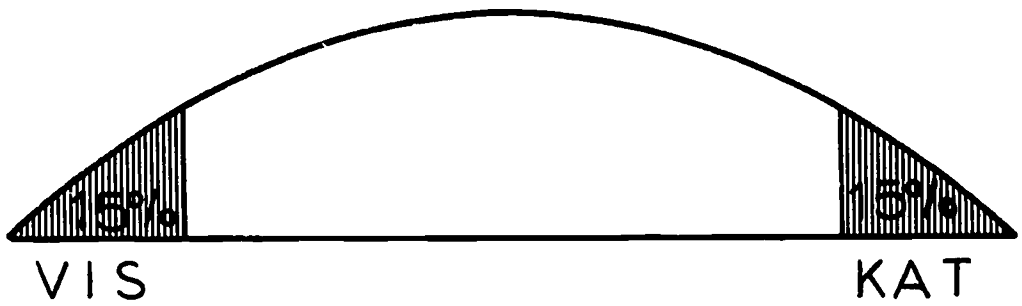
This investigation should include answers to such questions as:

"How should a room be designed in order to promote perception of presented stimuli? What are some lighting considerations?"

"What are some acoustical considerations? What audiovisual devices could be built into this plant? What environmental design principles must be considered by architects, school planners, and teachers if they wish to produce and utilize a healthy and productive learning environment?"

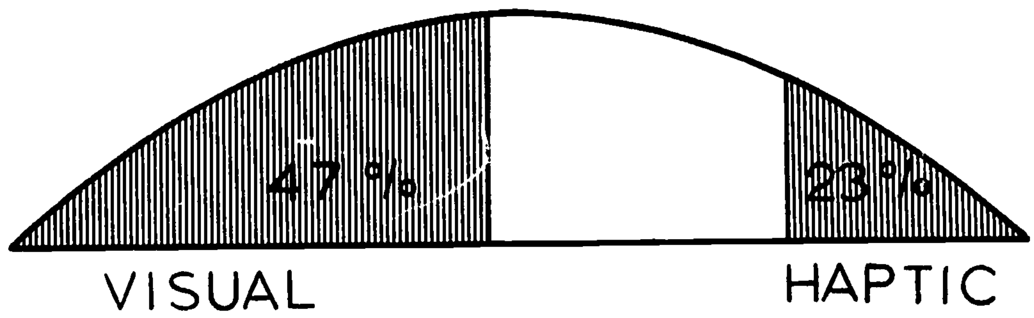
Granted it is not within the scope of this monograph to offer a complete coverage of the myriad studies relating specifically to the school environment, but it should at least introduce a few and, at the same time, offer a number of ideas related to experimental research that should prove of interest.

Man learns through all of his senses; yet there is evidence indicating the existence of heirarchy of learning. It is generally accepted that most learning is acquired through the sense of vision, then hearing, smell, touch, and taste.



In a general population, two distinct types of mode dominance are found: the visual and the kinesthetic, auditory and tactile.

(after Harmon, 1966)



Tests show the existence of two distinct creative types in a general population: the visual and the haptic.

(after Lowenfeld, 1946)

It is questionable, however, that all people perceive in the same fashion. In a series of lectures given two years ago to the Environmental Design Center at the University of Wisconsin. Dr. Darrell Boyd Harmon (1966) introduced British research that supported the theory that not all people perceive via the same mode . It was estimated that roughly 15% of the average population perceives principally through the sense of vision. Another 15% perceives principally through the combination of kinesthetic, auditory, and tactile senses. The rest of the population evidently falls somewhere in the middle of the curve.

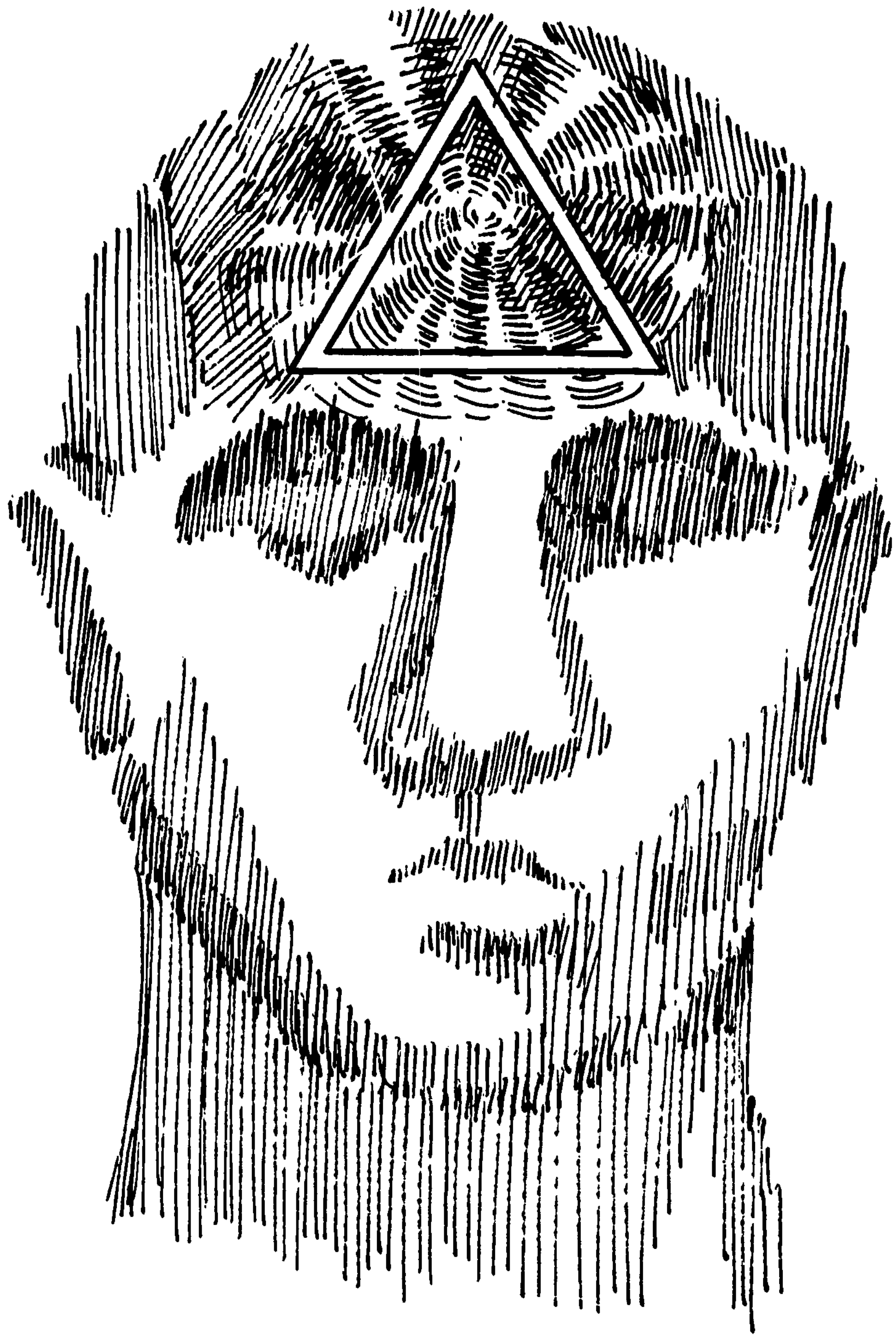
Along this same line of research, Lowenfeld (1959) concluded from a series of experiments that there were two distinct creative types. These he called the Visual and the Haptic. The Visual type includes those who instinctively use their eyes to maintain contact with their environment. They tend to transform the kinesthetic and tactile into visual experiences. They react strongly to light stimuli and are visually easily distracted.

Good vision is not a prerequisite for this type. In fact, this group generally includes many with the most rudimentary vision. The Haptic type, on the other hand, even though they may possess excellent vision, instinctively approach everything through the sense of touch and use their eyes only when compelled by some external force to do so. In his book The Nature of Creative Activity (1959) Lowenfeld stated:

> (p. 87) When we investigate the artistic products of these two types we find that the visual type starts from his environment; that his concepts are developed into a perceptual whole through the fusion of partial visual experience. The haptic type, on the other hand, is primarily concerned with his own body sensations and with the tactual space around him.

In a most interesting series of tests for determing the visual and Haptic aptitudes of 224 adults Lowenfeld (1946) concluded:

> (p. 111) From 1128 reactions, 47 percent of the Ss were clearly visual, 23 percent were haptic, and 30 percent either received a score which was below the line where a clear identification was possible or was otherwise not identifiable.



THE SENSES ARE FUNCTIONALLY LINKED AND THE STIMULATION OF ONE AFFECTS THE SENSIBILITY OF THE OTHERS.

CONCLUSION

From the above studies, although the figures vary, it can be concluded that not all people perceive via the same mode and that mode dominance is the rule rather than the exception. This the author feels is at least one justification for the construction of environmentally coordinated schools that would, by the very nature of their design, promote the multisensory approach to instruction. The classroom teacher, on the other hand, might find the Lowenfeld tests helpful in gauging the mode dominance of his own students prior to deciding upon his instructional approach and classroom activities.

