FREDERIC JOHN HERBOLD

METAL BUILDINGS AS
ARCHITECTURE

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METAL BUILDINGS AS ARCHITECTURE

by

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of the requirements for the degree

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Date August 18, 1978

Thesis Statement:

PRE-ENGINEERED METAL BUILDINGS

CAN BE ARCHITECTURE.

August, 1978

DEDICATION

This thesis is dedicated to the memory
of my father, a man of principles.

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Introduction

My thesis statement, "Pre-engineered metal buildings can be architecture" has organized a pursuit into the elusive essence of architecture and the character of single building system. I began with a personal feeling that most existing pre-engineered metal buildings are not architecture. Then I made the assumption that knowledge of the system and understanding the difference between architecture and mere building would be tools to transform metal buildings into architecture.

The first problem involved definitions of terms. There are several types of pre-engineered metal buildings and the abbreviated term "metal building" applies to quonset huts and steel sky scrapers. I have chosen to use the term "metal building" to mean buildings constructed on rafter and column frames spaced twenty feet to thirty feet apart sheathed with metal panels over secondary members that span between the primary frame. These are the buildings popularly called "Butler Buildings" (after the largest manufacturer, Butler Manufacturing Company). I chose this system as the subject of my thesis because it is the most common pre-engineered metal system currently used in the Montana region. In Bozeman, metal buildings serve a variety of functions -- farm buildings, warehouses, garages, wholesale and retail outlets, bars, offices, and churches. The fact that they

are so popular and that as an architect it is probable I will design metal building indicates I ought to study the system.

Working with this particular system has been a challenge. It is associated with its first use -- farm buildings and warehouses -- and its common present use -- an economic, monetary solution to a building problem. Also the metal building system carries associations with machines and manufacturing processes rather than hand built and craftsmanship. All these associations form preconception of what a metal building is, and I struggled with my preconceptions until I realized that I had to analyze metal buildings as a system instead of individual buildings. This brings us to the second term I had to define.

Architecture is the "art of space" or the "art of place" or the art of something. The key word is "art". I began with the premise that architecture is the intersection of art and building. Like a ven diagram of the union of two sets, architecture is defined when art and building intersect.

My starting point was the definition of art and my goal was to define art as a set of principles which could be used to derive a subset of architectural principles. The advantage of using principles was they could be used to analyze the metal building system and to derive a second subset -- principles for metal buildings. These last principles have guided my architectural design using the metal building system.

This thesis begins the proposition that all the arts share the same definite principles. In the first section I explain the art principles. I derive and explain the principles of architecture in the second section and use them in the third section to analyze the characteristics of the metal building system.

The immediate value of all this theoretical work is that it has filled a void in the execution of this thesis. I needed definite criteria -- architectural principles -- to evaluate metal buildings as a system. I also needed definite guides -- principles of metal building architecture -- to use metal building systems creatively.

For the most part the theoretical work I have done has not produced anything new. I am particularly in debt to the influences of of Susanne K. Langer and Christian Norberg-Schultz. However, to have formulated principles of architecture for myself has given me a better understanding of the terms applied to architecture; for example, organic form, order, and expression. I cannot say that my design ability shows the direct influence of this new understanding, but I can say that I have clearer intentions when I design and stronger criteria to judge my work.

When I conceived this thesis, I had a hidden intention -- to understand the essence by studying one aspect -- a material or building system. It seems that the idea was wrong but the intention was successful. It has been necessary to study metal building systems by first

understanding the essence of architecture. Then, by using design of metal buildings as an experiment I have attempted to create architecture (or rather drawings of architecture). Judgment of the experiment will test the validity of my thesis statement "Pre-engineered metal buildings can be architecture."

I. Art is human feeling objectified.

As mentioned above, the proposition that all the arts are unified under definite principles forms the base for a theory of architecture, by directing the theory to the most encompassing principles. A comparison of all the arts shows that they are as varied as individual members of an extended human family. While one person may exhibit similarities to other members of his family, there is often no single characteristic which is common to all the members of the family yet uncommon to other humans. Further two humans may resemble each other without being members of the same family. A Jackson Pollack painting and a Gothic cathedral seem to have nothing in common while the Gothic cathedral and a vertical rock palisade do have common characteristics. But in the same way that members of a family may be very dissimilar yet possess common ancestors and unexhibited genetic ties, the arts share a relationship to the human creative process and the role of art creation in human life.

Analogies like "architecture is the poetry of building", "architecture is the music of the spheres", and "architecture is the stage for the drama of human life" propose a relationship between two arts which use different materials but which apply analogous techniques or principles. This sort of analysis leads to the confusion noted above. It is not true to say that all arts are alike; only their materials differ, and that their principles are the same, and their

techniques are all analogous. However, an analysis of how arts are different will lead to the point where finally there are no more differences and their unity can be postulated.

When differences of materials and techniques, modes of perception, and individual principles have been exhausted, the principles that apply wholly and fundamentally to all the arts remain as a definition of what art is and what it is not. The gensis of all the arts is the same. Though works of art are not the same, they share a common principle of creation. The principle of expression has a special and shared meaning in all the arts. And "living form" or "organic form" applies to all the arts.

Art is expressive form created for our contemplation and it expresses human feeling -- feeling in the broad sense meaning everything that can be felt, from the sensations of our senses, pleasure and pain, excitement and repose, emotions, intellectual exultations, the existential tone of human life, or sensitivity to the human condition. The natures of form, expression and creation in art needs to be amplified to define how art is different from other human products and to understand art's role in man's life.

The word "form" can cause confusion in a discussion of art because it has several meanings. The popular meaning is the shape of an object or pattern. In architecture "form" may refer to the three dimensional shape of a building. In music or poetry "form" commonly refers to the most comprehensive order of composition as the "sonata

form" or "ballad form". There is a more comprehensive meaning of form which indirectly refers to shape and compositional structure, but directly means the way separate elements relate and are mutually dependent in a whole. When the artist speaks of "form following function" or achieving the "essential form", he is searching the wholeness or organic unity as a principle embodied in his work.

Logical discourse exhibits form in this abstract sense. Statements and arguments follow one another according to rules of logic, each element is related to form a whole, a new idea, through a long symbolizing process called reason. But reason has limitation in its ability to present us with reality. Only those experiences which are logically knowable can be informed by reason. Experience must be abstracted into symbols which stand for something in experience and can be manipulated to represent further abstractions or ideas. The limitation of reason or logical form is that it does not allow us to symbolize subjective experience. We can talk about emotions as we name the more predominant ones like love, hate, anger, or joy but these symbols do not inform us how emotion feels.

The subject of expression is the logically unknowable, those ellusive aspects of reality which remain amorphus and chaotic in our attempts to rationalize experience. Art is the objectification of human feeling in the expressive form. That is, a work of art does not refer to or stand for something outside itself. The way that elements in a work of art relate to one another forms something greater than

themselves which is the subjective feeling of art, the import of art, and seems to the beholder to be directly contained in it. The import of art is not inferable from a symptom, rather it is contained within the work. A scream is self-expression, a symptom of an internal state, a self expressive behavior from which we may infer to the state of the person who screamed. If art was merely self-expression, we would have difficulty explaining how Camus could have written L' Estranger if he constantly felt the anxiety and dispair we feel reading it. The embodiment of feeling in form requires concentration -- anticipation of the end to be achieved and clear understanding of the means to that end -- which is not required for self expression. Formulation of expression requires that the artist be conscious of the composition of his medium. Expression in art is not "the squeezing out of something". It is an intentional presentation of feeling in the overall composition of the medium, and the feeling quality or expression is perceived as part of the work rather than as part of the artist.

