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THE RATIONALIZATION OF A SYSTEM FOR THE MANUFACTURE AND SHIPMENT OF INDUSTRIALIZED HOUSING

by

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ABSTRACT

All too often interest in the industrialization of housing is concerned with the product rather than the process. Much effort has gone into the design and manufacture of many different building systems and yet, to date, industrialization has made little impact on the building industry.

The manufacturer has been unable to aggregate an adequate market to sustain sufficient production to justify the industrialization of the building process.

The complete process of manufacture and distribution must be considered if a successful system is to be designed for industrialization.

An understanding of the implications of -- the present constraints, the concept of the value

added in manufacture, the available methods and costs of product distribution, the limitations to successful market aggregation -- is necessary to the determination of the final product design.

This thesis demonstrates that by rationalizing these factors into a complete system of manufacture, distribution and construction it is possible to successfully overcome the obstacles of market aggregation to the realization of the successful industrialization of housing.

The thesis concludes that working within the framework of present-day transportation capabilities and costs, the core and panel method of manufacture and construction offers the housing manufacturer an economically effective means for furnishing industrialized housing without limiting his choice of transportation method.

"Let the house be changed and arranged in order, and this will easily be done when they are first made in parts on the ground and then the framework can be fitted together on the site where they are to be permanent."

Leonardo Da Vinci, 1515

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I

INTRODUCTION

PURPOSE

INDUSTRIALIZATION: THE PROMISE

Not since the development in the mid-nineteenth century of the wire-nail and the machine-sawed light framing member, which led to the development of the balloon frame, has the home building industry realized any significant breakthrough in construction technology.

Arguments for the need of taking building from a handcrafted technique to a machine technique of production have existed since the beginning of the twentieth century. Architects and industrial designers have prophesied and experimented with systems for industrializing the construction of housing. Manufacturers, builders, and industry associations have spent millions of dollars to develop new construction systems. Each new system has been accompanied by the confident statement that "here at last was the technological breakthrough which the industry has breathlessly awaited," yet the industry is still waiting.

What then is holding back industrialization with all of its potential and promise? Some blame building codes, others, restrictive labor practise, and others transportation. Some blame the lack of back-up from the manufacturers who supply the industry. But if we look beyond all of these surface problems, if we really reach into the problem that includes and perhaps exists because

of all these problems, it can best be summed up as the lack of the manufacturer to aggregate an adequate market for his product.

Many promising building systems such as the Fuller House, the Lustron House, the Alside House, failed almost before they were born due to the lack of an adequate market. Industry has the available technology if only an adequate market can be developed to sustain it.

Progress is being made on the problems of codes, labor and transportation. The Federal Government has applied pressure on state and local governments to unify and reduce the number of their codes. Confronted with an industry wide labor shortage, labor has not been overly concerned by industrialization. Manufacturers who supply the industry are developing more and more products and systems for industrialization. Highway regulations, prompted mainly by the mobile home industry, have been eased to permit the shipment of larger volume loads.

Admittedly, these problems still exist within the industry, but they are not the obstacles they were just a few short years ago.

The major obstacle to the aggregation of an adequate market at this time is the cost of shipping the completed product over a large enough radius to provide an adequate market for the manufacturer.

Colin H. Davidson, in an article on Industrialization in the October 1969 issue of Industrialization Forum, made the statement: ". . .the distinguishing characteristic of industrialization is process; deliberate attention by all parties to the way building is implemented."

COMPLETE PROCESS DESIGN

The purpose of this thesis is to demonstrate that when industrialization is considered as a complete process, from the design of the product through the design of a system for its manufacture and distribution, that there is available, now, the means of overcoming the economic obstacle of shipping costs in the aggregation of an adequate

market for the industrialized housing manufacturer.

The data which are used in the demonstration are based on current technology, methods of transportation, regulations, and rates. The system proposed in this thesis is compared with and tested against other systems currently employed by industrialized housing manufacturers.

DEFINITIONS

In this thesis, certain terms will be used to describe the processes of housing unit manufacture, some of these are defined in this section.

INDUSTRIALIZED HOUSING

Industrialized housing embraces all forms and concepts of housing manufactured by duplicative techniques on a production line operation; the shape, size and type of the resultant shelter, product or materials employed is not of significance, only that it is "production line" oriented in a major portion of its manufacture. The

industrialized process, including processes for producing both residential and non-residential structures, does not require a permanent factory. There are certain industrialized systems which permit portable manufacturing facilities and equipment, and certain other systems which may be job-established for a single project only. The industrialized housing processes are measured by the labor efficiency of production line techniques, and not by location, status or resemblance to more familiar permanent types of factory operations. Industrialization encompasses all categories of concepts, systems, sub-systems and processes. The final product may be a concrete wall panel or a completed wood frame module.

COMPONENTS AND PANELS

Components are manufactured elements which contribute to the total building package: roof trusses, gable ends, dormers, balconies, etc.

Panels are sections of exterior walls, interior walls, floors or roofs. Panels vary in length

from a few feet to the entire partition or exterior wall length. Panels may be constructed of many different materials: concrete, steel, aluminum, plastic, etc. However, when referred to herein, panels are generally considered to be of a construction type meeting conventional residential specifications. Panels may be finished to any desired degree, from open stud walls to walls complete with window and door units installed, with exterior and interior finish completed, and with electrical wiring attached.

MECHANICAL CORES

Mechanical cores are factory produced modular units which contain a majority of the mechanical, electrical and related systems of a living unit. Cores generally contain the kitchen, one or more bathrooms, and the utility room complex. Wiring, plumbing, heating and cooling ducts, and other associated items are factory installed. In addition, such units typically include stove, range, bath fixtures, lights, finished floors, cabinets, counters, sinks and the like. Mechanical cores are sometimes

referred to as "wet cores" or "utility cores." They eliminate from the job site the most expensive portion of the entire construction process, substantially reducing on-site need for skilled craftsmen. Because of their size, several cores may be shipped at one time from the factory to the building site on a single flatbed trailer. Once at the site, they are erected on previously prepared foundations. The remainder of the house is then built around the mechanical core by either conventional construction or component systems, but the use of core units does not preclude their combination with other modular systems. These units generally range in size from 8 by 10 feet to 12 by 20 feet. They can easily be stacked one on the other for multi-story constructions and have applications today ranging from rehabilitation work in the urban center to new construction in the suburbs.

CORES AND PANELS

Core and panel construction is simply a combination of wall and floor panels and the mechanical cores assembled at the job site for the construction of the living unit. The cores and panels may or may not be made in the same plant or by the same manufacturer. It is also possible that the panels may be made at the job site.

MODULES: WET AND DRY

Modules are factory produced boxes of room size or greater. Such modules are fabricated and assembled in a factory for shipment to a building site, where they are connected to each other or to other systems to form a structurally complete building. Modules are generally finished on both exterior and interior while in the factory. Certain modules are "wet" modules containing a core which will include the necessary mechanical and plumbing systems for the living unit. The basic material employed in the structure of a module may be wood, steel, aluminum, concrete, or a combination of

these and other materials. Again, however, in this thesis wood is the assumed basic material of fabrication, used in a conventional manner.

UNITS AND BUILDINGS

Unit or living unit is used to describe a complete living unit for one family. It may consist of two or more modules or a core and multiple panels.

Building is the total structure consisting of one or more living units.

LOADED MILE COST

Throughout this study reference will be made to transportation costs based on the cost per loaded mile. This term means that the total transportation cost is figured on the one-way distance to the point of destination, and includes the cost of permits and transporter return.

Loaded mile cost should not be misconstrued to be synonomous with unit cost per mile. Two transporters might have equal loaded mile costs for a given distance and yet one transporter have twice

the carrying capacity of the other. The result would be that the transportation cost per unit of the larger transporter would be effectively half the unit cost of the smaller even though their loaded mile costs were equal.

II

BACKGROUND

ORIGINS

THE BALLOON FRAME

The construction of American housing in the 1830's experienced a major revolution. The products of new industrial production techniques--the wire nail and power-sawed light wood framing member--were used to develop a completely new system of building. It was called variously Chicago, Western, and Balloon framing. A radical idea at the time

of its introduction, it effectively reduced the cost of housing by 25 percent over the next score of years and made it possible to supply housing for a growing nation.[1]

By 1900 many systems had been developed for farm buildings and houses consisting of pre-packaged and pre-cut, studs, girths, sheet partitions and fittings, together with simple assembly diagrams.[2] These systems were marketed in urban and rural communities by local lumber yards. Simple house plans accompanied by a complete list of materials necessary to build the house were made available to the local builder. The lumber dealer provided the complete package of material for the house. The plan of the house was purposely simplified, and allowed the home owner considerable latitude in the way some of the rooms, particularly the kitchen and bathrooms, were completed and equipped. Although this method is no longer the common method of home-building that it once was, it is still carried on in rural areas throughout the United States.

Over a century has passed since the development of the balloon frame, yet the building industry has not realized a significant change in construction technology since its introduction. Methods of material handling have advanced and some new products for the exterior and interior finish of housing have been developed but the basic method of constructing housing remains the same.

EXPERIMENTAL HOUSING

Architects, builders and developers have long realized the necessity of another breakthrough, a new technology of construction of housing. Walter Gropius stated:

> Since 1910, I have consistently advocated prefabrication of houses in numerous articles and lectures. . . . We are approaching a state of technological proficiency when it will become possible to rationalize buildings and mass-produce them in factories by resolving their structure into a number of component parts.[3]

And LeCorbusier stated:

> The problem of our day is the dwelling house. . . .large scale industry must enter the field of the building industry, prefabricated components of dwelling houses must be manufactured in series.[4]

In 1927, Buckminster Fuller designed a prototype mass-production, light alloy, air-freightable house. This project, the Dymaxion House, which continues to astound successive generations of architects by virtue of its usurpation of almost all the avant garde thrones of the next forty years, was intended at the time to sell for $3,000, provided volume production could be maintained.[5]

In the 1930's, highways were extended, widened and improved throughout the United States. The motor truck's carrying capacity was greatly increased and highway began to compete with rail as a major cargo route. Recognizing this the Tennessee Valley Authority began producing a truckable modular house in 1939 "which could be economically delivered over a radius of sixty miles."[6]

With the advent of World War II the nation underwent large scale demographic changes as large segments of rural population moved to the urban centers to man the vast military-industrial complex formed for the defense effort. The National Housing Agency turned to prefabricated housing methods to construct wartime emergency housing of over 850,000 units in 1942.

PROSPERITY AND NEED

Following World War II, the nation began a new period of prosperity. The government offered the returning veterans many housing benefits, including, low down payment, low interest, and government insured home loans. New families were formed, the birth rate climbed and the demand for housing reached new heights. To help meet this demand, the housing industry utilized the prefabricated building component.

PREFABRICATION OF THE HOUSE

These building components, such as the wall panel and the roof truss, made available to the building industry an efficient and economical means of closing in houses much more quickly than the conventional framing methods.[7]

The small builder, with roof trusses and wall panels purchased from a local pre-fab manufacturer, could close in a house in days instead of weeks. Not only did the builder realize savings in his on-site labor but in addition he made additional indirect cost savings as a result of the shortened construction time.

House prefabrication reached its zenith of popularity with builders in the mid 50's. In 1954, House and Home magazine devoted its December issue to the growing use of prefabricated houses. However, three brief paragraphs, which might have been easily overlooked in the series of optimistic articles, brought out points that would explain the decline of the use of prefabricated components

in subsequent years. One of these paragraphs was entitled "transportation is the vital problem" and read as follows:

> Most prefabricators ship their houses a radius of 250 miles. The great bulk of their production is shipped by truck, and overnight trucking distance has usually determined plant location. Although firms distributing over a short radius do not think transportation is a vital problem, many companies would be helped by cheaper rail transportation. Reason: Few plants; a prefabricator would be able to reach a wider market for the capital investment in only one plant.[8]

Why the prefabricator could not ship his product more than 250 miles and still be competitive with the on-site builder was explained in another paragraph:

> Value created through processing materials for house manufacturers is about 18 percent, far less than the manufacturing value created in other industries. Automobile manufacturers, for example, add 32 percent to the value of the materials they process. Even if a panel manufacturer cut his cost in half, he would be saving the builder only 10 percent of the cost of the finished house (excluding lot).[9]

The prefabricator was attacking the least of the builders growing cost problems. Almost all prefabricators limited their efforts to the structure of the building, which represented less than 33 percent of the finished cost of the house. The builder was experiencing his most serious cost problems with the plumbing, heating, electrical, millwork and trim of the house. These were areas where a manufacturer could add substantially to the value of the product, but these were the very areas the manufacturers were ignoring!

Perhaps the most prophetic for the immediate future was a paragraph from the introduction which read as follows:

> The distinction between "prefabrication" and efficient "conventional" building utilizing preassembly techniques is gradually disappearing and may not be apparent at all within a decade. Already big builders operate so efficiently they achieve factory engendered economies without having to set up a factory. Many in fact, have taken prefabrication methods further than almost three-fourths of the factory prefabricators.[10]

As the 50's progressed and the housing builder undertook larger and larger scaled projects, the advantages of time and cost provided by the prefabricated house manufacturer were off-set by improved on-site job methods and techniques, and the prefabricated housing industry declined in popularity.

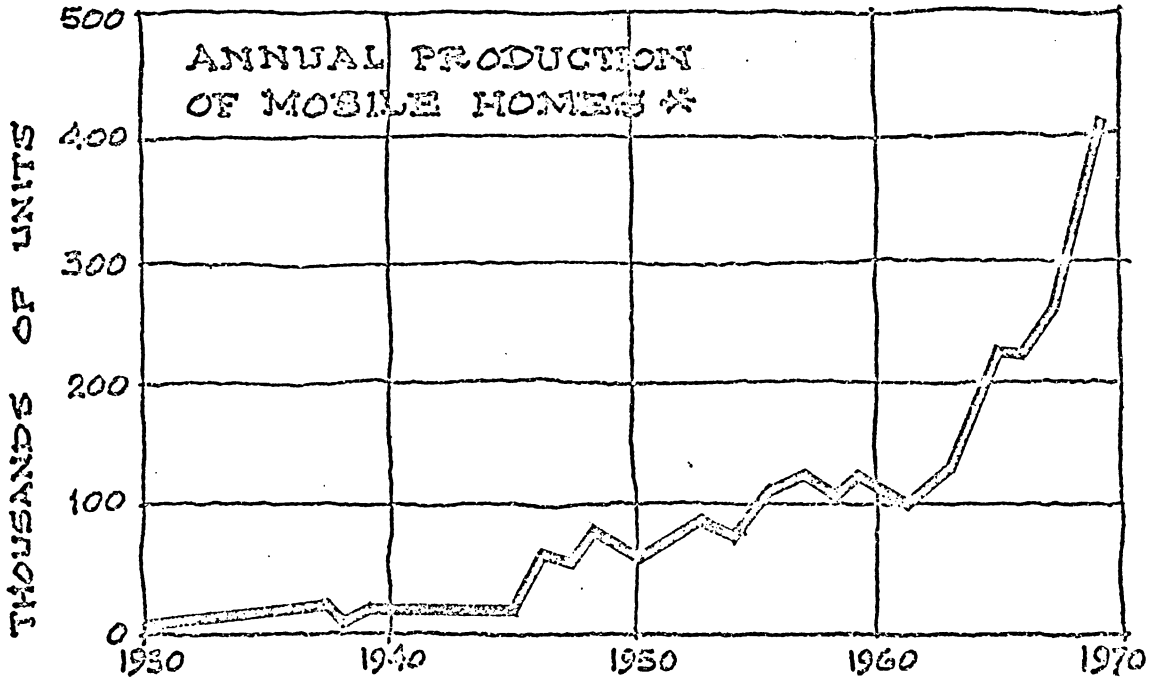
THE INDUSTRIALIZED HOUSE

Despite the above trends attempts were also made following World War II to industrialize the entire house. Experiments were made with new materials and construction methods. Perhaps the most notable of this era was the Lustron House. It was steel framed, with a skin of enameled steel. It was fire proof, vermin proof, rot proof, and inordinately strong. Today, Lustron Houses built 20 years ago look as good as new. The first Lustrons were built under subsidies from the Reconstruction Finance Corporation so their price was artificially low. It has been considered by the building industry to be one of the best production houses ever built--which may have led

to its undoing. It was too expensive. Perhaps volume production might have pulled the cost down in line with conventional wood frame construction. However, few Lustron Houses or any other industrialized experimental houses were built, and their systems died.[11]

MOBILES SHOW THE WAY

During the 1960's several factors brought about a renewed interest in industrialized housing. The first of these was the impact of the mobile home.



* ARTHUR D. BERNHARDT - THE MOBILE HOME INDUSTRY: A CASE STUDY IN INDUSTRIALIZATION

FIGURE 2-A

In 1930, 1300 units were reportedly shipped, by 1960, this number had increased to 90,000 units. The production figures continued to compound until by the end of the 60's mobile home production had reached 400,000 units a year (see fig. 2-A). A 1969 Department of Commerce study found that 48 percent of all new single-family homes built in that year were mobiles. They represented 94 percent of the homes under $15,000, 79 percent of those under $20,000 and 67 percent of those under $25,000 (see fig. 2-B). The mobile home industry had become a major force in the housing market.[12]

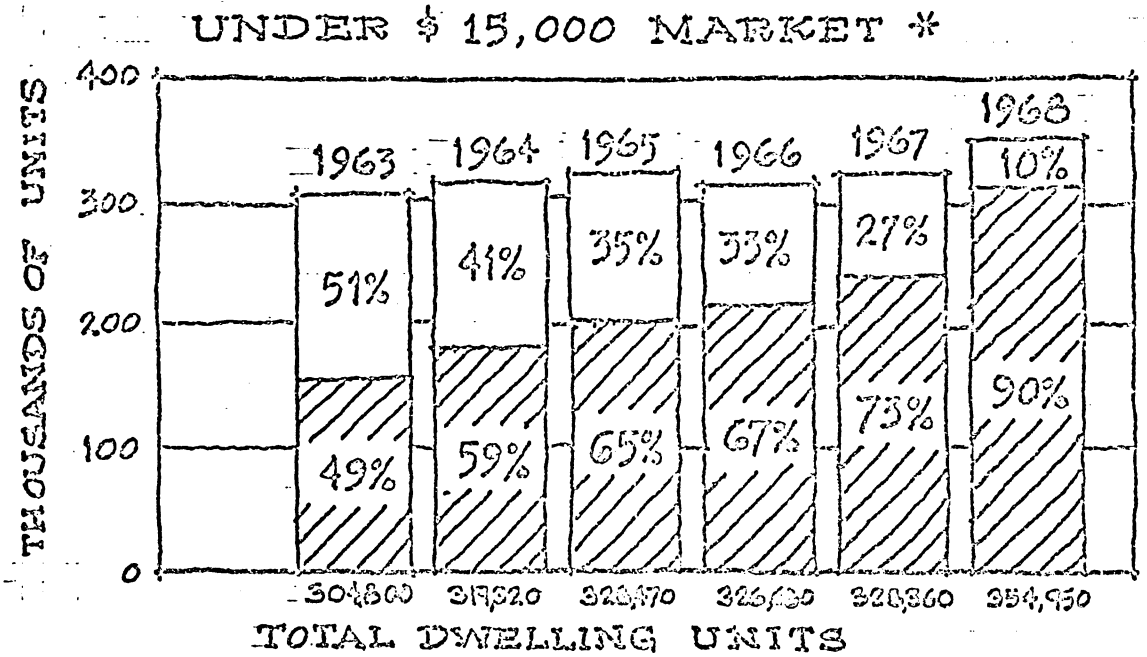


FIGURE 2-B

THE MANUFACTURED HOUSE: REDISCOVERED

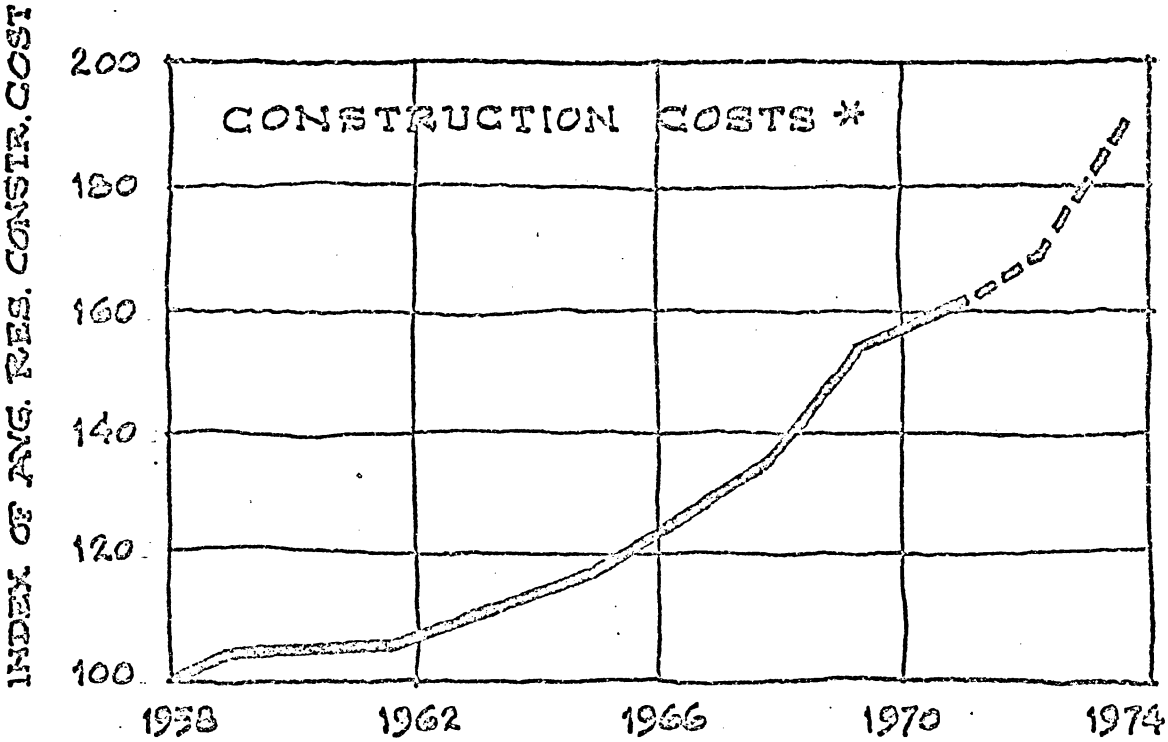
The homebuilder began his search for something to compete with the mobile home and rediscovered the manufactured house. Not only would it compete with the mobile home in cost, it added these additional benefits:[13]

> Better financing--the mortgage rates for mobiles were higher and the terms of the loan much shorter than for modular homes.
>
> Better code acceptance--the modular house is built to standard housing specifications, including plumbing and electrical.
>
> Less depreciation--the average life of the mobile home is only 12 years versus the modulars 20 to 30 years.

