RICE UNIVERSITY

VISUAL SIMULATION IN TIME

by

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ABSTRACT

Architectural design has always been limited to static procedures of study. The means of study has a profound effect on the shape and form of the result.

The discovery of perspective drawing during the 15th century had a strong influence on Renaissance architecture. Buildings and spaces were designed to be seen from static, fixed viewpoints. Space was regarded as a two-dimensional or pictorial composition.

Today we are witnessing the effect on architecture of another media: the chipboard model. Buildings are springing up with blank planes of natural concrete and detailing that makes them look like blown up chipboard models.

Motion is becoming an ever more important factor in architectural design as the architect must deal with spaces through which the viewer will be moving at a specific rate of speed (flying, driving, walking). Space can no longer be thought of as pictorial, from a static viewpoint. The fact that the viewer is moving and that he is moving at a given rate, not only has a profound effect on the way the spatial envelope is perceived, but on the way a building itself is perceived.

This paper describes a tool, developed at Rice University, which enables the architect to study, represent and communicate his designs in terms of movement.
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I. INTRODUCTION

Throughout the history of architecture, the problem of designing spaces has been a major concern of architects. "Space experience" began with Romanesque churches when architects went beyond just building a structure that would stand up and provide shelter, and started trying to achieve a spatial effect. Their concern was not with space for human accommodation, but with space to produce an emotional effect. The builder's desire was to represent the dominant, overwhelming spirit of God. Humans hardly belonged there.

During the Gothic period this idea of space forming was developed to its highest degree. The effort to create soaring, awe-inspiring spaces forced architects into great feats of structural ingenuity and sometimes went beyond the limitations of materials and construction methods. For instance, Beauvais cathedral collapsed several times during construction and was finally completed in a drastically revised form.

With the Renaissance came a greater recognition of human needs in architectural design. Spatial design was shaped largely by the invention of a new tool in the representation of space: the perspective. The perspective enabled the designer to represent a three-dimensional space on a two-dimensional surface in a mathematically precise manner. However, to think of a space as seen from a static viewpoint, as is necessary with a perspective, is to treat it as a two-dimensional composition. The way a designer thinks of space and can communicate it to others
Illust. 3 - Static

Illust. 4 - Dynamic
determines an architectural space. Renaissance spatial design, based on the perspective, became a series of "pictorial" spaces designed to be seen from specific, stationary points. This static view of space and architecture remains to this day one of the major determinants of architectural and popular thinking.

"Art, the graphic translation of culture, is shaped by the way space is perceived. Since the Renaissance, the Western artist perceived his environment in terms of the visual. Everything was dominated by the eye of the beholder. His conception of space was in terms of a perspective projection upon a plane surface consisting of formal units of spatial measure. ... This view is deeply embedded in the consciousness of Western art. (McLuhan, The Medium is the Massage)

The modern architect is becoming more and more dissatisfied with a static, "pictorial" conception of space. This can be seen in the greater reliance on three-dimensional models in place of the perspective in architectural studies. The designer has become concerned with three-dimensional space, a surrounding envelope (but not necessarily interior) through which the viewer moves. And today movement, and the speed of movement (airplane, automobile, monorail, pedestrian) are becoming ever more important in the shape and form of architectural spaces.

Designed spaces, incidentally, are not limited to interior spaces, like space capsules, automobiles, and rooms. They include on an increasing scale: the space between buildings, defined by groups of buildings, bigger and bigger to the scale of the city. All these spaces, closed or open-ended, have one thing in common: they are architectural spaces and should be designed for the purposes they serve, whether a hallway or an airport approach. If the architect is to design these spaces, he must have adequate means to conceive of,
FIG. 18.25 The horopter apparatus used for an observation distance of 6 meters. Only seven lanes are indicated. (From Ogle, 1950.)

Illust. 5 - The psychologists' approach
study and represent them, in the manner that they will be perceived and used: in movement.

Until recently, most research into space perception was conducted within the limited interests of either psychologists or painters. Psychologists were concerned with how the human being can extrapolate a three-dimensional world from a two-dimensional retinal image. The painter's problem was similar, how to create the impression of depth on a two-dimensional canvas. Both types of studies were based on the idea of depth -- from here to there, or from there to there, as opposed to the concept of a spatial envelope, encompassing and surrounding.

Architects rejected depth perception studies as a solution to space perception. They devised, instead, an elaborate descriptive vocabulary of their own. Interpenetration, balance, inner constitution, spatial sculpture, modulation, rhythm, delicacy, space emanation -- these are marvelous connotative words, but only descriptive and not definitive.

In 1950 J. J. Gibson proposed his gradient theory of space perception and in 1966 E. T. Hall published a book on spatial experience and reaction, based partially on Gibson's theory. They are, respectively, *The Perception of the Visual World,* and *The Hidden Dimension.* These two books made the first progress toward a complete psychological theory and definition of space perception that is useful to architecture.

With these theories as a basis for understanding and conceiving of space, the missing link was a medium to represent this new conception of space. The architect must have a means to study and communicate his design in visual terms. A perspective can only represent space from a
static point of view, and can never indicate movement through space. A scale model can better indicate three-dimensional space, but still does not allow the viewer or designer to move through the space.

Motion becomes an important factor in an architectural design as the architect must deal with spaces through which the viewer will be moving at a specific rate of speed (train, car, walking). The fact that the viewer is moving and that he is moving at a given rate, not only has a profound effect on the way the spatial envelope is perceived, but on the way the building itself is perceived.

This paper describes a tool which enables the architect to study, represent and communicate his designs in terms of movement. This paper does not propose a solution to a new form of architecture based on movement. But if the advent of the perspective caused the shape of Renaissance architectural space and chipboard models can be credited with producing their counterpart in planar, natural concrete buildings, then it is hoped that a media based on a fact of space perception and the reality of movement, with judicious use, will produce a more beneficial mark on architecture.
II. THE VISIT SYSTEM

Concept

VISIT, Visual Simulation in Time, is a system that enables an observer to see a scale model from the eye level of a scale person. The system also allows movement through the spaces of the model at scaled-down walking, driving or flying speed. Viewing what a periscope "sees" is usually by closed circuit television. Obviously, the dimension that has been added to previously available means of studying architecture is time, or in practical terms, movement, hence: Visual Simulation in Time.

Physically, VISIT consists of three elements: the "snorkel", the transport, and a viewing system.

The "Snorkel"

The "snorkel" is a high grade optical periscope, adaptable to several kinds of viewing devices. It gives roughly a fifty-five degree horizontal angle of view and about a forty-five degree vertical angle (with the TV format). It transmits the equivalent light of an f/45 aperture when adapted to accept a thirty-five millimeter camera. The lens has no diaphragm. The measured ratio of the diameter of the lens opening to the focal length \( f/\text{stop} = \frac{\text{diameter of opening}}{\text{focal length}} \) would indicate a much faster f/stop, but much light is lost in the optical system and adapters. With a sixteen millimeter television or movie camera fitted, the effective exposure is greater due to the smaller area of the film plane, about the equivalent of f/16 or f/22.

The optics have an integral focusing arrangement and an adjustment to change the angle of the objective or lower mirror. By tilting this
mirror, the lens is able to "look up and down" as a person would nodding his head or rolling his eyes up and down.

**The Transport**

The Transport system is comparable to an overhead travelling crane. The snorkel hangs down from the moving carriage. A beam which spans across the room moves up and down the room on tracks. The carriage moves back and forth across the beam. These two movements provide "X" and "Y" directions and combining the two will produce angular or curvilinear movements. The camera and lens are mounted on the carriage via a turntable that allows 360° rotation about the optical center of the lens.

At this time, the "Z" or vertical movement of the lens is limited to adjustment for working level. This cannot successfully be changed while formal viewing or recording is under way. Installation of a more versatile "Z" movement is being undertaken to allow the snorkel to change vertical levels simultaneously with horizontal movements.

The transport and mirror tilt provide every direction of movement a human eye might be subject to except sideways tilting. However,
simulation of the way a person sees is not the object of VISIT. The goal of the transport was to provide any direction or combination of movements. It is important to recognize that VISIT is not an attempt to copy human vision. It is only a medium of communication. This point will be discussed more thoroughly later.

**Viewing Systems – Television**

The basic viewing system for VISIT is television. Television has a great many advantages, the most important being instancy. It offers live television viewing and videotape recording which can be replayed immediately or stored for any future date. If storage is not desired, a videotape can be erased and re-used like any magnetic tape. The use of videotape has great implications for architects, because the backlog of tape time is comparable to a sheaf of yellow tracing paper studies — quick to produce, available at any time for re-study and comparison but finally disposable.