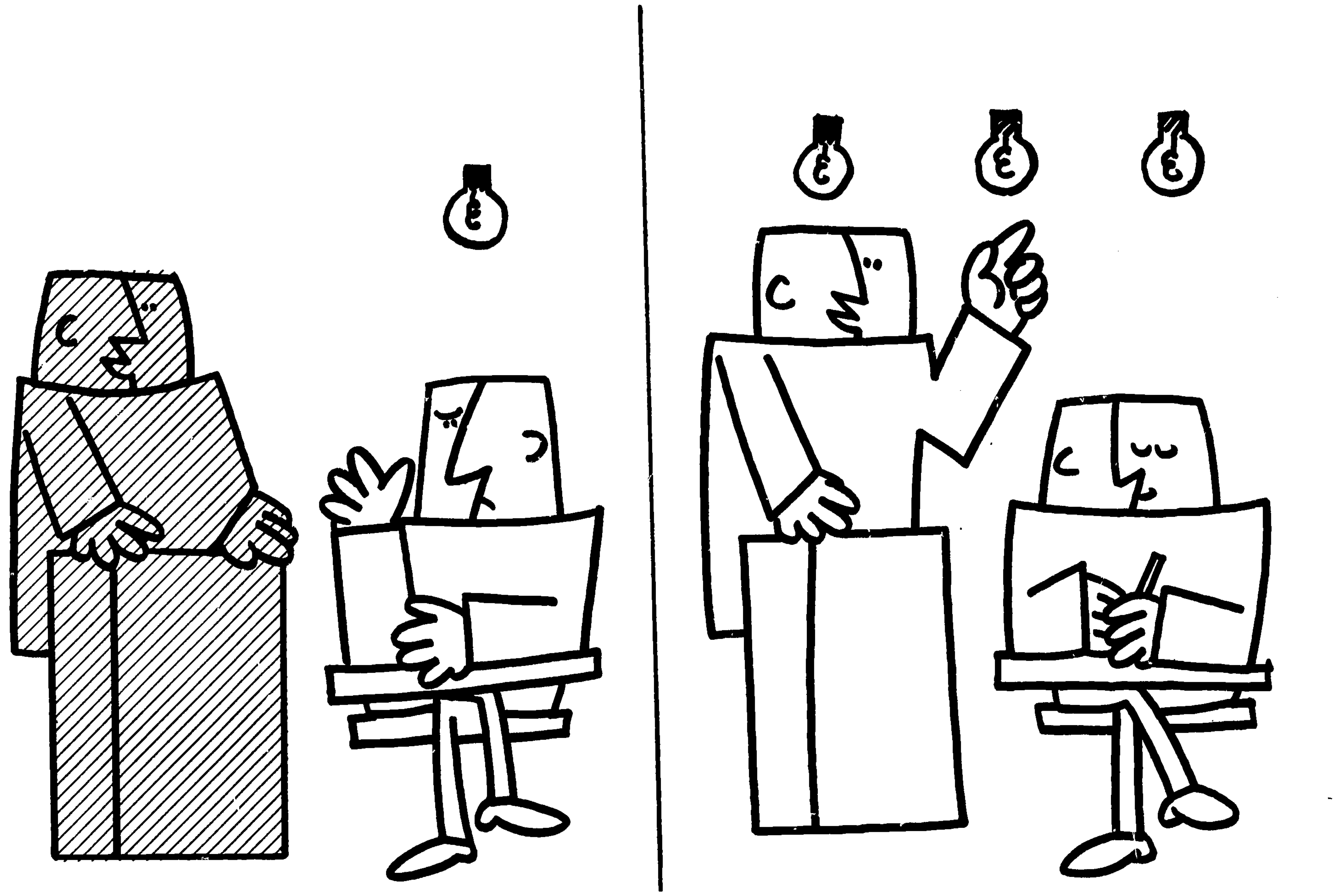
UNITY OF THE SENSES

One psychological theory that should prove of interest to educational planners is the theory of "Unity of the Senses." Researchers such as Kravkov (1934) and Bogoslovski (London, 1954) in Russia, Schiller (1935) in Hungary, Lietz (Hartmann, 1933) in Germany, and Hartmann (1933, 1934) Allen and Schwartz (1940), and O'Hare (1956) in this country have all presented experimental research showing that the senses are functionally linked and that an accessory stimulation of one sense affects the sensibility or acuity of the others. If the accessory stimulus is of a moderate nature, it will have a facilitory effect on the other senses. If, however, the stimulus is excessive, then its effect will be one of inhibition.

Much of the research in this area took place during the middle and late '30's. Studies showed how disagreeable odors had a negative effect on motor performance and vision and how moderate lighting in a room had a positive effect on the ability of people to hear. Actually there is experimental evidence going as far back as the middle 1600's supporting the facilitory effect of accessory visual stimulation upon hearing. In 1669 Bartolinus, an anatomist in Copenhagen, working with partially deaf children, observed that they could hear better in a lighted room than in a darkened one.

The message this research has for the educational planner is that if we want to improve verbal communication in a classroom it should be well lighted. In the case of an auditorium not provided with a sound support system, lighting could be an important factor affecting the ease by which the audience is able to hear a speaker.

What does the theory of the unity of the senses tell the audiovisual specialist? Obviously, classroom and auditorium projection screens should be of such a nature that they can be effectively used in



HEARING ACUITY IS INCREASED WHEN THE LEVEL OF ILLUMINATION IS INCREASED IN THE ENTIRE ROOM.

lighted classrooms. There are a few interesting developments along this line, such as Kodaks' Experimental High Brightness screen or the Sun Stereo Black screens. Another approach finding increasing interest is the installation of rear projection facilities. Rear projection generally provides adequate image brightness and resolution, yet allows high ambient light level as well as operator conveniences.

THE EYE A CAMERA?

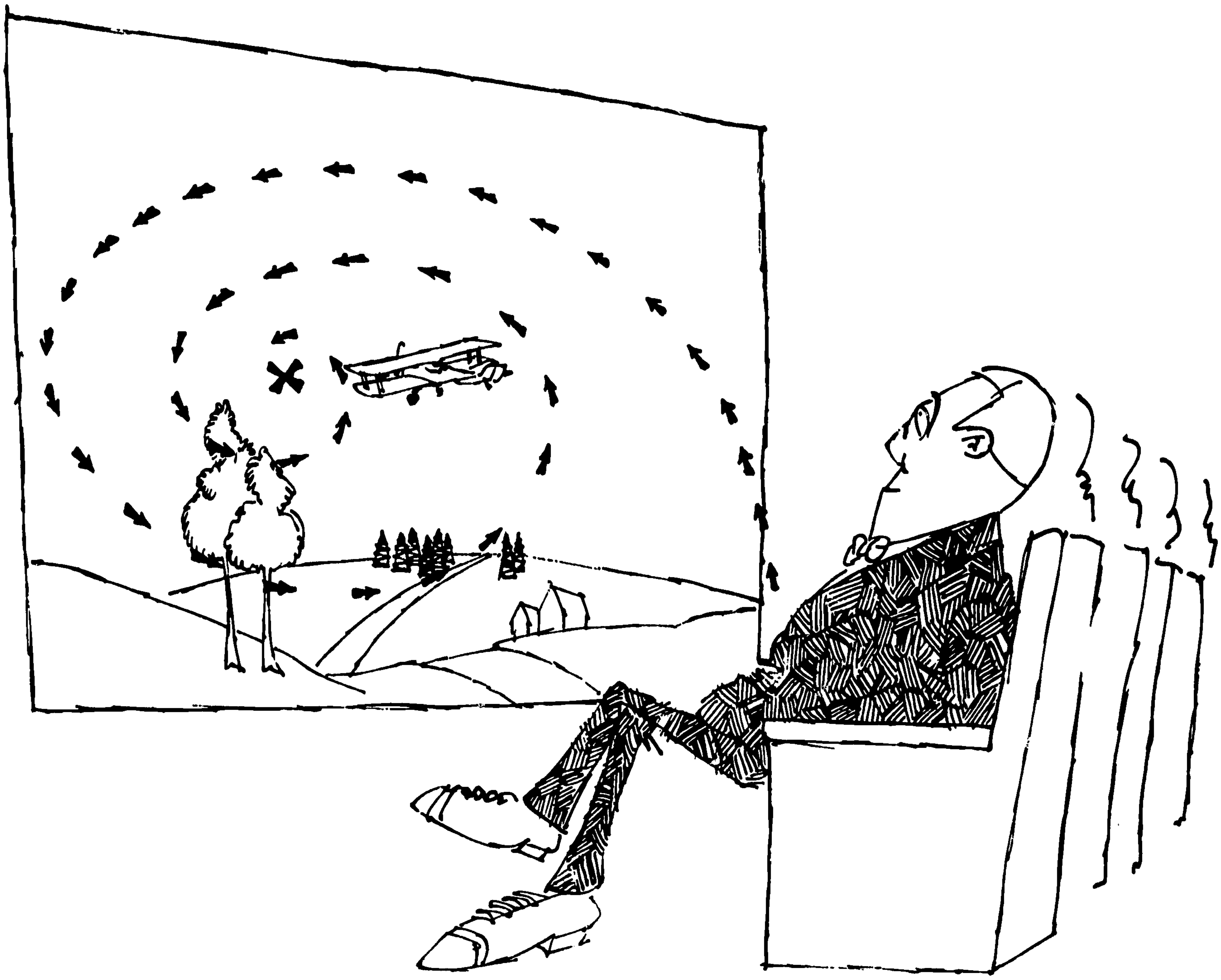
The eye is often compared to the camera and wrongly so because the eye with its flexible lens and curved retina is unlike a camera. More correctly, the eye is a combination of receiver, projector and transmitting device. It is a point-by-point receptor that scans visual space and projects these points onto the retina. The retina in turn transfers this information in the form of electrical stimulus to the brain. The brain then decodes this information in the light of past experiences, personal preferences, sexual make-up and so on. The result is what we know as vision.

VISUAL SCANNING

One of the principles related to eye movements offered by D. B. Harmon is that of logarithmic visual scanning. Harmon (1966) has shown via film how the eye followed a spiral pursuit pattern when confronted with a visual task. Research by Brandt (1945) on the psychology of seeing gives some evidence supporting this visual scanning principle. Brandt demonstrated that the eye follows predictable fixation points when looking at pictures.

The principle of visual scanning has had an interesting application in the history of art. It is believed that many artists throughout history have set up their displays in coordinates and their design lines in proportions that reflect this logarithmic scanning principle. Expressed verbally, the proportions are: the whole is to the largest segment as the larger segment is to the smaller. This proportion expressed mathematically as a decimal is .618.

Support for this design approach is said to be found in nature. The Hornbeck tree is one example where branches and other sections are related in predictable linear proportions of .618. In the poplar tree the branches are again the same, but the branches are arranged in a radial pattern. It is believed that the Greeks used a calibrated, scissor-shaped instrument to help them design their architecture to in-

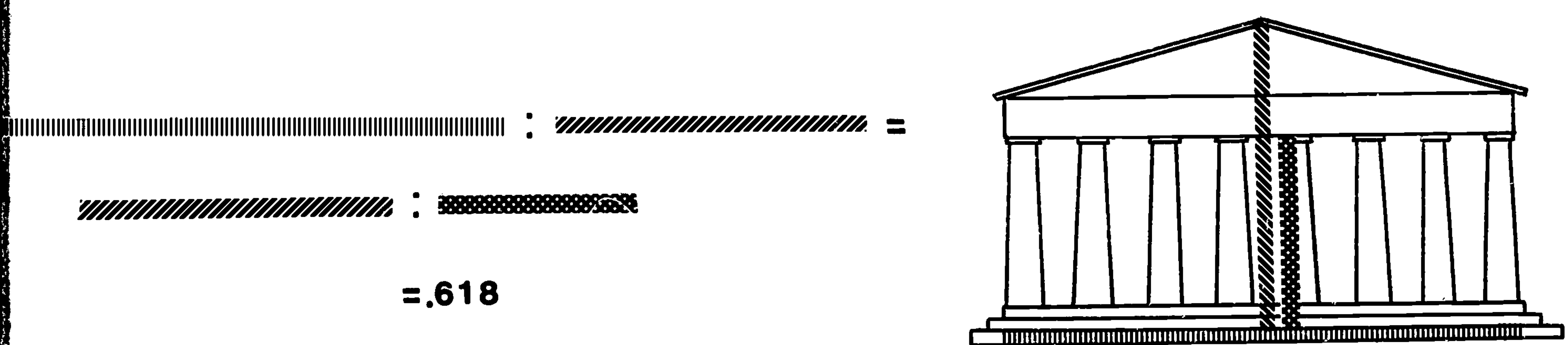


THE NORMAL VISUAL PURSUIT PATTERN IS THAT OF A LOGARITHMIC SPIRAL.

