

October 3, 1934.

Dean William Emerson  
Dean of the School of Architecture  
Massachusetts Institute of Technology

Dear Dean Emerson:-

I beg to submit to you, as Chairman  
of the Thesis Committee, this thesis entitled

"A Production Plant for Pre-Fabricated Houses,"  
as partial fulfillment of the requirements for the  
degree Bachelor of Architecture.

Very sincerely yours,

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Elisabeth Hilde Scheu.

EHS:A

I wish to acknowledge my sincere appreciation of the time and information extended to me by Dean Emerson and the other members of the Destructing Staff at M. I. T.; by Mr. Lawrence E. Kocher, of Kocher + Frey, in New York; by Mr. Arthur C. Holden, of "American Houses", N.Y.; by Mr. Lescaze, N.Y., and by Mr. Norris, of the Bakelite Co. in New York; also by Mr. John Nolan, Boston.

Elisabeth Schen

-- INTRODUCTION --

The first section of this report deals with the social and economical factors leading to the attempts that try to solve the housing problem from the industrial point of view, and with the product that is to cover the need, as it develops logically from this point of view.

The second section deals with the organization of a Production Company that is to manufacture and distribute this product; and with the planning of the buildings that are to house the organization and the manufacturing process.

## STATEMENT OF THE PROBLEM.

The last generation has witnessed a revolution. Architecture, up to a short time ago, was concerned with buildings that were meant to be significant beyond daily life, and often were. Architecture dealt with monuments, palaces, public buildings and cathedrals. The small house of the peasant in the country, of the tradesman and worker in town, took care of itself, was the product of a long tradition of living and marvelous craftsmanship. Only with the coming of the machine, and industry, did that quality get lost; and we suddenly realized that we are living crowded together in noisy, dusty, unhealthy and unpleasant cities, where slums breed sickness and crime, and hectic living creates nervous diseases. We are conscious of the vital influence of physical surroundings on the healthy mental development of the individual, and the race; and as it is clear that there is room for improvement, the next step is to provide efficient, clean, simple and pleasant homes. In addition to that, Industry, that crowded us into cities, is impatient to have us keep pace with its trends; we have not yet solved the city housing problem and Industry is already moving out of town again. Decentralization, the tendency to shift to

wider and cheaper areas, brings a steadily rising demand for small one-family houses.

But again, we are unable to meet this demand and make-shifts are taking the place of the desired family home. Apartment blocks and monotonous row houses carry city standards to the country. Any more satisfactory solution to the home problem of the individual is generally out of his reach economically. And it is an acknowledged truism that the percentage of income that <sup>one</sup> pays for shelter is altogether out of proportion with what is spent for other needs. Or else the quality of the living environments is far below the general standard of living.

What are the reasons?

There are four main factors that go into building a house:

1. Materials
2. Labor
3. Land, the basic raw material of building
4. Time

If one, or more, of these factors demand a price over their actual value, then the house will be disproportionately expensive.

An analysis of existing conditions is none too reassuring.

CHART A

	1926	1934
Cost of Living	●●●●●●●●●●●●●●●●	●●●●●●●●●●
All Commodity Wholesale prices	●●●●●●●●●●●●●●●●	●●●●●●●●●●
Index Cost of Building	●●●●●●●●●●●●●●●●	●●●●●●●●●●●●●●●●
Building Wages	●●●●●●●●●●●●●●●●	●●●●●●●●●●●●●●●●
" Materials	●●●●●●●●●●●●●●●●	●●●●●●●●●●●●●●●●

\*Compiled from:- American Architect, Jan., 1934

Materials are expensive, because they are used in such small quantities of so many kinds that they have to be bought in retail. Also they require either great initial expense- if you buy the best- or a lot of upkeep- if you don't.

Labor -is more expensive even. The materials and the present methods of construction are such as to require a maximum amount of handling, and allow a minimum amount of efficiency. Any change in the complicated procedure is carefully avoided and the different trades seem to cooperate only in their attempt to thwart possible progress.

Land -is another item that is becoming more of a political issue. It has been abused for speculation purposes. Land is the most preposterously priced commodity in the building of a house- and as it is the raw material and can hardly be dispensed with, it sets a great obstacle in the way of the housing reformer.

Time -is also an important factor. For one thing, the time that passes between the closing of the transaction with the builder, to the

Time

-time when the house can be inhabited, is lost to the owner. This stretch is very long at present- due to the fact that the work depends in its progress on the weather and that every house has to be assembled in the manner of a gigantic jig-saw puzzle out of thousands of parts. Also, usually there is a long drying period. The seasonal character of the work also raises the expense of the work about twenty to thirty per cent. And last not least, time has to be accounted for in the maintenance cost of a house.

Here, then, is the problem. To make the product accessible to the consumer, the cost of the factors that go to make it must be reduced. How this could be done is a question that has been widely discussed; and what this thesis proposes to do is to show the possible development from one of the solutions offered.



## THE INDUSTRIAL APPROACH.

During the last years housing has become more and more of a public issue, and the inadequacy of the building industry to meet the problem has been discussed far and wide. The reason for this complete failure that has crystallized out of the chaos of arguments is that the building industry really is no industry, in the modern sense of the word. It is rather an assembly of trades, poorly organized, working without proper cooperation and coordination. The tremendous waste of labor and material arising out of this situation can only be eliminated by application of modern industrial principles and methods in this field of production. These principles are:- Simplification and efficiency of procedure, elimination of waste, coordination of effort, standardization and mass production, and reorganization of the financial and economic methods. Applied to the specific case this means:

1. Use of as few, and efficient materials as possible; ideally, to find two or three basic materials that would serve the varied functions they have to perform, that would need little or no processing and finishing, and that would not deteriorate.
2. Centralization and coordination of labor, exact

machining to eliminate waste, careful organization of the processing to insure efficiency, mass production of unit parts that are standardized.

3. Solution of the "raw material problem" -the land value- and of the question of financing, through a special agency to handle mortgages and loans, probably also real estate, with no ulterior motive than to create a large market for the product and making it accessible to a larger number of people.

4. Independence of weather and season, thereby insuring continuous use of labor and machinery; concentration of the time span between the buying and the occupancy, thereby giving the buyer a better value.