Television can be transmitted (in this case by wire) to audiences in remote locations. Sound can be recorded onto the videotape at a later time than video recording, which allows selection of music, sound effects or narration. Some of the psychological implications of the television medium will be discussed later in the paper.

Television has some disadvantages, too, for instance: the relatively great initial expense of television equipment, even the simplest components; the lack of interchangeability of videotape-recorders, not only between manufacturers but between machines of the same make; the greater complexity of machinery and maintenance problems; the difficulty of moving the viewing components and setting up a presentation elsewhere; the general scarcity of closed-circuit
Illust. 7 - VISIT studio taken with fisheye lens
television equipment, although many schools and industries are installing CCTV; the inability to serve large audiences except by multiplication of monitors, until a good, economical projection device becomes available. Most of the disadvantages of television are technical problems of a new media. With time, technical advances and lower prices will probably bring television equipment within the amateur market. Increasing popularity in the future will negate many of the present disadvantages of the system.

**Viewing Systems - Motion Pictures**

The other viewing medium that can make use of the full potential of VISIT is the motion picture. This medium has the advantages of interchangeability of projection equipment, inexpensive color and projection for large audiences. Films need to be edited, and spliced, therefore tending toward a formal type of presentation. While more polished, films lack the spontaneity and inherent aliveness of television. The biggest consideration is time. Films necessarily must be processed, edited and spliced, the time factor, depending on the available facilities, varying from a day to weeks. Television can be replayed in the amount of time it takes to rewind a few feet of tape.

Motion pictures offer a much smaller initial and maintenance cost than television. Operating costs are probably about the same if videotapes are stored.

Viewing through the movie camera while in operating poses a problem with the present set up. It is difficult to see through the viewfinder of a reflex camera due to the small amount of transmitted light and the inaccessibility of the camera on the transport. An
auxiliary viewfinder system could be rigged, but this would not tell you exactly what you were getting on the film. When you are dealing with a model where a fraction of an inch represents a foot, a viewing parallax of only a half an inch becomes a big factor. The parallax problem can be solved with the use of a beam splitter (prism or semi-mirror) which directs half the light to a television camera and half to the movie camera. Besides, duplication of viewing systems, this solution aggravates an already vexing problem: providing enough light for proper exposure.

Sound can be added to movies by simple magnetic stripping of the film itself or by the use of an auxiliary sound tape recorder.

A further comparison of television and motion pictures will be undertaken in the section on Space Perception.

Miscellaneous Uses

There are some ancillary uses for VISIT which do not make use of the movement potential of the system. These are listed below but will not be dealt with in depth because they are simply concessions to older media and offer nothing new in the representation of space.

1. Perspective layouts over the monitor screen. The VISIT system allows the designer to select the best view of a model by live viewing, sketch a quick layout on clear plastic taped to the screen and use this layout to construct his final perspective. This takes some of the guesswork out of selecting viewpoints and cuts down on the mechanical construction tedium of perspective drawing.

2. Perspective layouts from Polaroid pictures. Polaroid prints or positive transparencies can be quickly made from the monitor. These can be projected later by opaque or lantern slide projector for
Illustr. 9 - Photograph taken through the "snorkel."
perspective layouts. This offers the same advantages as "1", but with less effort. A series of prints can be mounted on boards for presentation as long as they are kept small in size. A television image is generally not good enough to be accepted as a still picture if enlarged very much.

3. Still photographs through the snorkel with a thirty-five millimeter camera. Using a camera adapted to the snorkel allows views of tighter spaces than by using the camera straight. The photographer pays the price in poorer quality pictures. The snorkel simply cannot match the sharpness and resolution of a fine, conventional lens. (see illustration). There is some central fall-off, decided edge fall-off and noticeable barrel distortion. This is disturbing when examining a still photograph but barely detectable on the television screen. In general, the photographer's efforts to make physical room for his camera on the model or selection of viewpoint will pay off in considerably better quality pictures.

4. Viewing with an eyepiece. This method of viewing is mentioned here simply because it is not very practical. It is possible, but difficult. The problems are the same as with the reflex movie camera: inaccessibility and low light level. Of course, only one person can see at once and what is seen cannot be recorded.

Note that all these uses, except the last, in making concessions to existing media have negated the most important potential of VISIT, movement. All of them can be done as well without the VISIT system or by the use of a small periscope.

The one concession that VISIT is forced to make, is to the printing media. An adequate, but ineffective, idea of the impression of space
Illust. 10 - Taken by a camera with a focal plane shutter.
and movement VISIT provides can be achieved with a sequence of photographs. These can be shot through the snorkel or taken off the screen. Photographs of the screen indicate the television medium and are easier to make. * The effect can be seen from the series included in this paper.

* Still photographs of a television screen must be shot with a camera fitted with a leaf-type shutter. A focal plane shutter produces a diagonal streak on the negative, due to the directional motion of the shutter and the scanning of the television's electron beam.
III. SPACE PERCEPTION

This section deals with how the eye perceives space in a three-dimensional visual world and how space can be similarly perceived from a television screen.

It is a marvel that we are able to see and judge space at all. But a more amazing phenomenon is that the human eye can interpret a moving pattern of grey tones on a television screen as a recognizable scene with three dimensions.

While reading this section it is necessary to keep in mind how VISIT is functioning. The lens projects an image of a scale model (which is a copy of the real world) onto a vidicon tube. The image is transmitted and enlarged electrically onto a television screen. Here, our eyes see a pattern of grey tones and interpret them into a meaningful impression of the real, full-scale world. The television screen, then, must contain many of the same correlates\(^*\) to the physical world as an actual retinal image. However, VISIT provides, at best, an imperfect representation of the visual world and many correlates are lost. This section will deal with what these correlates are, the ones reproduced by VISIT, the ones missing and the effect on the resulting space perception.

* The term "correlates" comes from Gibson's vocabulary. It refers to the correlation between the real "visual world" and the "visual field" of the retinal image. ("Visual world" and "visual field" are also Gibson's terms.) Gibson uses this term to avoid the idea that the retinal image is a copy of the "visual world". He also wishes to avoid the connotation that the "visual world" itself somehow mysteriously stimulates the eye.
Illust. 12 - Spaces are defined by surfaces. Surfaces are defined by textures.
Gibson's Gradient Theory

Space perception is hardly a cut and dried topic of psychology as yet. Most of the present theories seem to have large gaps or deal with specific phenomena, unrelated to each other. However, J. J. Gibson's theory is complete and well thought out. It includes most of the percepts of the widely accepted "Cue or Clue" theory but places them in a new perspective. His book, The Perception of the Visual World, published in 1950, explains his theory. E. T. Hall says: "What Gibson has done is to analyze and describe the system and the component 'stimulus variables' which combine to provide the information man needs in order to move about effectively and do all that movement implies on the surface of our globe. The important thing is that Gibson has given us a complete system and not just unrelated parts." (The Hidden Dimension).

Gibson's Gradient Theory is based on the assumption that variations in stimuli arise from gradients in a continuous background, not the differences in stimuli of two objects. This implies that you can't abstract space perception studies away from the background of the visual environment and into the isolated situation of the laboratory. Surfaces are the basic elements of vision. The image on the retina, or Gibson's "visual field", is not a copy of the visual world. It merely contains correlates to the properties and relationships of surfaces. These correlates are interpreted by psychological processes of the eye and mind, mediated by past experience, into a visual sensation of space. These correlates of the visual field to the visual world are what Gibson has tried to identify. He refers to them as gradients because, in a visual world with a continuous background, these indicators tend to be
Illustr. 13 - Perspective of Texture
The following is a list of gradients as they are ordered in Gibson's book. I have added comments about each gradient's contribution to VISIT.

The list generally can be divided into two types of stimulus variables: perspectives, or impressions of depth along a continuous surface; and sensory shifts, or breaks in a gradient at an edge or contour. The list then breaks down into four categories: a) Perspectives of position; b) Perspectives of parallax; c) Perspectives independent of position or motion; and d) Depth at a contour.

a) Perspectives of Position

1. Texture Perspective.

Texture is considered by Gibson to be the basic quantity in the vision of surfaces. One cannot see any surface, or anything at all, in a completely homogeneous situation. The "ganzfeld" is the term for this situation. Hochberg accomplished a ganzfeld by placing half a ping pong ball over each eye. You might as well be in the dark.