Another important factor which had a relation to the renewed interest in industrialized housing was the increasing scarcity of labor. Since the peak of the homebuilding year of 1950, when a production rate of over 2,000,000 units per year was reached, there had been a steady attrition of skilled labor within the residential construction industry.

This was the result of retirement, lack of adequate replacement training programs and of low and inconsistent levels of housing construction activity. Every year of low housing starts saw a loss of some of home-building's best labor supply to industries offering more security and year-round employment.[14]

Added to this was a third and important factor--the spiraling cost of materials and labor (see fig. 2-C).



* OUTLOOK '72 - PROFESSIONAL BUILDER DEC 1971

FIGURE 2-C

The mobile home industry was able to show emphatically that industrialization had held costs of the finished product constant while conventional construction costs were soaring skyward.

THE UNFILLED NEED

The government has determined a need for at least two and one-half million new housing units per year for the next decade to meet our nation's housing needs.

In its greatest year, 1950, the homebuilding industry produced housing units at a rate of two million units per year. In the two decades following 1950, the housing industry has averaged less than 1.5 million units per year.[15]

Why this apparent paradox? Why with this great need has the housing industry dropped in its share of the gross national product from 4.5 percent in 1960 to 2.9 percent in 1969?[16]

The answer is the rising cost of housing.

Expensive land, high interest rates, increasing construction costs and rising real estate taxes have all contributed to pricing housing out of the market.

Vernon D. Swaback of the Frank Lloyd Wright Foundation in his book "Production Dwellings" comments on this problem:

> It is a tragic anachronism of our time that in the midst of affluence it is increasingly impossible for the majority of our citizenry to have individual dwellings on suitable plots of ground. Innovative design solutions are normally capable of revolutionizing procedures and creating whole new industries. This has not been the case where housing is concerned. The industry is dramatically unresponsive to both changing needs and changing opportunities.[17]

THE COST OF A HOUSE

Too often the industrialization of the production of housing is looked to as a panacea for the problems, it is only a partial solution. Too few realize that only about half the cost of the typical living unit is in the structure itself;

the rest is in land, foundations, financing, and other areas industrialization cannot touch.

Edgar F. Kaiser, Chairman - Committee on Urban Housing, spoke directly to this situation in his report to Congress when he stated:

> If it were possible to reduce the cost of building a housing unit itself, by 50 percent--that is, to cut in half the cost of materials and labor in constructing an apartment unit or a single-family residence--this would reduce the monthly costs to the occupant by only about 17 to 20 percent. The other costs--land and land improvement, interest, taxes, and maintenance and operating expenses--total, proportionately, so much more than the costs of materials and labor, that a 50 percent reduction in construction costs would not eliminate the necessities of subsidies in housing the poor. In comparison to the impact of new construction technology is the fact that a one-point reduction in mortgage interest rates would achieve nearly a 10 percent reduction in occupancy costs for the home owner or renter.[18]

INDUSTRIALIZATION: THE REASONS

It is important in hearing any argument for the industrialization of housing to recognize that there must be more justification than merely reducing construction cost.

Industrialization builds houses with less skilled and less scarce workers. Even at the current inadequate rate of housing production, skilled construction craftsmen are impossible to find. The promise of industrialization is that by standardizing many skilled operations, less skilled labor will be required to perform them.

Industrialization drastically cuts the weather-vulnerable part of the construction process. In one day a factory-built unit can be set in place; a conventionally built house may be susceptible to weather delays for weeks. Faster on-site construction reduces the cost of interim financing, and job overhead is reduced.

Industrialization will make it possible to introduce new materials into housing construction. Wood and wood products have historically been the materials of house construction--in addition to their relative low cost, their great asset is the ease with which they can be cut and fastened in the field with hand tools. Metals and plastics,

on the other hand, must be worked with heavy equipment that cannot be brought into the field, that requires volume production to justify this equipment expense. Since the present labor force for house construction is geared to wood-frame construction, many materials that could improve the quality of housing construction have never been commonly used. Industrialized housing could change that; built in a factory where machinery can be installed, housing can be standardized to the point where volume production is possible, and a new labor force can be taught to work with new materials.

Industrialization promises to be the best and perhaps the only way to increase housing production in the face of rising costs and a dwindling skilled labor supply.[19]

CONSTRAINTS

LACK OF AN INDUSTRY

It is the general consensus of the people who are involved in the homebuilding industry that industrialization of the building process is inevitable. Many reasons for this inevitability are offered, including:[20]

Shortened construction time

Lower production cost

Factory methods of production

Limiting the scope of site preparation

All-weather construction

Economical utilization of labor

Lowering the need for skilled laborers

Armed with these arguments, each year someone in the industry predicts that "now" is the time for industrialization. Each year, in increasing numbers, companies are created, plants are built, equipment installed, labor recruited, and material is purchased for the manufacture of housing. And yet, each year other manufacturers close the doors

of their factories, terminate their workers and leave the industry.

In the past 10 years over 15 million housing units were produced in this country, of this amount, industrialized housing--modulars, sectionals, and prefabs have contributed, less than 100,000 units (less than one percent).[21]

House and Home magazine published the results of a survey of industrialized housing production for the year 1970. Out of 1,800,000 housing units produced, less than 26,000 were manufactured. The bulk of these, about 19,000, were single family, the remainder, about 6,400, were multi-family.[22]

BREAKTHROUGH: THE HOPE

Concerned with the inability of manufacturers to contribute more significantly in meeting the nations need of economical housing, Congress authorized the creation of Operation Breakthrough.

Congress assigned to the Department of Housing and Urban Development the responsibility to demonstrate

to the nation the advantages of industrialized housing. During the demonstration phase of Breakthrough, some of the constraints to the existence of an economically sound and productive industry were brought forcefully and dramatically to the awareness of the government and the general public.[23]

Experienced housing manufacturers were keenly aware of the constraints to the creation of a viable industry. House and Home magazine brought together a panel of experienced housing manufacturers and asked them to identify some of these problems.[24]

They identified the same problems that Breakthrough had encountered. They discussed the problem of labor, both on site and in-plant, and the problem of convincing the manufacturers who supply the building materials of construction of the need to develop materials and methods aimed specifically at industrialization. They discussed the problem of working with a multiplicity of codes, the

problem of obtaining funds from a developer during the manufacture of units for his project and they discussed the problem of transportation.

SOCIAL AND ECONOMIC PROBLEMS

In the constraints to industrialization almost all are "people-related" problems. Attitudes of labor and management to unionism, attitudes of public officials to code reorganization, attitudes of financiers to construction financing, attitudes of suppliers toward the creation of new materials and methods--all have their effect.

Only one problem is essentially an economic one, only one is a problem with tangible dimensions, the problem of the cost of transportation.

All of the other problems are subject to negotiation. The Department of Housing and Urban Development through Operation Breakthrough has already commenced working to overcome many of those constraints sensitive to the pressure of public opinion.

However, even though solutions are found for these admittedly major problems, unless a solution to the problem of transportation cost is found it will remain a major obstacle to the aggregation of an adequate market by the industrialized housing manufacturer.

BACKGROUND

NOTES

1. Richard L. Bullock, Exec. V.P. National Association of Building Manufacture, Lytle, INDUSTRIALIZED BUILDERS HANDBOOK, Structures Publishing, 1971

2. Martin Pawley, ARCHITECTURE vs. HOUSING, Praeger Publisher, New York-Washington, 1971, p. 51

3. Walter Gropius, THE NEW ARCHITECTURE AND THE BAUHAUS, MIT Press, 1965, p. 40

4. LeCorbusier, TOWARDS A NEW ARCHITECTURE, Arch. Press, London, 1927

5. Pawley, Op. Cit., p. 51

6. Pawley, Op. Cit., p. 51

7. "The Housing Crisis," HOUSE & HOME, February 1970, p. 56

8. "Prefabrication has Something for Everyone," HOUSE & HOME, December 1954, p. 107

9. Ibid., p. 104

10. Ibid., p. 102

11. "The Housing Crisis," Op. Cit., p. 58

12. Mary E. Osman, "Mobile Homes: The third Alternative," A.I.A. JOURNAL, December 1971, p. 43

13. "Its Time to Take the Low Price Market Back from the Mobiles," HOUSE & HOME, April 1971, pp. 62-72

14. Joseph C. Grasso, "The Real Role for Industrialized Housing is to Make Up for the Growing Shortage of Skilled Labor," HOUSE & HOME, May 1971, p. 66

15. Edgar F. Kaiser, "Partnerships to Get Big Business into Housing," AIA JOURNAL, January 1969, p. 52

16. "The Housing Crisis," Op. Cit., p. 53

17. Vernon D. Swaback, PRODUCTION DWELLINGS, Frank Lloyd Wright Foundation 1970, p. 32

18. Ibid., p. 33

19. "The Housing Crisis," Op. Cit., p. 68

20. Laurence Cutler, "The Industrialized Evolution" INDUSTRIALIZED BUILDING SYSTEMS FOR HOUSING, MIT Press, 1971, p. 101

21. "Outlook '72," PROFESSIONAL BUILDER, December 1971, p. 110

22. "Who's Building the Modulars and How Many?," HOUSE & HOME, June 1971, p. 47

23. "Operation Breakthrough: Questions and Answers," U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, HUD 186 - 186 RT (2) March 1971

24. "Whats Holding Back the Real Breakthrough in Modular Housing?," HOUSE & HOME, October 1971, p. 86

III

ANALYSIS

MOVEMENT SYSTEMS

SYSTEM KNOWLEDGE

The fabrication of panels, trusses, component packages, and modules in a factory involves the application of industrialization techniques to the construction of buildings. Delivering these fabricated parts or modules to the site and putting them in place is the final step in the process; delivery and erection must be considered in every design

and system selected. Ingenious pieces of building demonstrating a high degree of industrialization are of little value if they cost too much to deliver and install.[1]

The industrialized housing manufacturer must thoroughly understand the regulations which control the shipment of his product and he must appreciate the added cost that such shipment will incur. The method and cost of transportation has a direct bearing on the design of the industrialized housing unit. Transportation has a direct relationship to the number of plant facilities and their location to the market in a given area. Failure to fully understand all of the ramifications of transportation may well lead to economic failure.

To aggregate a sufficient market to sustain the production capability of a manufacturer's plant facility requires a large geographic area involving relatively distant shipment destinations from the plant. The manufacturer must analyze the methods of transportation available to him, the distances

he will be required to ship, and the costs of these various transportation methods to establish the parameters which will control the design of the product.[2]

TOO MANY REGULATIONS

Highways offer the most accessible method for a manufacturer to reach a destination with his product.[3] Almost every city of major size can be easily reached on the near-complete inter-state highway system. In many cases the highway is the only feasible means of reaching a project site.

However, in the form of dimensional limits and over-load restrictions, highway regulations are important determinants to the design and manufacture of industrialized housing. A manufacturer may use rail or water as his primary method of shipment, but inevitably it will be necessary to transport the product from the barge or rail car, by truck, over the road, to the construction site.

State laws regulate width, length, height and weight of loads, and can vary greatly from one

state to the next. Perhaps the greatest single contribution by the mobile home industry to the industrialized housing manufacturer has been its relentless efforts to ease highway shipping regulations.[4]

As late as 1955, many states prohibited any unit wider than eight feet on their highways. The change in regulations to permit 10 foot wide units was started at this time.

By 1962, not only was the mobile home industry working with state legislative bodies to increase the 10-foot limit, but their ranks at that time were being joined by some of the producers of sectional homes who wanted more than a 20-foot completed double unit width imposed upon them by the 10-foot limit.[5]

Russel D. Jones, Director for Boise Cascade's residential communities group said in an interview:

> The next legal battle will be getting 14-foot wide modules on the highways, all but 11 states have a 12-foot wide maximum. There are some legitimate health and safety objections to 14-feet, but they can be resolved by specific routing.[6]

While the width limitation factor is important, the limitation imposed by the states as to overall height above the road surface is of equal importance. Currently, most states will allow 13'-6", but it should be noted that not all highways provide this height clearance due to low overpasses, bridges, viaducts and other overhead obstacles.[7]

Most state laws also impose severe restrictions on the time of day when overwidth shipments can be made. Nearly all states prohibit the transportation of oversized loads before sunrise and after sunset. Saturdays, Sundays, and holidays are generally restricted days and, although special use permits are issued, a number of states forbid such movements during periods of inclement weather. Rain, fog, high winds and other unsafe conditions,

including road repairs, can thus disrupt any well-planned shipping and erecting schedule.[8]

Illustrative of the plethora of regulations which may be encountered in the inter-state transportation of industrialized housing are the following excerpts from highway regulations of several mid-western states. These excerpts pertain to those portions of the regulations which apply to over-width loads and represent only a small part of the total regulations for highway transportation through these states.[9]

In most of the state regulations many of the decisions concerning the propriety of highway movement are discretionary on the part of the highway regulatory official. This leaves the manufacturer at the mercy of the State Trooper in determining what his total shipping costs will be. It is obvious that the longer the distance shipped and the more state regulations encountered, the greater will be the uncertainty of the final cost.

ILLINOIS ARTICLE II - OVERWIDTH - GENERAL REGULATIONS

IN ADDITION TO THE GENERAL RESTRICTIONS AND PROVISIONS APPLICABLE TO MOVEMENTS MADE UNDER PERMIT AUTHORITY THE FOLLOWING PROVISIONS WILL GOVERN THE MOVEMENT OF OVERWIDTH VEHICLES, VEHICLE COMBINATIONS OR LOADS.

1. THE OVERALL WIDTH OF A VEHICLE, VEHICLE COMBINATION OR LOAD SHALL INCLUDE PROJECTIONS, LASHING, CHAINS, CABLES OR ANY OBJECT OR DEVICE THAT MAY CONSTITUTE THE EXTREME WIDTH.

2. VEHICLES OR LOADS WHICH EXCEED 10 FEET IN WIDTH WILL NOT BE AUTHORIZED ON THE ILLINOIS TOLL HIGHWAYS OR ON CONTROLLED ACCESS HIGHWAYS IN COOK COUNTY EXCEPT INTERSTATE 80 FROM THE WILL-COOK COUNTY LINE TO KIDZIN AVE. AND ILLINOIS ROUTE 53 FROM ALGONQUIN RD. (ILL. 62) TO DUNDEE RD. (ILL. 68) AND INTERSTATE 57 SOUTH OF INTERSTATE 80.

3. VEHICLES OR LOADS WHICH EXCEED 12 FEET IN WIDTH WILL NOT BE AUTHORIZED ON INTERSTATE AND OTHER MULTI-LAND CONTROLLED ACCESS HIGHWAYS.

4. EXTREMITIES OF LOAD MUST BE MARKED WITH RED FLAGS.

5. ON CONTROLLED ACCESS HIGHWAYS SPEED MUST BE AT LEAST POSTED MINIMUM AND CAN'T BE 5 MPH ABOVE POSTED MINIMUM.

6. UNLESS OTHERWISE SPECIFIED IN A PERMIT SPEED LIMITS ARE AS FOLLOWS:

WIDTH RANGE	SPEED LIMIT
OVER 8' TO 10'	40 MPH
10' TO 12'	35 MPH
OVER 12'	30 MPH

7. A FLAGMAN MUST ACCOMPANY THE MOVEMENT WHERE THE OVERALL WIDTH EXCEEDS 10 FEET.

8. AN ESCORT VEHICLE, FURNISHED BY THE APPLICANT TO ACCOMPANY THE MOVEMENT OF AN OVERWIDTH LOAD IS REQUIRED WHEN; THE OVERALL WIDTH EXCEEDS 12 FEET, THE CHARACTERISTICS OF THE LOAD OR THE CONDITION OF THE HIGHWAYS IS TO BE TRAVELED ARE SUCH THAT AN ESCORT IS REQUIRED TO PROTECT THE HIGHWAYS FACILITIES OR OTHER TRAFFIC, AND HOUSE TRAILER WHICH EXCEEDS 10 FEET WIDE IS TRANSPORTED OVER A ROADWAY LESS THAN 20'.

KANSAS - GENERAL PROVISIONS FOR OVERWIDTH

A HOUSE TRAILER OR MOBILEHOME WHICH EXCEEDS THE WIDTH OF 8 FOOT MAY BE MOVED ON THE HIGHWAYS OF THE STATE WITH SPECIAL PERMITS. IT MUST BE COVERED BY LIABILITY INSURANCE OF $100,000 FOR INJURY TO ANY ONE PERSON, $300,000 FOR INJURY TO PERSONS IN ANYONE ACCIDENT AND $25,000 FOR INJURY TO PROPERTY.

PERMITS WILL NOT BE ISSUED FOR LOADS OF STRUCTURAL NATURE WHICH CAN BE READILY DISMEMBERED.

PERMITS FOR MOVEMENT OF MOBILEHOMES OVER 10'4" AND UNDER 12'6" IN WIDTH; PERMITS MAY BE ISSUED FOR SINGLE TRIP MOVEMENTS OF MOBILEHOMES OVER CERTAIN SPECIFIED ROUTES AND DURING DAYLIGHT HOURS. NO TRAVEL WILL BE ALLOWED AT NIGHT OR A SATURDAY, SUNDAY OR LEGAL HOLIDAYS. THE MINIMUM SPEED IS 35 MPH MAXIMUM SPEED 50 MPH. NO MOBILEHOME WILL BE ALLOWED TO TRAVEL WHERE THE WIND EXCEEDS 25 MPH OR DURING RAIN, SNOW, SLEET OR FOG.

ALL 12' WIDE MOBILEHOME SHALL BE PROTECTED BY AN ESCORT VEHICLE TRAVELING AT A DISTANCE NOT TO EXCEED 300' TO THE FRONT OF THE TRUCK TOWING THE MOBILEHOME ON ALL TWO LANE HIGHWAYS WITH CERTAIN EXCEPTIONG.

SPECIAL SIGNS REQUIRED

MOBILE HOMES OVER 10'4" AND UNDER 12'6" WIDE - FRONT ESCORT VEHIBLE REQUIRED ON 2 LANE HIGHWAYS OF THE STATE HIGHWAY SYSTEM EXCEPT DESIGNATED HIGHWAYS. COST OF PERMIT $5.00.

MISSOURI - GENERAL REGULATIONS PERTAINING TO OVER WIDTHS

THE CHIEF ENGINEER OF THE STATE HIGHWAY DEPARTMENT WHENEVER IN HIS OPINION THE PUBLIC SAFETY OR PUBLIC INTEREST SO JUSTIFIES, MAY ISSUE SPECIAL PERMITS FOR VEHICLES EXCEEDING THE LIMITATIONS. PERMITS ARE FOR SINGLE TRIP ONLY.

PERMITS WILL NOT BE GRANTED FOR MAJOR HIGHWAY MOVEMENTS REDUCIBLE IN DIMENSIONS OR WEIGHT. PERMITS WILL BE LIMITED TO SUITABLY AND REASONABLE DIRECT ROUTES BETWEEN REGION AND DESTINATION. PERMITS MAY SPECIFY MAXIMUM AND MINIMUM SPEEDS TO REDUCE HAZARDS OR CONTROL IMPACT FACTORS ON PAVEMENT OR STRUCTURES. TRACTOR UNITS SHALL HAVE SUFFICIENT WEIGHT AND POWER TO CONTROL THE COMBINATION AND MAINTAIN REASONABLE SPEEDS.

ALL MOVEMENTS UNDER PERMITS ARE LIMITED TO THE HOURS BETWEEN ONE-HALF HOUR BEFORE SUNRISE AND ONE-HALF HOUR AFTER SUNSET WHEN VISIBILITY IS 500 FEET OR MORE. NO MOVEMENT ON SATURDAY, SUNDAY AND LEGAL HOLIDAYS OR LONG WEEKENDS.

INSURANCE COVERAGE OF $25,000 PERSONAL INJURY, $25,000 LIABILITY, AND $50,000 PROPERTY DAMAGE IS REQUIRED.

COST OF PERMIT IS $4.00 PER PERMIT. PERMITTEE MUST ASSUME FULL RESPONSIBILITY FOR INJURY TO PERSONS, DAMAGE TO PUBLIC OR PRIVATE PROPERTY AND TO HOLD STATE OF MISSOURI HARMLESS FROM ANY AND ALL CLAIMS.

MAXIMUM SPEED 50 MPH, REDUCED TO 40 MPH OVER INTERSTATE ROUTE BRIDGES AND 10 MPH OVER ALL OTHER BRIDGES.

ANY PERMIT FOR AN OVERDIMINSION AND/OR OVERWEIGHT MOVEMENT WHEN THE LOAD IS IN FACT READILY REDUCEABLE IS VOID.

NO MOVEMENT (EXCEPT FOR OVERHEIGHT) OVER INTERSTATE 70, ROUTES 40 & 61, INTERSTATE 44 & 55 INSIDE THE CIRCUMFERMENTAL ROUTES OF 1-270; 1-244; 1-155 AND BP50 IN THE ST. LOUIS AREA.

OVERWIDTH PERMITS FOR MAJOR HIGHWAY MOVEMENTS WILL BE LIMITED TO NON-REDUCIBLE LOADS WITH NOT EXCEEDING 12'4". WIDTHS GREATER THAN 10'4" SHALL NOT BE TRANSPORTED IN EXCESS OF 10 MILES OVER PAVEMENTS WITH TRAVEL LANES LESS THAN 10' IN WIDTH. AN ESCORT WHICH WILL BE REQUIRED PRECEEDING THIS MOVEMENT 300' (IN THE REAR ON DUAL LANE PAVEMENT) WHERE THE VEHICLE AND LOAD EXCEED 10'6" IN WIDTH AND EXCEEDS THE WIDTH OF ONE TRAVEL LANE ON PAVEMENT OR STRUCTURES AND WHEN THE SIZE SPEED OR OPERATION OF MOVEMENT MAY INTERFER WITH TRAFFIC IN THE TRAVEL LANE OR THE ADJACENT TRAFFIC LANE. AN ESCORT VEHICLE IS DEFINED AS: A PASSENGER CAR OR SMALL TRUCK NOT BEING OPERATED UNDER PERMIT AUTHORITY.