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*achieve*

It will take years, possibly decades, to perpetrate these changes.- And it may also be that in the meantime a different approach will be found, more satisfactory than the industrial one. But the fact is that a great deal of experimenting, organizing and constructing will have to be done, and many mistakes are bound to be made. To attempt even a complete analysis of all the questions involved would in a thesis like this be impossible. And

it is clear that the theme I actually chose is a long way ahead of all practical possibilities. The more so because of the many attempts during the last year or two in this direction none have actually arrived, and the material that has been gathered by a few experimentally minded people is enviously guarded and almost impossible to get at. In spite of this I chose the subject, for two reasons. One, that the issue is very much alive and offers possibilities for study through the numerous connections with various aspects of our civilization- and two, that it is of vital importance to get the attention of the public, because of the many sides of the problem that can and will only be solved through pressure of public opinion and active participation of all the people who realize the importance of finding a solution to the housing question, for their own sake and that of society. That alone, I think, justifies the attempt to contribute even the slightest bit to the work that so many excellent brains are doing a great deal more thoroughly and completely. Having no laboratory I could only draw conclusions from the experiments of others, and make certain assumptions on the basis of the results. Considering that it will be at least a few years until a final scheme will crystallize, it was only reasonable to assume a probable development up to that time, and hence start from a

point, which, to my mind, forms a condition necessary to the actual materialization of the idea. Excepting this, I have tried to keep to solid ground as far as possible, and to avoid a guess whenever a clue was available.

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#### THE MARKET.

The need for decent living standards is being realized more and more as of vital importance to the well-being of society. As our demands grow, a larger percentage of dwellings has to be discarded each year as obsolete and replaced by new ones; and as the population of the United States is still increasing- although at a decreasing rate- a great number of new homes is required every year.

Statistics show that the number of replacements needed in each decade has risen steadily from an annual average of thirty thousand, during the decade ending in 1850, to one of 320.00, in the last decade; and the continuation of the curve shows that approximately 380.000 replacements will yearly be necessary in the current decade. The rate of additional new buildings

has also risen, though less abruptly, from 130.000 annual average in the decade ending 1850, to 360.000 in the years between 1920 and 1930. During that last decade the boom stimulated building to a degree that exceeded the needs, and therefore a reduction in the number of additional dwellings needed between 1930 and 1940 is reasonable.

Assuming an annual average of 210.000 additional homes and adding 380.000 for replacements, the total number of homes to be provided during the current decade amounts to 590.000 a year.

But there we have not taken into account the dead calm in the building activities since 1930. There definitely exists a shortage of homes in the United States and the conclusion from statistics of existing conditions, and from trends, range the deficit somewhere between 800.000 and 1,200.000 homes. This is a conservative guess. The shortage of decent housing has been estimated at 35% to 50% of the total.

This means that in order to eliminate a shortage of 1,200.000 for the next ten years America will have to put up 710.000 homes per year, and about 2000 per day! A formidable task, when one thinkd of the amount of work and time it takes to finish just one house, with present methods.



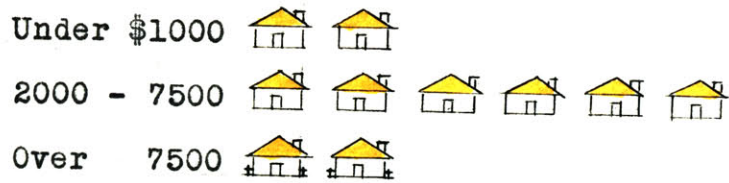
Surely, an enormous field like that should be able to keep many people busy- including some architects. And although residential architecture does not at first sight seem as interesting or impressive a problem as some larger scale building, yet that is where more than half the money spent by the nation on building goes; moreover, as a sounder investment. (Chart One)

Closer study shows that among the non-farm houses that are owned (not rented) the greatest number range between \$2000. and \$7500. in price. (Chart Two) The percentage of houses above 7500 dollars is quite a bit lower, and still lower under \$2000. This does not correspond with the distribution of income groups, for a simple reason: the lowest income group, although the most extensive, is the least represented among the small house owners, because they usually want to live near their work and cannot afford the cost of transportation to places on the outskirts of cities where a single house might be built; and the main reason, that the prohibitive land values and high building costs make it more rational to live in an apartment house. Hence few very small houses-that are not farms-are built.

It is mostly the professional classes that constitute the market for small one family houses. They can afford

PRICE RANGE

Owned Non-Farm Houses.



\* Each house represents 10% of total

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to give their families pleasant surroundings and to travel a distance from the suburbs into the city where they work; it is also the people in small towns that want a home of their own. But many more dream of it than can reach it; and when they do reach it, they very often have to sacrifice years of financial freedom and security. Buying a house will have to be made easier, simpler - not a nightmare full of threatening traps to stumble into. As it is now, the prospective owner has no way of judging the value he gets in return for his investment- till it is too late. He has to trust the innumerable people who have undertaken to build his house for him. If the market for small houses is to be reached to its full extent, the act of buying a house will have to be easier, clearer and safer.

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PRE-FABRICATION.

The statement that the building field is the only one that Industry (in its modern sense) has passed by so far has caused much raising of eyebrows.

"Houses made by machines" is a phrase that (conjectures)

*conjectures*

up before the eyes of the home seeking citizen pictures of endless rows of identical houses, drab and cheap; the individual would go mad, would actually cease to be an individual, in these standardized homes, they say. (But are the houses of yesterday really so varied?) And then: every house performs a different function, is dependent on the site, orientation, climate, and the environments. But these arguments can be met, and most of them do not go to the point at all. And as people begin to grasp, what really is meant by "pre-fabrication" their objections slowly vanish before the sound ideas of men who have arrived at this solution in the course of long study. Mr. Atterbury, in the "REGIONAL SURVEY of New York and its Environs" (1931) states the answer in the clearest possible way: "..... Now the obvious economic solution lies in the standardization, not necessarily of the general plan but of its various component units and structural elements. Carried to its logical conclusion this principle would result in a system of standard dwelling manufacture, in a ready-made system, if you please, of whole-sale fabrication like that which has already given the worker his cheap shoes and ready-made suit of clothes."

