JAMES THOMAS TRISCOTT

A STUDY OF THE RELATIONSHIP BETWEEN MEN AND MACHINERY BY MEANS OF DESIGNING AN INDUSTRIAL FACILITY

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A STUDY OF THE RELATIONSHIP BETWEEN MEN AND MACHINERY BY MEANS OF DESIGNING AN INDUSTRIAL FACILITY

by

JAMES THOMAS TRISCOTT

A professional paper submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

of

BACHELOR OF ARCHITECTURE

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MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 1974

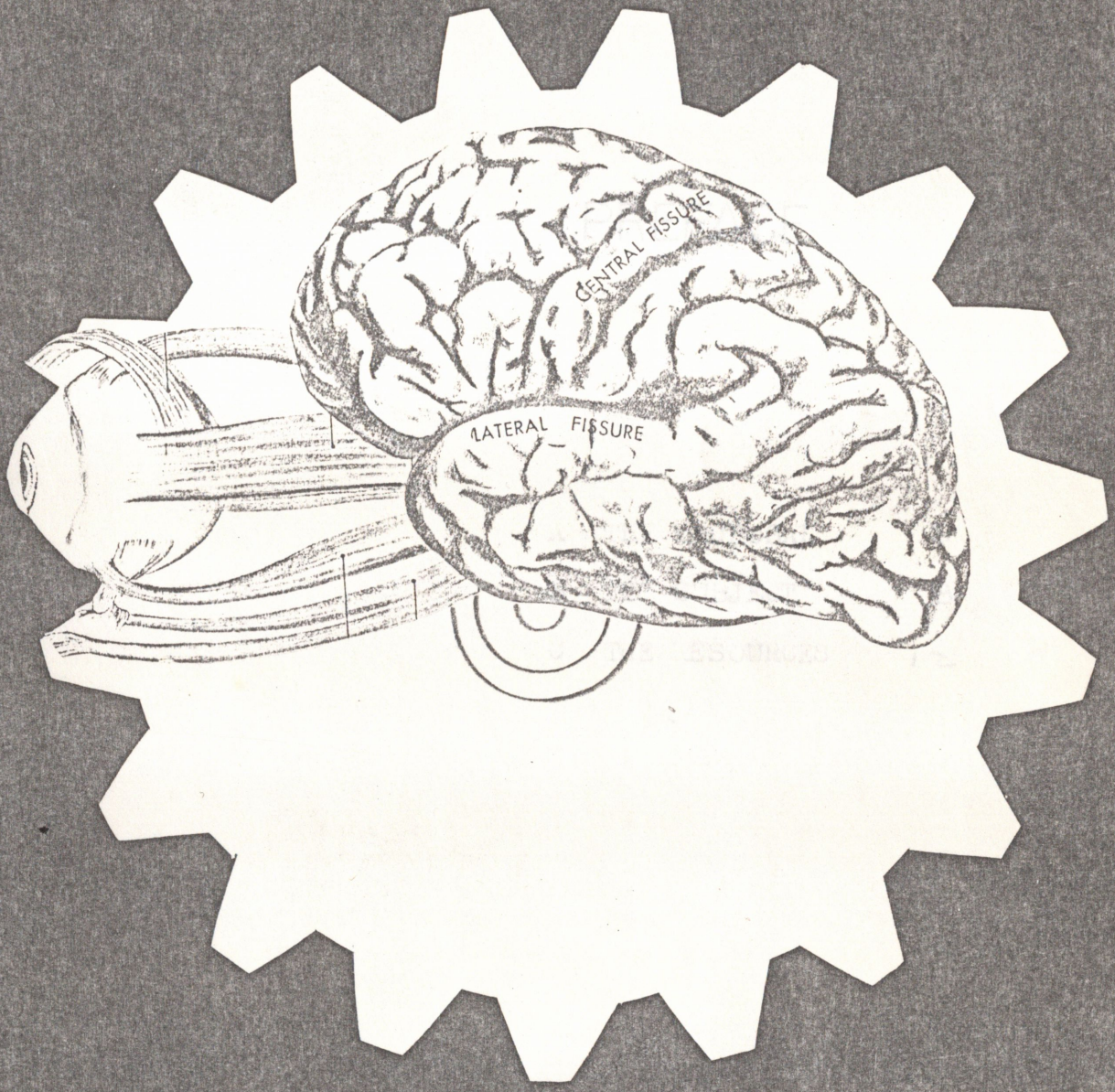
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Date June, 1974

TO MY PARENTS


CENTRAL FISSURE
LATERAL FISSURE

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A THE PROPOSAL

I propose to study the relationship between man and machinery by means of designing an industrial facility.

B THE SUBJECT

The subject of my study is a manufacturing plant which produces fruit and butter ballers, pastry crimper-trimmers and miracle roll can openers (Appendix A, Products; 1,2,3). The site will be in Bozeman, Montana.

It seems in my observations in the area of architecture that one area in the field of design and construction which is often either ignored or shoved into the background is industrial design. Most any planning class will use an industrial area as a bad, or negative example. This is usually justified. From personal observation and available literature these areas are designed for machines and the maximum in production efficiency. The human and the cultural aesthetics are omitted, or at best a feeble attempt is made at both, with neither really being accomplished. Often one result of industrialization is pollution, scrapyards and scarred landscape. There are exceptions of the industrial firms, particularly oil companies, but on the whole this general negative observation seems to prevail in my own judgement.

This does not seem to make sense. Large numbers of people in our society work everyday of their lives in such undesirable conditions. You spend approximately ten hours per day of your conscious life time at work, approximately four at home, and approximately two more traveling or running errands away from either. It does not seem logical that man's comfort and luxury should be

catered to only during the four hour home period when the majority of his time, ten hours, is spent at work in miserable surroundings.

The question is, "Why do such conditions prevail?" Unions have been pressing for years for improved conditions, but management resists such improvements. Management has reasons for this, primarily economics. Most improvements are viewed as unjustified expense which raises the cost of the production process, lowers the profit margin and raises the cost of the consumer items as a result. Management, I believe, would like a comfortable enviroment, but their industrial designers who set up these manufacturing plants specialize in economy and efficiency but to me seem to lack background in human relations and other areas such as structural engineering and aesthetic design. This is understandable because man's individual scope of knowledge is limited. Here, I can see the possibility of interdisciplinary action, such as combination of industrial engineers and architects, working to reach a goal of desirable environment which corresponds with the economics and efficiency needed to meet our society's standards.

The process I intend to employ to design my manufacturing facility will be based on a client-architect relationship, Student of the Industrial Engineering Department in

previous years put together a detailed program of a manufacturing company as described above for the Bozeman area. I intend to take this program, analyze and modify it into an architecturally oriented program suitable for the initiation of a physical design this spring. I will use the program as the source of most of my information, use industrial procedures with an architectural style of diagrams, charts and models to communicate my ideas.

C THE RESOURCES

This thesis subject is based on a senior design project done by the students in Industrial Management Engineering Department (IMnE 407-408) at Montana State University in 1971. This particular plant design was titled SWANDA INCORPORATED done by Roy E. Anderson, John B. Davenport and Randy B. Swartout. The items being produced were fruit and butter ballers, pastry crimper - trimmers and miracle can openers.

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PART ONE

THE THESIS 19

THE PROGRAM 32

THE THESIS

A THE FORMAL THESIS 20
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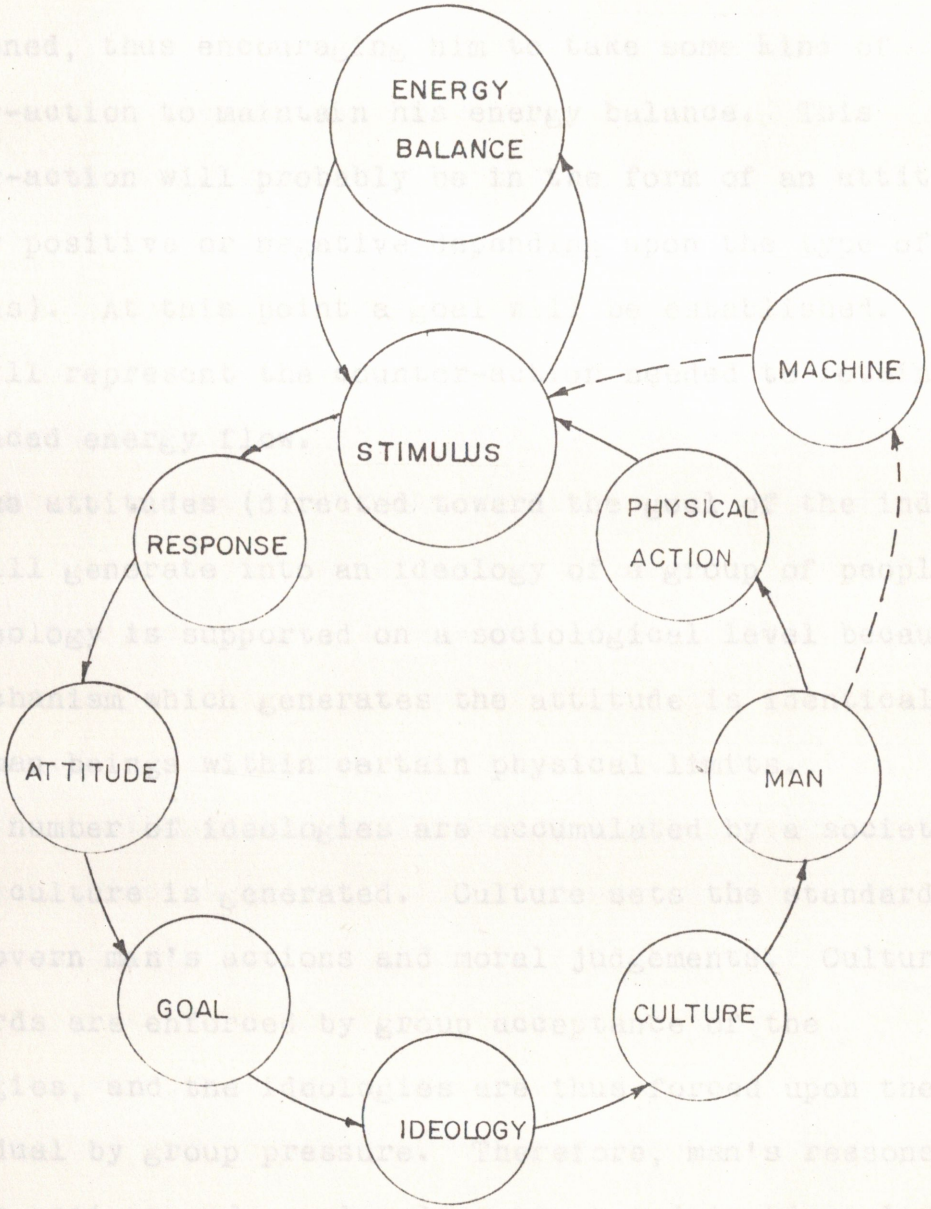
A THE FORMAL THESIS

As a final project I have chosen to do an industrial facility. This project brings together man and his machines. The questions of what is the relationship of man to his machines, why, and the morality of the machines used must first be considered. I also want to study the relation of architecture in the man and machine relationship.

I will describe my hypothesis by starting with the postulate that man's mind is constantly trying to generate a balanced form of energy flow, a situation known as homostasis.[1] This balance can never be reached due to energy expenditure of man's physical and metabolic processes. To complement this energy expenditure he must accumulate energy through the food and oxygen intake process. This mechanism, to remain balanced, is dependent upon man's physical health and abilities (Figure 1). Any method of preventing a malfunction from occuring in man's health and ability will be accepted by man. One means by which man's ability to keep this balance is the stimulus-response - reinforcement mechanism theory developed by B. F. Skinner.

The stimulus is a force from man's physical body or the objects of his immediate environment. The response is the positive or negative reaction generated to work toward

1. Homostasis process developed by Walter B. Cannon based on the 'model of motivation' as explained in D. F. Wrench's PHYCHOLOGY, A SOCIAL APPROACH, page 20.



BALANCING MECHANISM

FIGURE I

his energy balance. If the reaction to the stimulus is positive, an absence of action by man will be needed to keep the energy balance. However, if the reaction to the stimulus is negative, man's energy balance will be threatened, thus encouraging him to take some kind of counter-action to maintain his energy balance. This counter-action will probably be in the form of an attitude (either positive or negative depending upon the type of stimulus). At this point a goal will be established. The goal will represent the counter-action needed to retain a balanced energy flow.

The attitudes (directed toward the goal of the individual) will generate into an ideology of a group of people. The ideology is supported on a sociological level because the mechanism which generates the attitude is identical in all human beings within certain physical limits.

A number of ideologies are accumulated by a society, then a culture is generated. Culture sets the standards that govern man's actions and moral judgements. Cultural standards are enforced by group acceptance of the ideologies, and the ideologies are thus forced upon the individual by group pressure. Therefore, man's reasons for his actions and moral values are based in his culture. Culture is what sociologists claim governs man's superego. Therefore, the single human and the masses of humans can be considered as one person.

Man's psychological goals to balance his energy flow will be contained in his culture. To achieve his goals man must expend some energy through some kind of physical movement, to alter the stimulus, thus change the response and the attitude, to match the goal. One of man's problems is his inability to achieve his psychological goals without great expenditures of his own physical energy. To reduce this energy expenditure and aid him in attaining his goals faster, man developed the use of tools.

These tools can best be described as an extension of man's psychological and physical body. Man's original simple tools became more sophisticated and developed into the complicated machinery of today, representing nearly all parts of man's anatomy. Wheels are an extension of man's legs, the computer an extension of his brain, and buildings an extension of his skin. The form and the use of machines therefore manifests man's cultural values, or you can say the machine is an extension of man's culture. The machine in itself can not generate any attitudes because it is only inanimate material arranged by man.

From this point we can observe that the closer the psychological and physical relationship between man and his machine, the easier man will be able to operate his machines, thus achieve his goals. One could say that the better the environment to accommodate man and also his machines, the easier it will be for man to balance his

energy flow. The 'accommodating environment' is largely under control of the architect. Therefore I define architecture as the design of an 'accommodating environment' for man, his machines, and his activities (Figure 2).

An accommodating environment for the machines must provide required protection of the machine from the weather, provide sequential spaces for the machine process and enough space around the machine for maintenance and operation. An accommodating environment for humans is physical protection from weather, a space volume to function in, adequate safety protection and physical, psychological and sociological supportive conditions.

Therefore I summarize the above hypothesis in the following shortened thesis statement:

MAN, CULTURE AND MACHINE CAN BE UNITED
IN AN ACCOMMODATING ENVIRONMENT

Definitions:

MAN - A human being, as an individual or in groups.

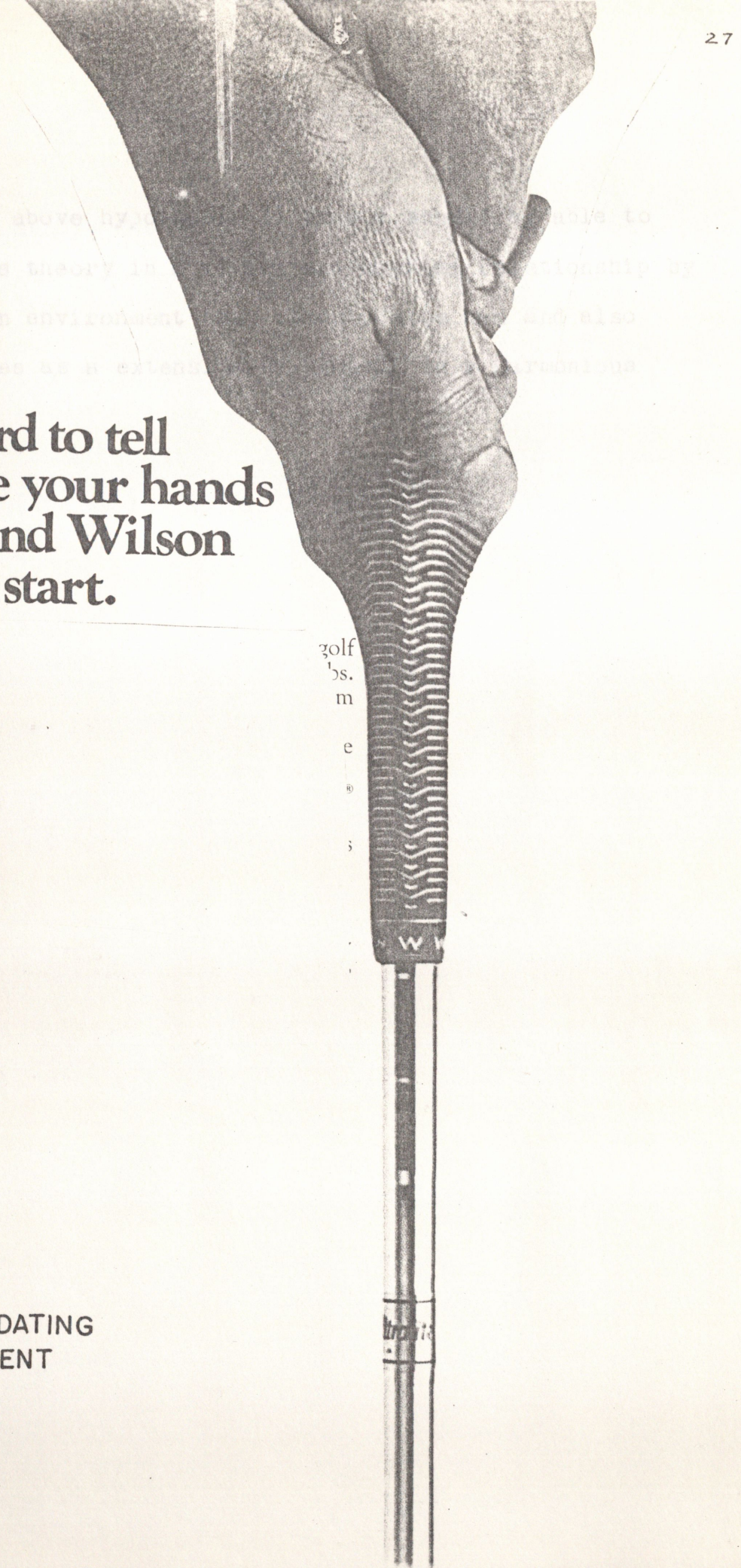
CULTURE - The civilization of a given race or nation at a given time or over all time; its customs, its arts, its conveniences; socially inherited artifacts.

MACHINE - An arrangement of fixed and moving parts for doing work, each part having some special thing to do; a tool; an extension of man's physical properties.

UNITED - Join together; make one; combine.

ACCOMMODATING - To make fit; make suitable.

ENVIRONMENT - All of the surrounding conditions and influences that effect the development of objects; surroundings.



ACCOMMODATING
ENVIRONMENT

FIGURE 2

If the above hypothesis is true I should be able to reflect this theory in a direct man-machine relationship by producing an environment that accommodates man and also his machines as a extension of himself in a harmonious manner.

B THE MAIN RELATIONSHIPS

The two main relationship groups I will concentrate on in this thesis are the culture-man-physical action relationship and the culture-man-machine relationship (Figure 1). These two groups are related in that they both attain the same goal of altering the stimulus. The main reason for concentrating on these two groups is because an architectural environment can influence each groups interaction. Their interactions are controlled mainly because of the physical arrangement of the environment which man and machine are in, while the rest of the relationships are internal in man's physical body and his macro-environment, of which an architect has little control.

First I will look at the culture-man-physical action relationship. The basic needs of the individual such as physical shelter, food, along with human activity by the designer. These basic needs are contained in our culture along with the standards of behavior for the physical action. If a person can not realize these needs and does not know the accepted standards of physical behavior, a state of frustration will be prevalent. This is best recognized in our society as illogical and deviant behavior. Therefore the designer morally should provide in his composition reference, elements to help the individual realize his culture.

Second, I will look at the culture-man-machine relationship. For much the same reasons as in the culture-man-physical action relationship, man must understand how the machine is related to himself. This I described in the thesis, however, to be of use to everyone, man must be in a physical environment that clearly shows the reasons for having machines, their relationships, the total organization of the industrial process and the goal of the industrial facility. If the individual does not understand such an organized activity he will exhibit a form of deviant behavior in the work situation. Again this problem can be influenced by the designer when composing his design by expressing the use and relationship of the machinery.

Therefore, its very good in this thesis to produce a physical composition containing both the needs of the culture-man-physical action relationship and the culture-man-machine relationship in the environment, which I call the 'accommodating environment'.

THE PROGRAM

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A HUMAN

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2. Health 50
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1. Man

Many people blame technology and industry for many of man's problems today. Such a raving generality as this, is misleading. The two most pressing problems of our times, self-identification and alienation of man from his processes, are most recognizable in the work situation. Both of these effect a person's efficiency. In the manufacturing process, the human efficiency factor is critical in keeping the cost of production down in our capitalistic structured society. These problems are most obvious in industry, however, they are also apparent in social, family and personal relationships outside of the work environment; but are not as well related. Self-identity and alienation contribute to such problems as the use of hard drugs, increasing crime rates, vandalism, and other social abnormalties existing today.

The American society, still young in relation to its European ancestors and Oriental neighbors, has been absorbed in increasing its material production and improving its technology while postponing its modification of cultural standards. Cultural standards exist on two levels, non-written and written. The non-written exists in such forms as clothing fashions, music or behavioral fads. The unwritten standards are modified quickly. The written laws are those standards as kept by such social institutions as governments and religions. These institutions have complicated systems of change which are very time con-

suming. The people involved in such institutions often are not in the social norm, thus not exposed to the stimulus promoting change in our culture, thus producing a resistance to cultural adjustment. Thus, there is produced ambiguity between the slow evolution of written standards and the speedy changes of unwritten standards. The results are standards, that the individual uses as points of reference which become blurred and irrevelant to his environment today.

Loss of self-identity and alienation of process are caused by four features of our present society:

1. An adequate sense of meaning in life. In the past, strong obligations to religious, family and simple nationalistic organizations gave a person a sense of belonging and a structure of standards to motivate and guide the individual through life. In our existing society, the traditional institutions are no longer valid. Ironically in their place the occupational identity and the status image have taken over, even though many people possess negative attitudes towards both.

2. Sharp increase of minority groups. This is partly due to an increase of specialization of functions, an unbalanced standard of living, a prejudiced political and economic system.

3. A change from a stabilized culture to a mobile culture. This is reflected in the number and types of

jobs a person is expected to have in his lifetime today; increasing nubers of religious organizations; increase and variation in the types and locations of schools; changes in family and friendship structures due to technical gadgets, increased travel and living locations. In short, a persons' physical environment which at one time was static and easily identified is now dynamic and blurred.

4. Lack of employment. This is caused by the increased changes to our technology eliminating old jobs and people are unable or unwilling to re-educate or adapt to fit into the modified environment created by the technological change. Thus a person loses his occupational symbolization point of refernce. Due to the continuing Protestant work ethic, a psychological stress is put upon unemployed people by society. Also the occurance of sexual equalization has produced a greater demand for jobs.

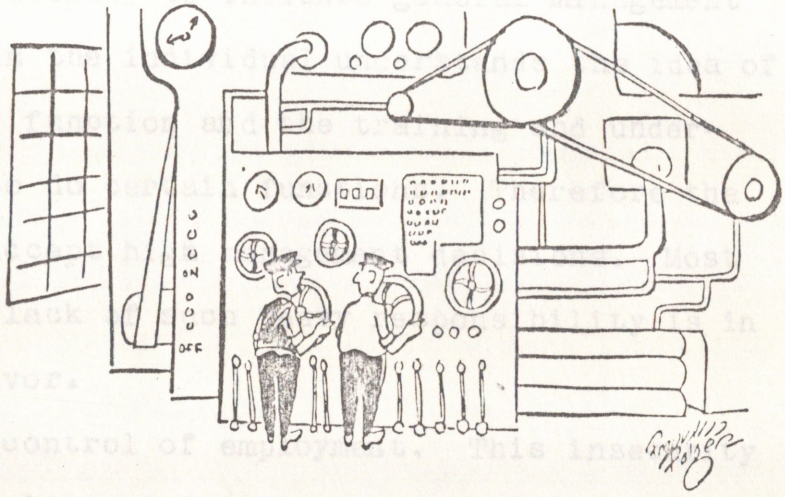
The combination of the above have produced a lack of emotional involvement in life for many modern people. Such problems produced by man with the means of machinery must be neutralized if man is to redundant to accomplish his goal; balanced energy flow.

The previous paragraphs indicate the importance of identity and alienation to the individual. Both are critical to industrial conditions as well. Just by being

present, a job in industry diminishes the identity problem. The problem, however, can be further narrowed down to the concept of self estrangement. Self estrangement refers to the fact that the individual has become alienated from his self-identity. He looses the inter relationships of his work, home, religion, politics and regional environment. Although this is largely a condition outside the work environment, it does effect the person's work productivity. This condition can be amplified in the working situation. Such a condition on the job we will call alienation. Alienation is a generalized condition made up of a number of minor conditions which emerge from certain relationships between the workers involved and the socio-technical settings of employment. In short, alienation is a breakdown of communication between the individual, his peers and his immediate environment. There are several reasons for this:

1. Loss of the relationship between the production and the economic market.

2. A high degree of specialization, forming a condition called compartmentalization. This occurs when the production procedure is broken down into small specialized work groups and the individual can not visualize his place and importance as a 'cog' in the total 'production machine' (Figure 3).



"I'd give anything to know what we're doing"

ALIENATION

FIGURE 3

3. An unclear definition of work and how it relates to his occupation, homelife, religion and recreation. This gets to be a personal judgement.

4. The seperation of ownership of the machine the individual operates. This is largely a historical situation and evident to the worker, it is something he is willing to accept. He understands that personal ownership of large machinery today is economically unfeasible.

5. Lack of ability to inflence general management conditions. Again the individual understands the idea of specialization of function and the training and understanding needed to do certain functions. Therefore the individual will accept high management decisions. Most workers feel the lack of such heavy responsibility is in their personal favor.

6. Lack of control of employment. This insecurity has largely been eliminated by pressure from unions, government regulations and the ability to be able to be re-educated for other jobs that are available.

7. Lack of control over an individual's immediate work process. This does not apply to the general overall flow pattern, but to the smaller semi-fixed items of the factory. The individual resents having the machine set his work pace, limit his motions, or put restraints on his socializing. These are all variables which a person

prefers to set himself. This situation can be improved with greater consideration of human psychology, human engineering and employee involvement procedures when designing industrial processes.

All the above observations are from the position psychologists and sociologists who are viewing industry and society from their own specialized point of view. We must now consider the viewpoint of the people who are responsible for financing, designing, building and managing industrial facilities, the industrial management.

First one must realize the goals of industrial management. Industry exists to make as efficiently as possible a product. This is a rather constricted goal in relation to our total society, but it is simple, straight forward and easy to understand. Traditionally when designing an industrial facility, engineers were used to design the production process and the equipment to be used. This procedure has become very scientific and technically advanced. However, more and more emphasis is being put on employee considerations by the management. It is being realized that the 'employee efficiency factor' can be altered by the designing of an environment to accommodate both the machinery of production and the men who operate the mechanical process. There are six major areas which management regards. They are:

1. Human design - not just machinery and economics.
2. An organized social environment.
3. Motivation of the workers.
4. Coordination of process.
5. Fulfillment of personal employee's wants.
6. A high overall working efficiency.

Let us look at each individual area.

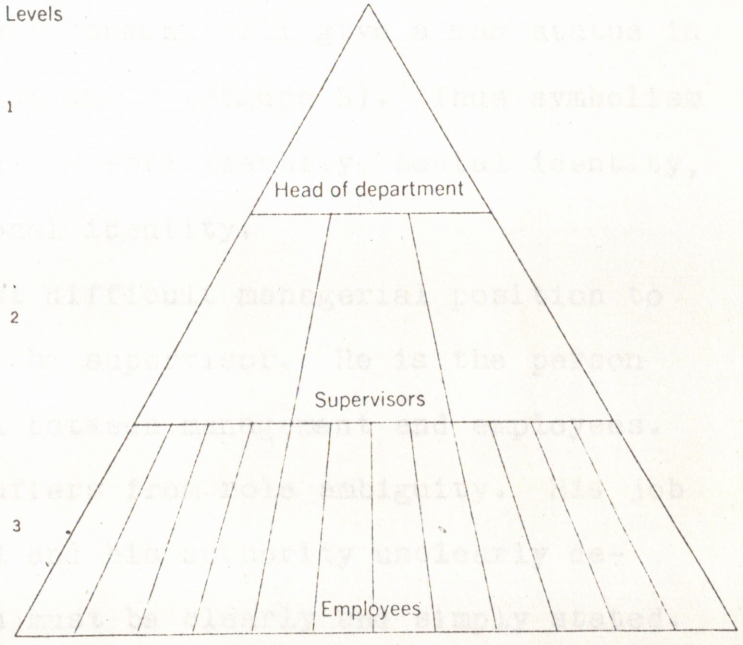
1. Human design. According to A.H. Maslow,[1] man's needs rank in the following order: physiological needs, safety and security, belonging and social activity, esteem and status, self-realization and fulfillment. Physiological needs are such items as light, temperature, color, clean air, washrooms, and other direct physical items. Safety and security overlap physiological needs by requiring such things as adequate light to see dangerous objects, clean air to prevent respiratory disorders, also including such items as safety railings and machine guards to prevent physical injury to the employee. Belonging and social activity are best described as 'being one of the group.' Esteem and status are of importance to an individual in establishing his place in the social organization. Self-realization and fulfillment are established by the type of work a person does and

[1] K. Davis, Ph.D.; Human Behavior at Work, Human Relations and Organizational Behavior; page 59.

seniority of position after years of work.

2. Organized social environments. There are two basic social structures in work organizations. First is the formal structure which is based on hierarchy of control and communication structure in the organization (Figure 4). The second is an informal organization which is spontaneously generated. Much of its structure depends on the number of people in the organization, working groups and interacting individuals. It is basically a non-productive organization. The often mentioned communication 'grapevine' is a symbol of this organization. The informal organization can have a great influence on an organization's work efficiency even though the formal organization is supposed to be controlling everything. Actual control is a fine balance between the formal and informal organization. The formal organization can be broken down into three distinct types: autocratic, custodial and supportive. Each has properties of its own that help suit the type of production system used.

Basically both formal and informal systems are communication systems. It is very important for the individual to know what his position is as to giving out and receiving instructions, as well as his function in the formal and informal communicating systems. Besides his official title or position in the work line



Division of work for sixteen persons by means of the scalar process and functionalization.

FIGURE 4

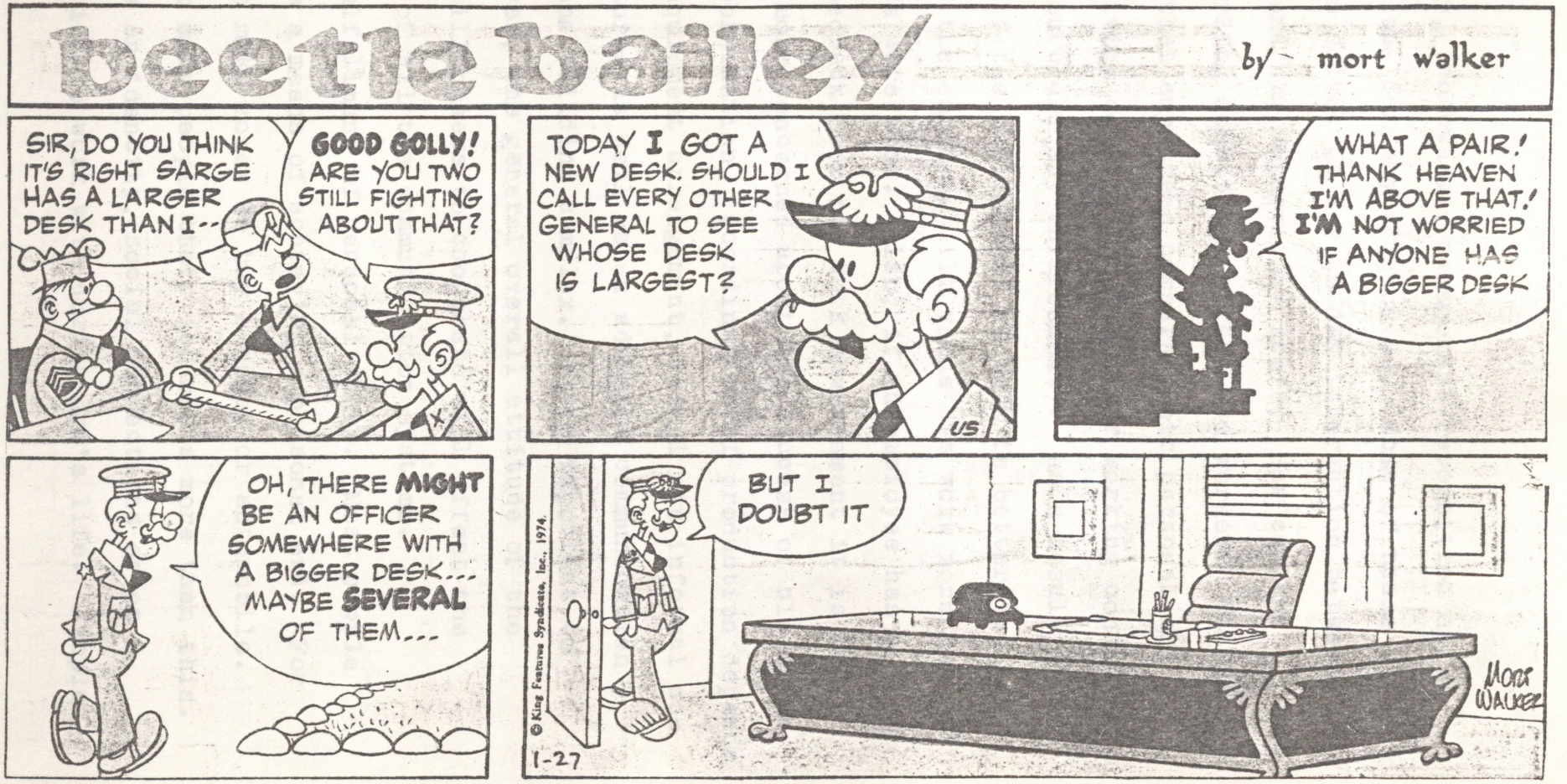
a person requires visual symbols as verification of his position, power, prestige and image. This 'object language' is often referred to as status symbols. A certain type of uniform or special equipment can identify a person with a work group, a blue or white shirt with a position of manual or managerial group, a certain size trash can or desk will establish a status in a group, a quality of working environment will give a man status in his profession and community (Figure 5). Thus symbolism preforms several tasks - work identity, social identity, and above all, personal identity.

Perhaps the most difficult managerial position to fill is the role of the supervisor. He is the person who is the middleman between management and employees. Often this person suffers from role ambiguity. His job is often complicated and his authority unclearly defined. His position must be clearly and simply stated. Many situations call for working supervisors who are sometimes called 'crew chiefs'. His main job is to coordinate activities of his group, build teamwork and communicate between management and his group of workers.

3. Motivation of the worker. Motivation is the willingness of a worker to function for his employer. This is an emotional attitude of the worker. The worker's attitude is effected by many variable conditions such as his personal life, salary, working conditions,

FIGURE 5

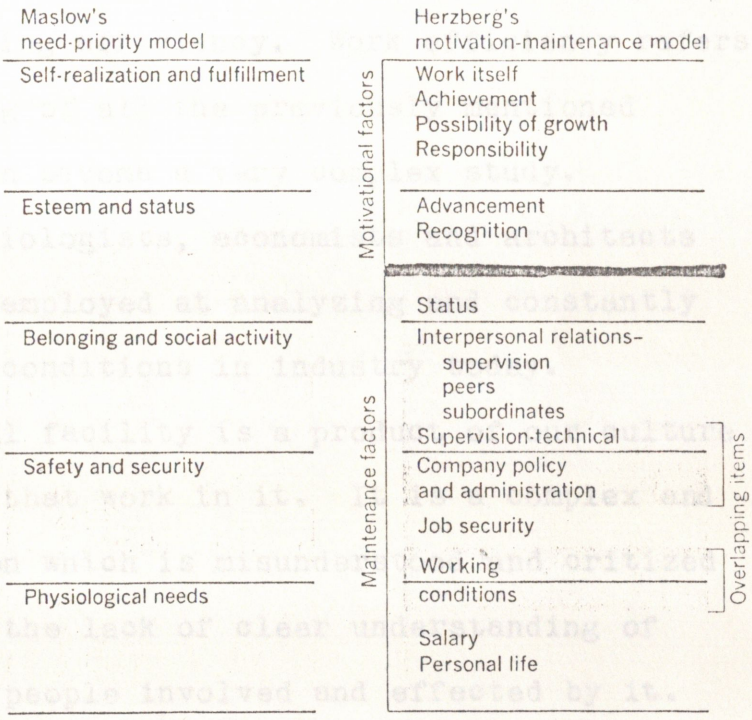
STATUS



job security, job status, management recognition and future with the company (Figure 6). Most of these problems are solved by day to day interaction between the worker and his supervisory staff. How can the physical working conditions effect the worker? It has been found that employees compare their personal and community living conditions with their working conditions (or you could say environment). As a result it is found that if the environment at work is better than it is at home, the employee will value his work more than if the opposite were true. Also, if an employee has a constant feedback from his work environment it is found he will be more concerned about the success of his work.

4. Coordination. Coordination of production depends mostly on equipment arrangement, formal and informal social structures as well as an adequate communication system in the building complex. It is important to note, however, the general overall attitude of the employees willingness to cooperate will effect the efficiency of all the communication systems.

5. Fulfillment of personal wants. Most people use work as a means of achieving a personal end. For example, to make money to buy a house or automobile. However, to many people their job means more than this. It provides an identity, social connections or an interest which to work with during one's life. People



[redacted]. A comparison of Maslow's need-priority model with Herzberg's motivation-maintenance model.

FIGURE 6

can have many goals for working and management finds it most beneficial to help their employees attain their personal goals. Often when a person does not achieve his goals the psychological problem of frustration appears. Frustration leads to a lack of purpose which is a symptom of alienation. Alienation as described earlier is the most pressing prblem management has.

6. High working efficiency. Work efficiency refers to the coordinating of all the previously mentioned material. This can become a very complex study. Psychologists, sociologists, economists and architects can all be busily employed at analyzing and constantly improving working conditions in industry today.

The industrial facility is a product of our culture and of the people that work in it. It is a complex and dynamic institution which is misunderstood and critized mainly because of the lack of clear understanding of the system by the people involved and effected by it.

2. Health

Much is written and talked about in the area of human health. In this thesis I am concerned with human health on three levels. First the psychological level concerning self-identity, second the sociological level concerning alienation, and the third is physical health concerning the problem of obesity. Obesity is caused by a person consuming too much energy (food) which gets stored in the form of fat. Unless this energy is released serious problems with mans physical body can occur as well as side effects in the psychological and sociological areas. To avoid this many people exercise or diet to keep energy intake and energy expenditure in balance. Therefore in the everyday environment conditions should exist so that one can increase or decrease his energy expenditure as he sees fit (Figure 6a).

FIGURE 6.2 HUMAN HEALTH

HEALTH — PSYCOLOGICAL – SELF-IDENTITY
SOCIOLOGICA – ALIENATION
PHYSICAL – OBESITY

HUMAN HEALTH – FOR BEST HEALTH ONE SOULD BALANCE HIS ACTIVITIES SO THAT YOU HAVE ENOUGH ENERGY TO FUNCTION (WORK) AND YOU GET ROUGH PHYSICAL ACTIVITY TO BURN OFF ACCESS ENERGY. [1]

ENERGY DISCRIPTION	TO WORK	WORKING	NOON	WORKING	LEAVING
DIRECTION	REPETITIVE	REPETITIVE ACTION	SPORADIC	REPETITIVE	REPETITIVE
INTENSITY	UNIFORM	UNIFORM	INCONSTANT	UNIFORM	UNIFORM
FORM	PHYSICAL	PHYSICAL OR MENTAL	PHYSICAL OR MENTAL	PHYSICAL OR MENTAL	PHYSICAL
	ENVIRONMENTALLY CONTROLLED	DETERMINED (TIME PROGRAM)	★ VARIES CAN BE DESIGNED	DETERMINED (TIME PROGRAM)	ENVIRONMENTALLY CONTROLLED

PHYSICAL (RECREATION)

INDOOR
TABLE TENNIS
BARMINTON
SHUFFLE BOARD
VOLLEY BALL

OUTDOOR
BARMINTON
VOLLY BALL
BASKETBALL
WALKING
ARCHERY
BASKETBALL
CATCH

PHYSICAL ⟷ SPECIAL INTEREST → MENTAL

SPECIAL INTEREST
CLUBS
HOBBIES
CHARITY ORGANIZATIONS
ENTERTAINMENT

MENTAL (COMMUNICATION)

LEARNING
READING (STUDYING)

ENJOYMENT
READING
TELEVISION
CHECKERS
CHESS
CARDS
TABLE GAMES

∴ THEREFORE IN MY DESIGN I WOULD RECOMMEND:
- PROVIDING A SMALL LIBRARY IN OFFICE AREA
- TV IN STAFF ROOM
- PROVIDE RECREATION AREAS AND FACILITIES

1 CONCEPT TAKEN FROM THE OFFICIAL RCAF FITNESS PLAN; ROYAL CANADIAN AIR FORCE EXERCISE PLANS FOR PHYSICAL FITNESS; SIMON AND SCHUSTER, INC. 1962.

3. Environmental Cognition
   a. space 54
   b. color 60
   c. culture 67
   d. art 69

a. space

Space is the architects ultimate medium. He uses space to manipulate and influence people as well as to express himself in three dimensions. However, first we must examine certain psychological effects of space on human beings.

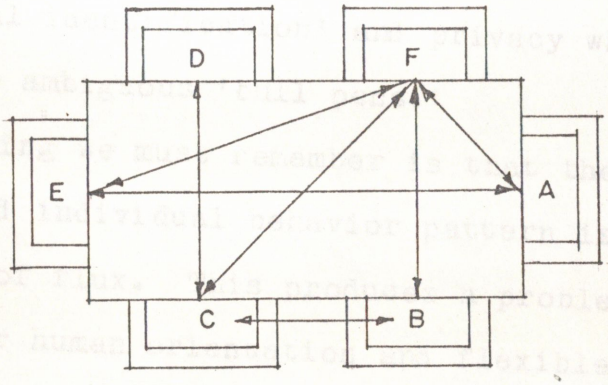
Many people speak of the 'feeling of a space'. This is ridiculous. Man can not experience space in the same sense as he can experience objects. For example, you can experience an object by touch and taste, however, space has no stmimulants. Space is understood by analyzation of visual hints. Eyes pick up light in a two dimensional plane and transmit the stimulus into electronic impulses to the auditory areas of the brain. Clues such as diverging lines, figure size, and detail perception give meaning to our three dimensional concepts. Manipulation of these clues can cause confusion to humans. Therefore, man can not feel physical space. Man can only analyze space.

People are basically confronted with three types of space: fixed, semi-fixed and informal. Fixed space is described as space bounded by statioanry objects such as wells and columns. The machinery of an assembly line is a precise organization of objects arranged in a fixed time and space sequence pattern. The fixed pattern is very important to man's orientation in space. Without an organized, simple, fixed fixured space, an individual becomes disoriented and eventually frustrated. This

emotional state relates to a need of sanity and survival. A state of alienation can thus be created. In our American culture a rectilinear grid pattern is predominantly used. The use of fixed featured space is what determines the visual aesthetic of our buildings.

The second type of space is the semi-fixed space. Semi-fixed space is a volume bounded by temporary or moveable objects. These objects are such things as chairs, tables, filing cabinets or moveable wall partitions. Semi-fixed space is a temporary identity which is highly flexible to meet the needs and wants of the individual. The arrangement of these spaces is basically what controls your social interaction and satisfies man's needs for territorial claims (Figure 7). Space is not the only determinant of communication. Such other variables as the science of proximics, types of conversation, personal relationships and cultural restrictions all inflance communication.

The third type of space is the informal space. This space is characterized by unstated, non-physical boundaries based on the security emotion of the individual and is controlled by the individual's feelings towards other people, loudness of voice, and the physical time-distance relationship of an approaching individual. The study of such behavior is known as proxemics. Four basic distances are



This is a diagram of Humphry Osmonds table observations of people (A through F). It was found the ratio of conversation between F-A was twice that between C-B. Also there was six times as many conversations between F-A than between F-B. Other combinations of communication were almost zero.

SEMIFIXED-FEATURED SPACE COMMUNICATION

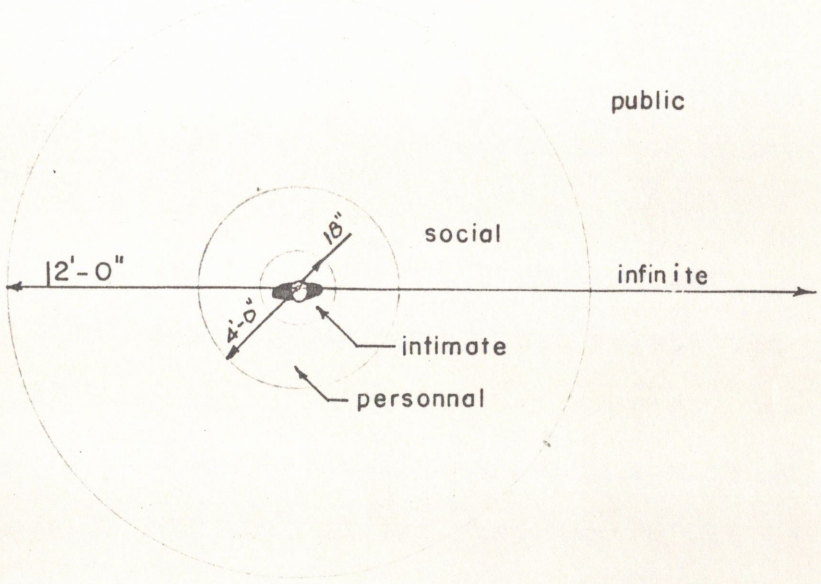
FIGURE 7

prevelant: intimate, personal, and public (Figure 8). These properties alter due to personal properties of the individual (excitement, depression, anger) and his environment (temperature, noise).

Due to the improvements in our technology we have been able to ignore cultural space patterns. The introduction of air conditioning, fluorescent lighting, and sound proofing have made it possible to produce large internal spaces with no window reference to the exterior. These 'barn like' spaces have no broken down 'territorial identification' and privacy which puts people into ambiguous 'bull pens.'

One thing we must remember is that the human function and individual behavior pattern is constantly in a state of flux. This produces a problem of fixed patterns for human orientation and flexible space for functional changes. If we balance large scale spaces with our fixed space definition and let the smaller spaces correspond with our definition of semi-fixed space, a balance between static pattern and dynamic functions can be reached.

It must also be remembered that the emotions of space become diluted the longer a person inhabits the space. A color which originally stimulated an individual will gradually be learned and expected by him, thus loosing its emotional value. This is known as



NORMAL SOCIAL DISTANCES (proxemics)

FIGURE 8

the development of a 'behavioral sink.' Learned reactions are slow to change or alter. However they can be altered over a period of time.

Finally it must be remembered that space can become a concepturalized symbol. Its shape (or you could say boundaries) and physical properties such as light, lines or colors can represent something to a person. Thus a space becomes a learned identity.

b. color

When architects design buildings they are often very conscious of form, mass, line and shadow and often leave color consideration till a final schedule is required. Faber Birren,[1] a follower of the Gestalt Theory of preception, claims that this design procedure is backwards. He claims that architects should consider color before other elements of design are considered.

Birren has several good reasons for this. He claims that visual preception is the greatest tool for us to use in communicating with our environment and that color is the most predominant element in preception. Birren claims that we identify an object by its color, then further our understanding of the object by the arrangement of line, shadow, texture; then relate the object to its surroundings with scale of distance. Gestalt psychology indicates that children rely heavily on color identification and that adults also use it but to a lesser degree because they combine the effects of such elements as scale and line perspective. In our culture colors have certain symbolic meanings such as red is warm, blue is cold, white is pure and black is evil. Thus, by indicating such symbolism, a persons emotions can be effected. Color also can be functional. Light or dark colors can control the amount of light

[1]Faber Birren; Color, Form, and Space; 1965

reflected. Color X can indicate dangerous situations and contrasting colors can be used to make signs readable from a great distance. Imaginative use of colors can be used to add interest to otherwise dull surroundings.

Another interesting concept of Gestalt perceptional psychology is that the human mind tries to simplify everything it sees. Therefore, the simpler the object, the more agreeable it is to the individual. On this basis we can say that good design will have the simplest of geometry, clearest of form and only use primary colors. Over-simplification of colors will be boring, therefore a balance of composition must be met.

Color according to Gestalt psychologists is in three distinct forms; pure color, white, and black. Pure color and white make up tints; pure color color and black make up the shades; white and black make up the greys; and the combination of all the above make up the tones (Figure 9). The pure colors are red, yellow, green, and blue. However, when we talk of colors we refer to a broader scope including mixing of the pure colors to form an overall spectrum of red, orange, yellow, green, blue, and violet (Figure10).

Each color has its own luminous qualities in daylight, darkness or in combination with other colors (Figure 11). Other qualities such as stability

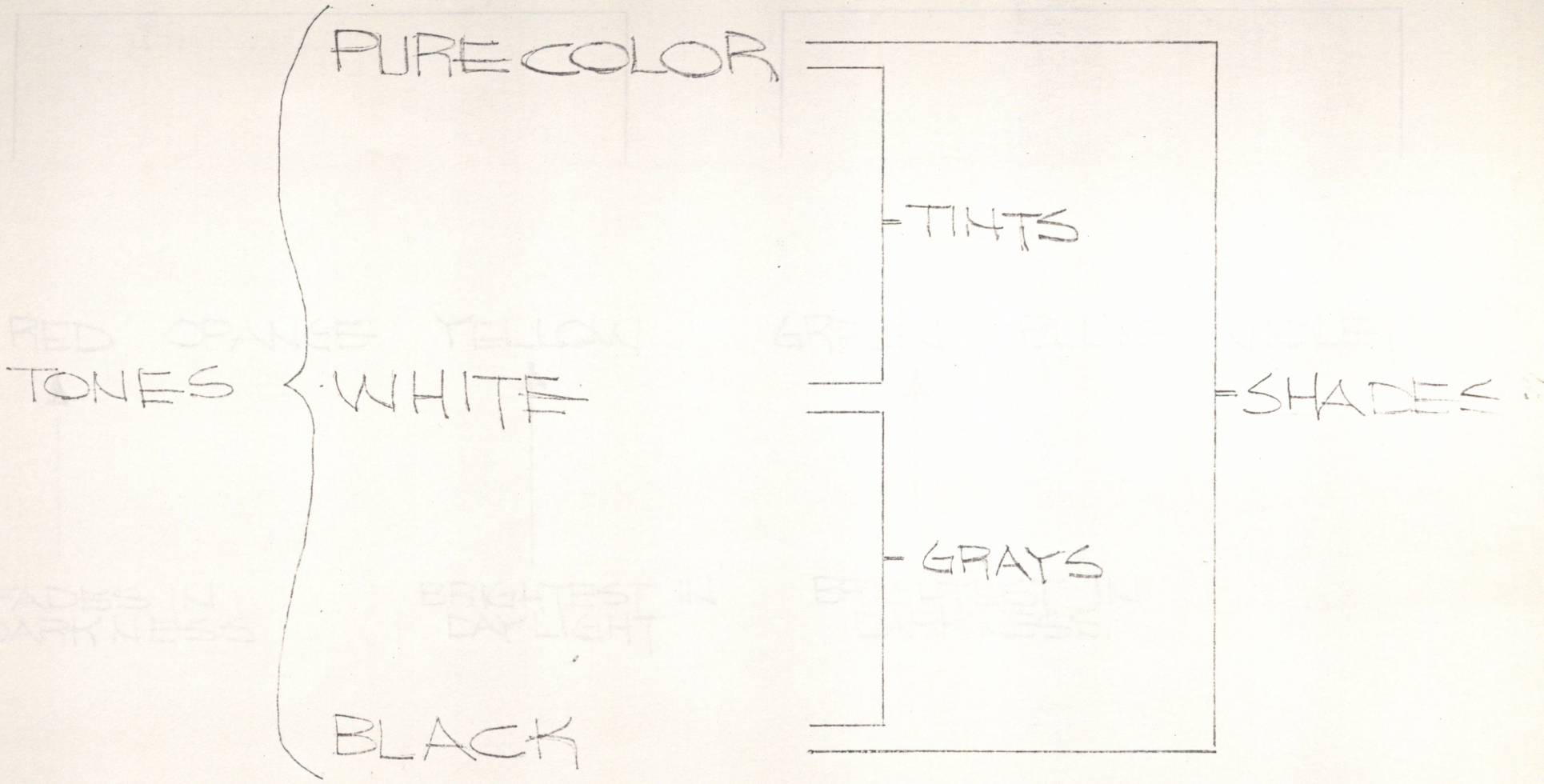


FIGURE 9

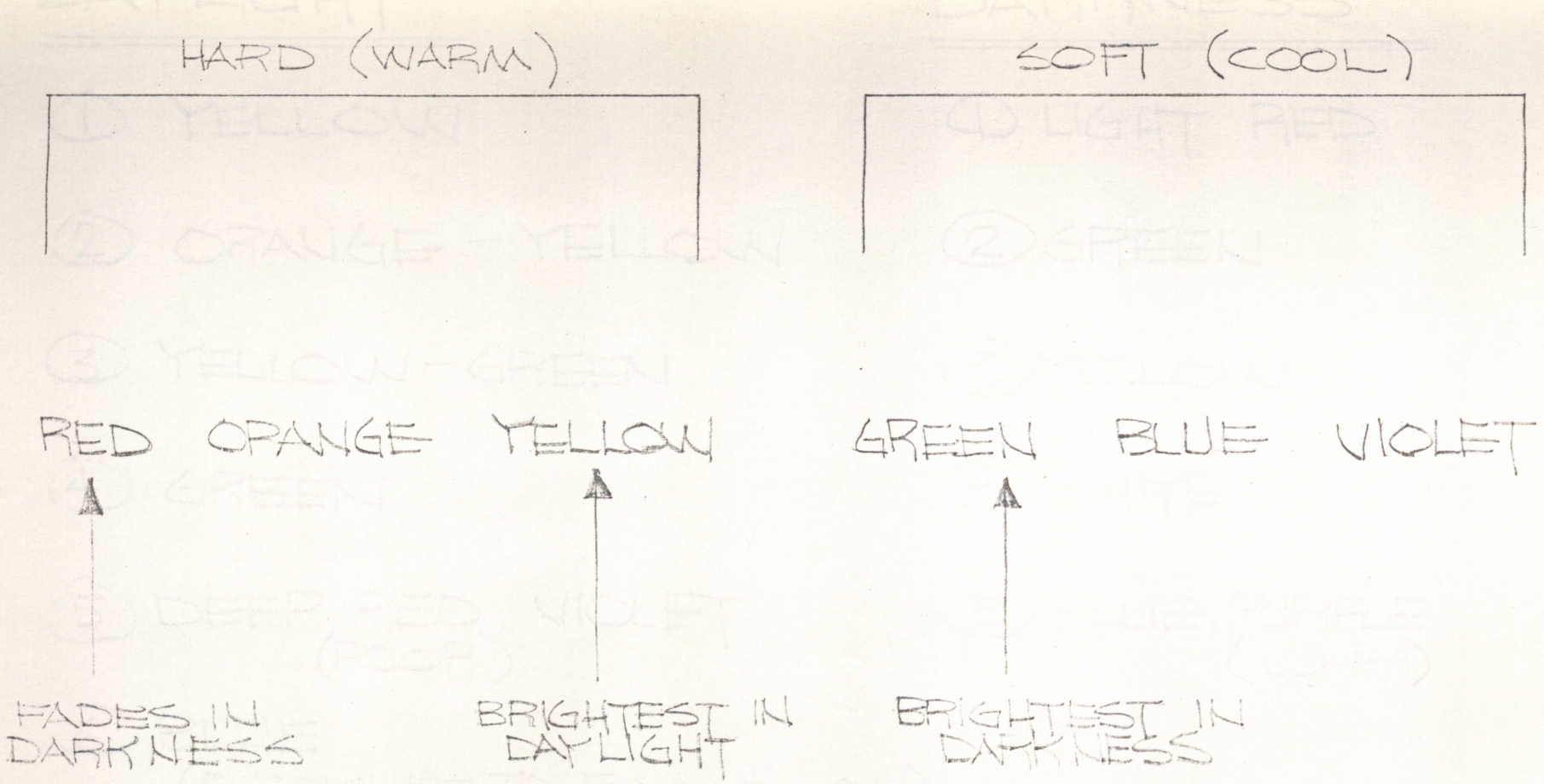

HARD (WARM)
SOFT (COOL)
RED
ORANGE
YELLOW
GREEN
BLUE
VIOLET
FADES IN DARKNESS
BRIGHTEST IN DAYLIGHT
BRIGHTEST IN DARKNESS

FIGURE 10

DAYLIGHT	DARKNESS
① YELLOW	① LIGHT RED
② ORANGE - YELLOW	② GREEN
③ YELLOW - GREEN	③ YELLOW
④ GREEN	④ WHITE
⑤ DEEP RED, VIOLET (POOR)	⑤ BLUE, PURPLE (LOST)
⑥ BLUE (DIFFICULT TO FOCUS ON)	

[BASED ON VISIBILITY AND RECOGNITION
LISTED FROM BEST TO POOREST]

FIGURE 11

depending on tone and ambiguity of mixing color patterns produce a medium of great flexibility to the designer (Figure 12).