RED FLAGS MUST MARK OUTSIDE AND WIDE LOAD SIGNS REQUIRED. MOVEMENT WIDTHS EXCEEDING 10'4" WILL BE PROHIBITED ON ALL ALTERNATE ROUTES INSIDE THE CIRCUMFERINTAL ROUTE OF 1-270; 1-244; 1-55 AND BP 50 IN THE ST. LOUIS AREA, BETWEEN THE HOURS OF 7:00 A.M. AND 8:30 A.M. AND 3:30 P.M. TO 5:30 PM.M.

WHEN CROSSING STRUCTURES IF THE LOAD EXCEEDS 1/2 WIDTH OF THE ROADWAY A FLAGMAN MUST BE USED TO STOP ALL ONCOMING TRAFFIC.

ONLY SPECIFIED MISSOURI AND MISSISSIPPI RIVER BRIDGES MAY BE USED FOR MOVEMENT OF LOADS IN EXCESS OF 10'4" IN WIDTH. THESE RULES ALSO APPLY TO MOBLE HOME MOVEMENT IN MISSOURI.

COLORADO: GENERAL PROVISIONS FOR OVERWIDTH MOVEMENTS

THE DEPARTMENT OF HIGHWAYS MAY DEMAND A PILOT CAR TO PRECEDE AND/OR FOLLOW THE OVERSIZE MOBILE HOME, PARTICULARLY OVER MOUNTAINS.

PERMIT LIMITATIONS SIZE 14 FT. WIDTH, COST $5.00 /PERMIT.

SPECIAL SIGNS REQUIRED. PERMITS MUST BE IN TOWING VEHICLE, MOVEMENT PROHIBITED ON SATURDAY AFTERNOON, SUNDAY AND LEGAL HOLIDAYS.

MICHIGAN - GENERAL PROVISIONS FOR OVERWIDTH PERMIT MOVMENTS

SPECIAL PERMITS WILL NOT BE ISSUED TO MOVE A MOBILE HOME OR BUILDING MODULE ON MICHIGAN STATE TRUCKLINES IF THE DIMINSIONS EXCEED THE FOLLOWING:

65 FEET IN ACTUAL BODY LENGTH
12 FEET IN ACTUAL LONG WIDTH & TECTURES NOT TO EXCEED 3 INCHES ON EACH SIDE
15 FEET IN HEIGHT
85 FEET IN OVER ALL LENGTH INCLUDING TOWING VEHICLE

NO CHARGE OF PERMITS

TOWING VEHICLE MUST BE AT LEAST C 1-1/2 TON TRUCK WITH DUAL WHEELS

MAXIMUM SPEED LIMIT IN THE MOVEMENT BY SPECIAL PERMIT SHALL NOT EXCEED 40 MILES PER HOUR. MOVEMENTS EXCEEDING 80 FT IN OVERALL LENGTH SHALL NOT EXCEED 25 MILES / HR

OVERSIZE LOADS REQUIRE SPECIAL SIGNS AND RED FLAGS[1]

LIMITATIONS IN OPERATION. THE PROPOSED MOVEMENT SHALL BE MADE SO THAT THE TRAVEL WAY WILL REMAIN OPEN FOR TRAFFIC AT ALL TIMES. MOVEMENTS LIMITED TO DAYLITE HOURS FROM 1/2 HOUR AFTER SUNRISE TO 1/2 HOUR BEFORE SUNSET AND PROHIBITED ON SATURDAY AND SUNDAY AND FROM 12 NOON BEFORE HOLIDAYS, UNTIL 12 NOON ON THE DAY AFTER A HOLIDAY.

INSURANCE REQUIRED IN AMOUNTS OF $100,000 EACH PERSON $300,000 EACH ACCIDENT, AND $100,000 PROPERTY DAMAGE.

INDIANA - GENERAL LIMITATIONS ON VEHICLE SIZE & WEIGHT

APPLICATION DOES NOT APPLY TO ANY ROADS OR BRIDGES CLOSED FOR CONSTRUCTION OR COUNTY ROADS OR CITY STREETS.

1. AT NO TIME WILL TRAFFIC BE BLOCKED FROM USE OF THE HIGHWAY.

2. PERMIT APPLICANT ASSUMES ALL RESPONSIBILITY FOR ANY DAMAGE TO PROPERTY OR PERSONS CAUSED DIRECTLY OR INDIRECTLY BY THE TRANSPORTATION OF SAID VEHICLE OR LOAD UNDER THE PROPOSED PERMIT.

3. APPLICANT MUST PAY FOR THE REMOVAL AND REPLACEMENT OF ANY BUILDINGS, RAILINGS OR OTHER STRUCTURE FROM THE HIGHWAY.

4. OBJECT WILL NOT BE LOADED OR UNLOADED FROM THE VEHICLE WITHIN THE TRAVEL LIMITS OF THE HIGHWAY.

5. PERMIT WILL BE IN POSSESSION OF DRIVER.

6. APPLICANT MUST FURNISH THE INDIANA STATE HIGHWAY COMMISSION UPON REQUEST WITH AN ACCEPTABLE BOND OR OTHER SECURITY TO COVER ANY DAMAGE THAT MIGHT OCCUR TO ROADS ETC. THE APPLICANT FURTHER AGREES TO FURNISH THE INDIANA STATE HIGHWAY COMMISSION, UPON REQUEST WITH A FINANCIAL STATEMENT.

7. SPECIAL PROVISIONS: THE MOVER AND/OR OWNER OF SAID VEHICLE AND/OR LOAD WILL BE HELD RESPONSIBLE FOR NECESSARY FLAGGING OF TRAFFIC. IF BY REASON OF WEATHER CONDITIONS, NARROW BRIDGES, LIMIT OF VISIBILITY OR ANY OTHER REASON THAT TRANSPORTATION OF SAID VEHICLE AND/OR LOAD CREATES A TRAFFIC HAZARD, TWO (2) FLAGMEN SHALL BE REQUIRED AS LONG AS SAID HAZARD EXISTS. ONE FLAGMAN SHALL BE PLACED NOT LESS THAN 500' NOR MORE THAN 600' IN FRONT OF SAID VEHICLE AND/OR LOAD AND ANOTHER SPACED THE SAME DISTANCES

TO THE REAR OF SAID VEHICLE AND/OR LOAD. IN CASE THE VEHICLE AND/OR LOAD BEING MOVED IS MORE THAN 12' IN WIDTH OR 70' IN LENGTH, TWO FLAGMEN SHALL BE FURNISHED AT ALL TIMES AND SPACED AS INDICATED ABOVE. SAID VEHICLE WILL NOT BE ON STATE HIGHWAYS DURING HOURS OF DARKNESS.

NO MOVEMENT ON SPECIFIED HOLIDAYS AND FROM 12:00 NOON THE DAY BEFORE A HOLIDAY UNTIL 12:00 NOON THE DAY AFTER A HOLIDAY AND/OR A LONG HOLIDAY WEEKEND.

VEHICLES MARKED WITH RED FLAGS AND AN OVERSIZE LOAD SIGN ON WHITE BACKGROUND. HOWEVER, OFFICIALLY APPROVED COLOR COMBINATIONS OR WORDING OF OTHER STATES WILL BE PERMITTED.

PERMITS WILL NOT BE ISSUED FOR HAULING OF HEAVY LOADS ON EXTRA LONG OR WIDE LOADS WHEN SUCH LOADS CAN BE REASONABLE SUBDIVIDED INTO SMALLER UNITS COMPLYING, OR MORE NEARLY COMPLYING, WITH THE RESTRICTIONS SET OUT IN THIS LAW.

George Romney, Secretary of HUD, spoke of the problem of highway regulations in his speech at the INBEX conference in November 1971. He said:

> Highway transportation has become an extremely complex problem. Each state has its own established set of codes for outsized loads. Generally, the same conditions covering the shipment of mobile homes have been superimposed on industrialized housing units. This is unfortunate, since modular loads are comparatively more rugged and stable in transit, and most of the loads remain within the 12-foot limitation.
>
> Our Operation Breakthrough producers estimate that two particular penalties alone add from 10 to 25 percent to the cost of shipment. One is the onerous requirement of demanding state-by-state highway permits. The second is the prohibition against shipping two modules on a single trailer. Recently Michigan amended its law to permit a two module load, but if you drive it outside that state your load will be outlawed.
>
> Mind you, I'm not in favor of abolishing all highway shipping regulations. Too many state highway departments have looked with justifiable concern at skimpy trailers, shaky tie-down systems, marginal hook-ups between trailer and tractor, and borderline ratios of horsepower to weight.

> What we are seeking is a change in some of the more extreme regulations in order to achieve a balanced highway transport system. In this respect Breakthrough has already been a catalyst, benefitting the housing producer, the trailer manufacturer, the highway carrier, and the states.

THE COST OF CONVENIENCE

Transportation cost has proven to be one of the most unyielding of problems. Technically, a manufacturer has his choice of road, rail, water, and air, but traditionally he has limited his choice to highway transportation.[10]

Highway transportation has severe economic limits. Costs rise so sharply with the distance of shipment that most manufacturers have considered 300 miles to be their economical shipping limit.[11]

Slayter and Associates, Industrialized Manufacturing Consultants, in a recent study arrived at a figure of $0.85 per loaded mile for over-width but legal length loads.[12]

RAILROADS AND BREAKTHROUGH

As the manufacturer expands the geographic area of his market, highway transportation becomes less and less economically feasible. For this reason industrialized housing manufacturers have been investigating the possibility of rail for long distance transportation.[13]

Until recently, however, existing rail rate classifications have all but placed this transportation method out of the economic reach of the housing manufacturer.

The Federal Government had this brought directly to its attention in the Operation Breakthrough Program. Several of the participating manufacturers were located hundreds of miles from their project sites. One of these manufacturers was Levitt Building Systems, Inc.; their Operation Breakthrough site was located at Seattle, Washington, 2500 miles from their Battlecreek, Michigan plant. The originally quoted rail costs for transporting modules this distance on 25 flat cars was $137,000![14]

This meant that the cost of each living unit would be increased from $7,000 to $10,000! This very quickly brought the Federal Government into the situation; transportation costs such as these could very well destroy the benefits expected from the Breakthrough Program. HUD Secretary George Romney spoke to this point at the 1971 INBEX conference in November:

> Now, we recognize that solutions to the highway problems are only a partial answer to the overall question of reducing the cost of transportation. In Breakthrough, we have felt intuitively that this country's vast railroad network must be utilized if we are to achieve the economies needed to insure the success of industrialized housing.
>
> Since May we have been in close touch with more than 300 of the nation's railroads in an effort to iron out technical difficulties and to reach agreement on a reasonable rate for long range shipments.
>
> I envision many such trainload movements during the next 12 months. Recently Trailer Trains, Inc.--a railroad car subsidiary of 33 carriers--voted to lease its flat cars directly to the shippers of industrialized housing. This is a first, since the corporation up until that time leased only to rail carriers.

> The implications of better and cheaper transportation are tremendous. As the industrialized housing market expands, it will have a dynamic effect on the location of plants, on the building of housing for workers near their place of employment, and on the very nature of both the inner city and the suburbs.

With government intervention, the rail charge for Levitt was negotiated down to $84,310, far less than the initial figure of $137,000.[15] While such charges might be justified in a HUD Demonstration program in which the government absorbs the extraordinary costs,[16] it was evident that if the production phase of Breakthrough were to be realized, rail rates more favorable to the housing manufacturer would have to be established. Housing and Urban Development turned to the General Services Administration to act in HUD's behalf in negotiating more favorable terms for the shipment of industrialized housing. James C. McCollom, Director of Transportation for Operation Breakthrough, emphasized the urgency of the problem when he warned:

> Modular producers soon will have to fish or cut bait on plant decisions, many plants now are pilot plants. If reasonable rail rates don't come into being, the manufacturers probably will follow the pattern of the mobile home industry which has never used rail.[17]

The tariff schedule proposed by GSA is extremely complex, but it would reduce present rail costs by about half. (The $137,000 charge originally quoted to Levitt would have been reduced by the GSA proposal to about $60,000.[18]) Rates now are established by negotiation for each trainload shipment. There are no published rates.

The following is the first GSA proposal:[19]

APPLICATION NO. D-5845

THE PROPOSAL SET FORTH BELOW HAS BEEN PRESENTED FOR CONSIDERATION

SHIPPER PROPOSAL: MR. M. J. NEWBOURNCE, ASST COMMISSIONER FOR TRANSPORTATION, GENERAL SERVICES ADMINISTRATION, WASHINGTON, D.C. 20405

HOUSE OR BUILDING SECTIONS, MODULAR, ETC., TRAIN LOAD, EB AND WB: REQUEST TO ESTABLISH MILEAGE TRAINLOAD RATES AS SHOWN IN EXHIBITS.

REASONS

ON BEHALF OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, OPERATION BREAKTHROUGH, THE GENERAL SERVICES ADMINISTRATION SUBMITS HEREWITH A PROPOSAL FOR THE ESTABLISHMENT OF RATES AND SERVICES TO COVER TRAINLOAD MOVEMENTS OF HOUSE AND/OR BUILDING SECTIONS, MODULAR, AS MORE SPECIFICALLY DESCRIBED THEREIN.

THE TRAINLOAD CONCEPT HAS BEEN SUBMITTED GENERALLY TO ALL INTERESTED CARRIERS AT VARIOUS MEETINGS INCLUDING PRESENTATION BY OPERATION BREAKTHROUGH ON APRIL 29, 1971, IN WASHINGTON, D.C. IN THE INTEREST OF BOTH CARRIERS AND SHIPPERS, NATION-WIDE IN THIS PROGRAM, ALL CARRIERS ARE URGED TO GIVE THIS NEW CONCEPT THEIR URGENT AND CAREFUL ATTENTION.

THEREFORE, THE GENERAL SERVICES ADMINISTRATION REQUESTS THAT EACH RAILROAD JURISDICTION ASSIGN THIS PROPOSAL FOR SHIPPER HEARINGS UNDER YOUR REGULAR DOCKET PROCEDURES.

MODULAR HOUSES
BREAKTHROUGH PROPOSAL

A. DESCRIPTION

HOUSE OR BUILDING SECTIONS, MODULAR, FACTORY MANUFACTURED, WITH OR WITHOUT HEATING, AIR CONDITIONING, PLUMBING EQUIPMENT, ELECTRICAL WIRING AND FIXTURES, REFRIGERATORS, STOVES OR CABINETS INSTALLED.

B. CHARGES

CHARGES ARE AS SHOWN ON ATTACHMENT 1. THE RATE SHOWN FOR EACH DISTANCE BRACKET IS APPLICABLE ONLY TO THE MILEAGE TRANSPORTED WITHIN THAT DISTANCE BRACKET. FOR EXAMPLE, A 400 MILE MOVEMENT OF A TRAINLOAD NOT EXCEEDING 3,000 FEET OR 2,000 TRAILING TONS WOULD BE CHARGED AT $17.50 PER MILE FOR THE FIRST 250 MILES AND AT $11.90 PER MILE FOR THE NEXT 150 MILES (PLUS X-267-B INCREASES.)

C. TERRITORIAL APPLICATION

THE RATES WILL APPLY ON SHIPMENTS BETWEEN ALL POINTS INTRA AND INTER TERRITORIALLY.

D. ALTERNATION

THE RATES WILL ALTERNATE WITH ALL OTHER CLASS, EXCEPTIONS, AND COMMODITY RATES.

E. MINIMUM CHARGE

THE TRAINLOAD MOVEMENT WILL BE SUBJECT TO A MINIMUM CHARGE FOR 250 MILES.

F. MAXIMUM LOAD

NO SHIPMENT MAY CONSIST OF MORE THAN 50 CARS OR 3,000 TRAILING TONS INCLUDING THE WEIGHT OF THE LADING. THE MAXIMUM WEIGHT LOADED ON ANY CAR IS THE CAPACITY OF THAT CAR AS SHOWN IN THE OFFICIAL RAILWAY EQUIPMENT REGISTER.

G. EQUIPMENT

EQUIPMENT NOT EXCEEDING 89' 6" WILL BE FURNISHED BY THE SHIPPER WITH NO PER DIEM OR MILEAGE ALLOWANCE. IF THE RAILROAD AGREES TO PROVIDE THE RAIL CARS, AT THE SHIPPER'S OPTION, THE CHARGES SHOWN IN ATTACHMENT 1 WILL BE INCREASED BY 10 CENTS PER CAR PER MILE IN THE TRAINLOAD REGARDLESS OF LENGTH OR WEIGHT.

H. EMPTY CARS RETURNED

SHIPPER-PROVIDED EMPTY CARS ARE TO BE RETURNED FREE OVER THE SAME ROUTE AS THE LOADED CARS ARE MOVED. CARS WILL BE RETURNED AT THE CARRIERS' CONVENIENCE, AND AT THE SHIPPERS' REQUEST, IN SPECIFIED LOTS UP TO 50 CARS AS A UNIT. IF SUCH CARS EXCEED STANDARD CLEARANCES PUBLISHED SPECIAL TRAIN CHARGES WILL BE ASSESSED.

I. ACCESSORIAL SERVICES

NO TRANSIT PRIVILEGES WILL BE PERMITTED. PUBLISHED SWITCHING CHARGES WILL BE ADDED TO THE CHARGES OTHERWISE COMPUTED THEN PERFORMED BY CARRIERS, NOT PARTICIPATING IN THE LINE-HAUL MOVEMENT. SEVENTY-TWO HOURS ADVANCE NOTICE OF CONTEMPLATED MOVEMENT MUST BE GIVEN THE ORIGIN CARRIER INVOLVED IN THE MOVEMENT.

J. MILEAGE

CHARGES ARE TO BE COMPUTED BY USE OF THE SHORTEST ACTUAL CLEARANCE ROUTE OF MOVEMENT FROM ORIGIN TO DESTINATION. WHERE THERE ARE TWO OR MORE AVAILABLE ROUTES BETWEEN ANY TWO STATIONS OVER WHICH THE TRAFFIC CAN PHYSICALLY BE HANDLED THE LOWEST MILEAGE CHARGE WILL APPLY VIA ALL ROUTES OF LINES PARTY TO THESE MILEAGED CHARGES.

ATTACHMENT 1

BREAKTHROUGH PROPOSAL
(SUBJECT TO X-267-B INCREASE)

ACTUAL (A) MILEAGE	CHARGE PER MILE (B) (C) PER BASIC TRAINLOAD	CHARGE PER MILE PER 100 FT. OR 67 TONS OR FRACTIONS THEREOF IN EXCESS OF BASIC TRAINLOAD, (B) (D)
1 TO 250	$17.50	54 CENTS
251 - 500	11.90	37
501 - 750	10.15	31
751 - 1000	8.93	28
OVER 1000	8.23	25

(A) RATE PER MILE APPLIES SEPARATELY FOR EACH MILEAGE BRACKET; E.G. FOR 400 MILES THE FIRST 250 MILES WOULD BE AT $17.50 PER MILE, THE NEXT 150 MILES WOULD BE AT $11.90 PER MILE.

(B) DISTANCE REDUCTION PERCENTAGE BASED ON HIGHEST MILEAGE SHOWN UNDER MILEAGE COLUMN EXCEPT FOR 1000 MILES AND OVER WHICH IS BASED ON THE 1250 MILE MILEAGE REDUCTION BASIS. ALL PERCENTAGE REDUCTION ARE BASED ON THE CHARGES FOR THE 1 TO 250 MILES BASIS.

(C) THE MINIMUM CHARGE IS THAT FOR 250 MILES FOR THE BASIC TRAINLOAD PLUS ADD-ONS FOR EXCESS LENGTH OR WEIGHT.

(D) THE BASIC TRAINLOAD CHARGE APPLIES ON TRAINLOADS NOT EXCEEDING 3000 FEET REFLECTING THE INSIDE DIMENSIONS ONLY OF THE FLAT CARS TO BE LOADED AND NOT EXCEEDING 2000 TRAILING TONS INCLUDING WEIGHT OF CARS.

Although this initial GSA rate proposal was rejected by five railroad rate-setting groups, federal officials expect a compromise. However, if the railroad's position remains rigid, the rate structure could be challenged before the Interstate Commerce Commission.

"I think the railroads will come up with a counter-proposal and I hope it will be acceptable to the manufacturers," said Robert F. Lenzi, Chief Contract Negotiator for GSA. "The last alternative would be the ICC, but I don't expect that to happen."[20]

A BEGINNING

A positive example indicating the railroad's interest in arriving at a satisfactory rate structure is the experience of DeBoer Building Systems, Inc., in their negotiations with Santa Fe Railroad. Original rates for trailer-train (piggy-back) cars were quoted in the spring of 1971 (prior to GSA's proposed rates) as follows:

Wichita to Kansas City (210 miles)
$2.22 per cwt - Minimum weight 10,000 pounds
+ 50 percent overlength charge

Withita to Chicago (660 miles)
$3.17 per cwt - Minimum weight 10,000 pounds
+ 50 percent overlength charge

Computing the module weights the total charges for the trips were as follows:

Wichita to Kansas City $429.22 or
$2.05 per loaded mile

Wichita to Chicago $620.17 or
$0.94 per loaded mile

After a trial run with two modules shipped by Santa Fe for demonstration purposes (and after GSA's proposed rates), DeBoer and Santa Fe renegotiated these rate charges:[21]

Wichita to Kansas City (210 miles)
$0.29 per cwt - Minimum weight 70,000

Wichita to Chicago (660 miles)
$0.73 per cwt - Minimum weight 70,000

Wichita to Kalamazoo, Michigan (700 miles)
$1.02 per cwt - Minimum weight 70,000

Wichita to Lansing, Michigan (870 miles)
$1.06 per cwt

This revised the charges on a loaded mile basis as follows:

Wichita to Kansas City $203.00
or $0.97/mile

Wichita to Chicago $511.00
or $0.77/mile

Wichita to Kalamazoo $707.00
or $0.76/mile

Wichita to Lansing $742.00
or $0.74/mile

The reduced average rate per loaded mile for rail is still higher than the average rate for highway transportation. However, when the additional carrying capacity of a rail car over a truck trailer is considered, rail becomes a very feasible alternative for a manufacturer who intends to ship his product over a large geographic area.