In other words, pre-fabrication of houses means practically this:

1. The transfer of the building process as far as possible from the field to the factory, thereby becoming independent of the seasonal restriction.
2. Standardization of the structural elements to a degree compatible with maximum flexibility and ease of handling.
3. Organization of wholesale production of houses on principles of shop manufacture, elimination of waste, standardized quantity production and machine manufacture.
4. Use of as few materials as functionally possible , because of manufacture and elimination of conflicting stresses.

In addition there is the possibility of having highly skilled talent generally available for designing the houses and combining out of the given unit any kind of house the client may desire.

The key to pre-fabrication of houses is <sup>the</sup> a unit. A structural unit that can be the basis for many different plans and various shapes; that can be used in an infinite number of combinations and variations; a unit that will be not too small for efficient production and easy assembly and not too large for transportation.

Anything on the scale of a brick obviously involves

too much handling. The first steps towards reform grew out of a realization of this fact, and the attempts to build out of larger, precast concrete blocks were the reaction. But the improvement here was naturally only a slight one, as the method, and the thought behind it, was inherently still the same. The house that was poured in concrete showed the search for new ways of thinking; but it shifted the problem of unit manufacture to the moulds, a method that proved unsatisfactory. The first scheme that really developed a unit based on the scale of the human figure was that which is being used by "General Houses" in Chicago and by "American Houses" in New York. It is a unit of storey height and door width- i.e., about nine ft. by four ft.- to form the walls, and the same width combined with different lengths to span the ceilings. Through the interchanging of the units and the substitution of a door, a window panel or a fire place, for the plain panel, flexibility is insured even in a finished house for changes or additions. The number of plans that can be derived from this basis certainly should suffice to cover practically any need that could arise in the way of one family houses.

In order to find criteria on the basis of which a pre-fabricated house can be termed successful, it

will be helpful to state what in general will be demanded.

Structural systems with pre-fabricated units joined together by pressure or bolting.

Materials for walls that effectually exclude heat, cold, dampness and sound.

Weathertight joints through-out, not subject to deterioration.

Exterior surface of walls should be hard and durable, requiring little or no maintenance.

Wall units of uniform size to permit interchange of parts, maximum flexibility of plan and elevation.

Interior wall surface suited to cleaning with soap and water.

Structure resistant to corrosion and attack by insects and fungi.

Absence of projections that gather dust.

Dry construction, rapid assembly, and hence early occupancy.

Light weight.

Minimum flashing.

Wall construction capable of housing or attaching heating, wiring and lighting, pipes and ducts; preferably

on the inside of the house.

Insulation that prevents condensation within interior of house or within walls.

Parts capable of replacement and addition.

Erection and installation of units by unskilled labor.

Possibilities for demolition and re-erection on a new site.

Resistance to earthquake and heavy wind pressure.

Lightning proof.

Fire-proof throughout.

Economical of space, because of thinness of walls.

Possibilities for natural or applied color.

Windows of uniform and standard size permitting maximum day-lighting and control of fresh air and sunlight.

Roof drainage through center of house for economy of required piping and to prevent freezing.

Soundproof partitions.

Interior partitions flexible and capable of varied arrangements.

Closets, cabinets and equipment as units.

Minimum cost of construction and upkeep.

In addition the house should offer more value for the money than a house built by usual methods. It should not jar too much with tradition, in use and appearance. It should also be economical and efficient in terms of living comfort.

## CONSTRUCTION.

The method of constructing and assembling the units has become the subject of many discussions and experiments. Among the many solutions offered there are some that mean a radical change from traditional construction methods—mainly the Dymaxion house of Buckminster Fuller, which is based on the principle of suspension and tension instead of weight-bearing compression members. His idea of uniting all the utilities in the house has been accepted as sound and will most likely be incorporated in the "house of the future." But his general scheme is too far ahead of our living traditions to be accepted today. The similar idea of the Bowman Brothers has not been realized yet for the same reason.

Whether a suspension or compression type of construction is used, will have to be determined by experience. At present the suspension types have not been very far developed; but they promise to <sup>be</sup> cheaper in the long run, partly because of the saving in foundation. The weight-bearing construction types are ahead at present, and several attempts are being made to adapt them to the new method of manufacture.

Here the alternative is between a frame structure of wood or steel with insulating board as filling material ("American Houses") and the wall-bearing type

of construction, usually with metal panels, covered with insulating material of some kind ("General Houses Inc.," American Rolling Mills). Concrete, the third possibility, has proved too costly in a small house, and it is hardly the right material for mass production.

But it seems that the other systems are not entirely satisfactory either.

Pre-cut wood has the long tradition of building use to recommend it, and the qualities that have made it one of the most likable materials- color, grain, workability, thermal insulation value and great tensile strength. But it has the disadvantage of being subject to deterioration through weather, worms, insect and fungi, and of great fire hazard. Besides, the fact that wood is subject to form alteration makes it unsuitable for exact machining. The treatment against some of these handicaps is long and clumsy. Also the material is not homogenous, which is another disadvantage in machine production. Steel frames, used as a substitute for wood, do not make for a great improvement because of weight, danger of corrosion and the difference in price; or, if steel is used in "skyscraper" construction it is also too costly and often a waste of material.

Steel panels have so far been the most successful; but even this is no ideal solution. Steel in addition



to the disadvantages just mentioned is no sympathetic building material to eye or touch. The finish- usually paint- has to be renewed frequently; also the panel has to be duplicated by the insulation material.

The ideal solution therefore would be a pre-fabricated wall- and floor unit containing its own finish, insulation and structural strength, with means for housing ducts and electric wiring. None of the units so far developed actually fulfill all these requirements, and the reason is that no material has been used that covers the need. Surely among the many thousands of materials that are available to the engineer of today there must be at least one that combines the qualities we are looking for?

## MATERIAL.

As a matter of fact, there are almost too many different kinds of materials in existence. The patents for various insulating boards invented during the last ten years would alone fill a small volume. But although there is much to be said for materials that have been made to perform one certain function, and one only, in the question of machine production the use of as few materials as possible is advisable, for reasons of exact machining, simplification of procedure and elimination of conflicting stresses.

The problem therefore consists in finding a material that combines as many of the necessary qualities as possible- strength, insulation value, hardness, and so on.