ATTENTION POWER	NEAREST OF COLOR
① RED-ORANGE	① YELLOW
② YELLOW	② WHITE
③ RED	③ RED
④ ORANGE	④ GREEN
⑤ ORANGE-YELLOW	⑤ BLUE
⑥ YELLOW	⑥ BLACK
⑦ YELLOW-GREEN	

NOTE: WARM COLORS IN FRONT OF COOL COLORS.
WHITE AND BLACK ARE CLOSE (WHITE DOMINATING)
GRAY RECEDES
PURE COLORS ARE THE CLOSEST.

FIGURE 12

c. culture

America is inhabited by the descendants of European explorers. Even today many Europeans do not feel comfortable in America due to a difference in environmental conditions. To many Europeans, America is vast, wild, empty, formless and unfinished. Its cities are in a constant state of casual chaos.

If we examine the relationship of the modern American-born man, as well as his topographical spaces and structures we will find some interesting relationships. American buildings mirror the nature of the topography. The buildings are large in size, open, unclear in boundaries as to the definition of inside-outside; and the views and lines of the structure reflect the far ranging perspective of the open prairie. Due to the harsh climate, buildings are functional, full of meaningful visual working relationships rather than appearance for aesthetic value only.

In America, buildings have a temporariness about them. Because of the rapidly changing society, a building may be obsolete within a few years. It will be removed and replaced with an improved structure. This again reflects the American idea of building for tomorrow, not today. America does not believe in making its buildings artifacts of the past, it is only interested in the future. Even though America does look forward the people are very conscious of the

past, but in a romantic image.

Most of American architecture has a European heritage or has been influenced by the European culture. Outside of the native Indian structure which have long since degenerated to the level of museum pieces, the only pure American architecture has been recognized by only two men, Frank Lloyd Wright (The Prairie School)[1] and Robert Venturi (Vagus Strip Theory).[2]

This to me represents a young, immature nation, not yet established in its culture. This can partly be the reason for the problem of personal identity and alienation of its people. Perhaps in another 500 years the country will settle down to the same patterns as its European relative countries.

1. F.L. Wright, A Testament, 1957

2. R. Venturi, Complexity and Contradiction in Architecture, 1966

d. art

Art is considered by many people to be a luxury item or a decoration, but art originally had functional qualities. Art was used by prehistoric and primitive people in rituals and religious ceremonies. The function of art was visual symbolization and communication (Figures 13 and 14). This function is prevelant even today. Art has evolved to more intellectual levels since the end of the neo-classical periods and the beginning of the Realist movement around 1800. Art stayed fairly object oriented with a definite symbolism through the impressionists, Art Nouveau, Futurism, Surrealism and the expressionists. However, the late expressionists, cubists and abstract expressionists have highly idealized and non objectives. Without an understanding of art the average person can not relate to such works. The primitive functional qualities have changed.

I conclude that the use of visual communication in art can be regenerated by using such modern art forms as Pop art, Primitive art and New Realism to convey cultured messages to Americans common people.



EARLY CHRISTIAN

FIGURE 13



BAROQUE

FIGURE 14

B THE MACHINE

This section will sum up the Industrial Engineering program and describe it in simplified terms.

Some general attitudes must be held when observing a production line. The equipment must be placed in the simplist overall process available, for the highest machine utilization and flexibility. Generally, a designer also tries to minimize the amount of material handling, although this varies with the type of equipment used.

There are three basic types of process layouts: production, departmental and fixed position. The production layout is better known as straight line process. These production lines are highly automated with very little handling. This is a highly fragile system and maximum machine utilization is difficult to obtain. The departmental layout is best described as a linear production line broken down into sections. This system has higher material handling time, but maximum machine utilization is easier to obtain. Fixed position layout is best described as the building construction process. In this system the product is too large to move so the equipment used to manufacture the product is moved as needed around the product. This is perhaps the most complicated and inefficient method of assembly.

The authors of the Industrial Program being used

as the subject of this thesis choose a departmental system of assemby (Figure 15). Refer to equipment description to study the machinery being used (Appendix B, Equipment; 1 through 20).

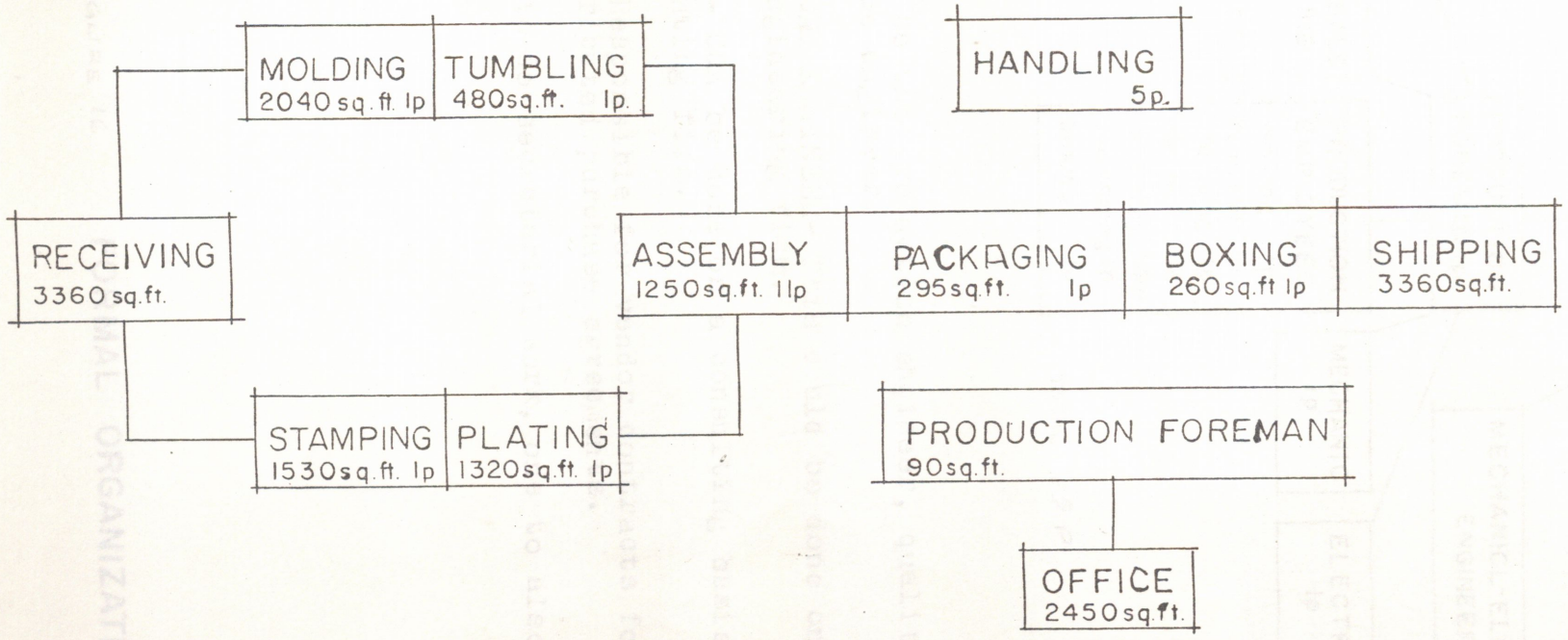
The handling system proposed is a tote box-pallet-fork lift system lift system (Appendix B, Equipment, 17 through 20). This allows a great amount of flexibility in handling and storing parts.

I proposed to reduce the number of office staff. I believe that the number of people in the front office can do duplicate functions and some of the jobs can be done on a consultant basis. For example, a full time production engineer could not be used efficiently in a manufacturing facility this small. I propose that such a person could also be the plant manager and quality control engineer. This would eliminate two jobs and keep one, thus lowering the non-productive personnel overhead. See the organizational chart for the revised personnel structure (Figure 16).

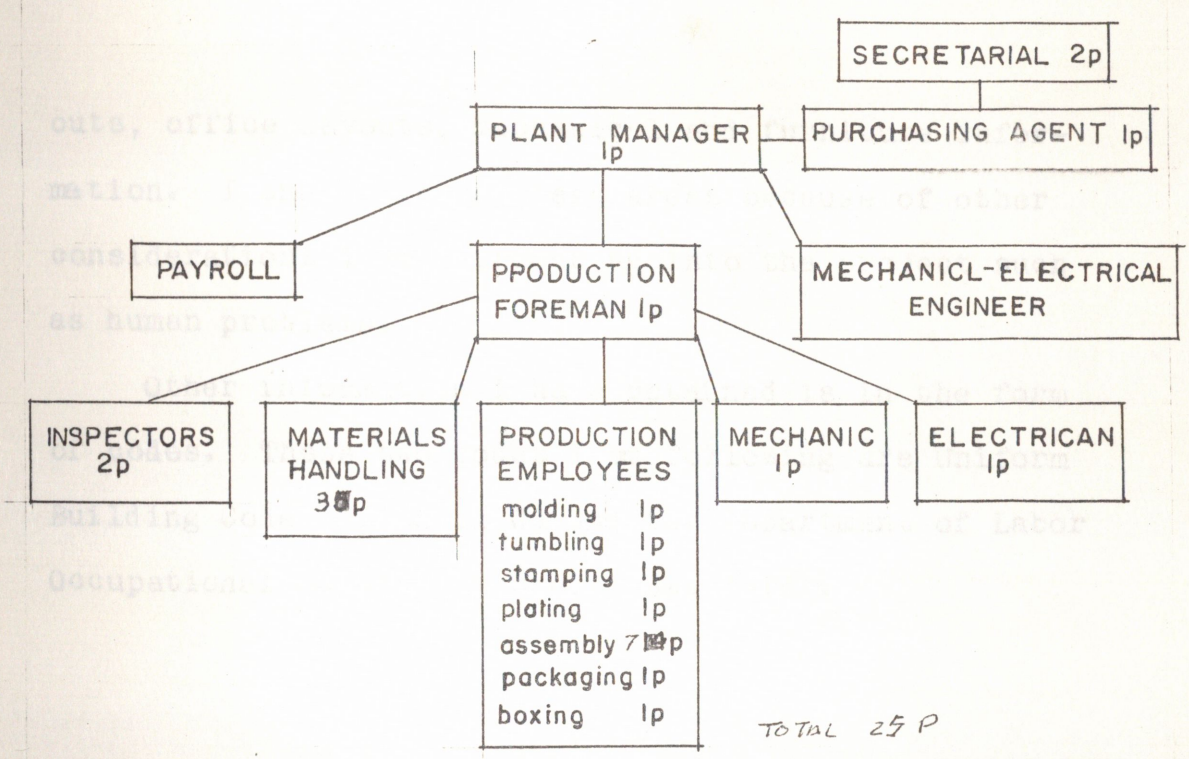
The second change I propose is the selection of another site. I questioned the proposed location on the grounds of lack of utilities, lack of flexibility of transportation modes and the lack of coherence with the overall planning (zoning) of the Bozeman community.

In the Industrial Engineering program a large part of the project was taken up by computerized area lay-

FIGURE 15



BUILDING PROCESS LAYOUT (DEPARTIMENTAL SYSTEM)



OFFICE STAFF

PLANT MANAGER- Can be the production engineer, quality controll-maintenance engineer.

MECHANICAL-ELECTRICAL ENGINEER- This could be done on a fee bases by a local engineering firm.

PAYROLL-ACCOUNTING- Can be done on a consulting basis with a local accounting firm.

PURCHASING AGENT- Responsible for vendor contracts for all commercial and fabricated purchase agreements.

SECRETARIES- Both to do secretarial work, one to also act as receptionest.

FIGURE 16 **FORMAL ORGANIZATION**

outs, office layouts, mechanical and furniture information. I shall ignore these areas because of other considerations I am introducing into the project such as human problems.

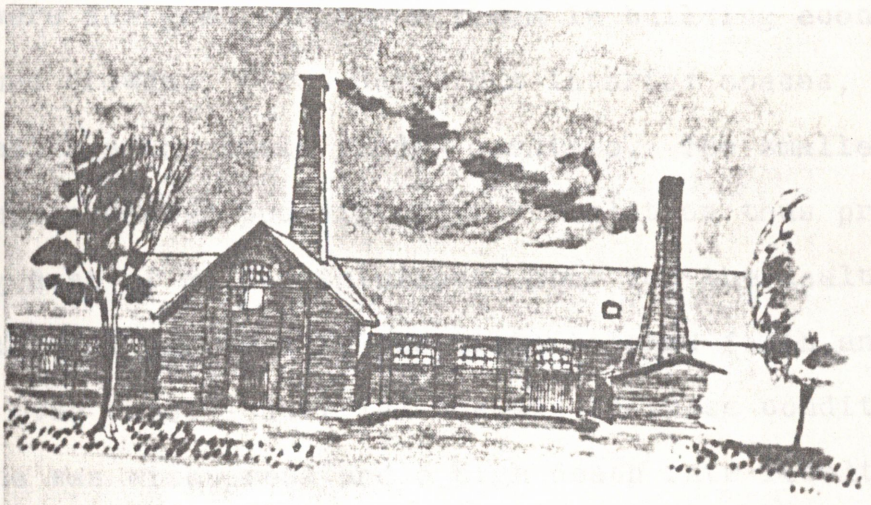
Other information I have obtained is in the form of codes. These two codes I am following are Uniform Building Code (Appendix C), and the Department of Labor Occupational Safety and Health Standards.

C LOOKING BACK

The modern industrial factory system grew out of a need to improve the living conditions of mankind. It offered an alternative way of life from rather a grim, degenerating medieval social structure. Although there have been times of intolerable living conditions the factory system as evolved has given us a high standard of living, technical asvancement and freedom which we enjoy today.

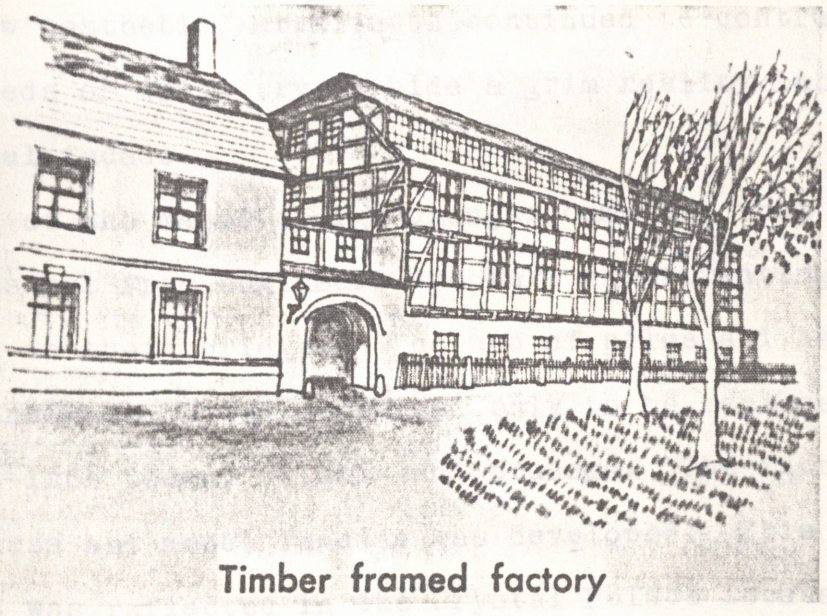
The modern industrial system has been a major element in our lives for the last 200 years. However the 'factory system' actually dates back 500 years in England. These factories were small and scattered, mainly producing cast iron. Two restricting factors kept these industries small: fuel and transportation. With coal replacing wood charcoal as a fuel and the use of Watts' steam engine, large scale production became possible. By 1740, large scale use of power and concentrated labor replaced the earlier 'cottage industries', particularly in the textile industry.

The early mills were composed of loadbearing masonary or timber with wood roof framing and very wide window openings (Figures 17 and 18). They were located in rural surroundings on the banks of rivers where they could use the water wheel for a power source. About 1750 came the steam age and with it the increased use of cast iron framework in a masonary enclosure.



Loadbearing brick factory

FIGURE 17



Timber framed factory

FIGURE 18

The industrial buildings themselves were poor. They were designed for the maximum in building economy. They had crowded, dark, dangerous interior spaces, with low ceilings and small window openings. The smaller openings produced poor interior ventilation thus promoting dust or mildew interiors, poor for the health of the workers. Above all, the mills belched filth and smoke over these industrial towns. In these conditions disease was widespread and a high death rate resulted.

By 1830 the laws of England began to respond to the grim situation of the poor. A few improved designed industrial towns were attempted. This was the time when architects had the opportunity to get involved in the industrial movement. However, not knowing how to deal with a new aesthetic, architects continued to contruct simple sheds or would try to hide a grim reality behind a classical facade.

Most of the major design changes came not from architects but from engineers who were experimenting with cast-iron in their bridges. The use of piles and heavy timber construction was perfected only to be replaced with cast-iron beams, columns and trusses. The increased use of glass and metal facades was developed. This aesthetic was reflected in the Crystal Palace located in London in 1851 (Figures 24, 25 and 26).

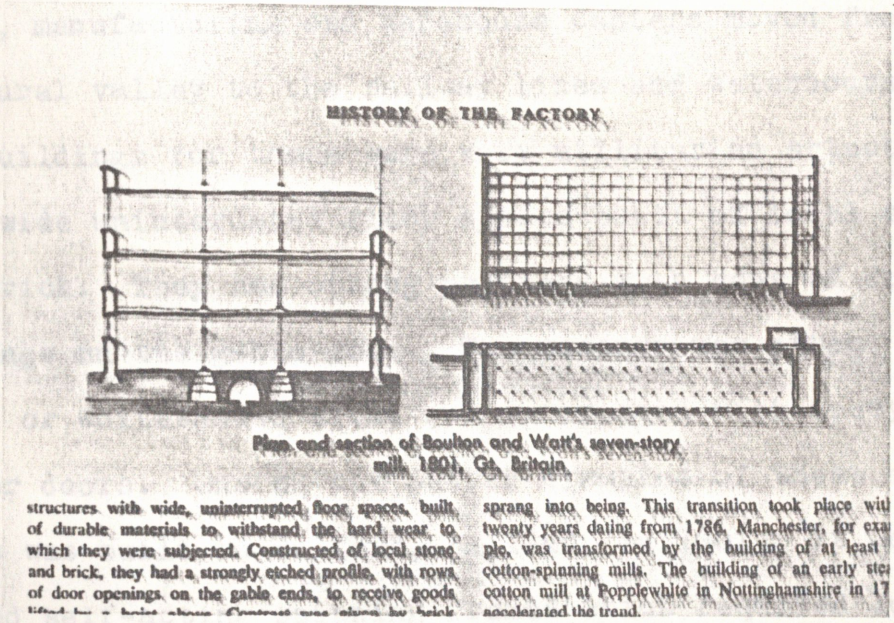
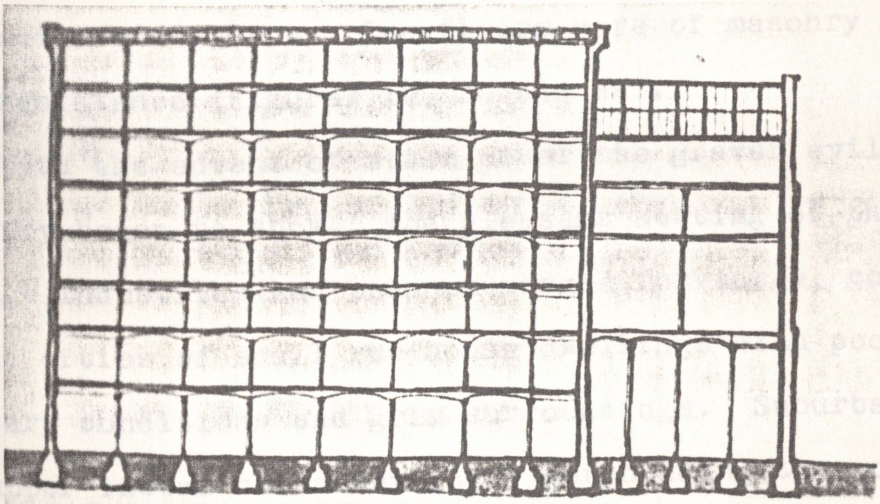


FIGURE 19



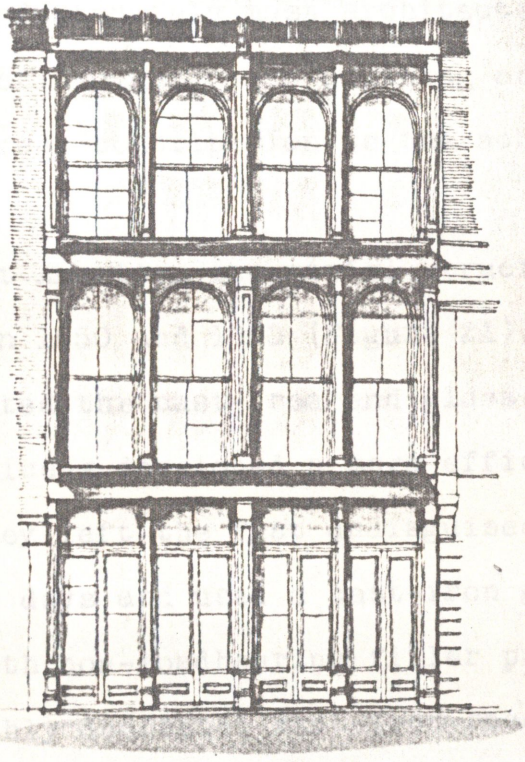
Fairbairn's refinery, cross section. 1845, Gt. Britain

FIGURE 20

With the passing of water wheels and the advent of steam, manufacturing and warehouse centers moved from the rural valley to the railway lines and watercourses. The buildings for these were very utilitarian srtuctures with wide uninterupted floor spaces built of local stone and brick. They had strong profiles with rows of door openings on the gable ends. The masonry was often plain or whitewashed brick and contrasted with heavy timber doors. One of the better examples of these early mills was built in Salford, England, in 1801. It contained self-acting spinning frames which required long narrow spaces. The mill was composed of a cast-iron framework enclosed in masonry. The beams were 'I' sections spanning the elongated structure with only two intermediate supports. The floors were of masonry for fire resistance (Figures 19, 20 and 22).

With the advent of steam power the graver evils of industry began to show. The pleasant setting of the cottage industries had been exchanged for large, congested cities of small row house dwellings with poor sanitary conditions and grim surroundings. Suburbs for the upper income class developed surrounding the poor worker tenements. The industrial buildings were located in the center of the tenements. Their conditions were prevalent throughout England in the 1800's.

span. These two great bridges awakened man to



Factory at North First Street. 1849–1850, St. Loui

FIGURE 21

It was about this time the Arts and Crafts Movement began. A few men like William Morris were disillusioned with the quality of the industrial products and living conditions so they counteracted in the form of an arts movement back to the medieval and classical worlds. They claimed that the world needed better craftmanship. Unfortunately most architects agreed with this train of thought, thus omitting architects from making any real contribution to the achievements of mankind.

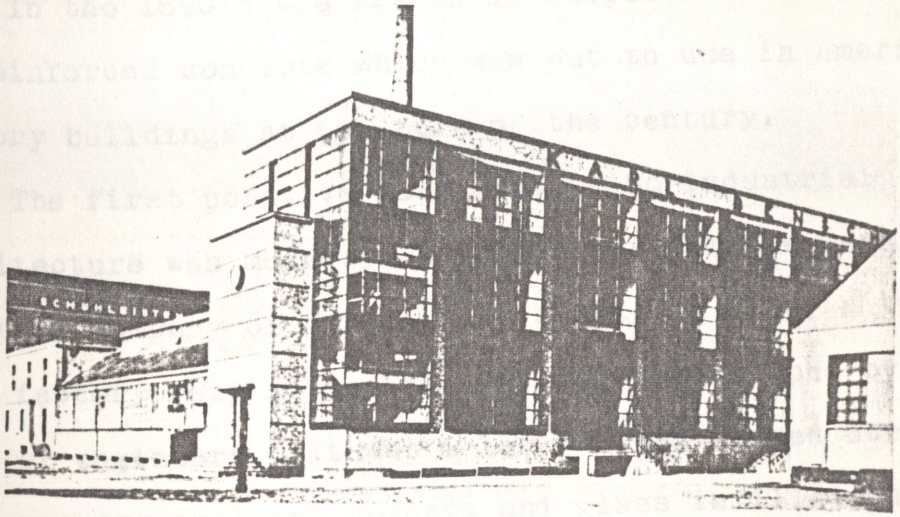
The earliest American industrial structures began to appear between 1850 and 1880 (Figure 21). The Americans inherited the cast-iron and glass aesthetic. However the Americans developed a more efficient style of building. They left the flat undisguised brick walls of the Civil War days and used a cast-iron gridded skeleton plan with non-loadbearing filler panel walls of glass and highly decorated cast-iron facades. By the 1870's steel had began to replace cast-iron in buildings.

By the end of the 1800's, architects began to accept the importance of industry. Architects began to recognize the social and functional reasoning of industry along with the structure and treatment of industrial buildings. The foremost idea of efficiency of production was beginning to be reflected in the design, layout, purpose and



Meunier Chocolate Works. 1871–1872, France

FIGURE 22



179 The Fagus factory at Alfeld on the Leine, designed in 1910 by Behrens' young pupil Walter Gropius, summed up all that had been achieved in pre-war industrial architecture. Slim brick posts, and all the rest glass; no posts at the corners at all

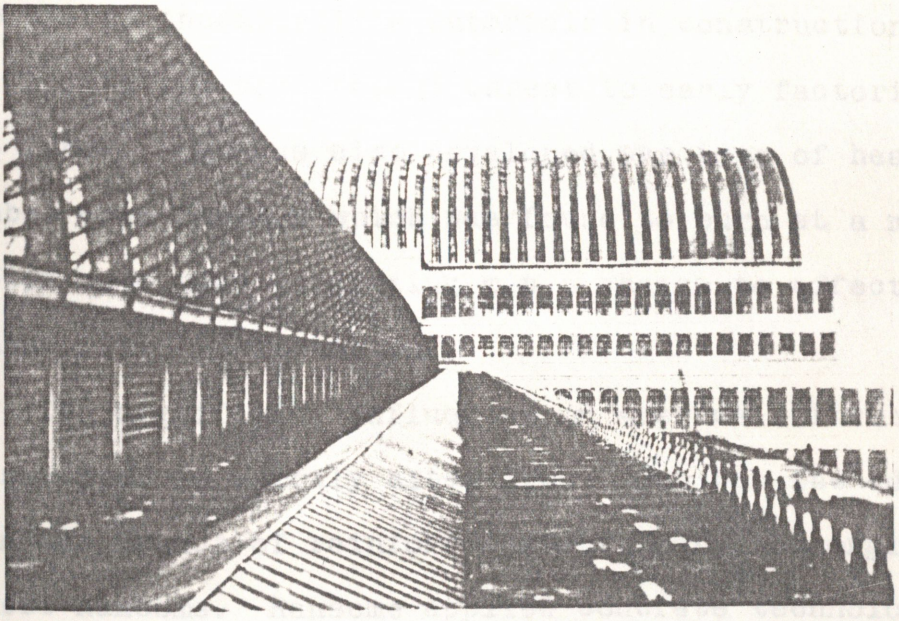
FIGURE 23

the appearance of the materials of these structures.

Conditions in the European industries differed from those in the United States at the turn of the century. The Europeans had great numbers of cheap but skilled labor and limited material supplies which did not promote a high degree of mechanization as possible. In America the situation was reverse. Due to the high numbers of unskilled labor a high degree of mechanization proved to be more feasible. The idea of the endless production chains appeared. The local butcher was replaced with the meat packing industries and with it the evolution of stockyards and methods of refrigeration. Some other industries, as the mechanized bakeries, appeared.

In the 1890's the French developed the technology of reinforced concrete which was put to use in American factory buildings at the turn of the century.

The first positive contribution to industrial architecture was made by Peter Behrens for the General Electric Company of Berlin. He built, in 1909, a turbine factory relying on the aesthetics developed by the work of engineers. It was a large steel framed structure, with masonry enclosed corners and glass infilled walls. This gave a great feeling of space. Walter Gropius, who formerly worked with Peter Behrens, designed the Fagus Shoe Factory in 1912 using the same properties



CRYSTAL PALACE 1851

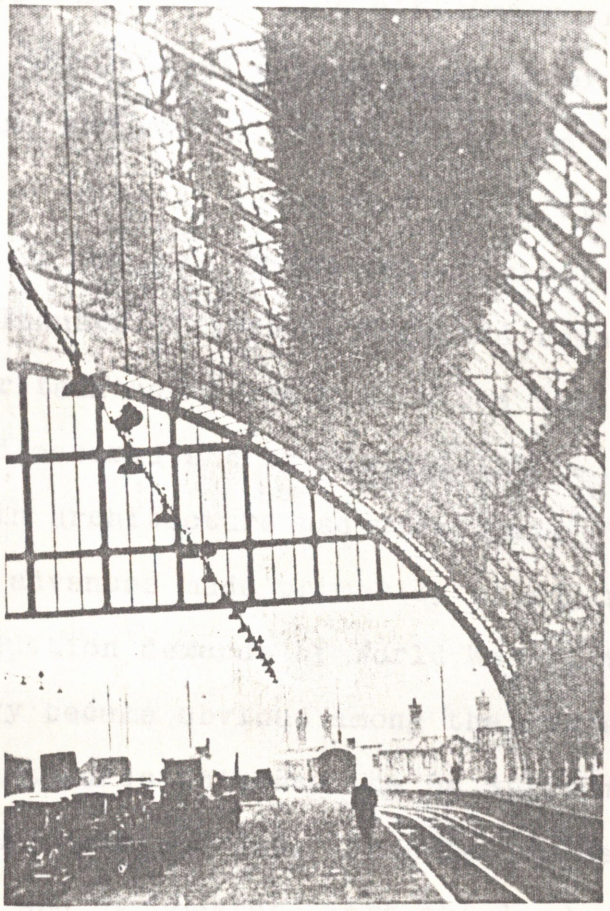
FIGURE 24

for an aesthetic (Figure 23).

The first American factories were much like those found in England. Many of these factories were like the water powered mills of the 1700's. However America was quick to adapt new engineering developments into their factories. The most influential American industrialist was James Bogardus. He pioneered the use of the cast-iron skeleton frame in the United States and promoted the use of incombustible materials in construction. In the 1800's the most feared threat to early factories was fire. Bogardus also developed the idea of heavy timber construction which was found to burn at a much slower rate thus permitting men a chance to effectively combat fires in factories.

Two significant influences on America's industrial scene appeared shortly after 1900. One was the adaption from the French of reinforced concrete by the engineer Ernest Ransome. Ransome applied concrete technology to structural and floor systems as well as prefabricated wall systems. The second major influence was the development of the automobile. This increased the mobility of transportation systems producing a decentralization of smaller industries all over America.

In the early 1900's most architects were still reluctant to deal with industrial projects. However in



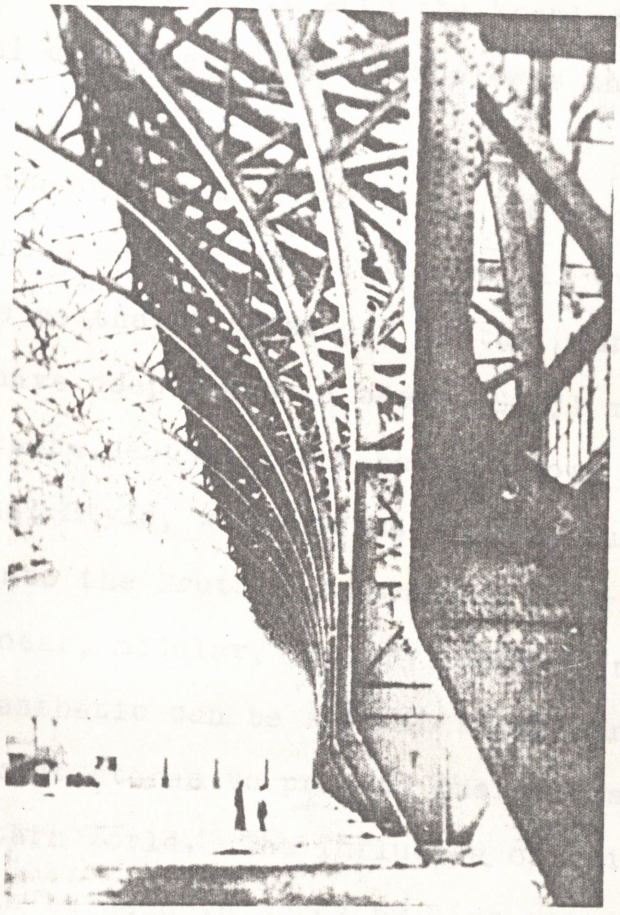
ST PANCRAS STATION 1861

FIGURE 25

the years around 1905, America's best industrial architect appeared, Albert Kahn. His contribution was in advancing of the industrial design process more than the physical structure. While doing Henry Ford's automobile assembly plants, which stimulated demands for high efficiency, Albert Kahn developed the idea of a team approach of specialists-production, structural, mechanical, and electrical engineers - to establish speedy and efficient design results. By the 1930's the basic principles of American Industrial Architecture had been formed.

In Britain and Germany much the same pattern of events had occured and by the mid-1920's a new machine aesthtic in architecture had developed. Thanks to the technical advances made primarily by engineers and the large production demands of World War I, the benefits of industry became obvious among the masses of people. A reaction towards this was the De Stijl movement in the arts and design areas. Such famous men like Mordrian, Oud and VanDoesburg were the leaders of this new movement. Their works were basically highly geometric, using simple rectilinear and cubic forms and only primary colors. This was very adaptable for the machine aesthtic.

At approximately the same time, The Futurist school of thought was to develope along the lines of



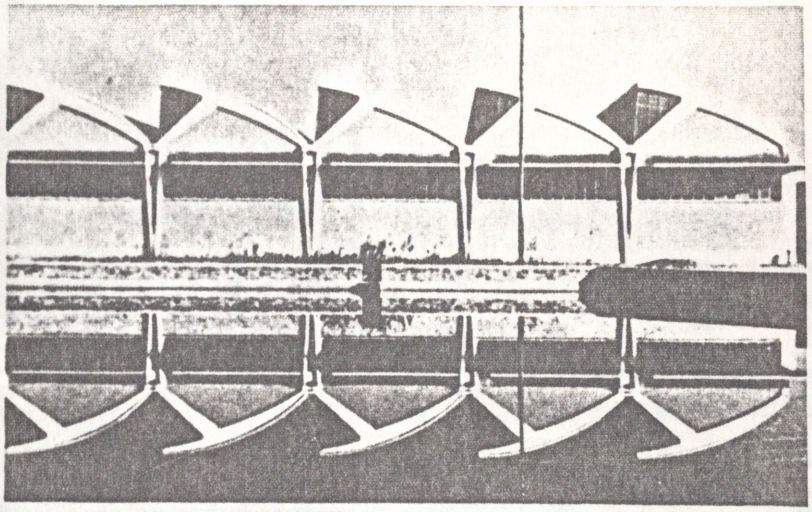
HALL DES MACHINES PARIS

FIGURE 26

advanced technical achievements. The members of the De Stijl Movement (machine aesthetic) and those of the traditional Arts and Crafts Movements (craftsmanship) were brought together by Walter Gropius with the idea of improving the quality of the machine aesthetic by combining it with the knowledge of the traditional craftsman. This school was known as the Bauhaus.

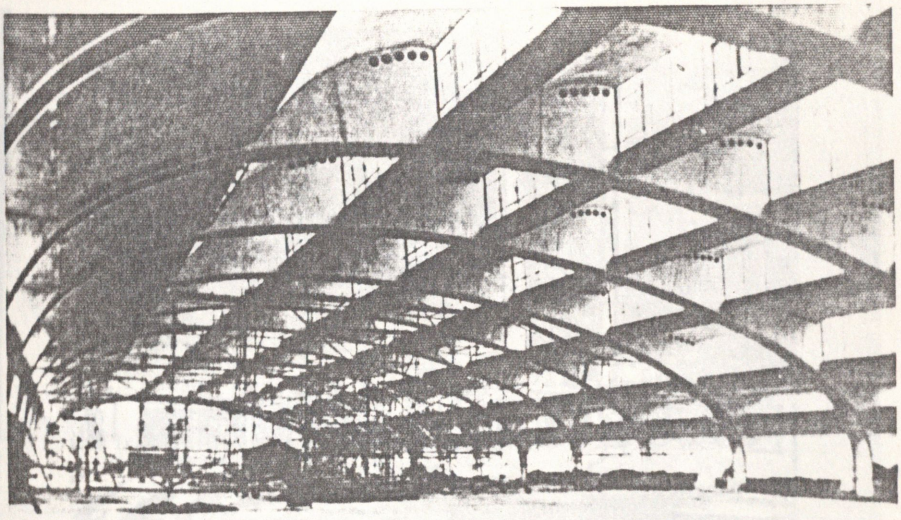
With the outbreak of World War II the members of the Bauhaus school were scattered all over the world. The aesthetic developed by the Bauhaus continued to have deep roots in the De Stijl movement and its machine aesthetic and became known as the International Style, which seems to have further developed into the Brutalist Movement in Britain. The rectilinear, modular, factory produced metals and glass aesthetic can be seen in works ranging from department stores to private residences throughout the western world. The influence of this machine aesthetic can be seen in works by Mies van der Rohe; Skidmore, Owings and Merrill, Eero Saarinen; Le Corbusier, and Oscar Niemeyer (Figures 27 through 33).

Since World War II there have been continued improvements in working conditions in industry for the worker. This movement dates back to the 19th century. Electricity has been increasing as a power



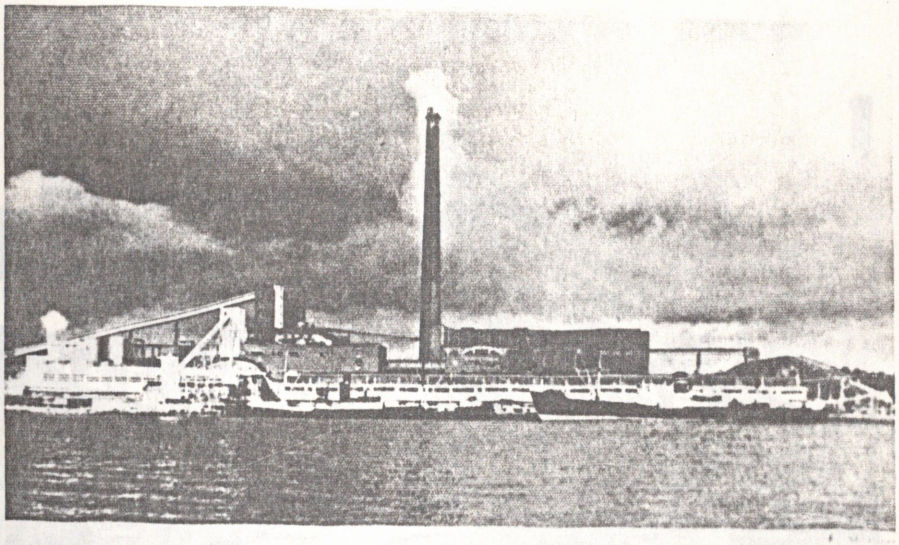
Roof construction of cyclindrical sawtooth shell, v
ually exciting. Italy

FIGURE 27



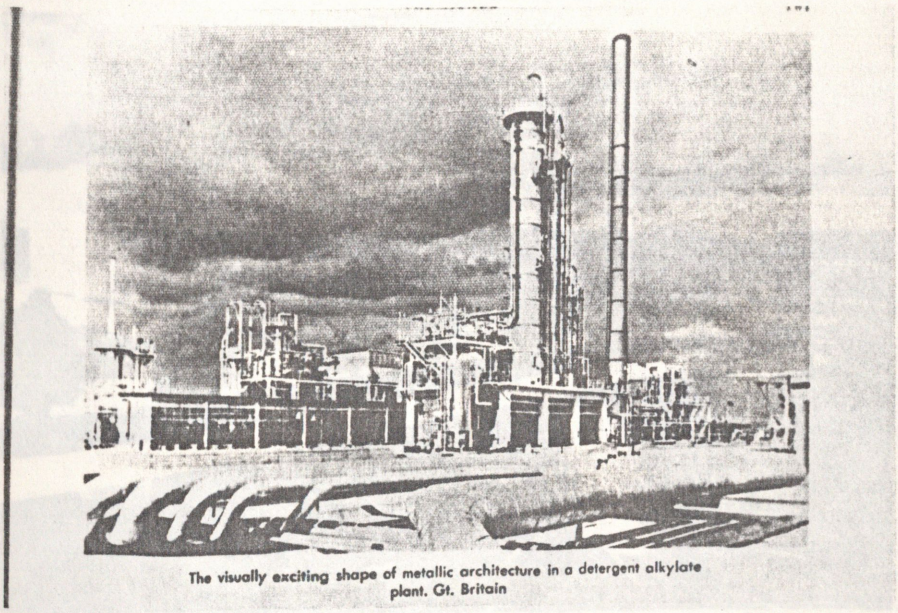
Bank of England printing plant. Gt. Britain

FIGURE 28



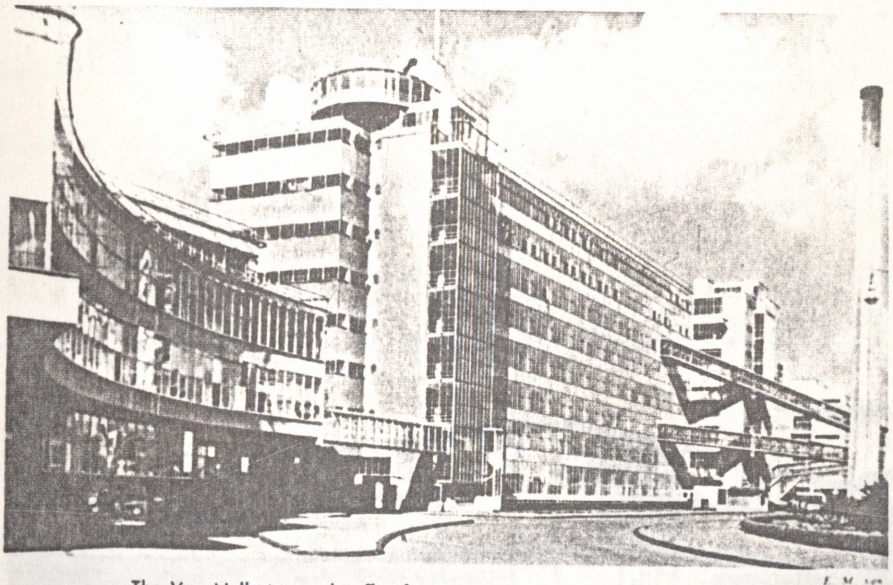
Sulphite mill. Finland

FIGURE 29



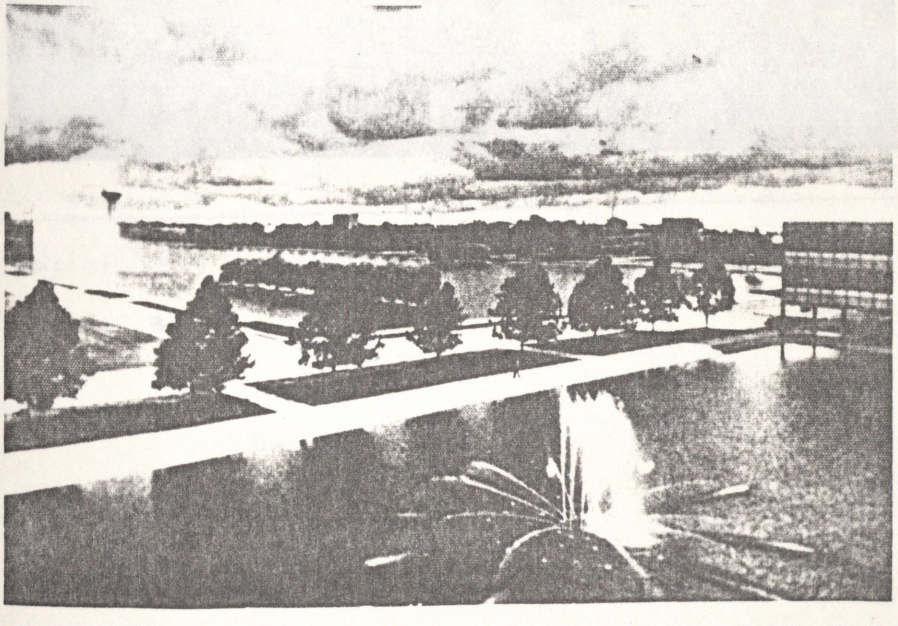
The visually exciting shape of metallic architecture in a detergent alkylate plant. Gt. Britain

FIGURE 30



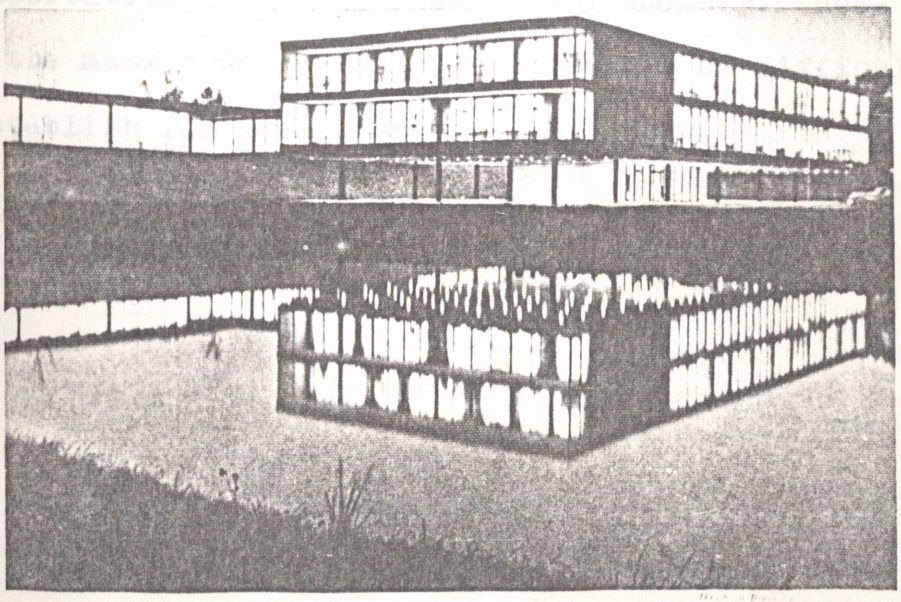
The Van Nelle tea and coffee factory, reputedly the finest example of the prewar factory and still in excellent condition. Netherlands

FIGURE 31



GENERAL REFERENCE

FIGURE 32



KIMBERLY-CLARK COPY (MISCONED)

FIGURE 33

source. There have been isolated industrial town developements like Ruskin but again this dates back to the early 1800's. Analytical and managerial procedures have become more sophisticated. However the energy and material limitations of the seventies will probably effect industries ideas of unlimited material resources and energy, freedom of transportation and an ever expanding economy. However the mass changes of the future will be difficult to establish for some time.

D ARCHITECTURAL CRITERIA

Upon complete analyzing of my program data I have resolved certain criteria must be established to be included in the final physical design.

1. Alterations to the project program obtained from the Industrial Management department will be rather minor. I suggest reducing the number of office staff from 11 to 4 (Figure 16). This facility has too many none producing employees. These people are highly trained and would demand a considerable wage. Many of these people could do several jobs while some other functions could be done by using consulting services.

2. I propose a different site located in the Bozeman industrial district (Figure 34). The site should have as many transportation modes as possible. The site I selected is in Bozeman, in an industrial transitional area for rail and truck transportation. The site also has utilities available.

As I researched the human factors in design it became obvious that in the areas of physical comfort and safety conditions for human inhabitation could be met. Many of the engineering ideas of space and light required for man can be programmed much as you would for a machine. However man is more com-

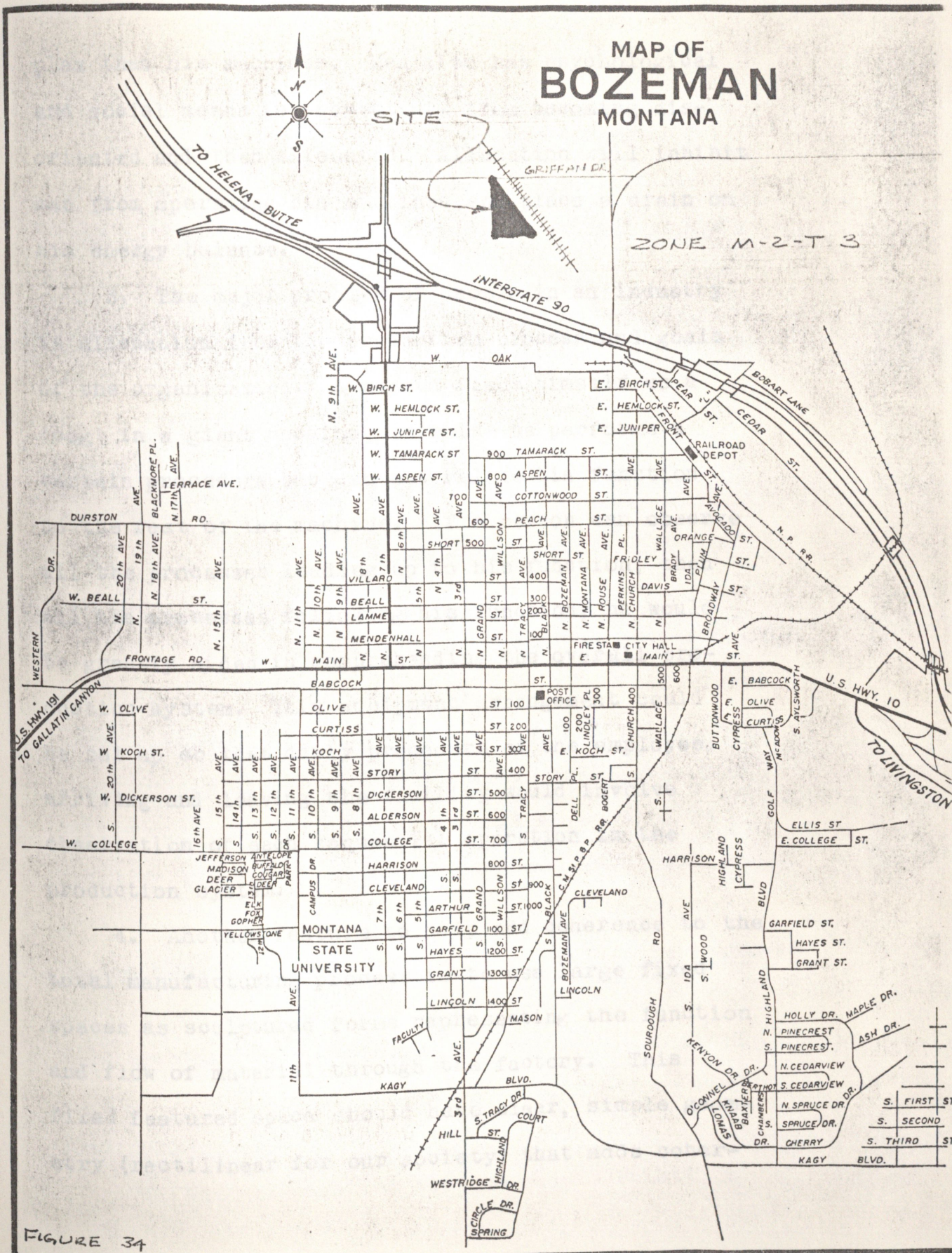

MAP OF
BOZEMAN
MONTANA
SITE
GRIFFITH DR.
ZONE M-2-T 3
TO HELENA - BUTTE
INTERSTATE 90
BOBART LANE
CEDAR ST.
PEAR ST.
FRONT ST.
RAILROAD DEPOT
N. P. R.R.
W. OAK
W. BIRCH ST.
E. BIRCH ST.
W. HEMLOCK ST.
E. HEMLOCK ST.
W. JUNIPER ST.
E. JUNIPER
W. TAMARACK ST
900 TAMARACK ST.
W. ASPEN ST.
800 ASPEN ST.
COTTONWOOD ST.
PEACH ST.
ORANGE ST.
SHORT ST.
FRIDLEY
DAVIS
BRADY
IDA
PALM
BROADWAY ST.
AVOCADO ST.
TERRACE AVE.
DURSTON RD.
BLACKMORE PL.
W. BEALL ST.
FRONTAGE RD.
WESTERN DR.
VILLARD
BEALL
LAMME
MENDENHALL
MAIN ST.
FIRE STA
CITY HALL
E. MAIN ST.
BABCOCK ST.
POST OFFICE
OLIVE
CURTISS
KOCH
KOCH ST.
STORY
DICKERSON ST.
ALDERSON
COLLEGE
HARRISON
CLEVELAND
ARTHUR
GARFIELD
HAYES
GRANT
LINCOLN
MASON
FACULTY
KAGY BLVD.
MONTANA STATE UNIVERSITY
YELLOWSTONE
JEFFERSON
MADISON
DEER
GLACIER
ANTELOPE
BUFFALO
COUGAR
DEER
ELK
FOX
GOPHER
CAMPUS DR.
U.S. HWY. 191
TO GALLATIN CANYON
U.S. HWY. 10
TO LIVINGSTON
BUTTONWOOD
CYPRESS
S. AYLSWORTH
McADON
WAY
GOLF
ELLIS ST
E. COLLEGE ST.
HIGHLAND BLVD.
GARFIELD ST.
HAYES ST.
GRANT ST.
HOLLY DR.
MAPLE DR.
ASH DR.
N. PINECREST
S. PINECREST
N. CEDARVIEW
S. CEDARVIEW
N. SPRUCE DR
S. SPRUCE DR.
CHERRY
KAGY BLVD.
KENYON DR.
O'CONNELL
BAXTER
KNABB
LOMAS
CHAMBERS
BROTHY
S. FIRST ST.
S. SECOND
S. THIRD ST.
SOURDOUGH RD
S. TRACY DR.
COURT
HILL ST.
HIGHLAND DR
WESTRIDGE
CIRCLE DR.
SPRING
BOGER
DELL
C.M. St. P. & P. RR.
BLACK
BOZEMAN
WILLSON
TRACY
GRAND
MONTANA
ROUSE
PERKINS
CHURCH
WALLACE
LINDLEY PL.
N. 9th AVE.
N. 11th AVE.
N. 17th AVE.
N. 18th AVE.
20th AVE
19th
W. 20th AVE
W. 16th AVE
15th
14th
13th
12th
11th
10th
9th
8th
7th
6th
5th
4th
3rd
2nd
1st

FIGURE 34

plex than his machines. Man also has psychological and social needs to prevent him from becoming disoriented and then alienated. Alienation will inhibit man from operating his machines and place a drain on his energy balance.