When the beholder contemplates or appreciates art he has an experience -- he is a participant in a relationship between himself and art. Science in its analysis of reality strips subjective aspects from the world and models man as a passive observer questing into truth. I think our reliance on science and its technology often makes us overlook the vital subjective way we are involved in life. Man is not only affected by reality in a casual way, but is also affected by the feelings he experiences in living. The beholder of art is not a

passive observer; he becomes inseparable from art in his perceptual field and part of a larger whole in that art influences him and he interprets art. The interaction between the beholder and art is the key to the interaction of expressive form and feelings the beholder experiences. As the beholder and his feelings are inseparable, the work of art and the feeling quality presented are inseparable. By the way art is presented, it is already weighted with this feeling quality -- expressive form -- which is the most salient quality of art.

The feeling quality embodied in expressive form is not a representation of an emotional state the artist experienced during its creation; art is more than a symptom or self-expression of a felt state. The creation of expressive form is an experience during which the artist establishes a rapport with his medium and more or less formulates his medium congruent with an image. The image may be informed by his own experienced feelings or may go beyond his experience, as when the artist imagines his entrance into heaven and objectifies this experience with music. For example, he must have a precognition of the felt response to his work and when he judges his creative success he says, "Yes, that is the feeling I wanted." The artist possesses some understanding about human feeling which may go beyond his own experience, he develops it into an organic unity that articulates the intended feeling, that is, makes the subjective aspects of reality imaginable or apprehendable for the beholder.

The means and principles of composition vary between the arts

and between artists and they are not limited to those of simple tradition or movement. Rules of composition, harmony, rhythm, representation, variety and counterpoint have changed over time and are not the same in all the arts. The meanings of symbols in art have all been redefined and revolutionized as artists rebel against previous traditions and establish new movements and rules. The few principles of art that do not vary are decisive and are exhibited by any work that can be judged "art": the creation of an imaginable quality, the development of organic unity, and the articulation of human feeling. This defines the role of art in our life which is to enrich our existence with the life feelings formulated and objectified for our direct perception.

II. Architecture is the objectification of human feelings in the built environment.

"Architecture is the union of art and building" does not mean that we are presented with a building to which art has been added as a surface application. The creation of architecture cannot be divided into two disparate processes; the solution of problems posed by a building program and the addition of expressive form. Or by opposition, the union of art and building is not of expressive form disassociated from building problems and then formulation by forcing materials and functions into an unsympathetic frame. Thus the discussion of architecture must by wholistic -- that is taken from the view that art and building exist simultaneously and inseparably in architecture, rather than the view that by defining building and applying the principles of art to building the principles of architecture will be apparent. The principles of art are primary in architecture and are infused in the specific architectural principles.

The principles of architecture as those of art are postulated after all the differences of materials, their techniques and specific rules have been excluded. They tell us what architecture is and what it is not; they indicate the role of architecture in human life; and they give direction for design. We begin with a positive statement about and only about architecture rather than analogies with other arts or between architectural types.

Architecture is a creative integration of inclusive dimensions

which order man's environment according to an hierarchy of needs and which provide man with an "existential foothold" in the world. Creative integration, inclusive dimensions, order, hierarchy of needs, and existential foothold are key terms, the elaboration of which will occupy us for some time and lead to the intended understanding.

It should be obvious that a building is not a simple object. There are many aspects which are related in some way: the structural system, the mechanical system, the layout of separate spaces, the way spaces are related to each other and their relationship to the mechanical system and structure, entrances and windows, their sizes and shapes and relation to other aspects. The more aspects and elements considered, the more interrelationships are apparent or possible, then the more comprehensive is the task of building. If architecture is an art then we should expect all the aspects and elements of a building we call architecture to be formulated organically. That is, each element and aspect is dependent upon the others for its articulation of the intended expression. This implies that at some time during the creative process, the designer considers the role of each element and system in the unifying expressive form and the user (I shall call the beholder of architecture the user) can be aware of the part each element plays in the organic whole.

Creative integration implies that systems which have their inherent form are interrelated and part of a larger whole -- the organic unity -- and that they articulate the creative intent which is living

feeling. We can measure architecture with a few broad categories -- I call these "inclusive dimensions" -- which in themselves have a unity of interrelated elements and aspects but are integrated by the architect's creative image. The user experiences the whole of architecture. Rather than the addition of structure to functions to form, he feels the simultaneous influence of these from the "living form".

There are three categories which I call inclusive dimensions. They are the functional, the technical, and the formal.[1] If we consider architectural design as a solution to a series of questions or problems, then these three dimensions organize the problems according to a common characteristic. Functional questions are those relating specific human tasks that occur in and around the building as well as the building's functions in its locale and its potential socio-cultural activating role. The technical problems are those concerned with means, such as what kind of structure will be used, how materials are joined together, which machines are used. Questions of form are those concerned with abstractions like space, mass, and surface or ideas which help to organize the entire project or what import the whole will embody. I have called these categories dimensions because they can measure a building's response to the circumstances of an architectural problem by re-asking the appropriate questions. Dimension also connotates a dynamic quality which implies the change in architecture through history, the change a building may undergo over time and the dynamic experience of using architecture. The adjective "inclusive"

implies that each dimension gathers from or refers to something beyond itself. The technical is indicative of contemporary techniques employed, the functional is related to urban context or social patterns, and the formal is embodied with as much feeling and meaning as can be included. Before discussing the three inclusive dimensions further we need to understand how and why architecture orders man's environment as solutions to problems of the three inclusive dimensions.

Order is an inherent need in man and is primary for understanding reality. The visual world is given to us as a pattern of color patches on our retinas that are constantly changing. We actively participate in the perception of the world as we integrate the patterns we see into coherent figures. Gestalt psychology of perception explains the simple organizing principles we apply to the world. For example; similarity - similar parts tend to be perceived as belonging together; proximity - elements are grouped by virtue of their nearness to one another; closure - completion of elements into a whole, or belonging together to complete an organization; common fate - elements which undergo similar change will be perceived as a group distinguishable from similar elements that do not undergo the change. These inherent ordering principles are used to construct a world of objects. For example, all table-like sensations are organized into properties of an object -- the table. When we perceive the world as a collection of objects, we can begin to take action toward a goal, such as when a baby reaches for and shakes a rattle in a purposeful way to gain the

pleasurable sensation of rattle sounds. When we begin to abstract objects into mental images -- words and pictures -- which are symbols, we can order them into classes and subclasses; understand relations between them such as bigger, smaller, and further; begin to manipulate the symbols according to a standard order (logic); and understand more complex relationships.

The manipulation of symbols according to established rules in order to formulate relationships between the designated objects is what we call reason. Reason enhances an otherwise chaotic environment with knowable order (logic relationships) so that we can interact or take action with the environment in a purposeful way. When certain logical constructs become particularly valuable to us -- that is they are useful when making decisions or taking action, or they are the ends toward which action is taken -- they become objects in themselves. Examples of these abstract objects are social groups, political organizations, atoms, and works of art. Inherent in all of these abstract objects is the order by which they were formulated and the value or usefulness with which they serve man. It follows that the most valuable objects are those that serve man best and that value is placed on objects by individuals, groups, cultures and the totality of humanity. Then "higher objects" are those whose inherent order is most valuable, that is useful or goal oriented as judged by individuals, cultures, and humanity. When the environment is organized according to the order inherent in a higher object such as democracy, individual freedom,

scholarly persuit, art or nature, and the inherent order is articulated -- made comprehendable -- then the environment is perceived as the embodiment of a higher object and is given its value. I used the words comprehendable and embodiment instead of knowable and symbol because I believe the order of reason begins to fail us when we construct higher more complex objects, and our feeling about the object affects its value. We will return to feeling and value later. The discussion of our need for order in the environment will be better served by starting with simpler orders.

We have seen that order is necessary to gain knowledge from and act according to our perceptions. We perceive our environment in degrees of tidiness to chaos. To interact with the environment we need a knowable order. To take action we need to be relatively assured of the outcome of the action. We can drive autos down a black top road at night because we know the road will very probably not end abruptly at a one thousand foot cliff. By the same need we have certain expectations of the organization of buildings. Related functions should be congruent to our behavior. We tend to make a "cognitive map" of buildings when we can symbolize the building's order. We also make decisions based on a stimulus such as the sign "men" on a door which elicits a certain response, either to open the door or to look for "women" adjacent.