Surfaces are seen because they have texture. A surface is seen as slanting or in depth because of the increasing density of texture with increasing distance (see illustration 13). A nearby texture is coarse, a distant one, fine. Texture perspective is intimately linked with the next two gradients, size and linear perspective, but Gibson claims it as the basis for depth perception along a continuous surface like the ground or floor plane.

In terms of VISIT, only the most coarse of textures can be defined by the television image. This means textures like cardboard, sand, wood, and other common model making materials are likely to reproduce as a
smooth gray tone on the screen. This is an advantage because it doesn't look like a model. It is a disadvantage because it means that only fairly gross construction details like mortar lines, expansion joints, reveals, window mullions, can suggest the building material instead of what is usually thought of as texture. For instance, the usual method of representing concrete is with a slightly rough surfaced cardboard. Expansion joints and form lines are omitted. To "read" as concrete on television, the joints and inlines must be emphasized.

2. Size Perspective.

This gradient simply states that relative object images projected on the retina get smaller as the distance of the objects increases. This follows the geometric laws of perspective. There is a hazy overlapping of "texture" and "objects" except objects tend to be made up of surface textures. (See illustration 15 ).

One of the often stated "cues" to depth perception is "size constancy", or the tendency of an object to appear the same size psychologically with increasing distance, as opposed to the decreasing size in the retinal image. This tendency is better defined as "scale constancy". Scale is an abstract concept that involves no particular dimensions, but the internal, psychological sense of the relationships of a full range of sizes. Usually, the basis of estimation of scale is "human scale" or anthropometric relationships. In other words, scale is the fixed overall relationship of all sizes within a total environment. The scale is constant, sizes vary with distance. One judges sizes at a distance by his built-in sense of scale. Scale divided by distance equals size. (See fig. 2 ).

In architecture, scale takes on some slightly different
Illust. 15 - Size Perspective

Fig. 2

Scale = A x a = B x b = C x c = constant

Scale = Size x Distance; Size = \frac{\text{Scale}}{\text{Distance}}; \text{Distance} = \frac{\text{Scale}}{\text{Size}}

Fig. 3 - Architectural Scale Indicators.
connotations. (See fig. 3). For instance, doors of Gothic cathedrals were often immensely large and heavy -- the spiritual scale of God. They were opened only for ceremony. Built into the large door was a "human scale" door for every day use. This is not the idea that a door for human passage measures seven feet high, but that it was built with human size in mind. Thirty foot tall doors are not practical for human usage, and are designed with other purposes in mind.

A sense of human scale, then, becomes extremely important in architecture. For a person to operate comfortably in an environment he must sense its' relationship to his basic unit of measure, himself. This relationship must be understood even when the person is not in the environment or building.

There are numerous architectural devices to indicate scale. In modern high-rise buildings, such things as floor heights expressed on building skin, vertical window spacing, door sizes, railings. In more domestic buildings, door sizes, furniture, steps or stairways, doorknob heights, and so on. Note that all these elements are based roughly on dimensions of anthropometry.

Familiar objects, whether related to human dimensions or not, are particularly useful clues to scale. Such things as automobiles, trees, general foliage, sidewalks, roads, signs, telephone poles, all bolster the sense of scale because they tend to fall into a size category. And of course, the most important clue of all in an unfamiliar space is the size of other people in it. The "scale figure" is a time honored tradition in architectural rendering. Perspectives are always brim full of them. I will talk more about the problems of modeling people in the section entitled "Implications to model building".
Illustr. 16 - Lack of scale and space indicators.

Better scale and space.

Illustr. 17 - Linear Perspective
The scale figure alone is not enough to give a sense of scale when using VISIT, probably because there is not enough time to study the relationships of a given image. Every possible indication is essential to bring home the proper impression of scale in such a tenuous situation: a fictitious space modeled at a tiny scale and artificially reproduced through an imprecise medium on a small television screen. The inclusion of "familiarly sized detail" becomes even more important when the design deals with a totally unfamiliar scale of architecture like the "mega-structure". If any sense of reality is to be retained, scale must be treated with great care, or what is meant to be a building becomes a series of abstract planes with no particular size for the viewer to grasp. (See illustration 16).

3. Linear Perspective.

This is the most commonly understood form of perspective and refers to the converging of parallel lines toward the horizon like railroad tracks. (See illustration 17). Linear perspective can be considered to be a special case of size perspective, since it is the distance between parallel lines that is decreasing with distance.

"With the Renaissance, three dimensional space as a function of linear perspective was introduced, reinforcing some medieval spatial concepts and eliminating others. Mastery of this new form of spatial representation began to draw attention to the difference between the visual world and the visual field and therefore the distinction between what man knows to be present and what he sees. ...However, there was an inherent contradiction in Renaissance painting. To hold space static and organize the elements of space so as to be viewed from a single point was in reality to treat three-dimensional space in a two-dimensional manner. ...Renaissance perspective not only related the human figure to space in a mathematically rigid way by dictating its relative size at different distances but caused the artist to accustom himself to both composition and planning." (E. T. Hall, The Hidden Dimension, p. 80).

It is this idea of space, left over from the Renaissance, from which
Illust. 18 - Aerial Perspective
modern architects are trying to break. The static linear perspective based on the stationary viewpoint cannot represent the movement of the present concept of space. VISIT, by adding movement, provides an infinite number of overlapping perspectives that denies any idea of static space.

b) Perspectives of Parallax

4. Binocular Perspective.

This gradient is more commonly known as stereoscopic vision. It refers to the slight difference in the images of the two eyes. (See illustration 19)

"It has been commonly believed for many years that the only important basis for depth perception in the visual world is the stereoscopic effect of binocular vision. This is a widely accepted opinion in the medical and physiological study of vision, ophthalmology. It is the belief of photographers, artists, motion picture researchers, and visual educators who assume that a scene can be presented in true depth only with the aid of stereoscopic techniques, and of writers and authorities on aviation who assume that the only kind of a test for depth perception which a flier need pass is a test of his stereoscopic acuity. This belief is based on the theory of the intrinsic cues for depth, which is rooted in the assumption that there exists a class of experiences called innate sensations (such as muscle sensations, Gardner). With the increasing tendency to question this assumption in modern psychology, the belief is left without much foundation. Depth, we have argued, is not built up out of sensations but is simply one of the dimensions of visual experience." (Gibson, The Visual World, pp. 107-8).

A binocular system for VISIT, using two separate television systems and a polarized viewing screen, has been considered. However, the slight advantages of binocular viewing are rather outweighed by the expense of a complete duplication of equipment. There are also complex technical problems, such as producing the views of a scaled-down person's eyes which are only 1/32 of an inch apart at 1/8"=1'-0". 
Illust. 19 - Binocular Perspective

Illust. 20 - Perspective of Focus or Blur
5. Motion Perspective.

This refers to the gradual change in the rate of displacement of objects across the visual field -- things that are close pass more quickly than distant ones. This effect is most easily observed in a car, viewing both parallel and perpendicular to the direction of travel.

Motion is the most important contribution to VISIT. The effect of motion on space perception takes two forms. Motion perspective is one. The other is "Shift in the Rate of Motion", number eleven in this list. A full discussion of the effects of motion will be undertaken then.

c) Perspectives Independent of Position or Motion

6. Aerial Perspective.

This refers to the gradual change in color (usually toward blue), haziness and lower contrast with increased distance, usually very great distance, such as far away mountain ranges. Although effective, this is obviously an undependable clue to distance because it depends on the atmospheric conditions and quality of illumination. Only the most artificial kind of aerial perspective, such as fog or mist, can be simulated with VISIT. (See illustration 18).

7. Perspective of Blur or Focus.

This is a very familiar problem to a photographer, but due to the great depth of field and instant refocusing of the human eye, not very noticeable in vision. The problem is a real one with VISIT. The viewer tends to fixate on various points within the picture so it is necessary to keep as much of the field in focus as possible. The depth of field of the snorkel is relatively large at normal operating distances.

The gradient of focus is an ambiguous one since blur is the same in planes both nearer and farther away than the point of fixation.
Fig. 4 - Upward Angular Location

Illust. 21 - Shift of Texture
Blur only indicates that an object is not in the plane of clear focus. (See illustration 20).

8. Relative Upward Location.

As a rule, objects higher toward the horizon in the field of view seem to be farther away (or downward toward the horizon like a flock of birds or a ceiling grid); things that are close are low in the visual field. (See fig. 4). Since this indicator seldom exists alone in nature, this cue is only a problem in painting where the placement of objects is often an aesthetic decision of the artist. In photographs and VISIT, objects automatically assume their correct relation to the horizon.

d) Depth at a Contour

9. Shift of Texture

The most basic indication of contour is a sudden change or break in the gradient of texture. (This shift usually coincides with a brightness or color change, but the two are wholly independent.) The recession in depth is on the side of the break with greater density. (See illustration 21).