3. The major problem of people in an industry is alienation from the production process and goals of the organization. A person finds himself as a 'cog' in a giant machine, in which he performs a certain procedure but can not relate his function to the rest of the machine. If a person can observe all the processes leading up to his function, then all the processes following his function, he would be greatly aided in comprehending the overall production system. This equipment arrangement could be set up so that daily procedure of the employee arriving and leaving the facility would involve observation of each sequential operation in the production system.

4. Another feature to help add coherence to the total manufacturing process is to use large fixed spaces as sculptured forms representing the function and flow of material through the factory. This fixed featured space should have clear, simple geometry (rectilinear for our society) that adds coher-

ence to the design but still provides us with a flexibility of internal functions.

5. A problem of industry is self-identity of the worker. This problem however is not only confined to the working environment, but to all aspects of our society today. This self-identity is caused by a person being overwhelmed by large complicated systems and not being able to identify himself in it. I propose improving this situation by breaking down each function into an identity of its own by the use of modulations in space size, visual barriers, level changes, along with such minor items as color coding.

6. The two problems, alienation and self-identity are basically communication problems. Besides visual communication with objects, social communication with other people is important to receive feed back from fellow workers. The Social communication will be aided by the use of smaller spaces but much more important is the positioning of people and machinery in the spaces. Communication can therefore be improved or discouraged as the situation demands. To do this I'll have to use information on proxemics and incorporate the use of semi-fixed space definers as control mechanisms.

7. Visual symbolism between people to aid in

determining a persons function and status will be an important factor in my design. Symbols will be accented in the design wherever possible.

8. Another form of communication which is often overlooked is art. I propose incorporating functional art in such forms as plant diagrams, formal structural diagrams, regional and culture subject murals.

9. It has been noted that a static space eventually becomes boring to the observer. I propose using systems of modulation to produce a built-in fluxional environment. As example I intend to use variations in light levels instead of one level system; varying the sound levels of machinery that is in operation; providing enough exposure to the outside natural environment to be able to note the movement of the sun, wind in trees or the occurrence of snow and rain. Also I intend to incorporate an internal 'building-scape' so I will be controlling visual fields that will inable a person to observe the dynamics of the production facility.

10. To comply with the fact that people become more concerned with their job when the physical properties of the manufacturing plant is better than that of their home or community, I propose to build my facility without overly concerning myself with the expense of materials or systems so that I can

produce a building above the standards of the surrounding community.

The above points are specific criteria I intend to use in providing an accommodating environment for both man and machine. The two major and opposite problem areas, identity and alienation, will be resolved into a balance that helps solve both situations.

PART TWO

THE SOLUTION 107

THE PROOF 155

THE SOLUTION

Upon completing the program of this thesis the next step is to take the architectural solutions and transform them into a three dimentional geometry that clearly illustrates the results of my program. I first reviewed my program and placed the architectural solutions in a tabular form (Figure 35). Also at this point I did a general analysis of the site that includes a topographical survey and a rough circulation analysis (Figures 36 and 37). I concluded that I wanted to use the larger central area of my site for vehicular circulation and utilize the south point of the site with my building, having my materials receiving and shipping next to the vehicular circulation. I also noted from the topographical survey that the site is (5 foot difference in the total length). The site is above all flood plains and the topsoil is sandy gravel for good water absorption however a sudden rainfall could threaten a flooding condition due to slow run off conditions. Therefore I concluded that I would keep my building and roadways slightly above the existing grade. Other physical properties of the site were a strong linear relationship to the Bridger mountains and the railroad. Both highway and railway are strong physical statements due to their unusual high elevations. Site vegitation is very minimal, being only wild grass. There are no trees or shrubs

THREE DIMENSIONAL SOLUTION

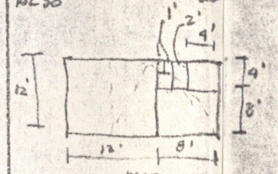
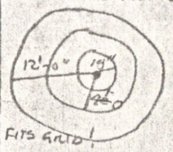
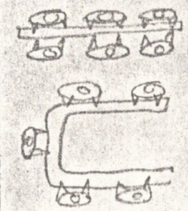
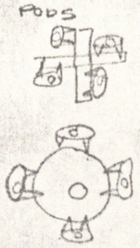
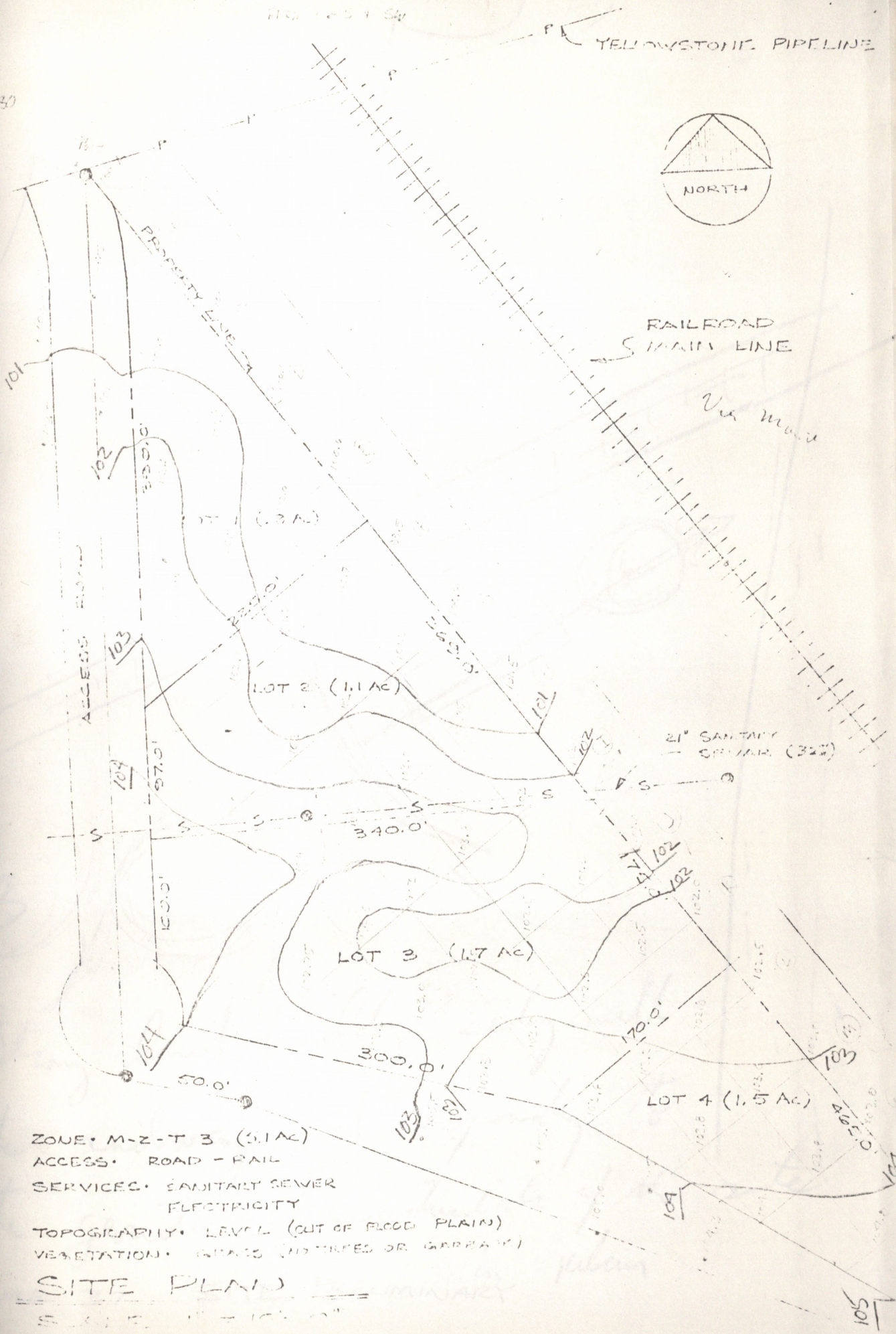
CRITERIA NO.	1	2	3	4	5	6	7	8	9	10
CRITERIA DISCRIPTION (PROGRAM)	ALTER I.M.E. PROGRAM	CHANGE SITE IN THE BOZEMAN AREA. NOTE: AM NOT QUESTIONING THE CLIENTS CHOISE OF AREAS TO LOCATE (MONTANA-GALLITAN VALLEY) BUT DO QUESTION SITE LOCATION IN REGARDS TO LOCAL PLANNING AND FACILITY REQUIREMENTS.	AVOID ALIENATION, AVOID THE 'COG IN THE WHEEL SYNDROME' A PERSON SHOULD EXPERIENCE TOTAL PROCESS EVERYDAY. OVERALL COMPREHENTION OF THE SYSTEM.	TO HELP ADD COHERANCE USE LARGE FIXED SPACES AS SCULPTURED FORMS REPRESENTING THE FUNCTION AND FLOW OF MATERIAL THROUGH THE FACTORY.	BREAK DOWN LARGE SPACES INTO SMALL IDENTITIES TO HELP A PERSON IDENTIFY HIMSELF.	COUNTER ALIENATION AND SELF-IDENTITY WITH COMMUNICATION IN SOME AREAS.	VISUAL SYMBOLISM BETWEEN PEOPLE TO AID IN DETERMINING A PERSONS FUNCTION AND STATUS.	INCORPORATE FUNCTIONAL ART	USE SYSTEMS OF MODULATION TO PRODUCE A BUILT-IN FLUX-ENVIRONMENT	WORK CONDITIONS BETTER THAN THE COMMUNITY WORKING CONDITIONS
SOLUTION	REDUCE THE NUMBER OF OFFICE STAFF FROM 11 TO 9. 1 PLANT MANAGER 1 PURCHASING AGENT 2 SECRETARIES THE REST USE ON A CONSULTANT BASIS.	LOCATION IS IN THE NORTHERN INDUSTRIAL AREA OF BOZEMAN ZONED M-2-T3 (5.1Ac) • ACCESS - ROAD & RAIL • SERVICES - SANT. SEWER ELECTRICITY • OUT OF FLOOD PLAIN • LARGE CENTER - GOOD SOURCE OF LABOR (BEST OF SEVEN CHOISES)	EMPLOYEES SHOULD BE ABLE TO EXPERIENCE TOTAL PROCESS EVERYDAY WHILE ENTERING AND LEAVING BUILDING, AS WELL AS DURING THE WORK DAY PROCESS. ∴ TWO CONSIDERATIONS - INITIAL FACILITY FLOW SYSTEMS — MATERIAL FLOW AND PEOPLE FLOW.	FIX FEATURE SPACE-SHALL BE LARGE AND CONTAIN THE BASIC STRUCTURAL AND MECHANICAL SYSTEMS. THE BOUNDED SPACE SHALL CONTAIN SEMI-FIXED SPACES THE FIXED SPACES SHALL BE SIMPLE IN A PLAIN GEOMETRY (RECTILINEAR IN OUR SOCIETY). RECTILINEAR SIZE -USE GOLDEN SECTION CORBUS RED SCALE 6' -INDUSTRIAL PASSAGES 11'-0" MIN. -PUBLIC DISTANCE 12' ', WILL USE A 12'-0" GRID FAYDERS PROPORTIONS AL 30  12" 8 (4) = 2-1' MODULE 48" = 12 OR 4" MODULES 12/2 = 6' 12x2 = 24' 12+6'	BREAK DOWN 12' GRID 12-8-6-4-2 (4") (FROM 4) CONSIDER THESE SPACES AS SEMI-FIXED -NO PREMINENT ELEMENTS. BREAK UP SPACE USING • STORAGE RACES • ~~LEVEL CHANGES IN FLOOR~~ • VOLUMN CHANGE IN SPACES. • TABLES, CHAIRS, • SAFETY FEATURES & RAILINGS-BARRIERS • SEMI-FIXED PARTITIONS.	COMMUNICATION AIDED BY THE USE OF SMALLER SPACES. BY THE USE OF SEMI-FIXED SPACES COMMUNICATION CAN BE PROMOTED OR DISCOURAGED — DEPENDS ON THE RESTRICTIONS OF THE FUNCTION BEING PREFORMED THE USE OF THE SCIENCE OF PROXIMICS TO PROMOT COMMUNICATIONS  WORK STATION DESIGN • CONVEYOR  • PODS 	SOME ELEMENTS THAT ACT AS SIGNS ARE: • COLOR CODING • SPACE SHAPE • UNIFORMS • SOUND IDENTITY • EQUIPMENT USED • SUCH THINGS AS- - DESK SIZE - TRASH CANS - EMBLEMS (CULTURE) - SOUND • SIGNS	USE ART THAT REPRESENTS CONCEPTS AT THE LEVEL OF THE WORKER. SOME OF THE SUBJECT MATTER WILL BE: • PLANT DIAGRAMS • SOCIAL STRUCTURE DIAGRAMS • REGIONAL AND CULTURAL SUBJECT MURALS AND BUILDING MATERIALS THE STYLE OF ART • NEW REALISM • POP ART • AMERICAN FOLK • RENAISSANCE - SCULPTURE - MURALS - PICTURES	THROUGH THE LEARNING PROCESS A STABLE ENVIRONMENT WILL LOOSE ITS IMPACT. THE POSSIBILITY OF ALLOWING FLUXUATION WILL PREVENT SUCH BOREDOM POSSIBILITIES ARE: • NATURAL LIGHT PATTERNS DIFFERING THROUGHOUT THE DAY (SKYLIGHTS) • SPOT LIGHTING - NO GENERAL OVERALL LIGHTING. • MUSIC INCORPORATED AT CERTAIN POINTS • NOT COMPLETE SOUND CONTROL - MACHINE ID. • TEMPERATURE (HUMIDITY) VARIATIONS • EXTERIORS OPEN TO OBSERVE WEATHER CONDITIONS • VIEWS OF SPACE TO OBSERVE MOVEMENT OF EMPLOYEES AND MATERIALS. (FACTORY SCAPE)	USE GOOD MATERIALS - EG. - INDOOR-OUTDOOR CARPETS - VINYL WALL COVERING - GLASS USE GOOD SYSTEMS - MASONRY WALLS - SPACE FRAMES

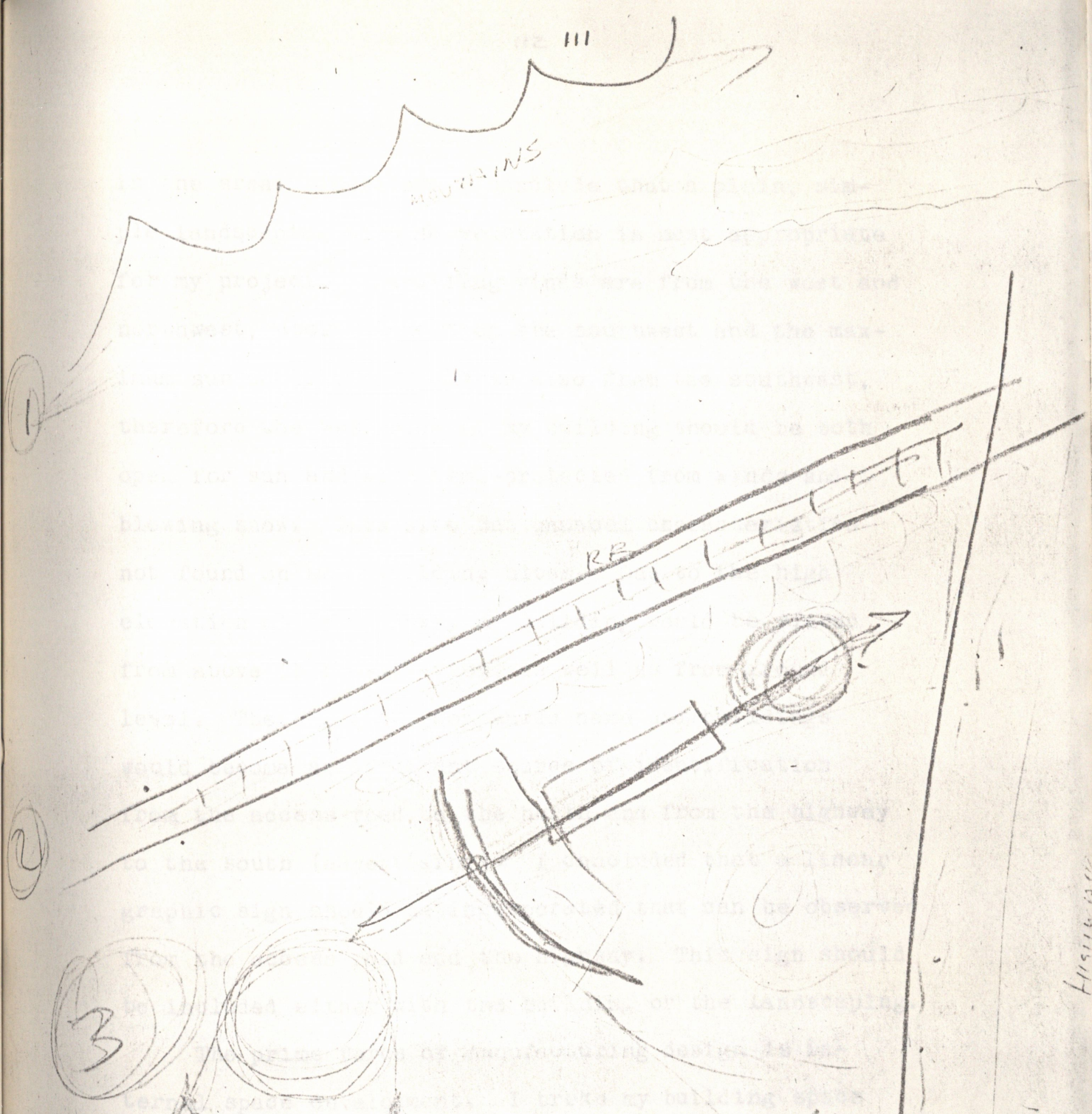
FIGURE 35 ARCH. CRITERIA



ZONE • M-2-T 3 (3.1 Ac)
ACCESS • ROAD - RAIL
SERVICES • SANITARY SEWER
ELECTRICITY
TOPOGRAPHY • LEVEL (OUT OF FLOOD PLAIN)
VEGETATION • GRASS (NATIVES OR GARDEN)

SITE PLAN

SCALE 1" = 100'-0"



Strong linear building axis with the railway and responding to the generic characteristics of the site in urban

FIGURE 37 SITE PRELIMINARY

in the area. Therefore I conclude that a plain, simple landscaping with no vegetation is most appropriate for my project. Prevailing winds are from the west and northwest, storms come from the southwest and the maximum sun condition (2 PM) is also from the southwest, therefore the west side of my building should be both open for sun and also semi-protected from winds and blowing snow. This site has unusual characteristics not found on most building sites. Due to the high elevation of the freeway my building would be viewed from above (birds-eye-view) as well as from ground level. Therefore the companies name and buildings would become an important source of identification from the access road to the north and from the highway to the south (advertising). I concluded that a linear graphic sign should be incorporated that can be observed from the access road and the highway. This sign should be included either with the building or the landscaping.

The prime force of manufacturing design is internal space development. I broke my building space design sequence into two parts; fixed and semi-fixed.

First I dealt with the fixed space. These spaces are large and contained one general function such as parts stamping and packaging-boxing. I first did a quick inspection of the equipment being used and came

to the conclusion that a 12 foot module would be used. This module can be expanded to 24 feet and reduced to 6, 4, 2 feet, or right down to a basic 4 inch unit. I generated three alternative floor layouts (Figures 38, 39, and 40) based on the functional relationships of the program (Figure 15). Then I made a layout comparison chart (Figure 41). I next combined the best features of the three alternatives into a fourth alternative (Figure 42). The characteristics of the fourth alternative floor plan were as follows:

1. The building was strongly linear, parallel to the railroad.

2. The assembly area was on the north end of the structure (next to vehicular ciculation) and the assembly area occupied the southern extremity of the building with the processing area (molding, stamping, packaging, offices) being located inbetween.

3. The foyer concept developed with the idea of a singular common circulation area so the fork lifts can reach all areas of the building; as well as to provide pedestrian circulation. This area must be large enough to accomodate fork lift circulation and safe maneuvering room for people. This area can also function as employee recreation space (Figures 43, 44, 45 and 46). The foyer

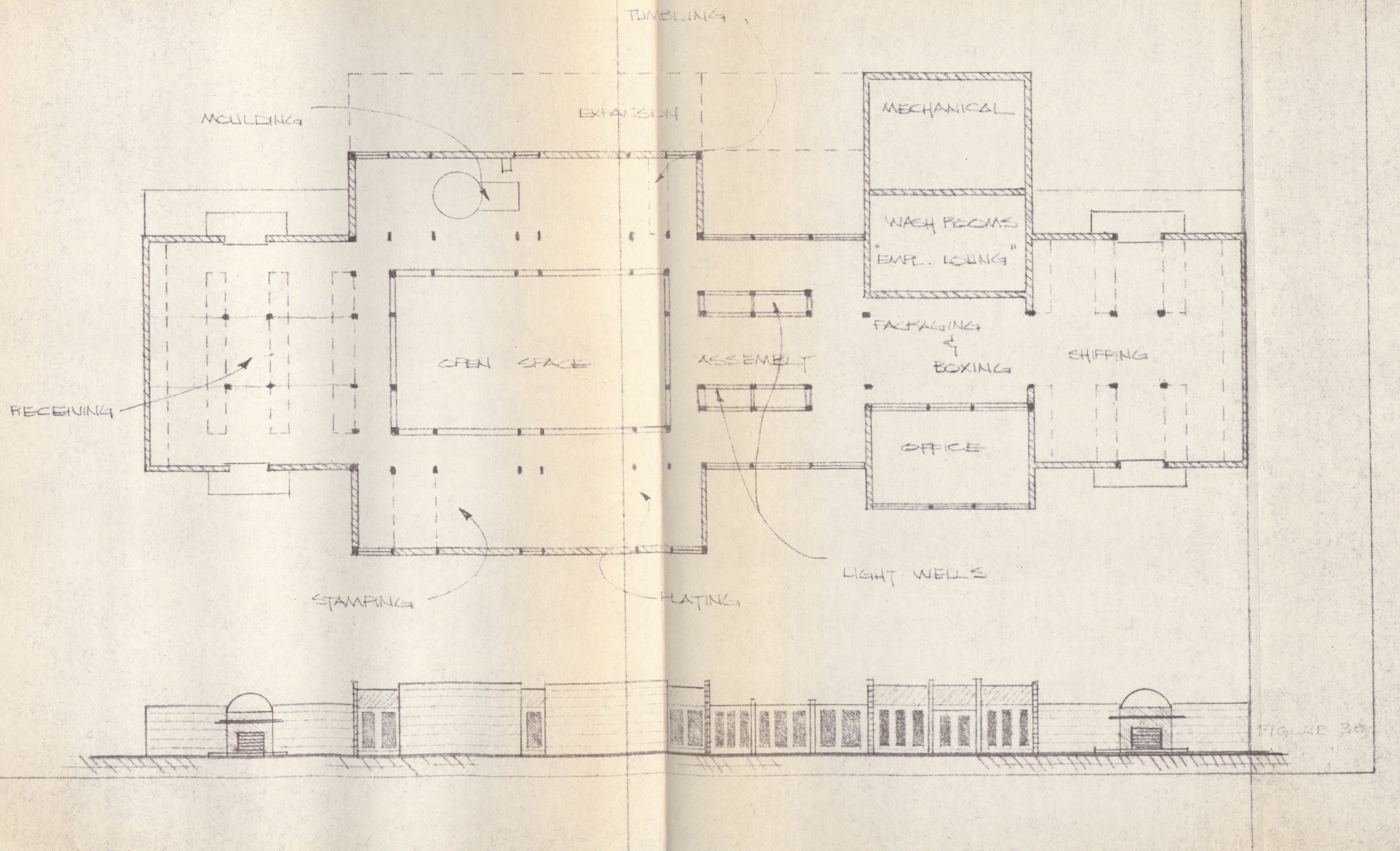

TUMBLING
MOULDING
EXPANSION
MECHANICAL
WASH ROOMS
"EMPL. LOUNGE"
PACKAGING
&
BOXING
SHIPPING
OPEN SPACE
ASSEMBLY
RECEIVING
OFFICE
LIGHT WELLS
STAMPING
PLATING

FIGURE 30

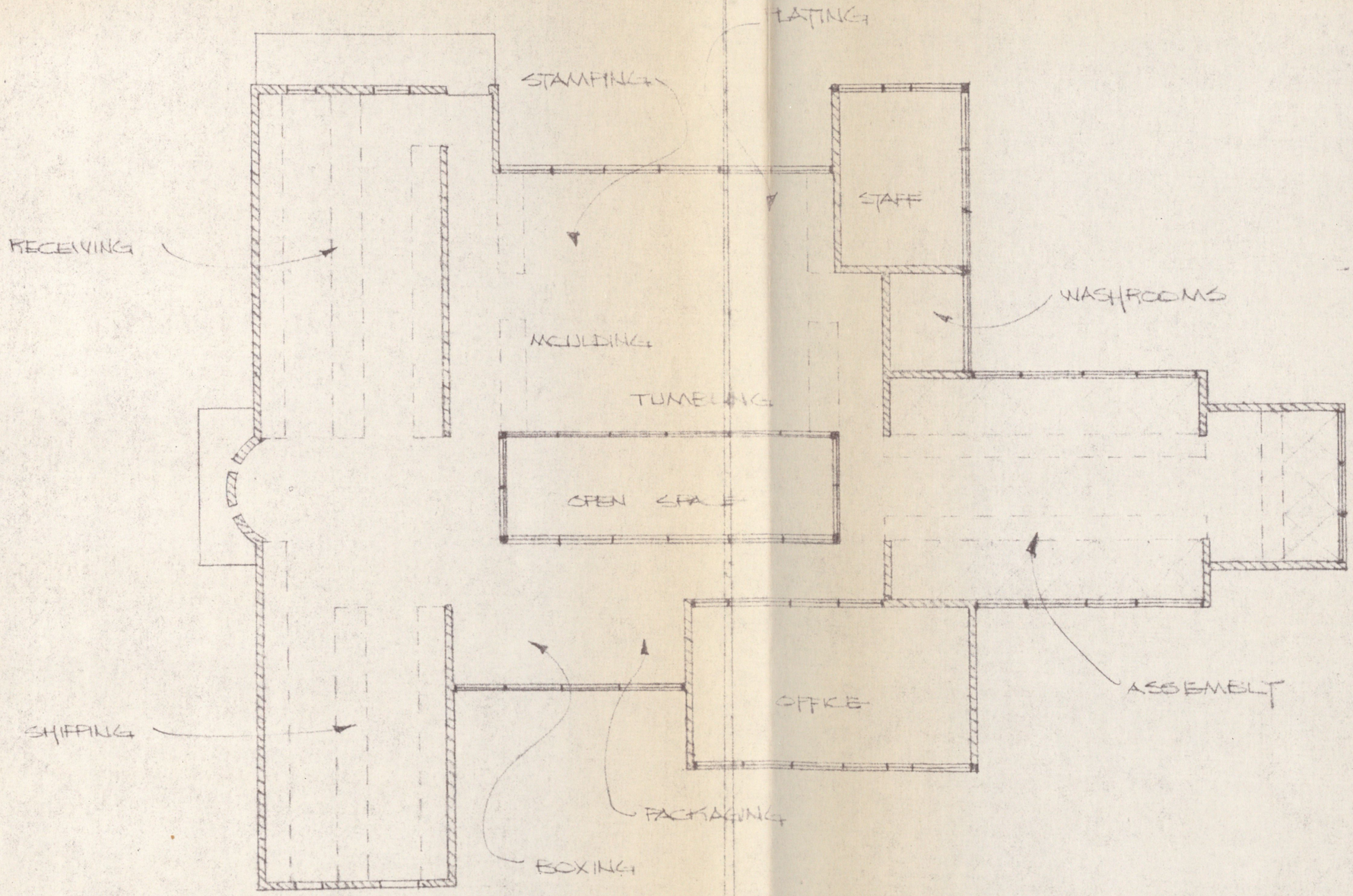

PLATING
STAMPING
STAFF
RECEIVING
WASHROOMS
MOULDING
TUMBLING
OPEN SPACE
ASSEMBLY
OFFICE
SHIPPING
PACKAGING
BOXING

FIGURE 32

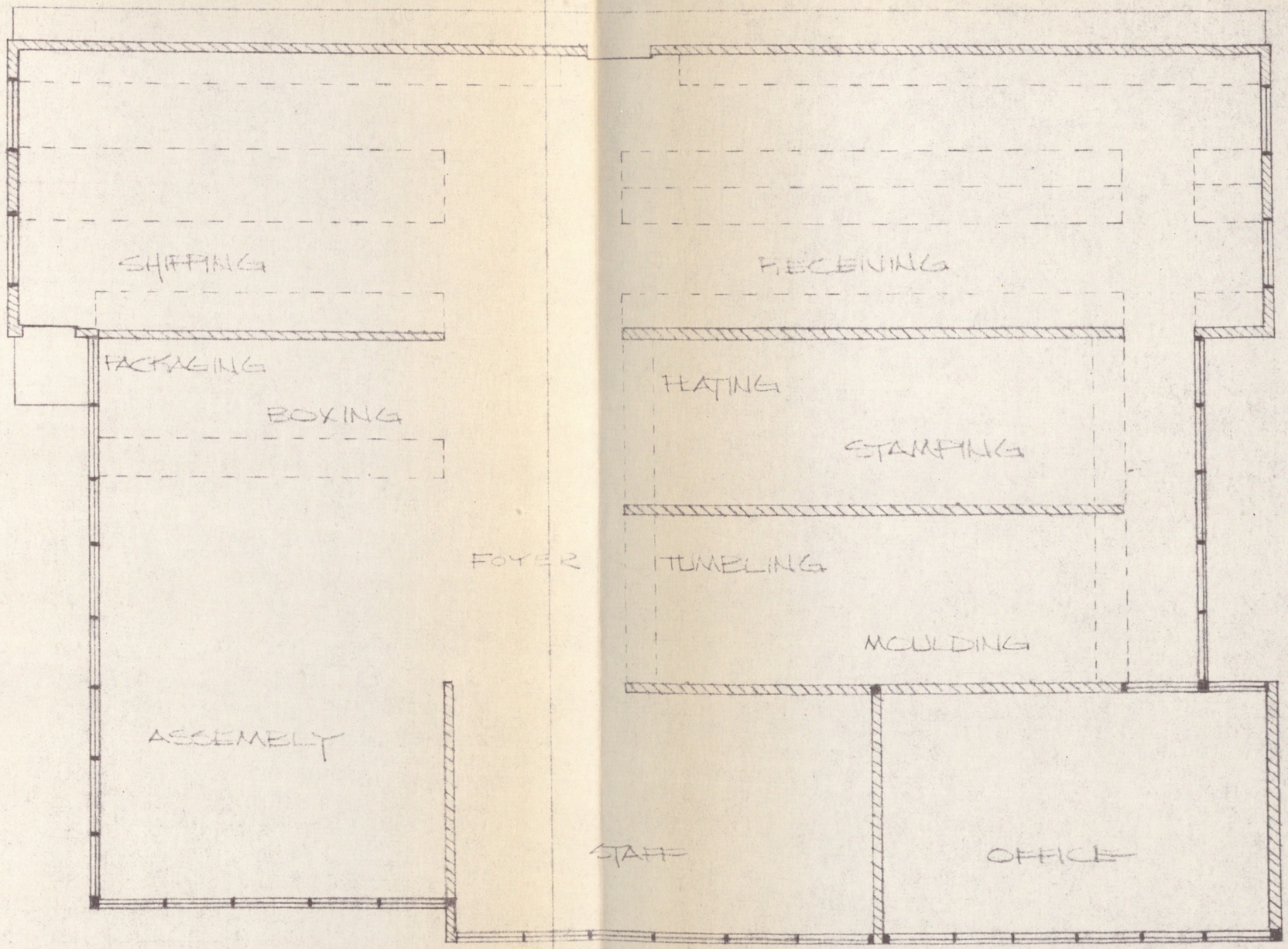

SHIPPING
PACKAGING
BOXING
FOYER
ASSEMBLY
STAFF
RECEIVING
HEATING
STAMPING
TUMBLING
MOULDING
OFFICE

FIGURE 40

LAYOUT VALUES

| PLAN NO | | |

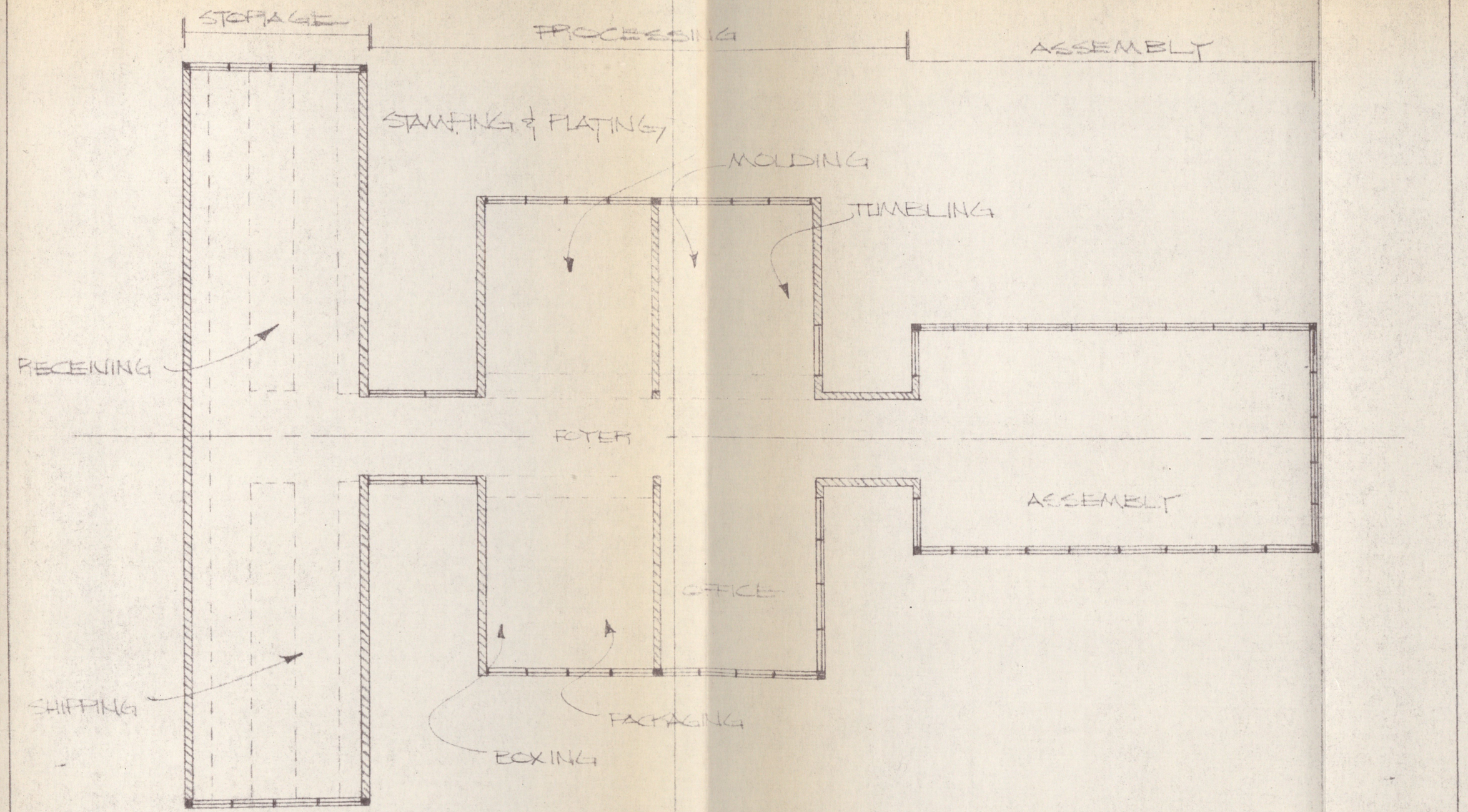

STORAGE
PROCESSING
ASSEMBLY
STAMPING & PLATING
MOLDING
TUMBLING
RECEIVING
FOYER
ASSEMBLY
OFFICE
SHIPPING
PACKAGING
BOXING

FIGURE 4.2

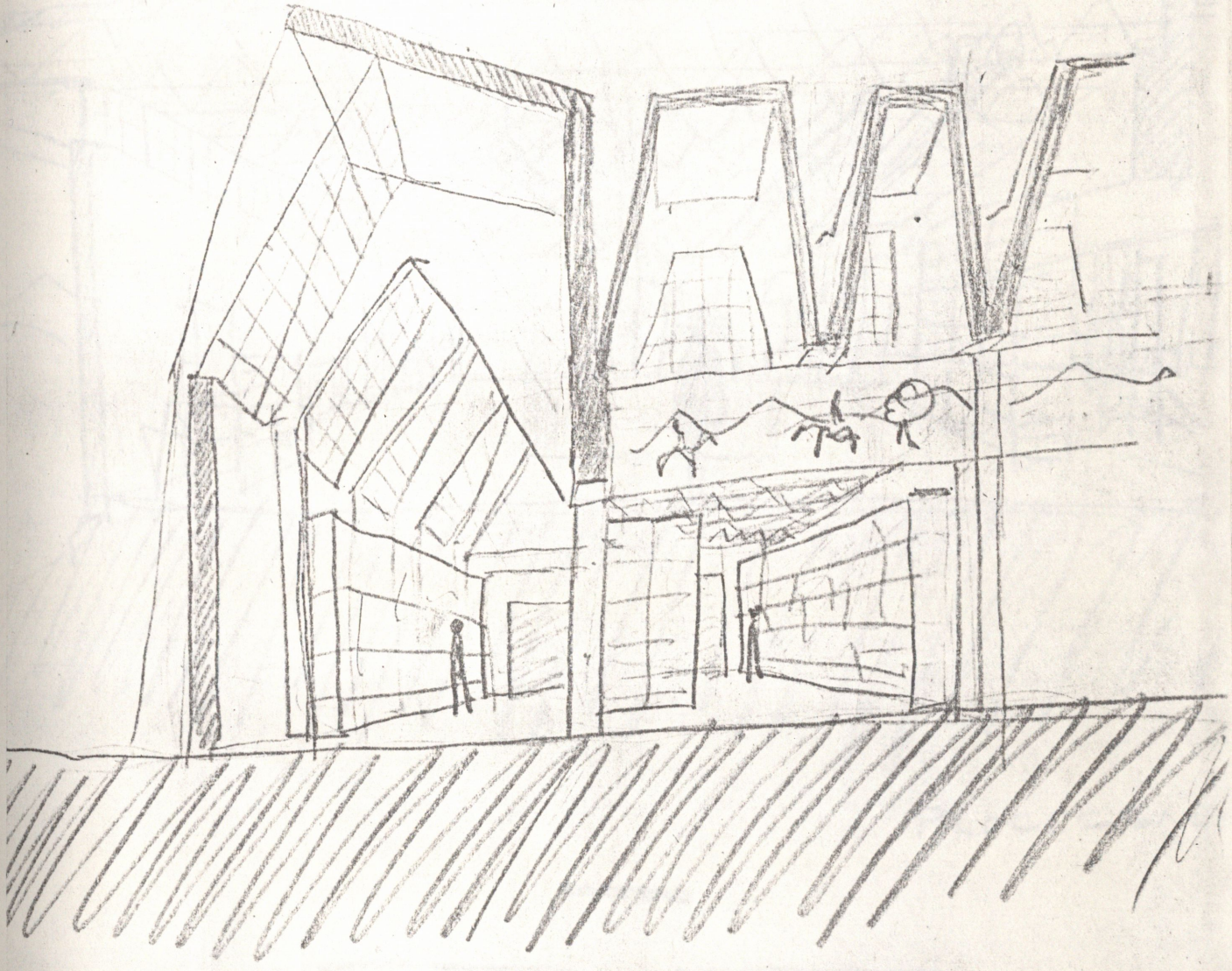


FIGURE 43 STORAGE AREA

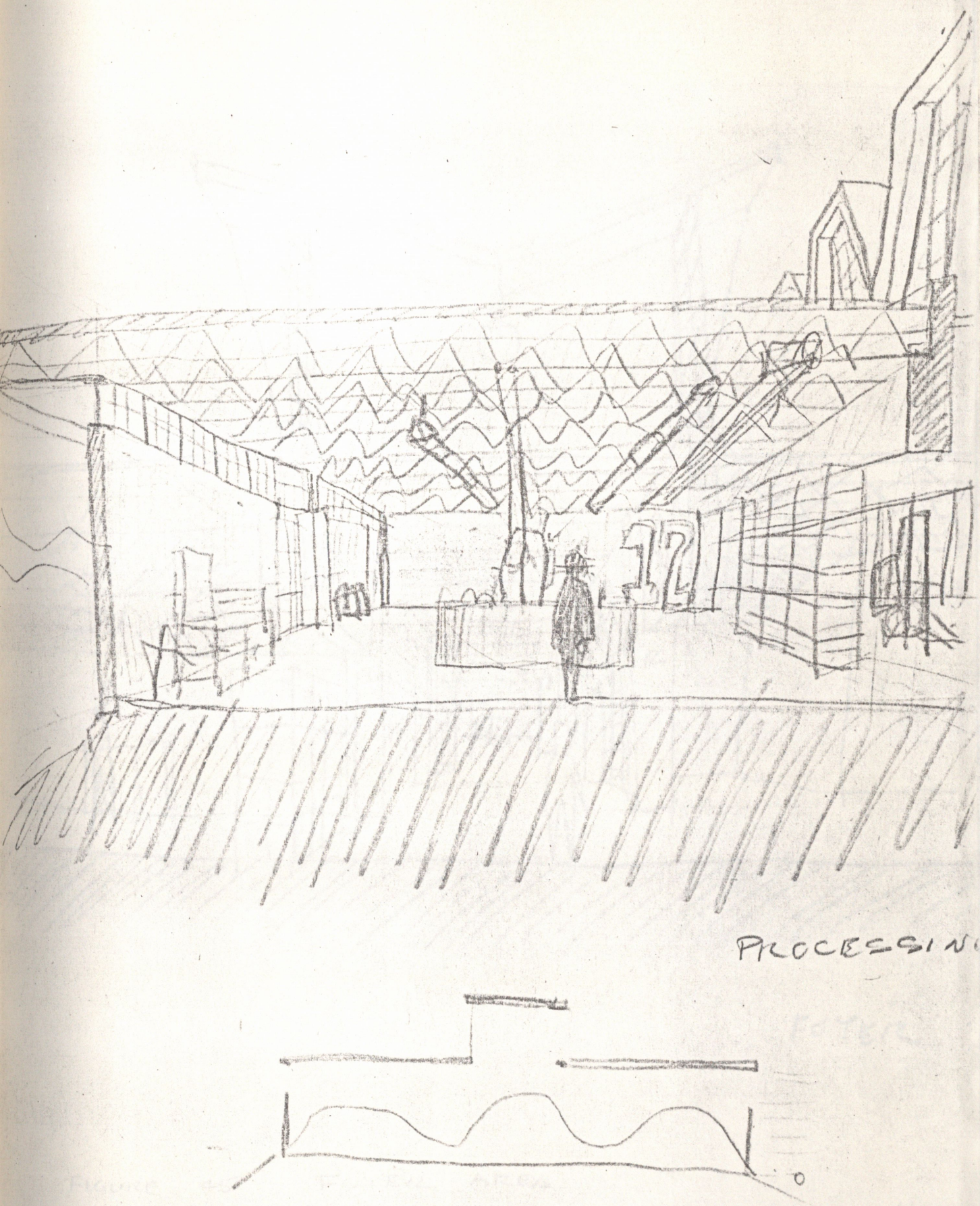


FIGURE 44 PROCESSING AREA

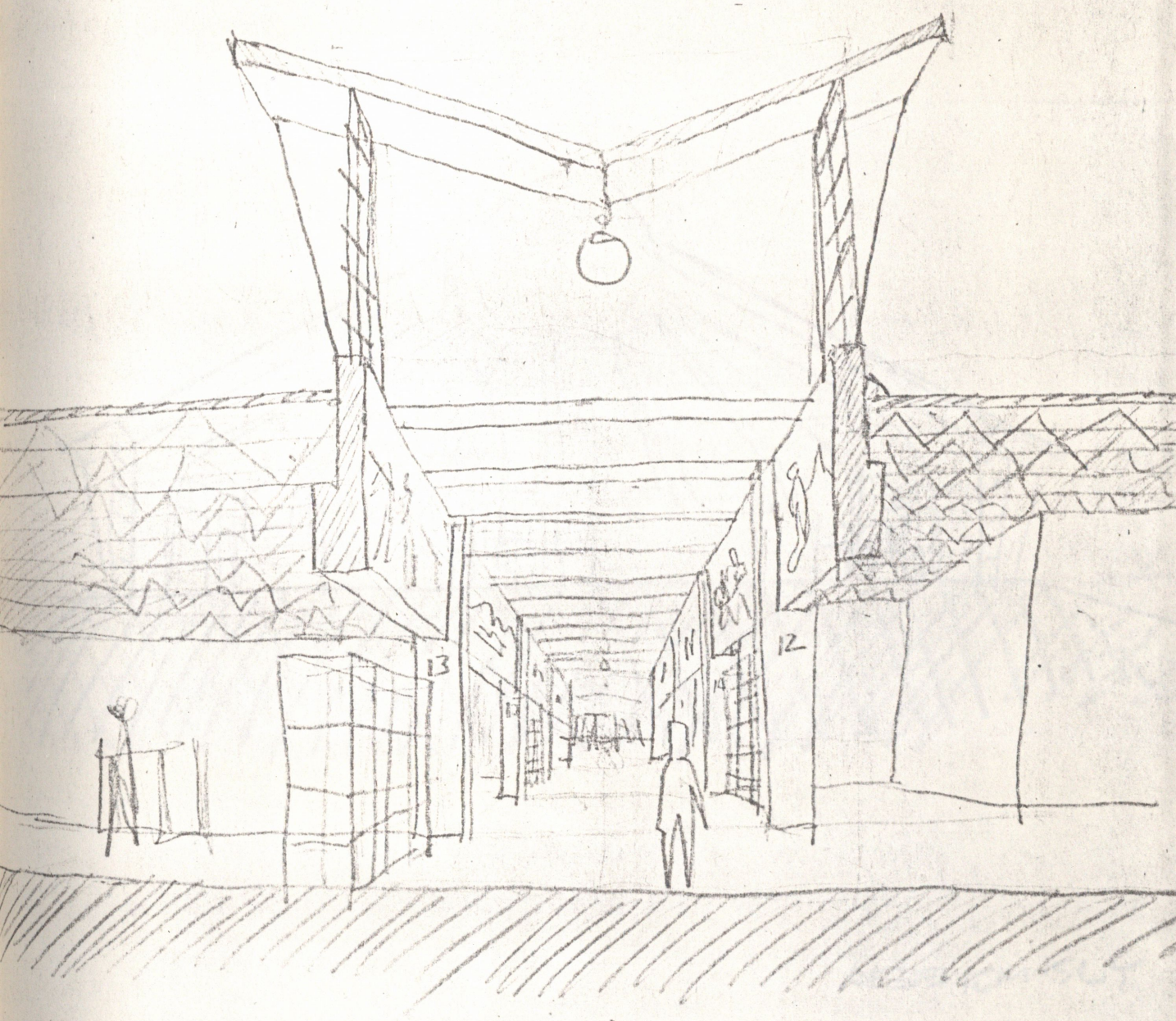


FIGURE 45 FOYER AREA

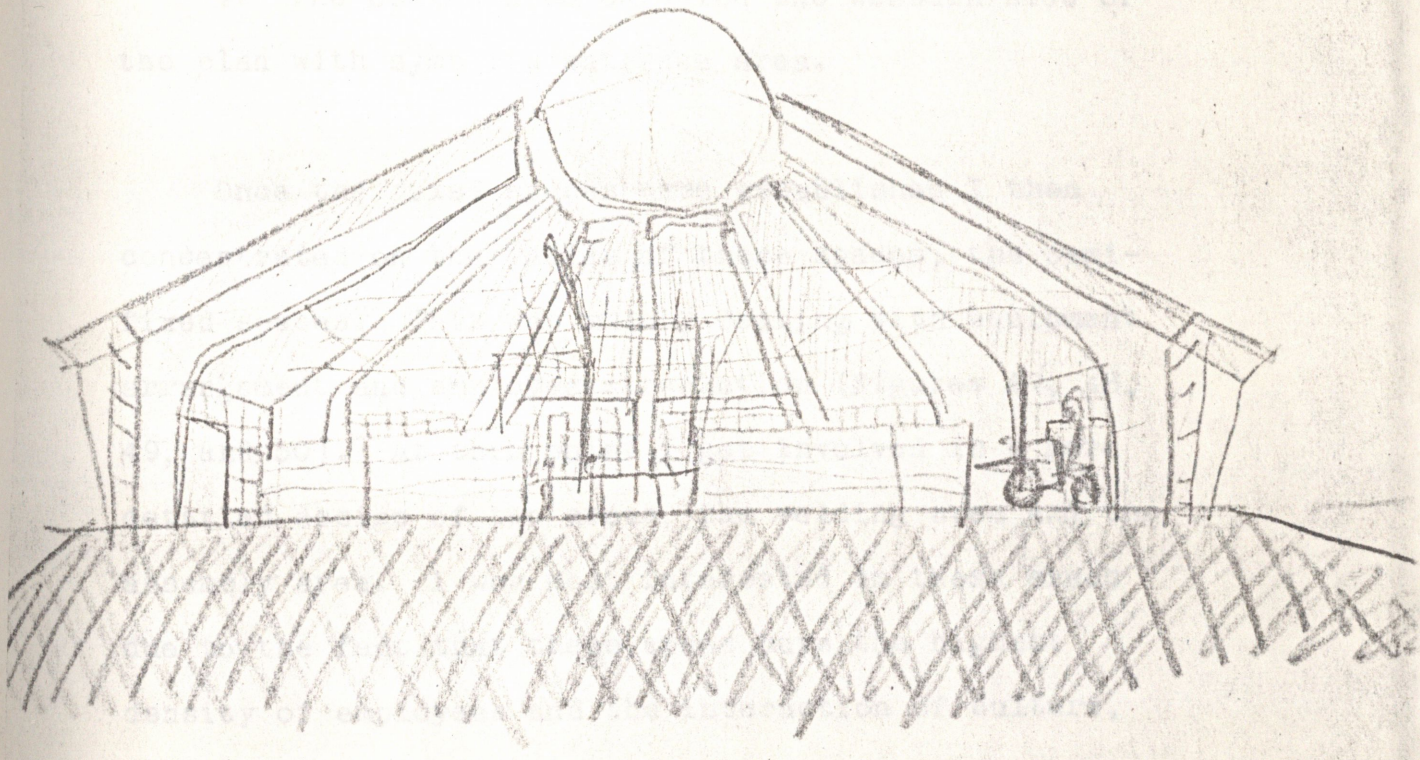


FIGURE 46 ASSEMBLY AREA

also accomodates an excellent location for skylights (natural light for a modulating environment) and if moveable skylights are used a location for natural air circulation and smoke exhaust.

4. The office area occupied the western side of the plan with symbolic entrance area.

Once the fixed spaces were established I then concentrated on the inside of these spaces, the semi-fixed spaces. This was mainly dealing with equipment arrangement and employee circulation (Figures 47, 48, 49, and 50). At this point I got involved in a more detailed design of two areas, the welding area and the assembly area. I was most interested in these areas due to the fact that these areas have the highest density of employees and the interaction of culture, machine and man are most predominant. In these areas I was very concerned with employee positioning (Figure 47) and social distances (Figure 48). Both these elements control the formal and informal communication which aids in combating alienation and self-identity.

The welding area needed to be surrounded by a visual screen and enclosed for air exhaust. All materials are distributed by a central chute system (Figures 51 and 52).