Before beginning the discussion of order in each of the inclusive dimensions, there are some general characteristics of order

that should be illuminated. We tend to be bored by simple order such as a long double loaded corridor with plane walls, flush doors, and no "relief" for our eyes. If an experience is so well organized that every action follows the preceeding action in a mechanical way we gain nothing from the experience but the end. However, a valuable experience proceeds from one problem to the next in such a way that each step contains something unexpected which holds our attention and yet is related to the end intended. From any point, the preceeding point and the following point are knowable to some degree because they are informed by the order of the whole experience which is wholly apprehended at the end. In terms of ordering the environment this implies that a unified order should not be apparent from any one viewpoint. The built environment should be modified by the specific circumstances at any place. Or a complex order, which at first appears chaotic, should be created by overlapping or integrating two or more simple (therefore immediately knowable) orders. Some building types, such as schools and hospitals, require an overall order which is knowable from any part of the building, but these usually have complex programs, and the variation can occur at specific places within the simple comprehensive order. This is, I believe, an abstraction of the traditional compositional techniques, such as counterpoint, (circumstantial modification) and variation on a theme (overlapping and intergration). An analysis of the dimensions of architecture will indicate there is a nearly limitless source for various orders.

The technical dimension includes all the materials and machines, their systems and the techniques employed making a building. A technical system is an ordered repetition of a limited number of technical elements and is best used when its inherent order is expressed in the whole form. For example, the skeleton frame has an order and a heirarchy within the order -- a girder is more important than a joist, a column carries more load than the girder -- and if span is determined by the size of the offices as well as the efficient span of members then the expression of the structural system is multi-dimensional. It tells us how the building is held up, how functions are arranged, and we may infer the character of the functions. But the expression of the technical systems is only as valuable as the systems are capable of articulating the functional and formal dimensions. The strong articulation of twenty foot bays on the exterior of an auditorium does not help us understand the two hundred feet scale of the space inside.

The technical system includes what is technically possible at a particular time. Mies van der Rohe's Seagram Building is a masterpiece in this respect. The skeleton frame is articulated by applied I beams as the form. Building design that responds to contemporary technology and values uses the physical objects of technology and contemporary society within traditional order and broadens our understandings of those objects. Bruce Goff has used dime store ashtrays set into his stone walls; Charles Eames put his house together with curtain walls, joists, interior partitions, and equipment, all selected

from catalogues. Technical possibilities include the uncommon use of common objects is an idea potentially rich for invention, new meaning, and superimposed order.

The correlation between the technical and functional dimensions is more basic than the formal relation possible between the structural system and the arrengement of functions. The basic need for shelter around human activities implies a technical solution. Certain activities, such as those in hospital operating rooms, require specific technical equipment effeciently organized. But the functional dimensions transcend the need to order physical objects according to specific human tasks. It includes the order of social objects like the family in housing, the neighborhood in residential development, the city in urban buildings, and cultural objects like democracy in town halls, or community participation in community centers.

The key to obtaining the most valuable functional order is to define the comprehensive function which most directly serves the community. The building which functions as a center of city government would be best organized as an office building if government served the community as a bureaucracy or would be best organized as a hall if government operated through community meetings. If the functions of a complex building can be organized around one comprehensive task, then the order of separate functions will form a pragmatic relationship to the central task and separate functions will have their place in the whole.

In a society whose members are specialist, the functions tend to be differentiated and form complex interrelationships where one function is not dominant. It is not always possible to organize the functions of a building according to hierarchy as indicated above and the order of hierarchy is not always appropriate to a valuable cultural expression. There is, however, one hierarchy which pervades all architecture and helps to determine the differences between architecture and mere building -- that is the hierarchy of architectural needs.

The concept is an adaption of Abraham Maslow's hierarchy of human needs in the psychology of motivation.[2] These needs are cross dimensional. I list them from basic to higher needs and will discuss the point that separates a mere building from architecture. The theory associated with this hierarchy is; a higher need cannot be satisfied until the lower needs are substantially satisfied. The list of architectural needs is: shelter, safety, function, comfort (physical and psychological), social (socio-cultural context), formal (sensual delight, intellectual tension, life-feeling). Architecture as such begins at the formal level. The term as used here does not designate the formal dimension which begins at the most basic comprehensive order in a building, but denotes a subset of the formal dimension which has previously been called the "creation of expressive form," the content of which is human feeling. The formal need or need for expressive form is subdivided into a hierarchy from sensual feelings to the more profound existential feelings and is congruent with the relative value

humanity attributes to these feelings. This feeling value will lead us to conclusive remarks about the role of architecture; we shall get there by discussing the third inclusive dimension.

The function of the formal dimension is to relate all other orders (technical systems and functional arrangements) and their elements into an organic whole. The sub-orders and elements articulate the intended meaning and feeling. The architectural requirement of an encompassing form is derived from the Gestalt law, "economy of organization,"[3] which is based upon the principles of similarity, proximity, closures, and common fate. It states that the most probable organization for perception is that which requires less information relative to other organizations. This implies that the user will attempt to perceive an encompassing form to organize the import or architecture before he perceives disparate parts which he must organize in some comprehendable order. By formulating the architecture into an organic whole the designer leads the user to his intended content.

The formal elements are mass, space and plane or surface and the qualities of these elements are determined by manipulating the architectural dimensions for an intended expression. The innovative use of new structural systems like the skeleton frame, shell structure, and diaphram skins in the late nineteenth century and twentieth century has opened buildings to experiments and new concepts of the element space. This emphasis on space has, I believe, led to the misleading definition of architecture as "the art of space."[4] By defining architecture in a

single dimension -- space -- it must include other dimensions -- mass, planes, lines, scale -- to express the totality of architecture. The concept of space becomes diluted and confusing as we discuss positive and negative space, the space of a Baroque facade, illusionary space, all as part of the same thing. Further, to say that the art principles are embodied in space rather than objects seems to take a concept so far beyond its popular perception as to be incomprehensible and of little value to anyone but architectural theorists and critics.

The formal elements and their relationships are organized on several levels.[5] The most basic level is ordered by 1) places, the points where we experience something valuable; 2) paths, the line of action from an experienced place to another object of reality; and 3) domains, the areas unified by similarity and closure of the more or less known objects they contain. This system of wholistic orders implies the inclusive aspect of the formal dimension. A single building like a house may be composed of these three orders -- the path as a circulation core, with domains off the sides like the public domain of a living room containing places like the fireplace and its hearth or a window seat. In this example, the path leads in and out of an entry and continues as an order on the site as the front walk and beyond the sidewalk. The house becomes a place in its domain within the neighborhood. The scale keeps increasing to the point where we realize the whole physical world can be organized into these three patterns. This implies that the architectural object has formal relationships with its immediate

and urban or rural environment and can use the larger order of these as an extension of its own order. Man, tending to perceive the most economic organization, thereby understands the building's intended import in relation to something greater than itself.

The development of articulation of the formal elements of space, mass and surface as they are organized by the three basic orders of place, path and domain use higher, more abstract levels of order. The abstract levels are composition, proportion, and symbolism and they vary between styles and materials. However, there are some constant relationships between the technical and functional dimensions and the formal articulation.

A composition of an apple, a pear and an orange communicates their commonness, they are fruit. It also demonstrates their differences. The appleness of the apple is different from the orangeness of the orange. The unification of separate but related functions in a complex building is formed from their common relation while their uniqueness is differentiated and the formal differentiation, the identification of one place from another, is articulation. A complex building program requires a greater degree of articulation relative to a simple program. The formal order of simple farm buildings remains relatively fundamental and simple compared to the formal order of culturally valuable and more complex religious buildings, which vary in style and import as cultures vary. Then the degree of articulation and functional complexity are interdependent and mutually dependent on the

capacity of technical systems. A wooden post and beam system can be varied more easily than can a hyperbolic-paraboloid shell. The post and beam system allows variation in shape, scale, and division of space while the hyperbolic-paraboloid makes one large characteristic space. The technical, functional and formal dimensions are all mutually related to a buiding's capacity toward an intention, which is the building's expressive form.