There are a number of materials answering these requirements in existence. The fact that they have not yet been used extensively in the building industry can only be explained through the circumstance that they are comparatively new inventions and as yet expensive in production. These materials have been termed "plastic" materials. They are resin products and vary with their chemical consistency. The one that has the best possibilities for building is bakelite. It is a

resinoid product made of phenol and formaldehyde under heat and pressure and can be moulded into different shapes. Once hardened, the compound cannot be dissolved again. Bakelite consists of this chemical blend with addition of fibrous material that gives it great tensile strength and toughness when hardened.

This material is light, very strong, hard, practically incombustible and not susceptible to influence of acids; it can be finished to any shape or color, has a very high insulating value, requires practically no maintenance and can be cleaned with soap and water; also it is vermin and insect proof and not subject to corrosion, and can be machined to great exactness. Its use so far has been multiple: for wall and table coverings, pipe joints, I- beams, gear-wheels, bath tubs, soap dishes, trays and bracelets- besides many other things. Although it is made out of the waste products of other industries, it is still too expensive to have found the extensive use it deserves. But the producers are sure that in large scale production it would become much cheaper; and it seems as though its application to house production would simplify the manufacturing process so much that it would mean a great saving very soon.

Bakelite may be an answer to the quest for a building material adapted to pre-fabrication. It is

difficult to tell before many experiments have been made and experiences gathered. But looking ahead about ten years it is very likely that some material of similar qualities will be found and that only this will be the starting point for quantity production of houses.- In this thesis I have assumed that bakelite will be the basic material of the production process, used for the structure and shell of the house, for the pipes and plumbing fixtures, for doors, built-in closets and possibly even some furniture equipment. This is no rash assumption- it is much more likely to be followed by success than the attempt to squeeze old construction methods into new ways of production- a half-hearted start that is destined to failure.

## ORGANIZATION OF THE PRODUCTION COMPANY.

In view of the urgent social and economic need to provide a type of house that is better planned, better built and better equipped than the house that is available at present for the same amount of money, it is assumed that a building company has decided to invest a certain sum in the formation of a new organization and a production plant to supplement its function. Their intent is to make the investment pay through access to a large market and carefully applied industrial principles, coupled with the greatest possible compliance with the wishes of their clientele. To this purpose the following outline is mapped out:-

Four functions are to be performed in general.

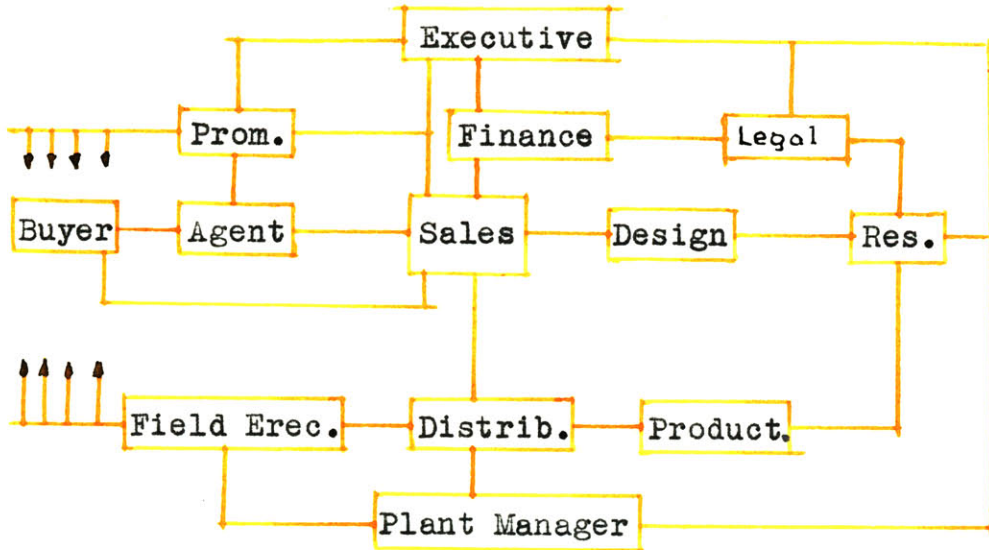
1. Administration
2. Research
3. Production
4. Distribution.

The Administration includes:-

A. Exectutive.

B. The Sales Department. This is the point of contact between the prospective owner and the production. The Sales Department will have agents, representative of the company, stationed in the main centers all over the country. A man wishing to buy a house connects up through this agent. He states his need exactly- either by

# ORGANISATION DIAGRAM



answering a questionnaire, or by correspondence, or in a personal interview with the agent or possibly with a "travelling salesman" who in this case, of course, would be an architect. This statement of the buyer is transmitted by the Sales Department to the Designing Department, where a house to meet the specific need is planned by skilled architects on the basis of the manufactured structural units and parts. On the other hand the Sales Department connects up with the

C. Financing Department. This arranges the terms of the sale with the prospective owner, possibly in form of long termed loans or through mortgages, in many cases probably simply as installment payments. The department can operate without looking for profits and only has to cover overhead costs. It will also take care of any land transaction that is made by the company.

D. Promotion and Advertising. In connection with the Sales Department there will be a small staff continuously studying the market, keeping statistics and charts to show changes at each moment. This staff will also do the work connected with publicity and promotion; they will design clear and striking posters to show the progress made, on the basis of the statistical material.

E. Legal Advice. In connection with the

Financing Department there will be a possibility for legal service; this department will also take care of all the questions regarding patented material or production methods, new discoveries in the research department, or involved labor conflicts.

F. General Management. Organization and adaptation of the production process in step with the progress made by the Research Department is the task of this department. It will also have control of the operating process and supervision of assembly, distribution and erection. It will have the management of the cafeteria and kitchen for the employees and be responsible for maintenance of the grounds and possible repairs. The employment office is coordinated and also has control of the social provisions for the employees. The most important among these will be the provision of housing in the neighborhood of the plant from products of the factory, thereby giving a demonstration ad oculos of what can be done in the way of efficiency, variety and pleasantness through the new method. This department is the link between the administrative and the manufacturing divisions of the plant.

The Research Department consists of three main



divisions:-

A. Designing. A staff of highly skilled and talented architects are available for every single client who applies for a house. They design the complete building, including standard equipment and possibly furniture, using the units and parts manufactured by the plant as basis. They give advice, if changes or additions are desired; and the success of the entire project depends on their ingenuity. They are connected with the Sales Department, and also, of course, with the

B. Engineering Department. Here new construction methods are developed and tested, and materials are tried for physical strength, in cooperation with the

C. Chemical Department, where materials are analyzed and tested for their consistency, purity and general qualities. New materials- compounds- are developed and tried, and the possibilities of color and texture explored.