As mentioned before, VISIT depends on fairly gross types of texture. If texture gradients and shifts are to be taken advantage of, these textures and inlines must be emphasized to reproduce on television.

10. Shift in the Amount of Double Imagery.

As a person fixates on a distant point, everything between him and the point of fixation will have a double image. The gradient of disparity grows smaller with distance. If a person fixates on a close object, the gradient is reversed. Breaks in the gradient of double imagery indicate a contour or an edge. (See illustration 22).
Illustr. 22 - Shift in the Amount of Double Imagery
It is easy when considering binocular vision to confuse binocular disparity and convergence. Disparity refers to the relative displacement of the images of the eyes due to the distance between the eyes. Disparity is a relatively strong indicator of depth and works over a large distance. Convergence refers to the angling inward or "toe-in" of the eyes and the sensations that result from "crossing the eyes". Convergence is a weak indicator of depth and only works at very close distances.

11. Shift in the Rate of Motion.

This indicator overlaps with the Perspective of Motion, but occurs when the viewer makes small movements, such as moving the head from side to side. A contour or edge stands out from the background because the edge moves with the head movement and the background remains stationary. A contour that does not shift, such as the bottom of a chair leg, is touching the background, in this case the floor. The degree of shift increases with the amount of separation of the object and the background.

A good way to illustrate the effectiveness of this type of motion in depth perception is to place a pencil or your finger perpendicular to this page of type. Close one eye and move your head slightly from side to side. The pencil will shift across the background page according to their separation.

Perspective of Motion refers to the effect of directional movement of the view on his visual field. Objects pass across his field of view fast if they are close and slowly if they are far away. The relative speed at which they pass is an indicator of the distance from observer. This is best illustrated by what a passenger sees while travelling in an automobile or train. (See illustrations 23,24).
Illust. 23 - Perspective of Motion, perpendicular to the direction of travel

Illust. 24 - Perspective of Motion, parallel to the direction of travel
The two indicators produced by motion are the most vivid and compelling of all the indicators listed. "...the visual field is usually alive with motion. This motion is not the absolute displacement which goes with eye movements, but the kind of relative displacement that goes with head movements." (Gibson, *Visual World*, p. 40).

Motion is what the VISIT system has added to the study of architecture. The implications of this dimension are two-fold: first, in the general enhancement of space perception; and second, the ability of the architect to study his design in terms of motion.

In space perception, the rotation of the snorkel brings a separation of near objects from the background, Shift in the Rate of Motion. A directional movement of the snorkel places all gradients into relative motion, Perspective of Motion. E. T. Hall remarks, "Television audiences have become used to perspective of this type, (Perspective of Motion and Shift in the Rate of Motion) because it is so pronounced whenever the camera moves through space in a manner similar to the moving viewer", (Hidden Dimension, p. 182). With VISIT, it should be noted that the motion is emphasized by the slightly wide angle characteristics of the optics. The wide angle produces some distortion of the image, a "stretching" effect at the edges, unnoticeable if the image is motionless. As motion occurs, the closer surfaces move more rapidly and literally stretch away from the center of the picture. This distortion is distracting, if specifically pointed out. It has been observed that during rapid movement, the viewer fixates on the center of the screen. The distortion of the television image then roughly corresponds to the normal distortion that would occur on the retina and the effect of motion and space is enhanced.
Illust. 25 - The chain of experience is incorrectly represented by "stopping" time for a view usually seen as indivisible from the continuous sequence of time.
The idea of "spatial experience" is inevitably bound up with memory. A feeling of space is the result of many visual impressions received over a period of time. These present impressions are continually mediated by past experience. In this context, it is obvious that only a minor indication of space can be put across with a static photograph or perspective. It would be a mistake to think of spatial experience as comparable to a movie, built up from a train of many individual frames. The spatial experience must be thought of as a unique and continuous unit, which we have arbitrarily divided into views, still photographs or perspectives. An ironic comparison, which is also a remark about media, is between movies and television recordings. A movie is made up of many individual frames, each a unit in itself. A videotape recording is a basically indivisible unit from which we can select an instant's view by stopping the machine. This is not to say that space perception or spatial experience is a remembered sequence of views. But certainly the phenomenon is largely dependent on the passage of time and all the impressions received during that time mediated by the impressions received in the past.

The other implication of movement is to the form of architecture itself and the study of movement through or past a building. The architect has never before had adequate means to study a design through movement. For this reason, the static impressions based on the perspective have remained the overwhelming determinant of architectural design. Today, when movement and the rate of movement are becoming ever more important to the function and perception of architecture, this static concept cannot be a sufficient means of study. The movement of the snorkel can be scaled to simulate walking, driving, flying or any other
Fig. 5 - Continuity of Outline

Illustr. 26 - Convex versus Concave
(Turn page upside down.)

Fig. 6 - Brightness Shift
Shade
mode of transportation. The designer can then judge the affect this particular rate of motion will have on his design. Use of the videotape allows instantaneous recording and replay of repetitive investigations in motion, like yellow tracing paper is used for static studies. Videotape studies are based on rapidly and crudely built models that can be repeatedly changed and improved after one form has been recorded on tape. The model itself can be altered or thrown away and replaced without destroying a record of the concept. A backlog of studies can be replayed, immediately and repeatedly, allowing the designer and his team to compare and from various experiments. I cannot predict what form the architecture will take as a result of these studies in motion. But certainly, whatever the result is, it will have grown from a more valid base than is possible with perspective or plain model studies alone.

12. Completeness or Continuity of Outline.

The traditional cue of superposition or interposition, Gibson claims is not actually an indication of depth. Intellectually a person knows that a nearer object can obscure a more distant one, but the retina does not. The key is actually the completeness, continuity or closure of outline. (See fig. 5). Note, however, that the situation where a viewer has to rely solely on contour outline as an indicator of depth seldom occurs, usually only in line drawings. Generally, one or more of the other gradient shifts occur at the same time and reinforce Continuity of Outline.

13. Transitions Between Light and Shade.

This indicator is associated with the modeling of objects rather than depth in space. It is, however, a paradoxical indication, because like aerial perspective, it follows no constant laws. Instead, it
Illustr. 27 - The Effect of Multiple Indicators
depends on the direction and quality of illumination. The traditional contradiction of convex versus concave shading illustrates the confusion. (See illustration 26).

Light and shade transitions usually occur along with other indications of contour, such as texture gradient shifts, and breaks in the continuity of outline. While shading is an effective indication of roundness when seen with respect to other cues, it merely becomes a brightness gradient when isolated. (See illustration 6).

A great deal of experimentation needs to be done with lighting to determine the most effective techniques. More than likely, no one formula will suffice, but techniques will have to vary with particular subjects. In general, cross-lighting or side-lighting, is best to render light and shade for modeling and texture. But this is difficult to maintain in all situations without excessive contrast. Completely diffused lighting on the other hand differentiates only tonal values with no light-shadow variations.

Brightness is sometimes mentioned as a cue to depth, a less bright plane supposedly farther away. However, this effect is instantly overpowered by another depth indication. It is false in a physical sense also, because the familiar law of illumination falling off with the square of the distance holds only for point sources and not for reflecting surfaces.

Multiple Indicators

As a rule, a single indicator is never as effective as several acting together. "We must remember that these cues are always interacting; under one set of conditions a particular cue may be more import-
**Fig. 7 - Space Perception Indicators Available to VISIT versus Traditional Media**

<table>
<thead>
<tr>
<th>Gibson's Indicators</th>
<th>Traditional Media</th>
<th>VISIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture Perspective</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Size Perspective</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Linear Perspective</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Binocular Perspective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perspective of Motion</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Aerial Perspective</td>
<td>sometimes</td>
<td>sometimes</td>
</tr>
<tr>
<td>Perspective of Blur or Focus</td>
<td>photographs</td>
<td>X</td>
</tr>
<tr>
<td>Upward Angular Location</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Texture Shift</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Binocular Shift</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shift in the Rate of Motion</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Continuity of Outline</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Transition from Light to Shade</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**VISIT - Using television or motion pictures media**

**Traditional Media - perspective drawings or still photographs**
ant, while under another set, a different cue is dominant; quite often a number of the cues are working together. ... It would seem, further, that when many of these cues are operating simultaneously, they facilitate greater accuracy of depth discrimination since they transmit a certain amount of redundant information (signs) about depth." (Forgus, *Perception*, p. 185).