The architectural intention is not to objectify the rational world, but to express in specific places the quality of human feeling with which users can identify and feel at home. The value of feeling in architecure is relative to its existential value, or its ability to bring meaning to man's life. Although we have great power over the world, and our dreams are manifest (we watched as man first set foot on the moon via the "miracle of television"), we find ourselves homeless when science has stripped nature of human symbols and presented us a neutral and alien universe, vast and forceful against our purposes. Where religion had before provided us with a life encompassing order and the images and symbols with which we could express our need for spiritual wholeness, we are now lost and drifting, free but dispossessed, and fragmented beings. We have looked over the abyss, beyond the vail, with no redemption. There is only anxiety and dread of non being in the alien indifferent universe. We have in common this human existence, the ultimate sublime of knowing the greatest fear, the insignificance of our being, and yet in knowing to become unified with the universe. The

prescription is a commitment to existence by being involved in the human condition and by being creative.

Then the human feelings we need to continue our being and to feel at home in the universe are those of creative fulfillment, deep reunion with religious insight, and the unifying feeling of the human condition. These are the positive existential modes and lead to an active adaption to reality. At the low end of the feeling-value scale are the simple sensual delights.

Even the sensual feeling genuinely embodied in a building defines the building as architecture. "Delight" is inseparable from the form. The negative feelings (with the possible exception of sensual feelings like cold, hard, sharp, glaring which may be "negative" compared to warm, soft, smooth, subtle) have no place in architecture because they would be counter to the basic need for comfort and the negative existential modes of anxiety, nausea, and despair, erode any foothold man may have in this world.

The role of architecture in specific places and beyond to paths and domains is to identify them with the quality of objectified life - feelings. The user who perceives that feeling in specific places experiences the unity of physical objects, human action, and spirit. He has a sense of his place in the world, what action he will perform there, and thus a hold on his own existence and a knowledge of who he is.

The process by which the existence of man is formulated in the built environment is complex and as various as cultures and individuals.

There are decisive principles which are common to all architecture and define it as more than mere building. They are: 1) to integrate the technical, functional and formal dimensions into an organic whole; 2) to facilitate human activity by ordering man's environment; 3) to satisfy building needs which are shelter, safety, function, comfort and social; 4) to differentiate specific places in man's environment; 5) to include as much of life as possible from physical, social, and cultural objects; and 6) to create an expression of human feeling. Architecture has the capacity to inform man of his existence in every day experience. It is our frame of the physical world and objectifies the order or rational aspects of reality. By also objectifying the elusive, amorphus aspects of reality we call feeling, it presents a comprehensive expression of reality for our contemplation.

The life feelings which architecture expresses are not a formulation of the architect's need for self-expression. They are derived from the circumstances of specific problems and the architect's life. I have outlined in their three inclusive dimensions the kinds of problems architecture solves. Technical, functional and formal problems and determinants are the source for ordering and feeling. For example, Le Corbusier's technical solution for Notre Dame du Haut at Ronchamp juxtaposes two structural systems. The "hat" which is a shell floats above heavy, rough walls. The solidity of the walls contains and protects the user and gives the feeling that this is a place firmly attached to the earth. The curved roof is slightly raised above these

earthbound walls. A slit of light illuminates the underside of the roof articulating its separation and etheral quality. This is also a place "under heaven" -- the user feels the presences of God here. The subtle and elegant articulation of structure can lift the spirit of man beyond the bounds of his rational concerns.

Function determines the quality of architecture. We expect that the office of a corporation executive will not feel the same as the employees' lounge and both should feel very different from Notre Dame du Haut. The executive may want to impress his visitors with a sober, formal, and rich image of his corporation. Walnut paneling and furniture, a high ceiling, and a strict order of all furnishings can contain this feeling. Bright colors, casual arrangement, and a more complex shape of the employees' lounge can embody the feelings of casual social interaction, humor, and emotional release.

Formal order embodies the attitudes and feelings of a culture as well as it denotes cultural ideas about universal order. The landscaping at Versailles represents the central power of Louis XIV and his orderly influence on the world. The feeling one has experiencing the central axis at Versailles is the immense power of man's rational order over nature, his dignity and his place at the center of the universe. By contrast, Wright's Kaufman House is the domain of man set in the midst of nature. The order of man is not impressed upon the environment. Rather it responses to the rhythms, scale and shape of natural order. Here, man is also forthright and proud but he has his place in a scheme

much greater than he is and beyond his control. We feel at home amidst the chaos of a world beyond our understanding when we are metaphorically sheltered by its forms. The attitudes of Andre Le Notre at Versailles and Frank Lloyd Wright at Bear Run are very different. Both are affected by different cultural attitudes, and the difference is expressed when both forms are compared.

The feelings an architect and his culture have about man's place in the world have been expressed in architecture throughout history. Architecture includes the security of order, the confusion of complexity and ambiguity, the awe of an unknowable and chaotic universe, and the humor of irony. It includes the vitality of everyday life, the power of man's intellect, and the sublime forces of nature. In specific and circumstantial locations it expresses what we are, what we do, and who we are in a whole, organic image.

III. Metal building systems: possibilities and limitations.

The principles of architecture are more meaningful when they are applied to a concrete system like that of metal buildings. As they have been stated above, they do not directly imply how architecture is made manifest in a physical object. They appeal to the designer's intuition rather than his need for practical, concrete principles. Architectural principles do not deal directly with materials and techniques because, as mentioned previously, attitudes and uses of materials are indicative of a particular time and place. Twentieth century man would not replicate the Great Pyramid as the Egyptians, almost entirely of solid stone. That would be an inefficient use of material and labor. We would rather build our monument in steel and glass. The pyramid itself does not have the same symbolic content for us and so that particular problem loses its meaning now. We may, from our twentieth century point of view, think the Great Pyramid an inefficient structure, yet it is architecture. The principles and techniques related to materials are indicative of specific cultures which employ them. By concentrating on one material system (metal buildings) and the culture which employs it (in the United States, 1970s), we can determine a more practical direction toward the creation of architecture.

The task at hand is to understand the characteristics of metal buildings in the realm of architecture. Because they are primarily a technical system we will begin our analysis with a description of their

ordered repetition of technical elements and the building needs they satisfy. Then we have a basis for discussion of their functional capacities as physical, social, and cultural objects and their formal characteristics of mass, space, and surface. Examining the feelings metal buildings express and their capacity to differentiate or unify the dimensions of architecture will give a full understanding of their possibilities and limitations and indicate some specific applications and remedies. The illumination of metal buildings in the light of architectural principles will lead to the goal -- defining the principles of metal buildings.

There are many manufactured pre-engineered metal building systems, but this analysis is limited to the type organized as a series of gabled bays framed by rafters and columns spaced twenty to thirty feet apart. The bays are spanned by cold rolled perlins and girts and enclosed by a variety of metal panels applied to the perlins as roofing and to the girts as siding. The system is a skeleton frame composed of a limited number of technical elements ordered in a hierarchy according to the loads they carry. The elements are all steel and are built up or rolled to carry the elemental loads most efficiently.

The rafters are either built up of plates in an H cross-section or of bars and angles to make an open web beam and are bolted to the columns to form either a rigid or plastic connection. The columns are made of welded plates in an H cross-section and are tapered to the ground from the inside when the column-rafter connection is rigid (rigid frame).

The column height establishes the building's "side wall" dimension and the rafters establish the roof pitch (4/12, 1/12, 3/4/12, and 1/2/12 are standard) and the building's width. Clear span frames are available with spans from 10 feet to 120 feet and continuous beam or truss frames with interior columns are common with spans from 80 feet to 300 feet. The building's longitudinal dimension is determined by the number of bays and an existing structure can be lengthened easily by adding more bays. The rafter-column frame carries all loads to the ground through concrete piers which maybe the only foundation work require, a common practice for farm buildings. Or the piers may be tied to a perimeter wall or floor slab.