WATERWAYS MEAN LOW COST

The combined inland inter-coastal waterway system serves many of the major cities of the United States. But, until recently, water transportation has been largely ignored by the manufacturers of industrialized housing. The Guerdon Company, on a special project basis, did ship some modular units by barges from the Pacific Northwest area to Alaska.[22]

In general, most manufacturers find their shipping requirements at variance with the advantages offered by barging. The manufacturer has been interested in quickly transporting relatively light modules short distances. Water transport has historically been a method of hauling extremely heavy loads over long distances, where time was not a critical factor to the customer.

However, as manufacturers continue to look for feasible means to expand their geographical marketing area, water transportation has come under renewed scrutiny. Recently two major housing manufacturers have announced plant locations on inland waterways with water transportation the specific reason for their location choice. Both the shipment of the raw materials of manufacturing and the shipment of finished manufactured units entered into their decisions.

BARGE TYPES

Barges are the most commonly used vessels used as freight carriers on the rivers and intercoastal waterways. They are not powered and depend upon a powered tug boat to pull or push them through the waterways. Barges used for transporting dry loads are generally found in one of two types.

The "hopper" barge is by far the more prevalent type; it is constructed so that its cargo is located within the hull of the vessel. The hopper barge is used to carry loose, particulate materials such as grain, rock and gravel, ore, iron and steel, lumber, etc.

The "deck" barge is less common. It is used to transport cargos that because of their size or construction could not be handled by "hopper" barges.

Barges may be built to various sizes, but because of the dimensional limits imposed by some of the river locks and the narrow widths of the inter-coastal waterways, "hopper" barges usually follow

a general specification of:

Overall dimension. . . .

195 feet long, 35 feet wide
x 14½ feet high
including 1½ draft

Inside dimension. . . .

160 feet long x 28 feet wide
x 13 feet deep

Load capacity 2,800,000 pounds

Barges may be leased from a carrier or they may be customer owned. The freight rates reflect the difference in ownership of the barge. Barges can be constructed for about $115,000.00.[23]

WATERWAY CHARGES

Barge lines quote shipping charges based on a one-way loaded trip. There is no additional charge to the shipper for the movement of an empty, unloaded barge to another location.

Excerpts from the Freight Tariff Manual are shown on the following pages. Typical examples are shown for rates between barge landings.[24]

WATERWAYS FREIGHT BUREAU TARIFF 8-A

SECTION 1
BARGELOAD COMMODITY RATES
IN CENTS PER TON OF 2,000 POUNDS

BETWEEN	AND	GROUP	MINIMUM WEIGHTS PER BARGE IN TONS			
			600	500	400	300
			RATES			
ST. LOUIS MO.	CATOOSA.....OKLA.	1	947	1042	1136	1260
	CHATTANOOGA.....TENN.	1	690	757	823	907
	CHICAGO.....ILL.	1	406	445	483	533
	CINCINNATI.....OHIO	1	630	691	752	831
	DUBUQUE.....IOWA	1	469	515	559	617
	HOUSTON.....TEXAS	1	1171	1282	1393	1538
	KANSAS CITY.....MO.	1	469	515	559	617
	MEMPHIS.....TENN.	1	412	450	489	541
	MINNEAPOLIS.....MINN.	1	638	700	762	842
	NASHVILLE.....TENN.	1	550	603	656	725
	NEW ORLEANS.....LA.	1	791	866	940	1035
	OMAHA.....NEB.	1	606	665	722	799

EXPLANATION OF TERMS AS USED IN THIS TARIFF

BARGE - A NON-SELF PROPELLED CARGO VESSEL.

BULK COMMODITY - A COMMODITY WHICH IS LOSSE OR IN MASS AND WHICH IS NEITHER IN PACKAGES NOR IN UNITS OF SUFFICIENT SIZE TO PERMIT HANDLING PIECE BY PIECE IN LOADING OR UNLOADING AND IS RECEIVED AND DELIVERED BY CARRIER WITHOUT TRANSPORTATION MARK OR COUNT.

CARRIER - MEANS CARRIER OR CARRIERS PARTY TO THIS TARIFF.

CUSTOMER - MEANS THE PERSON OR ORGANIZATION FOR WHOM CARRIER RENDERS A TRANSPORTATION SERVICE.

GROSS TON - MEANS TON OF 2,240 POUNDS.

IRON AND STEEL - UNLESS OTHERWISE PROVIDED, THE WORD "IRON" WHEREVER USED IN THIS TARIFF SHALL BE MEANT TO EMBRACE ALSO "STEEL" AND VICE VERSA.

LANDING - A DOCK, WHARF, MOORING PLACE, PORT, HARBOR, QUAY, RIVER TERMINAL, WHARFBOAT OR ANY OTHER LOCATION WHERE A BARGE OR BARGES CAN BE SAFELY HELD FOR LOADING, UNLOADING OR OTHER PURPOSES.

NET TON - MEANS TON OF 2,000 POUNDS.

CUSTOMER'S BARGE - MEANS BARGE FURNISHED BY SHIPPER, CONSIGNEE OR OWNER OF THE GOODS TRANSPORTED.

TON - IF NOT FURTHER QUALIFIED, THE TERMS "TON" OR "PER TON" APPLY PER TON OF 2,000 POUNDS OR PER TON OF 2,240 POUNDS, DEPENDING ON WHICH IS USED IN THE PUBLICATION OF THE LINE-HAUL COMMODITY RATE.

TOWAGE - THE TERM "TOWAGE" AS USED IN THIS TARIFF MEANS THE SERVICE OF TOWING, PUSHING OR OTHERWISE PROPELLING ANOTHER VESSELL (LOADED OR EMPTY) THE PROPERTY OF ANOTHER, BUT DOES NOT INCLUDE TOWAGE PERFORMED FOR ANOTHER WATER CARRIER OF ANOTHER, BUT DOES NOT INCLUDE TOWAGE PERFORMED FOR ANOTHER WATER CARRIER (COMMON ON CONTRACT) SUBJECT TO PART III OF THE INTERSTATE COMMERCE ACT.

WATERWAYS - MEANS ANY EXPANSE OF WATER NAVIGABLE BY CARRIER'S BOATS AND BARGES SUCH AS BAYOUS, BAYS, CANALS, LAKES RIVERS AND CHANNELS.

TERM	DIMENSIONS	
	LENGTH NOT IN EXCESS OF (EXCEPT AS OTHERWISE PROVIDED)	WIDTH NOT IN EXCESS OF
JUMBO BARGE	195 FEET 200 FEET	35 FEET 40 FEET
RIVER-GULF BARGE (NOTE)	195 FEET	35 FEET
STANDARD BARGE.....	132 FEET 175 FEET 195 FEET 200 FEET	35 FEET 26 FEET 26 FEET 26 FEET
SUPER JUMBO BARGE....	OVER 200 FEET	OVER 40 FEET

NOTE - "RIVER-GULF" BARGES ARE SPECIALIZED EQUIPMENT CERTIFICATED FOR SERVICE ON THE OPEN WATERS OF THE GREAT LAKES AND THE GULF OF MEXICO.

APPLICATION OF RATES - RULES AND REGULATIONS

SUBJECT	APPLICATION
METHOD OF CANCELLING ITEMS	AS THIS TARIFF IS SUPPLEMENTED, NUMBERED ITEMS WITH LETTER SUFFIXES CANCEL CORRESPONDING NUMBERED ITEMS IN THE ORIGINAL TARIFF OR ANY PRIOR SUPPLEMENT. LETTER SUFFIXES WILL BE USED IN ALPHABETICAL SEQUENCE STARTING WITH A. EXAMPLE: ITEM 445-A CANCELS ITEM 445, ITEM 365-B CANCELS ITEM 365-A IN A PRIOR SHIPMENT, WHICH IN TURN CANCELLED ITEM 365.
REFERENCE TO ITEMS, NOTES, NUMBERS, PAGES, RULES OR TARIFFS	(A) WHERE REFERENCE IS MADE IN THIS TARIFF, TO A TARIFF, ITEM, RULE OR NOTE, SUCH REFERENCE WILL ALSO EMBRACE ANY REVISION IN OR SUCCESSIVE ISSUES OF SUCH TARIFF, ITEM, RULE OR NOTE. (B) WHERE CONSECUTIVE NUMBERS OR PAGES ARE REFERRED TO IN THIS TARIFF BY THE FIRST AND LAST NUMBERS CONNECTED BY THE WORD "TO" THEY WILL BE UNDERSTOOD TO INCLUDE BOTH OF THE NUMBERS SHOWN.

SUBJECT	APPLICATION
GOVERNING PUBLICATIONS	WATERWAYS FREIGHT BUREAU CIRCULAR NO. 1-A, AGENT WESLEY A. ROGERS, I.C.C. NO. 15, ILL. C.C. NO. 9.
GENERAL APPLICATION OF RATES	(A) EXCEPT AS OTHERWISE PROVIDED, RATES NAMED HEREIN APPLY F.O.B. BARGE AT ORIGIN TO F.O.B. BARGE AT DESTINATION, AND APPLY FOR LINE-HAUL APPLICATION ONLY AND DO NOT INCLUDE COST OF ELEVATION, OPENING OR CLOSING HATCHES OF BARGES, LOADING OF FREIGHT INTO BARGES, UNLOADING FREIGHT FROM BARGES, SWITCHING DEMURRAGE, DRAYAGE, WHARFAGE, TOLLAGE, OR ANY OTHER TERMINAL EXPENSES AT ORIGIN OR DESTINATION. (B) ALL RATES IN THIS TARIFF SHOWN UNDER COLUMNS HEADED BY LETTERS "A" AND "C" INDICATE APPLICATION OF SUCH RATES AS FOLLOWS: COLUMN "A" RATES - APPLY ON SHIPMENTS MOVING IN BARGES FURNISHED BY CARRIER, INCLUDING FULL COMMON CARRIER LIABILITY, AND SUBJECT TO PROVISIONS OF ITEM 25. COLUMN "C" RATES - APPLY ONLY ON SHIPMENTS MOVING IN BARGES FURNISHED BY CUSTOMER, INCLUDING ONLY LIMITED LIABILITY, AND SUBJECT TO THE PROVISIONS OF ITEM 30.
	(A) RATES IN THIS TARIFF APPLICABLE IN CARRIER'S BARGES APPLY ONLY ON COMMODITIES IN PIECES OR UNITS, WEIGHING LESS THAN 100 TONS, AND ON COMMODITIES MOVING IN COVERED OR HOPPER BARGES. (B) ON COMMODITIES, IN PIECES OR UNITS, WEIGHING 100 TONS OR MORE, BUT LESS THAN 200 TONS, AND TRANSPORTED IN COVERED OR HOPPER BARGES, RATES WILL BE 150 PER CENT OF RATES SHOWN IN SECTION 1 OR 2 OF THIS TARIFF. (C) ON COMMODITIES, IN PIECES OR UNITS, WEIGHING 200 TONS OR MORE AND TRANSPORTED IN COVERED OR HOPPER BARGES, RATES WILL BE

200 PER CENT OF RATES SHOWN IN SECTION 1 OR 2 OF THIS TARIFF.

(D) ON ALL COMMODITIES TRANSPORTED ON "FLUSH" (FLAT) DECK TYPE BARGES THE APPLICABLE RATES WILL BE AS FOLLOWS:

APPLICATION OF RATES IN BARGES FURNISHED BY CARRIER

1. NOT OVER 200 FT. LONG AND/OR 35 FT. WIDE	150% OF RATE SHOWN IN SECTIONS 1 OR 2 OF TARIFF
2. OVER 200 FT LONG AND/OR 35 FT. WIDE BUT NOT OVER 240 FT. LONG AND OR 50 FT WIDE	200% OF RATE SHOWN IN SECTION 1 OR 2 OF TARIFF
3. OVER 240 FT LONG AND OR 50 FT WIDE	NO RATES IN EFFECT AS OTHERWISE SPECIFICALLY PROVIDED IN RATE ITEMS.

(E) RATES IN THIS TARIFF FOR MINIMA LESS THAN 600 TONS, NET OR GROSS AS RATED, WILL NOT APPLY ON SHIPMENTS TRANSPORTED IN RIVERGULF COVERED HOPPER BARGES (SEE NOTE 3) ORIGINATING OR TERMINATING AT MILWAUKEE, WISCONSIN.

NOTE 1. SUBJECT TO A MINIMUM CHARGE OF $3,150.00 PER BARGE PER MOVEMENT.

NOTE 2. NOT SUBJECT TO PROVISIONS OF ITEMS 250, 350 OR PARAGRAPH (A) OF ITEM 360.

NOTE 3. RIVER-GULF COVERED HOPPER BARGES ARE SPECIALIZED EQUIPMENT CERTIFICATED FOR SERVICE ON THE OPEN WATERS OF THE GREAT LAKES AND THE GULF OF MEXICO.

NOTE 4. ON COMMODITIES IN PIECES OF UNITS WEIGHING 200 TONS OR MORE, RATES WILL BE 200 PERCENT OF RATES SHOWN IN SECTION 1 OR 2 OF TARIFF.

NOTE 5. WHEN CUSTOMER DOES NOT ORDER A FLUSH DECK BARGE AND CARRIER, FOR ITS OWN CONVENIENCE, PLACES A FLUSH DECK BARGE, RATES WILL BE AS SHOWN IN SECTIONS 1 OR 2 OF THIS TARIFF, PROVIDED PIECES OR

UNITS DO NOT WEIGHT IN EXCESS OF 25 NET TONS AND ARE LOADED AND UNLOADED WITH CONVENTIONAL HOISTING EQUIPMENT, VIZ.; CRANES, DERRICKS OR HOISTS.

TRANSFER BETWEEN CONNECTING CARRIERS

EXCEPT AS OTHERWISE PROVIDED THE JOINT RATES PUBLISHED HEREIN INCLUDE ALL CHARGES FOR SWITCHING, DRAYAGE OR OTHER TRANSFER SERVICES AT INTERMEDIATE INTERCHANGE POINTS ON SHIPMENTS HANDLED THROUGH AND NOT STOPPED FOR SPECIAL SERVICES AT SUCH INTERMEDIATE INTERCHANGE POINTS.

MAXIMUM DIMENSIONS OF BARGES AND CHARGES FOR OVERSIZE BARGES UNDER COLUMN "C" RATES

(A) COLUMN "C" RATES NAMED IN THIS TARIFF APPLY ONLY ON BARGES NOT EXCEEDING 200 FEET IN LENGTH AND/OR 35 FEET IN WIDTH. TO DETERMINE RATES ON BARGES EXCEEDING THESE DIMENSIONS, SEE PARAGRAPHS (B) AND (C).

(B) ON BARGES EXCEEDING 200 FEET IN LENGTH AND/OR 35 FEET IN WIDTH, BUT NOT EXCEEDING 240 FEET IN LENGTH AND/OR 45 FEET IN WIDTH THE APPLICABLE COLUMN (C) RATE WILL BE 150 PERCENT OF THE RATE SHOWN IN SECTIONS 1 OR 2.

(C) ON BARGES EXCEEDING 240 FEET IN LENGTH AND/OR 45 FEET IN WIDTH, THE APPLICABLE COLUMN (C) RATES WILL BE 200 PER CENT OF THE RATE SHOWN IN SECTIONS 1 OR 2.

From the tables it can be seen that as the weight of the load increases, the cost per pound shipping rate decreases. The industrialized housing manufacturer, owing to the relative lightness of the manufactured housing, would be charged at the maximum rate based on the 300 ton minimum weight. The barge dimensions limit physically the amount of housing which can be shipped. Regardless of this, the manufacturer is charged based on a 300 ton minimum weight.

It can also be seen from some of the example rates that while distance is a determining factor for rates between points, other factors such as river currents, number of locks, and waterway traffic, also enter into the establishment of rates. The amount of traffic on the waterway is one of the most important factors in rate determination. On busy waterways such as the Mississippi and the Ohio rivers, where the carrier can expect to get the best utilization of his barges, the rates are lowest.

VALUE VERSUS VOLUME

There is a direct relationship between the value of a product to its volume and the type of transportation mode which can be employed for shipping. High dollar per cubic foot products can economically justify high cost transportation; electronic equipment can justify air transportation. Low value per volume products, such as ores and gravel, must use low cost water transportation. The need for speed and dependability can also justify more expensive forms of transportation. Medicines for emergencies and perishable foods are products that can justify expensive transportation. Accessibility is the other determining factor. The most economical means of transport may not be available. Even though it might be more economical to ship coal from the mines of West Virginia to the steel mills of Pittsburgh by barge, there is no waterway, and rail is used.

ADVANTAGES AND DISADVANTAGES

Each mode of transportation has its advantages and its disadvantages. The most flexible in regard to

scheduling, access to the project site, minimum load and expedience is highway.[25] It is, however, the most expensive form of transportation on a per unit basis of product shipped. Rail offers the next most flexible form of transportation. In addition to offering a lower cost of transportation than highway, cargo shipped by rail is not as subject to limiting shipment dimensions as highway. However, the final segment of the trip from factory to job-site must still be made over the highway.

Barge offers the least cost of transportation and the fewest limitations on the dimensions of the load. It is also the least dependable in terms of scheduling and has the greatest disadvantage in site accessibility.

STILL IN THE FUTURE

The potential of air transportation has been overstressed by dramatic newspaper pictures showing modules being lowered by helicopters. Actually, a helicopter costs from $300 to $1,500 an hour, depending on its size, and its range is limited to

about 75 miles under load. Federal regulations usually prohibit flight over inhabited areas and the tremendous downwash from the rotor blades makes accurate placement difficult.[26]

MARKET AGGREGATION

BREAKTHROUGH: GOALS AND OBJECTIVES

The issues and concerns which generated Operation Breakthrough reflect the findings of three national committees: The National Commission on Urban Problems, or The Douglas Commission; The Committee on Urban Housing, or The Kaiser Committee; and The Departments of Commerce and Housing and Urban Development Panel on Housing Technology. All three reports offered substantial documentation to support the need for greater governmental involvement in the entire field of housing.[27]

A major objective of this increased involvement was to increase the overall productive capacity of the American housing industry.

Breakthrough was created to act as an operational catalyst in a program to develop, test, and promote the best in technologically advanced systems for producing housing.

Breakthrough essentially addressed itself to two related problems. The first of these was the creation of housing production in large volume. This was to be accomplished by encouraging the creation of new housing producers, as well as developing the production capacities of existing housing producers, with the management, financial resources, and the technology in manufacturing technique, to produce quality housing on a volume basis.

The second problem was assuring the availability of markets to absorb the increased volume of housing production. The large initial investments by volume housing producers in plant, equipment, and management could be justified only on the basis of an assured continuing market.

Breakthrough proposed two methods for government assistance in market aggregation. One proposal would create in HUD a central clearing house of information listing land which is suitable for development, surplus government land, census data, and market studies which have been prepared by such housing related groups as utility companies and mortgage lenders. This information would be compiled and made centrally available to housing manufacturers and developers.[28]

The second proposal would pool the resources of government agencies which are active in housing such as public housing authorities, state housing financing agencies, and other state and city government departments sponsoring housing to create large, single housing orders.[29]

By the simultaneous purchase of housing for several government financed developments from a single producer, volume orders necessary to realize the full potential of industrialized production can be created. The Illinois Housing Development

Authority is participating with HUD in a demonstration of this type of market aggregation.[30]

LACK OF COMMITMENT

Critics of this approach to market aggregation have expressed their concern with the lack of a massive national commitment by government and with the lack of assurance of sufficient program continuity.

Robertson Ward in his article on Breakthrough voiced his concern:

> Undoubtedly, the most important single element in Breakthrough's strategy, and possibly the most vulnerable, is the effort toward market aggregation. Unfortunately, the means proposed for the task carry no certainty of success--the program's officials have stated that subsidy allocations are being made available to help stimulate market aggregation. Still, assurance of funding continuity may yet be insufficient to attract industry to make the investments required for volume production.[31]

To illustrate the difficulty of providing the magnitude of government commitment necessary to maintain an industrialized housing manufacturer the following example should be useful:

The Federal Government has set a national goal for the production of two million or more units annually for the next ten years.[32] This amounts to approximately 10 units constructed per year per one thousand population.

Kalamazoo, Michigan (one of the Operation Breakthrough sites), has a metropolitan population of less than 200,000. For the purpose of this example, assume that Kalamazoo's housing needs for the next 10 years parallel the nation's needs. To meet the goals established by the Federal Government, Kalamazoo should build at an average rate of 2,000 units per year.

Now in 1972, 25 percent of all housing starts will be built under one of the government's housing subsidy programs.[33] (Subsidy housing is the housing that is proposed that would be used to create the aggregate market which the government could control and offer to a manufacturer.)

Applying this percentage for subsidy housing to that estimated for the annual average total for

Kalamazoo (25% of 2,000), gives 500 units which could be annually directed to a housing manufacturer.

Slayter Associates in a recent study for a midwestern housing manufacturer, comparable in size to those firms participating in the Kalamazoo Breakthrough program, projected the minimum break-even point in manufacture for that firm to be 1,900 units annually.

This means that such a manufacturer with the entire federal subsidized housing market for a community of 200,000 people would still be shy of orders for almost 75 percent of just his break-even production! Add to this the problem of start-stop funding of government subsidy programs.