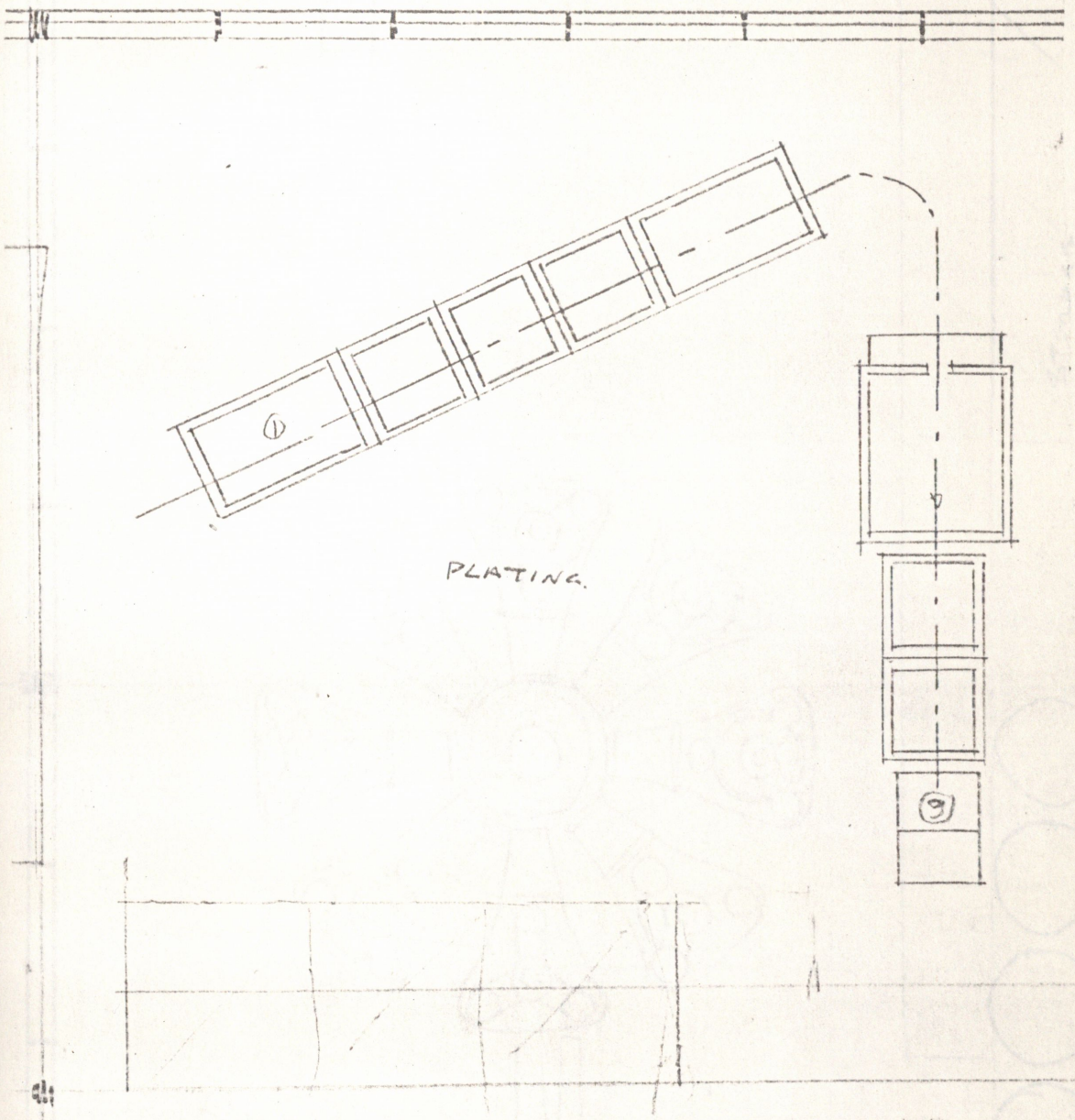


FIGURE 47 PLATING AREA

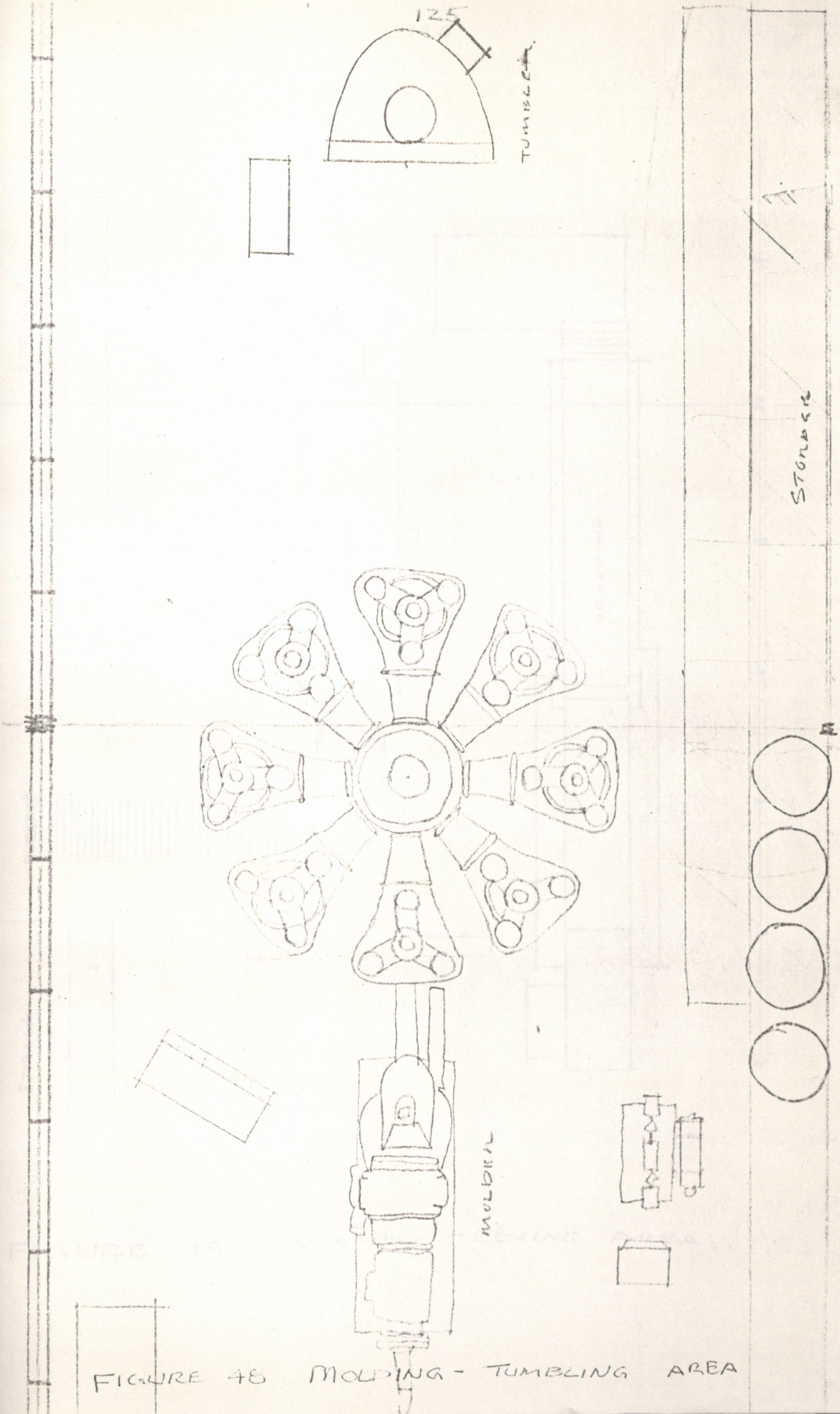


FIGURE 48 MOLDING - TUMBLING AREA

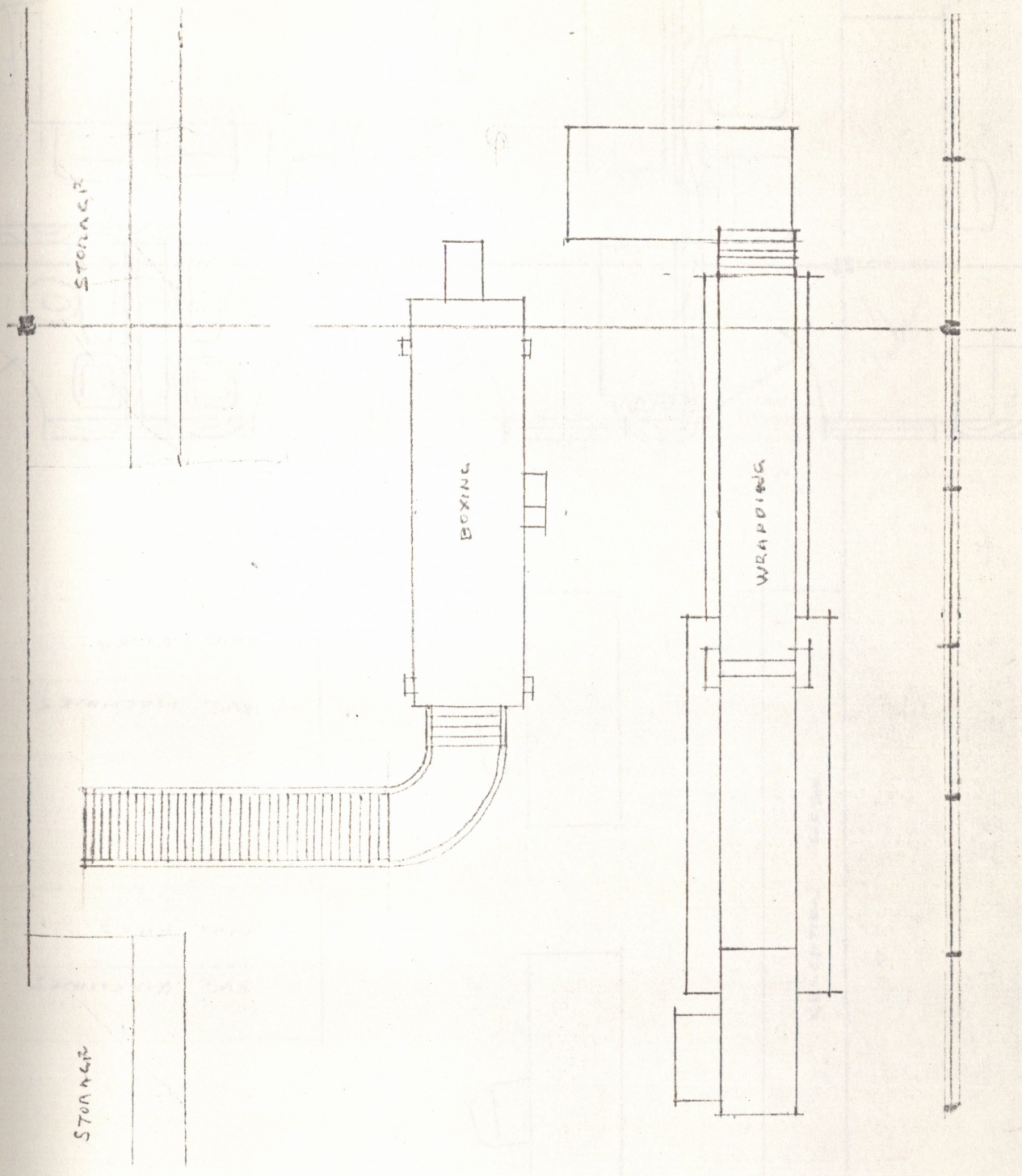


FIGURE 49 WRAPPING - BOXING AREA

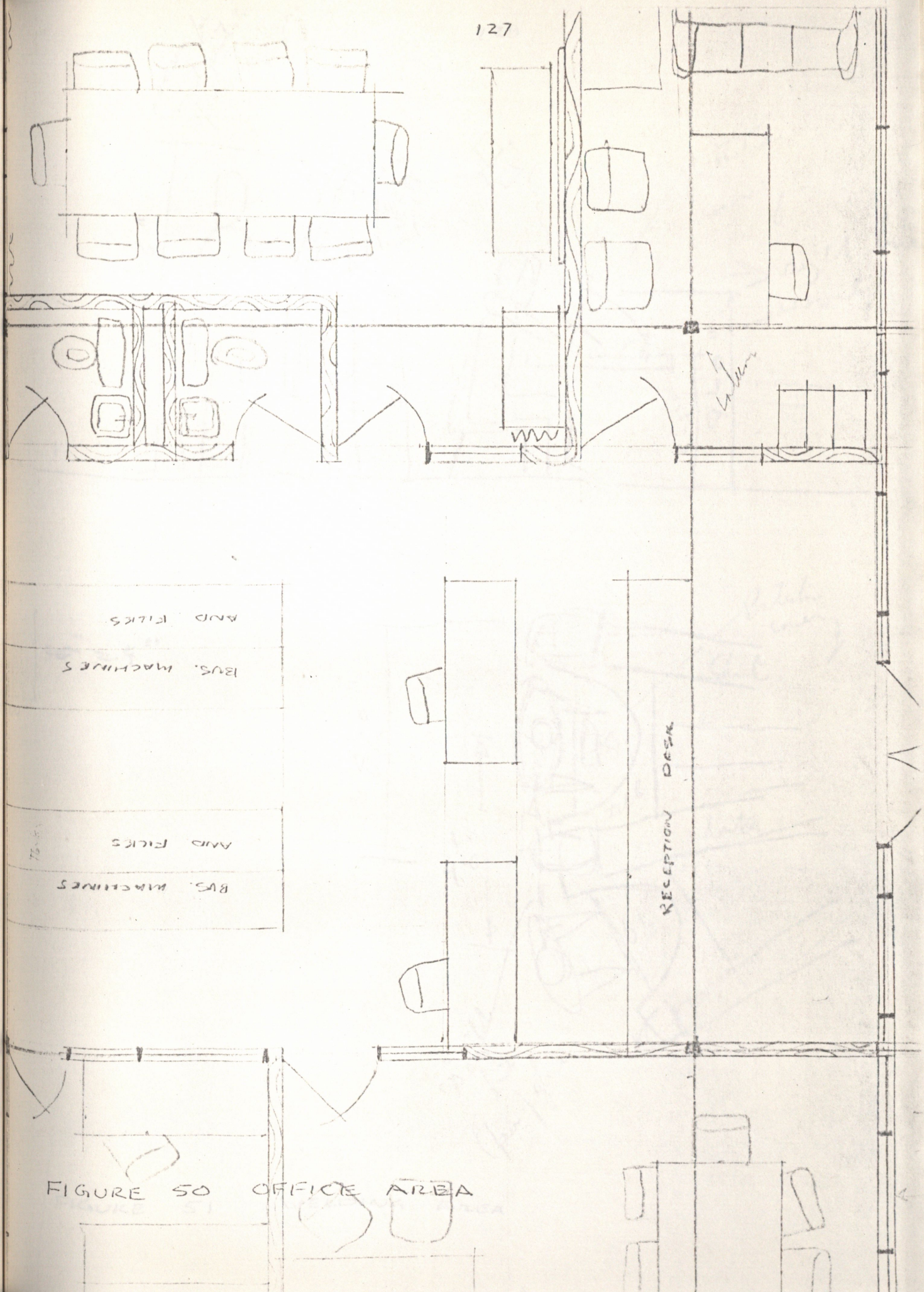


FIGURE 50 OFFICE AREA

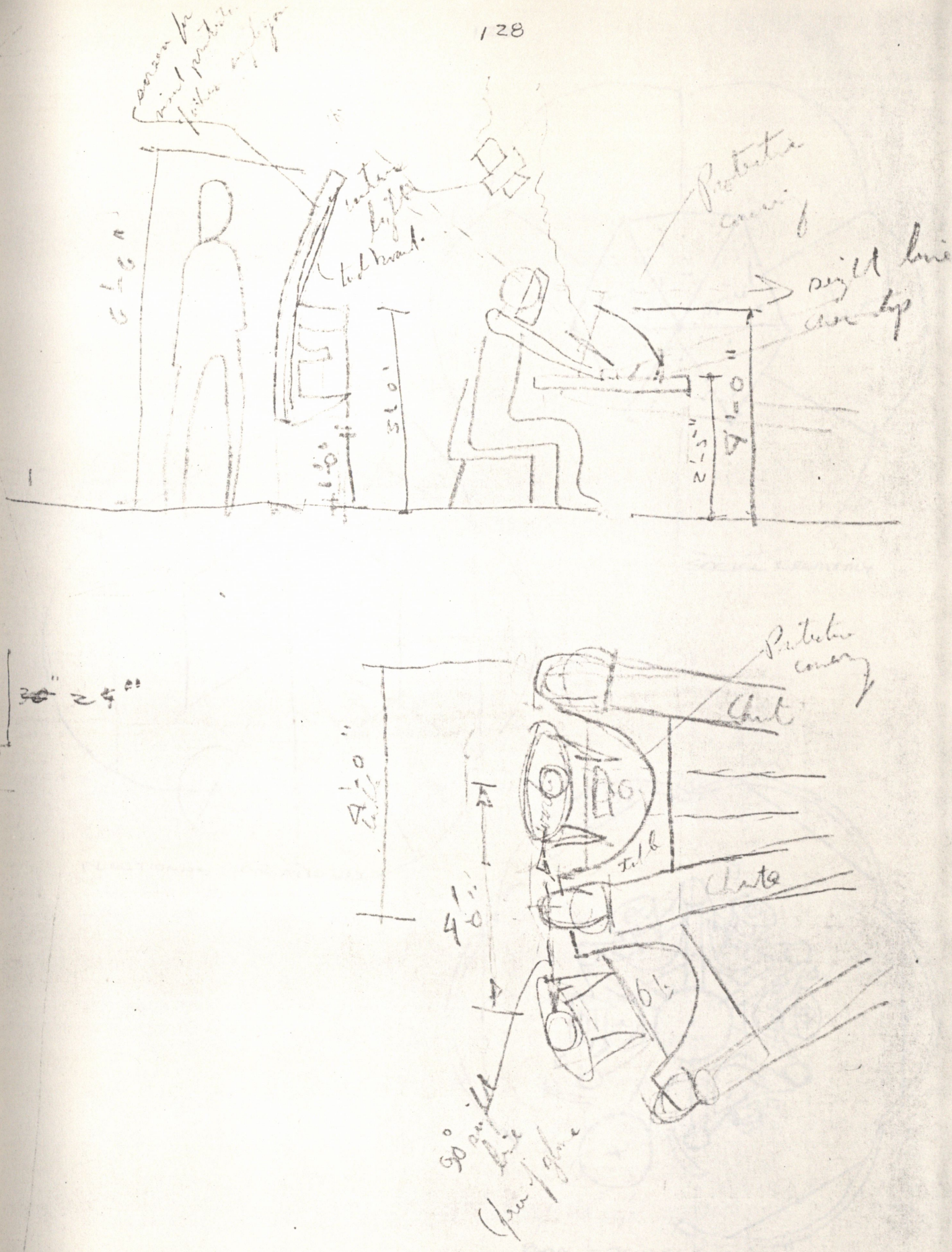
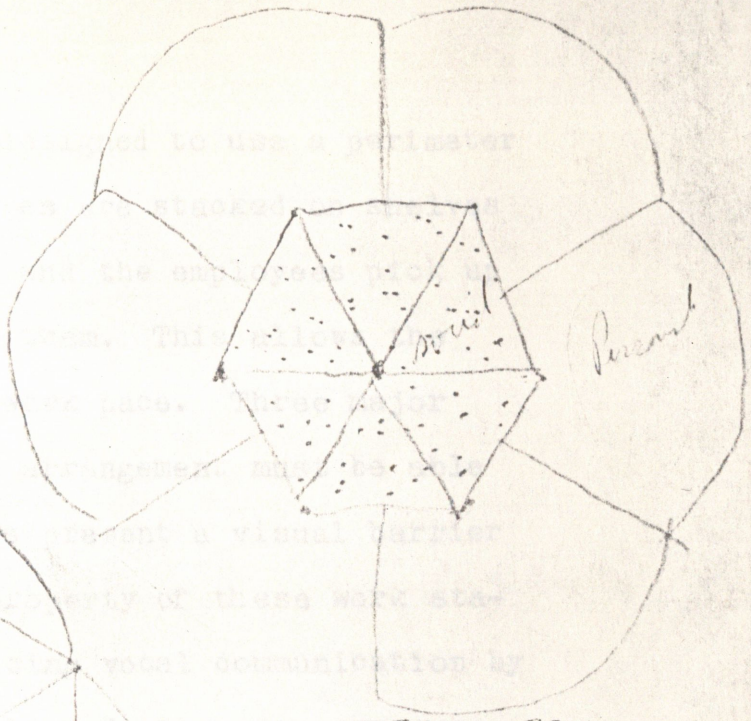
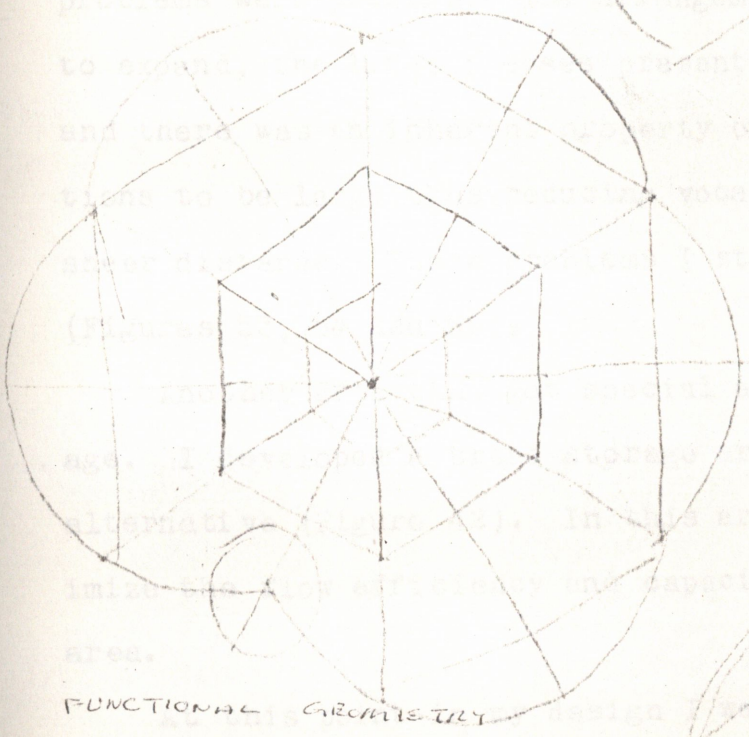


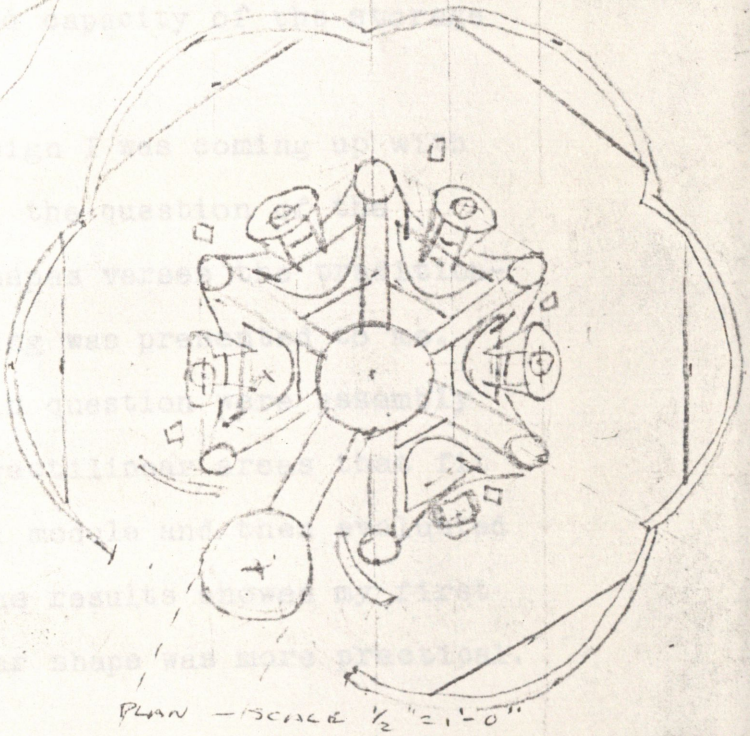
FIGURE 51 WELDING AREA



SOCIAL GEOMETRY



FUNCTIONAL GEOMETRY



PLAN — SCALE ½" = 1'-0"

FIGURE 52 WELDING AREA

The assembly area was designed to use a perimeter feed system. Small tote boxes are stacked on shelves surrounding the work tables and the employees pick up the tote boxes as they need them. This allows the employees to set their own work pace. Three major problems were present. The arrangement must be able to expand, the large presses present a visual barrier and there was an inherent property of these work stations to be large thus reducing vocal communication by sheer distance. These problems I strove to overcome (Figures 53, 54 and 55).

Another area that got special attention was storage. I developed a broad storage area in my fourth alternative (Figure 42). In this area I tried to maximize the flow efficiency and capacity of the storage area.

At this point in my design I was coming up with some very unusual shapes and the question of the practicality of irregular shapes verses the traditional square box form of building was presented to me. The two areas specifically in question were assembly and storage. I redesigned rectilinear areas that fit the process areas structural module and then evaluated the results (Figure 41). The results showed my first convection of using irregular shape was more practical.

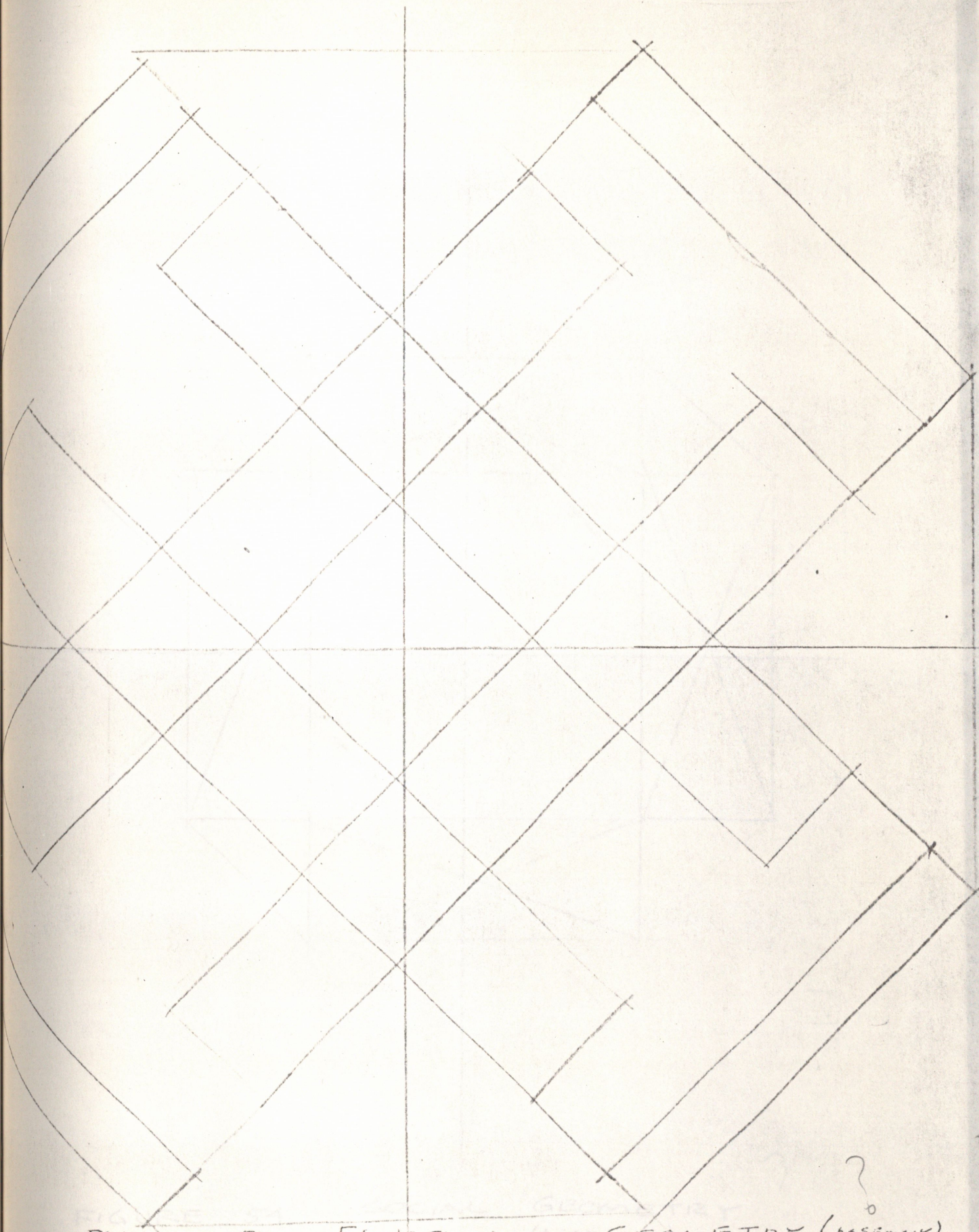


FIGURE 53 FUNCTIONAL GEOMETRY (ASSEMBLY)

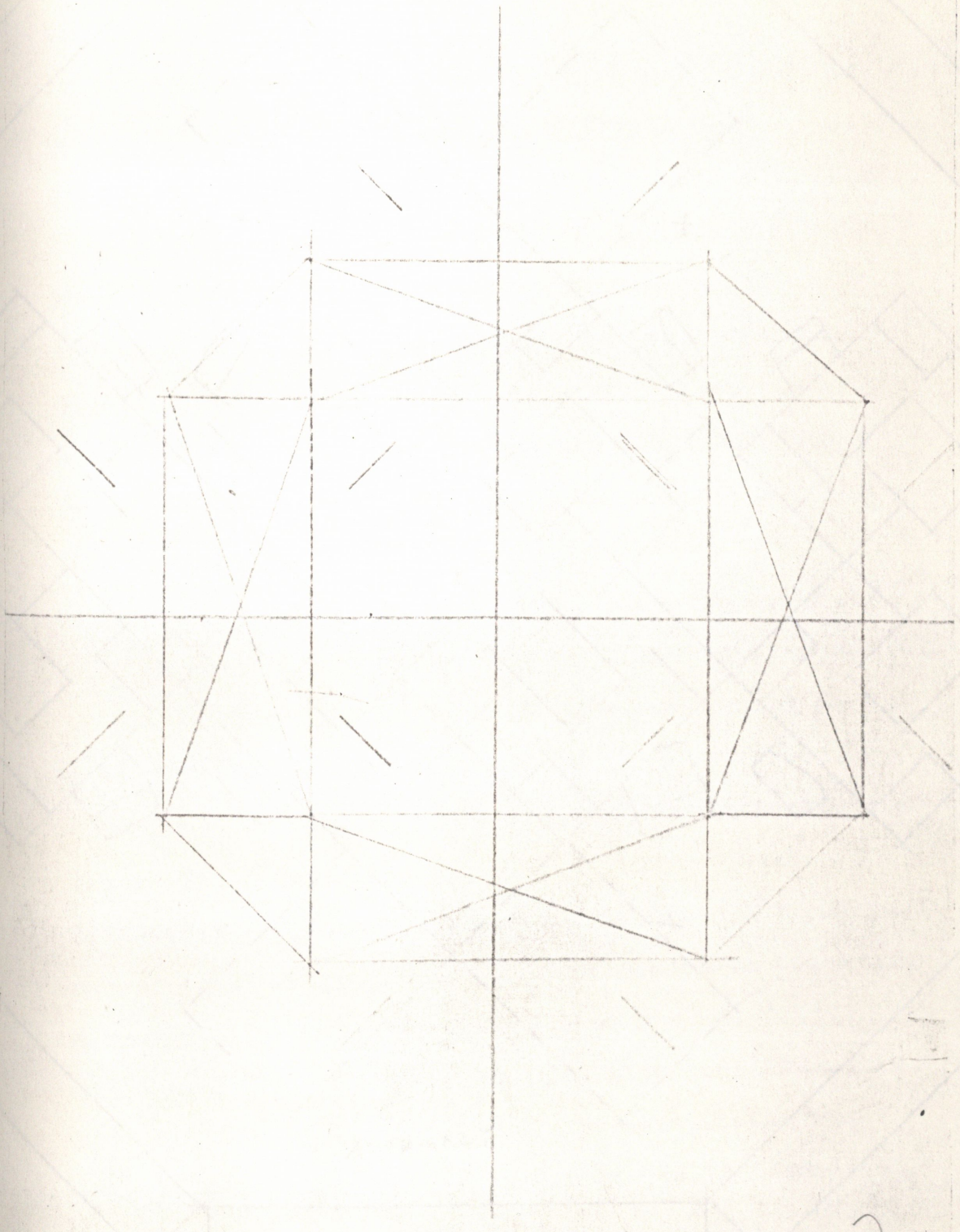


FIGURE 54 SOCIAL GEOMETRY (ASSEMBLY)

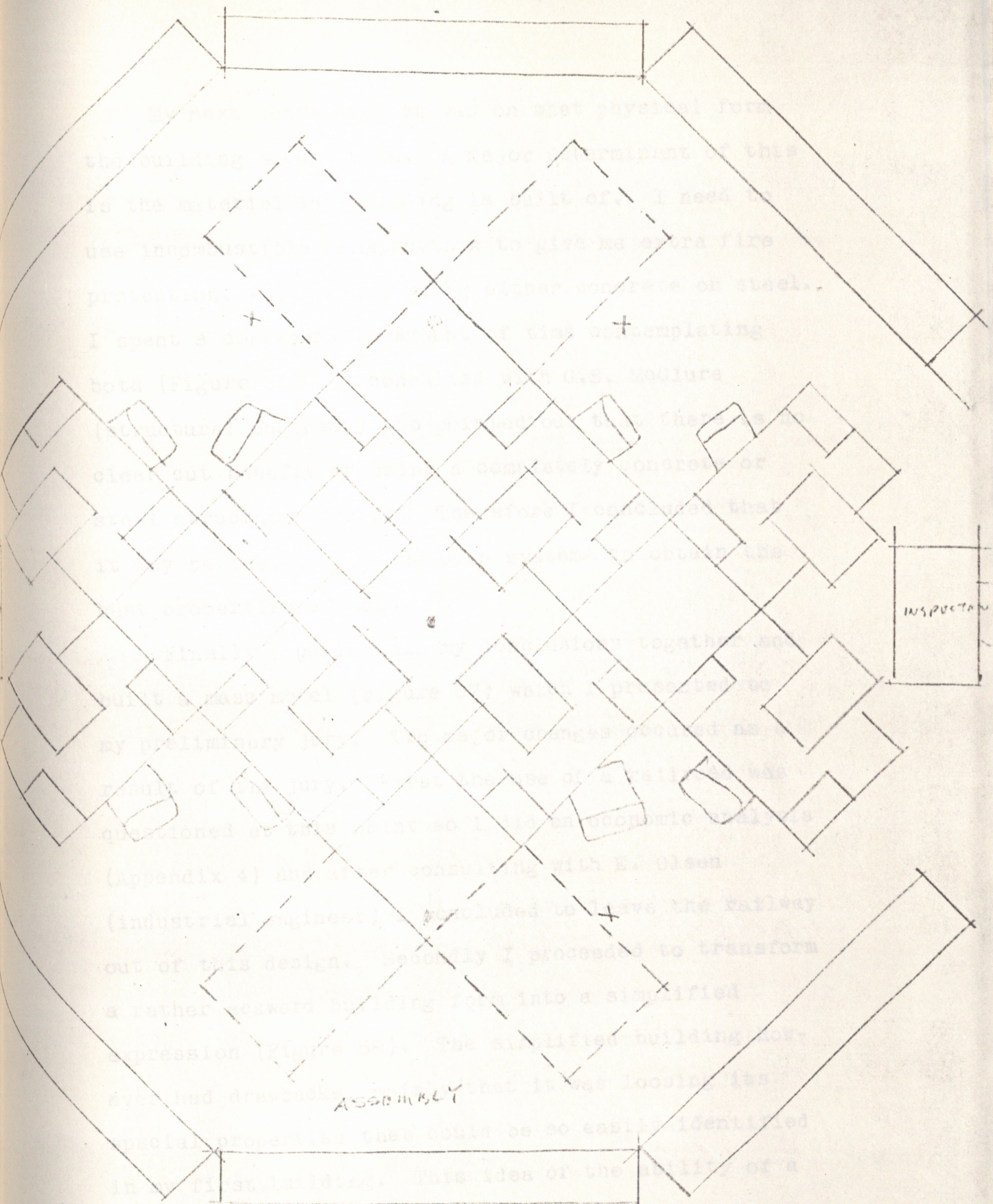


FIGURE 55 ASSEMBLY PLAN

My next consideration was on what physical form the building should take. A major determinant of this is the material the building is built of. I need to use incombustible construction to give me extra fire protection, which means using either concrete or steel. I spent a considerable amount of time contemplating both (Figure 56). I consulted with G.S. McClure (structural engineer) who pointed out that there is no clear cut benefit of using a completely concrete or steel structural system. Therefore I concluded that it may be best to combine both systems to obtain the best properties of each.

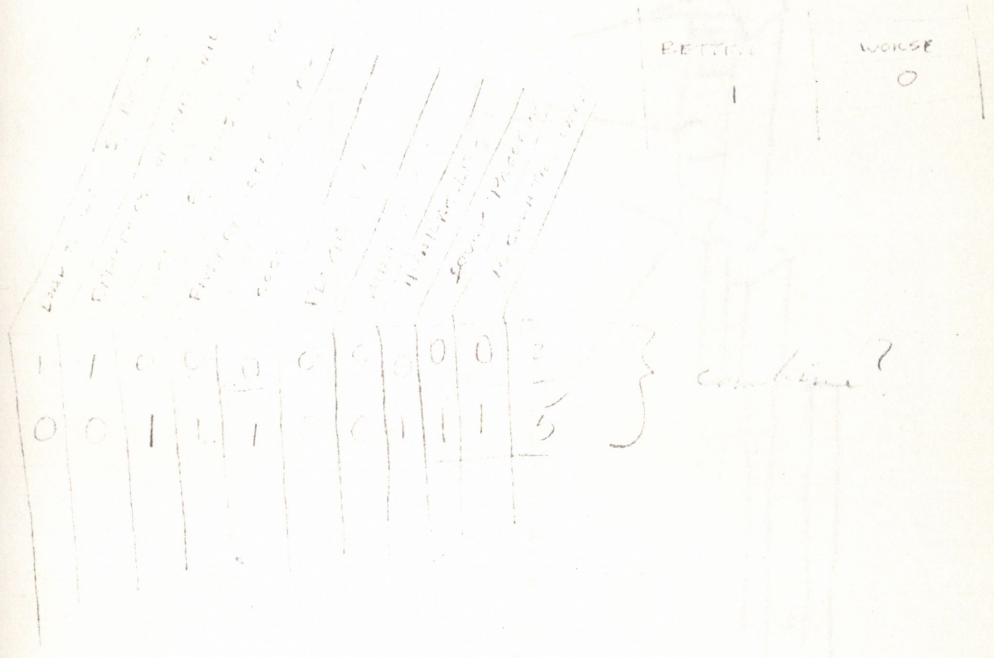
Finally I pulled all my conclusions together and built a mass model (Figure 57) which I presented to my preliminary jury. Two major changes occured as a result of the jury. First the use of a railroad was questioned at this point so I did an economic analysis (Appendix 4) and after consulting with E. Olsen (industrial engineer) I concluded to leave the railway out of this design. Secondly I proceeded to transform a rather ackward building form into a simplified expression (Figure 58). The simplified building however had drawbacks, mainly that it was loosing its spacial properties that could be so easily identified in my first building. This idea of the ability of a

space becoming a concrete symbol is mentioned in my program and this I want to keep. Also the basic linear geometry of the building produced ackward circulation patterns on my site. As a result I desired that a third design should be attempted that was somewhat simplified over the first, but not to the extreme of the second design, and the building should respond more to the site.

My final building evolved from my first two. I worked mainly with a plain geometry which was more sympathetic towards the site. I kept my 12 foot grid in the processing area but rotated the storage area to a 45 degree angle that opened the traffic circulation area to my main entrance at the office. Also this inabled me to locate a receiving area to the east side of the building thus protecting the loading area from winter winds. I kept my round assembly area but also rotated it at a 45 degree angle of the center of my processing area (the foyer). By doing this I was able to simplify my entrance into the assembly area and provided an end to my building mass which you could observe when entering the building. The main functions of the building did not change (Figures 59, 60 and 61). By using geometry I achieved a strong sense of organization and unity in my design. The

STRUCTURAL SYSTEMS

BASIC TYPES: -WOOD



Concrete - by pouring concrete

Ca · Heavy wt

· Energy

· Cheaper

· Durable

· Flexible

· Can

· Fireproof

s — members below the ceiling

COMPARING GOOD POINTS CONCRETE AND STEEL!

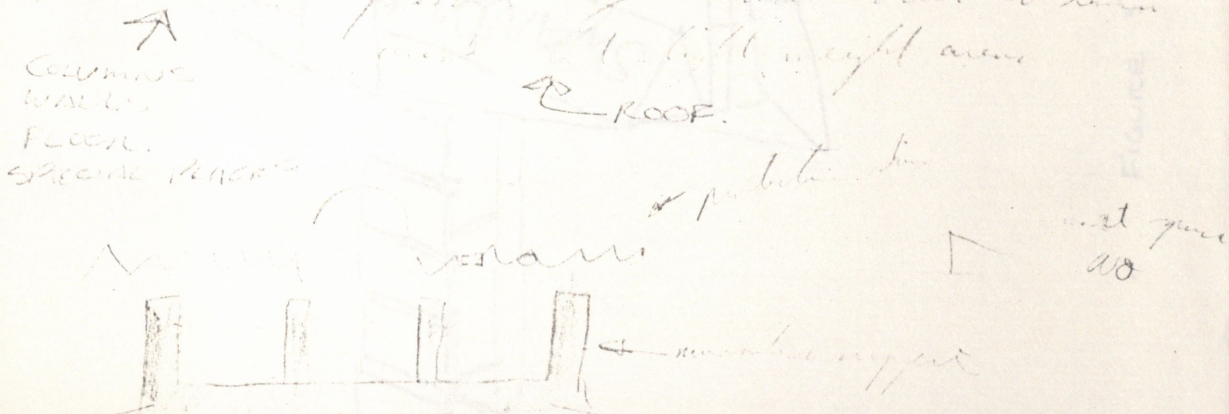


FIGURE 56 STRUCTURAL SYSTEMS

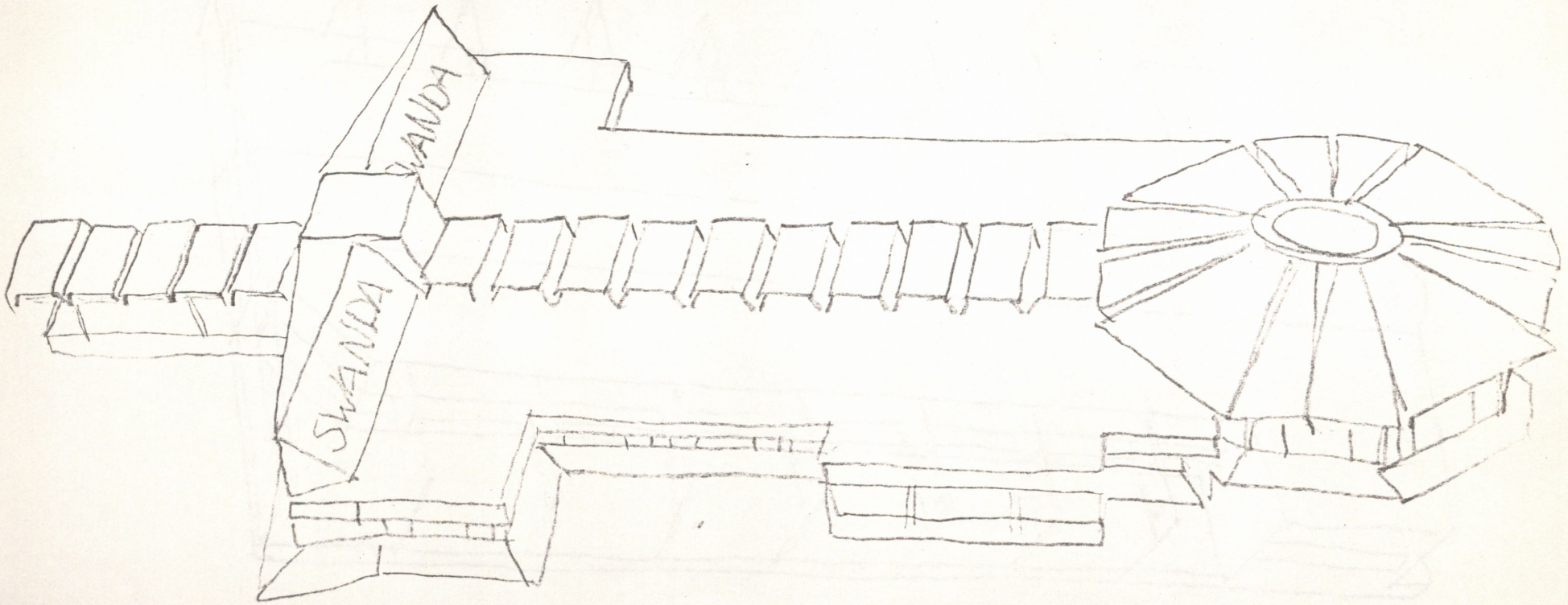


FIGURE 57 MASS MODEL ONE (PHOTOGRAPHIC [redacted] DRAWING)

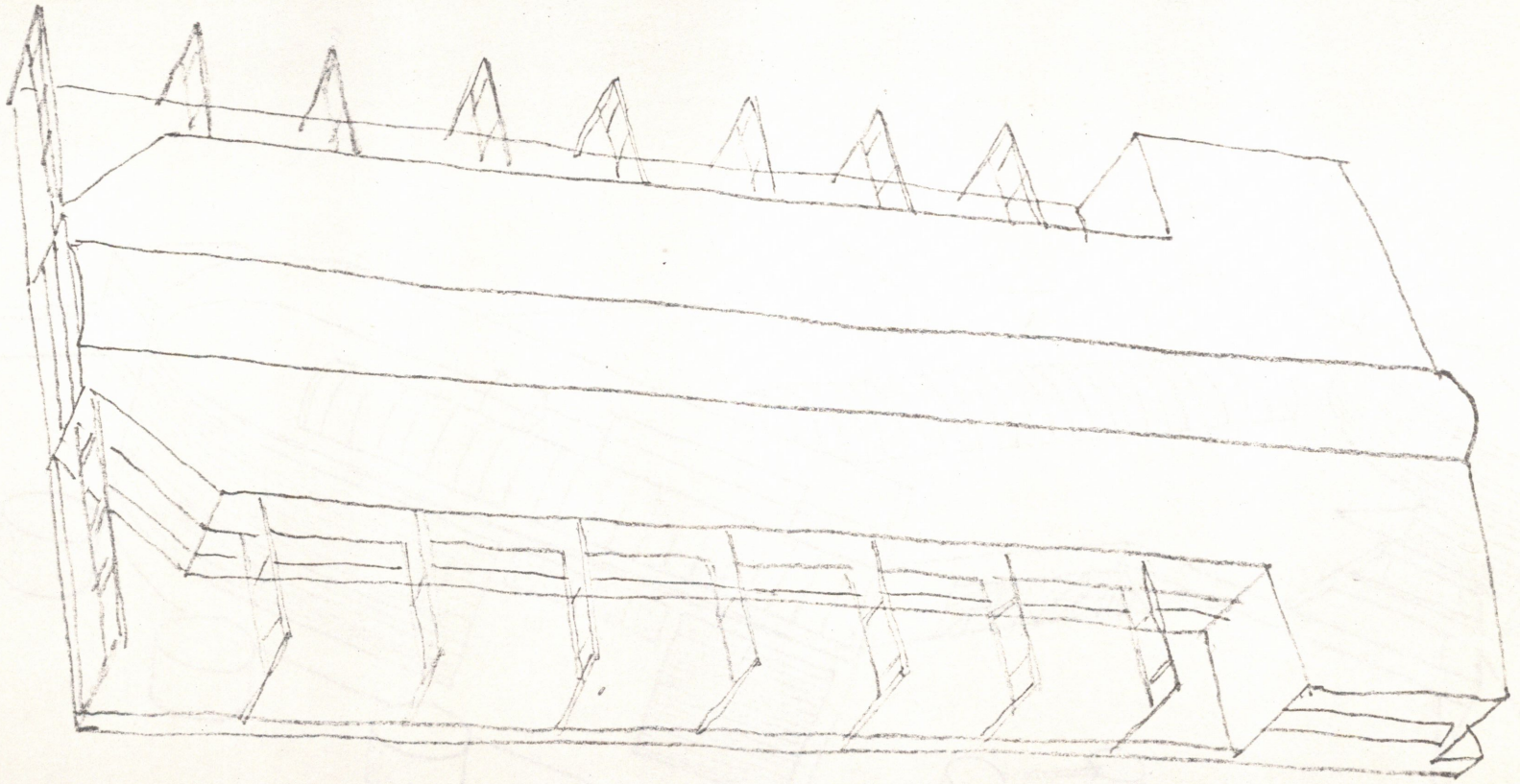


FIGURE 58 SIMPLIFIED MODEL TWO (PHOTOGRAPHIC DRAWING)

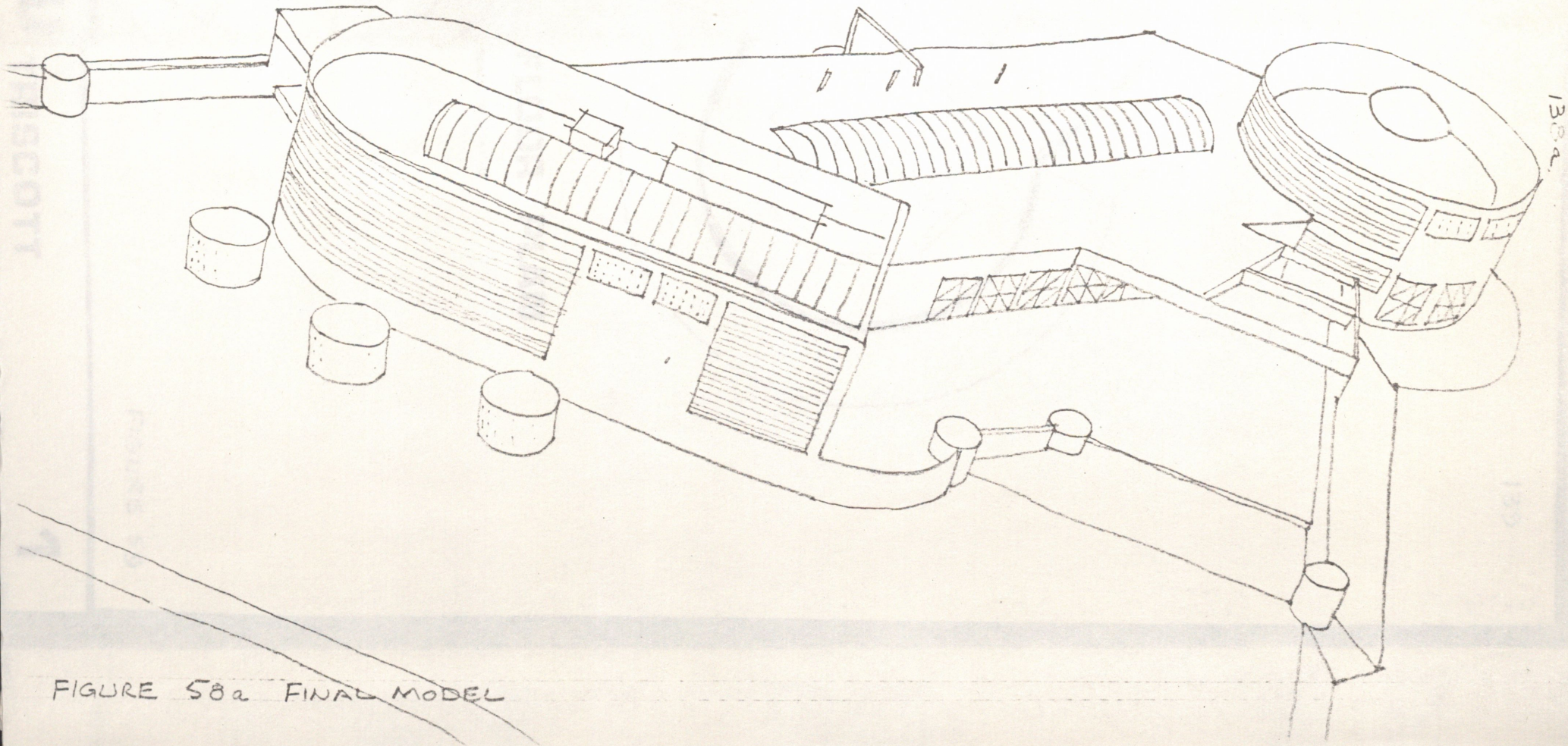
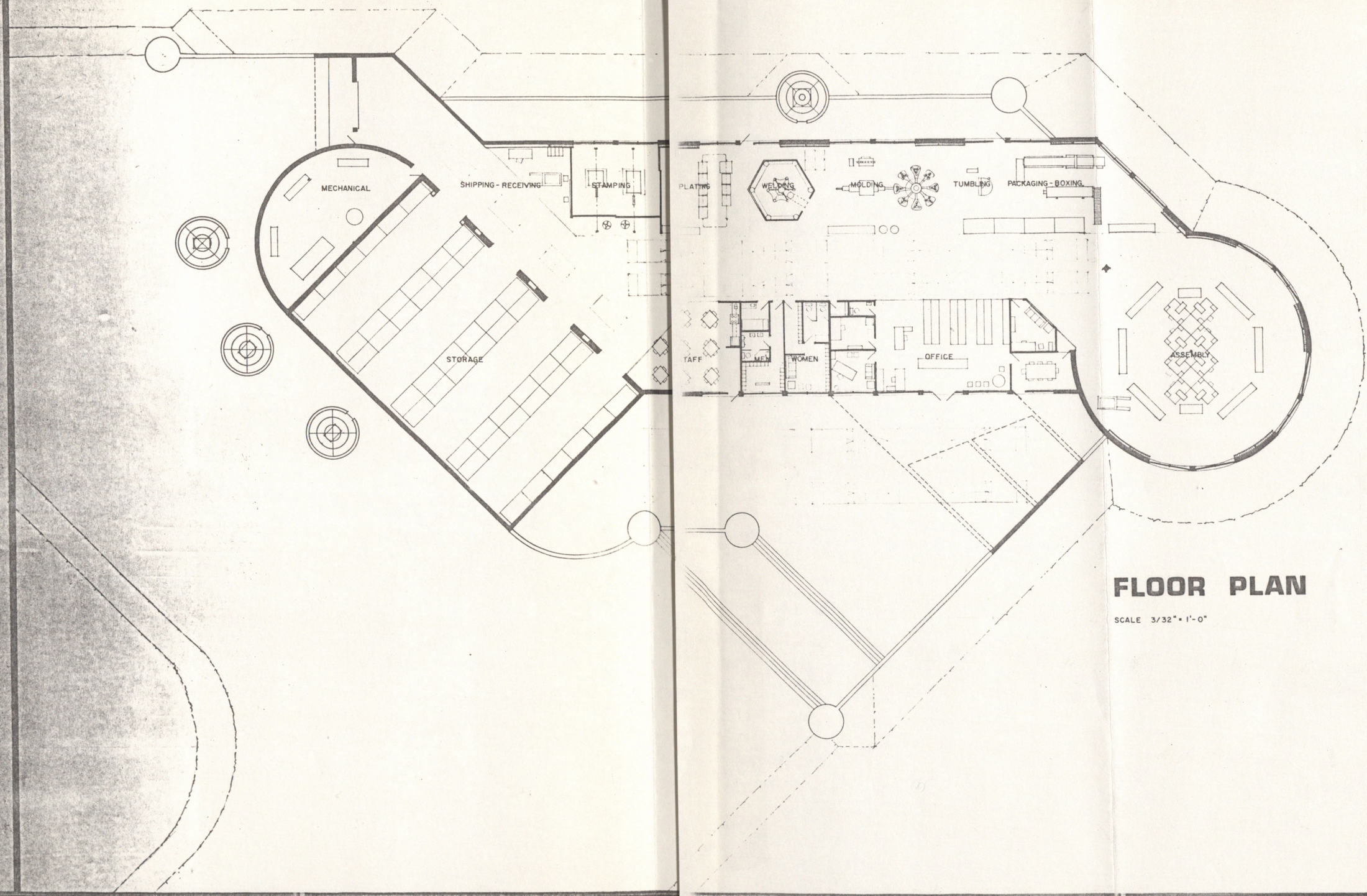


FIGURE 58a FINAL MODEL



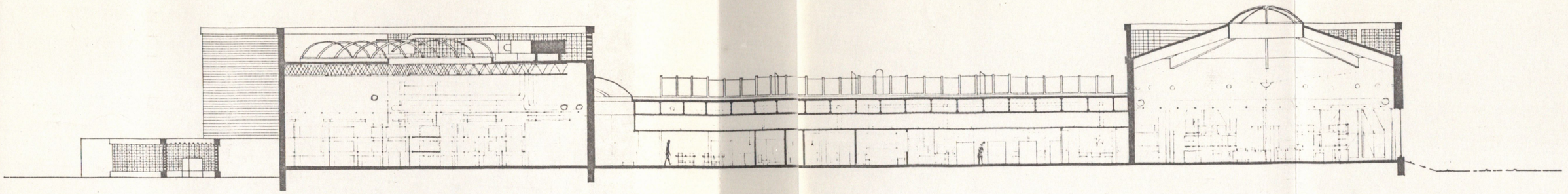
FLOOR PLAN

SCALE 3/32" = 1'-0"

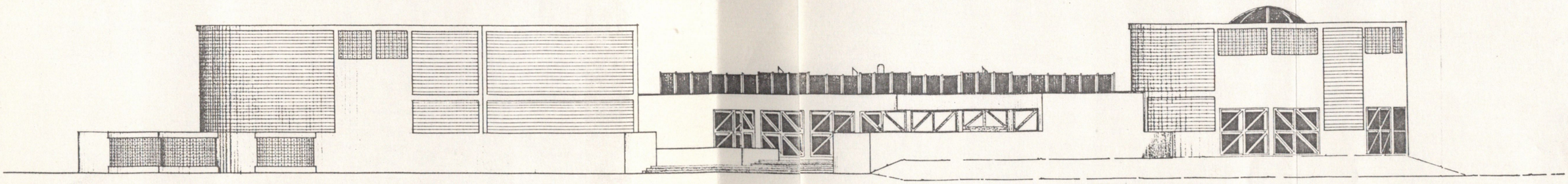
FIGURE 59

INDUSTRIAL FACILITY

TRISCOTT 1



BUILDING SECTION



WEST ELEVATION

FIGURE 60

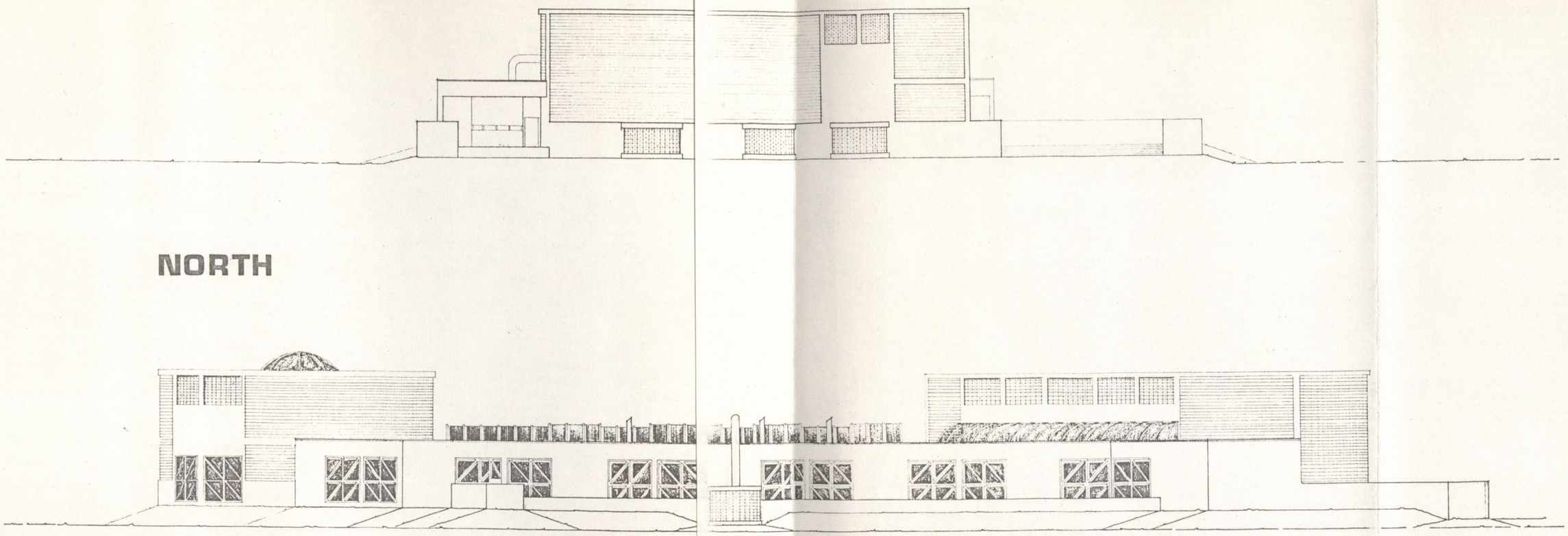


FIGURE C1

ELEVATIONS

plan then became very organic with a well organized growth pattern (Figures 62, 63 and 64).