Various experiments have attempted to isolate particular cues, such as retinal versus apparent size (Holoway and Boring, 1941; Gilinski, 1951). They have found that the accuracy of depth judgment or judgment of some characteristic (in this case, size), varies directly with the number of indications to distance.

With the effects of multiple indicators in mind, look at the chart (fig. 7) comparing the indicators available to traditional media and those of VISIT. The unique addition of motion to the indicators of traditional media has added a new dimension to the study of architecture. Plans, sections and elevations, the workhorses of architecture, incidentally, can only rely on continuity of outline, shading and cast shadows for minimal indications of depth.

Scale models seems to be a contradiction in that they offer all the visual indications of depth, even binocular cues. But a model is always nothing more than a model. The model exists in a real, full-scale environment, so all the indicators merely indicate that the model is very small. VISIT isolates the space indicators of the model away from the frame of reference of the real world. With no other clues, the viewer must assume that he is seeing the real thing. This is very important to the success of VISIT. Inclusion of "full-scale" things such as the studio in the background confuses the "real" impression of
the model.

As mentioned before, VISIT also provides a view from scale eye-level instead of the usual airplane view that goes along with viewing a model in person.

Psychology of Media

There are two viewing media or viewing systems that can make use of the full potential of VISIT: television and motion pictures. Aside from the technical advantages and disadvantages of these two media, there are psychological implications.

Television is a "live" medium. We are used to seeing events on television that are actually happening as we watch and listen. Marshall McLuhan discusses the mystique of television in *The Medium is the Massage*:

"Television completes the cycle of the human sensorium. With the omnipresent ear and the moving eye, we have abolished writing, the specialized acoustic-visual metaphor that established the dynamics of the Western civilization.

In television there occurs an extension of the sense of active exploratory touch which involves all the senses simultaneously, rather than sight alone ...

Television demands participation and involvement in the depth of the whole being. It will not work as a background. It engages you ...

It involves an entire population in a ritual process. (By comparison, press, movies and radio are mere packaging devices for consumers.) In television, images are projected at you. The images wrap around you. You are the vanishing point. This creates sort of inwardness, a sort of reverse perspective which has much in common with Oriental art."
There are several important ideas in this fragment of avant grade literature. First, television appeals to all the senses, not just sight alone. The viewer has a feeling of "being there". Second, television requires a high degree of attention from the viewer. "It demands participation" like a newspaper or book or movie never could. Third, is the "nowness" of television. While movies and printed matter are packaged, television is live. If you miss a second of it, just like living, you miss it forever.

Television makes the viewer a participant in the event. It becomes a part of his life, his experience, and he a part of the event. This phenomenon either helps account for, or results from the appeal to the many senses, the personal involvement and the liveness of television. Whichever results from which, the active participation of the viewer adds something to the success of VISIT that motion pictures can never do.

There is another factor in the choice of television over motion pictures that is more practical than McLuhan's theory. Surprisingly enough, it is the basically poor quality of the television image. The picture is so poor in definition, resolution of fine detail, and overall sharpness that it would be unacceptable in any other pictorial media (see enclosed photographs taken off the screen). Since VISIT deals with small scale models, the poor picture is actually an advantage. It hides bad cuts, fuzzy corners and the fact that there is practically no fine detail. No grass, no pebbles, no leaves, no faces, none of the millions of identifying features of the real environment. If fine details were reproduced, they would give the model away as cardboard, sticks of balsa wood, cut-out people and weeds for trees. Fortunately, all this gets lost in the television system. Motion pictures (and stills through the
Model building vocabulary must strike a compromise between ease of construction, significant configuration and degree of detailing.
snorkel) are too good and faithfully reproduce every distraction.

"As a result of adjusting to the environment, the organism has learned the significance of various patterns of energy." (Forgus, Perception, p. 176). Another way of saying the same thing is: "Man learns from what he sees and what he learns influences what he sees." (E. T. Hall, The Hidden Dimension).

Either way you say it, what it means for VISIT is that you don't need every detail; all you need is the suggestion of them. The abstract models that are usually built for architectural purposes simply don't have enough suggestion of familiar detail. You don't have to paint the door handles on a tiny car, so long as you have the configuration right. Most people are familiar with cars and experience will fill in for you. The line between suggestive detail becomes closely related to the absolute size of the model. It is important that these suggestions relate to familiar things like people, cars and trees. Everyone has experience with these.

Not only does the absolute size of the model determine the necessary degree of detailing, but the amount of scrutiny that a given area of the model will receive becomes a factor. A model of a building where the sequence of views leads up to the entrance must receive careful detailing. A building that is merely passed by on the way to an important scene need only enough detail to suggest reality. This leads to a "vocabulary" of model building techniques for the representation of significant details. This problem will be discussed more in the section on model building.
Illust. 31 - Academic Quadrangle of Rice University, model shot with 35mm camera

Illust. 32 - Same model, taken from VISIT television monitor
At this point let me stop to emphasize that VISIT is not an attempt to copy the way a person sees or the way a person experiences space. It is only a machine with its own very definite limitations, a medium between the eye and a model. The system itself perceives nothing. It only transmits a pattern of grey tones that correlate to situations in the visual world. It is the eye that perceives something in this pattern of grey tones.

The light sensitive process of television has nothing in common with the light sensitive process of the eye except light sensitivity. The visual field of the retina has no relation to the field of the snorkel. The observer tends to fixate over the entire area of the picture screen, not just in the center, so there is no correspondence between the stationary screen and the moving macular region of the eye.

The angle of acceptance of the snorkel was decided on the basis of the widest possible angle with the limitations of the complex optics and the degree of distortion. The correspondence to the eye was not considered.

In regards to the movements of the transport system, the aim was to provide the most flexible and versatile choice. A machine cannot be successfully made to copy human movement through a space. To attempt to live up to the versatility and limitations of human movement is foolish. Audiences are accustomed to accepting the limitations of television and motion picture production, so that scenes and sequences of scenes are legitimate representations of the uninterrupted chain of human visual experience.

The VISIT system will never provide the same experience that a
person would have moving through a space. Too much is missing: kinesthesia, touch, Kofka's idea of 360° awareness, smells, sounds and so on. I doubt that such a total experience can ever be simulated in a laboratory, even when scientists learn to "plug in" to the human brain. There is simply too much involved in the surrounding envelope of space we live in. Space perception cannot be simplified to a purely visual phenomenon. All the factors that play a part in space perception have not even been identified, much less how big a part they each play in the final experience. VISIT makes no pretense of producing the necessary elements for the full sensation of space. All VISIT can do is provide a representative image in which the human eye can find a few meaningful correlates to space in the visual world. In spite of its' limitations, VISIT is certainly better than the best of the traditional media for the representation of space. And there is no other feasible method of architectural study that can investigate the role of motion in architectural design.
IV. WHAT HAS BEEN DONE

The VISIT system as it exists now at Rice is an experimental model of what can become a sophisticated and complete package for commercial production and use. Though it is in a rough stage of development and refinements are continually being made, we know that what we have works.

The studies done with VISIT have been limited so far because most of the available effort has been directed toward making a machine that would work. Three major, publicly-presented projects have been undertaken and another is under way at the time of this writing.

The Kennon Project

The first project was a study of a city planning scheme developed during "Rice Design Fete IV", a condensed design seminar conducted under the auspices of the Rice School of Architecture and financed by the Ford Foundation. The sequence of photographs included is taken of one of the models produced by architect Paul Kennon and his team of students. (See illustration 35).

This presentation with VISIT was of limited success for several reasons. The problem itself dealt with a very abstract and unfamiliar (in terms of past experience) situation: the "mega-city". Models were correspondingly abstract and unfamiliar. While it was felt that the VISIT presentation added to the understanding of the problem, the experience of space perception was lessened by the level of abstraction. The only keys to the scale of the spaces were cars and people and sometimes trees. There were virtually no texture gradients, and size perspective effects were limited by the lack of familiar objects. The simple addition of grid lines on some of the model's clean white surfaces would have greatly heightened the sense of depth. (See illustration 16).
Illust. 35 - The Kennon Project
The Kennon team did not make use of VISIT as a design tool, only as a presentation tool. However, this was due to the shortage of time rather than a lack of interest. This meant that the models were not tried out along the way and were not seen through the system until it was too late for changes. The whole production was a rush job, the taping completed only a half an hour before the time of presentation.