SUBSIDIES: THE STAGGERING COST

Breakthrough did look to the use of government control of subsidy programs as a means of aggregating a market for a manufacturer.[34] Now, however, before Breakthrough has completed its demonstration phase, Housing Secretary George Romney is sounding

an alarm. In his housing goals report in June, he told Congress:

> Assuming completion of six million subsidized units....by 1978, estimates suggest the government will be paying at least $7.5 billion annually in subsidies. Over the life of the mortgages, this could amount to the staggering total of more than $200 billion.[35]

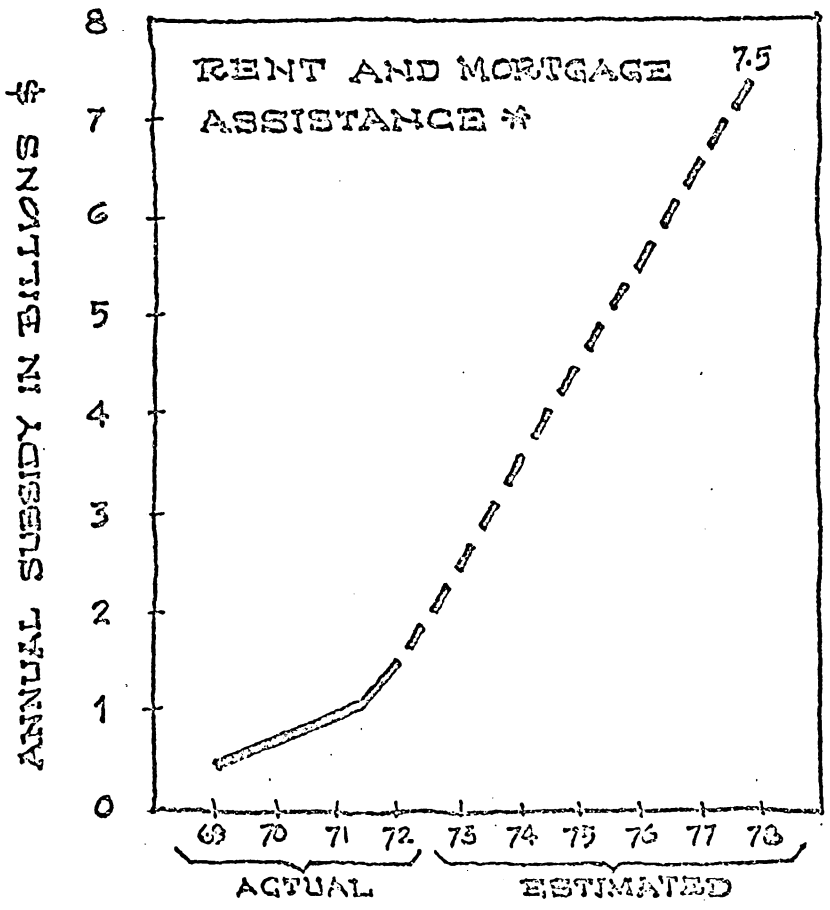


FIGURE 3-A

THE HOUSING ALLOWANCE

As a result of this concern with the expense of mortgage subsidies, Housing and Urban Development, in January 1972, announced a new experimental program: the housing allowance. Rather than subsidizing housing, HUD will subsidize the people who need housing. The housing allowance gives a poor family money or a certificate worth an average $900.00 a year to be applied to shelter, and then lets the family shop for itself in the open market. The present policy encourages the building and buying of new subsidized houses, but allowances will allow the recipients to shop for housing--they no longer will be required to live in government subsidized housing to receive assistance.

The housing allowance encourages people to look for the best housing available. It would mean that assistance would be available to all families that are qualified and not just the 10 percent of qualified families presently housed in projects constructed under current subsidy programs.[36]

With the instability of governmental policies and programs inherent in the political form of government of our nation, it is very difficult for private industry to make large scale investments based on the prospect of governmental program continuity.

THE PRIVATE BUILDER'S WAY

Private builders and developers who build the other 75 percent of the housing units which does not come under governmental subsidy programs, have had to use a different technique to aggregate an adequate market to sustain large volume production.

More and more, a larger percentage of the housing built is being built by large developers working on a national basis. Rather than trying to aggregate a large market in one community, these builders spread their operations over several states or across the nation. Using a large demographic base, they are able to transfer energies from one area to another in response to market demands.

For the conventional builder this means the necessity of a highly mobile organization. To effect this mobility the conventional builder maintains a very lean administrative staff. He relies on sub-contracting the actual construction to independent contractors throughout his area of operation. He uses to advantage his large purchasing capability to supply his various projects and he can close down an area of operation without financial loss.

THE NEWCOMERS

In recent years many of these large developer-builders have been entering the industrialized housing field: Levitt, Behring, Wickes, Boise-Cascade, Kaufman and Broad, Scholz and others are now operating manufacturing facilities.[37] The reasons for their entry into factory-built housing are: labor shortages; rising costs; and the need for improved control of cost, construction schedules, and quality.[38]

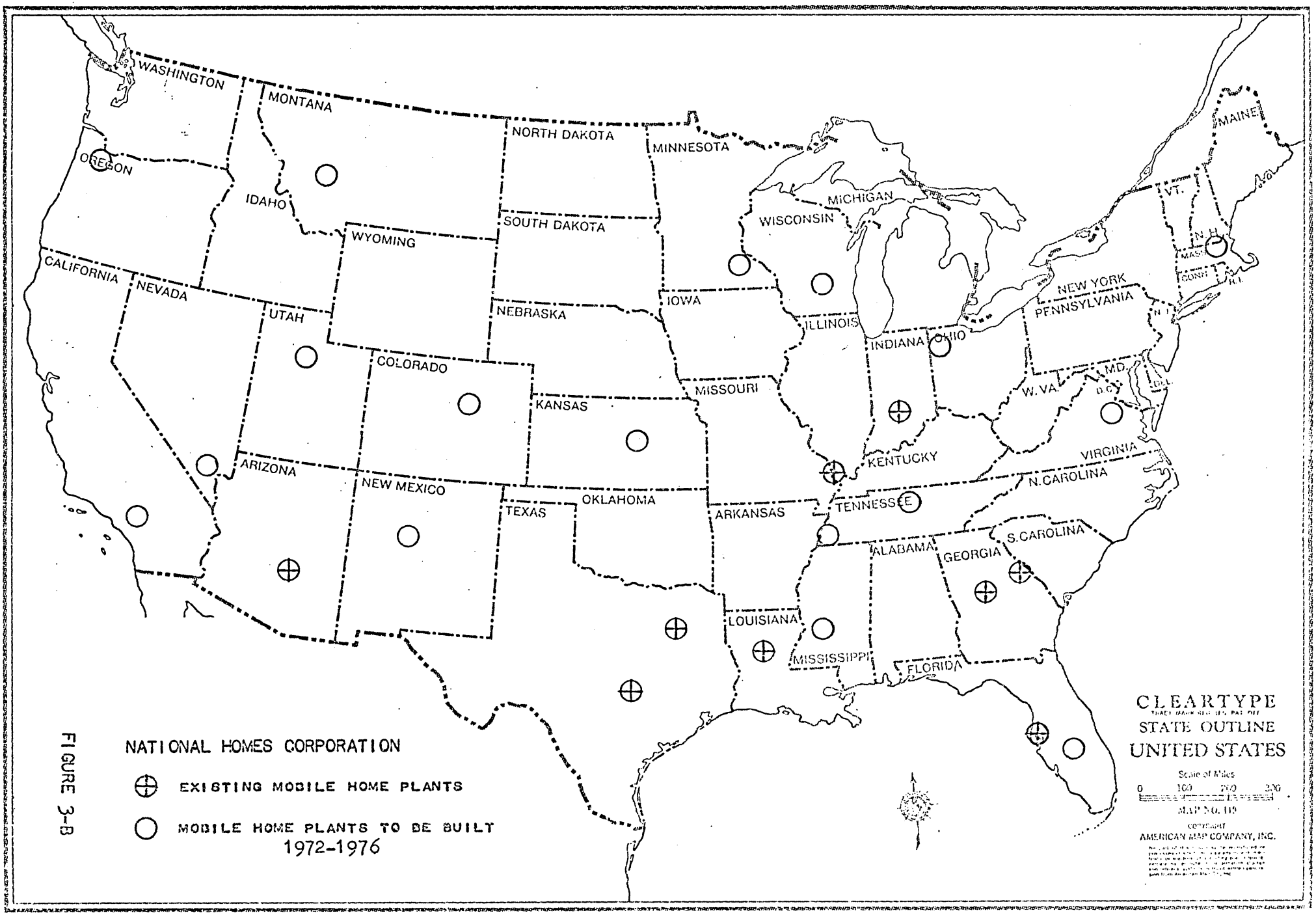

WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
WYOMING
SOUTH DAKOTA
MICHIGAN
WISCONSIN
MAINE
VT.
N.H.
MASS.
CONN.
R.I.
CALIFORNIA
NEVADA
UTAH
NEBRASKA
IOWA
ILLINOIS
INDIANA
OHIO
NEW YORK
PENNSYLVANIA
N.J.
COLORADO
MISSOURI
W.VA.
MD.
D.C.
DEL.
KANSAS
KENTUCKY
VIRGINIA
ARIZONA
NEW MEXICO
OKLAHOMA
TEXAS
ARKANSAS
TENNESSEE
N.CAROLINA
S.CAROLINA
ALABAMA
GEORGIA
LOUISIANA
MISSISSIPPI
FLORIDA
NATIONAL HOMES CORPORATION
EXISTING MOBILE HOME PLANTS
MOBILE HOME PLANTS TO BE BUILT
1972-1976
CLEARTYPE
STATE OUTLINE
UNITED STATES
Scale of Miles
0 100 200 300
MAP NO. 119
COPYRIGHT
AMERICAN MAP COMPANY, INC.

FIGURE 3-B

When the large developer becomes involved in industrialized housing, aggregating a market is much more difficult than when he built conventionally. He may be tempted to use the mobile home industry's approach to market aggregation. Confronted with the high cost of long distance transportation, mobile home manufacturers have followed a policy of building a large number of plants across the nation, so that each plant serves a segment of the total market that can be reached within an economically practical shipping distance.[39] (See map, Fig. 3-B.)

The difficulties in such a practise are twofold:

First, the result is a proliferation of smaller, less efficient plants.[40] Faced with sizeable capital requirements for building and equipping multiple plants, the mobile home manufacturer builds a comparatively small unsophisticated plant. Absent is the automated equipment that would improve the production process and make use of materials such as plastics and metals in the manufactured unit.

Second, it results in plant locations that are highly vulnerable to local market fluctuations. This means plant shutdowns, loss of trained labor, and loss of return on plant investment (another negative reason for keeping plant investment to a minimum).

To aggregate a sufficient market area for a single, highly capitalized, well-equipped plant, the industrialized housing manufacturer must find an economical system of long range transportation for his product.

VALUE ADDED

CONVENTIONAL BUILDING INDOORS

Industrialized housing is in its present state of development, little more than conventional construction which has been moved indoors.[41] Capital investment in plant and equipment is held to a minimum. The manufacturing facility is usually housed in a large metal building, served with a minimum of mechanical and electrical equipment.

Manufacturing equipment is limited to powered hand tools. Most of the material handling is by manpower.

The method of construction for wall and floor panels is virtually the same as on site framing methods; wood, composition board and gypsum dry-wall are the principal materials. In the interest of holding down the investment in plant manufacturing equipment and keeping the cost of developing specialized labor skills to a minimum, wherever it is feasible building components are incorporated into the manufacturing process and are obtained pre-manufactured from other vendors. These items include: aluminum doors and windows, kitchen cabinets, pre-hung interior doors, counters and plumbing fixtures, electrical fixtures, and any other items which can be furnished pre-finished. Inventories are held to a minimum with correspondingly a loss of advantage of volume purchasing.

With many of the material items of manufacture purchased from others, very little value is added

to the final product. For this reason, transportation cost has to be held to a minimum which correspondingly limits the geographic marketing area. To overcome this marketing area limitation the industrialized housing manufacture must follow the practise of other industries and add more value to his product. With increased value added to his product he will be able to justify a greater transportation cost, permitting him to expand his market area.

MANUFACTURING ECONOMICS

The "value added" economic concept has important implications for the production process. The manufacturer recognizes the cost of plant and equipment in his operational expense as depreciation. Depreciation is the amount that the plant and equipment annually lose economic value. A typical plant amortization schedule prepared by Slayter and Assoc. for a prospective mid-west manufacturer is shown in figure 3-C.[42] From the information in the table it is evident that the effect of plant and equipment depreciation on the

PLANT AND EQUIPMENT DEPRECIATION

LAND AND IMPROVEMENT	PURCHASE COST	LIFE	ANNUAL DEPRECIATION
BASIC STRUCTURE	$525,498	40	$11,137
SPRINKLER SYSTEM	72,932	33	2,134
RESTROOMS	11,700	20	510
LIGHTS AND ELECTRICAL	159,125	20	7,856
HEATING AND VENTILATING	54,432	20	2,896
GRADING AND LANDSCAPING	13,650	20	632
ASPHALT YARDS AND LOTS	40,297	10	2,821
FENCING	11,692	33	818
EXTERIOR LIGHTING AND SUPPLY	10,000	20	700
GRAVEL FILL	40,260	10	1,818
CONCRETE WALKS AND YARDS	9,528	10	667
STORM SEWERS	23,000	20	1,616
FIXED PLANT EQUIPMENT			
POWER CONVEYOR	5,000	15	320
MONORAIL AND CRANE	69,217	20	4,845
SAW DUST REMOVAL	21,000	10	1,470
HOGGER AND BAILER	34,000	10	2,380
AUTOMATED PANEL MACHINES	82,400	10	6,440
HOISTS	6,200	5	434
NON-FIXES TOOLS AND EQUIPMENT			
OFFICE FURN AND EQUIPMENT	39,000	10	2,730
JIGS, TABLES, RACKS & BINS	18,000	10	1,360
DOLLIES, CARTS, PALLETS	27,000	2	1,890
CONVEYORS	18,400	5	1,198
POWER TOOLS	51,000	5	3,570
SHOP EQUIPMENT	42,200	5	6,584
MAINTAINENCE & FIRE EQUIP	21,000	5	1,470
GLUE SYSTEM	10,000	4	700
HAND TOOLS	8,000	2	560
MATERIAL HANDLING EQUIPMENT			
FORK LIFTS (4)	34,000	5	2,380
TRACTOR AND TRUCK	9,000	3	630
			$74,666

COST OF PLANT AND EQUIPMENT DEPRECIATION ON A PER APARTMENT BASIS, WHEN THE ANNUAL RATE OF PRODUCTION IS 4000 UNITS/YR = $18.67 / APT UNIT.

FIGURE 3-C

manufacturing cost of an apartment unit is quite low.

For a comparison of the cost of depreciation with the manufacturer's other operational costs, a typical statement of operational expenses of a modular manufacturer is shown in figure 3-D.[43] The cost of plant and equipment has an almost negligible (0.3%) effect on the total operational cost! Even including the interest on the money which might be borrowed for the purchase of plant and equipment, the effect on the total cost is still less than one percent.

Now consider the relationship of depreciation to increased production. For illustrative purposes, assume the following:

1. A one million dollar plant will produce 2,000 units per year.

2. For each 500 thousand dollar increase in plant and equipment that there is a corresponding increase in the production rate of 2,000 units per year.

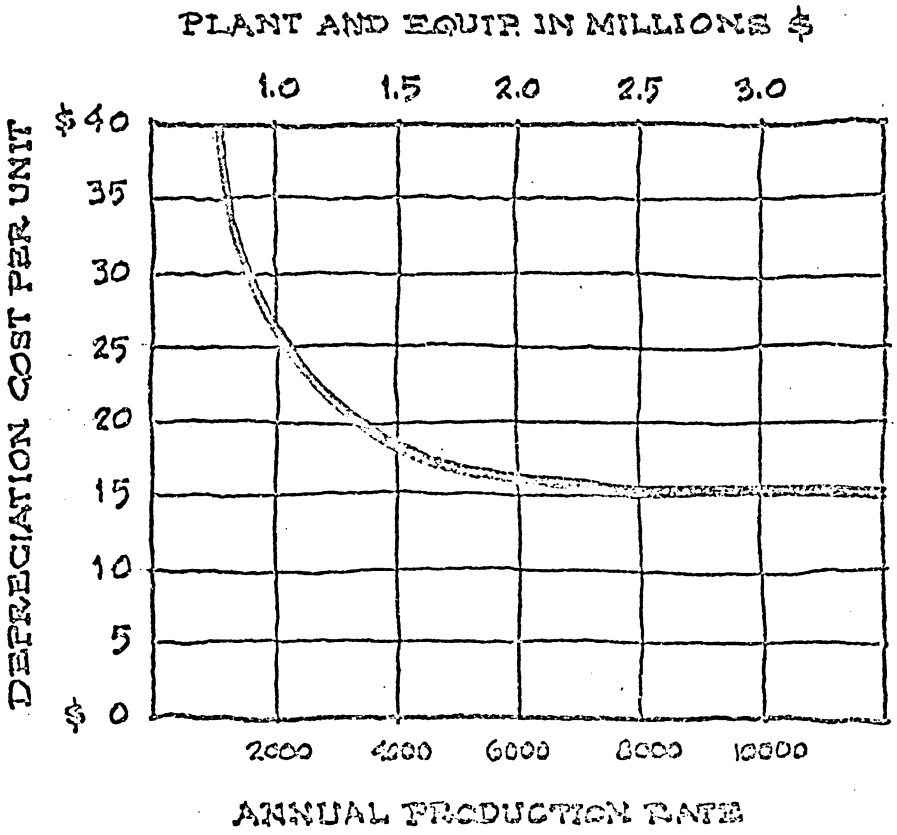
STATEMENT OF OPERATIONAL EXPENSES

	UNIT COST	PERCENTAGE
MATERIALS AND LABOR		
MATERIALS	$5,050.00	51.0%
DIRECT LABOR	1,185.00	12.0
INDIRECT LABOR	100.00	1.0
	$6,335.00	64.0%
MANUFACTURING COSTS		
PAYROLL TAXES	$ 315.00	
LIGHT, POWER AND UTILITIES	24.00	
REPAIR AND MAINTENANCE	30.00	
TRUCK EXPENSE	23.00	
DEPRECIATION	28.00	
LEASE AND RENTALS	80.00	
MISCELLANEOUS SHOP EXPENSE	45.00	
	$ 545.00	5.5%
SALES COSTS		
COMMISSION AND OVERRIDES	$ 395.00	
ADVERTISING AND PROMOTION	160.00	
LITERATURE AND PUBLICITY	40.00	
	$ 595.00	6.0%
ADMINISTRATIVE COSTS		
EXECUTIVE SALARIES	$ 216.00	
OFFICE SALARIES	279.00	
PAYROLL TAXES	61.00	
OFFICE SUPPLIES AND POSTAGE	17.00	
TELEPHONE AND OFFICE LEASES	71.00	
LEGAL AND AUDITING	24.00	
AUTO AND TRAVEL	71.00	
INSURANCE AND TAXES	62.00	
INTEREST	47.00	
MISCELLANEOUS	92.00	
	$ 940.00	9.5%
TOTAL COSTS	$ 8,415.00	
NET PROFIT BEFORE TAXES	$ 1,485.00	15.0%
SALES PRICE	$ 9,900.00	100.00%

NOTE: SALES PRICE IS NET F.O.B. PLANT PRICE AND IS EXCLUSIVE OF LOCAL TAXES, PERMIT, TRANSPORTATION, ERECTION AND OTHER FEES.

FIGURE 3-D

3. Amortization of plant and equipment is on a forty year basis. This would result in the graph:



As the investment in plant and equipment is increased to increase the rate of production, that portion of the unit cost for depreciation is dramatically reduced.

PLANT AND EQUIPMENT INVESTMENT

These illustrations merely reiterate a long standing axiom of mass production: increased capital investment in plant and equipment results in lower unit cost.

As the costs of conventional construction continue to spiral, the potential for profit from industrializing the process of manufacturing housing is increased. The promise of these profits has attracted companies with ample capital for investment in sophisticated plants and equipment to enter the industrialized housing game. Companies such as Westinghouse, General Electric, Levitt Building Systems, Wickes Corporation, U. S. Steel and others have opened new plant facilities which incorporate concepts of manufacturing employed in other industries.

These new plants are large and are well constructed with thoroughly planned production layouts. The mechanical and electrical systems of the plants are sophisticated and capable of adapting to changing production requirements. Large investments

have been made in all sorts of material handling equipment, overhead cranes, powered floor conveyors, powered hoists and an array of vehicular material movers.

AUTOMATED MACHINERY

Highly automated manufacturing equipment is incorporated into these plants. These include machines which automatically saw, nail, sheath, and cut openings.

Representative of the new developments in automated equipment is a "computerized wall framing system" recently offered to housing manufacturers by Kellner Industries of Fresno, California. From an architect's preliminary design, a computer programmer can overnight prepare, with a computerized-plotter, working drawings for the construction of all the walls of a building. Framing members are all located and properly sized for the various openings in the walls. As the computer is preparing the working drawing, it is also preparing a paper tape used to control the mechanical operator

of the wall building machine. This machine automatically feeds pre-cut wood studs into the nailing element of the machine where the studs are spaced and nailed automatically (including those for framing openings) by the tape-controlled machine operator. The plates are nailed to the studs by the machine, which drive up to eight 16-D nails at a time. Saws automatically cut the plates to the desired length. The wall is then moved by a powered conveyor to another machine where the wall sheathing is automatically fastened to each wall stud. After the sheathing operation, a third machine cuts out all of the wall openings, then the windows and exterior siding are applied. At the end of the line the semi-finished walls are lifted from the machine by a powered hoist for storage.

Through the investment in such automated equipment, the manufacturer is no longer limited only to wood as his fabrication material. With machines which rivet, screw, weld and cut, it is possible to utilize materials such as steel, aluminum and plastic, which heretofore have had limited use in

housing construction because of the difficulty of fabrication with conventional hand tools.

INCREASING THE MARKET AREA

By adding additional plant equipment the manufacturer can greatly increase the value added to the final product, by manufacturing as many of the components of the assembly as possible.

In adding value to the product the manufacturer can justify additional transportation cost thereby expanding his geographical marketing area.

The manufacturer of the past, undercapitalized, using hand labor in makeshift facilities, exposed to the economic vagaries of his limited marketing area, has little promise of success in the future, faced with the competition of the large manufacturers entering the field of industrialized housing.

UNIT DESIGN

PREFABRICATED COMPONENTS

The "value added" manufacturing concept becomes a very important consideration in the design of the manufactured unit and in the degree of its manufactured completion.

Companies active today in industrialized housing vary in manufacturing completion from those who build unfinished components of the structure to those who build a finished modular unit. Many lumber yards have gone into the production of the components of the structure. Such items as exterior and interior wall panels (usually unfinished), wood trusses, and all the other items required to erect the house structure are included in the package. Very little value is added to the value of the raw lumber and for this reason the delivery of the product must be limited to the plant's immediate locale.