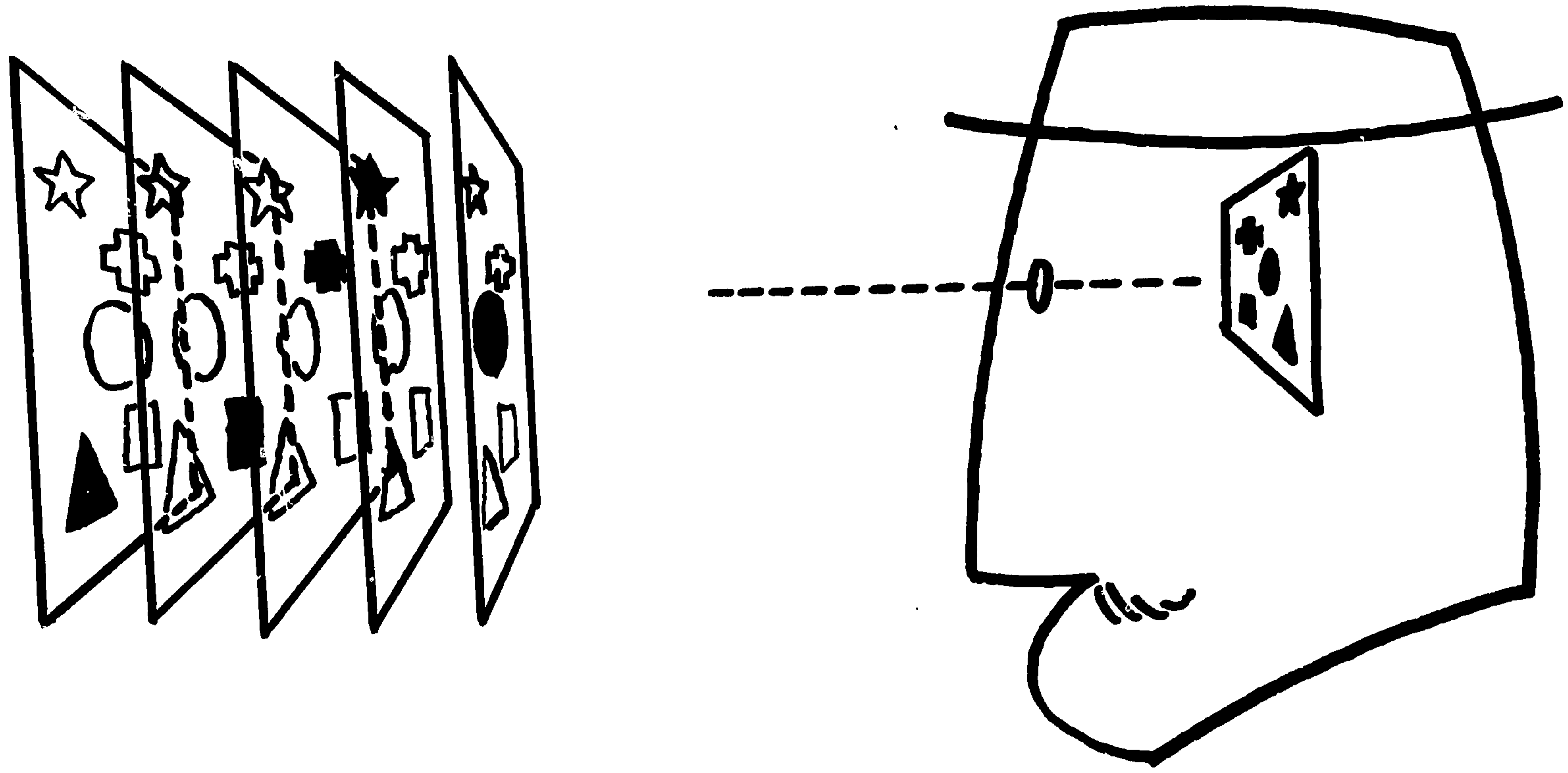
corporate this natural law of proportions which they called the "Golden Section." These proportions are thought to have been applied to their Apolio at Belvedere and to the greatest of Greek achievements, the Parthenon at Athens. It is not known for certain whether these sculptors and builders followed established rules or arrived at their design intuitively.

More recently, Le Corbusier is said to have made deliberate use of these measurements, devising a set of proportions based on parts and intervals of the human body. He has called this principle "The Modular System of Harmonious but Unequal Proportions," and has applied it successfully to both his exterior and interior design projects (Fleetwood Films, 1968).

It is quite apparent that this set of porportions has a timeless value. If it is true that in order to get significance out of any design pattern the eye must effect a closure out of the movement implied by that pattern and that the pattern of a logarithmic spiral is the basic pursuit scanning movement that the eye instinctively follows as a matter of reflex, then it is safe to say that visual displays as well as all other elements of our school house design should reflect this pattern and the proportions associated with it.



(After Fleetwood Films, 1968)



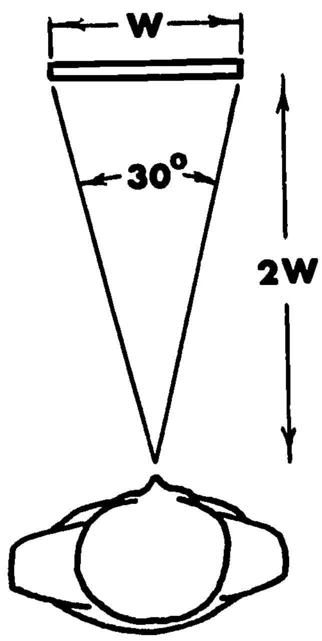
A PERSON CAN PERCEIVE 5 TO 8 CONCEPTS OR DESIGN ELEMENTS PER SECOND. A DESIGN DEMANDING MORE TIME CAUSES A DISRUPTED COMPREHENSION. A MUCH LESS COMPLEX DESIGN CAUSES BOREDOM.

There are others who say that eye movements are directed more by what one looks at than by any particular reflexive scanning pattern. Buswell (1935) and others, recording the eye movements of subjects looking at photographs, clearly showed that there was no specific pattern to their viewing. They concluded that people will fixate on the elements of a visual display that are most interesting and do so in the order of their own personal preference. Eckhard Hess of the University of Chicago recently presented evidence which supports this stand. Hess recorded eye movements and fixation points of both men and women when viewing identical photographs. His results showed them to have different fixation points, indicating that the sex of the viewer will also determine which elements are most interesting. (Life, 1967)

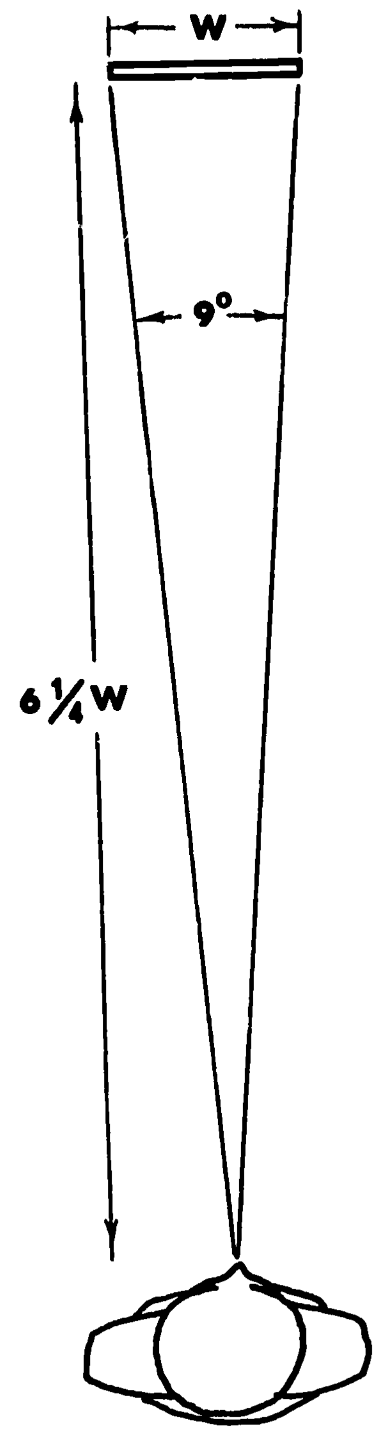
From the above evidence, it appears the reflexive pursuit movements of the eye in scanning space has the configuration of a logarithmic spiral. It is also noted from other evidence that the "informational structure" of the visual field will override this reflexive pattern. It follows then, that an effective visual design would be one that would place the most important visual elements at locations where reflexive fixation would normally occur in an empty field. In this way the two systems, reflexive scanning and eye fixation, would work in concert.

In any case, whatever the view, experimental psychologists have shown that the human organism prefers complexity and ambiguity in its visual field. Relating this to "information theory," we might say that man needs information in order to keep his brain interested in the task at hand. Unless the visual field can offer this complexity, and offer it at a rate that is manageable yet challenging, the viewer is going to lose interest. It makes little difference if this informational display is a set of slides, a bulletin board, or a piece of architecture; unless it presents information and enough complexity for his perceptual field, the human organism will not enjoy his environment. Various research studies involving both grade-school children and college adults clearly showed that they preferred complexity to simplicity in the environment (Rapoport and Kantor, 1967).

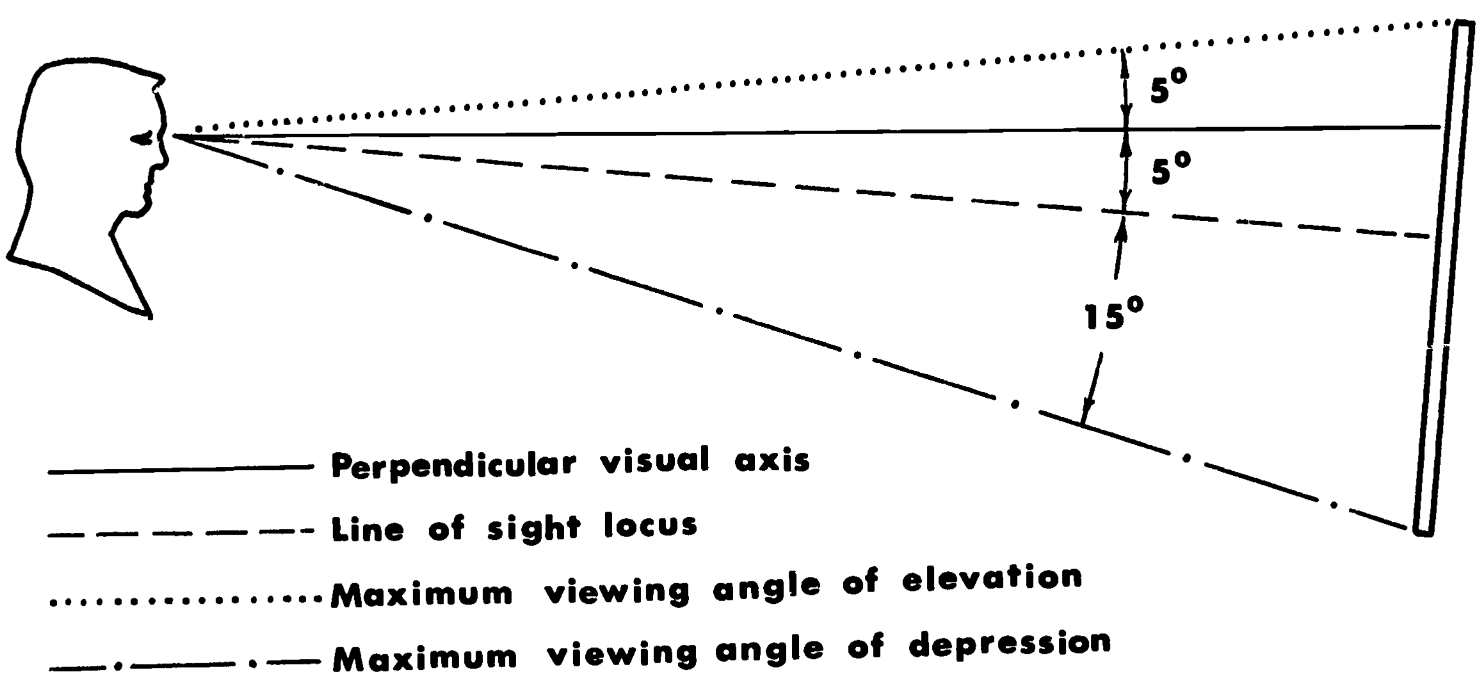
The educator is lucky to have at his command the means by which he may instantly change a generally dull room into one that is dynamic. The reference here, of course, is to the various audio-visual devices he works with each day.