Incidentally, in spite of the so-called spontaneity of television, it took about a half an hour of preparation to make one minute of final videotape. It is hoped that this ratio will improve with practice and refinements in the system.

This presentation in June, 1967, while only moderately successful compared to achievements since, was very well received by an initially skeptical audience. It was agreed that the results were good for a first try and provided a firm foundation for following studies. The system itself did not change, but the operators learned how to put its potential to better use.

The tape was later presented at the Teachers' Seminar in Chicago, sponsored by the American Institute of Architects and the Association of Collegiate Schools of Architecture.

The Caudill Project

The second major presentation involving VISIT was done for the architecture firm of Caudill, Rowlett Scott in July 1967. The project concerned the design of their own office building. The results were a considerably greater success than the Kennon project. Probably the most important reason for this was simply the improved production prowess. The operators knew better what VISIT could do and the designer in charge,
Illust. 36 - Academic Quadrangle at Rice University

Illust. 37 - Model of the Quadrangle
architect William Caudill, had a definite idea of what he wanted to accomplish and proved to be a capable director.

Again VISIT was regarded primarily as a presentation medium. However the limitations and advantages were better understood. Models were built with VISIT in mind instead of the usual "presentation model". Only one out of about ten models and "mock-ups" was a presentation model in the traditional sense. The others were built only for use with the system and were discarded after being recorded. This team quickly discovered the "mock-up" or the model with a single sequence in mind. For instance, a model was built showing only one facade of the building and the drive up to the entrance. The rest of the site was ignored because it wouldn't be seen in that sequence. A simple idea, but entirely different from the usual architectural model.

Another reason for the success was that the problem dealt with a small building of the type and scale with which everyone is familiar. The familiarity of the building type and of the site covered with trees, lent a feeling of realism that was lacking in the Kennon presentation.

The "All School Lecture"

The third presentation was prepared for a lecture in the Rice "Monday Lecture" series. I will deal with this project in more detail because it was specifically designed to investigate the potentials of VISIT and I did all the model building and production myself. I chose this occasion to find out how accurately VISIT could portray the spatial experience of an existing situation. If it could recreate the impression of a space that had already been built, then I could be sure it would be giving the correct impression of one that had never been built.
Illust. 38 - Detailed Model

Illust. 39 - Chipboard Model
For this task, I selected the main quadrangle at Rice University and its' surrounding academic buildings. There were several reasons for this choice:

1. It is a space with which everyone at Rice is familiar.
2. It is easily available to photograph and measure for a model.
3. It is easily available for movies or videotaping within the actual space, for comparison with what VISIT produced. This has not been done, but the possibility is there.
4. It contains a variety of types and sizes of spaces, building materials, textures, vegetation and other variables that VISIT must deal with.
5. The quadrangle is incomplete in that one building is still being designed and the model can lend itself for a future design problem.

As planning for the project progressed it became increasingly evident that how the model was built had a great bearing on the desired impression of the "real thing." For this reason I built two separate models of each of the five buildings. One was the usual chipboard variety, showing only massing and door and window openings. The second was also a cardboard model, but with attention to textures, scale giving elements, material indications and so on. Both sets of building models were at 1/8"=1'0" and were placed on the same site model. These two models can be considered to represent fairly wide extremes of detailing; one underdetailed and one overdetailed. An acceptable degree of modeling can be thought of as somewhere between these two extremes. (See illustrations 38, 39).

It must be remembered that the concern of this presentation was to build a model most successful in creating a sense of realism and space for a final television presentation. For this purpose, most
Illust. 40 - Front of Model

Illust. 41 - Back of Model
experimentation was with the more elaborate of the two sets of models. Since I was dealing with an existing space, there was no need for study models in the design sense. The chipboard model is entirely adequate for study. It was very quick to build and sufficient for preliminary purposes. This type of model can be very crude indeed and still tell the designer what he needs to know.

A number of discoveries were recorded from this project, ranging from model building shortcuts to possible psychological overtones that could negate much of my work. The conclusions can be grouped into:

1.) Model-building; 2.) Tape Production; and 3.) Presentation.

1.) Model-building

Model-building techniques take on unfortunately important overtones when dealing with VISIT, possibly because there is no standard and it is difficult to know what the results are going to look like on the television monitor. For this reason, it is necessary to develop a vocabulary of techniques to represent given textures, building materials, types of vegetation, people and so on. The idea is that no matter what these techniques look like in person, they must immediately and unquestionably suggest some particular thing on television. Another problem is that this vocabulary must be modified according to how closely it is seen by the snorkel. The image will show more detail the closer it is, so areas that are to be closely or continuously seen must be treated more carefully. Another important factor is that the model will be seen from scale eye-level instead of from above as usual. This means roofs can be left off, upper stories less detailed, rears of buildings ignored and so on.

For this reason models to be used on VISIT must be built with VISIT specifically in mind. It is a mistake to try to build a model for both
Illust. 42 - Bottom of Detailed Model (note arch thickness indication)

Illust. 43 - Bottom of Chipboard Model
VISIT and actual presentation. It is pointless to build into a VISIT model anything that will not be seen. The efforts spent on making a "pretty" model for presentation is better spent in planning and detail on the parts of the VISIT model actually seen. Models built with this attitude take on a very free character that only look true on television -- and no one should see it otherwise or it ruins the whole impression.

It is difficult to accept the fact that no one is going to see the physical product of your labor. But when you consider that what is recorded on that little piece of magnetic tape is a thousand times more convincing than any model viewed in person. And considering the "life-span" of models in storage, the tape will last infinitely longer.

One of the first questions always asked is why I didn't just use photographs of the building facades since I was working with existing buildings. I did in one case, which I will describe later, but generally they don't work. First it is extremely difficult to take a clear shot of a building without the numerous foreground distractions. Second, unless the facade of the building is absolutely flat, the sense of realism is destroyed because there is no shift in the rate of motion (11 in Gibson's list, see page 43) to separate projections and recesses on the surface of the facade.

Where photographs work extremely convincingly is as a background. Photographic blowups of the site simply held up in the background lend an extremely realistic air to the model that could not be obtained any other way, including building the entire site and surrounding areas. It might work to use slides projected onto a rear-projection screen in the background. It would be necessary to use an extremely bright projection lamp in order to bring it up to the brightness level of the model.
The chipboard model built for this project was the usual variety except that the buildings only had one or two sides and none of the flat roofs were included. The window and door openings were covered with black paper so you could not see through the building.

The detailed model deserves more detail in description. The cardboard used was "TV board" used generally in layouts and available in most art supply stores. The cardboard is a light grey. Pure white objects as well as shiny objects must be avoided since the throw off of the sensing mechanism of the television camera causes an overdarkening in the rest of image. Brick was indicated by scoring the board for horizontal mortar lines and marked with a small gear for the verticals. The texture was colored with a "Prisma-color" pencil to make the bricks darker than the mortar lines. Printed "Brick paper" which is much easier to use, seems to work almost as well, except under extreme crosslighting which emphasizes the texture rather than the tone. Marble was indicated by the natural grey of the board with penciled in mortar lines. Mouldings and other sculptured textures were indicated by drawing "shadows". This worked well regardless of the direction of the light in the final production.

One important difference of the detailed model from the chipboard version that played an unexpectedly important part is the sense of realism, was the thickness of the archways. A paper strip was glued to the inside of each arch to indicate thickness on the detailed model. The chipboard model arches were the thickness of the board. This was immediately noticeable in the comparison of the two models on television.

Incidentally, all models were built by scaling off photographs of the building facades that were blown up to 1/8"=1'-0" scale. This made measurement very easy and indicated the details that were important
Illust. 45a - Sequence from "All School Lecture"
photographically. Again, attention was paid only to the parts of the model to be seen by the lens. There were no backs or tops on any of the models. (See illustration 41).

The site, foliage, trees, sidewalks, grass, and vegetation were probably the least successful part of the model. The ground plane textures must be coarse enough to reproduce on television and this puts them out of scale. Variation on tone must be emphasized in grassy areas. Also the ground plane must be kept generally quite dark in tone and very dull to prevent specular reflections which can cause the camera's exposure mechanism to over-adjust and make the rest of the picture too dark. Foliage must contain fine enough texture to represent leaves and still be transparent. "Springtime" trees made from "Baby's breath" or similar weeds seem to work the best.