Subordinated to the Management Office are Production and Distribution.

The Production process consists in general of receiving, processing and shipping. The raw material- the Bakelite powder- is bought and shipped to the factory. There it is unloaded, tested and stored. Then it is machined and finished, and the different parts assembled to the degree that is compatible with efficient transportation.

A certain percentage of the finished houses will be put up on a test field as a control and then ~~taken~~ apart again and shipped away like the rest.

Distribution is handled by trucks and railway, if possible also by water. The parts are shipped to the site and assembled there by local (unskilled, not specially trained) labor under supervision of a skilled erection engineer in as short a time as feasible.

The cost of transportation is a serious obstacle to the pre-fabricated house, as the market decreases with rising prices and hence with increased distribution radius. Even a very cheap house would become unduly expensive if it had to be shipped across the continent. Hence the company proposes to start off with one medium size factory, that will supply the market as far as possible at the beginning, but, instead of expanding as the market increases, will be supplemented by other plants that will be built in succession at desirable points all over the United States. This will be a great saving in transportation, will also facilitate contact with buyers, and may even open up a possibility of ~~taking~~ into consideration the climate and location of the houses not only in the design (this of course would always be done) but also

in the units themselves. The company hopes to have about four or five plants scattered through the country finally. Combined, they should be able to meet any demand.

## THE SITE:

The company in the quest for a site for the first plant specifies the following requirements, as a logical conclusion from the functions outlined:

The location of the first plant is to be central in relation to the distribution of the population in the United States, to facilitate as even and complete a supply as possible. The plant is to be situated in or near a medium sized town, within easy distance of a labor market. It should have access- direct, if possible- to waterways, highways and railways. It should also have easy means of connection with some sort of power- oil, coal or water- and with the industries that manufacture products used in the houses but that are not made in the factory itself. The site should have pleasant open surroundings, if possible, with building lots available nearby, to offer the chance of developing in time a small settlement of pre-fabricated houses for the employees of the factory; at the same time this would serve as a most effective advertisement for the product of the Company.

## SELECTION OF THE SITE.

Following along the lines of the requirements the site is decided on by way of elimination.

Throughout the entire area of the United States

sites are available. The consideration of transportation, which should be possible in every direction with a radius varying in proportion to the density of the population, excludes the areas along the border lines and on the ocean shores. The States West of the Mississippi are also out; the railroad net is too scarce and the sources of power and material scattered. That leaves the middle West and the upper part of the Southern States. Transportation facilities are excellent all through this part. But the main sources of power and raw materials lie farther North, also the centers of the building industries, which will have to supply some finished parts and materials as glass, lighting fixtures, rubber, aluminum, etc. St. Louis is eliminated in spite of the advantages offered by the Mississippi, as it is not convenient to these industries, and too far removed from the densely populated Eastern States.

For closer choice there remain Pennsylvania, Ohio, Indiana, Illinois, Kentucky and West Virginia. A glance at the map shows that only a very few cities in these States can be considered. The towns where main railroad lines converge offer great advantages over all others; and the existence of a navigable waterway nearby is another important consideration. There are only six towns in the area that answer these requirements: Pittsburgh in Pennsylvania; Cleveland, Mansfield, Columbus and Cincinnati in

Ohio; and Chicago, Illinois. The latter would be well suited, but it is too large a city for the purpose; the company would prefer a smaller town with opportunity for development. Pittsburgh is slightly too far East and has too much of the character of an industrial town to provide the desired pleasant surroundings. Mansfield, Ohio, does not offer a waterway at close hand; and Columbus is not very convenient as a railroad center.

There are therefore only two cities left to choose from: Cleveland and Cincinnati. Both of these offer excellent connection and are well situated in relation to supply with material, labor, and power, and as distribution center. But it will be seen that Cincinnati is slightly more advantageous <sup>for</sup> to the purpose than Cleveland. It is closer to the population center and has better access to the South. It has, in fact, the advantage of being "the most" Southern" Northern city, and the most "Northern Southern " city. Railroad tracks radiate in all directions supplying direct connections with New York (and hence New England), Philadelphia, Washington, Charlottesville in the East, Birmingham, Memphis and New Orleans in the South, St. Louis and Kansas City in the West, and Chicago, Cleveland and Pittsburgh in the North. It has a navigable river, the Ohio, that constitutes a connection with the Mississippi

and hence the Gulf. There are large coal fields nearby in the East and West, also waterpowers, and gas production in the whole region. The centers of the building and glass industries are at hand, besides the steel and machine production. Also there is a Bakelite factory already in Cincinnati which fabricates a special type of thin laminated wall covering; not only could this product be used in the manufacturing and thereby duplication of processing avoided, but also the raw material for the compound could be supplied from the same source that the existing factory draws from. Cincinnati has an advantage over Cleveland in that it is smaller and more suited to the purposes of the Company, who wish to find a site in partly undeveloped surroundings, so that the opportunity is given to set off the plant by a carefully planned development around it, and so enhance the significance of the entire project.

For this purpose a suburb of Cincinnati, possibly a satellite town not too far away, would serve ideally. And the ideal answer is found in the town of Mariemont, ten miles from Cincinnati. This town has been developed according to a plan, primarily as a residential district, intended for wage earners of different economic grades. It has been planned on the modern principle of space, light, air and healthy living and consists mostly of

small of small houses, but also of some apartment houses. It is thirty minutes from the center of Cincinnati by bus or train.

The state highway from Cincinnati to Columbus enters the town on the Southwest and intersects at that point with the Norfolk and Western Railroad, and the Pennsylvania Railroad (The Baltimore and Ohio R.R. passes near to the town). This is where the railroad station is placed. From this intersection a long piece of land stretches along the railroad, bordered on one side by an industrial road and the tracks, and on the other by a main thoroughfare, Mariemont Avenue, that meets the highway a hundred yards before the railroad crossing. This stretch of land has been set aside in the town plan of Mariemont as an industrial site. So far it has not been used.