30° Cone of Critical Viewing



9° Cone of Optimum Viewing



Visual Comfort Cone for Distant Tasks

INFORMATIONAL DISPLAYS

Informational displays do not necessarily have to be visual in order to be effective. In fact, there are many cases where a word either printed, projected or spoken is clearly much more effective than a picture. One research study by Wayne Otto (1964) in the area of concept attainment showed that when trying to elicit desired responses from students. the slide caption elephant elicited more desired responses of large, big, size, etc. than did its picture. However, in testing for desired responses via the tactile sense, the picture of a needle elicited more of the desired responses of sharpness, pain, etc., than did the word needle itself.

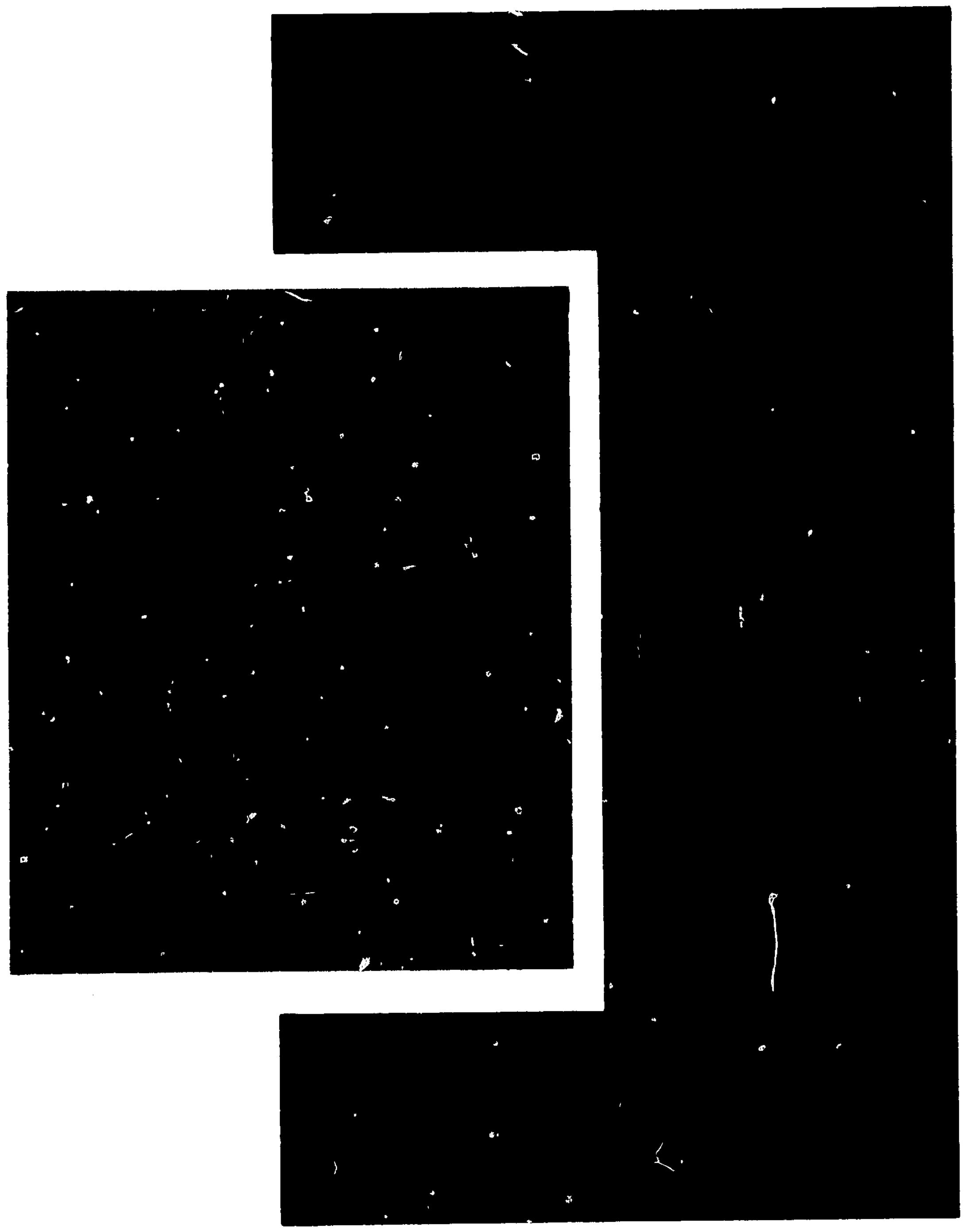
Obviously, the old adage, "a picture is worth a thousand words," does not always hold true. In planning an informational display, we should look very closely and keep the above in mind when deciding whether or not to use pictures, printed words, or a combination of the two if we want to communicate effectively.

THE VISUAL FIELD

Although we possess the ability to perceive objects over an extremely wide visual field covering a horizontal area of approximately 200°, our major visual field (wherein most of our critical vision takes place) consists of a cone of thirty degrees: fifteen degrees each side of center (Carson, 1965). It has been estimated that seventy per cent of all of vision takes place in this visual field; therefore, if we wish for a display to be viewed effectively, the minimum distance at which it could be placed would be 2W.* At this distance, the display would subtend at the eye a visual angle of 30°. For optimum viewing, however, the display should be placed at a distance where it would subtend at the eye a visual angle of 9°.

Eye fixation research by Enoch (1959) using aerial maps of different sizes for "search" tasks indicated that when maps subtended visual angles greater than 9°, fixations tended to be concentrated around the center of the map with few fixations near the maps borders. With maps subtending visual angles less than 9°, there tended to be more fixations outside the display area. A visual angle subtending 9° when transposed into a viewing distance, becomes 6 1/4 W. Audiovisual specialists for years have been recommending the 2W and 6W figures for minimum and optimum viewing distances. The above research supports their recommendation.

*Recommended viewing distances for most visual displays is between 2W and 8W where W represents the width of the display.



BECAUSE OF CHROMATIC ABERRATION COLORS HAVE A SPACIAL QUALITY. REDS APPEAR TO "APPROACH" THE VIEWER WHILE THE BLUES "RECEDE".

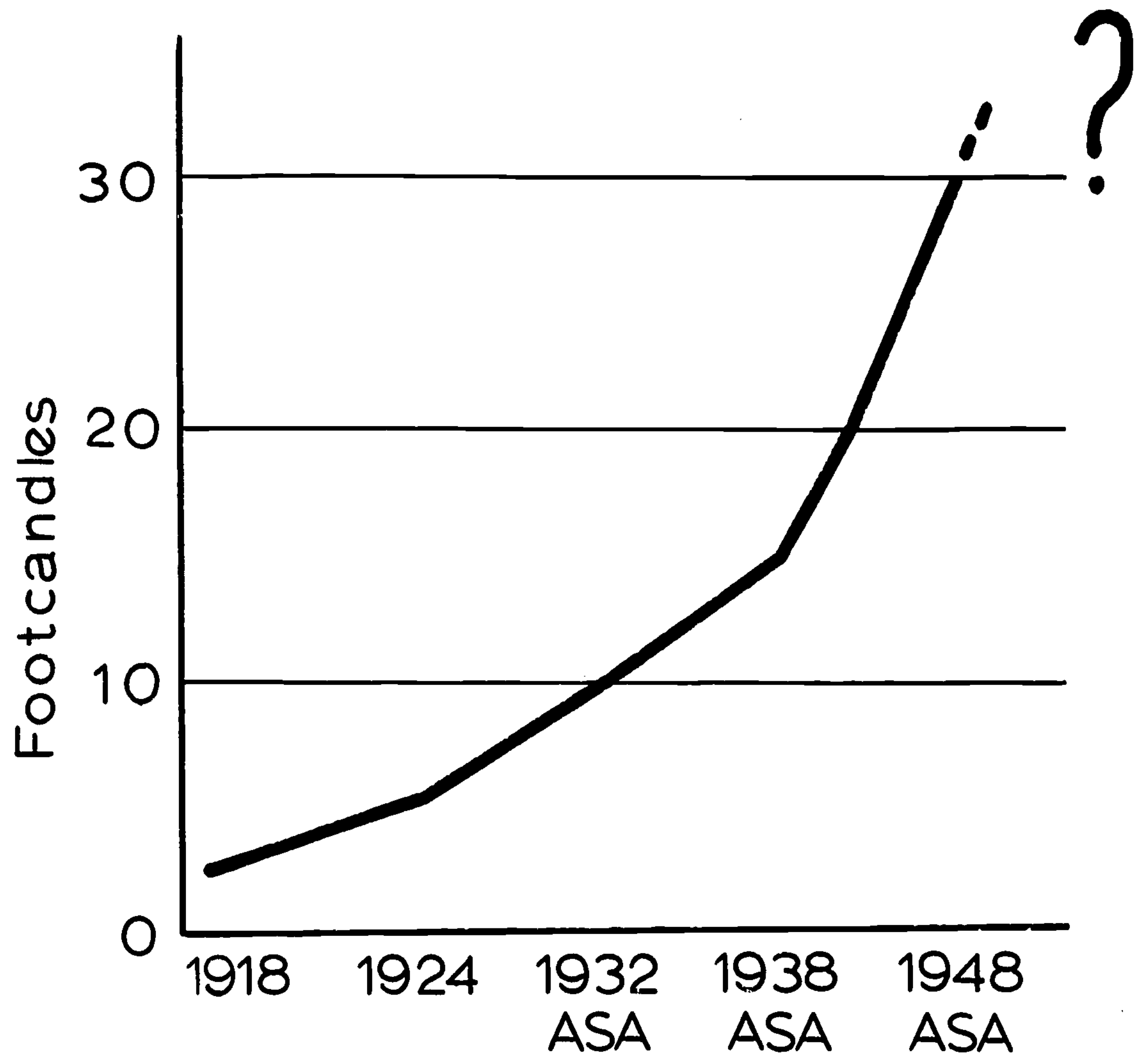
It has been noted that display areas subtending visual angles greater than 30^{o} or viewing distances closer than 2W increase visual fatigue. Weston (1953) in England has shown that visual fatigue is also increased when there is an extreme viewing angle. He has indicated that a viewing angle depressed more than minus twenty-four degrees (for a seated individual; -27^{o} for a standing one) and an elevation angle of a lesser extreme will increase visual fatigue.