Girts and perlins span perpendicular between the frames and are bolted in place. They are cold rolled Z sections 8 inches to 9 inches deep and vary in thickness (11-16 ga. steel) depending upon the design loads. Perlins are spaced from 4 feet to 5 feet while girts are spaced 6 feet apart with the exception of the first girt which may be 7 feet 4 inches above the floor to allow for standardized doors and windows. These members carry loads from the panel surface to the frame by beam action as well as lateral loads from adjacent surfaces to the frames axially. Their flat outer surface provides a place to bear and attach the next member.

The exterior surface is made of color coated deformed sheets of galvanized steel (26-22 ga.) which are cold rolled in various shapes and width. The deformations facilitate more efficient beam action as

loads are carried to perlins and girts, but give the panels a one directional quality which necessitates running the deformations perpendicular to perlins and girts and which exclude diaphram action. Then the whole building is prevented from racking or swaying with cross bracing provided by rods or cables stretched diagonally between at least one bay on every surface. While panel sheets are available in up to forty feet lengths, the length is also limited by handeling, including transportation to the job site and installation. They are best fastened with lock-rivits which will not require periodic maintenance as screws do. There is also available through several manufacturers a roofing panel with a double folded standing seam and integral clip which allows expansion and contraction in all directions with no breaks or holes in the surface. Interlocking foam core panels with exterior finished sheet steel on one side and interior finished sheet steel on the other are available and can span up to fourteen feet.

Accessory, non-structural members include trim for corners, eaves and ridges, insulated plastic sky lights, ridge ventilators, louvers, and metal doors and windows. There are also standard members and details to extend eaves and add canopies, to make parapet walls or add false parapets, to add side wings, and to line the interior, insulate the walls and ceiling and to add large areas of glass. The number of accessories and variety of panels available in recent years has increased the flexibility of metal building. As a system, it is adapting to a widening range of building fuctions which require satis-

faction of more building needs. The degree to which the needs can be satisfied indicates advantages and limitations.

The need for shelter is well satisfied by metal buildings with minor qualification. In a climate like Bozeman has, ice dams can form at the eaves on metal buildings and the rubber closure under roof panel ends may not prevent water backing up or ice bridging. Part of the problem is that the newer systems use the lowest pitched roofs; the other part is detailing. From my experience, the buildings that seem to have this problem are those that don't use the eave trim pieces. These pieces flash the area and help seal the foam closure under the roof panels. Also, the use of heavy insulation in the roof can minimize melting and the whole eave area can be foam insulated from the inside. Another leaking problem is caused by thermal expansion and contraction of the roof. Movement can be up to 3/4 inch over one hundred feet with a change of 100 degrees fahrenheit. The solution is to use control joints more often than the manufacturers recommend or to use a standing seam roof that is designed to give with temperature changes.

Some care needs to be exercised for structural safety. For best results, one should check the standards used for structural design and the manufacturer's warranty and reputation. Fire safety systems or protection are usually not included, and the designer must either protect the primary and secondary structural members or provide an extinguishing system because the structure is not fire resistant. The building itself needs some means of protection if vehicles are to be driven adjacent to

or inside it. The appearance of the skin is not improved by dents from automobiles and trucks, but more important, the primary structure if dented or knocked out of place is no longer reliable.

Metal building systems enclose one simple volume and are most appropriately used for functions that require this kind of volume. The traditional use of the system is for simple and undifferentiated tasks like those contained in farm buildings, warehouses, freight terminals and garages, aircraft hangars, manufacturing facilities, and small retail outlets. These are utilitarian tasks associated more with machines and technology than with human interaction, and the association of metal buildings as an industrial product rather than a hand made object may limit their use as higher socio-cultural objects. However, it is also possible to manipulate the system, to differentiate the interior as well as the exterior by various techniques and to extend the system's capacity to adapt to and express more complex functions without destroying its positive characteristics. This is the tack we shall follow as we analyze the need for comfort.

Like most building systems, physical comfort is not well satisfied by metal buildings in a climate like that of Bozeman. The insulated panels are satisfactory (R 30) though they should be more efficient. There are windows which are operable and integrated as accessories as are louvers, roof ventilators and sky lights. Separately these items do not indicate a comprehensive solution to the problem of physical comfort because the manufacturers do not organize them into a climatizing system.

They are disparate accessories; they need to be organized into a system to satisfy comfort. The concept for organizing these accessories can be stated as a specific search for light and its warmth, air and its coolness, and view. The specific is related to functions and people. Light, air and view are included aspects of climate and site in buildings. Then operable windows can let in warm winter sun, provide a selected view, and let in cool summer breezes. Louvres and ventilators can exhaust the air displaced by the cool air windows and other louvres let in. Other problems of comfort are similar to any building system. The solutions have to be added on or detailed as required.

Now we have discussed the technical and functional dimensions as they exhibit the characteristics of metal building systems and we move on to analysis by formal elements surface, space, and mass. Because the formal dimension includes characteristics which separate architecture from building, the following analysis will begin to define principles. The primary characteristic of metal buildings' surface is their skin-like quality. In fact, the building is wrapped with thin metal sheets that are relatively fragile. Door and window openings are trimmed minimally and appear best when they begin and end at the simple rhythmic pattern of ribs. Contrary to the taut character of skin, there has been a trend by manufacturers to produce siding that has more relief, with a larger repetitive pattern, and that makes more play of light and shadow. Coupled with a window system framed within vertical mullions that run the full wall height, the effect is to lend the appearance of solidity.

Both the more fragile, simple and skin-like surface and the bolder dramatic panel-like surface are possible.

The interior surface when it is not lined is articulated by the primary and secondary structural elements which show the building's lightness. This character is accentuated by the cross bracing. The rafter-column frame, which articulates the modular character, also defines potential dividing planes. For example, a metal building made of five bays could be divided into five equal spaces by four parellel walls at each of the interior frames. Perlins and girts unify the surface with direction which in perspective moves toward infinity. When the interior is lined with the building system liners, their smooth surface appeas as a skin predominantly broken by the rafter-column frame. We can conclude that the frame within a simple building shape is the primary and sometimes only surface articulation. It indicates how the system is put together (a frame with a sub-structure or skin applied) and how the building is supported. An intention to give a metal building the feeling of firmness or permanence should begin by expressing the frame.

The interior space of a metal building is shaped and moderated by the frame. The scale is "measured" by the repetition of columns and rafters. They indicate the building's modular character. The shape of the space is prismatic and abruptly cut off by the end walls. A glass wall at one or both ends could imply the projection of the prismatic space beyond the confining structure. The building system need not be

limited to repetition of one frame. Frames of a variety of widths and heights can be put together to change the scale and shape of the interior space. The building system provides an opportunity for more variety than is usually employed.

To talk about mass, we must analyze a metal building as an object, a primary geometrical shape set abruptly on a plane. This is the context that first comes to mind -- the farm or industrial building juxtaposed and unyielding to its environment. The cold, glaring, clanging metal of man's machine conquering nature in the "green" and industrial revolutions. Their place is the farm yard and the industrial park, not the domain of human interaction and culture. If we use them within our domain, we must cover them and conceal their character with the crafts of the mason and the carpenter. This is a pervasive attitude about metal buildings. Their association with their original uses has limited understanding of and experimenting with the system. The abrupt meeting between the building and the ground is a result of using the system with a flat concrete slab. Though a flat slab contributes to the economy of a metal building, the system is not solely limited to one floor system. We noted above the fact that all the building loads are concentrated through the columns to piers. This implies that the system has more variety and adaptability than a flat slab has. For example, a metal building can "step down" a hill side. It can be raised above the ground on canted foundation walls or the floor can cover a basement. Therefore, metal buildings need not be limited to one type of site and

floor system.