It is obvious that this is an excellent location for a plant of the type that is being planned. It is complete with railroad and highway facilities; this proximity to the main public thoroughfares also is a good advertising feature. Close to the site are building lots, partly already built on, all completely provided with sewer system, water, gas, telephone and electric light. On the other side of the main highway (to the North West) is undeveloped area, which would be



suitable for any new housing development the company would propose.

The main disadvantage of this piece of ground lies in its shape, which is very long and narrow; but this is no serious objection, as the factory itself easily and logically takes that form because of the line of production. For all these reasons the company decides on the Westover Industrial Section of Mariemont as a suitable site for the first production plant of Bakelite houses.

#### THE PRODUCTION PLANT.

##### BUILDING PROGRAM.

After deciding on the appropriate site for the location of a factory the company states to an architect the demands that have to be considered.

The statement follows:

The proposed building program consists in providing shelter for the entire production process. This process is divided, as usual, into two functions: Research and manufacturing, both under the control and supervision of the administration. The administration building shall house offices of the executive, sales and financing department, promotion, legal service and comptrolling department. It shall be accessible from the research building. This comprises

a section for designing, and space for chemical and engineering laboratories. There shall be, if possible, a connection between the administration and the manufacturing division through the offices of the general management which should for control purposes be housed near the manufacturing building. This should have provision for receiving and storing material, a large and flexible section to house the machining process, a section for storing the finished parts and space for assembling and shipping. It will also contain the shop offices which control these operations. In conjunction with the final assembly there will be required a field to test procedures of final assembly on the lot. Social facilities- assembly hall, club house, and a cafeteria will be provided for the employees. There also will be an exhibition ground near the administration building where model houses are put up for demonstration to visitors.

There follows a detailed description of the requirements.

## REQUIREMENTS:

The problem presented to the architect for solution is the planning and coordination of the required buildings according to their functional relationship.

### A. Administration Building.

1. Lobby, Information Office, Waiting Room, Lounge.
2. Executive Offices: Private Offices for President, Vice-president, Research Manager, Secretary, Treasurer, Managing Director, Sales Manager, Production Manager. Board Room. Office space for secretaries.
3. Sales Department: Office of Assistant Sales Manager. Space for Sales Records, and for Promotion and Statistical Division. Files.
4. Comptrolling Department: Private office of Comptroller. Space for accounting and files.
5. Financing Department: Offices for Financial and Legal Service.
6. Garage: Parking for cars of the personnel of Administration and Research Buildings. Service Station.
7. Services: Necessary elevators, stairs, lockers and toilets throughout the building.

### B. Research Building.

1. Designing Department: Offices of Chief Architect and four assistant architects. Drafting space. Space for making models.
2. Engineering Department: Offices of Chief Engineer and four assistants. Testing Division for trying physical qualities of materials. Drafting space.
3. Chemical Department: Offices for Chemist and four assistants. Laboratory for testing and

analyzing materials. Space for studying visual, acoustical and thermal qualities of material.

5. Reference Library.

C. Manufacturing Buildings. (One or more.)

1. Management Offices: Private Office of Factory Manager. Secretaries. Offices for assembly and shipping managers. Space for employment offices with doctors examination room, and for managers of employees' social facilities. Offices for Inspectors.
2. Receiving Section: Covered Loading Platform adjacent to railroad siding and industrial road. Inspection rooms for testing of raw material and finished parts.
3. Storage Section: Space directly connected with the Loading Platform for storage of raw material, half finished products that come from other factories and stock room for the finished machined parts.
4. Tool Storage: Office of Supervisor, and space for tool storage.
5. Molding Shops: Space for housing the molding machines. Division according to the parts molded.
6. Finishing Shop: Space for soundproofing and finishing molded panels.
7. Metal Shop: Space for machining window frames, reinforcements and special fixtures of metal.
8. Primary Assembly Shop: Space for Assembling and joining foreign materials and pre-made parts with the panels and necessary fixtures.
9. Final Assembly Shop: Space for assembling parts as far as possible according to the specific plan; this should be adjacent to the Stock Room where the finished parts are sold. stored.
10. Shipping Section: Office of Shipping Manager. Space for packing and loading.

11. Power Plant: Space for power and heating equipment.
12. Services: Washrooms and lockers for the workers.
13. Test Field: To control ease and time of erection on site.

D. Social Facilities.

1. Auditorium: To seat <sup>three</sup> four hundred at lectures and assemblies. Private room for lecturer. Services.
2. Club Rooms: Games, reading rooms and library. Lockers.
3. Cafeteria: Kitchen; cafeteria to seat two hundred at a time. Private dining room for members of the administration.
4. Parking: To serve in connection with the Club and Auditorium at night.
5. Noon-time Recreation Grounds: Accessible from the Club rooms.

## LAY-OUT OF THE FACTORY.

The following section of the report deals with the arrangement of the factory buildings on the selected site. This arrangement has to be determined on in view of the main considerations that affect the planning of any production plant: ease of receiving, processing and shipping, flexibility, interrelation of coordinated departments and clean division of functions; also, of course, circulation and control. —

### Description of the site.

The Westover Industrial Section is a flat piece of land that stretches along the railroad line nineteen hundred feet long and two hundred and eighty feet wide. Beyond the railroad tracks the ground slopes rather abruptly down toward the river. Between the main tracks and the building site there runs an industrial road and a railroad siding which is adjacent to the building line. The main approach to Mariemont from Cincinnati enters from the Southwest and intersects Mariemont Avenue- on the Northwest side of the lot- nearby. The part of the grounds which lies closest to that intersection therefore has the most advantageous location as far as advertising value goes. This part is separated from the rest by a small industrial road; another one,

parallel to it, divides the remaining lot into two equal parts. Both of these roads might easily be eliminated, as they duplicate the function of the road on the south of the lot, which connects up at both ends with the Avenue. The first and more important of these streets might be well utilized as way of access to the factory. It forms a natural division between the manufacturing buildings,- on the larger pice of land, utilizing the full length of the railroad siding for receiving and shipping purposes- and the smaller part of the lot, nearer to the main highway and approach, and hence better suited for the representative and more public part of the plant.

The administration tower, as connecting and coordinating link between the two parts, is situated on axis of and over the entrance driveway.

The Administration Building.