The customer of these structural components can erect his buildings faster, but he must still perform all of the mechanical, electrical, and plumbing work in the field as well as apply the exterior and interior finish to the building. The result is that there is little difference in cost between this industrialized method of construction and the conventional "stick-by-stick" method. The principal customer for this method of manufacture is usually the small builder who is more interested in the design service and the financing which is provided by the manufacturer and the ability to more quickly get his house "under-roof," avoiding costly weather delay, than in any savings offered in the direct construction cost.

MECHANICAL CORES

When a builder undertakes a large volume of construction he can employ industrialized processes at the job site. He can build his own wall components and roof trusses and purchase his material in large quantities from a wholesaler. He has no need of the pre-fab component manufacturer. What

he needs is a way to control the cost and scheduling of his mechanical, electrical and plumbing work. To answer these builder-needs industrialized housing manufacturers, in recent years, have begun the manufacture of mechanical cores. The use of mechanical cores greatly accelerates the construction process in addition to diminishing the dependence of the builder on the mechanical subcontractors.

In the manufacture of the mechanical core much more value is added to the product than in the manufacture of the structural component. As a result of this added value and the compactness of the core, several cores may be shipped by a single transporter. Consequently, it is possible for the core manufacturer to cover a much larger marketing area than the component manufacturer.

MODULAR UNITS

The manufacture of a modular unit is essentially the assembly of core and panels in the manufacturing plant, instead of at the job site. The

Wickes Corporation in their Mason, Michigan plant literally follow this method of construction. One section of the plant is devoted to a manufacturing line for mechanical cores, and another section for panel production. When the cores are nearly complete they are joined with prefabricated wall and floor panels in a second assembly line where they are completed as modules.

The modular unit offers both the small and the large builder the ultimate control of cost, time of completion, and quality of construction. When the site work is completed and the foundations are ready, the modular units can be set very quickly and the time of completion is held to a minimum.

For the small builder the modular unit (if competitively priced with conventional construction) offers the most advantages. His money is tied up for the least amount of time, his exposure to weather is at a minimum, his sub-contracting is held to a minimum and he utilizes design and

engineering provided by the manufacturer. For the larger builder, the advantages are not as substantial, in fact the disadvantages can outweigh the advantages. In a large operation a volume builder using mechanical cores and panels which have their exterior and interior finishes, can erect his building almost as quickly as with modules. His erection is simpler, because the units are smaller. The smaller unit is less susceptible to shipping damage, consequently there is less repair on the manufactured units.

TRANSPORTATION LIMITATION

The modular unit has a much lower cubic foot value than the mechanical core unit which makes the ratio of transport cost to product cost much more advantageous for the mechanical core. For this reason, the additional cost of completion of the core and panel system may be more than offset by the added transportation cost of the modular units.

Another disadvantage of the modular system when compared with the core and panel system is its

limitation of design. As discussed earlier, highway regulations control the design of the unit shipped over the road. In attempting to maximize the utilization of the envelope that is to be shipped, the design will use all the space within the limiting dimensions.[44] This often results in the completed building, particularly the multi-family building, being criticized for its "boxy" look. The panels in the core and panel system, because they are not assembled until they are incorporated into the building, and therefore not limited as severely to dimension, offer much greater building design opportunity.

ANALYSIS

NOTES

1. R. J. Lytle, INDUSTRIALIZED BUILDERS HANDBOOK, Structures Publishing Co., 1971, p. 179

2. J. A. Reidelbach, Jr., MODULAR HOUSING IN THE REAL, Modcox Inc., 1970, p. 121

3. Ibid., p. 127

4. J. A. Reidelbach, Jr., MODULAR HOUSING SYSTEMS, 1971, Cahners Publishing Co., Inc., 1971, p. 91

5. J. A. Reidelbach, Jr., Op. Cit., p. 121

6. "Where do you Put the Factory House?", PROFESSIONAL BUILDER, October 1971, p. 128

7. Ibid., p. 123

8. Ibid., p. 125

9. Excerpts from State Highway Regulations for the State of: Illinois, Indiana, Missouri, Michigan, Kansas, Colorado

10. "Where do you Put the Factory House?," Op. Cit, p. 128

11. "The Problem of Transportation Can Severely Limit Modular Breakthrough," HOUSE & HOME, October 1971, p. 94

12. Slayter Assoc. Inc., BUSINESS PLAN FOR THE MANUFACTURER OF CORE AND PANEL HOMES, January 6, 1971

13. "Where do you Put the Factory House?," Op. Cit., p. 128

14. "Railroads Sidetrack National Rail Rate for Mods," INDUSTRIALIZED BUILDING, December 1971, p. 146

15. Ibid., p. 148

16. "Operation Breakthrough: Questions and Answers," U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT HUD 186 - 186 RT (2) March, 1971

17. "Railroads Sidetrack National Rail Rate for Mods," Op. Cit., p. 148

18. "Railroads Sidetrack National Rail Rate for Mods," Op. Cit., 148

19. GENERAL SERVICES ADMINISTRATION Transportation and Communication Service, Economics and Statistics Branch, April 1, 1971

20. "Railroads Sidetrack National Rail Rate for Mods," Op. Cit., p. 148

21. Proposal from Atchinson, Topeka and Santa Fe Railway Co. to DeBoer Building Systems, Inc. January 14, 1972

22. J. A. Reidelbach, Jr., Op. Cit., p. 129

23. Interview with W. G. Carlisle, Traffic Manager, DIXIE CARRIERS, INC., February 15, 1972

24. Freight Tariff No. 8-A WATERWAYS FREIGHT BUREAU, November 9, 1970

25. J. A. Reidelbach, Jr., Op. Cit., p. 125

26. "Where do you Put the Factory House?," Op. Cit., p. 129

27. Robertson Ward, Jr., FAIA, "Breakthrough?," AIA JOURNAL, March 1971, p. 18

28. "Operation Breakthrough: Questions and Answers," Op. Cit.

29. "Operation Breakthrough: Questions and Answers," Op. Cit.

30. John H. Betz, "State Housing Programs: Minor Venture or Major Initiative," HUD CHALLENGE, June, 1971

31. Robertson Ward, Jr., FAIA, Op. Cit., p. 19

32. "Operation Breakthrough: Questions and Answers," Op. Cit.

33. Don Loomis, "Romney Cries a Warning," HOUSE & HOME, September, 1971, p. 28

34. Robertson Ward, Jr., Op. Cit., p. 20

35. Don Loomis, Op. Cit., p. 28

36. "Housing Money That Goes to the People," BUSINESS WEEK, January 8, 1972, p. 51

37. "Modulars the Phantom Industry," HOUSE & HOME, June 1970, p. 66

38. "Where do you Put the Factory House?," Op. Cit., p. 128

39. "The Problem of Transportation Can Severely Limit Modular Breakthrough," Op. Cit., p. 94

40. "Railroads Sidetrack National Rail Rate for Mods," Op. Cit., p. 128

41. "Modulars the Phantom Industry," Op. Cit., p. 65

42. Slayter and Assoc., Op. Cit., p. 76

43. J. A. Reidelbach, Jr., MODULAR HOUSING, 1971, Cahners Publishing Co., Inc., 1971, p. 79

44. J. A. Reidelbach, Jr., MODULAR HOUSING IN THE REAL MODOCO, 1970, p. 175

IV

STRATEGY

CONCEPT

The generally accepted concept of industrialized housing as a system of manufacturing modular units which are transported over the highway to the job site, has not been successful in aggregating an adequate market for the manufacturer.[1]

In the manufacture of the modular unit very little value is added in proportion to the volume which

must be shipped. In the vernacular of the industry, the result is "shipping too much air." Adding to this economic disadvantage of low value added in manufacture is the choice of highway transportation as the movement system. Given equal access, highway is a more expensive method of shipping industrialized housing than either railway or waterway transportation.

Even though some manufacturers have experimented with shipping their modular units by rail in an effort to effectively increase their shipping radius, the cost of shipping low value modules long distances eliminates their ability to compete with conventional construction. Encountering these excessive costs of transportation manufacturers have, as a result, kept their operational radius small, with a correspondingly small marketing area.

As stated in the introduction, this thesis holds that with a rationalization of the processes of industrialization an economically feasible system

may be designed for the manufacture and shipment of industrialized housing.

It is the proposition of this thesis that the manufacture of mechanical cores in a central plant and the manufacture of panels in a satellite plant, will overcome the economic barrier of transportation costs in the aggregation of an adequate market for the manufacturer.

The concept is as follows: A primary plant for the manufacture of mechanical cores should be centrally located with respect to the market it is to serve, in an area served by all systems of transportation. This plant should be fully equipped with the most automated systems of production available. As many as is feasible of the manufacturing processes should take place in this plant, maximizing the value added to the product.

To overcome the economic infeasibility of transporting wall and floor panels over long distances, satellite plants should be established in locations within short transportation distance of several

projects. These plants require low capital investment; they should provide the minimum required shelter for the panel manufacturing equipment. These plants could be set up in existing industrial buildings or in portable facilities. Rail and highway service should be available for receiving raw materials and for shipping the finished product.

An additional utilization of a satellite panel plant could be the assembling of cores shipped in from the central plant and the panels into modules.

The building would have to be slightly larger than the panel plant alone to allow for an assembly line. It would be convenient to locate a satellite assembly plant on a major waterway linked to the central to permit the shipping of cores to the satellite plant.

The advantage of a satellite assembly plant is a reduction in the required shipping distance of the modular units. The compact, high-value per volume cores would be shipped to the satellite plant, a shipment representing the major portion

of the overall distance to the project site. After assembly, the modular units could be shipped the balance of the distance to the project site by either highway or rail. The resulting modular building could be erected for less cost than the core and panel building; however, if the satellite assembly plant were too distant from the project site, any savings in erection cost would be offset by handling and shipping expense.

RATIONALE

The base design and cost data in this section were derived from the experience of DeBoer Building Systems, Inc., Wichita, Kansas.

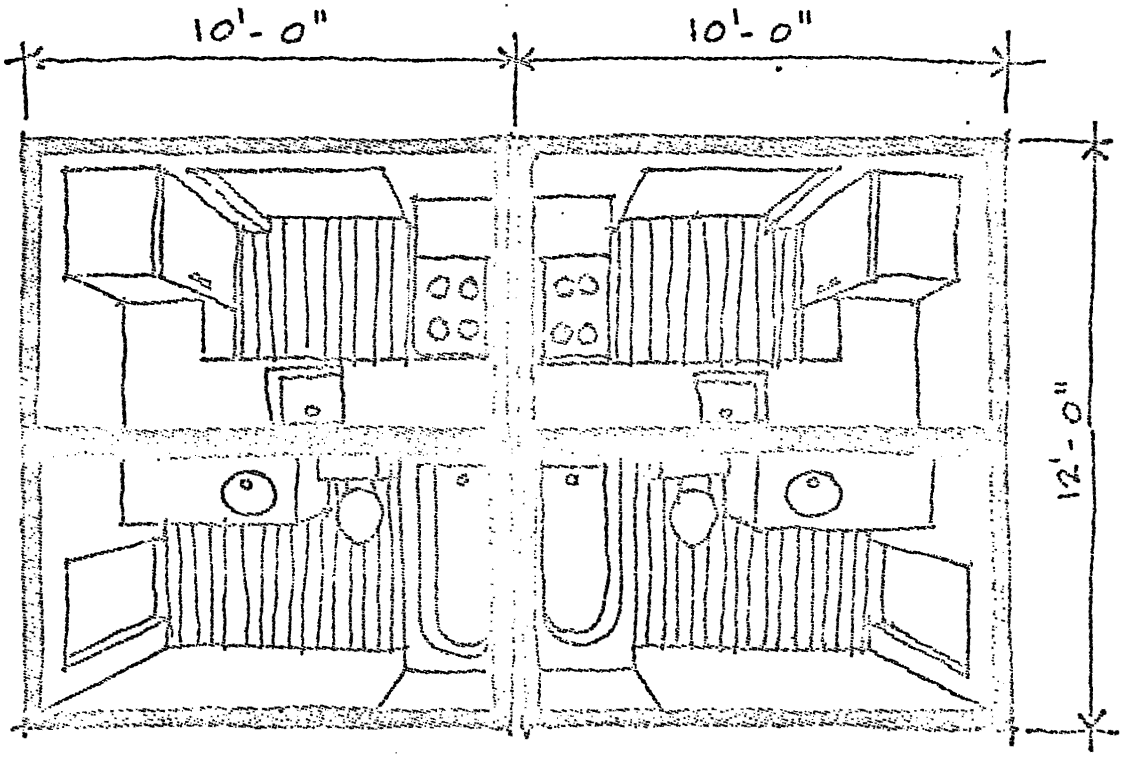
DeBoer Building Systems operates from a $2½ million production facility which has the capability of manufacturing either building modules or mechanical cores and panels. The plant contains 100,000 sq. ft. of manufacturing area and has the production capability of 4,000 core and panel apartment units or 2,000 modular apartment units per year.

DeBoer Building Systems is typical of an emerging pattern of industrialized housing manufacturers. It is a subsidiary of a parent organization, DeBoer Associates, Inc. The parent company is a large, national, developer of apartment communities. This relationship is closely paralleled in the industry by other manufacturers who have been formed as subsidiaries of larger parent organizations. Some of the parent companies who have formed manufacturing subsidiaries are: Levitt and Sons, Boise-Cascade, Wickes Lumber, Behring Corp., Kaufman and Broad, Westinghouse and General Electric.[2]

Though systems of manufacture and shipment do impose additional conditions to the design of housing, design variations of industrialized housing are nevertheless seemingly endless. Many designs have been proposed in the past and many more will be proposed in the future. But, it is not the intent of this thesis to propose a

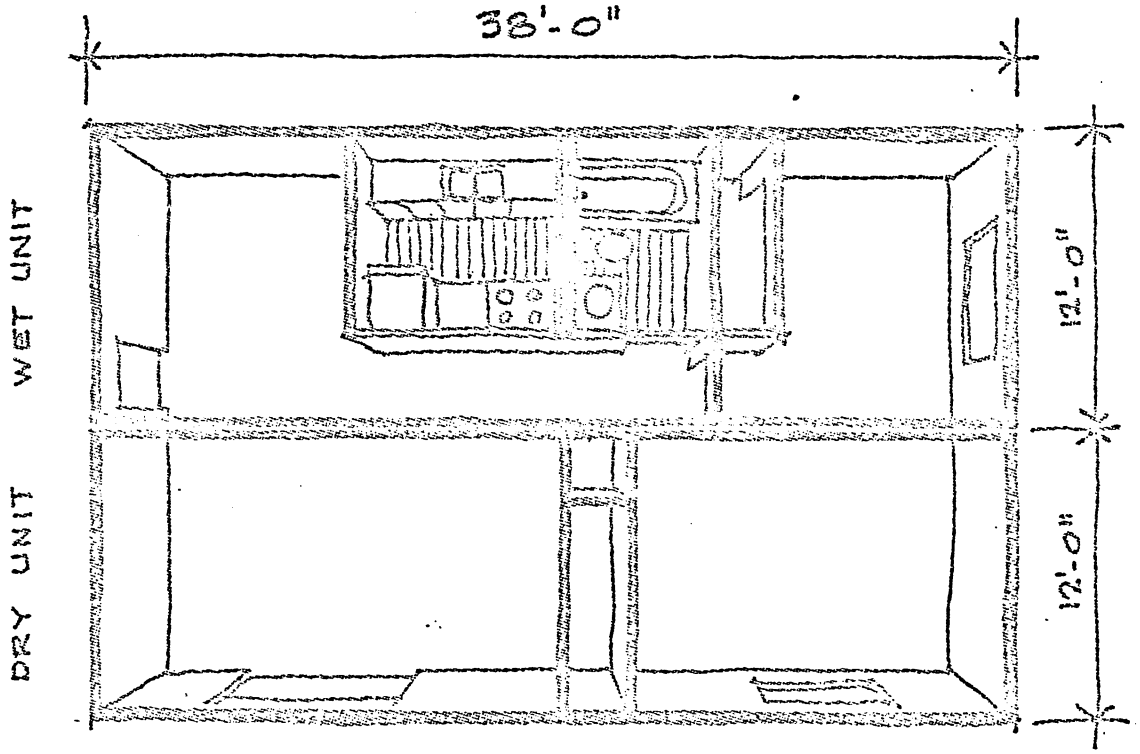
design for a manufactured unit. The sole purpose of using the designed unit in this thesis is to provide a basis for the data which is necessary to carry out the demonstration examples of the thesis. The apartment design which is used in the examples could be manufactured in either a core and panel or modular system of manufacture.

The apartment unit is designed so that one mechanical core serves two apartments. The core (12' by 20') would contain two kitchens and two bathrooms built around a common utility wall. The construction elements for the remainder of the apartment unit are wall and floor panels.



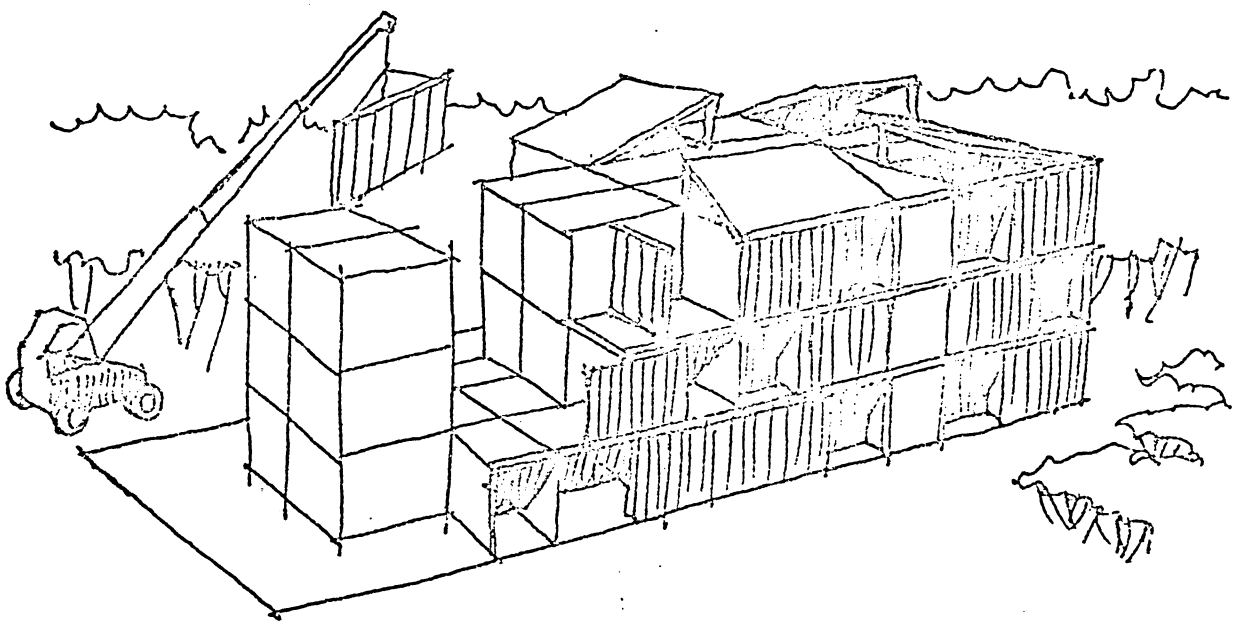
10' x 12' DOUBLE CORE UNIT

The apartment unit for modular manufacture is constructed with two modules. One module is a "dry" module and contains the living room and bedrooms of the apartment. The other module is a "wet" module and contains the mechanical core of the unit.

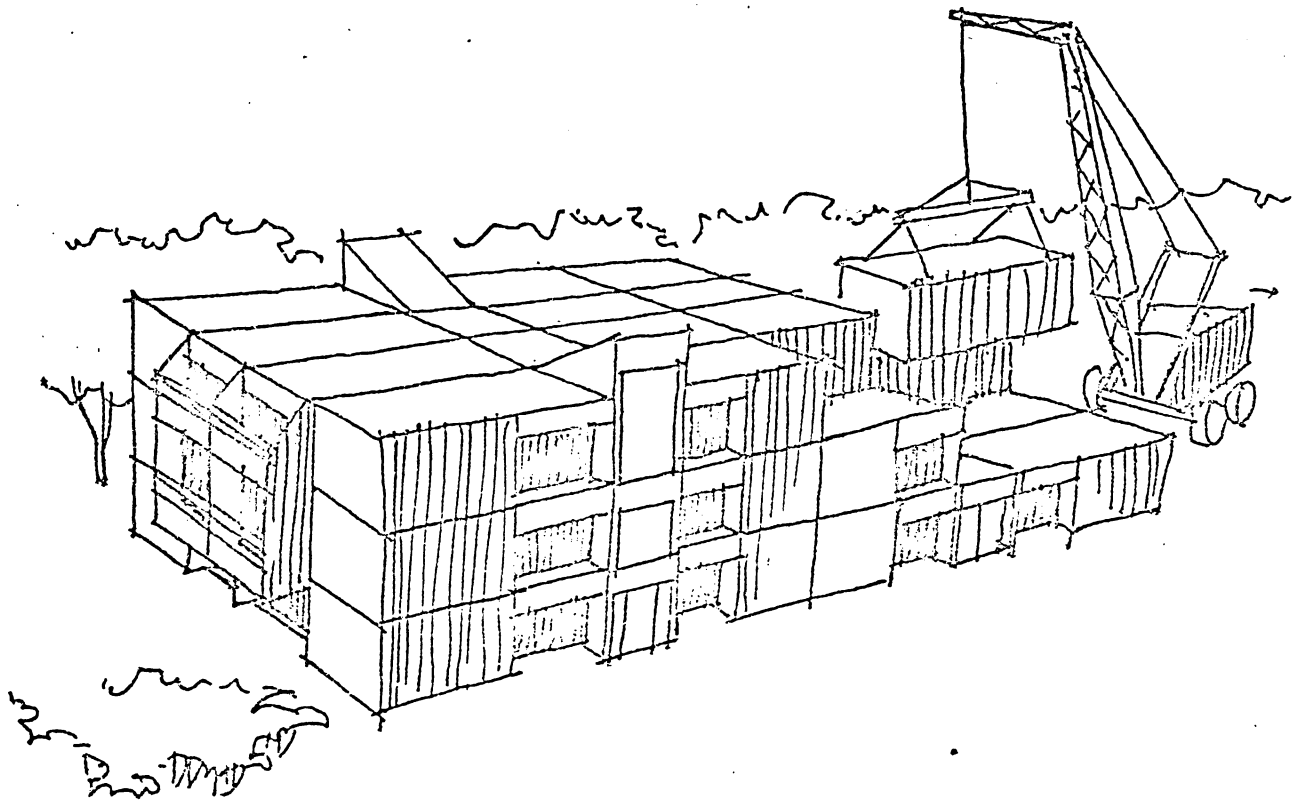


TWO MODULE APARTMENT UNIT

All of the examples in the demonstration are based on the transportation of the manufactured items necessary for the construction of a single apartment building. The building selected for the demonstration is typical of the type of building widely used in apartment development, the low-rise, garden apartment building. It consists of twenty-four apartment units arranged eight on a floor, three stories high. There are laundry-utility units attached to the building.