If architecture is to include values and techniques of the culture, then metal buildings should be considered as a possible solution to the architectural problem. Metal building systems represent efficiency and economy. They have developed as a response to the need for a building system that can be easily erected out of manufactured pre-engineered parts for relatively low initial cost and requiring relatively little maintenance. The values of efficiency and economy are not limited to agriculture and industry. Evidence of the number of institutional, recreational, and government buildings constructed of pre-engineered metal systems indicates the broad base these values have in our culture.

The question of which problems metal building systems can solve hinges on the element of time as well as economy. Metal building systems are commonly used as an immediate response to economic problems. For example, the owner of a bar located on a commercial strip may have decided to build his bar in a metal building without regard for the building's longevity because he assumes his business will survive for only ten to twenty years. I think a similar attitude is common among the owners of metal buildings. Consequently, the use of the system in general seems to communicate a "thrown up cheaply for now" attitude by association with poorly detailed examples. However, a building constructed by this system should last as long as each of its members lasts. And color coatings, aluminized surfaces, rivet fasteners, and

flexible closures are now available which do not fade, corrode or fail for periods well over twenty years. Metal building systems are appropriate for buildings with a short "life" but these are not the only buildings that can use the system. When the system is used with all its trim pieces and the best fasteners and siding, it is appropriate technical system for building programs that require low initial cost and low, long term maintenance costs.

Much of this analysis has considered a metal building to be of a simple shape, but what is at issue is not a building, rather it is a construction system which implies more flexibility and variety than one building shape. The design principles for metal buildings should be based on a system and not a preconceived image of one building. Though we may abhor the fact that most metal buildings look alike, it is not correct to assume they have no capacity for creative expression. The capacity lies within the designer's knowledge of the possibilities and limitations of a particular medium and his ability to manipulate it and add to it according to his creative imagination. There are limitations of metal building systems; no exterior structural expression, the cold feel of metal, fragile panels and columns, poor sound quality, and abruptness in meeting the ground, and negative socio-cultural associations. And there are possibilities: manipulating the system, adding other systems or elements, freedom to articulate a large interior space, modularity, using accessories to invent a unique system, the machine-like quality, and the efficient-economic association. These are the guide lines for the

principles that follow: correct or compensate for limitations and take advantage of the possibilities.

IV. Principles: Metal buildings becoming architecture

Design principles for metal building systems are a tool for the architect. These principles should respond to the metal building's characteristics and provide constraints which limit the architect's imagination to a purpose. Without the touchstone of reality, the imagination wanders aimlessly in fantasy and reaches an end only after exhaustion. Principles do not inhibit creativity but provide a frame of questions and possibilities which direct the imagination toward a valuable end. Now the frame and purpose of these principles are to guide formulation of metal building systems into a valuable object that is an architectural expression.

The principles of art and architecture should be used to organize the principles of metal buildings. This organization will accomplish two tasks: amplification of architectural principles as they are applied to a specific construction system; and the formation of each metal building principle as a response to an encompassing architectural principle. Because the principles of architecture must apply to all construction techniques throughout history, they tend to be vague and of little use for the designer until they are interpreted with characteristics of specific materials or construction systems. Metal building principles will amplify and clarify architectural principles by demonstrating how the possibilities of the system can be used to create an architectural expression. Formulating each principle of

metal buildings as a response to an architectural principle will insure the derivation of principles which guide the designer to the goal of this thesis -- metal buildings which are architecture.

1. Formulation of an organic whole

The first principle of the metal building system should be to maintain the integrity of the system. The manufacturer is able to provide an efficient economical system by using mass production techniques to form one material -- steel -- into separate elements which fit together as an integrated system. Changing any element to another material will affect the economy and efficiency of the system. For example, if the metal siding were replaced with brick veneer, a supporting structure of ties, plywood sheathing and stud frame would have to be provided. Detailing the connection of brick and mortar to metal siding is difficult and the cost and the difficulty of construction is greater.

I do not mean to imply that other materials or construction systems should not be used with metal buildings. I do think that, in general, other materials should not be used to replace metal elements that are integrated into the system. The design challenge is to use the characteristics of metal siding, for example, to produce an intended feeling by manipulating color, texture, and scale. If the qualities of brick -- heavy, load bearing, permanent, small module -- are necessary, then brick should be used as a building element separated from the metal system.

The character of metal building siding is either skin-like or panel-like and should be maintained. While changes of siding color help to break down the scale of a building, the skin quality is maintained. Accessory windows are fitted so as to keep the plane of glass very near the plane of siding. They should be used as a continuation of the skin across a puncture. The sidings that appear as panels should be used with window-door systems that are framed within continuous vertical mullions. These window-door systems are made for the panel-like siding. They are easy to install and they accentuate the panel quality.

When the interior surface needs to be lined, it should also be treated as a simple skin-like plane. Textured metal liners and gypsum wall board on firring produce this planar quality. Because the walls are nine inches to ten inches thick and the window glass is near the exterior surface, a deep relief is produced at windows. This produces a contradictory but, I think, comforting appearance of mass on the interior. The wide window sill should be designed into a special place -- for example, a window seat or a shelf for plants.

Maintaining the integrity of the metal building system will aid in the formulation of an organic whole. Economy and efficiency should be maintained by using the elements of the system to solve problems of scale and proportion and the surfaces should be treated as skin or panels.

2. Order in Man's environment

The inherent order of metal buildings should be used to order the environment they create. By extending the system for overhangs, canopies and parapets, these elements are integrated with the building and extend the building's order beyond the confines of its walls.

The modular bay system should be used to order the interior because the column-rafter frame predominates the interior volume. Major divisions should occur along the module lines. The module, which is twenty or thirty feet long and the building width wide, can be subdivided into smaller modules (perhaps based on the interior construction system or the dimension of the human figure) and will help order interior spaces. The bay system should also be exploited when planning for future additions. Additions can be made by continuing the length of the building with similar bays or by extending the width with "lean-to" additions.

Punctures and openings in the skin should not occur haphazardly. The rhythm of deformations on the siding is dominant. Therefore, the openings for windows and doors should match this rhythm. Utilities for existing metal buildings are often attached to the surface and puncture it without regard for the obvious intrusion they make on the system. They need to be grouped at a special location -- perhaps on a panel specifically designed for meters, regulators, junction boxes, utility attachments, and punctures.

3. Inclusive architecture

The design of a metal building should include elements that compliment its character and elements that add a new desirable character. I mentioned the industrial machine-like quality of metal buildings and the fact that metal buildings as a technical system represent a technical achievement by our culture. By selecting other common metal items such as shelving and mezzanines, culverts, pipe and greenhouses, and incorporating them in uncommon ways, the metal building can become a machine turned to man's use and pleasure. There is a common notion that man may no longer have control of his technology. I think it is reassuring to find the use of common, machine-like, "inhuman" objects like metal buildings and culverts creatively redefined as shelter for man's spirit and body.

Elements that can add new qualities to metal buildings are materials that weather gracefully. Color coated metal siding is made to be weather resistant. The combination of the skin's resistance to weather, its susceptibility to denting, and the understood impermanence of the metal buildings causes an unresolved conflict with time. The metal building is a man made object disassociated from gradual changes of weathering but vulnerable to the same economically motivated consideration that caused man to erect it. The elements that can lend metal buildings a relation to natural processes are trees, rocks and wood, to name a few. Trees should be used for shading and wind pro-

tection; rocks for walks or free-standing walls; wood for railings, shading devices, or applied trim. These are not used to replace metal building parts. They are added to perform functions that are not considered by the manufacturer. The choice of material and detailing will determine how much "grace" an additive element can lend to a metal building.

4. Differentiation of place, path, and domain

A complex program such as that of a town center or a large school contain more valuable social and cultural objects than does the program for a garage or a farm building. The designer needs a hierarchy of strategies for manipulating the metal building system which are congruent with the complexity of the program. From simple to complex these strategies are: surface design, shape design, volumetric additions, and arrangement of volumes. The more complex program will require a more complex method of articulation. I will now explain each of these methods.