At this time I transposed my building from a two dimensional floor plan to the three dimensional form. To do this I attempted to relate the two dimensional geometry into the third dimension. Here I used the basic 12 foot dimension and the radius of the assembly area (Figure 65). Most of the vertical proportions of the buildings elevations are based on this transformation.

Once I had established the three dimensional form I proceeded to consider the technology of constructing the building. I first studied the structural system. I desired to use a light weight metal deck on open web steel joists at 6 foot on center, supported by 12 inch load bearing hollow core concrete block walls (appendix 2). Secondly I considered the mechanical system (appendix 3). For this building I went to a forced air system. When doing my mechanical calculations I came across the problem of energy conservation. For my extreme temperature conditions (winter and summer) I desired to use a movable panel system to cover my skylights and window areas. As part of the conservation process I reduced my windows as much as I could without loosing the effect of the natural light. To

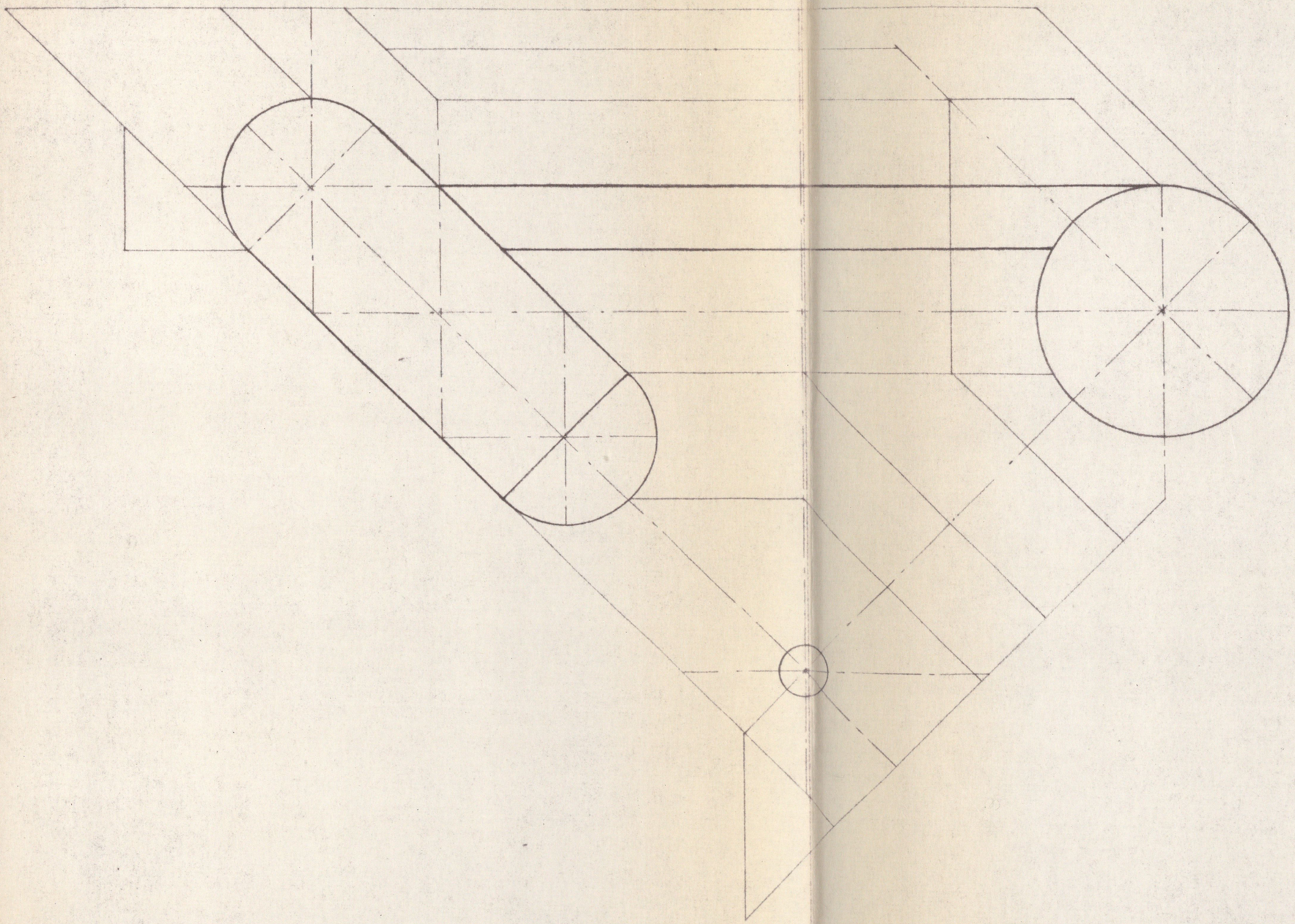


FIGURE 62

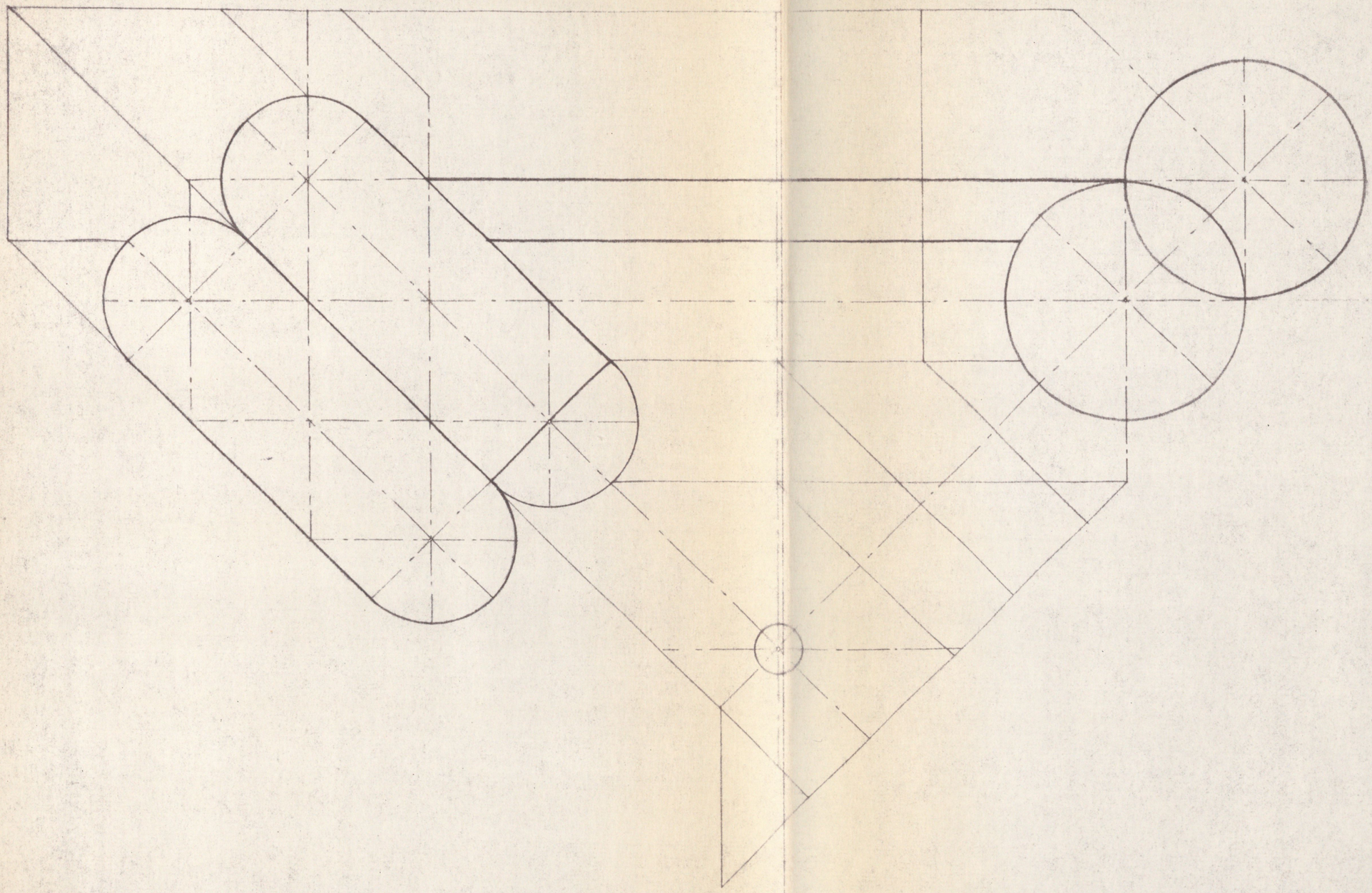
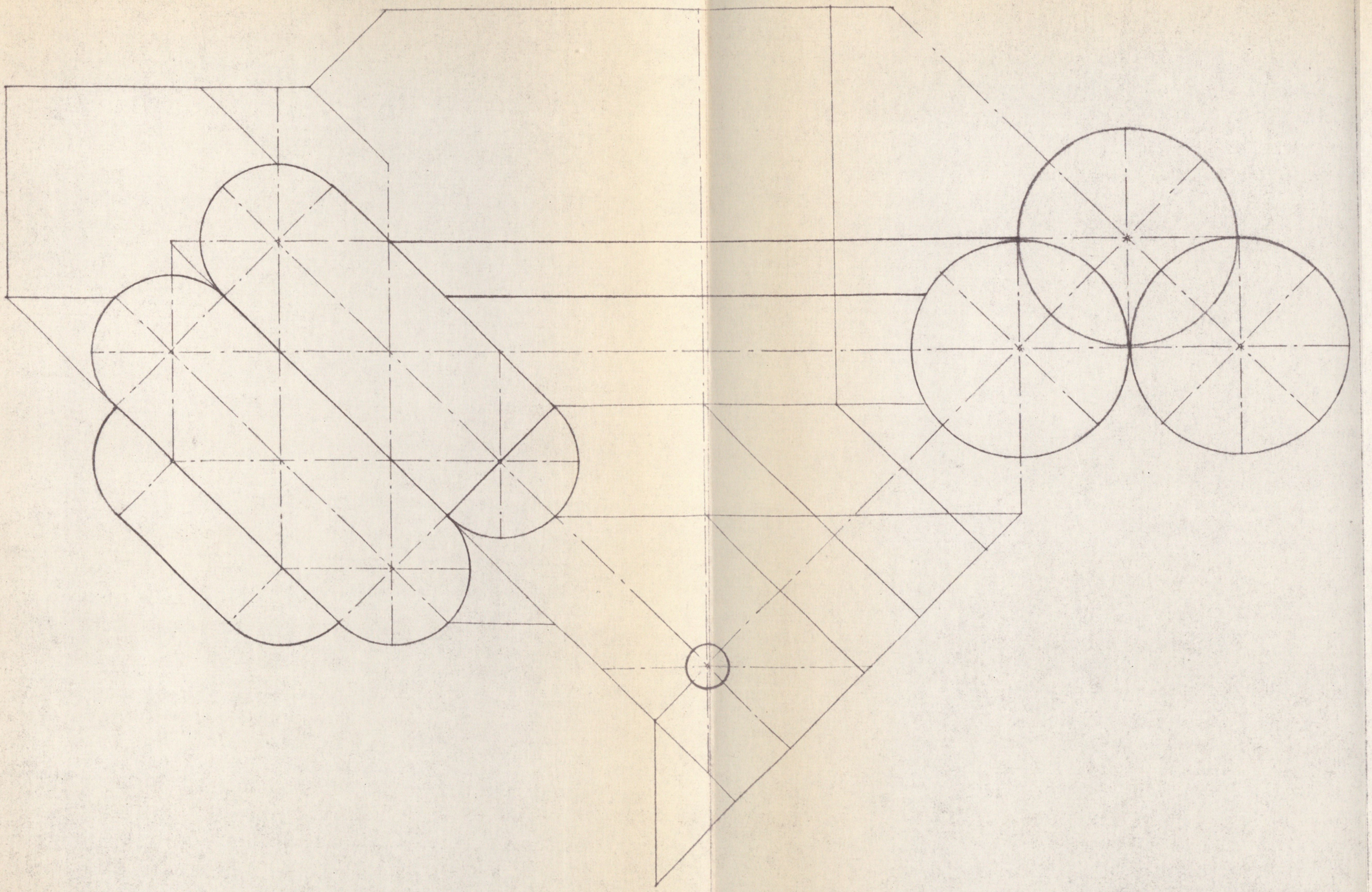
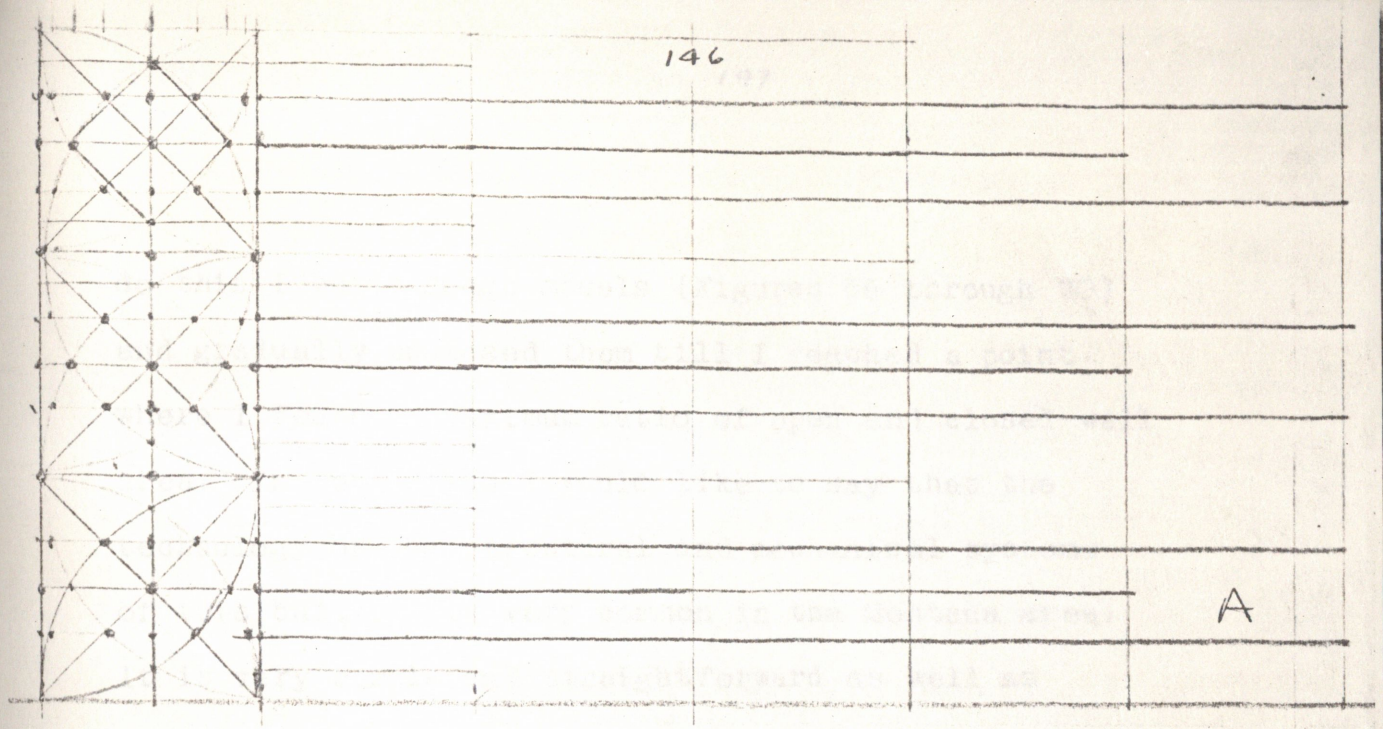
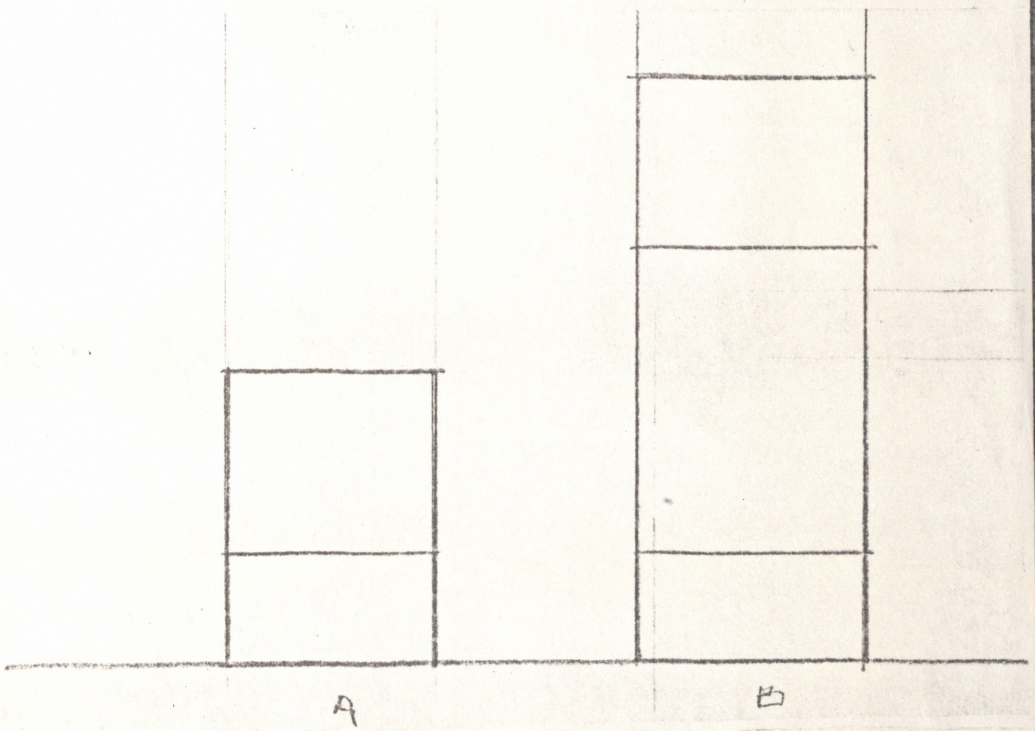


FIGURE 63







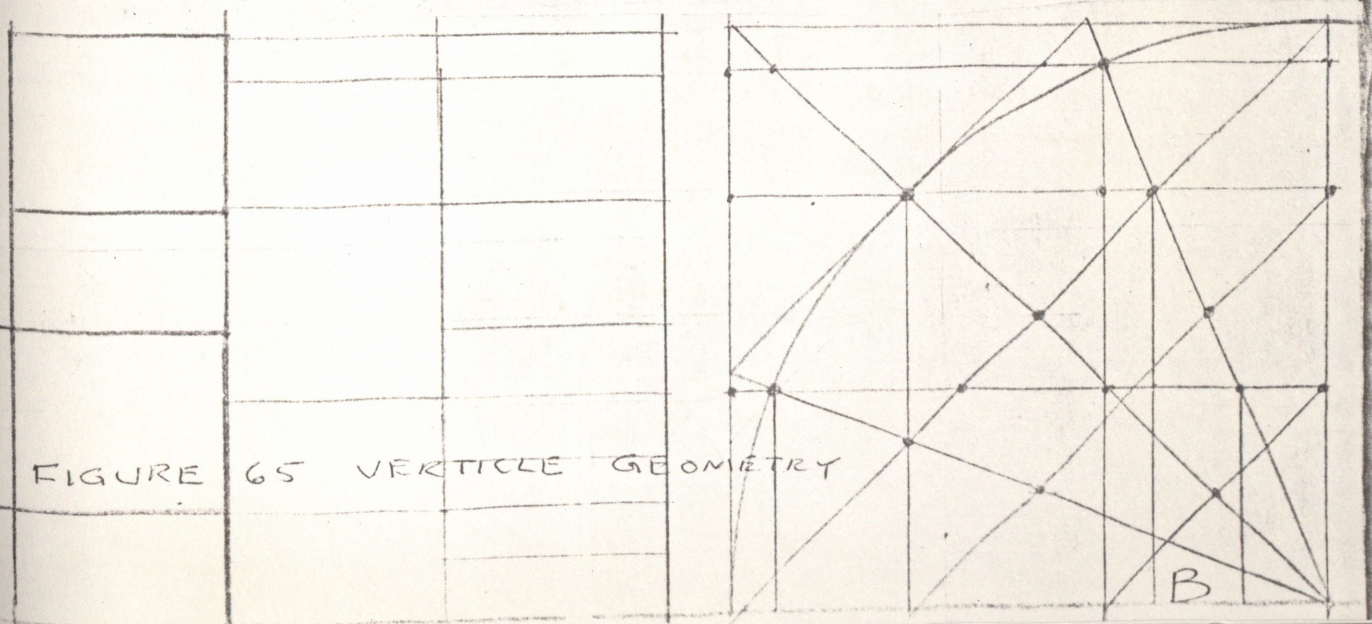


FIGURE 65 VERTICLE GEOMETRY

do this I built rough models (Figures 66 through 70) and gradually enclosed them till I reached a point where I found my maximum ratio of open and closed wall area. In conclusion I would like to say that the technology of the structural and mechanical systems of this building is very common in the Montana area. It is very simple and straightforward as well as economical to use.

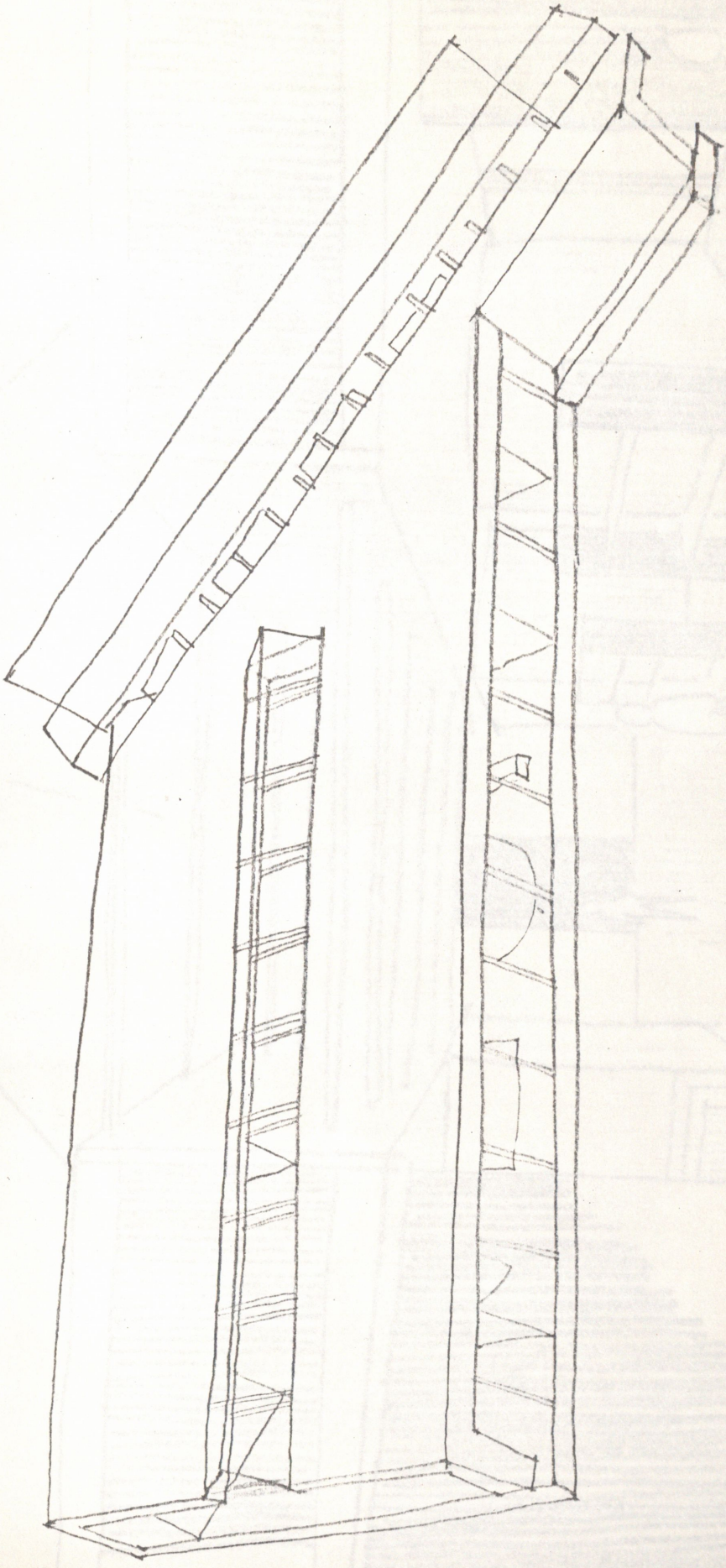


FIGURE 66 PROCESS AREA STUDY MODEL (PHOTOGRAPHIC DRAWING)

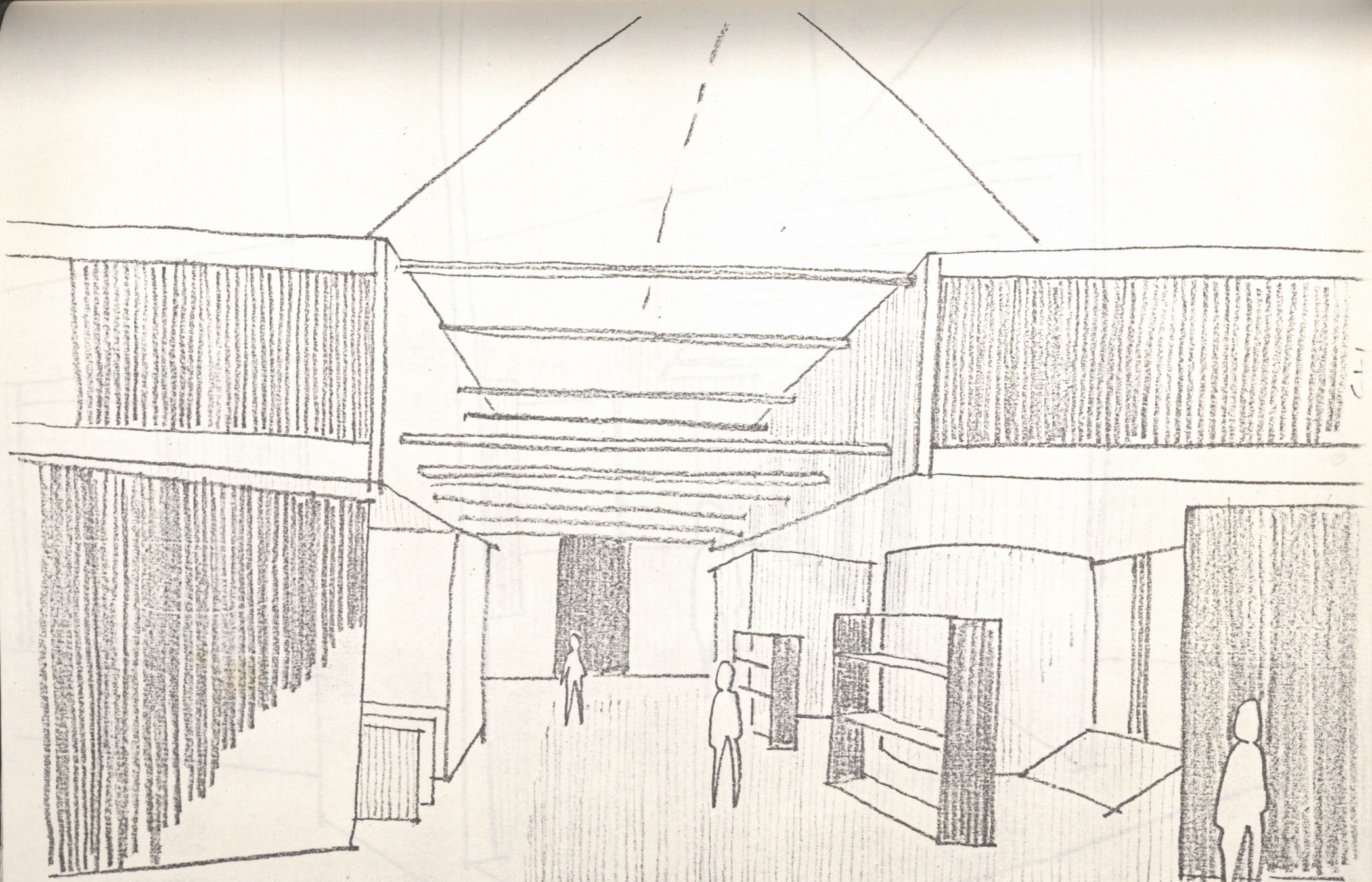


FIGURE 67 PROCESS INTERIOR (PHOTOGRAPHIC DRAWING) LIGHT STUDY MODEL

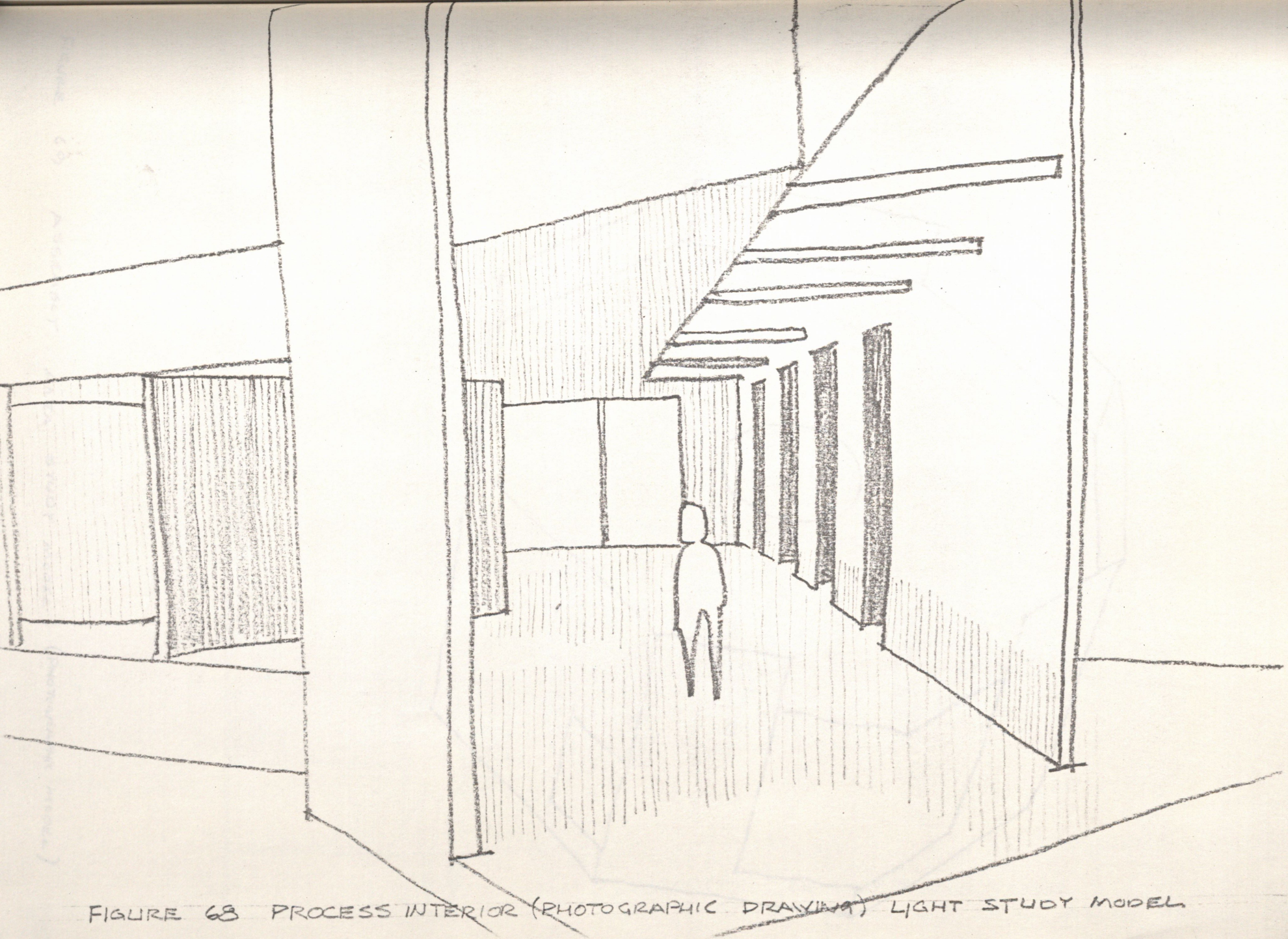


FIGURE 68 PROCESS INTERIOR (PHOTOGRAPHIC DRAWING) LIGHT STUDY MODEL

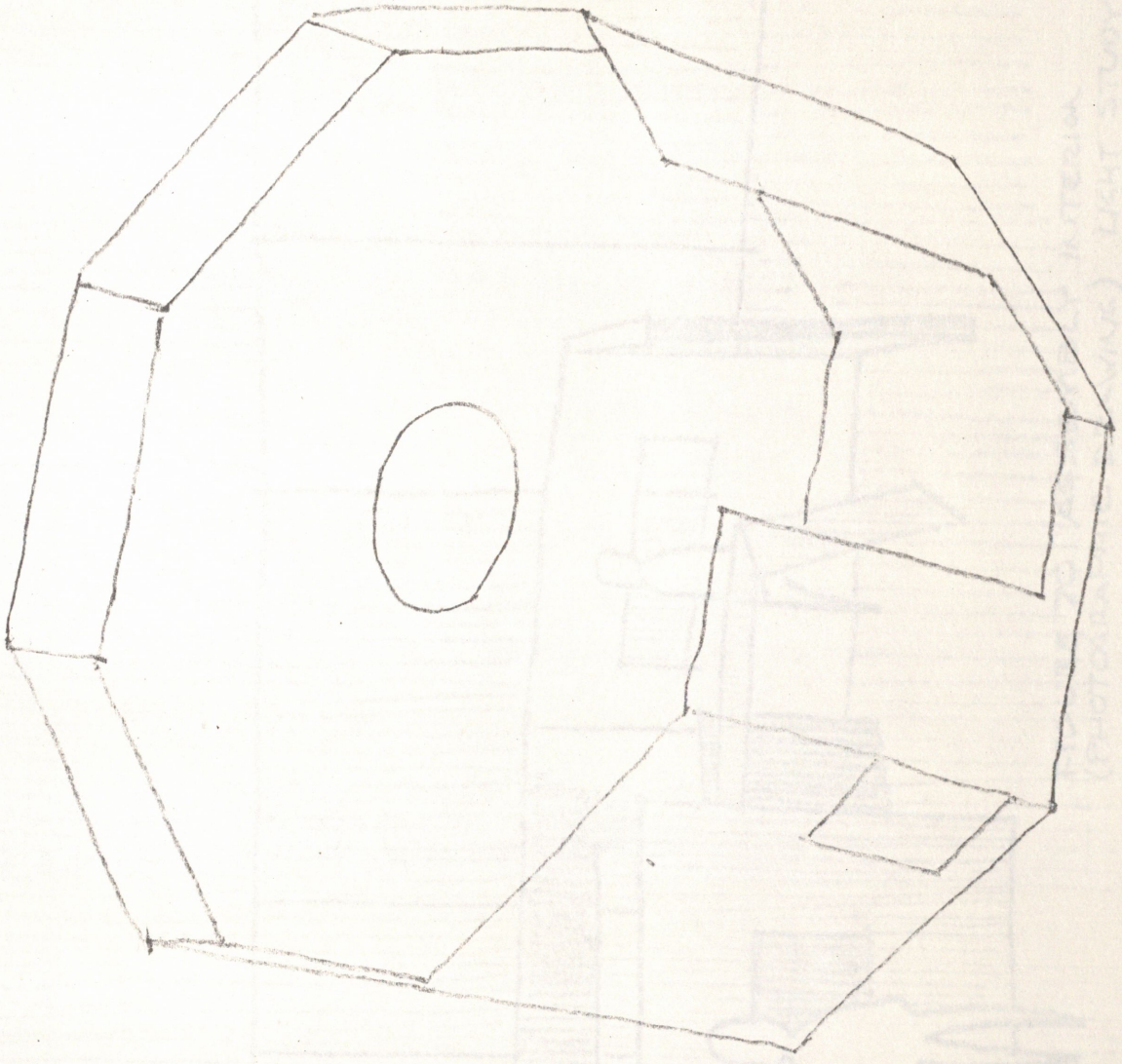


FIGURE 69 ASSEMBLY AREA STUDY MODEL (PHOTOGRAPHIC MODEL)

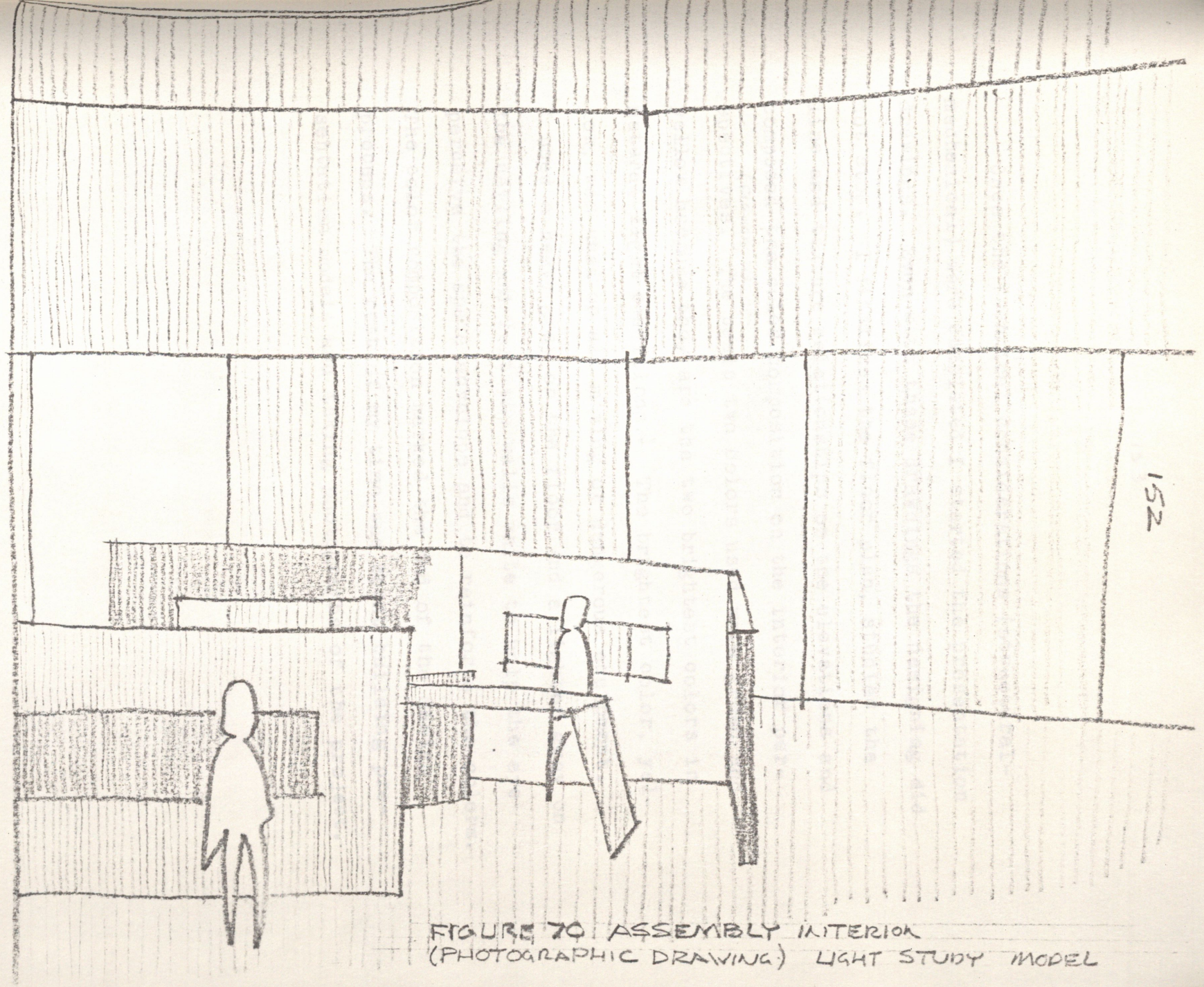
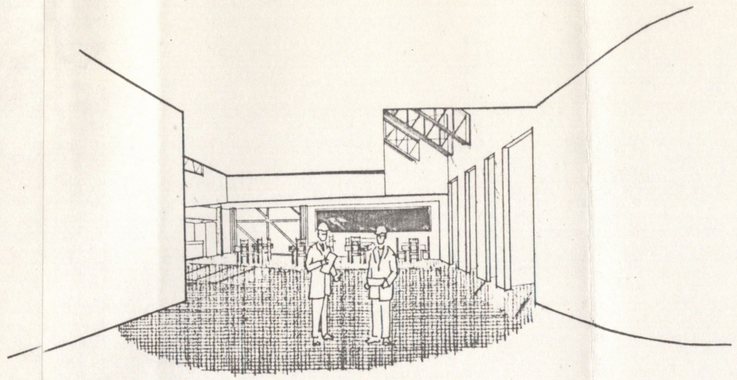


FIGURE 70 ASSEMBLY INTERIOR
(PHOTOGRAPHIC DRAWING) LIGHT STUDY MODEL

Once the technical considerations (structural-mechanical) were completed I started the presentation drawings. Even with these drawnings the designing did not stop. I finalized the floor plan, studied the line and texture relationships on the elevations and composed the color composition on the interior perspectives. (FIGURE 71) The basic two colors used were green and yellow because they are the two brightest colors in natural light conditions.[1] The brightest color, yellow, was used on all moving or dangerous equipment. I used a heavy gray on the floor and a lighter gray on the ceiling and left the walls white to help the eye perceive the space envelope and to reinforce the colors. The color composition marked the end of the design process. The rest of my time was spent building presentation models and taking photographs of the project.

[1]As described in Color, Form and Space, by F. Birren, Richold Publishing Corporation, page 44.



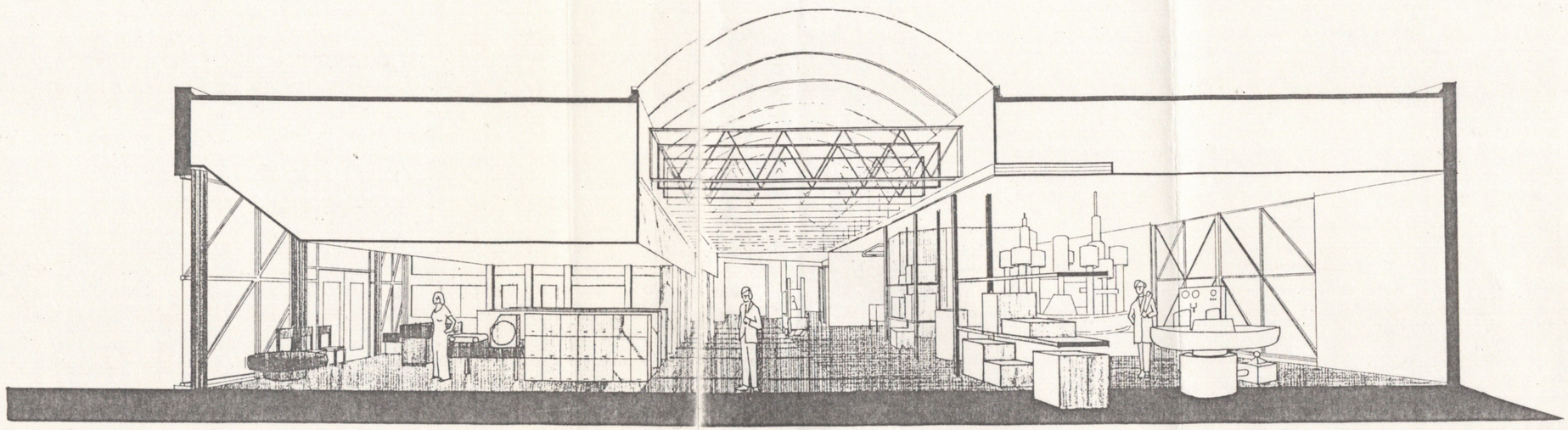


FIGURE 71

INTERIOR PERSPECTIVES

THE PROOF

I deem this project as successful on several levels for the following reasons:

A. Machine Level

1. I managed to keep an excellent machine functional relationship in the final product. The number of staff was reduced to a more practical size. The facility remained highly efficient (Figure 59).
2. An improved site over that of the initial program (Figure 37).

B. Man Level

1. I designed mechanically efficient as well as humanly functional work. People can communicate both visual and vocally. This aids in avoiding alienation and self-identity problems (Figures 52, 55).
2. Space modulation and geometry to provide a functional identity (Figure 60).
3. A modulating environment with the uses of natural lighting, views of surrounding countryside as well as views of activities being carried on inside the facility (Figure 71).
4. A simplicity of organization of functions and static space geometry that aids man in perceiving his total environment (Figure 59).

5. Broke down the large uniform work space into smaller work spaces to aid with self-identity (Figures 59, 52, 55).

C. Cultural Level

1. I used a common American building system (concrete block and open web steel joists) (Appendix 2).
2. Provided exposure to the surrounding landscape as well as incorporated American art (the mountain scape in the staff area (Figure 71).
3. Provided areas for cultural activities such as American shuffleboard in the foyer (Figure 59).
4. The ability to reinforce cultural standards by improving communication channels in the work stations (Figures 52, 55).

On the basis of the above points that are illustrated in my industrial facility subject I claim that it is a proof that man, culture and machine can be united in an accomodating environment as described in my thesis.

Upon completing this project I re-examined it and found the following weak points.

1. The need for moveable insulation panels over the glazed areas of the building indicate to me an inconstancy with the local environmental conditions.
2. Poor area utilization in the storage area and assembly area even though other considerations are met.
3. The awkward geometry of the site that I selected makes for poor utilization of the extremities of the site.
4. The mens and womens locker areas seem to be awkward.
5. By incorporated ramps in the entrance area I could easily accomodate the handicapped thus aid in solving another problem in our society.

These short-comings I feel could be easily overcome by further work in each area.