As the most representative of the structures, and the one controlling all operations, this building is given a location which makes it possible to relate it to all parts of the plant. It is placed in a position commanding the view from the main highway, right over the entrance drive, which leads under it directly into the garage in the rear. From this first floor<sup>r</sup> vertical circulation is provided up through the centre of the building to all floors above. There is space for visitors to park their

cars without driving into the garage. The main floor containing the lobby, and waiting room with information is on the floor above, with a terrace overlooking the exhibition grounds, This lobby can be reached by stairs directly from the street.

The exhibition area is placed on the most prominent position west to the Avenue, where it can also be seen from the cars passing on the highway. Special house models are exhibited here on a setting of trees and planting.

#### The Research Building.

The main consideration here is isolation from the noise of the processing and the railroad. For this reason the building is placed on the smaller lot, away from the manufacturing buildings, toward the exhibition area; on one side it faces the Avenue from which it is separated by a garden and a row of trees, on the other is the parking space for the Auditorium, which would only be used at night and hence insures quiet working hours.

#### The Manufacturing Building.

The position and plan of the Manufacturing Building are determined by the relation of the line of production to the points of control and to the transportation facilities. It will easily be seen that it will be more advantageous to bring the finished but not yet assembled product as near as possible to the center of Management.



For as the sequence of assembly and the choice of the parts to be assembled is dependent on the specific plan, a connection between the Assembly Supervisor and the Administration is desirable. There is also the added advantage of bringing the field for erection testing closer to the Management Offices. This test court creates a very desirable open space between the building housing the machines and the administrative parts. For these reasons the receiving end of the loading platform will be farthest removed from the entrance.

#### Management Offices.

Ease of control and supervision, access to the Administration Building on the one hand, the Manufacturing Plant on the other, are the important considerations here. There is only one possible location that complies with these requirements: North of the testing field, between the Administration Building and the Assembly Shop of the factory. By situating the Employment Offices there it is possible to control the workers main circulation and entrance from the Avenue.

#### Lounge, Cafeteria and Kitchen.

The cafeteria, of all the buildings in the recreational

group, is the one that is used by most workers and requires most servicing. It should be served by the same kitchen, if possible, as the private dining room of the Administrative Staff. The major factors that influence the location of the kitchen and cafeteria are easy connection to Administration, Research and Manufacturing: good servicing and distance from the noisy machine halls,- and isolation because of kitchen smells. The best solution possible in this case is to place the cafeteria above the garage in the rear of the Administration Building. Here it can be reached by the same staircase either from the field directly, or through the lounge which is situated on the ground floor alongside the Administration facing the field, and accessible directly from the workers main entrance. The cafeteria is also in direct connection with the main lobby of the Administration, and is serviced from the same pantry as the dining room, which is placed above the workers lounge. The kitchen is directly underneath the pantry, beside the garage, where it can be serviced easily from the main truck circulation and possibly even the railroad.

The Clubrooms- are placed on the opposite side, on two floors- the top one directly accessible from the circulation to the cafeteria, with stairs leading down to the game rooms and lockers. The recreation field is reached directly by passing <sup>in back of the Auditorium - it is shielded from</sup> the railroad by a wall and

faces the exhibition grounds. The trees and planting on the recreation field would serve as a background for the exhibited houses.

#### The Auditorium.

This building is the one that would be used at a different time, and possibly by different people, from the rest of the plant, To make it possible to use it independently it is <sup>placed</sup> on the outer end of the clubrooms, terminating these, with a separate gate open only at these occasions, and a drive leading directly up to the Hall past the exhibition area. The parking space is adjacent to it shielded from view of the street by the research building, and enclosed on the other two sides by the Administration Building and the Clubrooms.

#### The Power Plant.

In order to be easily supplied with the fuel necessary for operating the power and heating plant, this building has to be near the railroad siding. The other important factor influencing its location is the equal and efficient distribution of energy and heat. As central a position as possible will answer that requirement. There is one obvious place, namely on the South of the testing field, adjacent to the loading platform; with the shipping section on one side, and the kitchen

on the other, separated from them by the truck drive  
to and from the test field.

#### ARRANGEMENT OF DEPARTMENTS WITHIN THE BUILDINGS.

The factors that influence the placement of the different departments are in general: Inter-relation, coordination and production character- plus considerations of lighting, ventilation and circulation;- line of production, sequence of machining processes and organization of material handling as to quantity, weight and direction. Efficiency will be insured through centralization of control and distribution of the general services. Flexibility is desirable in the manufacturing process in order to accommodate changes in production. It will not be necessary to provide for expansion, because an increase in demand will be covered by the additional production plants that are projected at other points of the United States.

Administrative Department.

The considerations governing planning of the Administration Building are ease of control, accessibility to the public or privacy, light and air and connection with the corresponding department.

A number of reasons make it desirable for the Administration Building to be multi-storied. It makes it possible to relate departments through the vertical component, thereby facilitating a clearer and more direct organization. This also gives the building the architectural expression of its importance as dominating power over the entire plant. The ground level of the square building is kept entirely open except for the necessary columns that support the structure and the elevator shaft in the centre- to facilitate free circulation of the cars through to the garage or around and out, with clear space for parking a few visitor's cars.

The second floor contains the main lobby and waiting room, with circulation leading all around it and opening out one side onto a terrace which overlooks the exhibition grounds. On the opposite side it opens into the lounge of the Administrative Staff, which is adjacent to the dining room and leads over to offices of the Management, with a small staircase

connecting with the Employment Office below. The third side of the square opens directly onto the hall serving the cafeteria.

The third and fourth floors house the offices of the Executive and are arranged in such a way that the General Manager and the Research Manager are placed at the point of connection with the Research Building; in this way access to the Research Department is impossible for the public, but very easy and direct for the staff of the related offices.

The fifth floor contains the Sales Department, connected with the office of the Sales Manager below through a small private staircase, and placed in the logical position next to the Designing Department in the Research Building. The Promotion and Advertising staff is housed on this floor, for reasons of coordination.

On the sixth floor there are the offices for the Financing and Legal divisions, and space for the Comptrolling Department, with a private office for the Comptroller and his secretaries and room for accounting and files.