The simplest way to articulate a metal building is to apply the design elements of scale and proportion to the color, texture, and openings of the surface and to surface applied scaling devices. For example, the scale of a large building can be broken down by dividing its surface into a series of different color areas. Or a redwood board can be mounted in front of the metal siding as a horizontal ribbon to indicate the scale of the human figure or to divide the surface according

to a pleasing proportion. A change of siding can indicate a different function inside the building using texture.

Changing the shape of the building includes adding canopies, extending the roof for overhangs, and extending the end wall as a parapet. The entrance into a metal building needs to be differentiated from the planar facade and extended beyond the plane of the outside wall to provide a protected transition into the building. The easiest way to accomplish this is to provide a canopy that gives the entrance its own scale and protection. Overhanging eaves can provide sun protection for windows. It may be necessary to square off the building's shape with a parapet in some urban settings where a gable end roof would be especially out of place.

A more complex way to deal with shape and scale is to add volumes to the basic metal building shape. These may be simple "lean-to" additions which contain particular functions or entrance lobbies. A manufacturing facility with a front office and reception lobby could be differentiated by three volumes beginning with a small lobby in front of a larger office volume in front of a huge building containing manufacturing.

More complex programs may call for the differentiation of domains. A large departmentalized school could be organized as an arrangement of separate metal building pavillions, each housing the classrooms and offices of one department. Or the same school could enclose courts if the pavillions were linked by passageways. A smaller

school using common facilities for classrooms that are divided into groups can be organized as a large, central volume, with smaller wings arranged around it.

I mentioned dividing the interior volume using the metal building system grid. This is the simplest method for dividing the interior. However, a metal building encloses a large area. They are used to provide a large volume with free floor area. This implies flexibility when designing the interior arrangement and the possibility of redesigning the arrangement in the future. Though the interior order should key off of primary structural members and the modular grid, it need not be a scaled down version of the building grid. The interior can be ordered as freely as the program and designer's imagination allows.

The encompassing principle, which determines the use of one or more of these techniques is the degree of articulation, should be congruent with the complexity of the program. I have described the various techniques to demonstrate that theoretically metal building systems can be used to articulate complex building functions.

5. Satisfy building needs

I have mentioned the fact that some existing buildings leak and I believe this is primarily due to poor construction techniques. The design of metal buildings should specify lock rivet type fasteners or standing seam roofing. The eave, gable, and window trims that are designed for the system should always be used if the building must be

water tight.

To insure a safe structure, I recommend that the manufacturer be given design live loads at least fifteen percent in excess of those actually expected to be carried by the building. This margin of safety should insure safe performance of the structure -- secondary members in particular because their capacity cannot be easily checked by an engineer.[6]

Like any steel structure, the structural members of this particular system need to be protected from fire. The required protection is established by code, so I need not set down a special principle for metal buildings. Instead, I suggest that a liner integrated with the building system can be developed which incorporates fire protection by backing the available liners with fire insulating materials. This would eliminate the need for firring strips and gypsum wall board to provide adequate fire safety. The integrated panel can be prefinished, thus saving at least three construction steps -- firring, taping, and painting.

The thermal expansion and contraction of metal siding causes the building to be noisy, as metal scrapes across metal. This noise can be substantially reduced by using the manufacturer's standard one and one-half inches of blanket insulation between the siding and the secondary members. Another way to provide a pad between the skin and its support would be available if the manufacturer produced a two and one-half inches

square rubber pad with a hole in its center and adhesive on its back. The pad would be placed over each hole on perlins and girts used to attach the siding.

Activities that may damage the siding or structure should be separated from the building. This is a consideration when planning the building and site. When it is not possible to sufficiently separate vehicles, for example, from the building, sufficient provisions should be designed to protect it -- guard posts, high curbs, and planting to name a few.

The satisfaction of building needs requires an understanding of specific problems and good detailing for their solutions.

6. Expression of feeling

There are feelings we associate with metal that are inherent in a system made of metal -- cold, hard, and machine-like. And there are feelings that are associated with metal buildings -- cheap, light, and impermanent. These are feelings that must be modified before metal buildings can be accepted as valuable objects.

We cannot change the cold sensation of metal. Materials that are pleasant to touch should be used at entrances or placed where someone might want to lean against the building. Wood door pulls and handles, railings and seats are a pleasant sensation at places where users must touch the building. The feeling of this sensation is magnified into an attitude toward the whole building.

The choice of color for metal siding is very important. I can imagine a building with white siding and seafoam green trim as being bad taste. The same building takes on somber qualities with dark earth tones siding and bronze tone trim or playful, cheerful qualities with orange, red and gold siding and light gray trim. I shall not prescribe specific color choices because I believe the feelings associated with color are culturally bound and subject to change when fashions change. Color does affect the way we feel about objects. Because variety of color is one of the characteristics of metal buildings, the designer has in color a good tool with which he can control the expression of feelings.

When a building makes a specific response to existing characteristics of its site -- for example, a window that views a tree -- or when the site is modified according to the order of a building -- a tree is planted in front of a window to provide shade -- the building and site are interrelated. This is not a new idea or unique for planning metal buildings. It is important that a perceivable relationship is established between metal buildings and their surroundings because they would otherwise appear to be metal objects plopped down without really belonging to the site. The arrangement of the site according to the order of metal buildings and the response of metal buildings to existing characteristics of the site embodies the feeling of belonging and permanence in the building.

What feelings can metal buildings express and which ones can they not express? I have been struggling with this question and cannot find a clear answer. Metal building systems have been used for building programs that require an economical and quickly errected solution, but there are metal buildings that look rich. I think the major problem with metal buildings is that very little care is taken in their design. If the system is understood and the same amount of time and care is used in their design as is used for other building systems, then metal buildings can be architecture. The principles I have formulated are guides to help create architecture with metal buildings. The capacity of metal buildings to express feeling must at this time be demonstrated through design rather than theory.

V. BUILDING PROGRAM FOR A NEW PRIMARY SCHOOL (K-4) IN BOZEMAN, MONTANA

1. Existing site conditions

Location: 10.105 acres, NW ¼, NW ¼, NW ¼ of section 20 T2S R6E excluding .792 acres 150 feet by 230 feet at the northwest corner. The site is bordered by Kagy Boulevard on the north and Highland Drive on the west.

Terrain: a cultivated treeless field except for an extensive wind break 10-15 feet wide on the east boundary of the Hausser plot, gentle rolling terrain 0 to 10 percent grade.

Soil: Bozeman silt loam probably 20-50 feet deep over unconsolidated tertiary gravels.

Wind: prevailing westerlies and strong cold winter wind from the east.

2. Phase Development

The school is planned as a small primary school that grows to medium sized primary school as the number of students increases.

Phase I 200-250 students

Phase II 275-375 students

Phase III 400-500 students

3. Site Development

playfield (20,000 sq. ft.)

play ground and equipment

bus drop (3 buses)

parking (15-20 cars)

4. Building Requirements

classrooms	8	+4	+4	850 sf
kindergarten	1	+1		1000 sf
special classroom	1			800 sf
media center	1			1800 sf
multi purpose	1			1900 sf
gymnasium	1			1800 sf
teachers' lounge				400 sf
reception and principal				350 sf
conference room				150 sf
clinic				80 sf
book storage				350 sf
janitor's shop				200 sf
toilets				1200 sf
mechanical				800 - 1200 sf
Total Phase I				17,500 sf
Phase III				25,000 sf
15% circulation Phase I				20,000 sf
Phase III				29,000 sf

VI. CONCLUSION: CRITIQUE OF THE SOLUTION FOR A PRIMARY SCHOOL

This analysis follows two main points: the explanation of techniques employed to express and improve metal building systems, and an explanation of techniques used toward an architectural expression. The two are not necessarily exclusive of one another. For example, changing the eave detail can change the technological imagery of a metal building and therefore its expressive quality. Also, the solution to a tactile problem -- making the building inviting to touch may necessitate an addition or modification to the standard building system. Regardless of the logic for employing a technique, its success toward making metal buildings into architecture must be judged by its relationship in an organic expression.