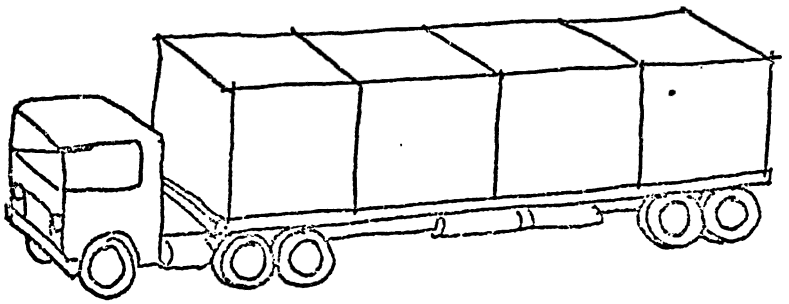
CORE & PANEL BUILDING

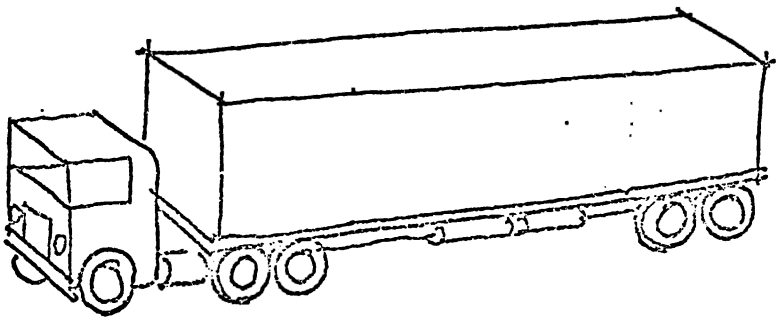


MODULAR BUILDING

The carrying capacity of truck, rail car, and barge is based on existing conventional equipment. This generally follows the actual practise of manufacturers, although there are exceptions. Several manufacturers own and operate their own truck fleets, some own their own rail cars and some are even considering owning and operating their own barges.

To ship one - 24 unit apartment building constructed of core and panels requires 6 trucks for the cores, 2 double cores on each truck. The floor and wall panels to complete the building require 12 additional truck loads. For an apartment building constructed of modular units, 50 trucks, one module per truck would be required. In both instances, the loads would be overwidth.

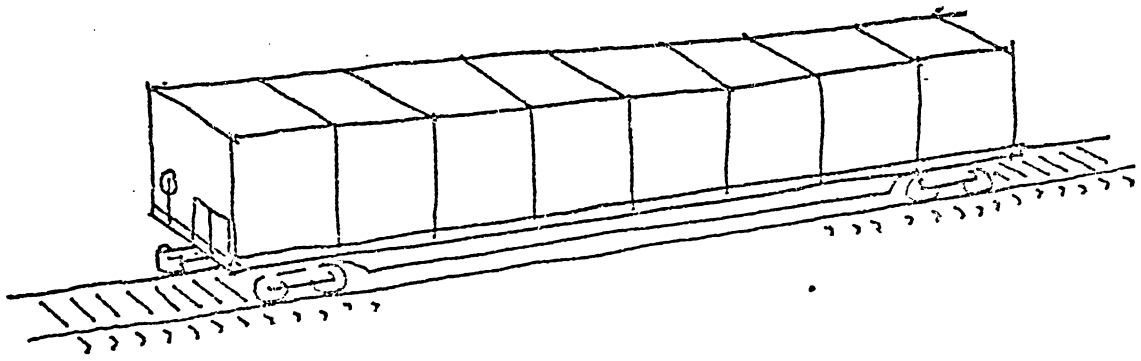


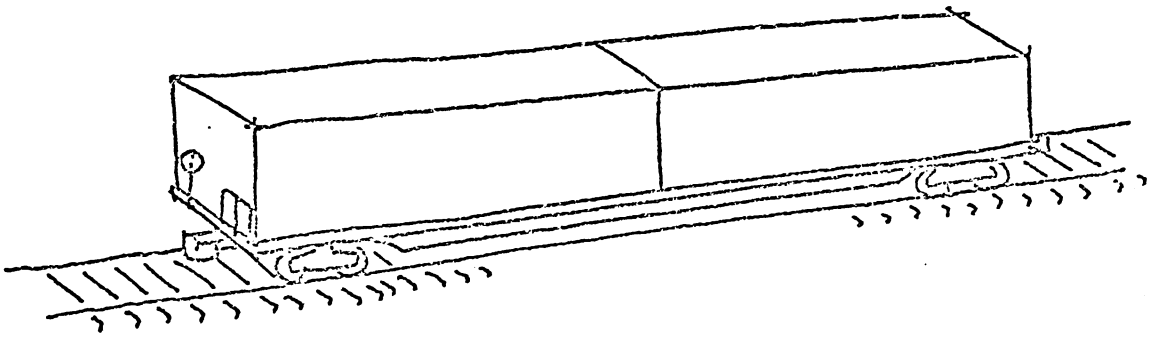


Truck = $0.85 per mile

This is the average loaded mile cost for overwidth loads on an intra-state basis and includes costs for driver and equipment, fees, and permits, and the equipment return.

To ship the cores of a core and panel building by rail requires 3 flat cars. 25 flat cars would be required for the modules. Piggy-back cars could also be used in place of flat cars, the number required would be the same.

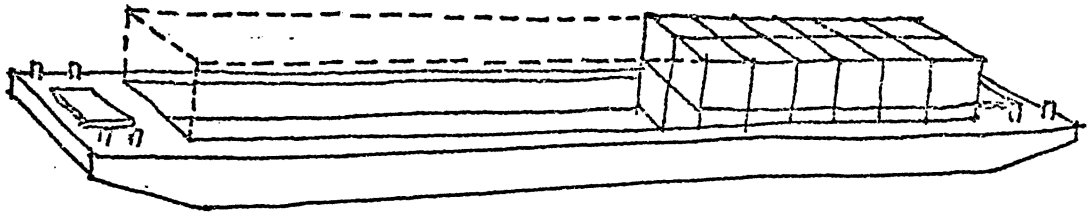


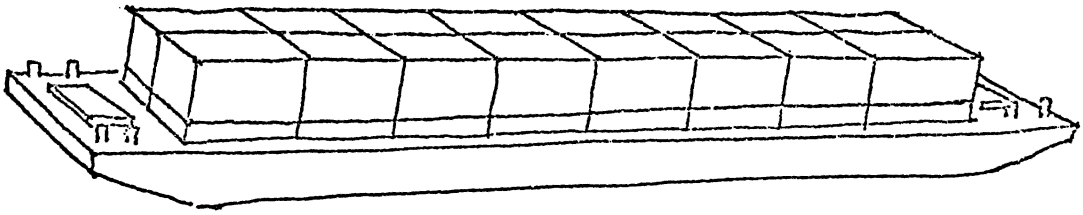


Rail flat car = $1.00 per mile

This is an average train mile rate based on the charge for pulling leased 90' flat cars with loads up to 12' wide.

All of the cores required for a building could be shipped on a barge and require only 3/8 of its carrying capacity. It requires 1½ barges to carry one building of modules.





Barge = from Tariff Manual = $ per ton
(300 ton min.)

The barge rates are taken from Freight Tariff Manual Number 8-A for the waterways freight bureau.

In addition to the basic costs of transportation, additional costs would be incurred in the transfer of the product from one mode of transportation to another, in delivery from rail terminal to job site, in transporting panels from a satellite plant to the job site, and in the erection of the building.

Cores:

Cost of transfer from barge to rail or truck:
$1,200 per building

Cost of transfer from rail yard to job site:
$600.00 per building

Modules:

Cost of transfer from barge to rail or truck:
$2,400 per building

Cost of transfer from rail yard to job site:
$1,200 per building

Panels:

Cost of transportation from satellite plant to job site (maximum 150 miles):
$1,200 per building

Erection:

A comparison of erection costs for a 24-unit apartment building (see fig. 4-D) shows that modular erection costs $6,000 less than core and panel erection.

COST ESTIMATE

COMPLETED 24-UNIT APARTMENT BUILDING

	Core and Panel	Modular
Site Work	$ 15,000.00	$ 15,000.00
Lt. Wt. Conc.	2,150.00	2,150.00
Orn. Iron	350.00	350.00
Roofing	3,575.00	3,575.00
Masonry	8,550.00	8,550.00
Mechanical	8,000.00	4,000.00
Electrical	9,000.00	5,000.00
Drywall & Painting	18,300.00	4,850.00
Insulation	1,850.00	-0- **
Indus. Bldg. Package	136,175.00	163,675.00
Erection	8,950.00	5,000.00
Fireplaces	1,600.00	-0- **
Misc. Equipment	2,750.00	-0- **
Floor Covering	14,300.00	14,300.00
Job Expense	8,000.00	8,000.00
Curb and Parking	6,000.00	6,000.00
Bldrs Fee O'hd + Profit	14,500.00	12,500.00
TOTAL	$259,050.00	$252,950.00

**Included in the module

Completed modular building $6,100.00 less than core and panel building

STRATEGY

NOTES

1. "Modulars: The Phantom Industry," HOUSE & HOME, June 1970, p. 66

2. "Who's Who in Industrialized Building," PROFESSIONAL BUILDER, October 1971, p. 103

V

DEMONSTRATION

SCHEMES

The following demonstration examples provide the data for the evaluation of transportation costs for two schemes of industrialized manufacture, modular and core and panel. Different combinations of transportation methods are used in the examples for both schemes.

The modular method is referred to as Scheme A; the core and panel method is referred to as Scheme B. The alternate use of the satellite panel plant as a modular assembly plant is evaluated; it is referred to as Scheme B-alternate.

The assumed location of the central plant for both the modular and core examples is in accordance with the criteria developed for the location of manufacturing facilities in the concept section of the thesis. St. Louis, Missouri, is used in the examples. It is well located on major water, rail, and highway routes. Other locations along the Mississippi and Ohio rivers would also meet the criteria.

Twenty example sites are assumed for evaluation of the transportation costs between the central plant and the job site. These sites were selected to offer a full range of conditions of distance and transportation method for comparison. Some of the sites are close to the central plant, others are distant, some are located on or near major

waterways, others are not. The number of sites used assures that the conclusions drawn from the examples are based on a satisfactorily broad sampling.

The location of sites for the satellite panel plants is flexible. An important feature of these plants is their movability.

For the alternate scheme of manufacture (the satellite modular plant) two locations were selected--Pittsburgh, Pa. and Dubuque, Iowa. Both are accessible to highway, railway and waterway transportation.

The locations of the sites and plants used in the examples are shown on the map Figure 5-A.
Highway routes are shown on the map, Fig. 5-B.
Highway distances are shown on the map, Fig. 5-C.
Railroad distances are shown on the map, Fig. 5-D.

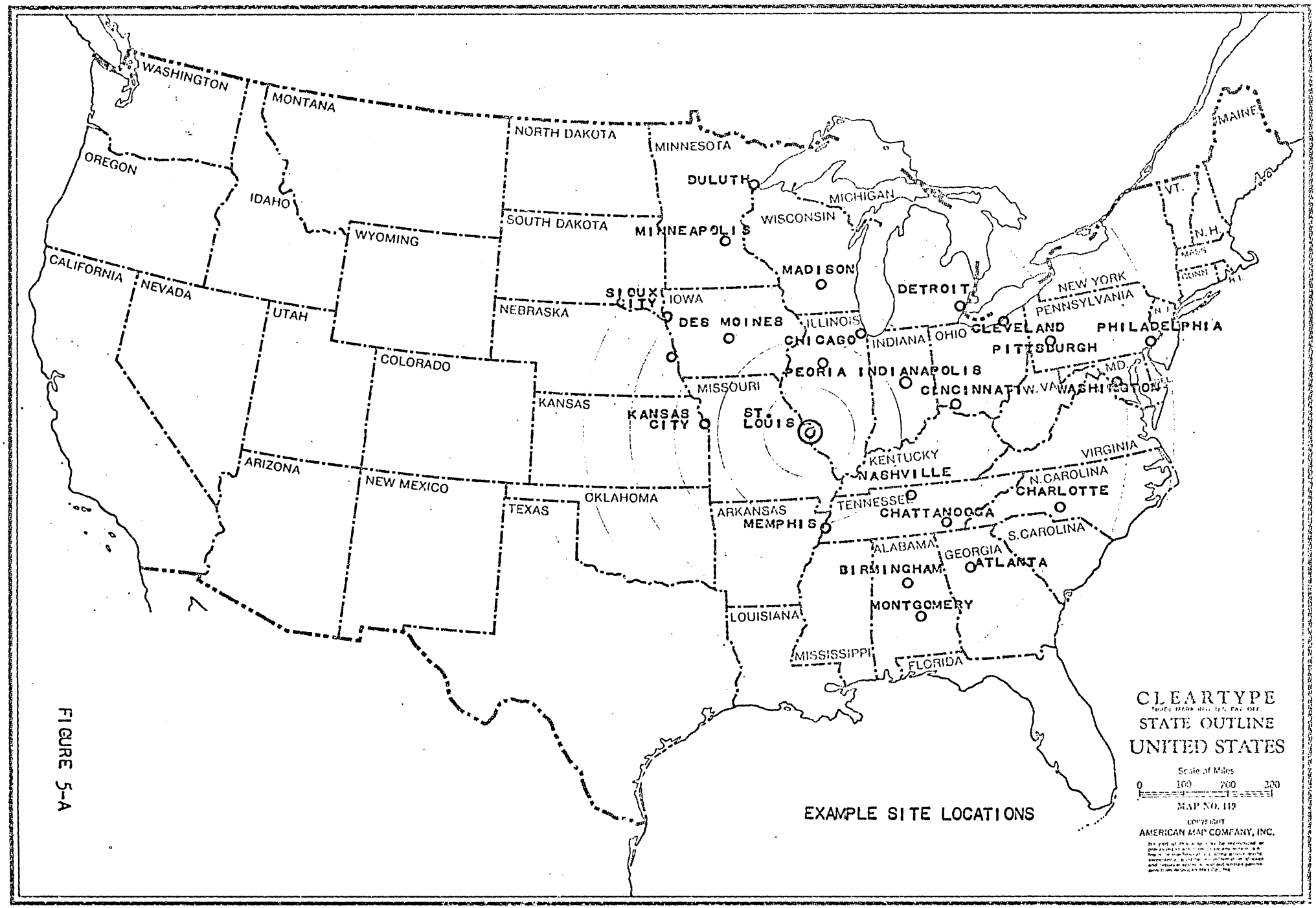
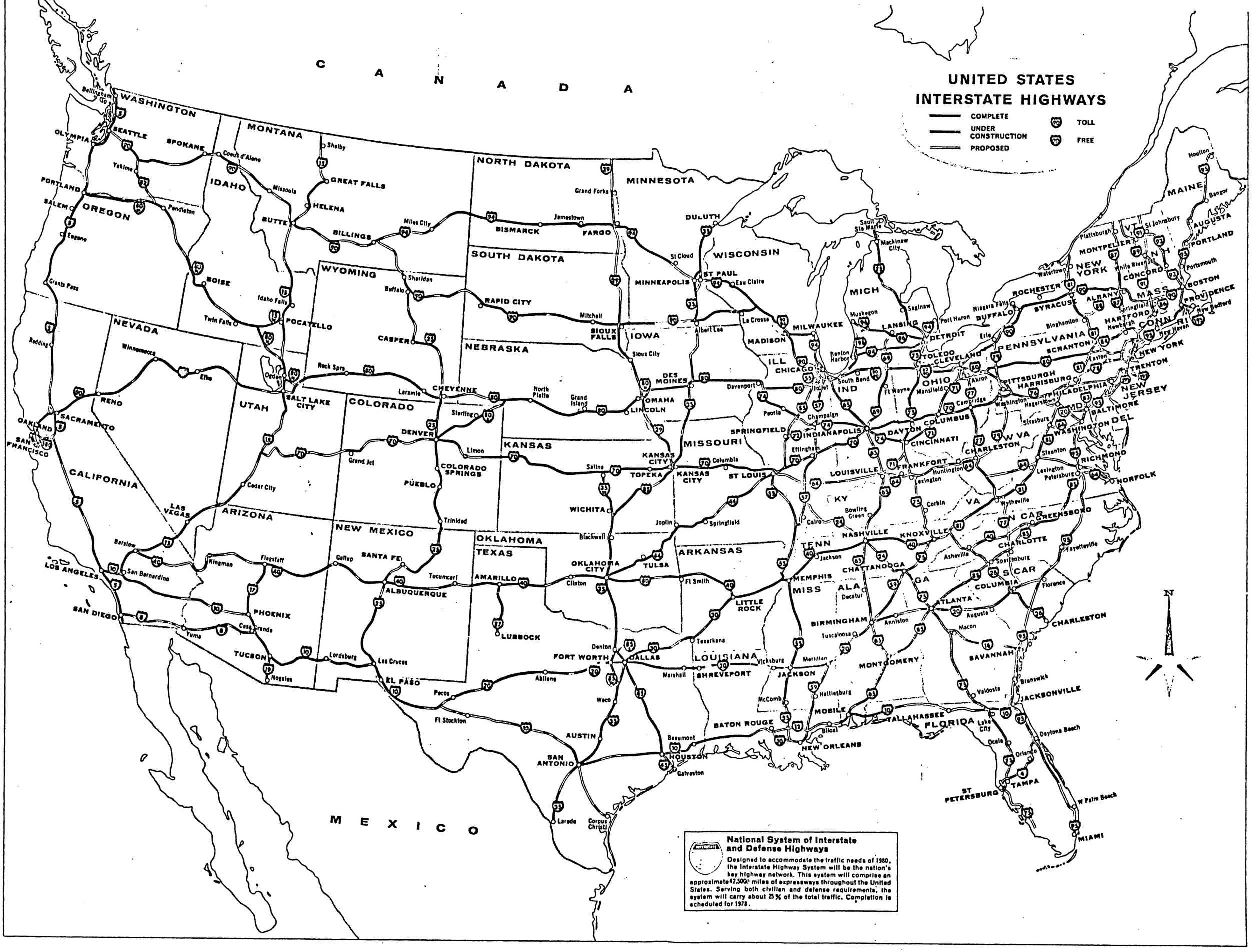

WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
DULUTH
MICHIGAN
WISCONSIN
MAINE
VT.
N.H.
MASS.
CONN.
R.I.
SOUTH DAKOTA
MINNEAPOLIS
WYOMING
CALIFORNIA
NEVADA
UTAH
NEBRASKA
SIOUX CITY
IOWA
MADISON
DETROIT
NEW YORK
PENNSYLVANIA
N.J.
DES MOINES
ILLINOIS
CHICAGO
INDIANA
OHIO
CLEVELAND
PHILADELPHIA
PITTSBURGH
COLORADO
PEORIA
INDIANAPOLIS
MD.
DEL.
MISSOURI
CINCINNATI
W.VA.
WASHINGTON
KANSAS
KANSAS CITY
ST. LOUIS
KENTUCKY
VIRGINIA
ARIZONA
NEW MEXICO
NASHVILLE
N.CAROLINA
CHARLOTTE
OKLAHOMA
TEXAS
TENNESSEE
ARKANSAS
CHATTANOOGA
MEMPHIS
S.CAROLINA
ALABAMA
GEORGIA
ATLANTA
BIRMINGHAM
MONTGOMERY
LOUISIANA
MISSISSIPPI
FLORIDA
EXAMPLE SITE LOCATIONS
CLEARTYPE
STATE OUTLINE
UNITED STATES
Scale of Miles
0 100 200 300
MAP NO. 119
COPYRIGHT
AMERICAN MAP COMPANY, INC.