COLOR

The combination of two physiological elements, the flexible lens and the curved retina of the human eye, results in an amazing psychospatial effect. This phenomenon, known as chromatic aberration, first caused considerable interest in the middle 1800's when it appeared in Helmholtz's monumental work, A Treatise on Physiological Optics. It is based on the theory that the colors of the visible spectrum fall on different levels of the retina. In order to bring the individual colors into focus, the lens of the eye varies its shape. For example, the colors violet and blue fall in front of the retina, the lens flattens and the resulting effect is that these colors appear to recede. Red and orange, on the other hand, fall somewhere to the rear of the retina, the lens, in this case, grows convex and the result is that these colors appear to approach the viewer. Objects either colored or illuminated by the color blue will appear to be at a greater distance and smaller in size than a red, orange, or even yellow object.

Chromatic aberration is the physiological basis for the psychological effects of colors, i.e., "warm", "stimulating", "approaching", or "cool", "relaxing", and "receding." Color specialists like Faber Birren (1958) recommend that rooms scheduled to be action oriented be decorated in the brighter, warmer colors (i.e., yellow-orange, red) while those planned for quiet activities be decorated in the cooler colors, (i.e., green-blue).

Visual displays such as slides, bulletin boards and dioramas can also make good use of the psychospatial effect of colors by using red and orange to high-light the most important elements and blue to add depth to the backgrounds. Yellow should be used for elements of the display that are to be seen at maximum viewing distance since it is the best color for visual acuity (Ferree and Rand, 1929).

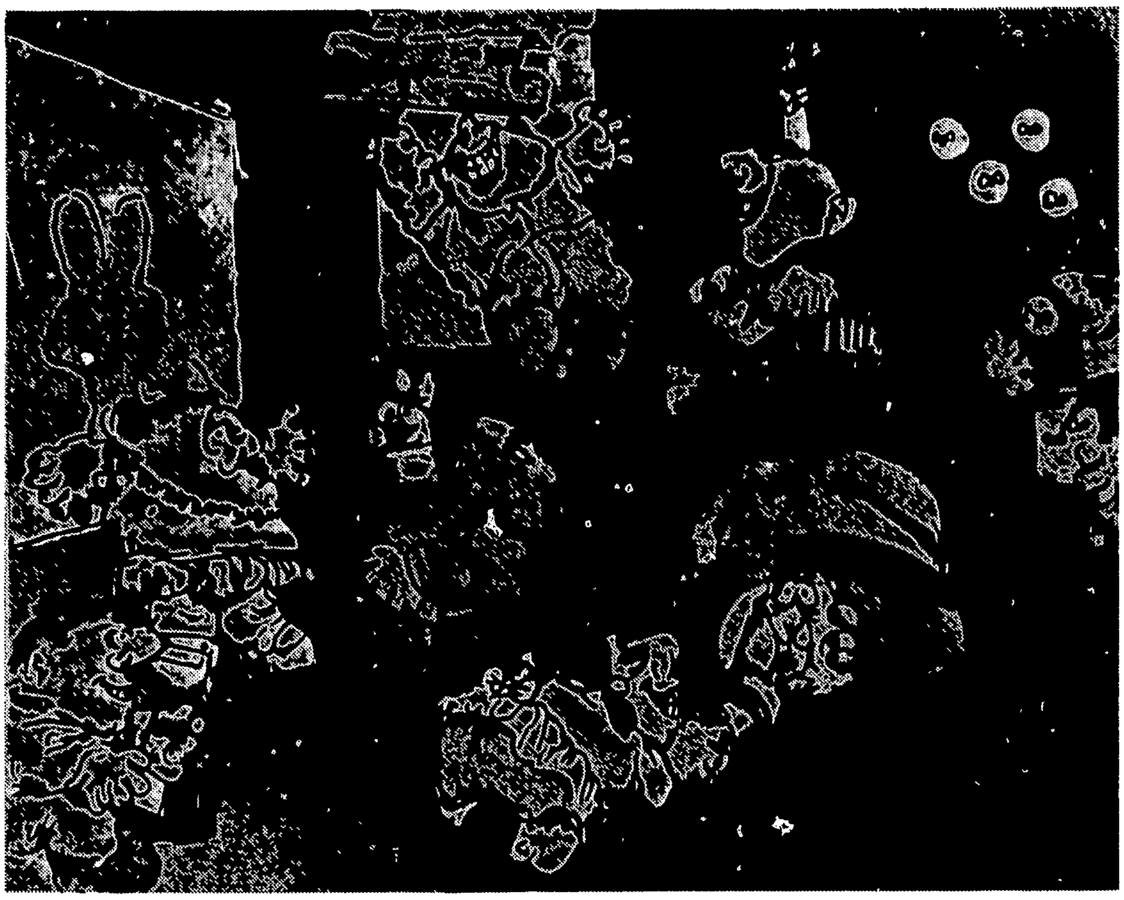


Minimum Recommended Classroom Illumination
(after I.E.S., 1956)

Period	Rec. Illum.	% Max. Visibility NO DAYLIGHT	W/10 fc. DAYLIGHT
1910	3 fc.	78%	88%
1910-30	+15 = 18	90%	92%
1930-50	+12 = 30	93%	94%
1950-60	+40 to 120 = 70 to 150	96-7%	97-8%

INCREASED FOOTCANDLES vs IMPROVEMENT IN VISIBILITY

note: The recent increase of 40 to 120 fc. resulted in improving visibility by only 3 to 4%.
(after Lam, 1964)

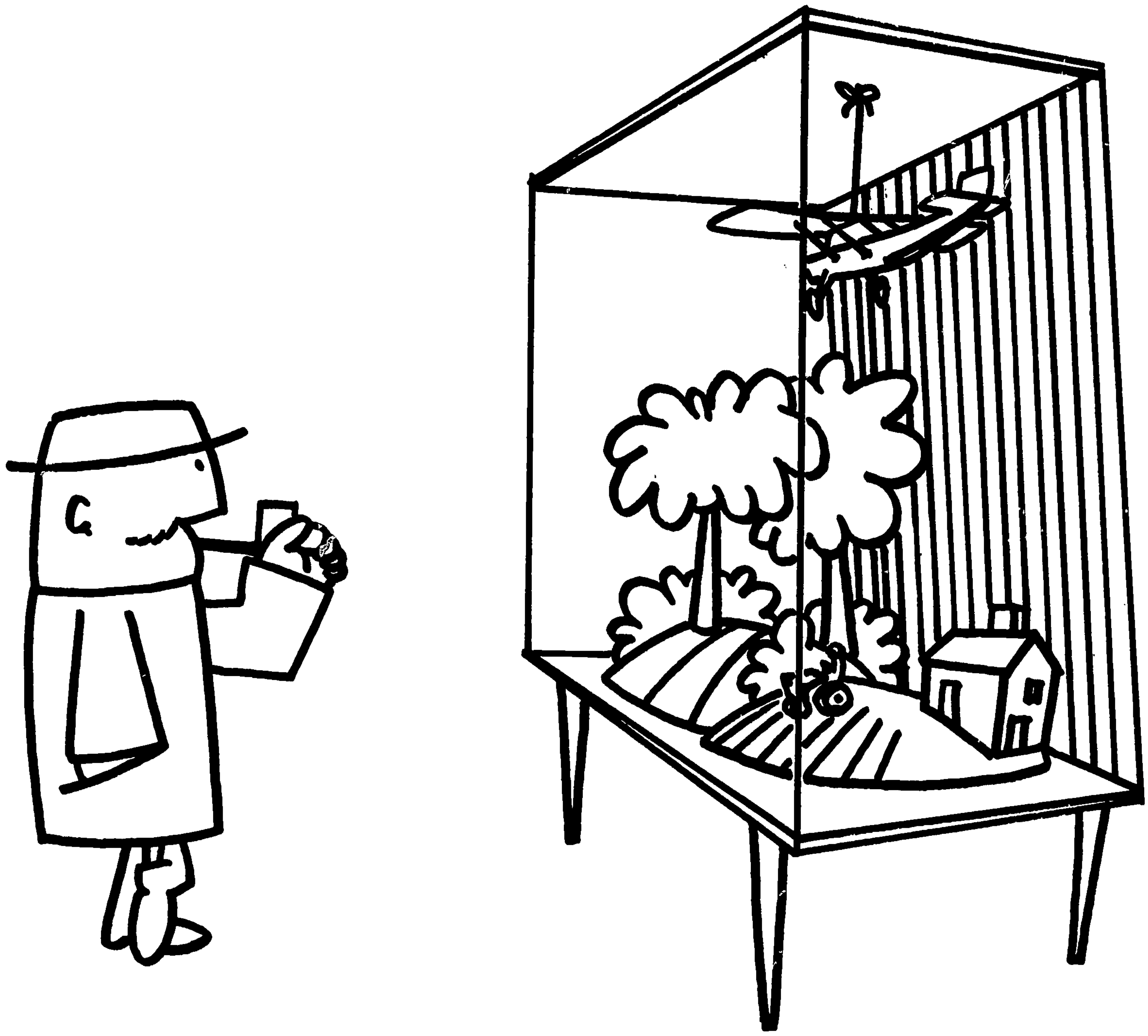


LIGHTING

Perhaps the most important element to be considered in schoolhouse construction is "lighting", yet it is clouded by confusion. Recommendations vary depending upon the consultant. It has been interesting and often amusing to read in the various lighting journals the arguments and counter-arguments of American and English authorities. The English, apparently, have been more interested in the quality of lighting, the Americans in its quantity.

Ever since illuminating engineering became a science, the American lighting specialists have raised their minimum standards. A few observers have commented that this was because many of the Americans were in the business of making light bulbs; others have passed it off as just being a reflection of the "American way of life." In any case, research has established that the quality and the placement of light is more important than its quantity. (Feree and Rand, 1917) (Cogan, 1941)

Although current engineering journals recommend much higher levels of illumination, research indicates that a lighting somewhere between 20 and 50 foot-candles is adequate for the comfortable and effective completion of most classroom tasks. As Tinker (1948) noted, "....data reveal that the visual acuity curve is practically horizontal from 50 foot-candles to the higher levels."