People are a special problem. The most abstract kinds of scale figures in very static positions worked the best. Scale figures cut from magazines and photographs will work but placement is a problem because they have no thickness. People must always be modeled in stationary poses, standing still or sitting. Figures in action poses are very distracting because they don't finish the movement; they remain curiously frozen with a leg or arm extended. The most successful policy seems to be the minimal use of scale figures and then only in unimportant placements and static poses, singly or in groups.

In general, it is necessary to make the VISIT system available for viewing during the construction of the final model to allow judgment of tonal contrasts, textures, degree of detailing and so on. In this way, the maximum effect can be obtained with a minimum of effort.

2.) Production of the Videotape
The individual scenes and sequences of scenes should be planned during the construction of the model. It is important to remember that a videotape presentation is subject to all the limitations of traditional movie-making. The production cannot simulate the continuous experience of a person moving in the actual space, but must use cuts, fades and so on to indicate the passage of time. Care must be taken so that a series of scenes are sequential in movement. This can be achieved by non-sequential taping of scenes to suit the most practical order of setting up and shooting. Then the tape can be edited onto another videotape recording machine. Physical editing of the tape like movie film is beyond the technical abilities of an amateur production, not to mention the extra time involved.

Lighting techniques can be very casual as long as there is enough light to produce a good exposure. If the major source is kept in the same direction, changes of fill lights are not very noticeable. However sometimes it is necessary to change the main light too so that the shadow of the lens does not fall across the field of view. The original plan of motion through the model should take this into consideration.

Sound can be dubbed onto the finished videotape. Our present tape recorder provides only one sound track so that if both narration and background music are desired, they must be recorded at the same time. Incidentally, selection of music for the videotape must be done with care so that the music is not inappropriate to the architecture being presented. It is not necessary to key the music to the action of the video: relatively unnoticeable, unaggressive music better. However, some sort of sound is recommended since it seems to make the presentation flow more smoothly and continuously.
Illust. 46a - Sequence through the "Sallyport"
Two sequences of this presentation are worth describing here. Both are concerned with passing through interior spaces and were included just to see if it could be done. It worked so well in the presentation that no one was even impressed. The problem, of course, is that the snorkel extends down from above so that a permanent roof was not possible.

The first sequence was a passage down a covered arcade that looked out into the quadrangle. This was accomplished by constructing the arcade without its' attached building, ie: the inside wall, the arches, and the floor. The roof was made from a sheet of brown paper on a roller which was rolled up by an assistant as the snorkel moved down the arcade.

The second sequence was passing through the main arch or "Sallyport" which penetrates under the building at the end of the quadrangle. The building was approached from the "back" or the side away from the quadrangle. A photograph blown up to 1/8"= 1'0" was used here. As the snorkel approached the building the sides of the arch disappear from view and the photograph is lifted out of the path of the snorkel. It next passed into a mock-up of the two sides and far end of the arch, which was kept in shadow by holding a piece of paper over it. As the sides of the far end of the arch pass out of view, it too was removed and the snorkel moved into the quadrangle and the actual model was replaced behind it. Then as the snorkel turned and looked behind, there was the solid building under which we seemed to have passed. Actually, these manipulations seem rather taxing on the imagination and dexterity but they are very successful and impelling when viewed on the screen. (See illustration 46).

3.) Presentation

It is curious that audiences are more impressed with humorous effects than with serious accomplishments. Out of the presentation for the lecture, the one scene that drew the most comments was an amusing one.
Illust. 46b - Sequence through the "Sallyport"
The scene began with a scale figure standing behind the Sallyport. A blob appeared behind her and gradually became recognizable as a gigantic hand. The hand plucked the figure up and disappeared. The effect is a telling one because the hand is invariably regarded as enormous and the model as normal. This shows how effective the sense of scale is and how absorbed the viewer becomes in this television world.

The big blow of the afternoon, however was when a voice in the back of the room asked why there was so much distortion in the distance, everything looked too far away. This was a two-fold shock. First, in two years of working with VISIT I had never noticed any distortion in the distance nor had anyone ever mentioned it before. Second, if there really was distortion of distance, even psychological, it meant that the space was not properly represented and the whole VISIT project was for naught. Other people in the audience agreed that distant things looked too far.

After some investigation, it seems that the problem was that the distance of the viewer from the monitor was too far. It is a photographic fact that the viewer must assume the same relative position to the final enlargement as the taking lens from the film plane, in order to see the correct perspective. The formula is; Viewing distance = focal length of lens x degree of enlargement. With a twenty-five inch screen, the distortion of perspective is not noticeable up to a distance of about fifteen feet. This is further than the formula would account for (it works out to about three feet), but this distance seems to be that acceptable limit. This phenomenon means that to serve a large audience, a great number of monitors is required for all the audience to see the correct perspective — about one monitor for every fifteen or twenty people.
Overall Success

Before seeing the VISIT system in operation, people seem to be rather skeptical. After a demonstration, this questioning attitude changes to a reaction of amazement. This is particularly true when the person can see the model and the television screen at the same time. Unknowledgable people tend to take the whole thing for granted, if they don't see it in operation.

Architects seem to break down into two distinct classes of reaction. Either they are tremendously impressed and enthusiastic, or they are very cynical and discount the system's potential in affecting architecture. There doesn't seem to be anyone in-between.

The general reaction to all the presentations has been very favorable, the main conclusion that they understood the spatial qualities of the problem better from the VISIT presentation, much better than they would have without it. This is very encouraging, but the next step is to effectively utilize the system during the design process while the spatial configurations and the architectural expressions are being shaped.
V. IMPLICATIONS

Technical

The research for this paper and continued use of the VISIT system has suggested a number of improvements that can be made in the system itself and its use.

Technical refinements require money for their realization, the amount depending on the kind of change. Some of the most pressing problems can be solved quite inexpensively. However, much of the equipment could be effectively upgraded, now that we know better what is needed.

Probably the most immediate need at this point is better lighting. There are simply not enough lights to provide an adequate level of illumination over a big enough area. The present arsenal consists of two Color-Tran quartz iodide lights. One is a four-hundred watt flood which is mounted on the snorkel providing good illumination for a small area directly in front, but it also makes moving shadows. The other, a one-thousand watt adjustable spot is used as the main light. Several standard theater spots are used as fills. These two lamps are ample for small models, but cannot cover a five-by-twelve foot area like the model of the Rice quadrangle with an adequate light level. If the present room remains the VISIT location, heavier wiring needs to be installed, whether more lights are added or not.

The television equipment we have at this time is about the best quality "amateur" equipment available. The next level is "professional" and moves into a much steeper price range. At some later date, perhaps color television might replace the present equipment, but the cost is rather prohibitive. If color is absolutely essential, movies are a better route at this time.
If a new location for VISIT facilities becomes available, a number of improvements should be included in the move to make operation easier and more effective. The most basic consideration should be access to the studio. Students must be able to maneuver large and bulky models to and around the room. In terms of size, the room must be considerably larger than the largest model to be handled to facilitate operation of the system and the placement of lights. Some provision should be made for an "artificial sky". This can be as simple as featureless walls painted matte, light grey. An arrangement of rear projection screens might be worked in to allow the projection of backgrounds. On a more elaborate scale, a domed ceiling could be provided to simulate a cloudy sky, which would also give better over-all illumination.

In terms of equipment for a new location, a better transport rig should be incorporated. Westinghouse makes an excellent transport system designed for X-ray machines that would be perfect for our purposes. This rig operates on exactly the same principle as our present system, but is fantastically smooth and easy to operate. It also incorporates an ingenious "Z" or up and down movement. It can be motorized in any of several ways, depending on the preferred kind of operation, from manual assist to preprogrammed. Motorization would provide much smoother operation, with less jerks, stops and starts, and better curved movements. Remote controlled operation is also an advantage because much larger models can be handled. Perhaps some day the whole system can be hooked up to a simple computer for pre-programmed operation.

One other device needs to be incorporated into a new location. A base that will allow gross adjustment of level of the model and
rotation of the model within the room should be provided.

At the present time, the only feasible changes in the system seem to be in lighting and some sort of "Z" movement. Most of the major improvements depend on the assignment of a better location.

**Implications for Model Building**

Model Building techniques for VISIT have already been covered extensively throughout this paper. Here I would like to summarize my conclusions.

1. The most important single thing to remember about models to be used with VISIT is that they should be built for VISIT and not for presentation. The model will be seen from scale eye-level, not from above as models usually are. The major concern should be for what the snorkel will see from this viewpoint and that view should be treated in detail. The ground plane and things near it are important, not the roofs.