Five important conditions of the site, sun, wind, terrain, nature of soil, and earthquake zone, have influenced the design. Each classroom is oriented to take advantage of the sun's light and heat. The building is arranged to deflect strong east and west winds and to gain wind protection from the terrain. The school steps down the sloping site to the south and digs in on the west while a burm provides protection on the east. Given very poor load bearing soil and a high earthquake hazard, the building is organized into small units with a separate corridor structure between them so that independent settling and vibration can occur without damage.

By exposing the rafter-column frame on the interior (and in a few places on the exterior) and by maintaining a standard metal skin

which is continued on the inside of each classroom unit to express the independence of each building, there can be no doubt that this school is made with a metal building system. There are some suggested details and materials which are not standard in the system. Rather than treating the roof and wall surfaces as two separate skins whose junction is covered by trim and enclosed with closures and tape, this design calls for a die formed roof sheet that raps the eaves and ridges. This detail cleans up the eaves and ridges, makes them simple to construct, forms a tight seal, and unifies the roof and wall into one skin. To protect the structure from fire, a standard, prefinished metal liner is laminated with fire protection gypsum board. The perlins are covered with a similar liner which is in addition perforated and lined with fiber glass between the metal and gypsum board to absorb sound.

Four techniques are used to articulate the various function in the school. These demonstrate the flexibility that is possible using this metal building system. A large central volume housing the activity core of the school is subdivided into the media center, multi-purpose and gymnasium areas to provide flexibility in the overlapping use of these areas. Additive lean-to units reduce the scale of the central structure and borrow circulation area from it. The classrooms are housed in two room modules that are linked by corridors. The exterior space between classrooms and corridors is used as a sheltered outside classroom-court. In section the shape of the classroom modules is

modified to accept south light by the addition of a triangular frame to the rafter-column frame. While not a standard metal building element, the light monitor is designed as an extension of the system. It is easily fabricated, is bolted to the main frame, and continues the same perlin-metal panel construction.

The structural bay system and its diagonals are used to define walls and areas. The diagonals are used to provide an active transition from general circulation into the two classroom domains as well as a dramatic, multi-focusing and therefore flexible classroom.

The linear character of the metal building panel is exploited as colorful pipe structures and rails that invite a child to touch or sit on them. Technically they stop snow slides on the roof, shade unwanted sun from the windows, support lights and provide safety rails on inclines. Architecturally they scale, express circulation and linearly tie the inside to the outside. Color applied to exposed mechanical systems adds graphic definition to spaces and paths.

My intention has been twofold; to express metal building clearly and as a simple form which can be manipulated to articulate a complex program, and to embody inviting, friendly, playful feelings. While I doubt the probability of a metal building becoming architecture when used for a simple economically tight program like a tire store, I think the implication of this project is clear. Many of the details employed would add cost over an unmodified metal building, but those

additive features are important for architectural expression. Though the most severe of budgets might prohibit metal building systems becoming more than a metal box, this school demonstrated at least the potential that metal buildings can be architecture.

NOTES

1. This is an interpretation of Vitruvius Pollio's "utilitas, firmitas, venustas".

2. Chaplin, James P. and Krawiec, T.S. Systems and Theories of Psychology. New York: Holt, Rinehart and Winston, 1974; p. 454.

3. Ibid, p. 147.

4. Encyclopedia of World Art, rev. ed. (1972), s.v. "Architecture" by Bruno Zevi.

5. Norberg-Schulz, Christian. Meaning in Western Architecture. New York: Praeger, 1975: p. 430.

6. Interview with Dr. George McClure, School of Architecture, Bozeman Montana, March 1978.

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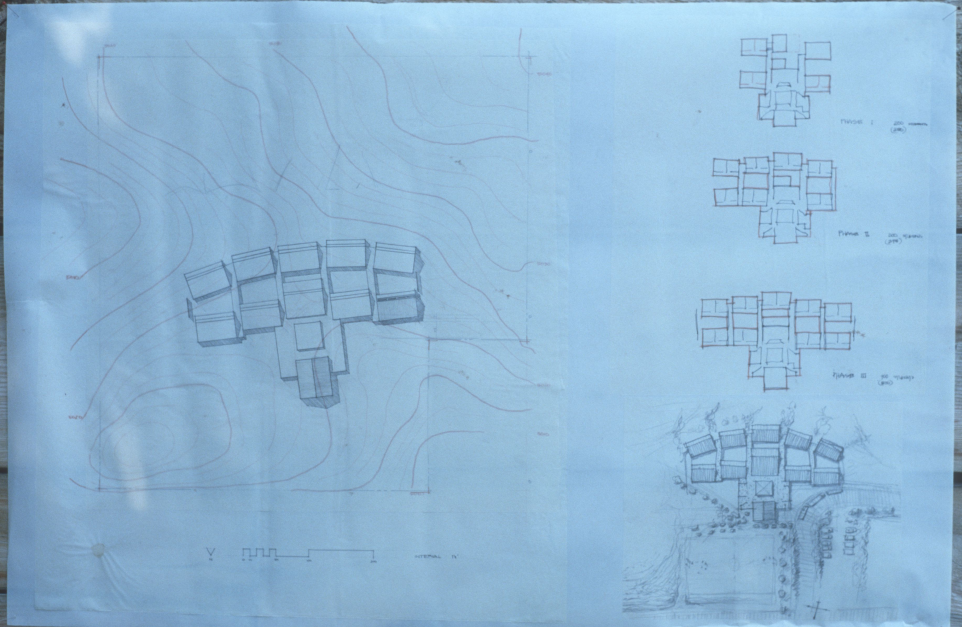
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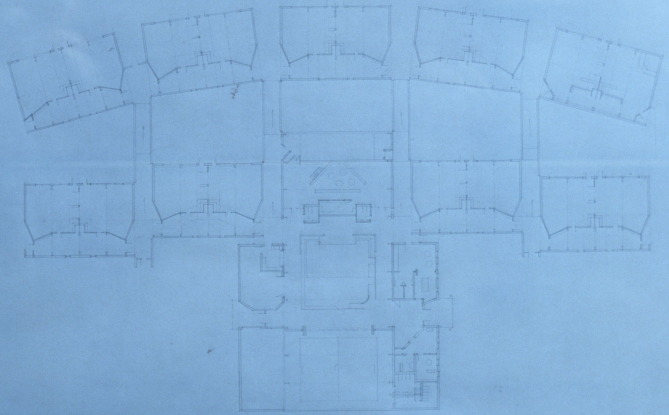
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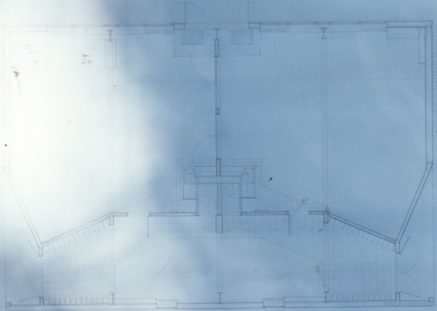
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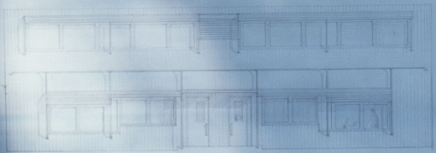


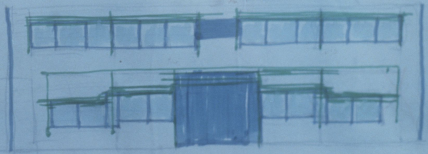


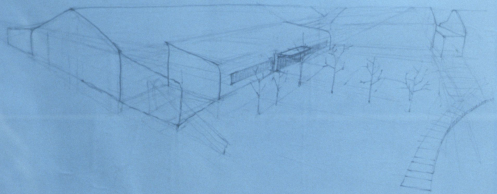
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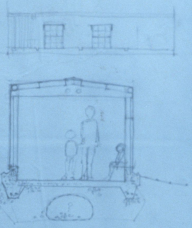












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