TO PERCEIVE A SPACE IN ITS TRUE THREE DIMENSIONS, THE ILLUMINATION IN THE SPACE SHOULD HAVE A CONTRAST RATIO OF NO MORE THAN 1:10 OR NO LESS THAN 1:3. CONTRAST RATIOS HIGHER THAN THIS TEND TO GIVE DISTORTION AND RESULT IN A LOSS OF THE THREE DIMENSIONALITY OF THE SPACE, AND UNDER 1:3 MAKE THINGS APPEAR FLAT.

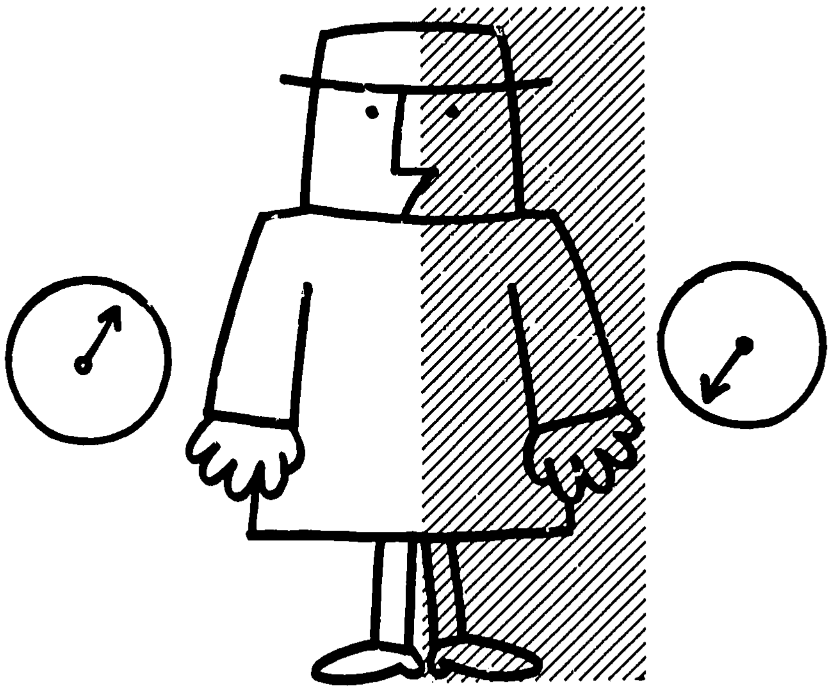
One of the most important qualities of classroom lighting is the Brightness-Contrast Ratio (BCR), i.e., the ratio of the brightness of the central task to the brightness of the "surround" or background. A proper BCR will enable viewers to accurately detect contours, locations, and depth relationships in complete visual comfort. Luckiesh et. al. (1944) noted that the "idealized" BCR was 1:1; that is the object in the central field has exactly the same brightness as the surrounding field. However, in order to perceive depth in three dimensions and still maintain visual comfort the BCR should be somewhere between a minimum of 2.5:1 and a maximum of 10:1. The brightness of the surrounding field should never be as high as the object of the central field The optimum BCR is 3:1, the standard adopted by the Illuminating Engineering Society, based upon the extensive research of Moon and Spenser (1954) and supported by the "blink rate" tests of Luckiesh and Moss (1940).

Those responsible for visual displays should cordinate their lighting so as to produce these recommended brightness-contrast ratios. Classroom lighting should be high,* even, and non-directional.

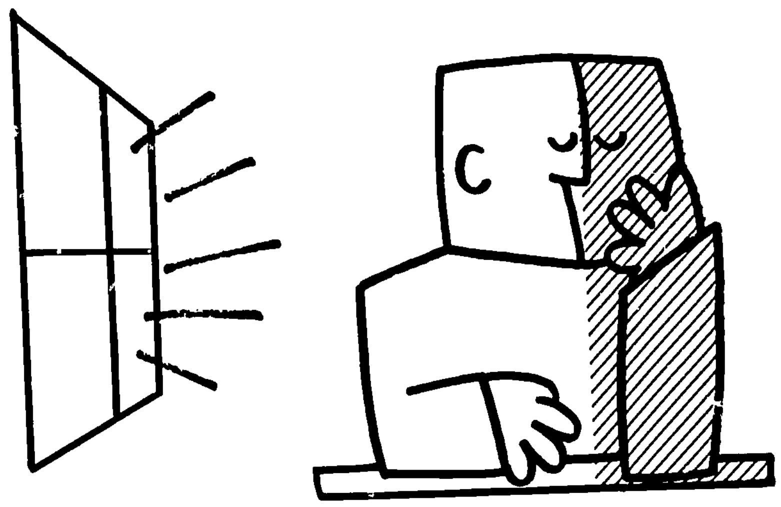
Whatever the level of illumination we choose, it is imperative that it remain relatively constant throughout the work period. Research has shown that visual fatigue increased drastically when the light level in a room alternated from one basic level to another. Infractions of this principle can be seen every time we witness a typical slide presentation in a classroom. Usually all the lights are turned off and the visual field is alternately filled with high illumination and then sudden and complete darkness as the projector's slide-changing mechanism readies the next "visual" to be projected.

"Rear-projection" or the use of Kodaks' new high gain screen are two approaches that could eliminate this problem. Either will make it possible to maintain high ambient light levels and still produce bright sharp projected images. At present the Kodak screen (not in production at this writing) is limited to a 40" x 40" maximum size, but since there is considerable interest being expressed in this screen by the drive-in theaters, we might see the development of larger high gain screens by Kodak in the near future.

*This refers to the placement of the luminaries and not to a particular intensity range.



THE HUMAN EYE IS CAPABLE OF ADJUSTING FROM A DARK TO LIGHT ENVIRONMENT QUICKER THAN FROM A LIGHT TO DARK ENVIRONMENT.



IMPAIRMENT OF VISION CAN BE CAUSED BY A 12% DIFFERENCE OF ILLUMINATION BETWEEN THE TWO EYES.

Several basic ways to control classroom lighting are by: placing frosted glass diffusers under the lamps; reflecting the natural lighting coming through the top sections of windows to the white ceiling and then down to the desks; using light-directional glass blocks or polarized glass for light-emitting spaces at eye level; using recommended paints and trim for classroom interiors.

Another phenomenon relating to the visual comfort and safety is light and dark adaptation. The author's own experimentation has shown that partial yet safe light adaptation takes about 35 seconds whereas minimal dark adaptation takes at least two minutes. Total dark adaptation will take up to thirty minutes.

Flagrant violation of this visual process can be seen daily. A prime example is found on our school sites where students enter a building from the outdoors where the light level is somewhere between 2000 and 5000 foot candles and then immediately face a motor task such as descending stairs where the lighting is less than 50 foot candles. The foyers of buildings should be bright, compelmenting the outdoors if posible, so that dark adaptation is gradual. Staircases should have built in directional high intensity lighting. This lighting should be restricted to outlining the stair's handrails and other important elements showing clearly the stair's configuration and thereby making it easier to follow.

Some classroom lighting environments are so poorly designed that at times an individual seated at a close visually sustained work task is actually subjected to possible physical impairment.

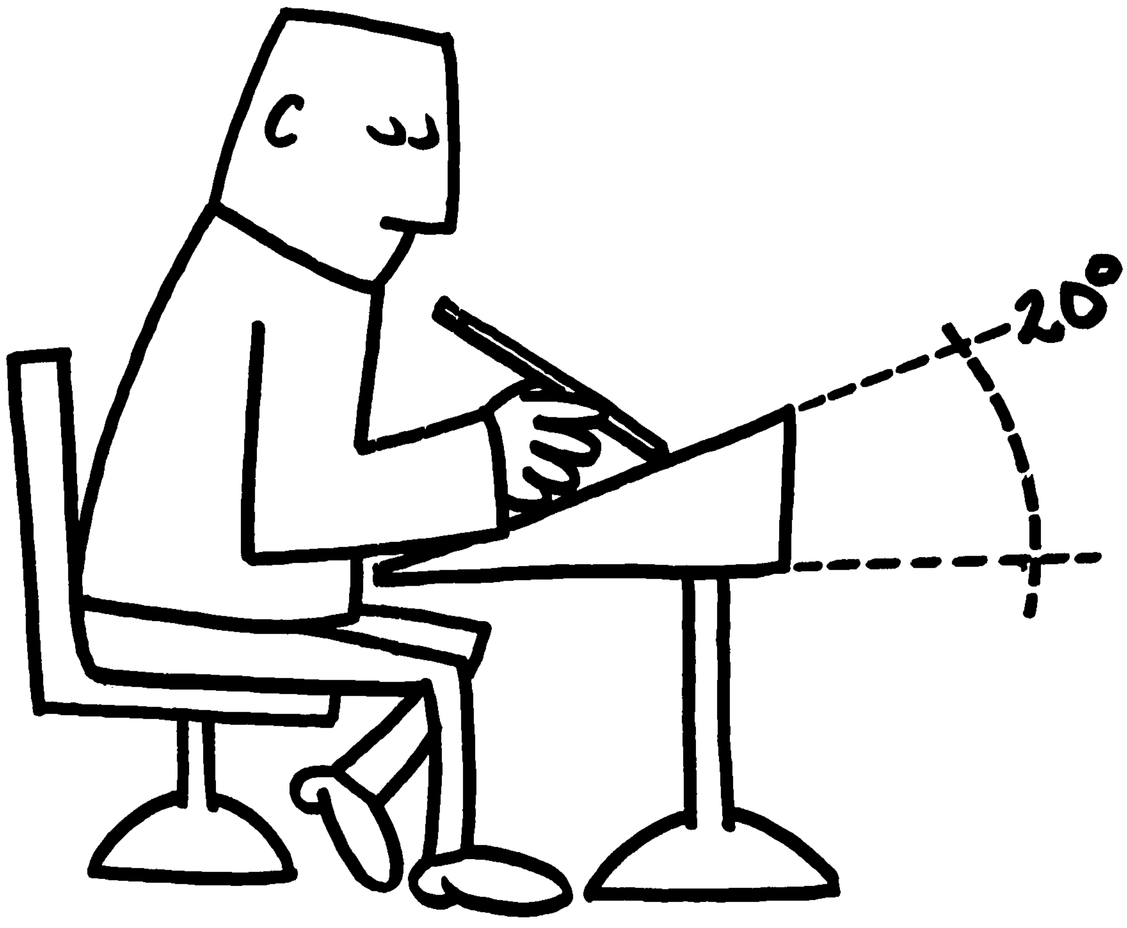
> An established opthomological principle states that a difference in intensity of illumination between the two eyes amounting to over 12% leads to a suspension of vision in one eye which may very well be followed by injuries to that eye. (Harmon, 1951)

A CHILD WILL AUTOMATICALLY ADAPT TO AN ADVERSE LIGHTING CONDITION BY ADJUSTING HIS SEATING POSTURE, THEREBY SETTING UP STRESSES IN BOTH HIS VISUAL AND SKELETAL SYSTEMS.

This often happens when you have an exposed pane of glass which allows light to stream in from one side of the classroom into a student's field of vision. Students automatically adapt to this adverse lighting condition by adjusting their seating posture, using the elements of the body to shield their eyes from the glare. Unfortunately, by adapting in this manner they are altering their angle of view and postural balance. The result: efficient physiological functioning is interfered with, visual images become distorted, energy is wasted, and damaging stresses are set up either in the child's eyes or in his body.