   All models built for VISIT should be regarded as "throw away" models. They are simply means to an end, the result being the videotape. Models built in the fashion are only true on television and are very disappointing in person. Seeing the model along with the tape, while impressive, destroys the mystique that this is a look into the future.

2. The snorkel can operate at eye-level down to a model scale of $1/8" = 1'0"$. If the project is too large to build at this or larger scale, important pieces should be built for viewing at eye-level and perhaps related back to a site model seen from "flying" level.

3. Models being built for VISIT should be frequently viewed through the system. It is difficult to judge the effect of tonal contrasts, degree of detail, and acceptable textures with the naked eye.
The success of the vocabulary of representation depends on how they are reproduced by television in terms of black and white.

4. Study models built during the design stage can be treated very freely. Quick chipboard models that can be easily rearranged or rebuilt are acceptable for the designer's purposes. A detailed model is obviously a waste of time at an early design stage. However, the degree of abstraction traditional in presentation models is unsatisfactory for a final model.

5. When a final design is reached, it is necessary to sit down and plan what the designer wants the audience to see. Significant scenes and sequences of movement through the model should be decided before the model is built. This means that careful detailing can be limited to significant parts of the major model and necessary mock-ups can be made for special scenes.

6. In terms of detailing, it is necessary to develop a vocabulary of representation for various materials and according to how closely they will be seen by the lens. For instance, printed brick paper might be found sufficient for close views, while in the background, brick can be represented by a corresponding tone.

7. The same concept is true for foliage and ground plane treatment. This is, however, one of the more difficult impressions to bring off. Foliage generally has a very fine texture, that must "read" from nearby as well as at a distance. Lichen moss works well as bushes or trees if stuck on twigs with thick enough stems to reproduce on television, but fine enough to stay in scale. Variations in ground plane tones should be emphasized, since they will be seen from a very sharp angle.

Expansion joints in sidewalks and roadways heighten the feeling of
movement along them. Any type of shiny materials should be avoided, especially on the ground plane, or specular reflections from the lights will throw off the exposure mechanism of the camera. It is also a good idea to avoid pure white materials for the same reason.

8.) It is imperative to include familiar objects to heighten the sense of scale and prevent the model from looking unreal. Such objects as furniture, light and telephone poles, automobiles, fences and other paraphernalia that are usually excluded from models are effective. This is not merely to make the model look real and "lived in" but to help the viewer adapt to the scale of an unfamiliar environment.

9.) People are a special problem, since we are used to them moving. Until some one figures out how to make 1/8" scale people move, the best solution is to avoid them. Scale figures must be modeled abstractly and used as little as possible. People should be placed in out of the way places where they will be seen by the lens but not concentrated upon for any length of time. And where they are used, they should be modeled in stiff stationary poses, sitting or standing still.

10.) The use of photographs is most successful as a background. They cannot be used satisfactorily for a significant building unless the facade is an absolutely flat plane or the snorkel approaches it perpendicularly like a zoom lens and without looking from side to side.
In general, use of the VISIT system forces the designer to be concerned with all the visual factors that will affect his final building. He must be aware of building materials, textures, landscaping, scale, entrances and approaches, detailing, furniture and spatial characteristics. This is obviously very good practice. You can't "fake it" with VISIT. If the model is built from chipboard, with no concern for the building material, it will look like chipboard on television.

**Implications of Presentation**

In the future, it is hoped that VISIT will become more of a design tool instead of just a presentation tool. Presentation, while the most obvious and sensational use, just scratches the surface possibilities. The idea of impressing the client with such dramatic techniques and exotic equipment appeals instantly to the "old show biz" in every architect. It is the idea of communication that is important, however. Television is something that the layman can understand because he has dealt with it all his life. The usual methods of presentation, elaborate drawings of plans, elevations, sections and perspectives, require years of training for the architect to understand himself. Most laymen have very little experience with such visual media. Television becomes a link between very different but equally legitimate ways of thinking.

E. T. Hall is very concerned with the problem of differences in perceptual meaning and thinking. Different people have entirely different ways of seeing the same view or sequences of scenes. Hopi Indians, for instance, have virtually no concept of abstract space. This is not to say Hopis don't live in and build spaces. But spaces are thought of as a by-product of the objects that define them. The Japanese, on the other
Illust. 55 - Language-thinker
hand, have a highly developed sense of abstract space. They have words to describe kinds of spaces and their configurations. The inter-space, as contrasted to Hopi thinking, is an entity. Obviously, this contrast in thinking and cultural pre-programming will result in completely different experiences of the same visual world.

Another example: my father is a writer and a very language-thinking person. He used to work in Rockefeller Center where every year they erect a monstrous Christmas tree. I always would ask him if he saw it. He never saw it. He was completely oblivious to this considerable change in his environment. On the other hand, he is extremely sensitive to inflections of speech and written language. Some casual remark is likely to cause that squinty-eyed, questioning look and "What do you mean by that?" How does the architect go about demonstrating the effect of variations in space and environment envelope to a person who thinks so entirely differently?

This is a very real problem in architecture. The building profession brings together people from all fields: visual-thinkers (architects, artists, photographers), language-thinkers (businessmen, writers, lawyers), tacile-thinkers (carpenters, builders, sculptors). Every new project becomes a small scale United Nations, with a variety of languages and no interpreters. A great deal of effort is expended merely reaching a common ground of communication.

Television is a common link of experience. Everyone is used to television. Everyone is used to television. It can never be the final answer because, for instance, you can't measure from a television screen. But it can be a giant step towards a commonly understood vernacular.
IMPLICATIONS TO DESIGN

The other day as a student was viewing his final model made for a videotape presentation, he remarked: "Gee, I wish I had been able to see this view when I was designing. I thought I had made the sidewalks wide and spacious. And now I look at it this way and it looks like some narrow back alley."

The most important feature of the VISIT system is that it gives the designer a new way of seeing. This new way of seeing enables him to use motion in the study of space and in molding the shape and form of architecture as in the past he has used static composition. VISIT permits experimentation with dynamic composition.

The movement of VISIT is an indication of space that neverbefore has been available in the design stage. Movement as a factor in space perception has been treated in detail in the paper, a new dimension in the study, communication and representation of space. However, more important to the future of architecture is the effect motion studies can have on the configuration of architecture itself. Today, architecture (from separate buildings to entire cities) is seen by an observer in some form of movement. People walk through buildings, they drive down streets, and fly over cities. This speed of motion has a powerful effect on how the environment is perceived. Did you ever walk down an airport runway? The impression is entirely different from the view in an airplane travelling a hundred miles per hour. If architecture is to cope with the variable of speed and movement, there has to be a method of study which can simulate motion.

The tool shapes the outcome. The media is the message, in McLuhan language.
Renaissance architecture was strongly influenced by the perspective. Designers thought of space and architecture from a static viewpoint. This concept grew from the method of representing space from a static viewpoint. Three-dimensional space became two-dimensional pictorial space, subject to composition, rules of geometry and mathematical relationships. The architecture that resulted from this type of thinking made sense only if viewed from the selected, stationary viewpoints the architect used.

Today we are experiencing the effect of another tool: the chipboard model. Buildings are springing up with blank planes of natural concrete, buildings that look like a very big chipboard models with folded corners, bent ramps, thin walls and the detailing of cardboard.

VISIT, too, can have its effect on architecture. It should be a more beneficial effect than chipboard models, since it is based on a fact of space perception and the reality of movement. The study of movement's role in architecture is not a new one. Circulation is one of the determining factors in design. But it has always been studied with static drawings.

The effects of movement on architecture and the effects of architecture on movement are practically unknown territory. Now there is a way to study it. There are the "nervous Nellies" who grasp tight their ruling pens and say it will never replace the perspective (or model or designer or whatever). But VISIT doesn't replace anything. It is in addition. It does something no other media does: it moves.

And as it moves, it records that movement and allows the
designer to see as if he were moving. Just as the architect has used yellow tracing paper in static studies, he can use videotape in movement studies. The architect can make overlays and restudies. Then he can go back and compare them all, judge and select. He can experiment in model form instead of having to build a real building to be able to walk through it. Students in schools can have a taste of what it is like to design a building instead of designing a drawing of a building.

In the curriculum, VISIT can expand the means of study and enhance the feeling of really building something. For the professional, VISIT means a serious method of studying a major architectural problem and having an equivalent method of communicating his solution to the client.

VISIT can have a profound effect on architecture. It gives the architect a new dimension in space perception. It gives the architect a new dimension in the study of architecture for movement. In short, it takes architecture out of the realm of the static and into the world of the dynamic.
BIBLIOGRAPHY