The top floor, commanding the view of the entire plant, and the pleasant outlook over the river, is partly taken up by the Boardroom. The rest of available space is developed into clubrooms and smoking lounge

for-the administrative staff surrounded by a terrace on three sides.

#### The Research Building.

The arrangement of the Departments are dependent on the functional relationship with the different Departments in the Administration Building, and on the consideration of accessibility to the public. It may be necessary to keep secret some of the procedures, and the actual work will therefore be done away from the " public eye, " which is always inquisitive.

For this reason, the ground floor is utilized mostly for storage of the materials to be used; but the part that faces the public parking space and the exhibit area will contain a small museum, or possibly photographs, to be seen by the visiting public.

The second floor, connecting up with the main lobby of the Administration Building, houses the Reference Library,- as being the only part that should be accessible to visitors.

The third floor contains the chemical laboratories and offices; the fourth the engineering division. On the last floor the Designing Staff is placed, connected with the Sales Department as mentioned above, and getting additional light from skylights for the drafting rooms.



The elevators are placed near the entrance to the Administration, with lockers and washroom close at hand.

#### Management Offices.

The functions of the Management are twofold:

First, all negotiations with the employees, payment of wages and hiring of workers, and second, responsibilities connected with the actual operating process, production management, supervision of grounds and repairs,- also all social and welfare activities for the employees.

In order to keep these two functions clearly separated they are located on two floors above each other. The employment offices are placed on the ground floor alongside the main circulation near the entrance. A control office is adjacent to it opposite the entrance; from here a stair leads up to the Administrative Lounge and the other offices.

#### Manufacturing Building..

Line of Production. In general the flow of materials has already been decided on. The raw material- the Bakelite powder- is received at the far end of the long and narrow Manufacturing Building. This being the basic material for most of the parts manufactured, the longer part of the loading platform is used for this purpose. The material

goes through the stock rooms and the inspection offices to the machine hall where it is moulded into the different required shapes- plain panels, joints, floor, roof and ceiling parts. It goes through a narrow shop to be soundproofed and finished and is taken past the inspectors into the storage room section. The more complicated panels- windows, doors, cabinets- also pass through the soundproofing shop and then are assembled with frames, fixtures etc.; then they also pass through a finishing process into the storage section. From here the parts are taken out as needed into the final assembly hall and thence to the shipping platform, or sometimes to the testing field.

Production Character. By far the most extensive procedure, and the one requiring most space, is the moulding operation. For purposes of flexibility between the subdivisions the entire moulding process takes place in adjacent shops with removable partitions. The difference between the simpler parts and the more complicated panels that require more machining is expressed through the direction of the production flow. This is also in accordance with the fact that a great number of the plain panels have to be fabricated to every door or window panel. Therefore the majority- all the simple ones- are moulded and machined in parallel production lines that start at

the storage section and cross the width of the factory to a conveyor which transports them to the final stock room. The panels that require assembling and fixing with equipment are the fewer but have by far the longer way of production to go through; therefore they follow along a line parallel to the long dimension of the factory, starting from a small storage section which branches out from the main stock rooms and passing through the machining shops in sequence.

These shops are connected with corresponding sections of the storage which supplies them with the necessary materials and parts.

For reasons of simplification of control the simpler moulding procedures are placed at the far end of the factory while the more complicated processes that also are more dependent on specific plans are located nearer the management and the assembly shop. This arrangement also makes it possible to maintain an uninterrupted storage line for the Bakelite powder that is clearly separated from the stock rooms for the other materials.

Circulation. The question of separating human traffic from the traffic of materials is an important one for the efficient operation of the factory. Due to the shape of the lot, a long circulation artery for the workers cannot be avoided. This artery runs along the entire length of the plant on the side opposite the

storage section with smaller branches going off at right angles to it. These smaller circulations run between the subdivisions of the moulding department, thereby connecting up with every shop and the storage section. The main artery is parallel and adjacent to the conveyor (which transports the finished panels past the inspectors into the stock room). Thus it does not cross the line of material handling at any point. It runs past the stock rooms and the assembling division, passing the offices of the assembly supervisor and the management offices, directly to the entrance hall. Directly off the hall the entrance to the lounge is placed. A secondary entrance, with Time-keeper, is located at the far end of the passage. The great length of the plant prohibits having only one entrance; ease of control has to go before convenience, efficiency, and safety. A number of emergency exits lead off the main artery out to the street.

For the workers occupied on the loading platform in the receiving and shipping sections a covered circulation leads away from the main artery passing the assembling room on one side, the testing field on the other, and terminating in the shipping section from where on the loading platform itself serves as circulation.

Storage. There are two kinds of things to be stored: materials and tools. Tool storage for greater convenience shall be distributed in a similar way as the other services throughout the factory. Space for this purpose is provided near the machines where they are used,- mainly in the shops for finishing and assembly. Materials will be stored at the places that logically evolve for this purpose out of the line of production. Here again there are two kinds: storage for raw materials and pre-made parts, and stock rooms to store the partly assembled and finished units before they are chosen for final assembly. The former space is provided along and parallel to the loading platform, the order being thus that the raw material is stored at the far end and the pre-made parts that are partly or entirely ready for assembly, nearer to the final stock rooms, because these, of course, need a shorter line of machining to reach the finished stage. The final stock room is placed at right angles to the long section and goes clear across the entire width of the factory, separating the processing from the assembly. Every piece of material that enters the assembling room has to pass through the stock room first and is inspected again before it leaves.

Shop Offices. Two considerations decide the position of the shop offices; one, ease of control through central position, and two, isolation from noise. It is usually difficult to satisfy both conditions, but in this case because of the unusual shape of the building it can be done. The offices controlling the operating process are placed at regular intervals corresponding with the shops on the other side of the **main** circulation artery- away from the machines, and facing towards the street, but separated from it by about thirty feet distance and planting.

The offices of the Assembly Supervisor and his assistant are placed adjacent to each other at the end of the assembling hall and open into it. The assembly shop as well as the stockroom are together then the general machine hall- the former in order to gain the clear height necessary for easy handling, the latter to make possible the storing of the <sup>n</sup>pareels vertically, which means a saving of space.

From the assembly shop the units go to the loading platforms, which are arranged at right angles to each other, with the trucks coming into the test court, while the railroad cars are shunted onto a separate siding under cover to keep the tracks clear for cars going to the receiving platform.

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