SEATING

D. B. Harmon (1951), in his book The Coordinated Classroom, a presentation of environmental considerations based chiefly on studies in Texas during 1938-1948, offers dramatic evidence of how lighting and posture effects the skeletal system of a child. In an attempt to correct the problems found, Harmon produced a tri-stage desk that coordinated the viewing and postural angles of the student and the seated task. For working on three dimensional objects, the desk top remained level. For reading or writing the desk top was slanted 20^{o}. This desk is a radical departure from the ones found in the typical classroom where the tops are usually inclined only 4^{o} -6^{o}. These relatively horizontal surfaces force the students to bend over their desks thereby setting up stresses in their skeletal and visual systems.

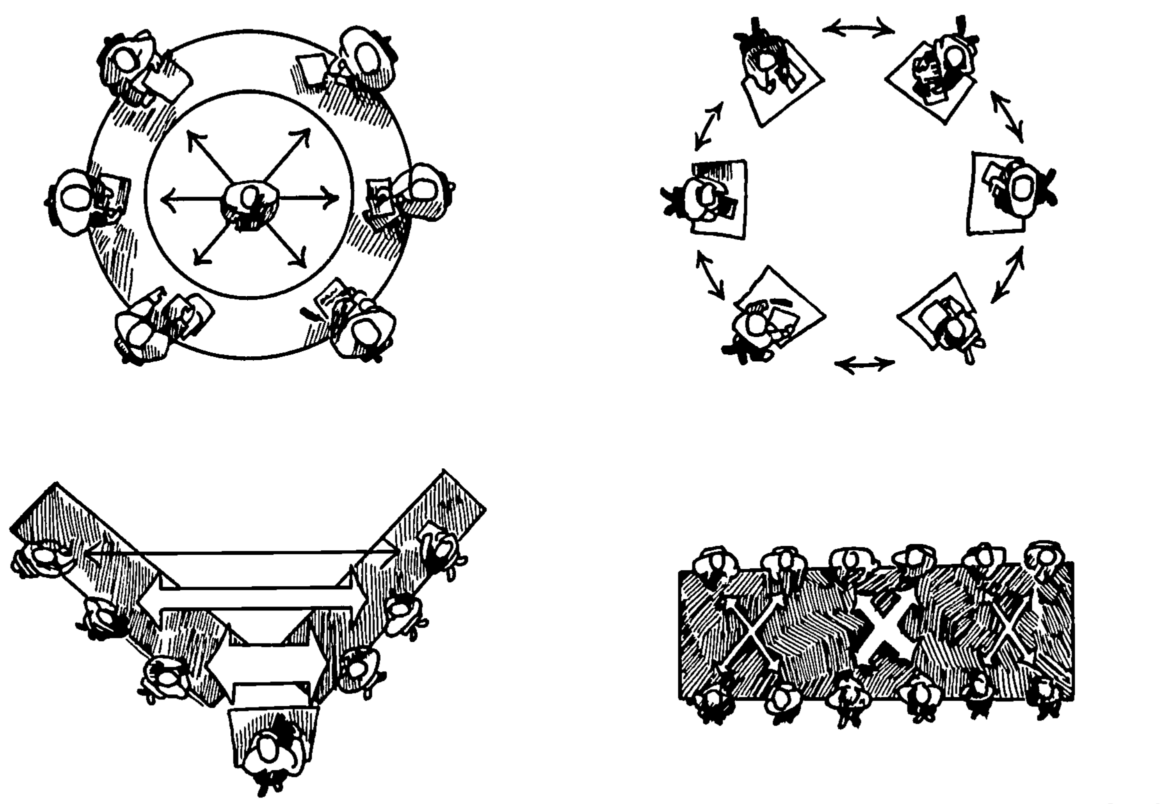


PROPER VIEWING POSITION
FOR CLOSE, SUSTAINED,
VISUALLY-CENTERED TASKS.

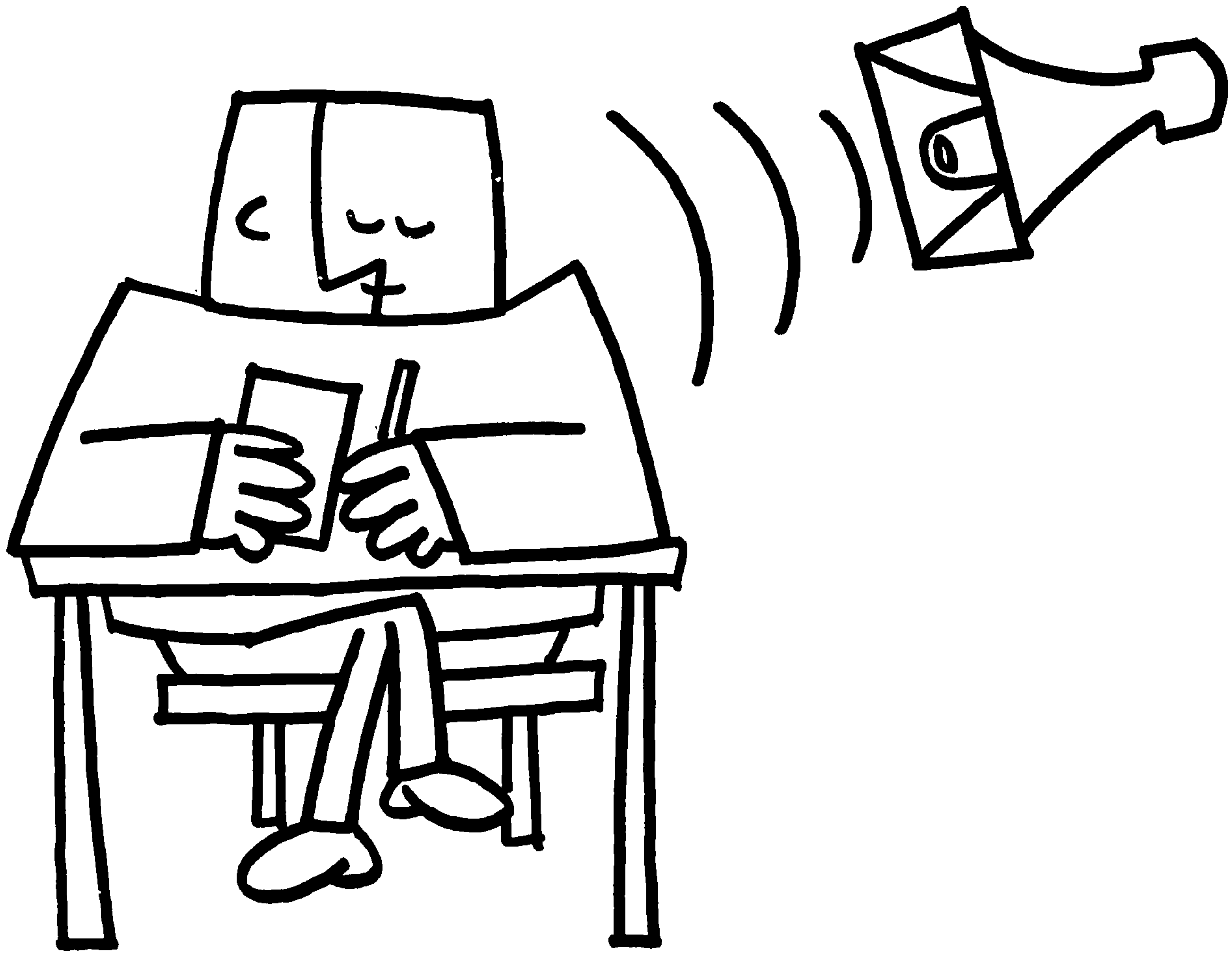
Another aspect of classroom seating that should be mentioned here is its role in student interaction. By the very nature of its configuration, a particular seating arrangement will promote certain types of interactions and retard others. Bass and Klubeck (1952) experimented with different seating arrangements and found that students experienced a greater feeling of equality and uniformity while seated around a rectangular table than one that was either V or Y shaped.

Steinzor (1950), when experimenting with a circular seating arrangement, found that interaction was affected by gestures, posture, and other physical impressions individuals made upon each other. Placement and physical distance were important factors affecting interaction. Students tended to speak to those opposite them rather than to those seated on each side. When there was an authority figure placed at the center of the circle, the group showed more progress and produced a greater number of ideas. However, with this arrangement there was also more dissatisfaction noted (Leavitt, 1951).

It would be well for the classroom teacher to be made aware of these things and other research findings dealing with the ways in which seating arrangements promote or retard social interaction. By linking a specific configuration with an appropriate activity the teacher might well be promoting greater productivity and student involvement.



PATTERNS OF SOCIAL INTERACTION RESULTING FROM DIFFERENT SEATING ARRANGEMENTS



THE ADDITION OF THIRTY DECIBELS OF WHITE SOUND PRODUCES OPTIMUM BODY TONUS NECESSARY FOR ALIGNMENT OF ATTENTION TO A PERFORMANCE TASK.

THE ACOUSTICAL ENVIRONMENT

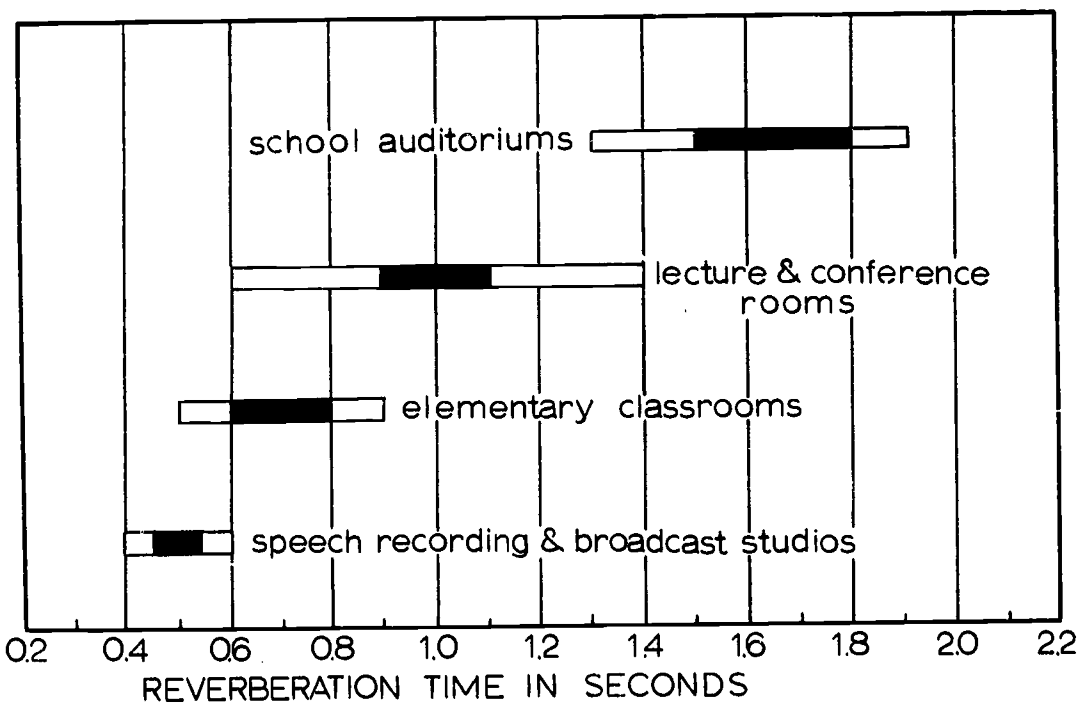
Space does not permit the extensive treatment that the subject of acoustics deserves. Suffice it to say that all forms of acoustical treatment are based upon three basic steps: isolation, absorption, and containment. Sound needs a vehicle in order to travel and isolating the source of unwanted sound by, for instance, placing neoprene pads under a vibrating motor will do much to keep this noise from being transmitted to other areas of a building. The treatment of a noisy space with sound absorbing material such as fiberglass, acoustical tile, rugs, or drapes will help keep reverberation to minimum. However, unless these materials are backed by solid, hard, thick walls they will be ineffective in keeping noises from disturbing adjacent classrooms.