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APPENDIX

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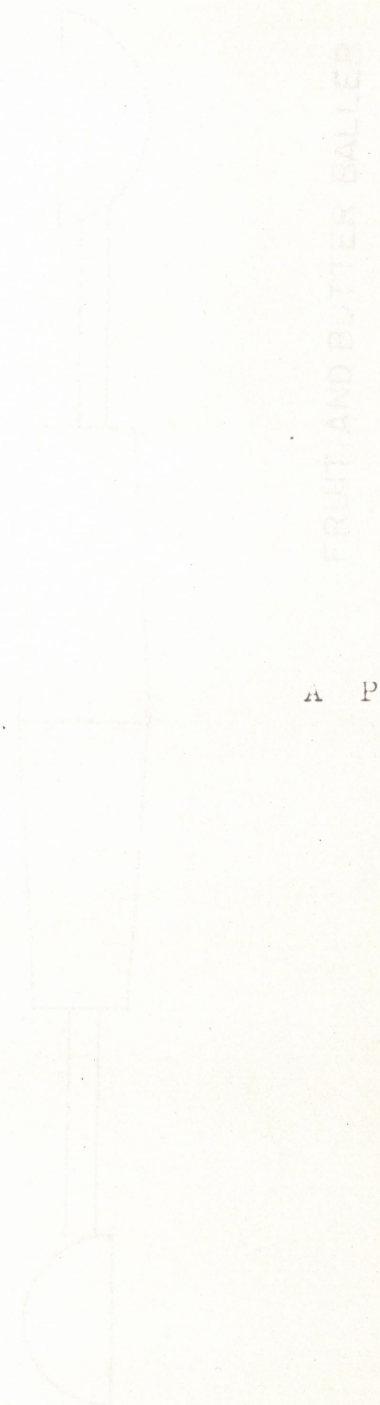
C CODES 194

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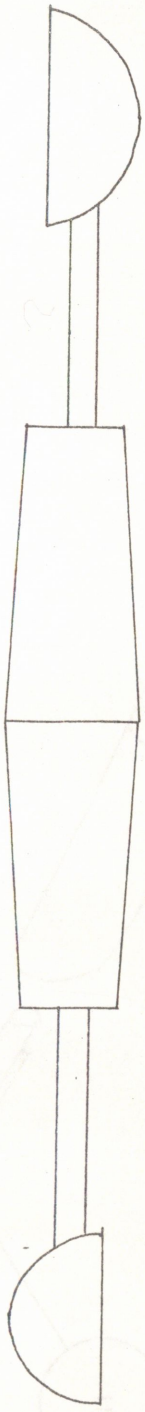
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   a. general 221
   b. railroad 225

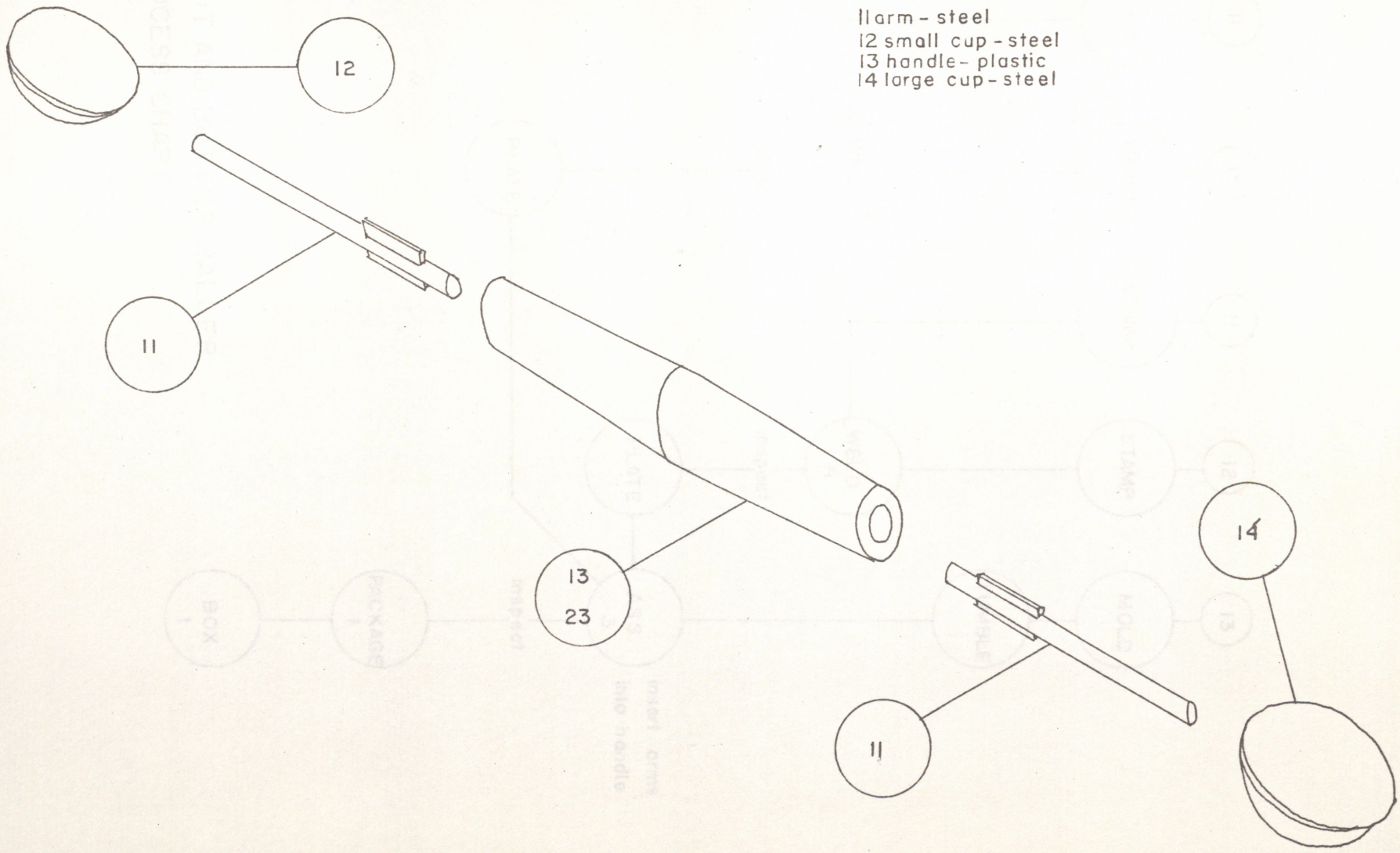


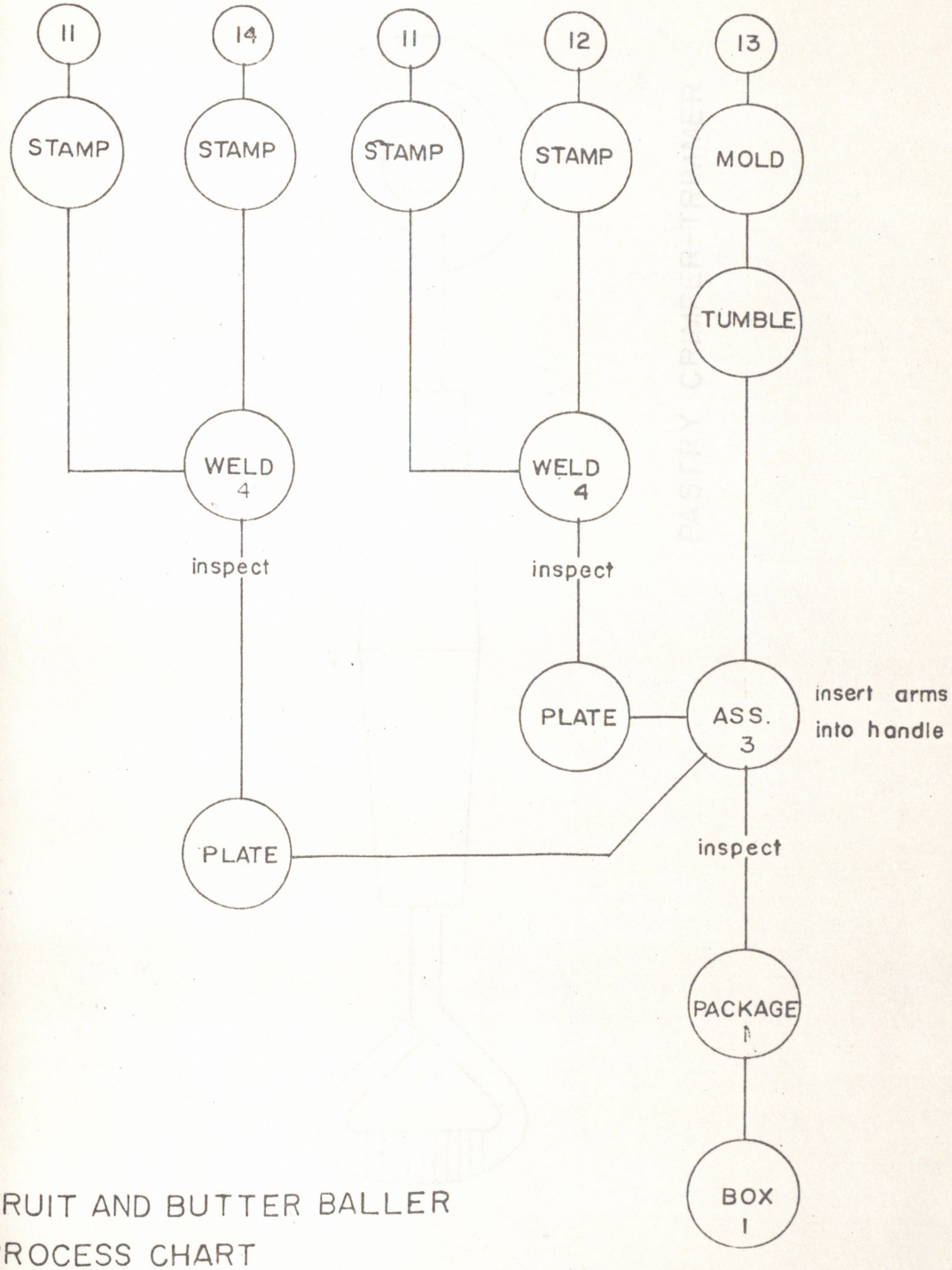
A PRODUCTS



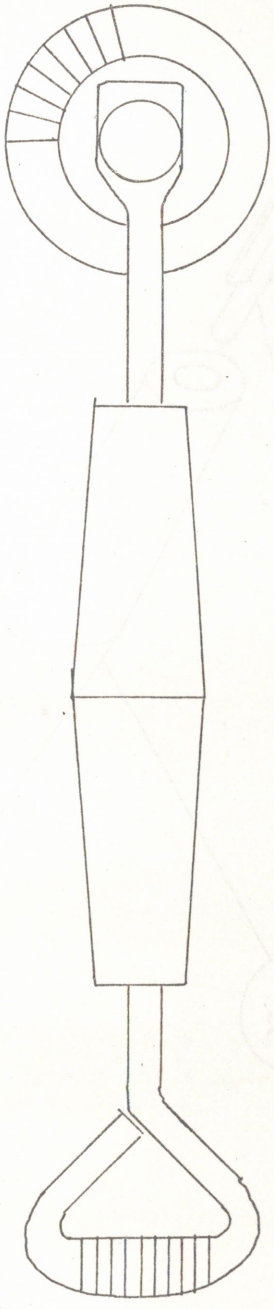
FRUIT AND BUTTER BALLER

11 arm - steel
12 small cup - steel
13 handle - plastic
14 large cup - steel



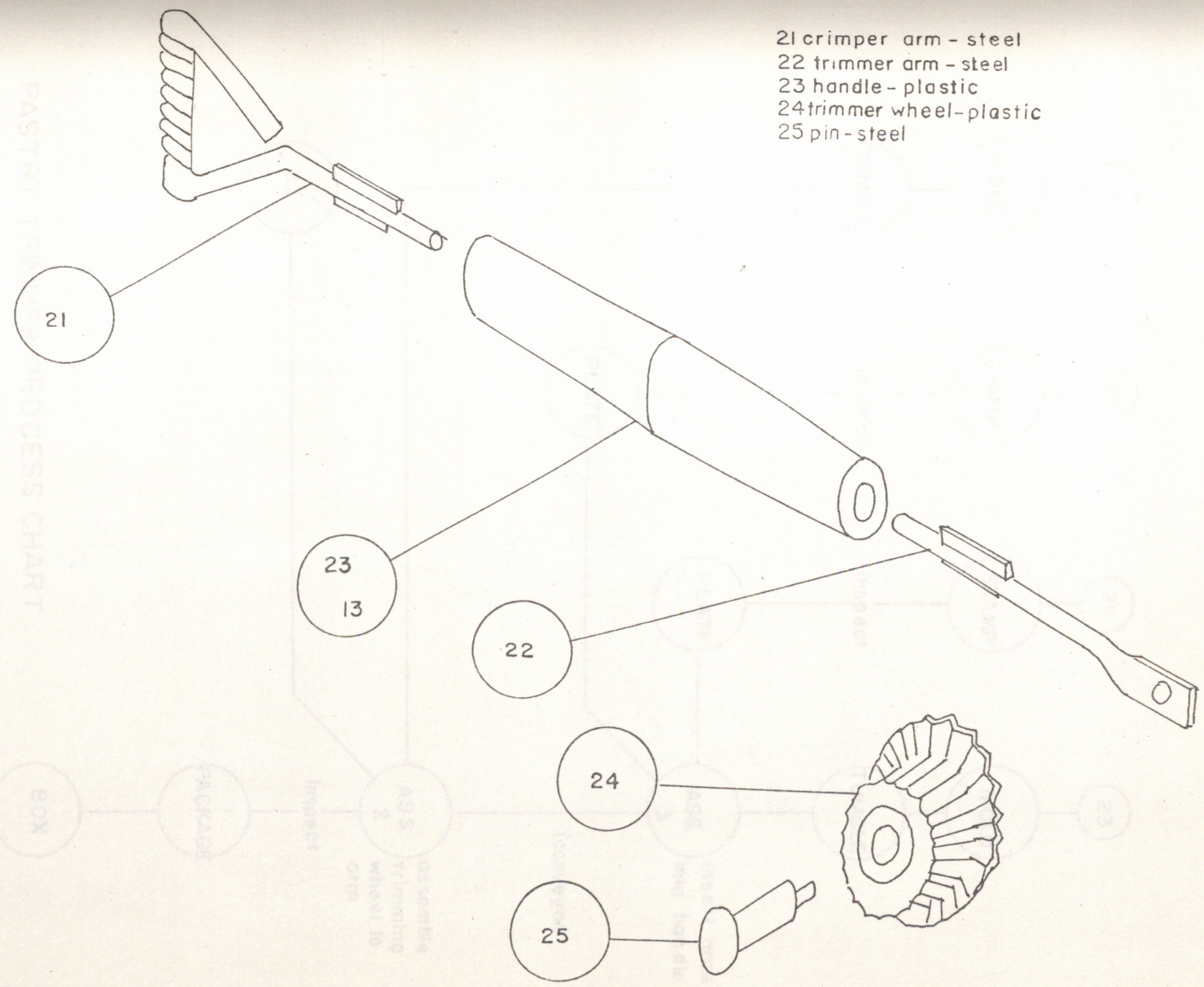


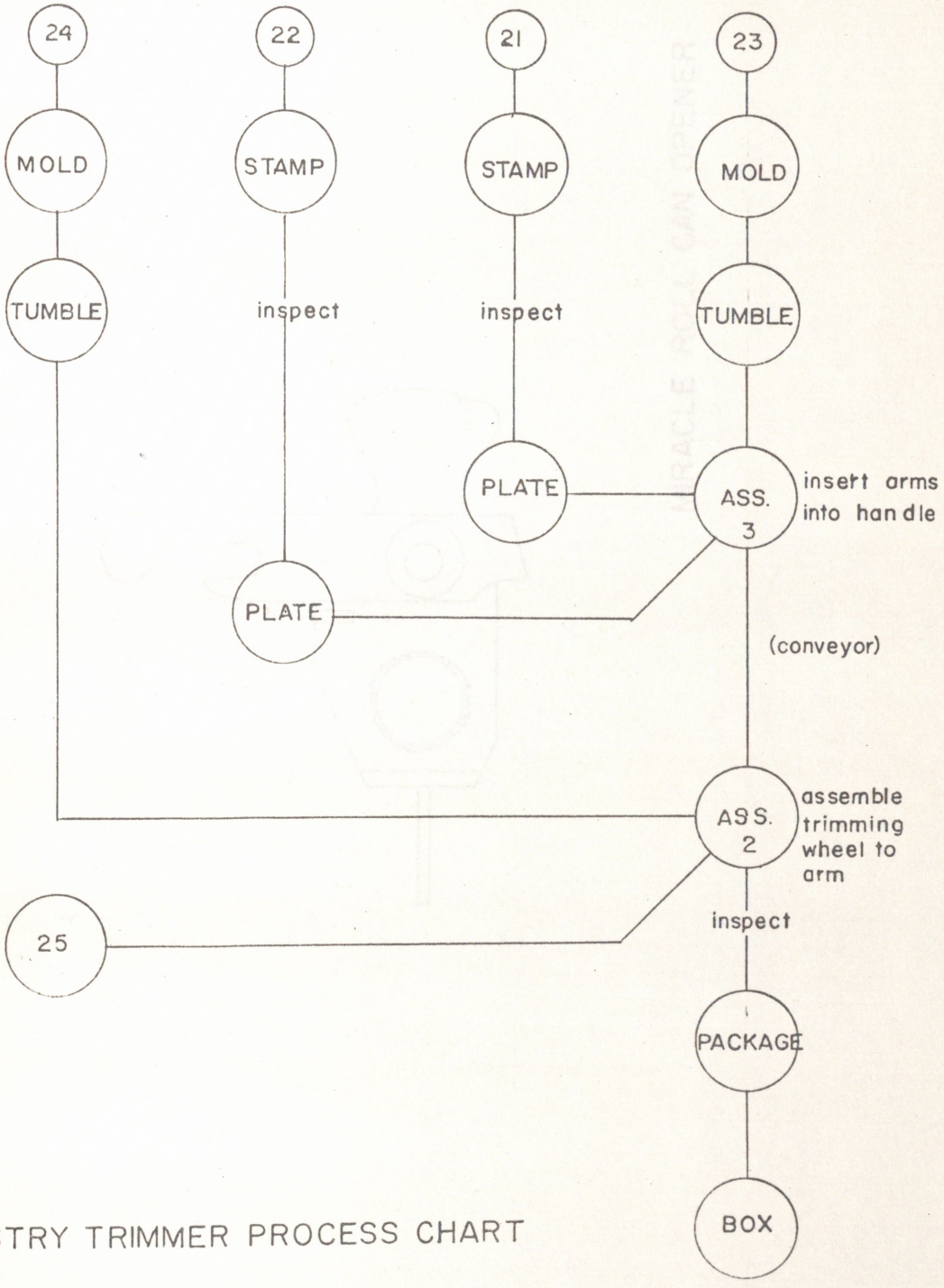
FRUIT AND BUTTER BALLER
PROCESS CHART



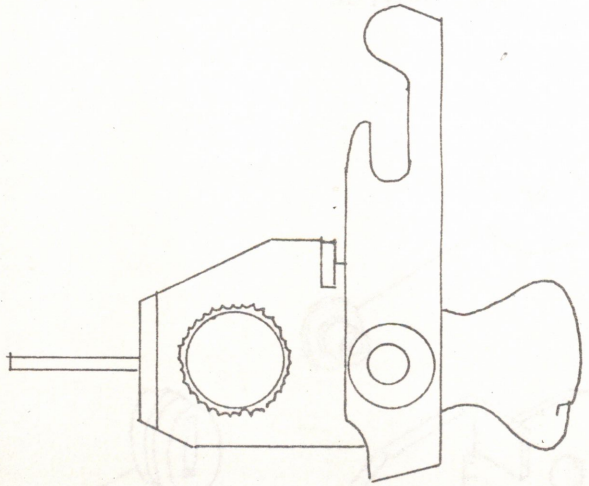
PASTRY CRIMPER-TRIMMER

21 crimper arm - steel
22 trimmer arm - steel
23 handle - plastic
24 trimmer wheel - plastic
25 pin - steel



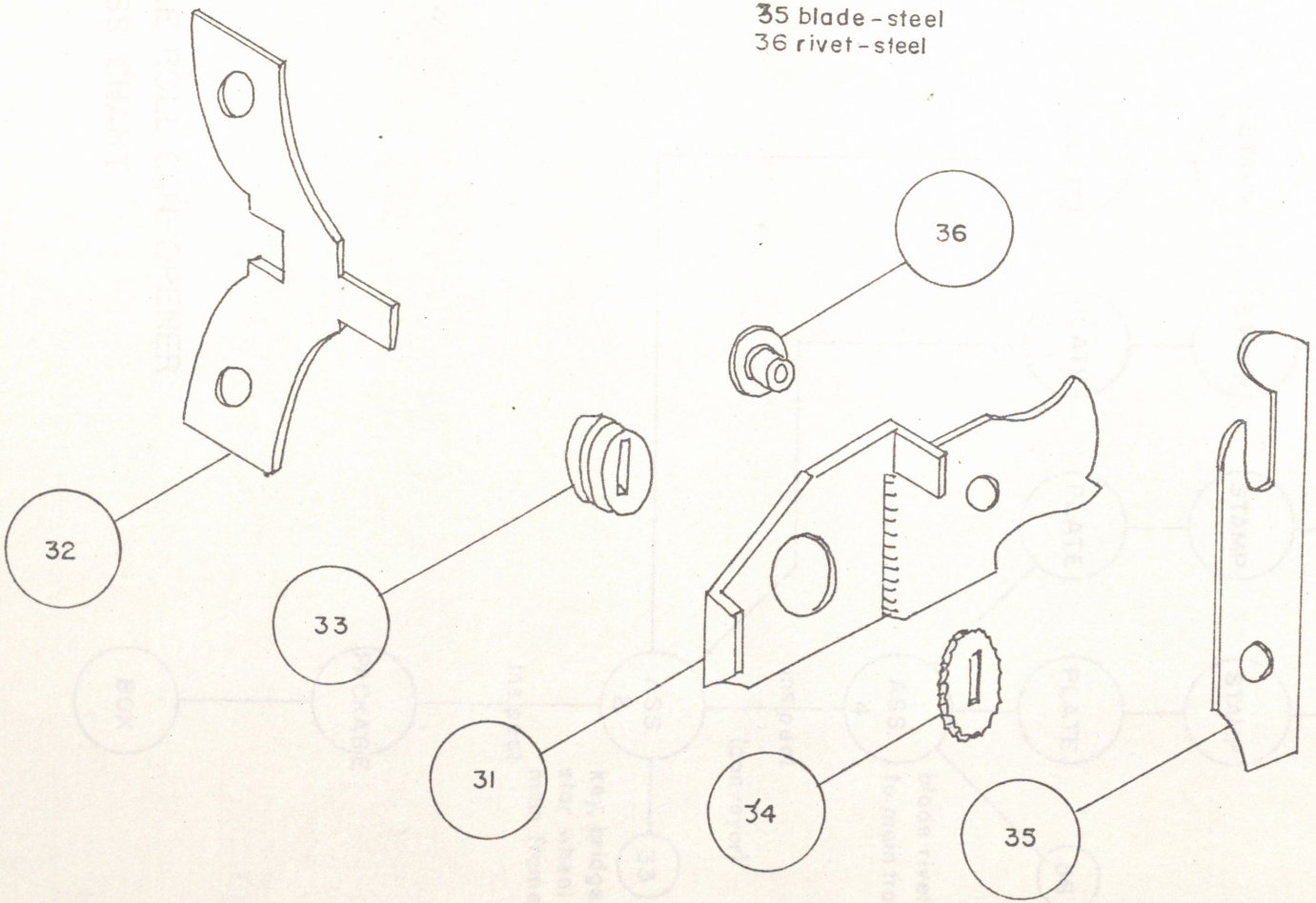


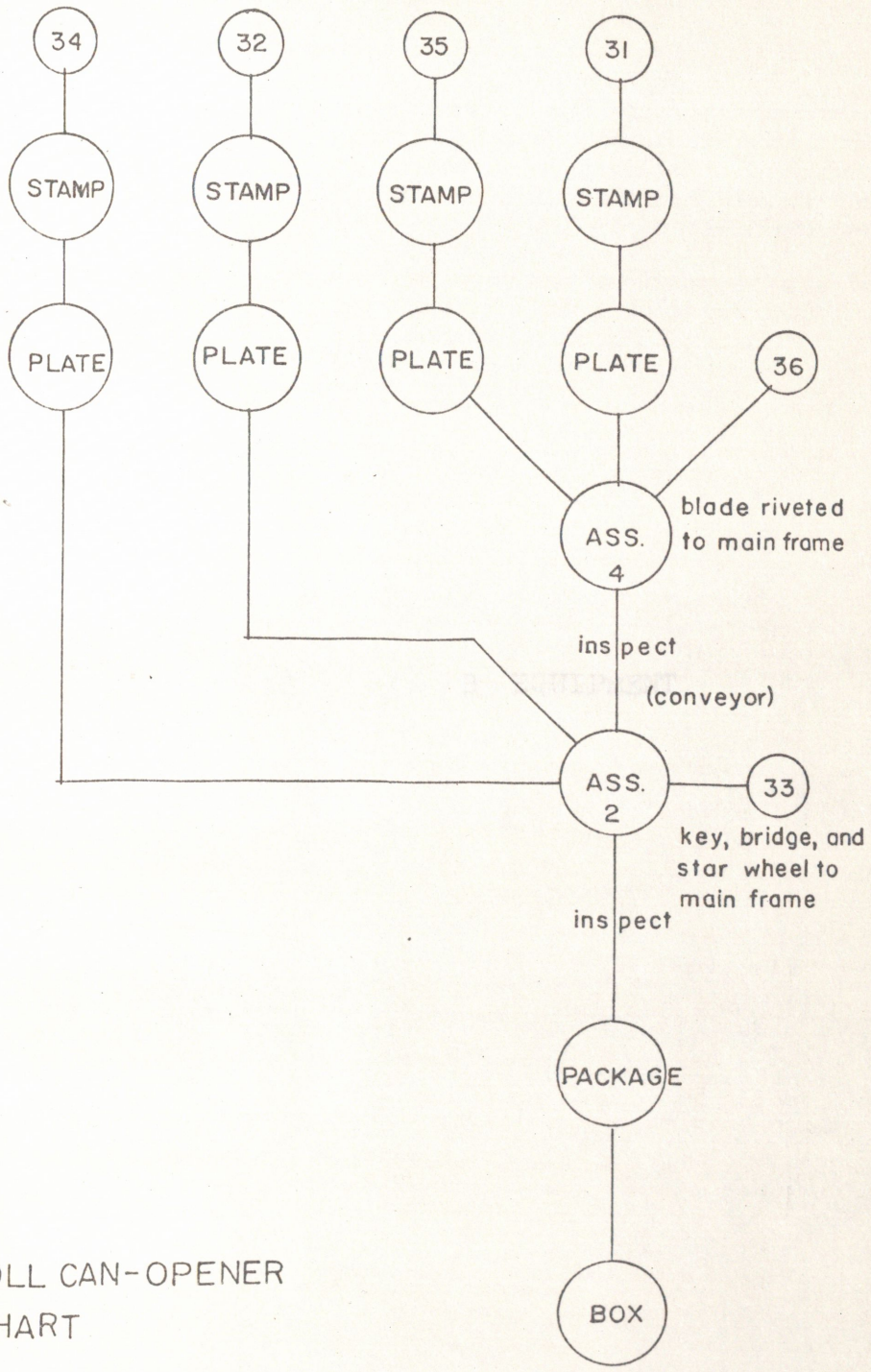
PASTRY TRIMMER PROCESS CHART



MIRACLE ROLL CAN OPENER

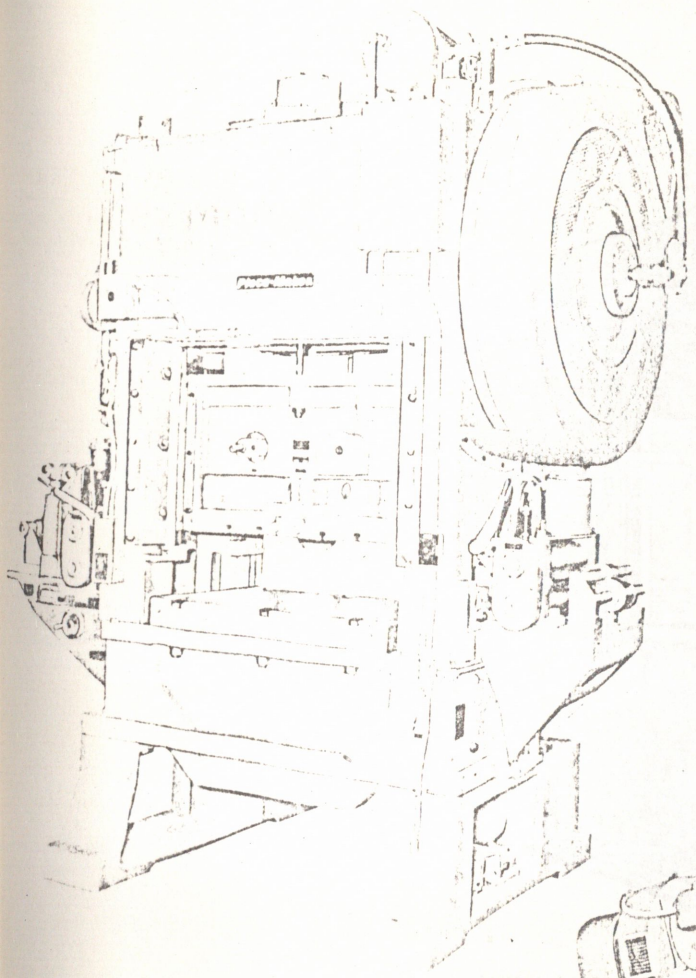
31 main frame - steel
32 wing key - steel
33 bridge - plastic
34 star wheel - steel
35 blade - steel
36 rivet - steel



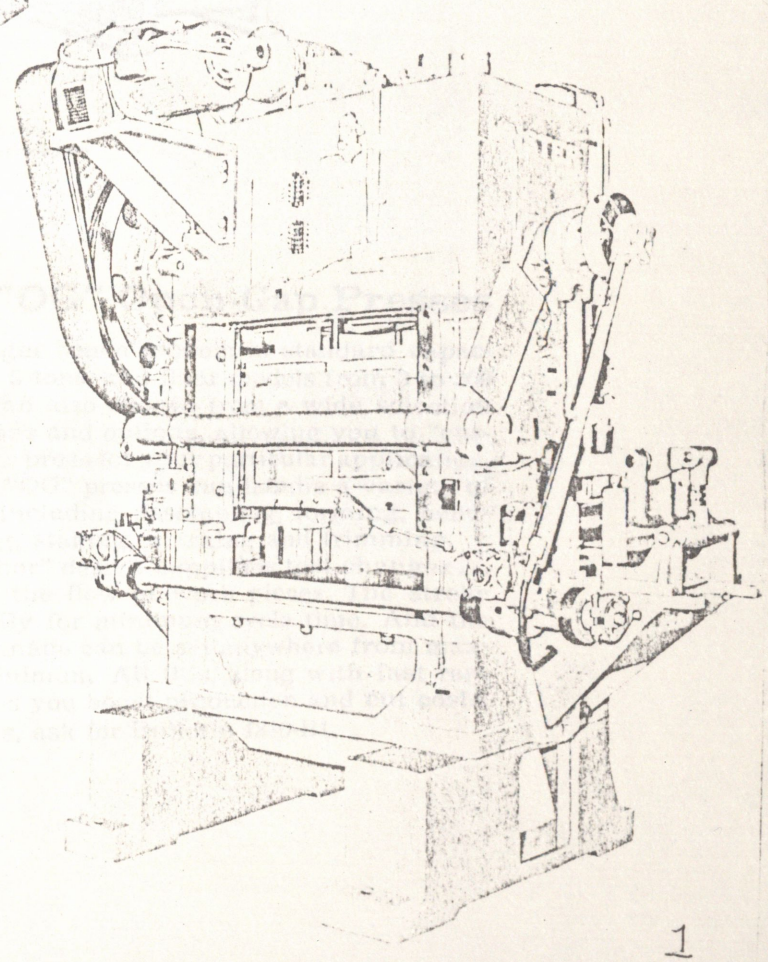


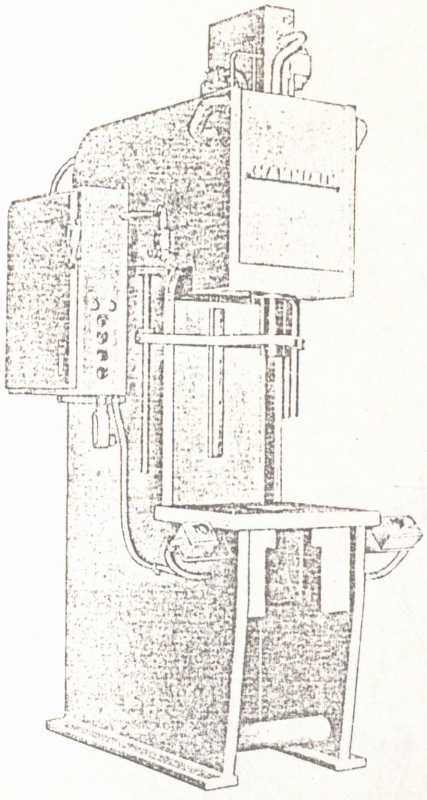
MIRACLE ROLL CAN-OPENER
PROCESS CHART

B EQUIPMENT



P2-100-42—Flywheel Type
Double Roll, rack and pinion driven, feed with Micro Running Adjustment, disc type roll brakes and rotary cam roll lifters. Feed equipment also includes Scrap Cutter and Stock Oiler as well as stock buckle and end of stock detectors.
Feed Length: 0 to $4\frac{3}{8}$″
To feed material: .125″ thick x 14″ wide
1200″ per min. High Speed feed
Press Speed: 100 to 300





Presses shown
with guards removed

Series "OG" Open-Gap Presses

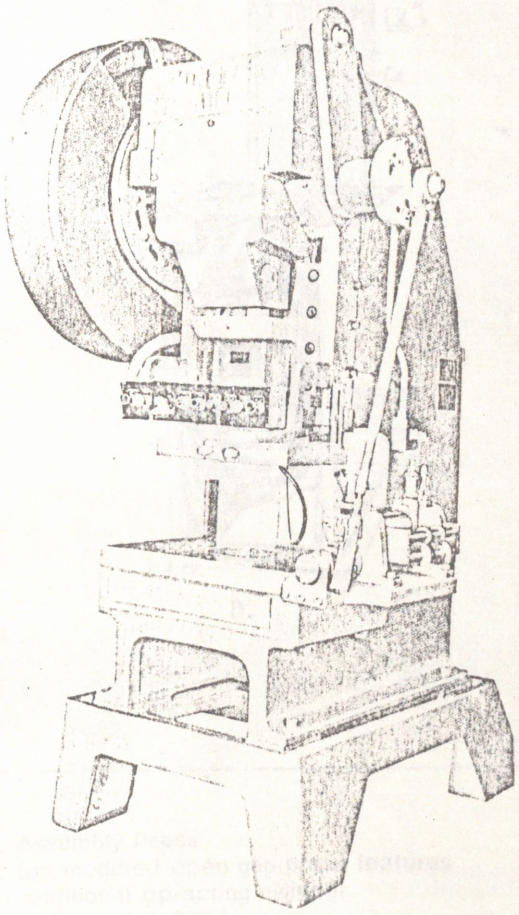
You can get bench models in standard capacities of 3 to 5 tons, and floor models from 3 to 200 tons. You can also choose from a wide selection of ram speeds and options, allowing you to "customize" your press for your particular application.

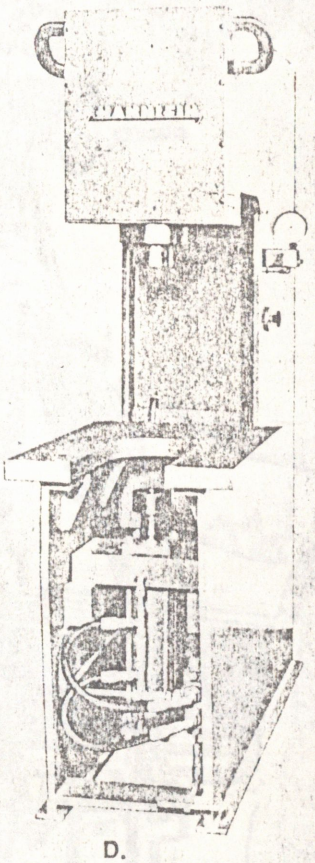
Standard "OG" presses can handle a variety of operations including assembling, forming, bending, riveting, staking, marking and trimming.

Their "arbor" design simplifies tool changes... and speeds the flow of work pieces. The stroke adjusts easily for minimum cycle time. And the working tonnage can be set anywhere from maximum to minimum. All this, along with fast ram speeds, helps you boost production and cut costs.

For details, ask for Bulletin 1210-B1.

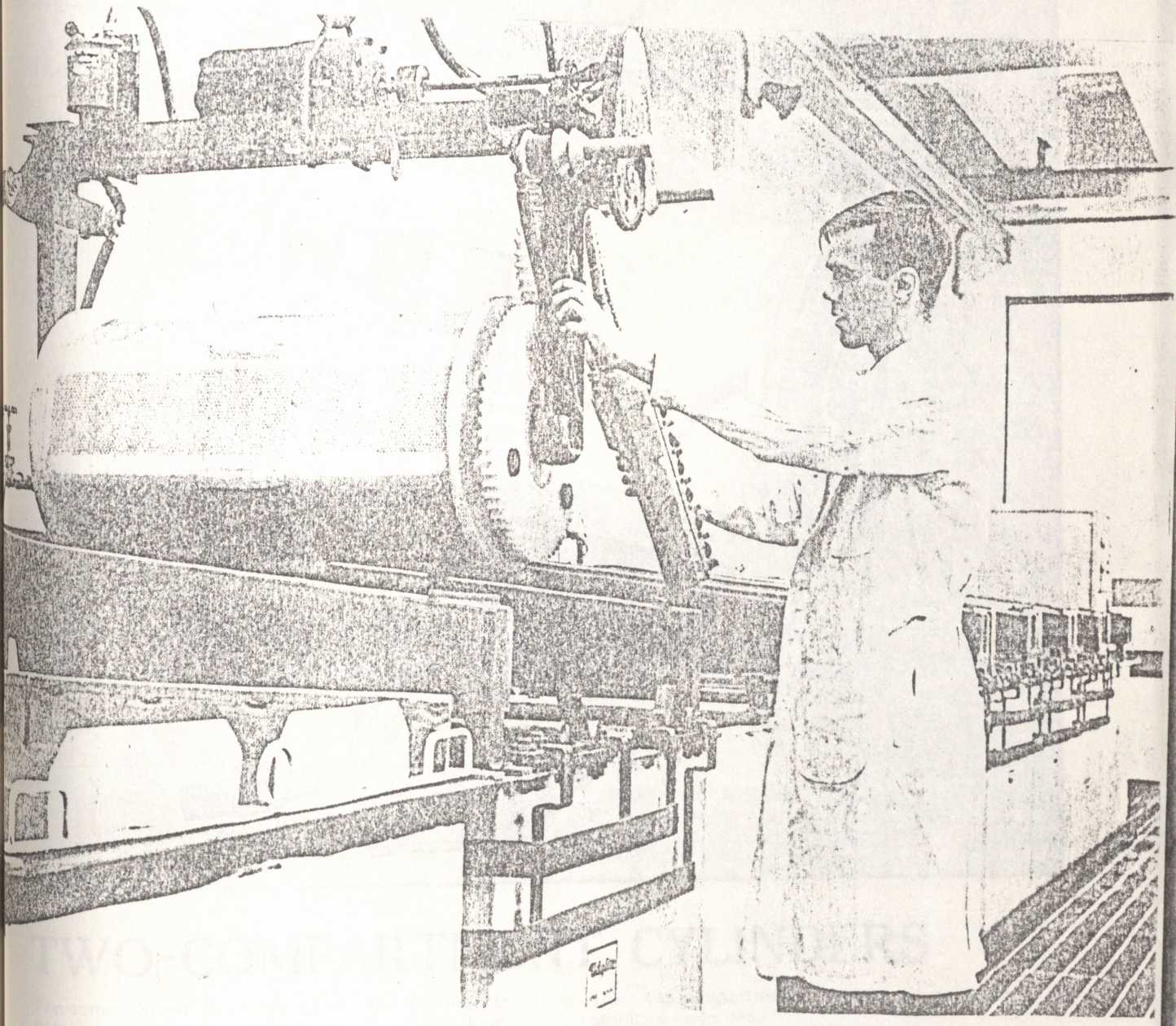
B1-60 / Stroke 1¼" / *Speed 166 to 500 SPM
(*Full energy at 250 SPM.) Bolster mounted high speed, single roll feed with bell crank drive and feeding from right to left. Air blow-off -- Special bolster machining. Die safety switch receptacle and plug.

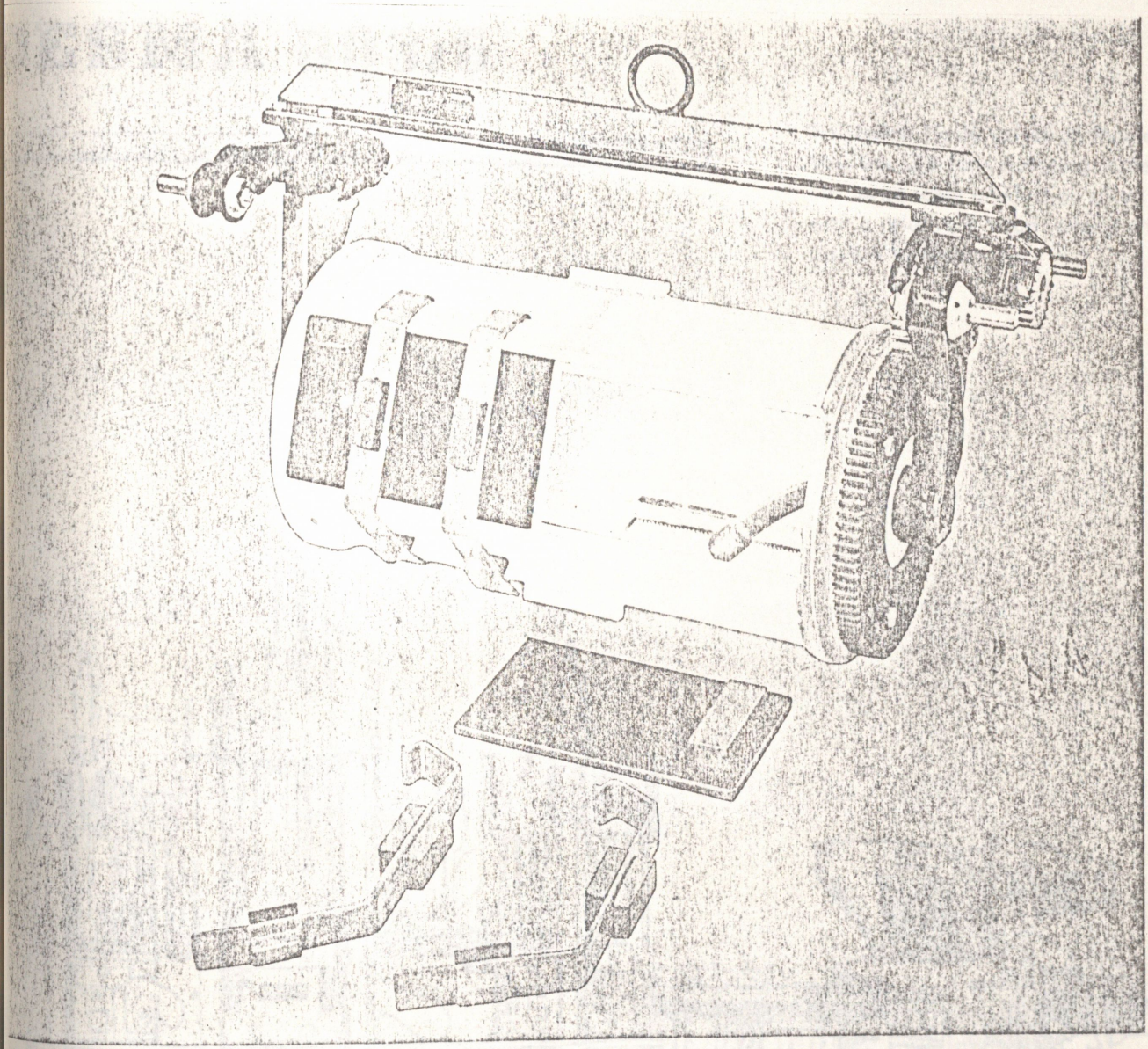




D.

D. Assembly Press
12-ton modified open gap press features an additional up-acting cylinder.
Our job no. A-41249.





TWO-COMPARTMENT CYLINDERS

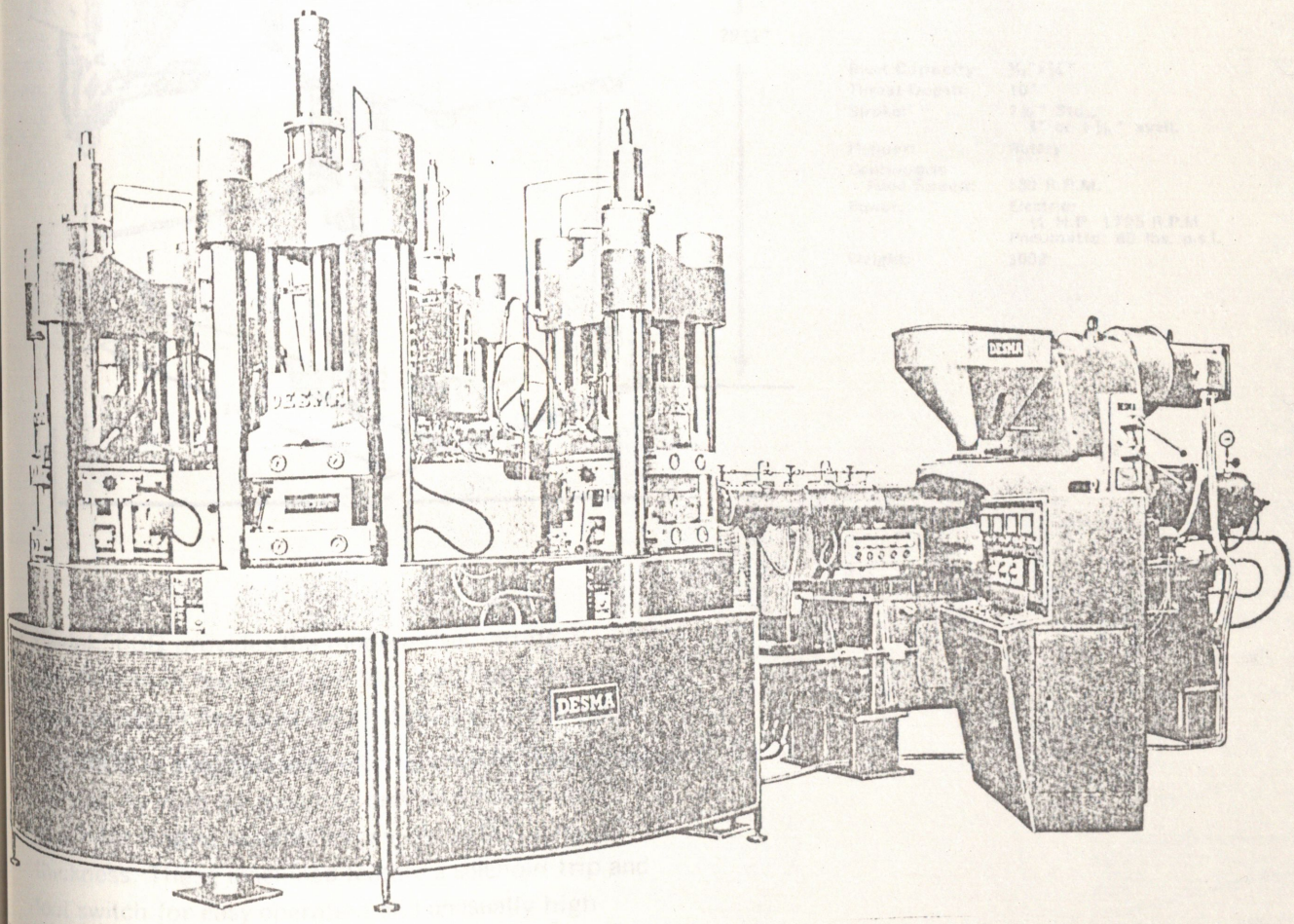
Two-compartment cylinders permit the plating, or processing of two dissimilar parts at the same time. Parts can not be mixed, which eliminates the necessity of sorting. Also, a small load can be handled in just one of the compartments.

The two-compartment cylinder is available in all standard materials.

It can be used on automatic or manual operations.

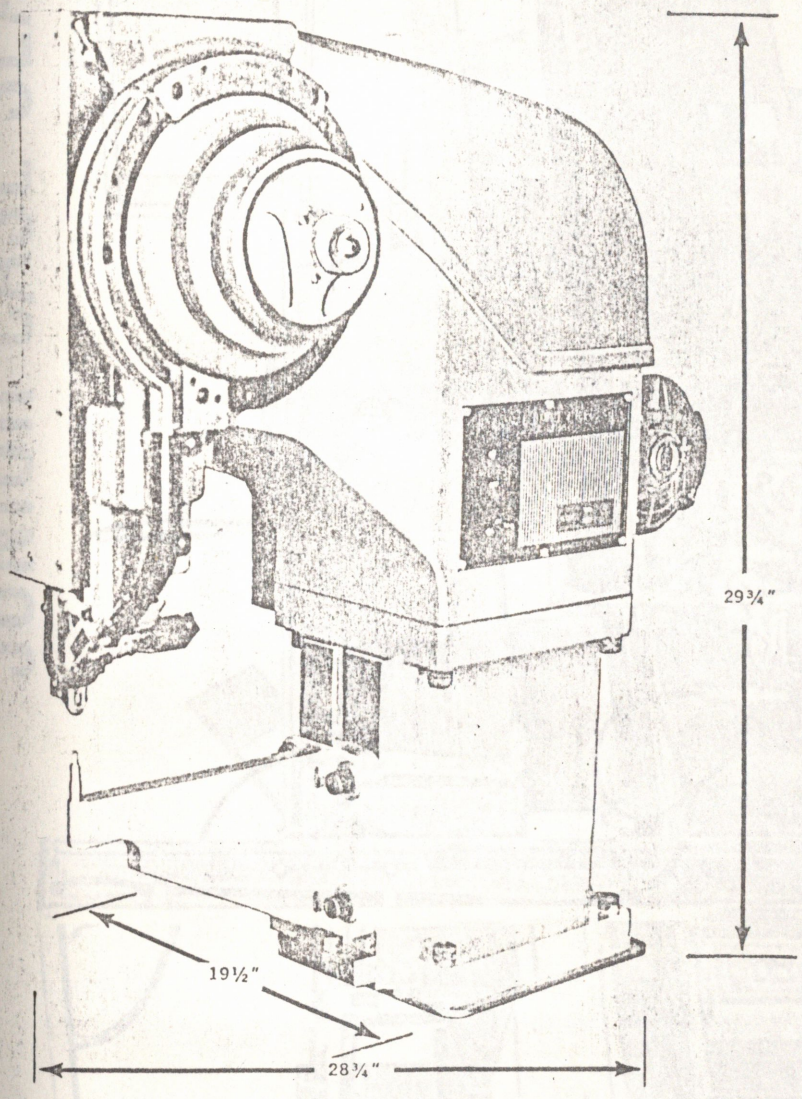
DESMA 803/6

Six-station Plastic Injection Moulding Machine, 300 tons clamping force. For large-scale production of articles with a relatively large volume and a small surface area.



MODEL 500B

- ELECTRIC
- PNEUMATIC



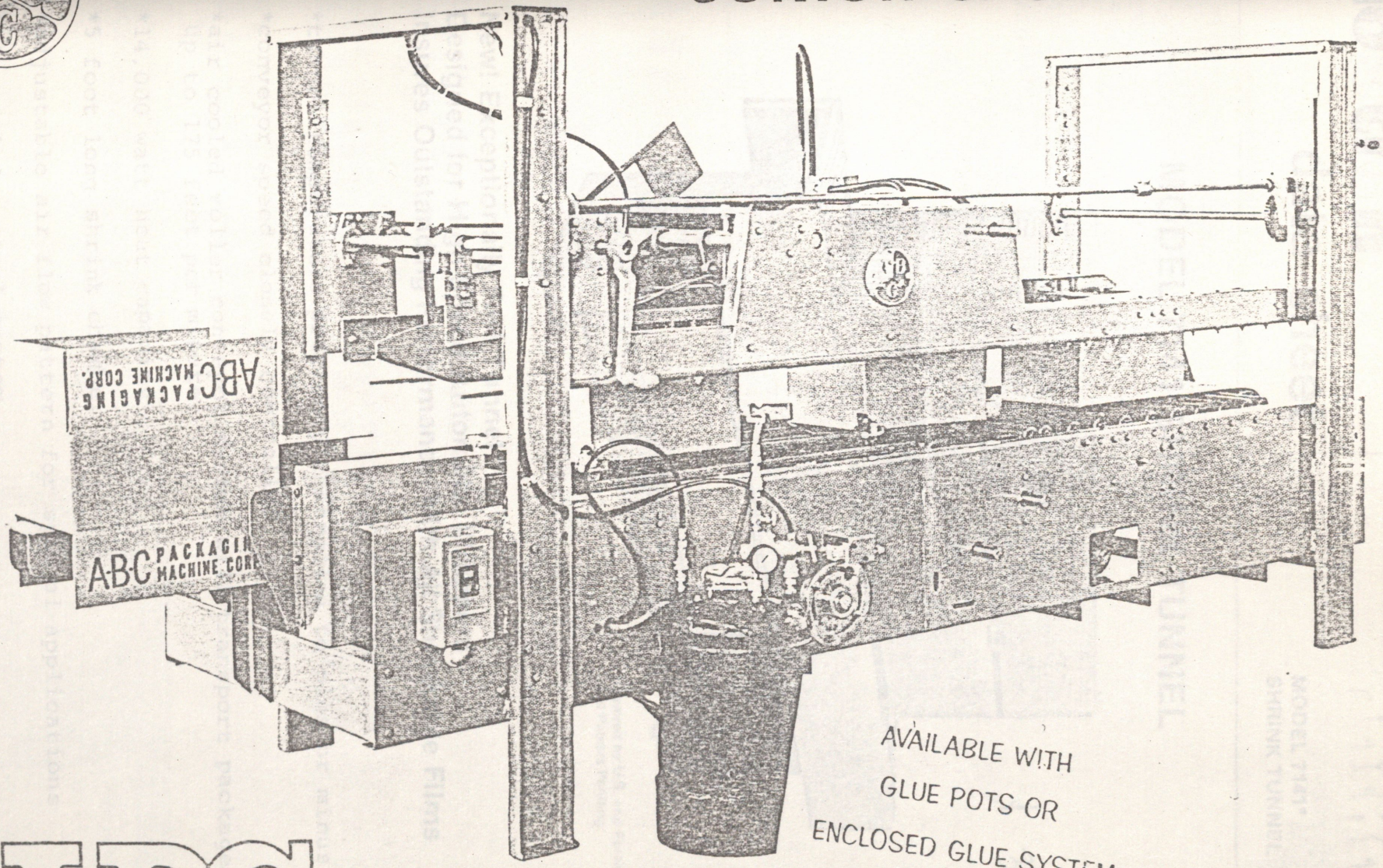
Rivet Capacity:	9/32"x¾"
Throat Depth:	10"
Stroke:	2⅛" Std., 3" or 1⅞" avail.
Hopper:	Rotary
Continuous Feed Speed:	180 R.P.M.
Power:	Electric: ¼ H.P. 1725 R.P.M. Pneumatic: 80 lbs. p.s.i.
Weight:	300#

Model 500B provides the modern rivet setting capabilities of the floor type Model 500 with a compact, short pedestal designed for efficient bench mounting.

The 500B is available with electric drive for fast, positive riveting, or with air power to provide a cushioned clinch for fragile assemblies, and parts that vary in thickness. These machines feature a solenoid trip and foot switch for easy operation and unusually high operator productivity.

Additional hopper assemblies can be provided to allow one machine to set a variety of rivets within its capability. Hopper assemblies may be changed easily in a few minutes.

JUNIOR CASE SEALER



AVAILABLE WITH
GLUE POTS OR
ENCLOSED GLUE SYSTEM

ABC PACKAGING MACHINE CORPORATION

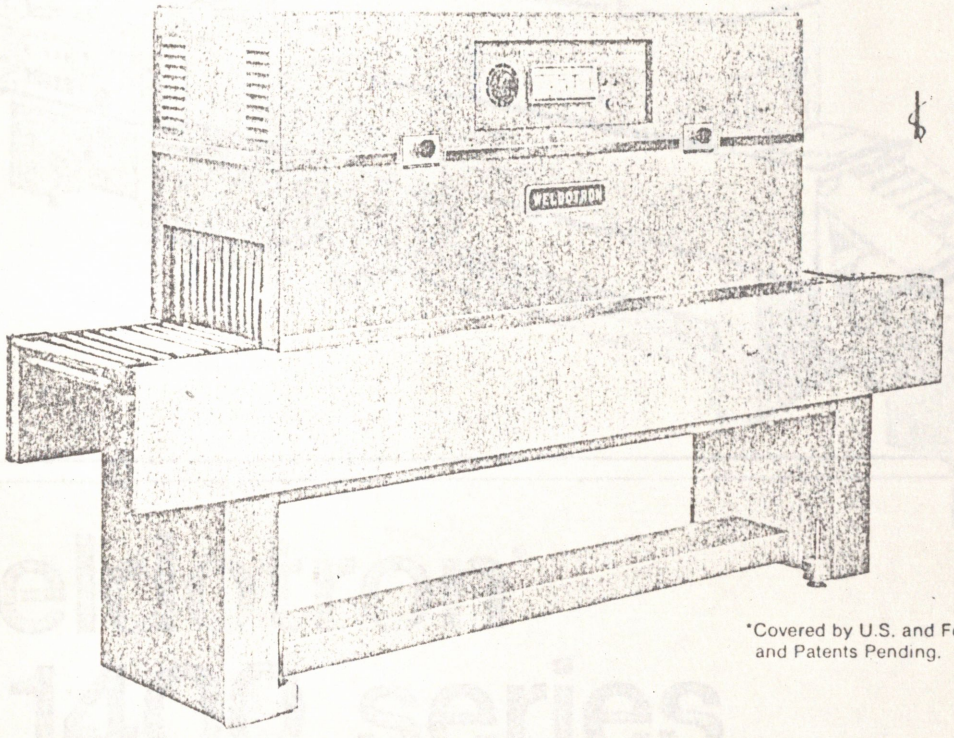
230 Commerce Drive N. • Largo, Florida 33540

eldetron®
data sheet

packaging 213

MODEL 7141*
SHRINK TUNNEL

MODEL 7141 SHRINK TUNNEL



$ 3900.00

*Covered by U.S. and Foreign Patents and Patents Pending.