Some kinds of noise can actually be useful in the classroom. "White noise" or full spectrum sound may be used as a "masking" agent keeping students from being disturbed by extraneous classroom sound like talking or traffic, thereby aiding their concentration on the task at hand. Research (Harmon, 1966) on the subject of "white sound" indicates that a level of 30 decibels produces an optimum body tonus for sustained study tasks. White noise sounding something like the rush of an air conditioner generally has a soothing yet stimulating effect. The distribution of white sound in a school plant can often be a simple matter. A number of schools have found it economically feasible to install white noise generators in air and heating ducts, thereby insuring even, building-wide distribution.

PEOPLE TEND TO ORIENT THEIR EARS IN DIRECT LINE WITH THE PATH OF THE SOUND AND POSITION THEIR BODIES TO FACE THE DISPLAY AREA

When using audio-visual aids, the direction of sound is quite important and should be coordinated with the location of the projection screen. The use of audio-visual devices in the classroom presents the student with the unique problem of orientation. In setting up projection rooms the direction of sound and the students orientation to the projected visual display should be coordinated. Research (Ryan, 1940) indicates that people tend to orient their ears in direct line with the path of the sound and to position their bodies to face the display area. Loudspeakers should be placed next to the projection screen or at the rear of the room in a direct line with the projected image in order to promote sight and sound orientation.

When making tape recordings teachers should be aware of the difference in reverberation time* between different classrooms, for these will affect the intelligibility of the tapes when they are played back. An excellent example of this problem can be heard when a recording made in a studio or classroom having a short reverberation time is played back in an auditorium or classroom having a long reverberation time. In such situations words seem to run into each other, pauses are lost and speech unintelligible. A teacher can easily compensate for this by making a concerted effort to slow down his speech when recording in a relatively "dead" room.



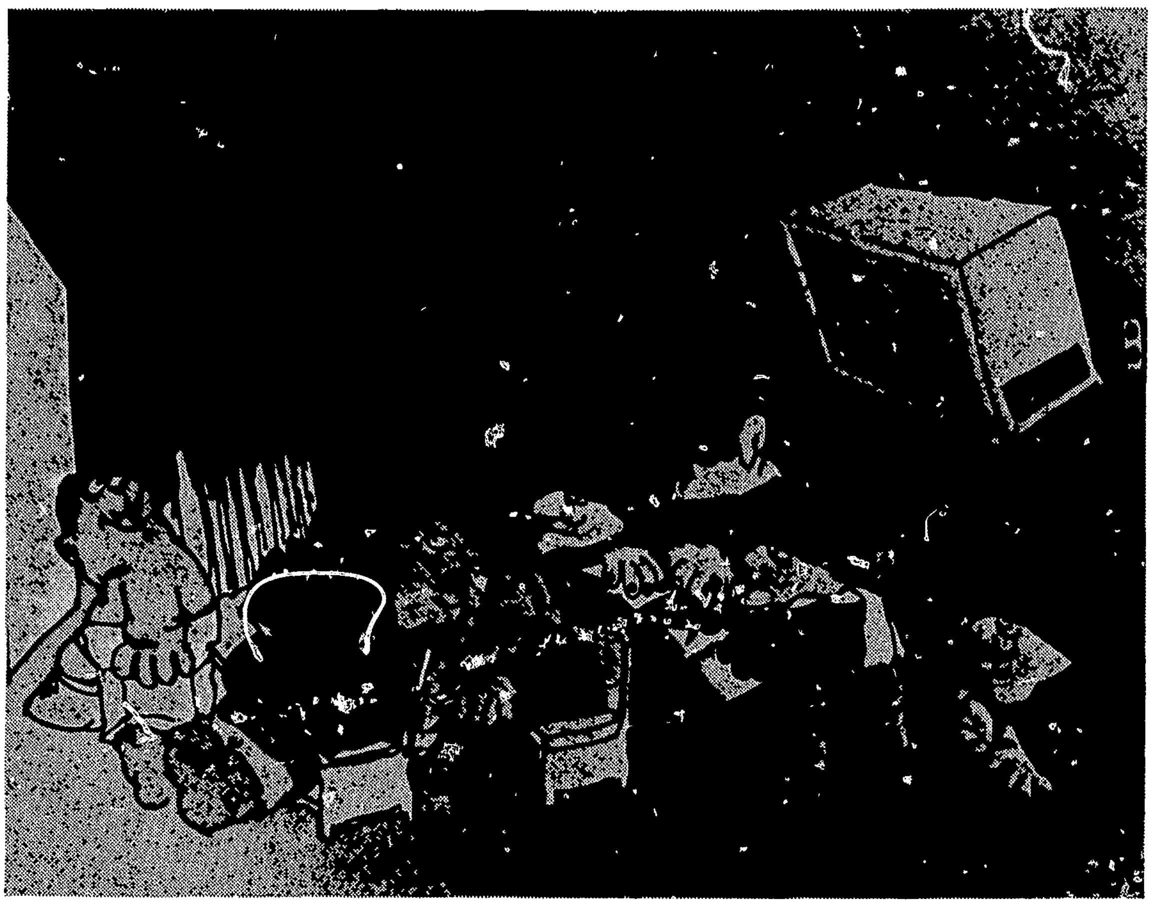
SAMPLE REVERBERATION TIMES FOR DIFFERENT ROOMS

*Reverberation time--the time a sound persists after its source has been cut off.

Influence of High Temperatures on Some Tasks

Task Description	Maximum Temperature (F) for Normal Performance	Demonstrable Impairment at this Temperature (F)
Typewriter code (scrambled letters)	80	87
Locations (spatial relations code)	80	87
Mental multiplications (problems)	80	87
Number checking (error detection)	80	87
Pursuit (visual maze)	80	87
Lathe operation (hand coordination)	80	87
Morse code reception	87.5	92
Block coding (problem solving)	83	87.5
Visual attention (erratic clock test)	79	87.5
Pursuitmeter	87.5	92
Reaction time (simple response)	93	..
Motor coordination	64.5	91

(After Eckenrode and Abbot, 1959)
as reported in SER 2, 1965



THE THERMAL ENVIRONMENT

The four basic factors of thermal environment are radiant temperature, air temperature, air velocity, and humidity control. The amount of radiant temperature necessary for comfort will vary with a student's age, sex, level of physical activity, clothing density, and adaptation to local climate. An older teacher, for example, would find an optimum comfort level at a higher temperature than the younger, more lively student (NCSC, 1965).

Unfortunately there are not many studies available concerning the optimum classroom temperature for children. One such study that does exist, however, was conducted in Canada by Partridge and MacLean (1935) and indicates that the optimum temperature in summer for students is 70.5° fahrenheit with a relative humidity of 50% or a dry bulb temperature of 75.5°. In winter this optimum temperature changes to 66.5° F with a relative humidity of 35% or a dry bulb reading of 71°. This, however, cannot be accepted as a rigid recommendation, for thermal needs are quite individualistic. A study by the Environmental Physiology Committee of the National Academy of Sciences showed that radiant temperature needs varied with different individuals.

In a classroom of young children, a rule of thumb to follow would be for the teacher to wear a sweater or jacket and then set the temperature for her comfort. The children, because of their higher rate of metabolism, should now be comfortable in their shirt sleeves.

CONCLUSION

In conclusion, we have discussed environmental design principles which, if followed, will help us establish the optimum schoolhouse environment. We are fairly certain that the human organism will be healthier and more productive if we follow these guidelines. However, it is possible that by rigidly following optimum standards and specifications without providing for the element of variation, we risk producing a static environment. This can, by its very nature, be adverse.

A California study supports the above statement:

> A group of men with cholesterol levels two to four times that of normal individuals were removed from their usual environment of office deadlines and urban activity and "rewarded" with a noncompetitive existence of a Pacific cruise. Diet, exercise and heredity factors remained unchanged, but the cholesterol levels of the subjects fell to normal. Upon return, their levels rose within 24 hours to the previous pathological high. (Hanson, 1966)

Recently there has been a concerted effort by schoolhouse designers to include variation in schoolhouse design. One such architect is John Andrews. His Scarboro College is so designed he says, that "it changes color and feel when it rains or when the sun shines."

Simulation (projected images) can help provide this variation in the environment. Artist Harley Parker has recently designed a gigantic environmental display at the Royal Ontario Museum. His new display includes the smell of the sea, the noise of thunder, sand under foot, and fossils and rocks people can touch. The emphasis, he says, is tactility. This approach is also being pursued by the U. S. Department of the Interior with their National Seashore Awareness Centers.

Another way in which environments can be simulated is through projected visual scenes. The June, 1967 issue of Progressive Architecture devoted a whole section on simulated interior environments under the title, "Instant Interiors."

> Sleep and instant dreams now turned on environments are products of our instant age. Why not? For special occasions we can change a room simply by flicking a button on a new projected transparency: one day the Sistine Chapel; the next a sunset scene beneath fall foliage; when guests come, the lambent light of a lingering meteor. It is an instant planetarium--but on home or office ceilings.

Why couldn't this approach be applied to the design of our classrooms? Why couldn't our architects design classrooms to take on one configuration and appearance, for example, when students are studying math in the morning, and after recess time change to reflect a whole new environment, maybe one that compliments the subject area about to be taught. In the future, the science of holography may help us by providing some realistic three dimensional environmental settings with which to work.

Finally, our schoolhouse environment should provide stimuli which continuously vary within permissible parameters of a coordinated classroom. The diversity of the classroom and schoolhouse exteriors should be promoted while physiological and psychological considerations are integrated into its design. Administrators, teachers and, in particular, schoolhouse designers, should acquaint themselves with the results of environmental research in order that they may produce this integration. Winston Churchill once said, "We shape our buildings and then they shape us." If this is true, and it is the author's belief that it is, then there is no design area that needs our immediate attention more than does that of the schoolhouse.

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