New! Exceptionally Fast Tunnel
Designed for High Speed Automatic Wrappers
Insures Outstanding Performance With All Shrinkable Films

*tunnel temperature precisely controlled to plus or minus 1%

*conveyor speed closely controlled

*air cooled roller conveyor system will transport packages up to 175 feet per minute

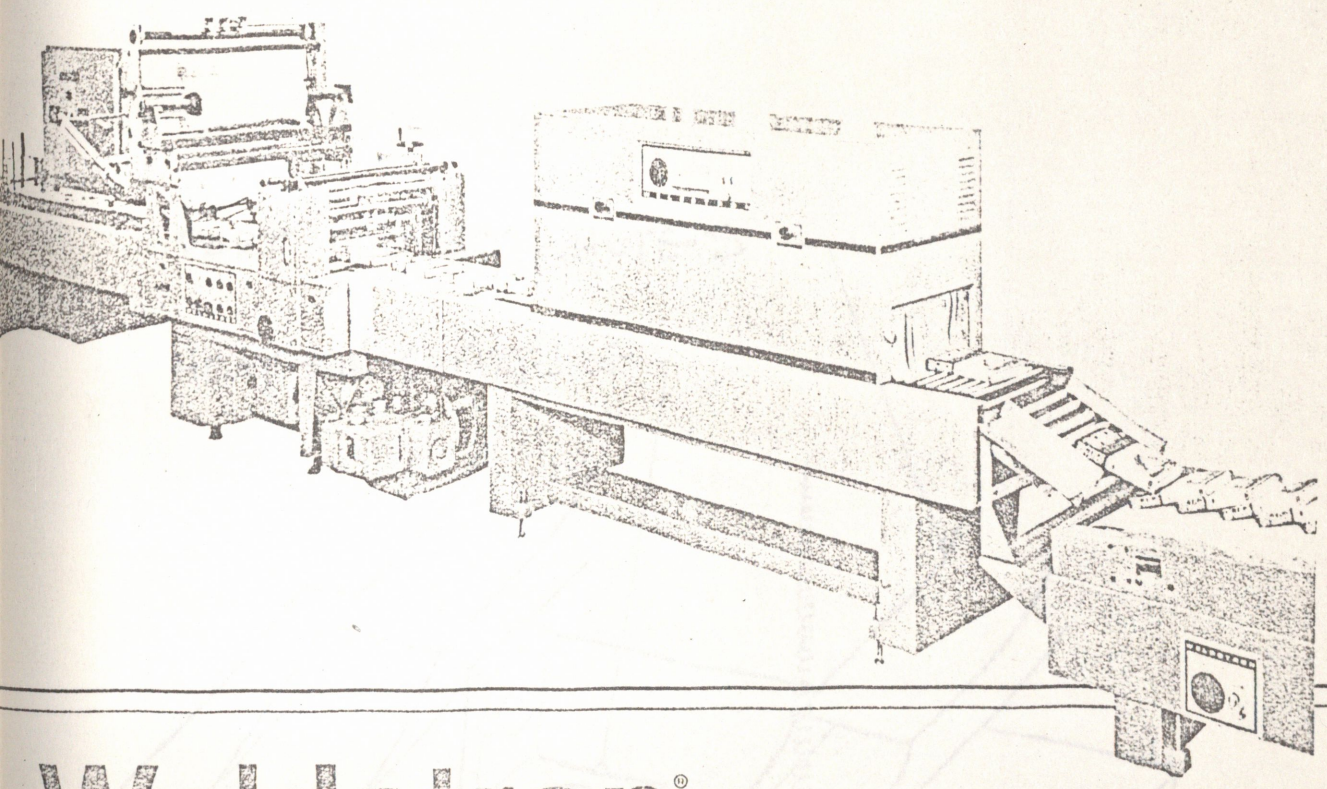
*14,000 watt heat capacitv

*5 foot long shrink chamber

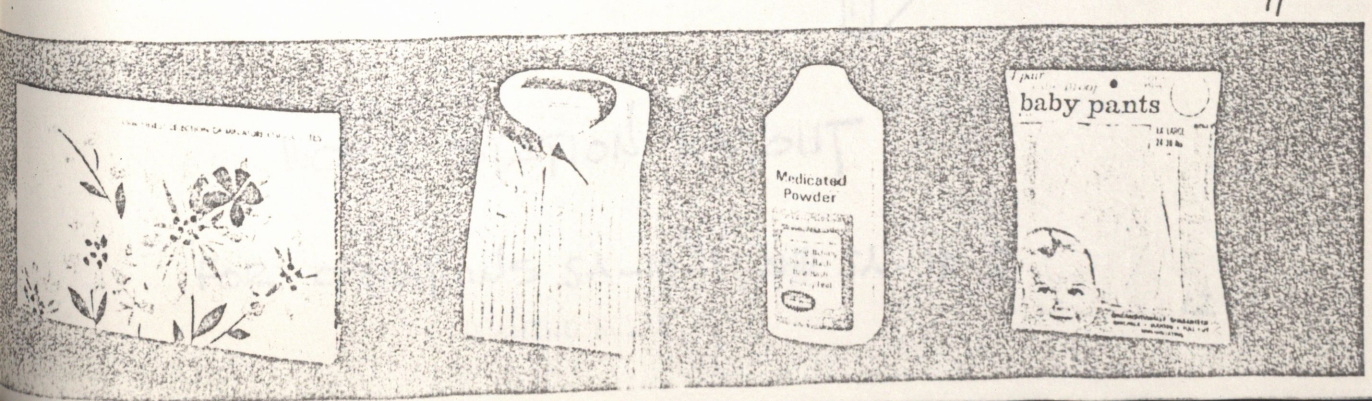
*adjustable air flow pattern for special applications

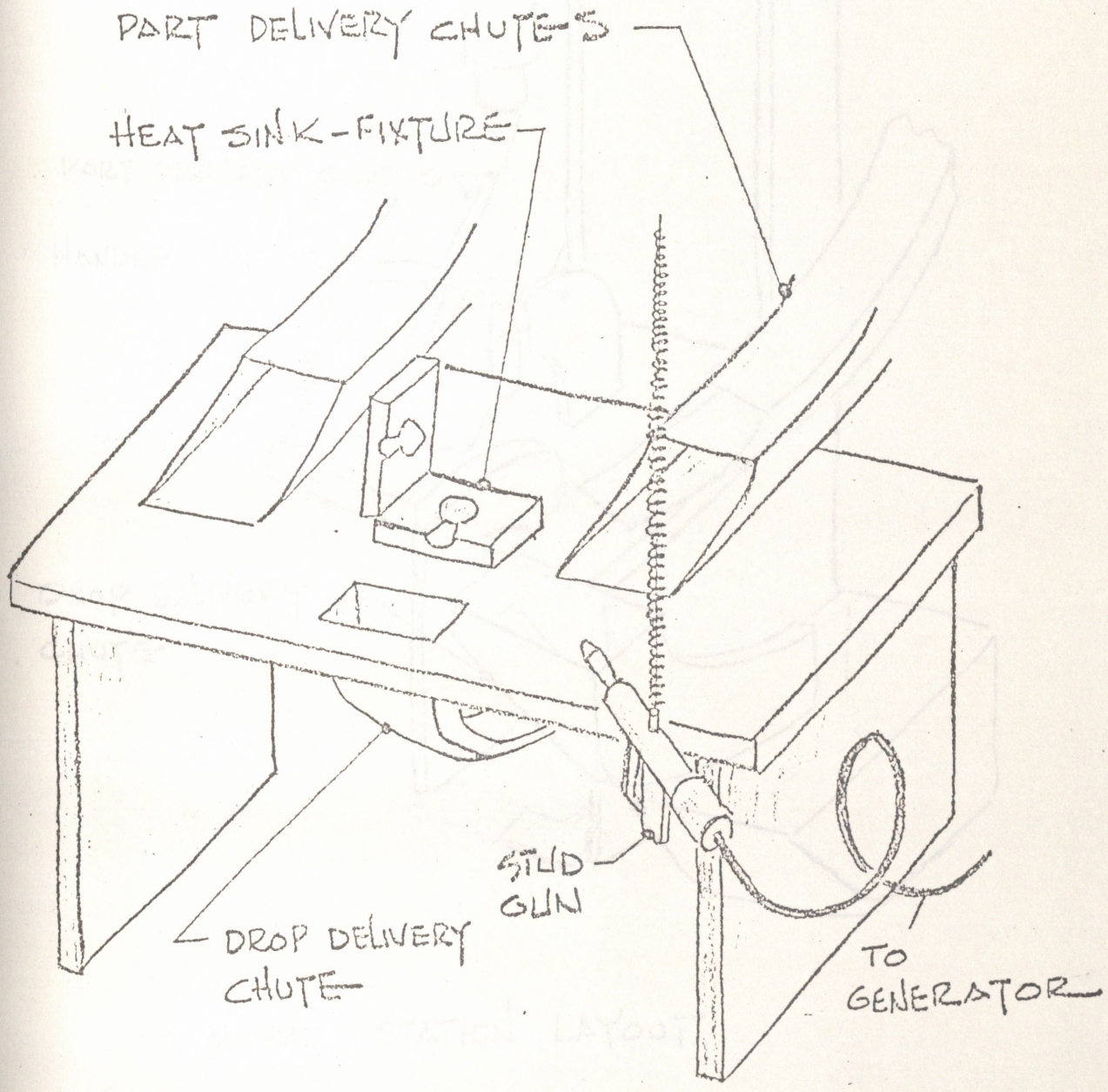
*air cooled control system

*capable of handling PVC, polyethylene and polypropylene films



Weldotron® 1400 series high speed shrink wrapping system

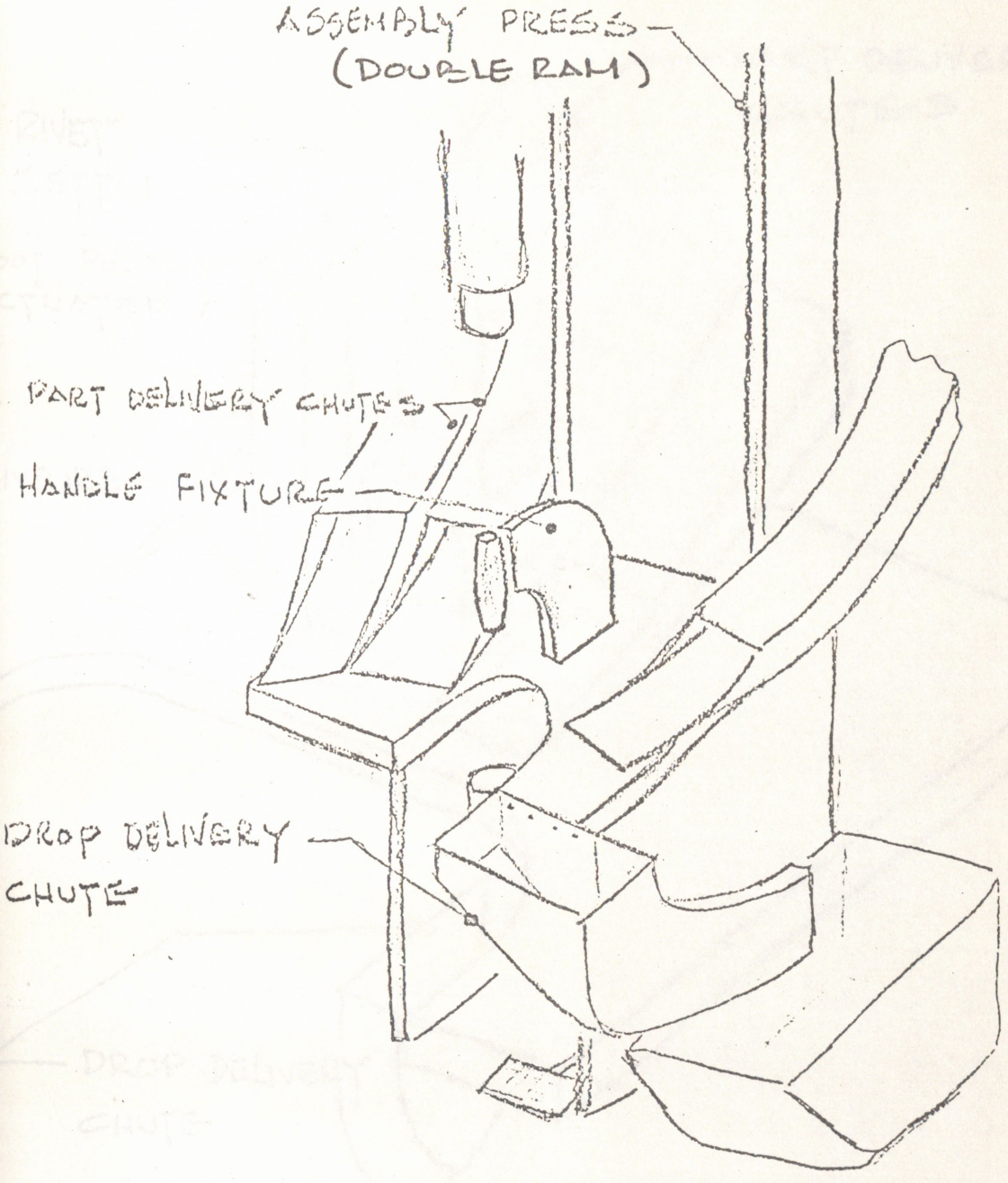




WORK STATION LAYOUT

FOR OPERATIONS SA-10-1 AND SA-10-2

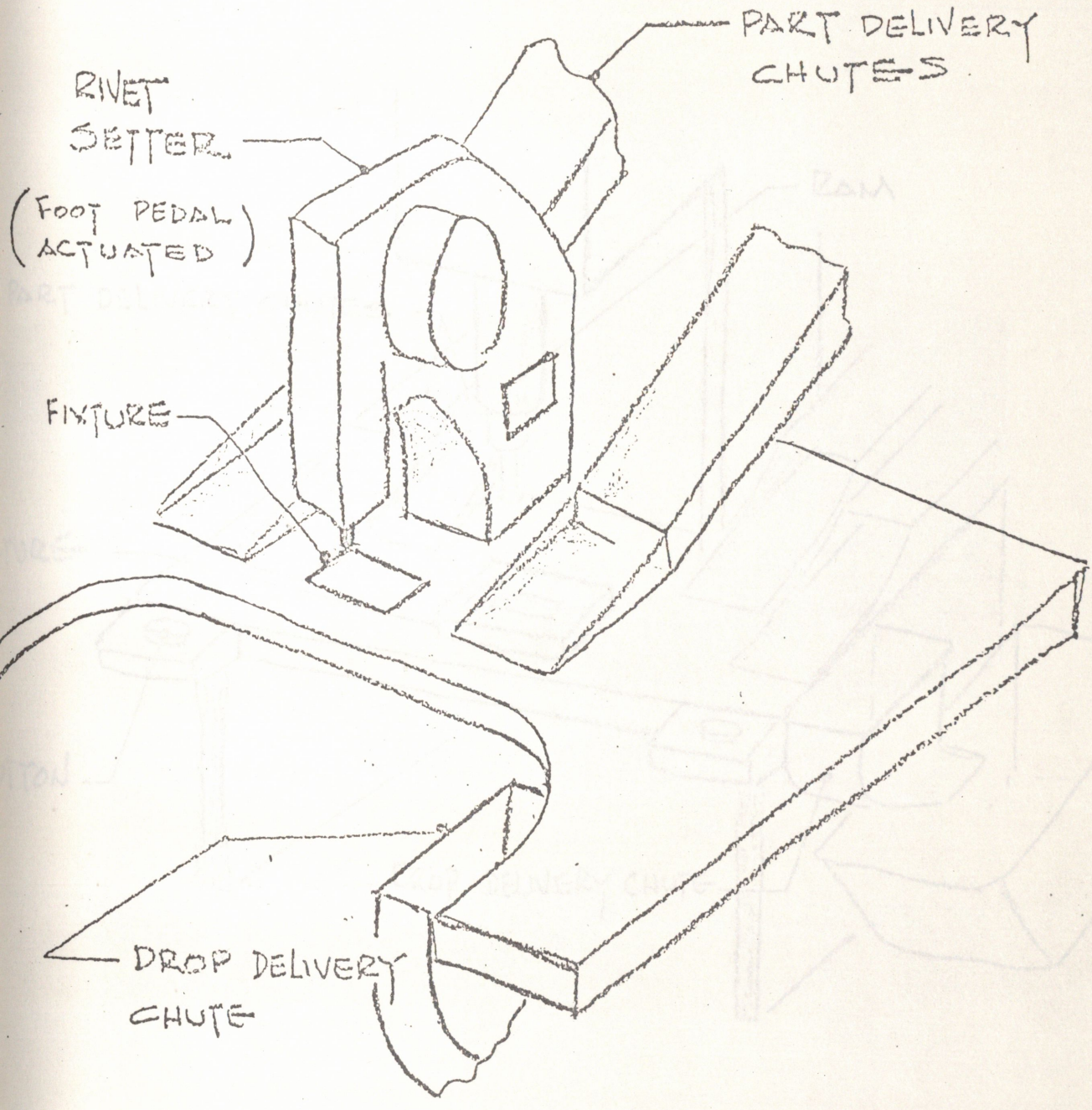
DRAWING NO. 1



WORK STATION LAYOUT

FOR OPERATION A-10-1 AND A-20-1

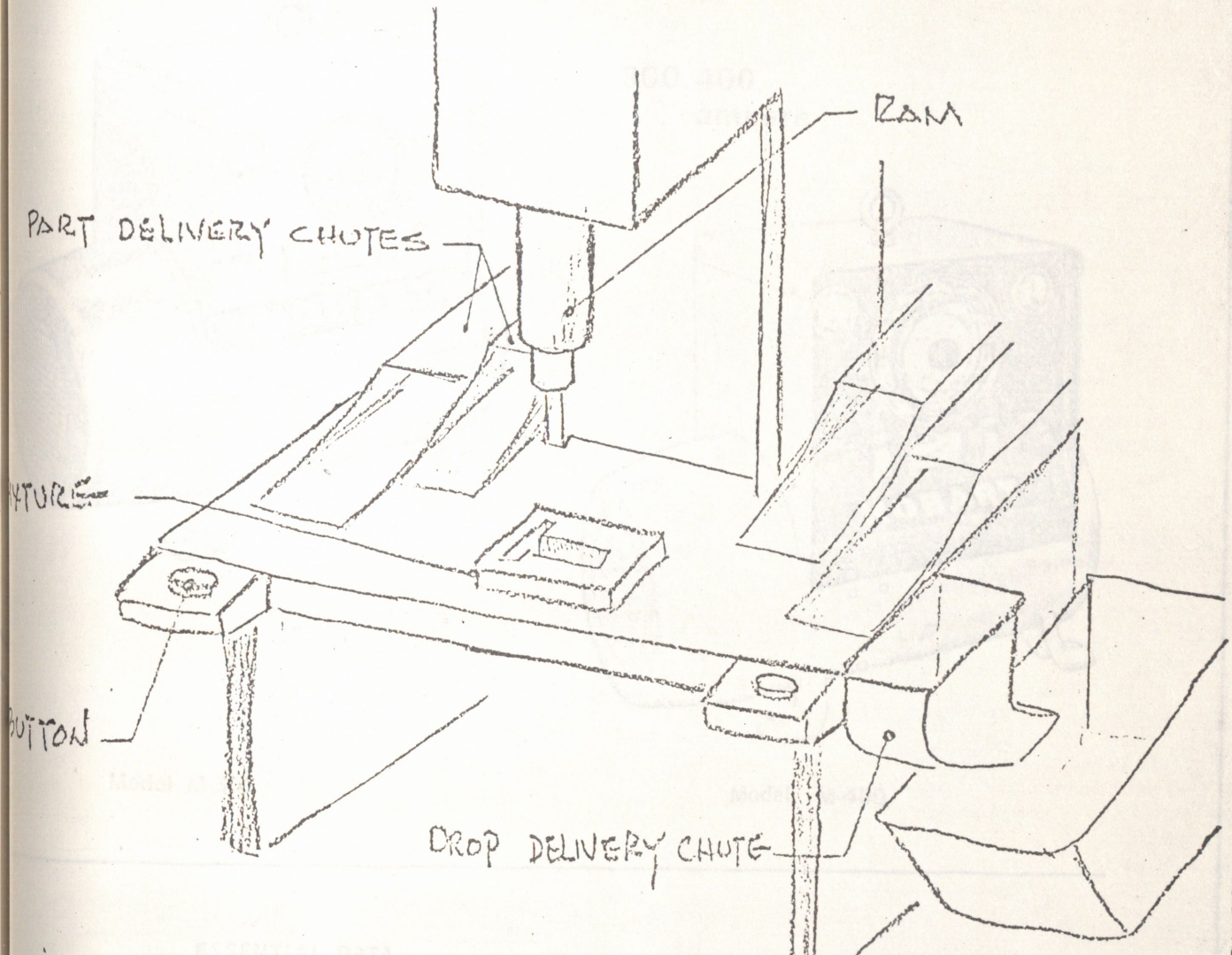
DRAWING NO. 2



WORK STATION LAYOUT

FOR OPERATIONS A-20-2
AND A-30-1

DRAWING NO. 3



WORK STATION LAYOUT

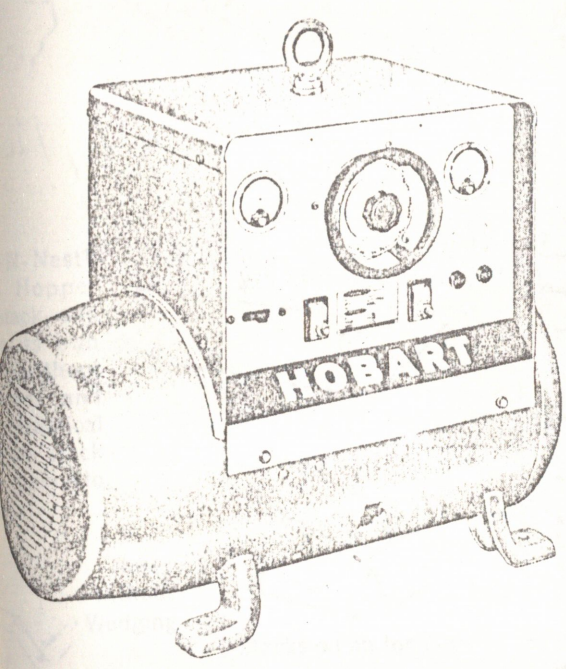
FOR OPERATION A-30-Z

DRAWING NO. 4

DC MOTOR GENERATOR ARC WELDERS

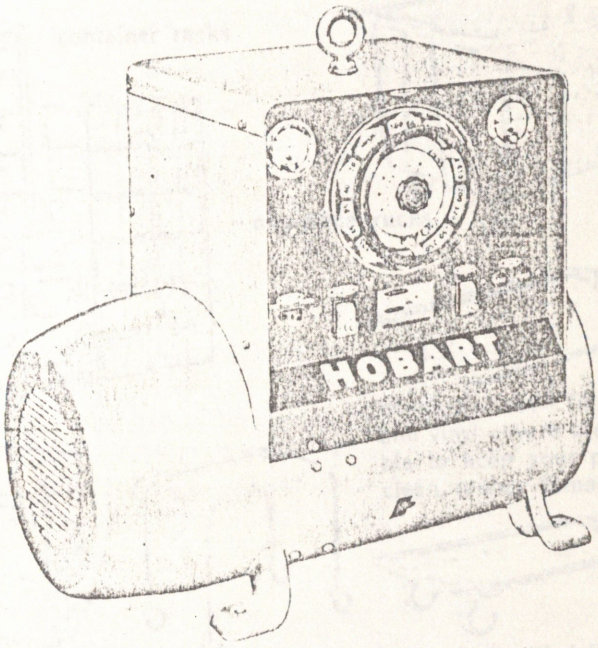
NWSA 313-A
INDEX: 690920
REPLACES: 670620

60 Hz



Model M-300

300, 400 ampere



Model M-400

ESSENTIAL DATA

MODEL NUMBER (Stationary)	M-300	M-400
Rating (Equalling or exceeding NEMA specs.)		
—Amperes	300	400
—Volts	40	40
—Duty Cycle	60%	60%
Current Range—Amperes—60 Cycles	30 to 450	40 to 600
Operating Speed—r.p.m.—60 Cycles	1750	1750
Generator Poles	4	4
Brushes—Main Generator	8	12
Motor Rating—Horsepower	20	25
Dimensions Overall—Length	35"	38-1/2"
—Width	17-5/16"	18-11/16"
—Height	32-9/16"	36-1/4"
Approximate Net Weight (stationary)	725 lbs.	890 lbs.

For Aircraft Welding:

Model M-300, when used with No. 1192 Portable Thinweld Attachment, lets you weld with current as low as 1 ampere, making it ideal for aircraft welding and other light metal welding applications. The No. 1192 Portable Thinweld can also be used with other welders listed above. For details, see current data sheet 303-C.

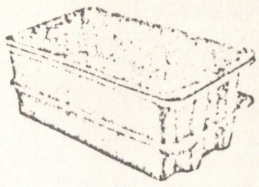
Meters and Portable Mountings Optional.



Lewis Stack-N-Nest® containers feature smooth seamless one-piece fiberglass construction with molded-in hand grips. They won't rust, rot, corrode, dent or burr out. Molded-in steel wire in rim adds strength. Resist water, oil, detergents and most chemicals. Available in a wide choice of permanent molded-in colors.



Interstack



Internest

k-N-Nest®
ss Hopper
stack and
in its own
ns without
ends and
mechanical
also stack
on incline to
es.

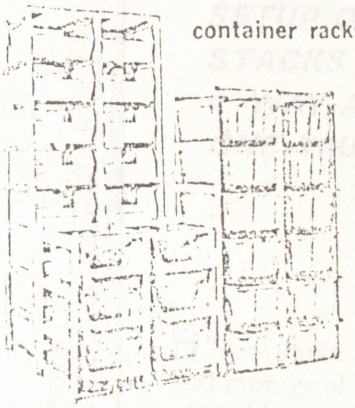




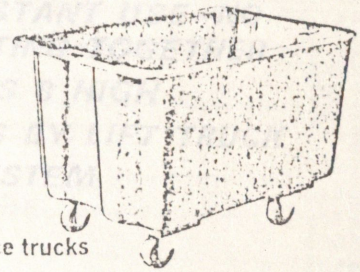
Nests without Wedging



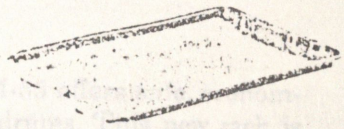
Stacks on an Incline



container racks

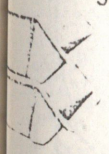


one-piece trucks



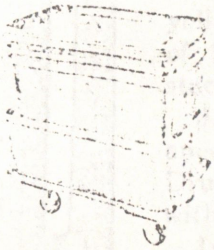
Stack-N-Nest® fiberglass and vinyl covers are available to keep your products clean, reduce damage.

Stacks Securely

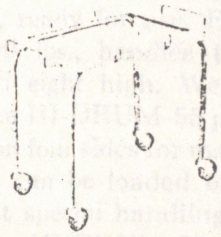




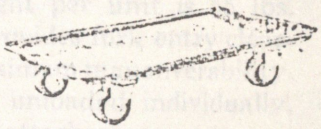
Hopper Box Dolly



Stacking, nesting saves time, space.



RAISED DOLLY



Stack-N-Nest® dollies allow safe, rapid movement of stacked pans.

STACK-N-NEST TOTE PANS

DIMENSIONS (inches) B	C	PAN CAPACITY (cu. ft.)	MODEL NO.	COLOR AVAILABLE	WEIGHT (Pan Only) Lbs.	COVER NO.	DOLLY NO.
10	5	.33	SN1610-5	R, Gy, Gn, Of	2.7	CO1610-1	DO1610-1*
12	6	.58	SN1812-6	R, Gy, Gn, Of	3.7	CO1812-1	DO1812-1*
12	8	.81	SN1812-8	R, Gy, Gn, Of	4.6	CO2013-1	DO2013-1*
10	7	.72	SN2010-7	R, Gy, Gn,	4.6	CO2010-1	DO2010-1*
10	9	.96	SN2010-9	R, Gy, Gn,	5.2	CO2010-1	DO2010-1*
14	5	.66	SN2214-5	R, Gy, Gn,	5.0	CO2214-1	DO2214-1*
14	8	1.11	SN2214-8	R, Gy, Gn, Of	5.9	CO2214-1	DO2214-1*
17	6	1.15	SN2217-6	R, Gy, Gn,	6.5	CO2217-1	DO2217-1**
17	10	1.8	SN2217-10	R, Gy, Gn, Of, B	8.5	CO2217-1	DO2217-1**
19	14	3.0	SN2419-14	R, Gy, Gn, Of, B	12.3	CO2419-1	DO2419-1**
16	11	2.3	SN2716-11	R, Gy, Gn, Of, B	11.3	CO2716-1	DO2716-1**
23	8	2.03	SN3023-8	R, Gy, Gn,	14.2		
24	19	8.3	SN3424-19	R, Gy, Gn, Of	28.5		
19	14	5.4	SN3919-14	R, Gy, Gn, Of, B	18.9	CO3919-1	DO3919-1***

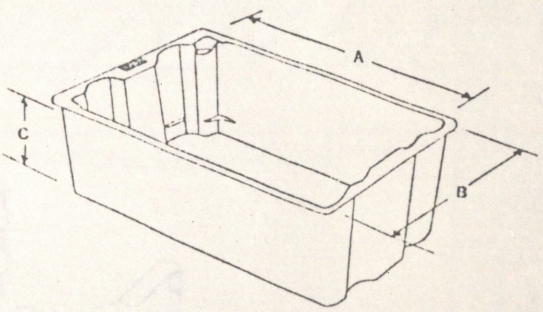
STACK-N-NEST HOPPER BOXES

PAN DIMENSIONS (inches) B	C	INSIDE HEIGHT D	MODEL NO.	COLOR AVAILABLE	AVERAGE WEIGHT LBS.	Height 10 pans (inches) nested	stacked	DOLLY NO.
11⅛	7⅛	7¼	SH2411-8	R, Gy, Gn	4.8	24¼	62	DO2411-1**
16¼	8	7⅛	SH2416-8		7.0	24¼	75½	DO2217-1M

*pped with 4-3" dia., hard rubber swivel casters
pped with 2 swivel & 2 rigid 3" hard rubber casters
pped with 2 swivel and 2 rigid 4" hard rubber casters

R—Red
Of—Off White
Gy—Gray
Gn—Green
B—Lt. Blue

PATENTED
2,823,828
2,823,829

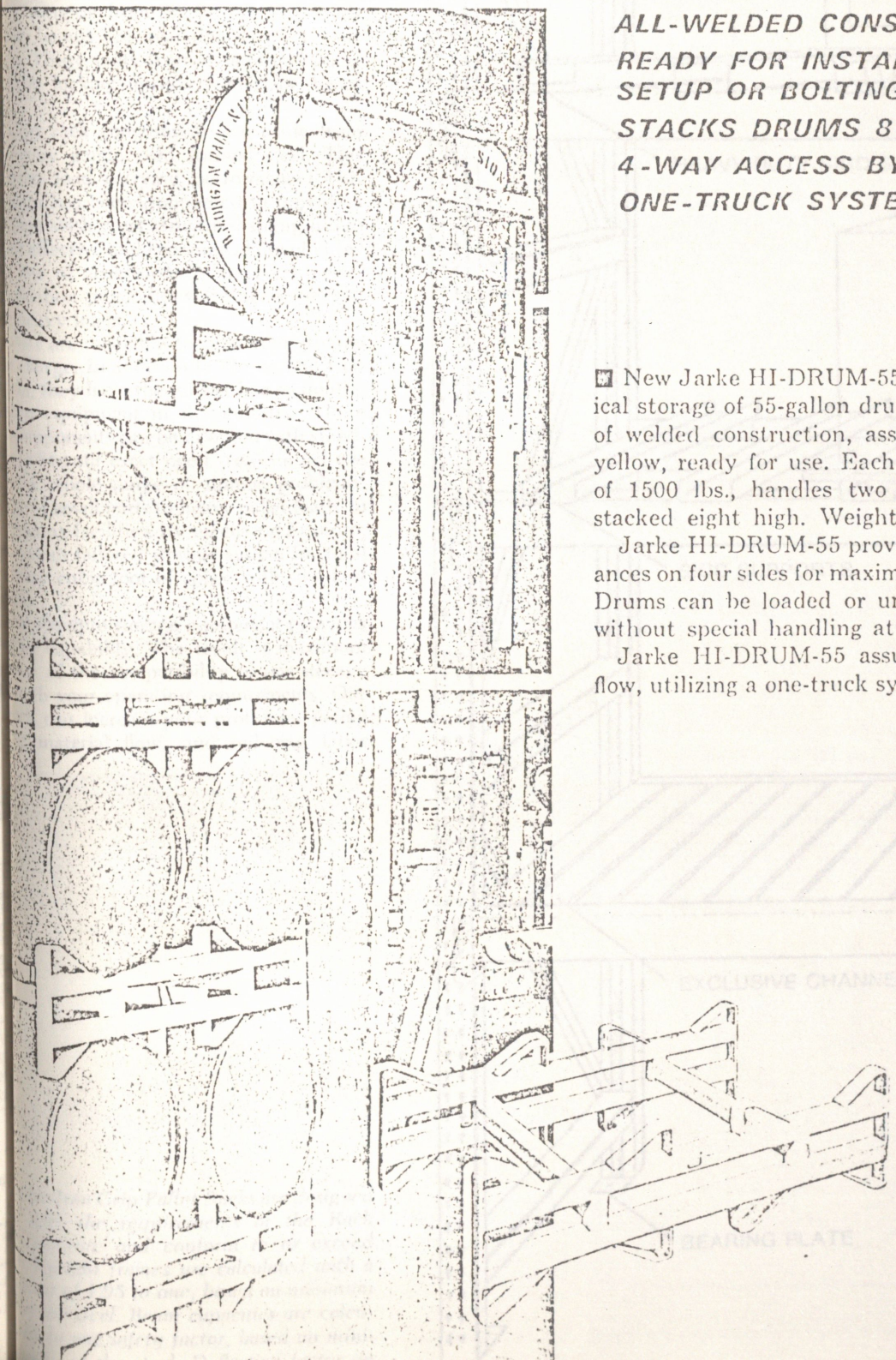


Positive Stack-N-Nest® tote pan nest stop prevents jamming when nested. Lock stop prevents shifting when stacked.

New Space-Saving Vertical Drum Storage

ARKE®

U.S. Patent No. 3,476,260



ALL-WELDED CONSTRUCTION
READY FOR INSTANT USE—NO SETUP OR BOLTING TOGETHER
STACKS DRUMS 8 HIGH
4-WAY ACCESS BY LIFT TRUCK
ONE-TRUCK SYSTEM

New Jarke HI-DRUM-55 offers safe, economical storage of 55-gallon drums. This new rack is of welded construction, assembled and painted yellow, ready for use. Each unit has a capacity of 1500 lbs., handles two drums, and can be stacked eight high. Weight per unit is 55 lbs.

Jarke HI-DRUM-55 provides fork entry clearances on four sides for maximum maneuverability. Drums can be loaded or unloaded individually, without special handling attachments.

Jarke HI-DRUM-55 assures rapid inventory flow, utilizing a one-truck system.

pto Grip t Racks

Systems approach solves storage and ma- g problems, saving space and money. designed a standard series of storage insure economies in erection, storage ial cost. Iron Grip racks are available for ipment from stock in a wide range of ies, ranging from 2000 to 8000 pounds helf beams are available to meet your eds. These units feature industry's most matic locking upright frame and beam

Grip rack components are made from heavy gauge cold formed steel. This imum load carrying performance. This design has been engineered to provide a ystem with great structural strength and ost effective and economical use of cubic e line of accessories offers great versa- pplication possibilities are almost unlim- g heavy loads.

ialists are available to plan your storage t charge. In addition to the rugged Iron acks, they have the widest line of quality shop equipment in the industry. These k components can be adopted with stand- s to fit your exact need. You can get the to a whole range of storage problems. ge of small parts to heavy pallet loads to ezzanine facilities. By specifying Equipto, custom tailored storage system for total every cubic foot of space with standard ents.

y of Equipto storage equipment provides tems capability. The result is maximum ause of the compatibility of our storage with your operating requirements. Our oach can increase your profits by saving ing material flow, and reducing labor

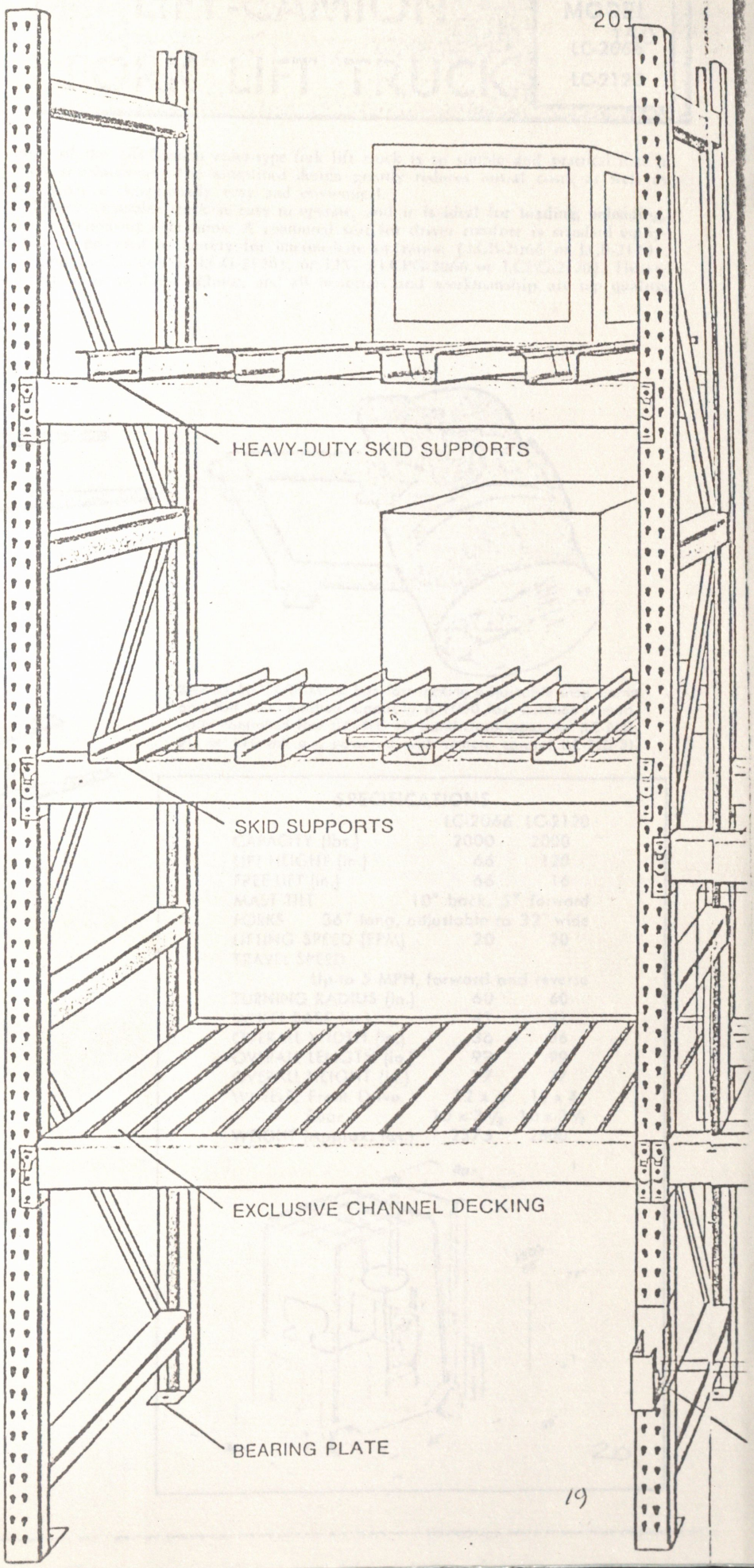
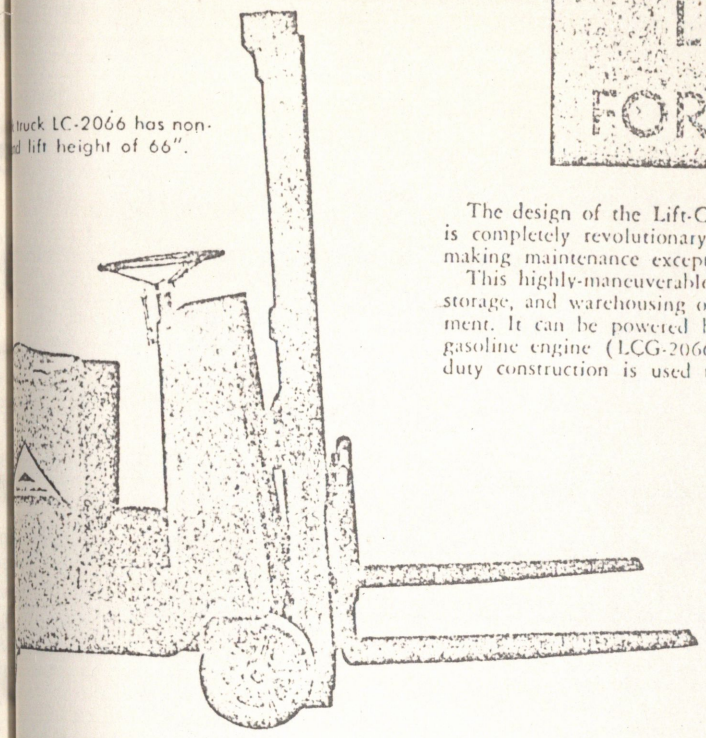


table Iron Grip Pallet Racks are designed with the requirements of the Rack 's Institute and conform to or exceed ds. Upright frames are calculated with a factor of 1.95 to one, based on minimum of the steel. Beam capacities are calcu- 1.65 to one safety factor, based on mini- trength of the steel. Deflection factor on

LIFT-CAMION FORK LIFT TRUCK

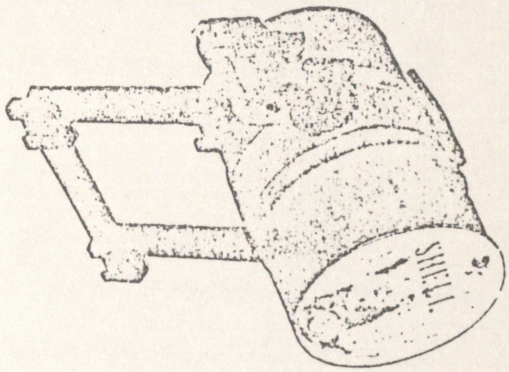
MODEL
150
LC-2066
LC-2120

truck LC-2066 has non-
d lift height of 66".



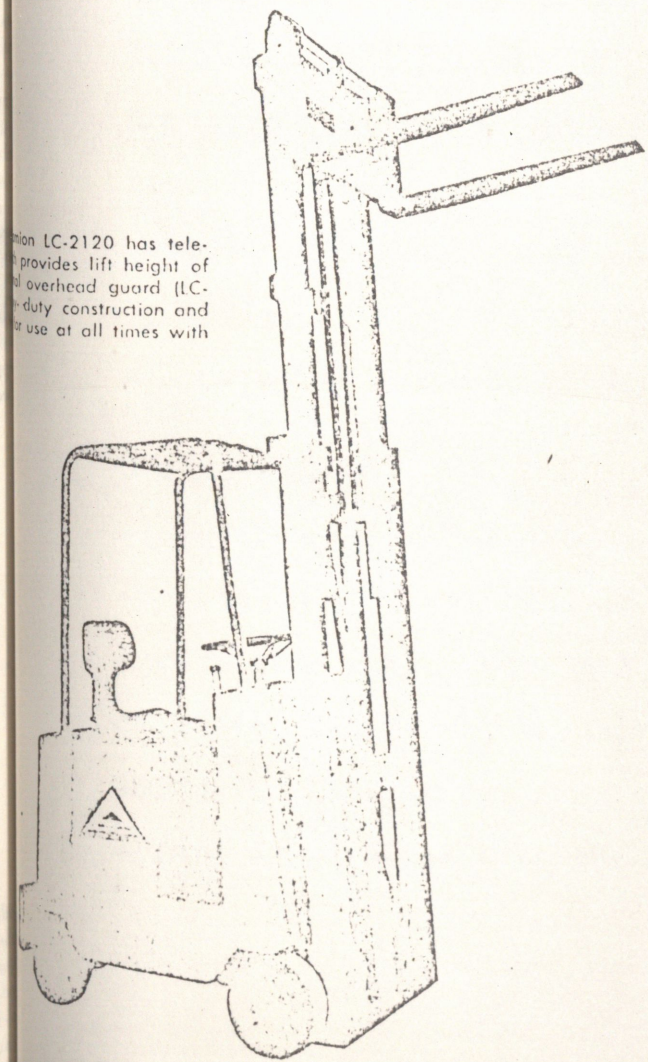
The design of the Lift-Camion rider-type fork lift truck is so simple and practical that it is completely revolutionary. The simplified design greatly reduces initial costs, as well as making maintenance exceptionally easy and economical.

This highly-maneuverable truck is easy to operate, and it is ideal for loading, unloading, storage, and warehousing operations. A contoured seat for driver comfort is standard equipment. It can be powered by battery for intermediate operation (LCB-2066 or LCB-2120), gasoline engine (LCG-2066 or LCG-2120), or LPG (LCPG-2066 or LCPG-2120). Heavy-duty construction is used throughout, and all materials and workmanship are top quality.



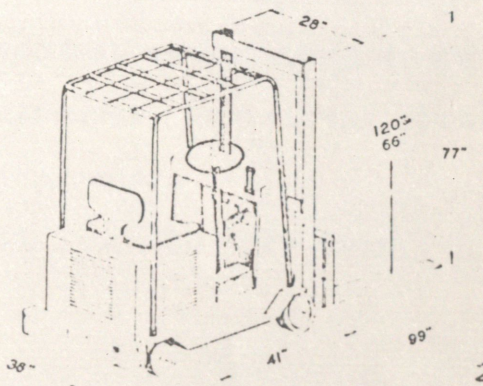
BARREL LIFTER/DUMPER has fast-locking adjustable snap clamp and full 360° rotation. Capacity is 1000 lbs. Rotation is manually-controlled free (LC-BLD-1), hand-crank-operated (LC-BLD-2), or 110-volt a.c. powered with remote control (LC-BLD-3).

ion LC-2120 has tele-
provides lift height of
overhead guard (LC-
duty construction and
r use at all times with



SPECIFICATIONS

	LC-2066	LC-2120
CAPACITY (lbs.)	2000	2000
LIFT HEIGHT (in.)	66	120
FREE LIFT (in.)	66	16
MAST TILT	10° back, 5° forward	
FORKS	36" long, adjustable to 32" wide	
LIFTING SPEED (FPM)	20	20
TRAVEL SPEED	Up to 5 MPH, forward and reverse	
TURNING RADIUS (in.)	60	60
WHEEL BASE (in.)	41	41
OVERALL WIDTH (in.)	36	36
OVERALL LENGTH (in.)	99	99
OVERALL HEIGHT (in.)	77	77
WHEELS, Front Drive	12 x 4	12 x 4
Rear	10 x 3½	10 x 3½
WEIGHT (Approx. lbs.)	2375	2600



C CODES

The first code I investigated was the Uniform Building Code. In it I was looking for general information that may have some limiting effects on my physcial design.

Building Discription

My building is a single story manufacturing facility of temporary occupancy, no explosive materials, containing approximently 40,000 square feet of floor area.

FIRE

- Building clas G, Fire zone 1, Occupancy separation of 1.
- Will require a one hour fire rating on all structural components and the use of wired fire glass (if cooridoors are less than 10 feet wide). All stairways require a two hour fire rating and must be smoke proof. However fire protection of structural components is not required if a sprinkler system is incorporated in the building design. All materials must be incombustable.

Occupant Load

- Requires one hundred square feet of space per occupant.
- Exits must be continuous and unobstructed means of egrees to a public way, and shall include intervening doors, doorways, stairways, smokeproof enclosures, horizontal exits and exit passageways, exit courts and yards.
- In a unsprinkled building exits must not be more than

150 feet from any point in the building. For sprinkled areas exits may be 200 feet from any point in the building.
- Exit doors must have a minimum width of three feet.

Skylights
- All skylights must have metal frames and be designed to carry required roof loads. Glass must be wired and located at an angle of 45 degrees with a single light area not to exced a distance of 25 inches in one direction.

Restroom Facilities.
-The facility must contain three toilets and three lavatories in the womens restroom and two toilets, two urinals and one lavatory in the mens restroom.

1. MISCELLANEOUS

2. STRUCTURAL

ROOF LOADING

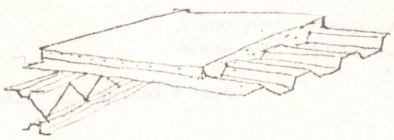
A. DATA

LIVE LOAD 40 lb/ft² LL

STRUCTURAL LOAD 15 lb/ft²]
MECHANICAL LOAD 5 lb/ft²] DL

TOTAL 60 lb/ft²

STRUCTURAL SYSTEM TO BE USED.

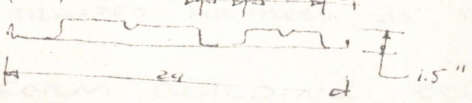


LIGHT WT. CONCRETE - GYPSUM ROOF DECK (8 lb/ft²)
CORRUGATED METAL ROOF DECK
OPEN WEB STEEL JOISTS
CLEAR SPAN OF JOISTS IS 68'

B. STEEL DECK LOAD 60 lb/ft², $\frac{L}{240}$

ROBERTSON ROOF DECK (SWEETS CAT. [5.5/RO]) S = .29 IL = .47

USE NC 1.5 - 18/18 4.4 lb/ft² S = .43



C. STEEL JOISTS (FROM MANUAL OF STEEL CONSTRUCTION, AISC)

LOAD 60 #/ft x 6 = 360 #-1 SPAN 68' END LOAD 12,200

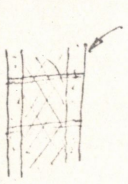
USING A DEFLECTION OF $\frac{1}{240}$ I CAN REDUCE LOAD BY 1.5 TO 240

USE A LONG SPAN STEEL JOIST OF:

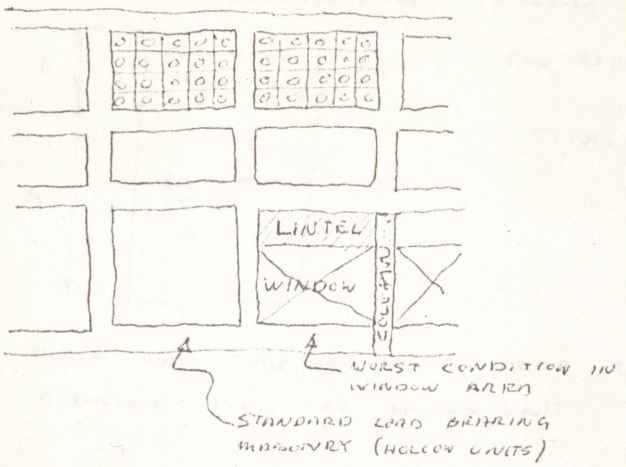
36 LJ 12 LOAD CAPACITY 310, END LOAD CAPACITY 12,657
DEPTH 36" LOAD PER FOOT 30 #

MASONRY CONSTRUCTION (USING A 6" CONC. SLAB FOR HEAVY FLOOR USE IN INDUSTRIAL BUILDINGS).

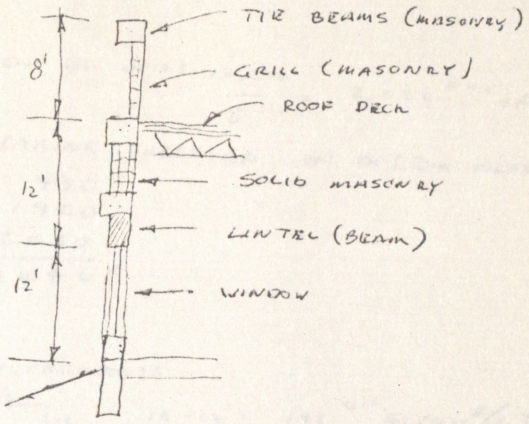
A. DATA



TYPICAL WALL SECTION



WALL ELEVATION



WALL SECTION

I WANT A STANDARD SECTIONAL AREA FOR:

(a) ALL LINTELS AND BEAMS

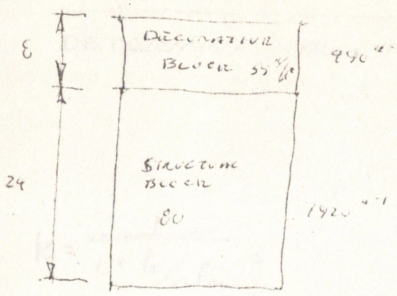
(b) ALL COLUMNS AND FOUNDATIONS

THEREFORE I MUST DESIGN FOR THE GREATEST LOADING CONDITION AND REDUCE THE REINFORCING IN THE OTHER RELATED MEMBERS AS THE LOAD PERMITS

UNIFORM BUILDING CODE REQUIREMENTS.

- USED CORROSION RESISTANT METAL TIES EVERY 34 INCHES VERTICALLY
- LENGTH OF WALL SHOULD NOT BE MORE THAN 18 TIMES ITS THICKNESS ∴ 12" x 18 = 216/12 = 18'-NEED PILASTERS EVERY 18'.
- MINIMUM THICKNESS OF WALL IS 12" FOR THE FIRST 35'!
- NO DIMENSION LESS THAN 12" ON COLUMNS

B LOAD BEARING WALL



END REACTION OF JOIST $\frac{12{,}200}{6'} = 2{,}030$ #-1 OR WALL

TOTAL BEARING PRESSURE ON BOTTOM BLOCK:

490
1920
2030
4440 #

BLOCK WALL MEETS ALL CODE REQUIREMENTS

BEARING AREA OF NELSON UNIT 

16 × 12 = 192 in² @ 1000 #/in²
= 192 000 lb

SAY 30% BEARING AREA

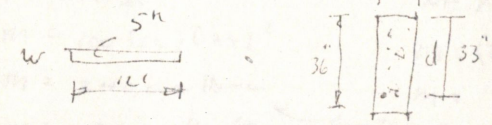
192 000 × .3 = 57,500 #

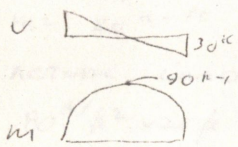
57,500 × $\frac{12}{16}\frac{3}{4}$ = 43,000 # < 4,440 #

OK

C GRADE BEAM[1]

LET 4.44K = 5K





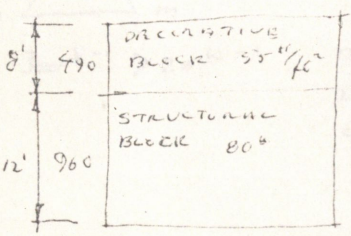
$R = \frac{M}{bd^2} = \frac{90000 \times 12}{12 \times 33^2} = 82 < 161.4$

$f_s = 24000$ $f_c' = 3000$ $p = .00959$ $j = .8863$ $R = 161.4$

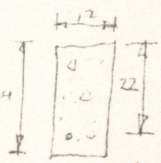
$A_s = \frac{M}{f_s j d} = \frac{90{,}000 \times 12}{24000 \times .8863 \times 33} = \frac{45}{29.2} = 1.54 \text{ in}^2$

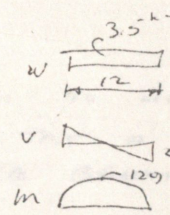
USE 2 #8 (1.58 in²

D WINDOW LINTEL



ROOF LOAD 2,030
TOTAL 2,030
490
960
3,480 #-1





$f_s = 24{,}000$
$f_c' = 3{,}750$
$j = .8781$
$R = 271$

$R = \frac{M}{bd^2} = \frac{129000 \times 12}{12 \times 22^2} = 268 < 271$ OK

$A_s = \frac{M}{f_s j d} = \frac{129000 \times 12}{24000 \times .878 \times 22}$

$A_s = 3.34 \text{ in}^2$

USE 2 #9 AND 2 #8

$A_s = 3.58 > 3.54$

OK

1 DESIGN PROCEDURE OUTLINED IN STRUCTURAL ENGINEERING HANDBOOK, by GAYLORD AND GAYLORD, 1968, P. 11-10

B1 MASONRY BEAM[1] (LINTEL)

$f_m' = f_m = 225$ (TABLE 6)

DETERMINE ALLOWABLE f_s

$E_m = 1000$ (TABLE 7)

$E_s = 400$ $\quad \therefore n = \frac{E_s}{E_m} = \frac{400}{1000} = .4$

$k = .30$

$j = .90$

$$k = \frac{1}{1 + \frac{f_s}{n f_m}} =$$

$$.30 = \frac{1}{1 + \frac{f_s}{(.4)(225)}}$$

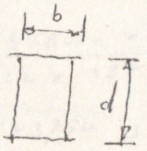
$f_s \cong 300$

$K = \frac{1}{2} f_m j$

$K = \frac{1}{2}(225)(.9)$

$K = 101.5 \cong 100$

DETERMINE b, d AND A_s



$b = 16$

$d = 24$

$A_s = 3.84$

$M = K b d^2$

$M = 100\,(16)(24)^2$

$M = 240{,}000$ lb-in

$M = 20{,}000$ lb-ft ← CONTROLS

$M = 20$ k-ft

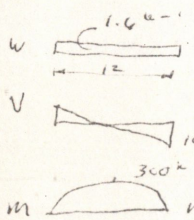
$M = A_s f_s j d$

$M = (3.84)(300)(.9)(24)$

$M = 250{,}000$ lb-in

ACTUAL LOAD

$80^{\#}/ft^2 \times 20\,ft = 1600^{\#}\text{-ft} = w$

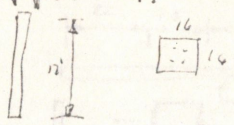


$300^{k\text{-}'} > 20^{k\text{-}'}$ REAL M TO HIGH FOR MASONRY BEAM — TRY A REGULAR REINFORCED CONCRETE BEAM.

1 DESIGN PROCEDURE OUTLINED IN STRUCTURAL ENGINEERING HANDBOOK, BY GAYLORD AND GAYLORD, 1968; 15-5

E COLUMN (BETWEEN WINDOWS)[1]

8.5 + 8.5 = 17"



ASSUME $P_g = .04$ $f_c' = 3000$ $f_y = 60{,}000$ psi

$P = D^2(.25 f_c' + f_s P_g)$

$17 = D^2 (.25 \times 3.0 + .9 \times 60 \times .04)$

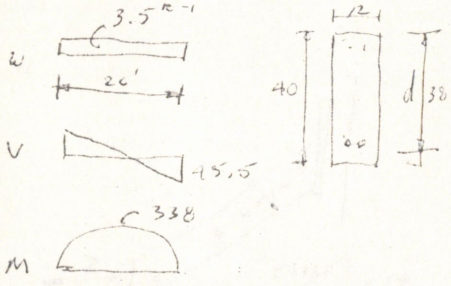
$D^2 = 1.64$ ← VERY LOW!

USE REGULAR PILASTER BLOCKS.

F. BEAM IN WALL OF ASSEMBLY AREA.

ASSUME A 20' SPAN

USE SAME LOADING AS LINTEL.



$R = \frac{M}{bd^2} = \frac{338000 \times 12}{12 \times 38^2} = 239$

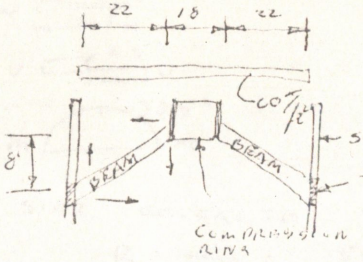
$f_s = 24000$ $f_c' = 3{,}750$ $j = .8781$ $R = 271.0$

$A_s = \frac{M}{f_s j d} = \frac{338000 \times 12}{24000 \times .8781 \times 38} = 5.05 \text{ in}^2$

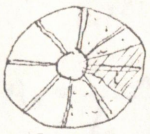
USE 2#10 AND 2#9 $A = 5.37$ OK

1. DESIGN PROCEDURE OUTLINED IN STRUCTURAL ENGINEERING HANDBOOK, by GAYLORD AND GAYLORD, 1968, P. 11-10

ASSEMBLY ROOF SYSTEM



THIS SYSTEM PUT DOME STRUCTURE IN COMPRESS



LOAD ON EACH BEAM

$A = \pi r^2$

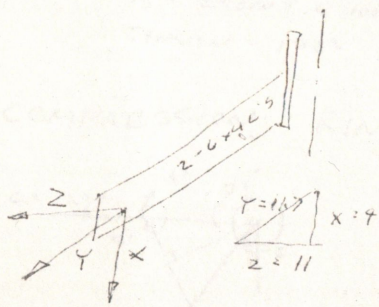
$A = \pi 32^2$

$A = \pi 960 = 3000\ ft^2$

FOR ½ THE DOM $\frac{3000\ ft^2}{2} = 1500\ ft^2$

FOR EACH MEMBER (4) $\frac{1500}{4} = 750\ ft^2$ OF ROOF

LOAD ON EACH MEMBER $750\ ft^2 \times 60\ \#/ft^2 = 45^k$



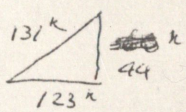
$X = 4 = 45^k$

$\frac{4}{45} = \frac{11}{Z}$

$Z = 123^k$

$\frac{4}{45} = \frac{11.7}{Y}$

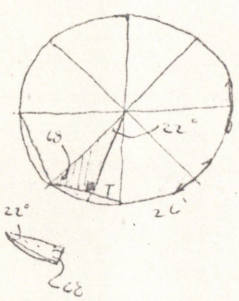
$Y = 131^k$



BEAM - SUPPORT TOTAL LENGTH, L = 25' USE ~~W 24 x 76~~ W 30 x 108

$S = \frac{44^k \times 25' \times 25}{24} = 550$

TENSION RING

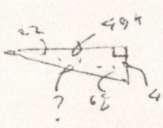


$\cos 22^\circ = \frac{ADJ}{HYP}$

$ADJ = HYP \times \cos 22$

$ADJ = 131^k \times .375$

$ADJ = 49^k = T$



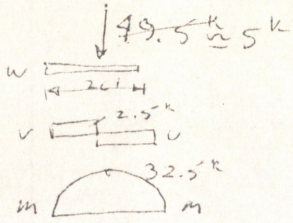
PERIMETER CABLE TENSION

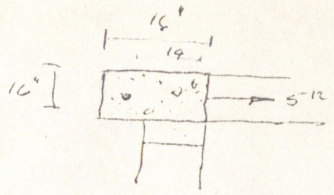
$\cos 22 = \frac{ADJ}{HYP}$

$HYP = \frac{ADJ}{\cos 22} = \frac{49}{.375} = 132^k = T'$

$\sin 22 = \frac{OPP}{HYP}$

$OPP = HYP \times \sin 22 = 132 \times .375 = 49.5^k$





SIZE CONCRETE TENSION RING [1]

$$R = \frac{M}{bd^2} = \frac{5000 \times 12}{16 \times 14^2} = 18.6 < 209$$

$f_s = 24000$
$f_c' = 3000$
$j = .8863$
$R = 209$

$$A_s = \frac{M}{f_s\, jd} = \frac{5000 \times 12}{24000 \times .8863 \times 14} = .2\ in^2$$

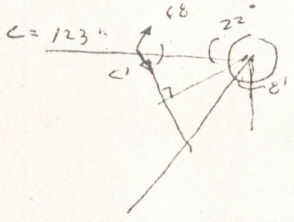
∴ USE 1 #3 BAR (.376)

ALLOW FOR TENSION

$f_s = 24000 \times .4 = 1000\ psi$

TENSION = 132K ∴ ≈ .132 in^2 f/n TENSION → TOTAL AREA .2 + .132 = .332 < .376 OK

COMPRESSION RING. C = 123 K



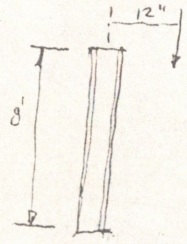
C' =

$\sin 22 = \frac{opp}{hyp}$

$opp = hyp \times \sin 22$

$opp = 123 \times .375 = 46\ K$

CONSIDER BEAM ACTION [2] (ECCENTRALLY LOADED)



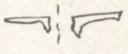
$k = 1$

$KL = 1 \times 8' = 8$

$P + P' = 46 + (.185 \times 46)$

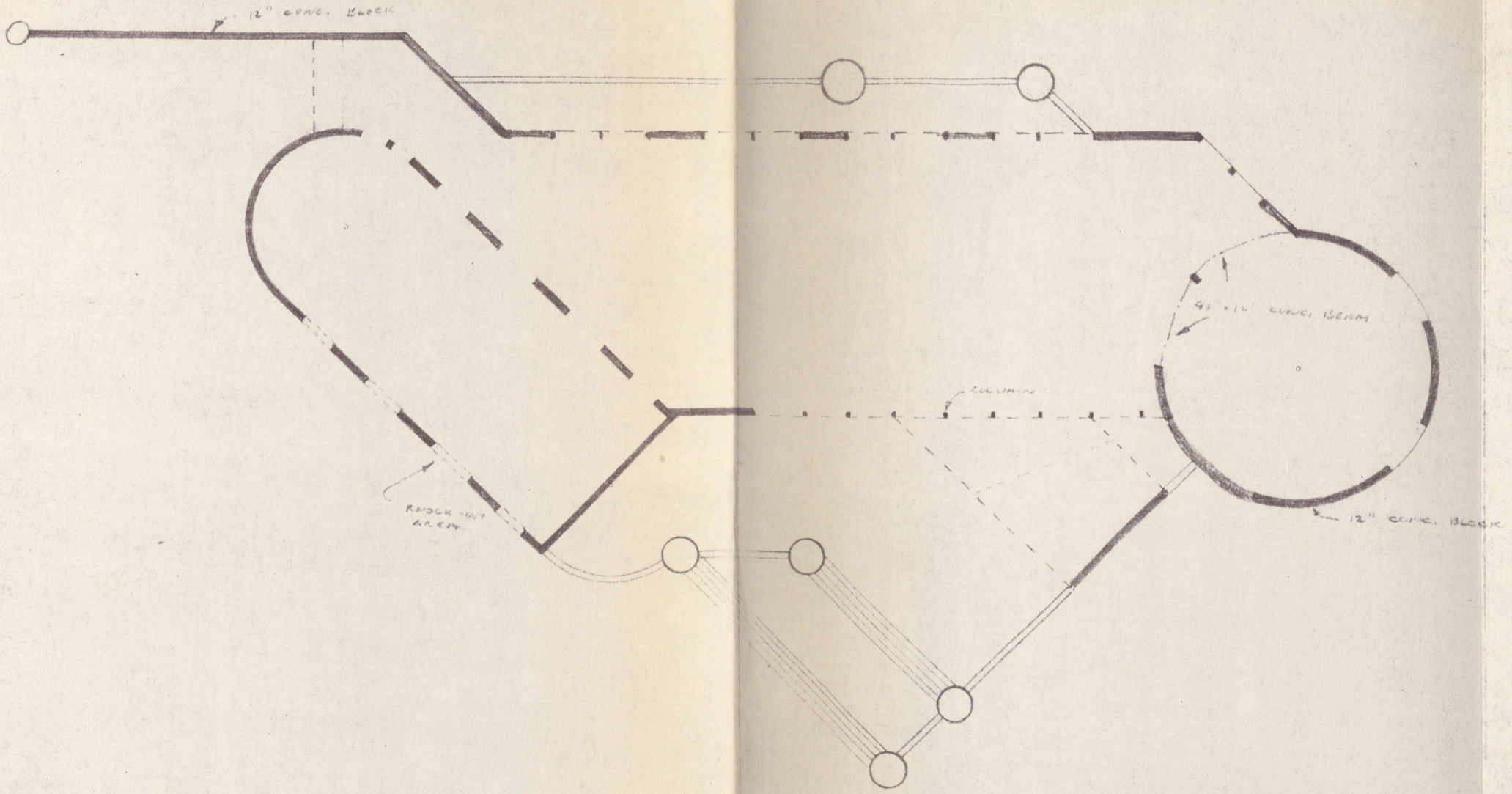
$= 46 + 8.5 \approx 55\ K$

USE 2 - $3\frac{1}{2} \times 3$ C'S

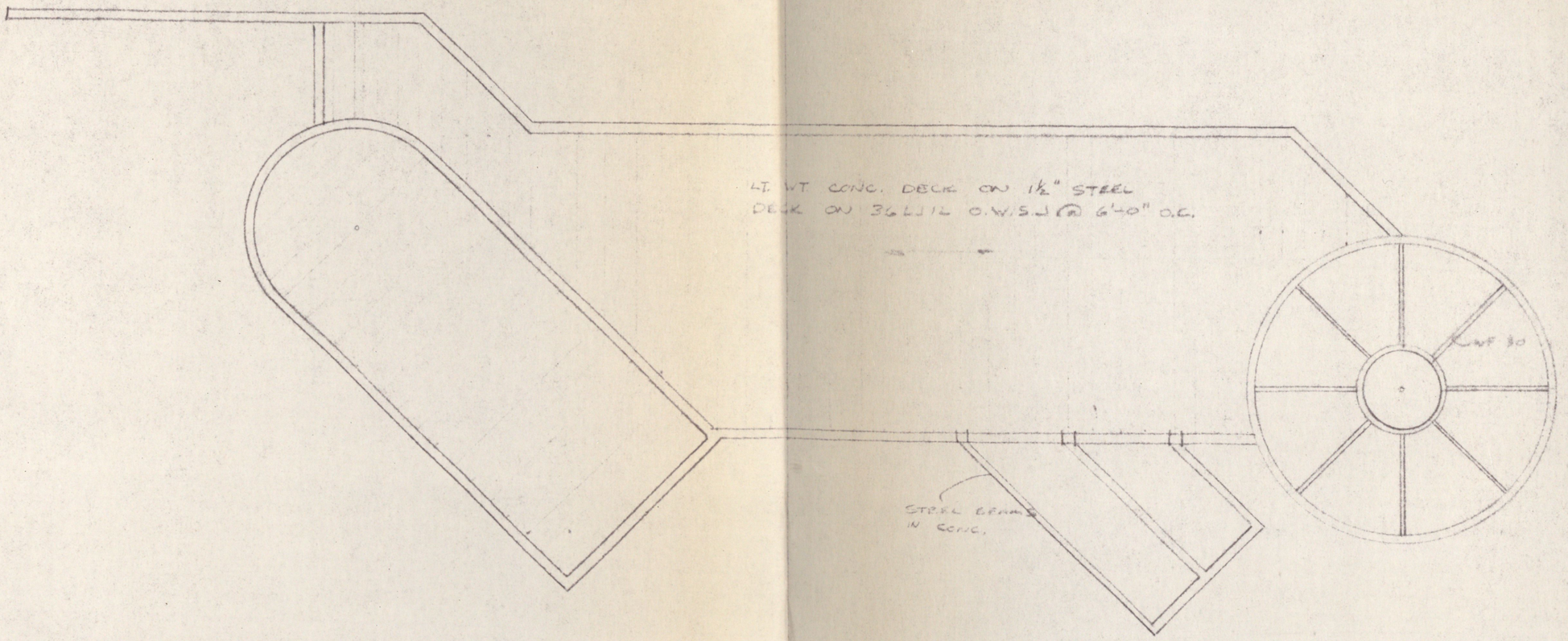


1 DESIGN PROCEDURE OUTLINED IN STRUCTURAL ENGINEERING HANDBOOK, by GAYLORD AND GAYLORD, 1968, P11-10

2 DESIGN PROCEDURE OUTLINED IN THE MANUAL OF ~~ENGINEERING~~ STEEL CONSTRUCTION (AISC).



LOAD BEARING WALLS (12")



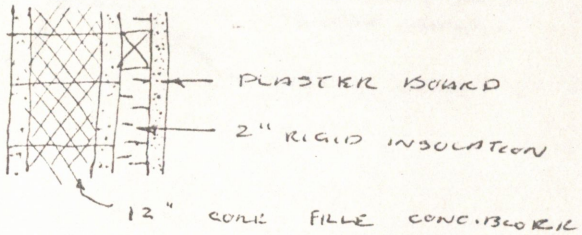
FRAMING LAYOUT

3. MECHANICAL

A HEAT LOSS CALCULATIONS

I U VALUES (DESIGN TEMPERATURE -20 OUTSIDE, 70 INSIDE)

a. WALLS



TYPICAL WALL SECTION

	R.
OUTSIDE AIR FILM	.17
12" FILLED CONC. BLOCK	5.82
2" RIGID INSULATION	2.88
PLASTER	.11
INSIDE AIR FILM	.68
	9.56

$U = \frac{1}{9.5} \simeq .1$ BTU/ft²/hr.

TEMPERATURE GRADIENT

$H_L = AU(t_1 - t_2)$

$H_L = 1 \times .1(70 - -20)$

$H_L = 9$

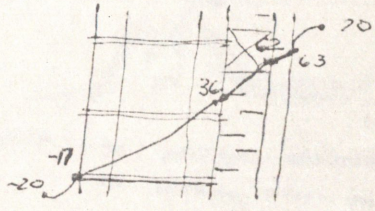
$T_2 = t_1 - R_1 H_L$

$\therefore T_1 = 70 - (.66 \times 9) = 63$

$T_2 = 63 - (.11 \times 9) = 62$

$T_3 = 62 - (2.88 \times 9) = 36$

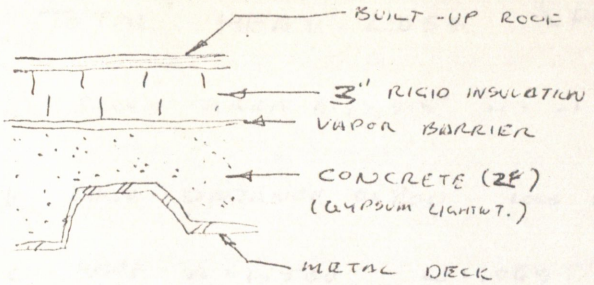
$T_4 = 36 - (5.82 \times 9) = -17$



RESULTS — NO MOISTURE ON INSIDE WALLS

- MUST THOROUGHLY SEAL BLOCK TO INSURE NO DEGENERATION FROM PENITRATING MOISTURE AND THE FREEZE THAW CYCLE
- MUST REINFORCE BLOCK AND ALLOW EXPANSION JOINTS (20') FOR ALLOT OF EXPANSION AND CONTRACTION IN WALL.

b. ROOF



	R.
HORIZONTAL AIR FILM	.17
BUILT-UP ROOF	.33
3" RIGID INSULATION	~~5.26~~ 7.90
VAPOR BARRIER	0.00
CONCRETE	5.55
HORIZONTAL AIR FILM	.61
	14.56

$U = \frac{1}{14.56} = .0685 \pm .07$ BTU/Hr/ft²

TEMPERATURE GRADIENT (APPROX.)

$H_L = AU(C_1 - C^2)$

$H_L = 1 \times .07(70 - -20)$

$H_L = 6.3$

$T_{in} = C_1 - R_1 H_L$

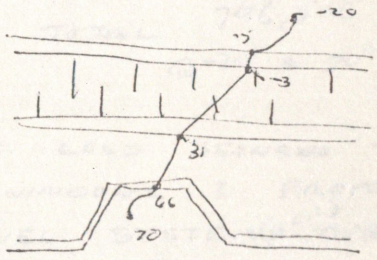
$T_1 = 70 - (.61 \times 6.3) \cong 66$

$T_2 = 66 - (5.5 \times 6.3) = 31$

$T_3 = 31 - (5.26 \times 6.3) = -3$

$T_4 = -3 - (.33 \times 6.3) = -5$

ERROR SMALL ENOUGH



RESULTS - NO INTERIOR CONDENSATION
- NO THERMAL LOAD ON ROOF STRUCTURE

c GLAZING - WILL USE A THERMOPANE GLASS WITH A 1/4" AIR SPACE, U = 2.60. GLASS IS 5/8" PLATE AND IS WIRED. SOLAR TRANSMISSION IS 64
(DATA FROM LIBBEY-OWENS-FORD COMPANY - SHEETS 8.264)

II BUILDING AREAS AND VOLUMNS

a. FLOOR AREAS (TAKEN FROM PRELIMINARY DESIGNS)
ASSEMBLY 3200
PROCESSING 10,115
STORAGE 4100 — 17,515 ft²

b. SKYLIGHT AREA — 2.000 ft²

c. EDGE DISTANCE OF SLABS — 800 ft

d. WALL AREA — 17000 ft²

e. GLASS IN WALLS — 4800 ft²

f ROOF — 15500 ft²

g. VOLUMNS
ASSEMBLY 3200×24 = 77000
PROCESSING 10,115×16 = 162000
STORAGE 4200×~~24~~ 16 = 100 000
340,000 ft³

~~4²~~ 4.0 BTU/Hr/ft²

III TOTAL HEAT LOSS (DESIGN TEMPERATURES -20, 70)

a.	FLOOR AREA A=17,515 U = .1 ΔT 30° (ON GRADE)	52,500 BTU/hr.
b.	EDGE DISTANCE D=800' LOSS 55 BTU/hr-ft	44,000 BTU/hr
c.	ROOF A = 15500 U = .069 ΔT 90	99,000 BTU/hr
d.	WALLS A = 17000 U = .1 ΔT 90	160,000 BTU/hr.
e.	GLASS A = 4800 U = .60 ΔT 90	228,000 BTU/hr
f.	SKYLIGHT A = 2000 U = .60 ΔT 90	108,000 BTU/hr.
g.	FRESH AIR @ 10° V = 39000 ft³ x .018 x 90	55,000 BTU/hr
	TOTAL @ -20° & 70°	746,500 BTU/hr.

IV DUE TO THE LARGEST HEAT LOSS BEING THROUGH THE GLASS SKYLIGHT AND WINDOWS I PROPOSE PLACING A MOVEABLE PANEL SYSTEM (R = .1) OVER ALL GLASS AREAS TO BE USED IN EXTREME TEMPERATURE TIMES (>0°F).

a.	FLOOR AREA	52,500 BTU/hr
b.	EDGE DISTANCE	44,000 BTU/hr
c.	ROOF	99,000 BTU/hr.
d.	WALL	160,000 BTU/hr.
e.	GLASS A = 4800 U = .1 ΔT 90	43,200 BTU/hr.
f.	SKYLIGHT A = 2000 U = .1 ΔT 90	18,000 BTU/hr.
g.	FRESH AIR @ 10°	55,000 BTU/hr.
	TOTAL @ -20° & 70° F	471,200 BTU/hr

† ALSO MAY CONSIDER REDUCING THE AREA OF EXPOSED GLASS IN FINAL DESIGN.

V DUE TO THE WORK PATTERN IN THIS PLANT, THE FACILITY IS ONLY USE 8 HOURS A DAY. THIS MEANS WE ONLY NEED TO HEAT THE AIR TO 70° FOR 8 HOURS AND WE COULD REDUCE THE TEMPERATURE TO 50°F AT NIGHT WHEN THE BUILDING IS UNOCCUPIED. ∴ ΔT = 70°

∴ a. FLOOR AREA 52,500 BTU/hr

b. EDGE DISTANCE 44,000 BTU/hr

c. ROOF A=17,500 U = .07 ΔT 70 76,000 BTU/hr

d. WALLS A=17000 U = .1 ΔT 70 119,000 BTU/hr

e. GLASS A=4800 U=.1 ΔT 70 33,600 BTU/hr.

f. SKYLIGHT A= 2000 U=.1 ΔT 70 14,000 BTU/hr.

g FRESH AIR @ 5 ℄
39000 x .05 = 1700 ft³ x .018 x 70 21,400 BTU/hr.

TOTAL 359,500 BTU/hr.
@ -20 & 50°F

VI THERE IS A HEAT GAIN IN THIS BUILDING FROM THE MACHINERY AND LIGHTS. I CONSIDERED A 50℄ WASTE HEAT FACTOR FROM THE MACHINES AND LIGHTS AND NO HEAT FROM PEOPLE.

TOTAL POWER 200,000 WATTS x 50℄ = 100,000 WATTS

100,000 WATTS/hr @ 3.41 BTU/WATT = 341,000 BTU/hr

∴ ACTUAL EXTRA HEATING NEEDED IS
FOR SITUATION IV 471,700 BTU/hr.
341,000 BTU/h
130,700 BTU/h.

FOR SITUATION III 746,500
341,000
405,500 BTU/hr

FOR SITUATION V THE FACILITY IS UNOCCUPIED AND ALL EQUIPMENT IS SHUTDOWN THERE FOR NO EXTRA HEAT IS PRODUCED

B HEAT GAIN

WILL USE DESIGN CRITERIA OF A SUMMER BUILDING TEMPERATURE OF 80°F (INSIDE), AND MAX. SOLAR ENERGY OF 200 BTU'S OUTSIDE TEMPERATURE. 100°F OUTSIDE.

I HEAT TRANSMISSION [1]

a. ROOF - 2" CONC. DECK WITH A REFLECTIVE SURFACE OF 50% U = .07 BTU/ft²/hr. 6" ABSORB A ADDITIONAL 17° A HOUR.

$$[(200 \times .5) \times .07 \times 20] - 17 = 0 \text{ BTU/hr.}$$

b. WALLS - 12 INCHS OF INSULATED MASONRY - WHITE STUCCO R=50% U = .1

$$[(200 \times .5) \times .1 \times 20] = 30 \text{ BTU/hr.}$$

c. GLASS - PARALLEL - 0 - PLATE (SUNRAYS) - TRANSMISSION 60%.
200 x 60% = 150 BTU/ft²/hr (IN DIRECT SUN ONLY)

II HEAT GAIN

a. ROOF = 15,500 ft² x 0 = 0 BTU/hr.

b. WALLS = 17000 ft² / 2 IN DIRECT SUN = 8500 ft² x 30 BTU/hr = 255,000 BTU/hr
8500 ft² x .1 x 20 = 17,000 BTU/hr

c. GLASS = 4800 ft / 2 IN DIRECT SUN = 2400 ft² x 150 BTU/ft²/hr = 375,000 BTU/hr
2400 x .6 x 20 = 480 BTU/hr

d. SKYLIGHTS = 2000 ft² x 150 BTU/ft²/hr = 312,000 BTU/hr.

e. AIR CHANGES (10%) = 34000 x .018 x 20 = 12,300 BTU/hr.

f MACHINERY = 341,000 BTU/hr.

TOTAL HEAT GAIN 1,282,780

1. USED MECHANICAL AND ELECTRICAL EQUIPMENT FOR BUILDINGS by McGUINNESS AND STEIN AS REFERENCE

III BY OBSERVATION OF THE ABOVE FIGURES I OBSERVED THAT THE GLASS AREA ACCOUNTS FOR THE GREATEST HEAT BUILD-UP. AS IN THE HEAT LOSS CALCULATIONS I PROPOSE TO USE PANELS OVER THE GLASS AREAS THAT ABSORBS OR REFLECTS THE HEAT WITH THE SAME VALUE AS THE WALLS. (30 BTU/hr)

a. ROOF		0 BTU/hr
b. WALLS		255,000 BTU/hr
		17,000 BTU/hr
c. GLASS	2400 ft² × 30 BTU/hr	72,000 BTU/hr
d. SKYLIGHT	200 ft² × 30 BTU/hr	480 BTU/hr
		20,000 BTU/hr
e. AIR CHANGES (10%)		12,300 BTU/hr.
f. MACHINERY		341,000 BTU/hr
TOTAL HEAT GAINS		717,780 BTU/hr.

C. DECISIONS (ECONOMIC) FOR THE PANELS

	WITHOUT PANELS	WITH PANELS	SAVING
HEAT LOSS	746,500 BTU/h	471,700 BTU/h	274800
HEAT GAIN	1,282,780 BTU/h	717,780 BTU/h	565000

I WILL USE ELECTRIC ENERGY DUE TO THE DECLINING USE OF PETROLEUM PRODUCTS AND BECAUSE OF THE LARGE USE OF ELECTRICAL SYSTEMS - ~~BY~~ BY THE FACILITIES MACHINERY. — CONSIDER ELECTRICAL SYSTEMS 90% EFFICIENT.

a - FUEL NEEDED EXTRA FOR COOLING

$\frac{565,000}{90^{\circ}} = \frac{X}{100}$ $X = 625,000$ @ 1 WATT = 3.41 BTU'S

∴ YOU NEED $\frac{625000}{3.41} = 183,000$ WATTS

183 KWATTS/h

THE NUMBER OF HOURS.
SAY 6h A DAY OVER A PERIOD OF 60 DAYS
∴ 360 h x 183 kw/h = 65,000 kwh

COST (AS BASED ON MONTANA POWER PRICES 1967) IS APPROX. ~~$4.23~~ 7.19 /yr extra

b FUEL NEEDED EXTRA FOR HEATING

$\frac{274,800}{90} = \frac{Y}{100}$ $Y = 306,000$ BTU/h @ 1 WATT = 3.41 BTUS

∴ YOU NEED $\frac{306,000}{3.41} = 90,000$ WATTS

≈ 90 KW/h.

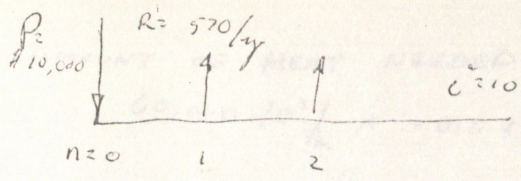
THE NUMBER OF HOURS
SAY 24h A DAY OVER A PERIOD OF 30 DAYS
∴ 24 x 30 = 720 h x 90 = 64,800 kwh.

COST IS APPROX = $560/yr extra

C. COST OF MOVABLE PANELS

$5/ft² x 2000 ft² = $10,000

d ECONOMIC MODEL.



QUESTION: HOW LONG WILL IT TAKE S TO EQUAL P

R = $7.19
$560.00
56719 ≈ $570/yr

i = BA INFLATION → 10%
n = NUMBER OF YEARS
S = P
P = INITAL COST

P = S = P' = R USCAF
i=8

$10000 = S = P' = 570/y USCAF 18.531
i=8 n=11

$10,000 = S = $10,500 ∴ P < S IN THE 10TH YEAR.

A INDUSTRIAL BUILDING IS EXPECTED TO LAST ABOUT 20 YEARS THEREFOR IT IS A GOOD LONG RANGE IDEA TO PUT IN THE PANELS.

D. SOLAR ENERGY

WHEN I FIRST STARTED THIS PROJECT I CONSIDERED USING SOLAR ENERGY AS A HEATING AND COOLING SOURCE. HOWEVER AFTER TALKING WITH I. PAYNE (PROFESSOR M.S.U.) I DESIDED AGAINST IT ON THE GROUNDS THAT THE TECHNOLOGY HAS NOT YET BEEN FULLY DEVELOPED, SOLAR INFORMATION FOR THIS AREA IS LARGLY UNKNOWN IN THIS AREA AND I MIGHT AS WELL USE A ELECTRICAL CENTRAL SOURCE BECAUSE THAT IS WHAT IS RUNNING MY MACHINES.

E WELDING AREA (PROCESSING)

IN THIS AREA 5 PEOPLE ARE 'TACK WELDING' PARTS TOGETHER. AND NEED A SELF CONTAINED ENVIRONMENT WITH A FRESH AIR SUPPLY AND A AIR EXHAUST BECAUSE OF DANGEROUS FUMES. REGULATIONS STATE YOU NEED 600 CFM FRESH AIR PER WELDER. THIS IS BASED ON LARGER WELDING PRACTICES. I PROPOSE SUBMITTING A REQUEST TO THE 'OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION' TO REDUCE THIS AIR FLOW TO 200 ft^3/PER WELDER/PER MIN.

200 ft^3/min x 5 WELDER IS 1000 ft^3/min x 60 min/hr = 60,000 ft^3/hr

THE AMOUNT OF HEAT NEEDED TO IS:

60,000 ft^3/hr x .018 x 90 = 96,000 BTU/hr.

F. THIS BUILDING CONTAINS OPENING WINDOWS AND SKYLIGHTS TO ALLOW NATURAL AIR CIRCULATION FOR COOLING AT MARGINAL TIMES. ALSO THE GLASS ACTS AS A 'HEAT SINK' TO AID IN HEATING AGAIN AT MARGINAL TIMES. ALTHOUGH DESIGNED FOR CLIMATE EXTREMES MUCH OF THE COST OF HEATING AND COOLING CAN BE AVOIDED.

G. THIS BUILDING IS TO HAVE A SPRINKLER SYSTEM. THIS PLUS THE FACT WE ARE USING INCOMBUSTIBLE CONSTRUCTION GIVES ME A TWO HOUR FIRE RATE THUS LOWERING INSURANCE COSTS.

IV DUCTS

~~VOLUMES~~ AREAS OF BUILDING:

ZONE I ASSEMBLY 3200 ft^3

ZONE II PROCESSING 10185 ft^3

ZONE III STORAGE 4100 ft^3

17,515

AIR CHANGE WILL USE .1 cfm/ft^2 of floor

∴ MUST MOVE 1,751.5 cfm

LIMIT DUCT VELOCITY TO 1000 FPM

VOLUMES TO EACH SPACE

ZONE I $\frac{3200}{17,515} \times 1751.5 = 320$ cfm

ZONE II $\frac{10115}{17,515} \times 1751.5 = 1011.5$ cfm

ZONE III $\frac{4100}{17515} \times 1751.5 = 410$ cfm

USE MULTI ZONING

MAIN DUCT	SMALL DUCTS
4"Ø	4"Ø
16"Ø	4"Ø
5"Ø	4"Ø

MAIN RETURN 24"Ø

I THINK THE AIR CHANGE IS TO LOW TO HANDLE COOL AND HOT CONDITIONS. WILL NEED TO CIRCULATE AIR ABOUT 10 TIMES AN HOUR TO KEEP IT WARM.

REVISED DUCT SIZES

ZONE I 3,200 CFM

ZONE II 10,000 CFM

ZONE III 4000 CFM

17,200 CFM → MAIN RETURN 40" Ø

MAIN DUCT	SMALLER DUCTS
20" Ø	12" Ø 4
30" Ø	16" Ø 10
20" Ø	16" Ø 4

V HEATING SYSTEM.

MAX. HEAT LOSS = 359,500 BTU/h (NIGHT) ✓

MAX. COOLING LOAD = 717,780 BTU/h. ←

USE CARRIER ROOF TOP AIR COOLER — HEATER (ELECT) SYSTEM. THIS MAKES USE OF THE ROOF AND DOESN'T USE UP FLOOR SPACE.

EACH UNIT HEATING CAP. 400,000 BTU/h ✓ < 359,500

COOLING CAP 430,000 BTU/h. ← CONTROLS

THIS FACILITY WILL NEED 2 UNITS. COOLING CONTROLS THE CHOICE, HOWEVER THIS IS NOT BAD BECAUSE IT LEAVES ~~US~~ US WITH A BACK-UP HEATING SYSTEM FOR THE WINTER — THE CRITICAL TIME OF YEAR. COSTLY!

TRY

SPECIFY A ~~TOO~~ 360,000 (360,000 BTUS) CARRIER HEATING UNIT AND A CARRIER COOLING UNIT (777000 BTU/h). CHEAPER!

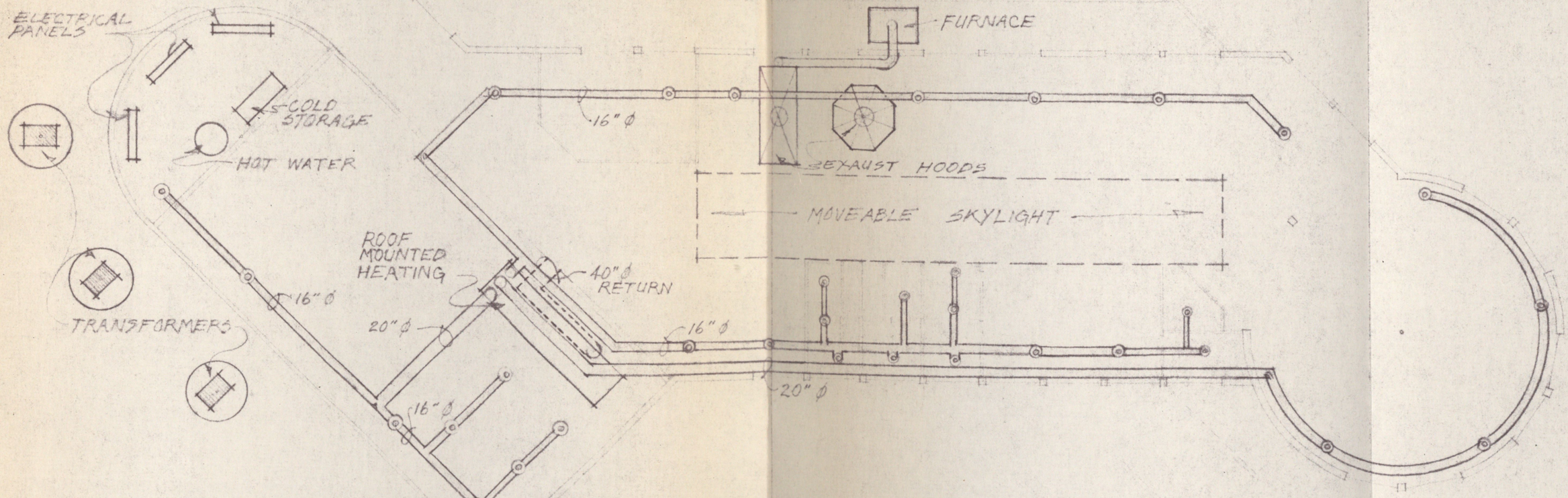
VI FACILITY WILL REQUIRE A SEPTIC TANK AND DRAIN FIELD BECAUSE OF THE LACK OF A SANITARY SEWER — HOWEVER IT WILL NOT REQUIRE ANY SPECIAL FACILITIES BECAUSE OF THE STORM SEWER

WILL REQUIRE A WELL FOR WATER.

NO STANDBY GENERATORS NEEDED.

NEED A MECHANICAL ROOM FOR ELECTRICAL CONTROL PANEL, SUMP PUMP, WATER PUMP ETC.

WILL ONLY INDICATE SEWAGE, AND WATER LINE BUT WILL NOT SIZE ON DRAWING DUE TO THE FACT THEY WILL NOT OVERLY EFFECT THE DESIGN.



EQUIPMENT LAYOUT

4. ECONOMICAL ANALYSIS
a. general 221
b. railroad 225

A GENERAL

ONE OF THE MOST COMMON QUESTIONS ABOUT PROPOSALS SUCH AS MY SOLUTION IS HOW MUCH WOULD IT COST. FIRST I WOULD LIKE TO STATE THAT SUCH ENVIRONMENTAL IMPROVEMENTS ARE NOT NON PRODUCTIVE INVESTMENTS. A INDIVIDUAL MUST RECOGNIZE THAT A BUILDING (AND SITE) ARE AS MUCH A MACHINE DOING A FUNCTION AS ANY OTHER PIECE OF EQUIPMENT THAT WORKS DIRECTLY ON THE PRODUCT BEING PRODUCED. THERFORE A BUILDING AND A PUNCH PRESS SHOULD BE VIEWED IN THE SAME LIGHT. THE BUILDING INFLUENCES PRODUCTION COST MORE INDIRECTLY THAN SUCH EQUIPMENT AS PUNCH PRESSES.

AS MY FINAL COMPARISON I COMPARE MY SOLUTION WITH THE SOLUTION OF THE INDUSTRIAL MANAGEMENT ENGINEER DEPARTMENTS (WAS PART OF THE IME. PROGRAM). I NOTED THE FOLLOW IMPROVEMENTS.

1. SIMPLIFICATION OF OVERALL PROCESS ARRANGEMENTS.
2. HIGHER LEVEL OF EMPLOYEE EFFECTIVENESS
3. MAINTAINED A HIGH MACHINE UTILIZATION
4. HIGHER SPACE UTILIZATION
5. LOWER MATERIALS HANDLING COSTS
6. MAINTAINED INVENTORY REQUIREMENTS
7. A MUCH HIGHER EMPLOYEE MORAL.
8. REDUCED DIRECT LABOR COSTS
9. REDUCED FIXED COSTS

I MUST NOTE ALSO THAT MANY OF THE COSTS INVOLVED IN THIS DESIGN COMPARISON ARE FIXED COSTS, AND THAT THE BUILDING DIFFERANCES WILL NOT CHANGE THEM (eg. MACHINERY BEING USED).

THE MAIN IDEA OF THE THESIS HOWEVER IS BASED ON THE MAN - MACHINE RELATIONSHIP. THIS IS PREVALLANT IN THE WORK STUDY ANALTSIS IN PLANT DESIGNING. IN R.A. OLSENS' BOOK (MANUFACTURING MANAGEMENT) HE POINTS OUT THAT THE PACE A WORKER FUNCTIONS AT MAY CHANGE DUE TO SUCH FACTORS AS MECHANICAL, PHYSIOLOGICAL, PSYCHOLOGICAL AND SOCIOLOGICAL SITUATIONS. HE ALSO POINTS OUT THAT THESE EFFECT THE TRADITIONAL FORM OF CALCULATING MAN-MACHINE EFFICTIVENESS. THE CONSTANT FOR THE MACHINE REMAINS THE SAME BUT ANY ONE OF THE ABOVE FACTORS CAN ALTER THE 'HUMAN CONSTANT'.

IN GENERAL I INCREASED THE BUILDING AND HUMAN EFFICENCY BY:

BUILDING AREAS:
MINE $17,575\ ft^2$
I.M.E. $25'120\ ft^2$

$$\frac{25'120}{17'515} \cong 1.4 \times 100\% = 140\%$$

WITH THE SAME PRODUCTION.

ECONOMICS

I FIRST WOULD LIKE TO POINT OUT THAT BOTH BUILDING SYSTEMS COST APPROXIMENTLY THE SAME (IME - METAL PREFABS @ $\$2.50/ft^2$ VS. MINE - OWSJ & BLOCK @ $\$2.62/ft^2$[1]) AND BOTH ARE BASED ON BUILDING SHELL AND SUPERSTRUCTURE COSTS ONLY. THE AVERAGE TOTAL COST OF MY BUILDING IN 1972 WOULD HAVE BEEN APPROXIMENTLY $\$13.00/ft^2$

$\therefore 17,515\ ft^2 \times \$13./ft^2 = \$228,000.$

MY BLDG. WOULD BE CHEERER DUE TO ITS SMALLER SIZE YET MORE EFFICIENT BECAUSE I MAINTAIN THE SAME PRODUCTIVITY.

1 COSTS ESTABLISHED FROM PERSONNAL EXPERIENCE.

THE FOUR MOST COSTLY HUMAN FACTORS I CAN USE AS AREAS OF IMPROVEMENT ARE EMPLOYEE TURNOVER, ABSENTEEISM, QUALITY OF PRODUCTS AND INCREASED PRODUCTION. FROM PAST STUDIES I PRODUCED THE FOLLOWING PERCENTAGES.[1]

VOLVO IMPROVEMENTS · 50% TO → 12% TURNOVER = 38% ↓
25 → 17 ABSENTISM = 22% ↓

AVERAGE 30% IMPROVEMEN OF EMPLOYEES.

∴ ASSUME 30% CAN BE APPLIED TO COST COMPARISON

10% IMPROVEMENT IN QUALITY
30% IMPROVEMENT IN PRODUCTION

AVERAGE 20% IMPROVEMENT IN OUTPUT. ∴ ASSUME 20% CAN BE APPLIED TO COST COMPARISON.

∴ TOTALS OF SOME OTHER EXPERIMENTS HAVE SHOWEN NO IMPROVEMENT, THEREFORE CONSIDER THEM AS 0% AND AVERAGE WITH THE VOLVO PLANT.

EMPLOYEES $\frac{0\% + 30\%}{2} = 15\%$

PRODUCTION $\frac{0\% + 20\%}{2} = 10\%$

SAVINGS IN LABOR WOULD BE:

8hr-day, 250 days a year, $5/hr/man } @ 15% a DAY ↑ EMPLOYEES

$8 \times 250 \times 15\% \times \$5 = \$1500/yr$ (SAVING)

SAVINGS IN PRODUCTION (INCREASE IN PRODUCTION)
FROM PROGRAM [redacted] $5,436,000
× 10%
$543,600/yr. (INCREASE)

TOTAL INCREASE − $543,600 PRODUCTION
1,500 LABOR
$545100
≈ $550,000 yr.

1. INDUSTRIAL ENGINEER; AMERICAN INSTITUTE OF INDUSTRIAL ENGINEER INC.; TECHNOLOGY PARK, ATLANTA; JAN 74, VOL 6, NO1. PAGE 32.

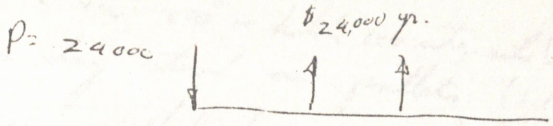
BUILDING COST - £228,000

INCREASE BY 10% FOR EXTRAS (eg SKY LIGHTS)

£228,000 × 110% ≈ £252,000

∴ INCREASE OF £24,000.

A TIME MODEL



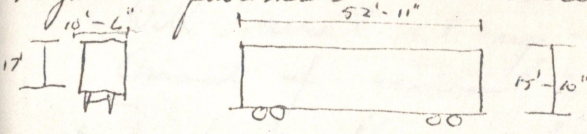
n = LESS THAN 1 YEAR

THEREFORE IT WOULD BE ECONOMICALLY FEASIBLE.

ALTHOUGH THESE FIGURES ARE EXTREMELY ROUGH THEY SHOW THAT IT IS ECONOMICALLY JUSTIFIED TO INCREASE THE COST OF THE BUILDING TO INCREASE THE RETURN ON PRODUCTION.

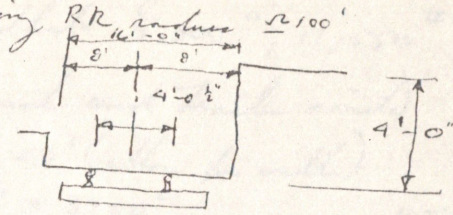
B RAILROAD

Legal Requirements - Clearance by American Railway Association



Need 16' clearance

Turning RR radius ≥ 100'



Small car interior volumn - 3,468 cu'

Box size 12" x 16" x 10" → holds 100 utensils [1.16 cu'] 1 utensil 4 oz 4 : 16 $\frac{16}{4}$ = 25 $\frac{4}{case}$

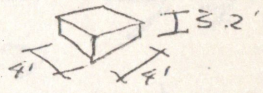
153 cases a day stored on pallets (1.16" x 153 = 178 cu']

44 cases per pallet (4' x 4' pallet) = 3.5 pallets per day [44 x 1.16 = 51 cu' ; 51/14 = 3.2'/hi]

44 x 25 = 1100 #/pallet

Two week storage time = 105 pallets

105 x 1100 = 11,550 # in 2 weeks



10 box cars every 2 week (single shift)
5 box cars every week (double shift)
2 box cars every 5 days (triple shift)

No expansion to the assembly or storage area needed.

2 increase in facility by 25%
∴ probably need a box car every 4 days ← expansion only in Processing area

HANDLING COST (not based on detailed cost estimate

Plant → H → Storage → H → truck → train

16 hi - 1 fg 80% H 100 x 2 < q. l = 25 cu. $\frac{10}{25,000}$ yrs.

+ type of use of entire fork lift

Storage → H → Train & Reduce handling in large shipments

large time investment - flexibility of transportation - increase facility value

INCORPORATE R.R. SIDING

Economic Analysis.

1. With present set-up - 1 box cars every 2 weeks
Amount of material to be handled 5,300 ft³; 11,550 #

- Truck handling ability (large truck and trailer rented)
13' hi × 45' × 8' (allow for walls)
12 × 44' × 7' = 3700 ft³

	1850 ft³
extra truck	3700
	5550

∴ need 1 large truck + one medium truck.

∴ load per truck is $\frac{3700}{5550} \times 11{,}550 = 11{,}550 \times .7 = 8000$ #

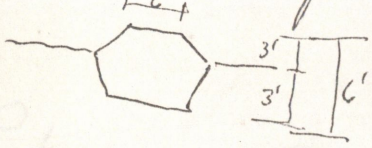
Note: Piggy back train - truck not economical - only if combined in ocean shipping

- Use an economic model (Based on 1965 freight rates).

Train - LOADING - one man and one ~~fork lift~~ fork lift 1 day worth of work - used 8 hr @ $10 = $80 man
say machine = $20
$100

cost per train 11550 # = 115.5 × 7.05 = $810
810 + 100(2) = 810 + 200 = $1000 per trip
in one year $\frac{52}{2} = 26 \times 1000 = \$26{,}000$ per year
extra engine = $26000

Construction of R.R. Bed



36' × 600 = 21600 ft³
27 ft³/cy/yd = 800 yd³ × 2.25 $/yd³ = $2000

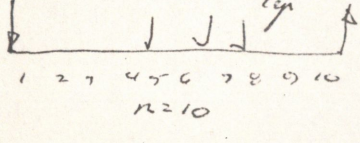
Excavation = 3 × C = 18 × 600 = 10800 / 27 = 400 cy × 1 = $400

Survey = 3 men. 2 dy @ $100 ea = $600

Steel @ 30 #/ft³ × 2 60 #/ft³ × 600 = 36000 @ .50 ¢/# = $8000

Labor - 5 men @ $100/day for 10 days = 1000 × 5 = $5000

Total	2000
	400
	600
	8000
	5000
	17000
	× .20 overhead
	3400
	17000
	20,400



note = slow delivery with train
- need a rigid schedule.

TRUCK wt = 11,550 # = 115.5 × 7.78 = #900 F → T → W → T → W

same loading on rail car 100 per loading × 4 times = #400

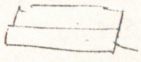
∴ 900 + 400 = #1300 per trip.

shipping out handling

∴ in one year $\frac{52}{2}$ = 26 × 1300 = #33,800

≈ 34,000/year

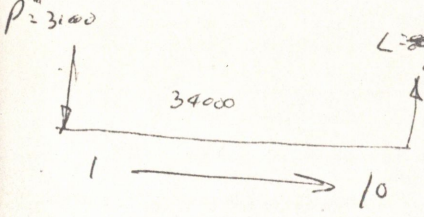
Construction of paving area - (for heavy trucks - concrete)



1.5'

1½ ⌣ 20000 × 1.5 = 30,000 ft

$\frac{30,000}{27}$ = 1100 yds



TRUCK

1100 × 2.25 = #2500 gravel

Bituminous concrete

20,000 × .5 = $\frac{10000}{27}$ = 370 gal

370 × 1.50 = 550 + paving

#3050

10 men = 10 × 100 m/hr = 1000 × 20 = 20000

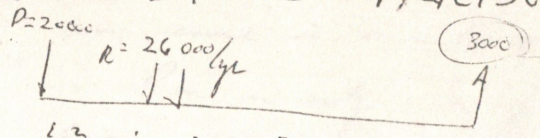
25500
3050
20000
25550
≈ 26000
2
52 00
24 000
31200 ≈ 31000

...ipt delivery - short haul (300 miles)

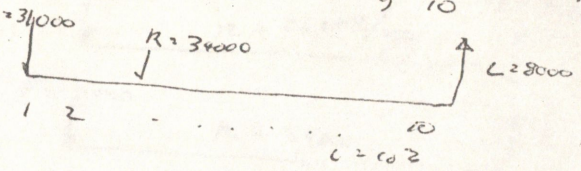
~~Rate of Return Comparisons~~

ANNUAL COST COMPARISONS (for transportation alternatives only = savings)

TRAIN A



TRUCK B

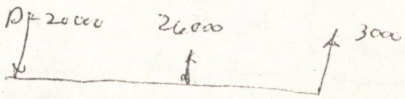


$AC_A = 26000 + 20{,}000\,(.10,10)\,crf\,.16275 = \frac{26000}{3250} = 29250 \approx \$30000/yr$

$AC_B = 34000 + 31000\,(.10,10)\,crf\,.16275 = 34000/500 = 39000 \approx \$40{,}000/yr$

$10,000 a year savings by having a R.R. Outgoing only. Need Truck for Delivery

INVEST IN BANK SAVINGS



$P = 20000 + 26000\,(12,10)\,USPWF\,9.222 + 3000\,(SPPWR)\,.96167$

$= 20{,}000 + 24000 + 26000$

$P = \$20{,}000$

$AC = 20{,}000\,(i=10)\,crf\,.13587 = \$9{,}800 < \$10{,}000$

@ i=6% bank interest rate on savings

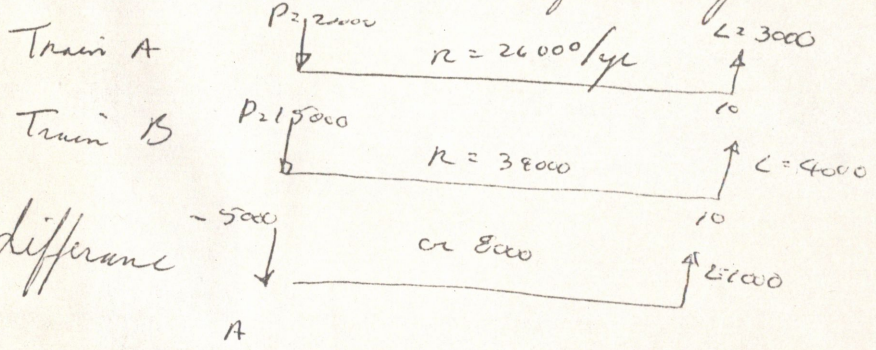
If you can find another source with better than 6½% rate of return, use it to carry the extra cost of the truck.

Conclusion – ship everything out by Rail Road.
– I need a Truck access

Low Cost of the Development by omitting railroad

Alternatives — need truck even because supplies can come in small quantities.

∴ Pay in only ½ of building cost.



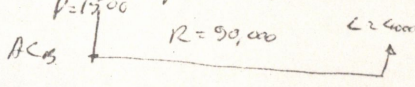
AC = 8000 = -5000 i -10 cr A - Truck is feasible

Annual Cost Comparison of AC_B

15000 + 31,000 10 10 crf .16275 = 15000
5000
20000 < $30,000 by $10,000
For Trucking

If there was triple production

R=34000 / 3 = 11,2000 / 90000



AC_B 15000 + 90000 10-10 crf .16275 = 15000
14600
29600 ≈ $30000 < 50000

AC_R 20,000 + 178000 (.1627)
29000 < 50,000

RR never economical

∴ Design for use of other warehouse facilities by others — cheaper

OLSENS RECOMMENDATION — USE ONLY TRUCKS FOR FLEXIBILITY AND SPEED OF DELIVERY

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