FIGURE 5-A


UNITED STATES
INTERSTATE HIGHWAYS
COMPLETE
UNDER CONSTRUCTION
PROPOSED
TOLL
FREE
CANADA
MEXICO
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILL
MICH
IND
OHIO
KY
TENN
MISS
ALA
GA
FLORIDA
S CAR
N CAR
VA
W VA
PENNSYLVANIA
NEW YORK
VT
N H
MAINE
MASS
CONN
RI
NEW JERSEY
MD
DEL
SEATTLE
SPOKANE
OLYMPIA
PORTLAND
SALEM
BOISE
POCATELLO
BUTTE
HELENA
GREAT FALLS
BILLINGS
BISMARCK
FARGO
RAPID CITY
CASPER
CHEYENNE
SALT LAKE CITY
RENO
SACRAMENTO
OAKLAND
SAN FRANCISCO
LAS VEGAS
LOS ANGELES
SAN DIEGO
PHOENIX
TUCSON
DENVER
COLORADO SPRINGS
PUEBLO
SANTA FE
ALBUQUERQUE
EL PASO
AMARILLO
LUBBOCK
OKLAHOMA CITY
TULSA
FORT WORTH
DALLAS
AUSTIN
SAN ANTONIO
HOUSTON
WICHITA
KANSAS CITY
TOPEKA
OMAHA
LINCOLN
DES MOINES
SIOUX FALLS
MINNEAPOLIS
ST PAUL
DULUTH
MADISON
MILWAUKEE
CHICAGO
SPRINGFIELD
INDIANAPOLIS
ST LOUIS
LITTLE ROCK
MEMPHIS
NASHVILLE
KNOXVILLE
CHATTANOOGA
BIRMINGHAM
MONTGOMERY
ATLANTA
JACKSON
BATON ROUGE
NEW ORLEANS
MOBILE
TALLAHASSEE
JACKSONVILLE
TAMPA
ST PETERSBURG
MIAMI
CHARLESTON
SAVANNAH
COLUMBIA
CHARLOTTE
GREENSBORO
RICHMOND
NORFOLK
WASHINGTON
BALTIMORE
PHILADELPHIA
HARRISBURG
PITTSBURGH
CLEVELAND
TOLEDO
DETROIT
LANSING
DAYTON
COLUMBUS
CINCINNATI
FRANKFORT
LOUISVILLE
CHARLESTON
BUFFALO
ROCHESTER
SYRACUSE
ALBANY
HARTFORD
CONCORD
MONTPELIER
AUGUSTA
PORTLAND
BOSTON
PROVIDENCE
NEW YORK
TRENTON
SCRANTON
BINGHAMTON
Bellingham
Yakima
Pendleton
Eugene
Grants Pass
Redding
Winnemucca
Elko
Ogden
Rock Spgs
Laramie
Sterling
Limon
Grand Jct
Cedar City
Barstow
San Bernardino
Kingman
Flagstaff
Gallup
Tucumcari
Yuma
Casa Grande
Nogales
Lordsburg
Las Cruces
Pecos
Ft Stockton
Abilene
Waco
Denton
Marshall
Texarkana
Vicksburg
Meridian
Hattiesburg
McComb
Biloxi
Beaumont
Galveston
Laredo
Corpus Christi
Clinton
Blackwell
Joplin
Springfield
Salina
Columbia
Ft Smith
Jackson
Decatur
Anniston
Tuscaloosa
Macon
Augusta
Valdosta
Lake City
Ocala
Orlando
Daytona Beach
W Palm Beach
Florence
Fayetteville
Spartanburg
Asheville
Staunton
Petersburg
Lexington
Huntington
Corbin
Wytheville
Bowling Green
Cairo
Jackson
Sault Ste Marie
Mackinaw City
Saginaw
Port Huron
Muskegon
Benton Harbor
South Bend
Ft Wayne
Mansfield
Akron
Cambridge
Washington
Hagerstown
Strasburg
Easton
Newburgh
Springfield
New Haven
New Bedford
Portsmouth
Bangor
Houlton
St Johnsbury
Plattsburgh
Watertown
Niagara Falls
Erie
Binghamton
Sault Ste Marie
Albert Lea
La Crosse
Eau Claire
St Cloud
Grand Forks
Jamestown
Miles City
Sheridan
Buffalo
Mitchell
Sioux City
North Platte
Grand Island
Davenport
Peoria
Champaign
Effingham
Columbia
Huntington
Lexington
Corbin
Wytheville
Spartanburg
Florence
Augusta
Macon
Brunswick
Valdosta
Lake City
Ocala
Orlando
Daytona Beach
W Palm Beach
Miles City
Shelby
Coeur d'Alene
Missoula
Idaho Falls
Twin Falls
Winnemucca
Elko
Ogden
Rock Spgs
Cedar City
Trinidad
Gallup
Tucumcari
Las Cruces
Pecos
Ft Stockton
Abilene
Denton
Marshall
Texarkana
Vicksburg
Meridian
Hattiesburg
Biloxi
Beaumont
Galveston
Laredo
Corpus Christi
Clinton
Blackwell
Joplin
Springfield
Salina
Columbia
Ft Smith
Jamestown
Grand Forks
Sault Ste Marie
Mackinaw City
Saginaw
Port Huron
Muskegon
Benton Harbor
Ft Wayne
Mansfield
Akron
Cambridge
Washington
Hagerstown
Strasburg
Easton
Newburgh
Springfield
New Haven
New Bedford
Portsmouth
Bangor
Houlton
Plattsburgh
Watertown
Niagara Falls
Erie
Binghamton
Sault Ste Marie
Albert Lea
Eau Claire
Sioux City
Grand Island
Davenport
Peoria
Champaign
Effingham
Huntington
Lexington
Corbin
Wytheville
Spartanburg
Florence
Augusta
Macon
Brunswick
Valdosta
Lake City
Ocala
Orlando
Daytona Beach
W Palm Beach
N
National System of Interstate and Defense Highways
Designed to accommodate the traffic needs of 1980, the Interstate Highway System will be the nation's key highway network. This system will comprise an approximate 42,500 miles of expressways throughout the United States. Serving both civilian and defense requirements, the system will carry about 25% of the total traffic. Completion is scheduled for 1978.

UNITED STATES MILEAGE & DRIVING TIME MAP

EXPLANATION

277 Light numerals indicate mileage.
Heavy numerals indicate driving time.

Driving time shown is approximate under normal conditions. Consideration has been given to topography, speed laws, and congested areas.

Allowances should be made for night driving and unusually fast or slow drivers.

Limited Access Expressways have been used in determining the shortest driving time. These routes are not always the shortest distance.

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GENEX TOFC CONSOLIDATION SERVICE

KEY TO ABBREVIATIONS TO RAILROADS

A & W P	Atlanta and West Point	D. & R. G. W.	Denver and Rio Grande Western	N. Y. N. H. & H.	New York, New Haven and Hartford
A. T. & S. F.	Atchison, Topeka and Santa Fe	E. L.	Erie Lackawanna	P.C.	Penn Central
B & A	Bangor and Aroostook	D. W. & P.	Duluth, Winnipeg & Pacific	P. R. S.	Pennsylvania-Reading Seashore
B & M	Boston and Maine	F. del P.	Ferrocarril del Pacific	Q. C.	Quebec Central
B & O	Baltimore and Ohio	F. E. C.	Florida East Coast	READ	Reading
C & E I	Chicago & Eastern Illinois	F. W. & D.	Fort Worth and Denver	R. F. & P.	Richmond, Fredericksburg and Potomac
C. & N. W.	Chicago & North Western	G. M. & O.	Gulf, Mobile and Ohio	S-B. C.	Sonora-Baja California
C & O	Chesapeake and Ohio	G. N.	Great Northern	S. C. L.	Seaboard Coast Line
C. & S.	Colorado and Southern	G. T.	Grand Trunk	S. I.	Spokane International
C. B. & Q.	Chicago, Burlington & Quincy	G. T. W.	Grand Trunk Western	S. L.	Soo Line
C. M. S. P. & P.	Chicago, Milwaukee, St. Paul and Pacific	I. C.	Illinois Central	S. L. S. F.	St. Louis-San Francisco
C. N.	Canadian National	K. C. S.	Kansas City Southern	ST. L. S. W.	St. Louis Southwestern
C. N. J.	Central of New Jersey	L. & A.	Louisiana & Arkansas	SOU	Southern
C. of G.	Central of Georgia	L. & N.	Louisville and Nashville	S. P.	Southern Pacific
C. P.	Canadian Pacific	L. I.	Long Island	S. P. & S.	Spokane, Portland and Seattle
C. R. I. & P.	Chicago, Rock Island and Pacific	L. V.	Lehigh Valley	T. & P.	Texas and Pacific
C. V.	Central Vermont	M. C.	Maine Central	U. P.	Union Pacific
D. H.	Delaware and Hudson	M. K. T.	Missouri Kansas-Texas	W. of A.	Western Ry. of Alabama
		M. P.	Missouri Pacific	W. P.	Western Pacific
		MONON	Monon		
		N. & W.	Norfolk and Western		
		N. de M.	National de Mexico		
		N. S.	Norfolk Southern		
		N. P.	Northern Pacific		

RAILROAD MAP OF THE UNITED STATES

This map shows only main line railroad service between leading cities. The figures give the railroad mileage, and the initials indicate the railroads operating between these points

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EXAMPLES

For each scheme the following formulas have been developed to calculate the total comparative transportation cost.

Scheme A

Module by Highway = COSTMY

COSTMY = 50(Y) 0.85

50 truckloads X highway distance X rate/mile

Module by Rail = COSTMX

COSTMX = 25 (X) 0.77 + 1200

25 rail carloads X rail distance X rate/mile + terminal to job site cost

Module by Water + Highway = CSTMWY

CSTMWY = W (300 1.5 + 2400 + 50 (Y1) 0.85

Barge rate/ton X 300 ton minimum X 1.5 barge loads + transfer barge to truck + 50 truck loads X highway distance (landing to job site) X rate/mile

Module by Water + Rail = CSTMWK

CSTMWX = W(300) 1.5 + 2400 + 25 (X1) 0.77 + 1200

Barge rate/ton X 300 ton min. X 1.5 barge loads + transfer barge to rail + 25 rail cars X rail distance (landing to terminal) X rate/mile + terminal to job site cost

Scheme B

Core only by Highway = COSTCY

COSTCY = 6(Y) 0.85 = 1200 + 6000

6 truckloads-cores X highway distance X rate/mile + panels to job site + construction cost differential

Core only by Rail = COSTCX

COSTCX = 3(X) 0.77 + 600 + 1200 + 6000

3 carloads-cores X rail distance X rate/mile + terminal to job site + panels to job site + construction cost differential

Core by Water + Highway = CSTCWY

CSTCWY = W(300) 0.75 + 1200 + 6 (Y1) 0.85 + 1200 + 6000

Barge rate X 300 ton min X 0.75 barge + transfer to truck + 6 truckload cores X highway distance X rate/mile + panels to job site + construction cost differential

Core by Water + Rail = CSTCWX

CSTCWX = W(300) 0.75 + 1200 + 3 (X1) 0.77 + 600 + 1200 + 6000

Barge rate X 300 ton min X 0.75 barge + transfer to rail + 3 carloads-cores X rail distance X rate/mile + terminal to job site + panels to job site + construction cost differential

Scheme B Alternate

Core by Water + Module by Highway = CSTBWY

CSTBWY = W (300) 0.75 + 2400 + 50(Y2) 0.85

Barge rate to satellite plant X 300 ton min X 0.75 barge + plant to barge to plant + 50 truckloads modulars X dist satellite to job site X rate/mile

Core by Water + Module by Rail = CSTBWX

CSTBWX = W2(300) 0.75 + 2400 + 25 (Y2) 0.72 + 1200

Barge rate to satellite plant X 300 ton min X 0.75 barge + plant to barge to plant + 25 carloads modulars X dist satellite terminal X rate/min + terminal to job

Water, Rail and Highway transportation costs are the variables in the equations. The cost of transfer from one transportation method to another, delivery from terminal or landing to job-site, cost of panel delivery and construction differential between modular and core panel constructions are identified as constants.

Figures 5-E and 5-F are summaries of the transportation costs derived from the execution of the above formulas for twenty example sites.

	ST. LOUIS TO:	PEORIA ILL.	INDPLS. IND.	KANS. CITY MO.	CHICAGO ILL.	MEMPHIS TENN.	NASHVILLE TENN.	DES MOINES IOWA	MADISON WISC.	CINCINNATI OHIO	OMAHA NEB.
	APPROX. MI.	170	240	270	280	300	330	340	360	360	440
SCHEME A MODULAR	HIWAY	7012	9945	10752	12027	12835	13982	14450	15215	16277	19465
	RAIL	5450	7225	8275	8300	8825	9300	9675	10325	9675	11525
	WATER & HIWAY	6424	10665	7301	6923	6954	7787	12158	10961	8264	8120
	WATER & RAIL	6794	9905	7626	7248	7284	8112	10570	9748	8589	8445
SCHEME B CORE & PANEL	HIWAY	8041	8393	8490	8643	8740	8877	8934	9025	9153	9535
	RAIL	8310	8523	8649	8652	8715	8772	8817	8895	8817	9039
	WATER & HIWAY	9129	9847	9349	9254	9263	9470	10038	9739	9589	9553
	WATER & RAIL	9624	10212	9844	9749	9755	9965	10303	10049	10084	10048
B-ALT SATTELITE	HIWAY	7012	9945	10752	12027	12835	9200	14397	15417	16284	18817
	RAIL	5450	7225	8275	8300	8825	8395	11322	11797	12409	13722
	PLANT LOCATION	ST. LOUIS	ST. LOUIS	ST. LOUIS	ST. LOUIS	ST. LOUIS	CHATTAN.	MPLS.	MPLS.	PITTS.	MPLS.

FIGURE 5-E

ST. LOUIS TO:		BRMGHM. ALA.	DETROIT MICH.	SIOUX CITY IOWA	CLEVELAND OHIO	ATLANTA GA.	MNTGMY. ALA.	DULUTH MINN.	CHARLOTTE N. C.	WASHINGTON D. C.	PHILA. PA.
APPROX. MI.		500	500	520	530	600	600	750	780	850	910
SCHEME A MODULAR	HIWAY	20697	22270	23162	24692	24692	31917	31620	31620	35785	35335
	RAIL	14450	13425	14050	14325	16500	16800	19700	22700	22975	24150
	WATER & HIWAY	12601	19898	9052	12631	11411	16554	12691	16840	17348	19898
	WATER & RAIL	11256	16061	9377	11411	11106	13681	11264	15328	15686	16861
SCHEME B CORE & PANEL	HIWAY	9683	9372	9892	9979	10163	10163	11030	10994	11494	11800
	RAIL	9390	9267	9342	9636	9672	10020	10380	10380	10413	10554
	WATER & HIWAY	10154	11089	9786	10217	10011	10629	10127	10767	10783	11089
	WATER & RAIL	10449	11085	10281	10527	10431	10740	10412	11041	11040	11181
B-ALT SATTELITE	HIWAY	9540	16496	14694	9229	8350	13492	9849	16650	13946	16496
	RAIL	8195	12659	11197	8009	8045	10620	8422	14245	12284	13459
	PLANT LOCATION	CHATTA.	PITTS.	MPLS.	PITTS.	CHATTA.	CHATTA.	MPLS.	CHATTA.	PITTS.	PITTS.

FIGURE 5-F

SUMMARY

The results obtained from performing the examples in the demonstration make it evident that the type of unit and the method of its transport have a major effect on the economic feasibility of industrialized housing.

The examples confirmed the constraint of transportation to the commonly accepted method of transporting modular units by highway. In distances over 300 miles, transportation cost adds from 10% - 25% to the product cost.

The core and panel system offers the manufacturer an effective way to increase the radius of his operation. In distances up to 900 miles transportation of the core and panel units add less than 10% to the product cost. Also, all methods of transportation are within the economic means of the manufacture of mechanical cores. There was less than $1,000 difference between the four proposed transportation methods of core and panel units.

Using the satellite plants for the assembly of modules did not, except in a few isolated instances, offer sufficient cost efficiencies to warrant considering this scheme as a solution to the transportation problem. In the future if the differential cost of completing a core and panel building increases, the feasibility of satellite modular assembly plants should be re-examined.

VI

CONCLUSION

"Mechanical core units may well become known as the most important development of our time in building, far exceeding the highly publicized complete modular building."1

CONCLUSION

The need for reasonably priced housing, available in adequate quantities, is well established. Time Magazine reported recently, "the lack of decent housing for poor people living in the nation's largest cities has long been a national scandal."[2] I agree, new, non-subsidized housing is rapidly becoming a luxury item.

Early in this thesis, I emphasized the fact that the cost of the structure of the house is not the entire

problem. Other cost factors - cost of land, cost of financing, and cost of taxes - contribute to the increasingly prohibitive cost of housing. All of these areas are critical problems, and solutions to each must be found before there will be any measurable increase in the supply of moderate and low cost housing.

But, this thesis is concerned with just one element of the overall problem of housing cost: how the cost of transportation limits market aggregation. The cost of transportation is one of the major obstacles to the creation of a viable manufactured housing industry. Martin Skala of the Christian Science Monitor, writing on the failure of modular housing reported:

> Although about one out of every four homes built last year involved significant amounts of prefabrication, only about 50,000 truly three-dimensional units were shipped to developers..... often any savings realized through factory efficiencies have been offset by high transportation costs of finished modules.....one of the toughest challenges producers have discovered is establishing an effective distribution system. To prevent short and costly fluctuations in factory output it is important to ship modules on a regular basis.....[3]

It is my position that the core and panel method of

manufacture, distribution and construction offers to the housing manufacturer an effective means of overcoming the present obstacles of transportation cost. Core and panel offers to the manufacturer, with transportation equipment and methods that are available today, the choice of highway, railway, or waterway for his transportation route.

Because of the mechanical core's physical similarity to the overseas shipping container, it will be possible for the transporter of industrialized housing to take advantage of the new developments in equipment and handling techniques of "containerization." He will have access to machines which can transfer cores from barge to railcar and from railcar to truck, quickly and efficiently.

Solving the problem of transportation cost, the manufacturer will be able to serve a large geographical area from a single plant. Serving a large area will mean aggregating a sufficient market to support mass production, which is essential for cost efficiency in the manufacture of industrialized housing. Larger more efficient plants will produce greater profits.

Greater profits will mean more capital available for investment in sophisticated manufacturing equipment for ever higher levels of efficiency and production capacity. More effort could be concentrated on the necessary research and development required to provide the housing consumer improved housing at a price he can afford. By solving the problems of manufacture and shipment, the housing industry may yet realize Walter Gropius' dream of..... "A state of technical proficiency when it will become possible to rationalize buildings and mass-produce them in factories....."4

CONCLUSION

NOTES

1. "1972 Market Report: The Sum of the Parts," SYSTEMS BUILDING NEWS, February, 1972, p. 41

2. "Ghetto Shakedown," TIME, April 10, 1972, p. 14

3. "Modular Housing Loses Some Glamor," THE HOUSTON POST, April 2, 1972, p. 7/CC

4. Gropius, Walter, THE NEW ARCHITECTURE AND THE BAUHAUS, MIT Press, 1965, p. 39

BIBLIOGRAPHY

BIBLIOGRAPHY

BOOKS

Cutler, Laurence, INDUSTRIALIZED BUILDING SYSTEMS FOR HOUSING, MIT Press, Cambridge, 1971

Gropius, Walter, THE NEW ARCHITECTURE AND THE BAUHAUS, MIT Press, Cambridge, 1965

LeCorbusier, TOWARDS A NEW ARCHITECTURE, Architectural Press, London, 1927

Lytle, R. J., INDUSTRIALIZED BUILDERS HANDBOOK, Structures Publishing Co., Farmington, Mich., 1971

Pawley, Martin, ARCHITECTURE vs HOUSING, Praeger Publishers, New York - Washington, 1971

Reidelbach, J. A., Jr., MODULAR HOUSING IN THE REAL, Modco, Inc., Annondale, Va., 1971

Reidelbach, J. A., Jr., MODULAR HOUSING SYSTEMS, 1971, Cahners Publishing Co., Inc., Boston, 1971

Swaback, Vernon D., PRODUCTION DWELLINGS, Frank Lloyd Wright Foundation, Spring Green, Wisc., 1970

Toffler, Alvin, FUTURE SHOCK, Random House, New York, 1970

Wright, Frank Lloyd, THE NATURAL HOUSE, Horizon Press, New York, 1953

Wright, James R., INDUSTRIALIZED BUILDING IN THE SOVIET UNION, National Bureau of Standards, May, 1971

PAMPHLETS AND BROCHURES

FREIGHT TARIFF, No. 80A, Waterways Freight Bureau, November 1970

INDUSTRIALIZED HOUSING, American Plywood Association, 1969

INDUSTRIALIZED STRUCTURES, Slayter Associates, January, 1971

MAKING MOVES IN THE MODULAR '70's, Southern Railway Co., 1971

MISAWY TOTAL SYSTEM, Misawa Homes Co., Ltd., 1971

MODULAR APARTMENTS AND TOWNHOUSES, General Electric Company, 1971

MODULAR HOUSES BREAKTHROUGH PROPOSAL, U. S. General Services Administration, April 1, 1971

OPERATION BREAKTHROUGH SITE PLANNING, INDIANAPOLIS, INDIANA, Skidmore, Owings and Merrill, December 1970

OPERATION BREAKTHROUGH: QUESTIONS AND ANSWERS, U. S. Department of Housing and Urban Development, March, 1971

RAIL TRAILERLOAD CHARGES, GENEX TOFC Consolidation Service, June, 1971

VOLUME HOUSING SYSTEMS, Boise Cascade Housing Development, 1971

WET CORE AND COMPONENTS vs MODULARS, Westinghouse Electric Co., August, 1971

WICKES UTILITY MODULES, The Wickes Corporation, 1971

ARTICLES

Betz, John H., "State Housing Programs; Minor Ventures or Major Initiatives," HUD CHALLENGE, June, 1971

Endicott, Wayne A., "An Open Letter to Secretary George Romney," AUTOMATION IN HOUSING, December, 1971

Grasso, Joseph C., "The Real Role for Industrialized Housing is to Make-up for the Growing Shortage of Skilled Labor," HOUSE & HOME, May, 1971

Johnson, Jeh V., "Report from the Douglas Commission," AIA Journal, January, 1969

Kaiser, Edgar F., "Partnerships to Get Big Business Into Housing," AIA JOURNAL, January, 1969

Loomis, Don, "Barriers Down: The Battle to Modernize the Nations Building Codes Begins to Pay Off," HOUSE & HOME, January, 1972

Loomis, Don, "Romney Cries a Warning," HOUSE & HOME, September, 1971

Osman, Mary E., "Mobile Homes the Third Alternative," AIA JOURNAL, December, 1971

Ward, Robertson R., "Breakthrough," AIA JOURNAL, March, 1971

Zapp, Kenneth, "Industrialized Housing and Public Policy," TECHNOLOGY REVIEW, February, 1972

"1972 Market Report," SYSTEMS BUILDING NEWS, February, 1972

"Ghetto Shakedown," TIME, April 10, 1972

"Housing Money That Goes to the People," BUSINESS WEEK, January 8, 1972

"How Strong are the State Factory Housing Laws?", INDUSTRIALIZED BUILDING, December, 1971

"Its Time to Take the Low Price Market Back from the Mobiles," HOUSE & HOME, April, 1971

"Modular Housing Loses Some Glamour," THE HOUSTON POST, April 2, 1972

"Modulars the Phantom Industry," HOUSE & HOME, June, 1970

"Outlook '72," PROFESSIONAL BUILDER, December, 1971

"Prefabrication Has Something for Everyone," HOUSE & HOME, December, 1954

"Railroads Sidetrack National Rail Rate for Mods," INDUSTRIALIZED BUILDING, December, 1971

"The Housing Crisis," HOUSE & HOME, February, 1970

"The Mod Business," PROGRESSIVE ARCHITECTURE, May, 1971

"The Problem of Codes is Holding Back the Real Modular Breakthrough," HOUSE & HOME, October, 1971

"The Problem of Transportation Can Severely Limit the Real Modular Breakthrough," HOUSE & HOME, October, 1971

"Whats Holding Back the Real Breakthrough in Modular Housing?," HOUSE & HOME, October, 1971

"Where Do You Put the Factory House?," PROFESSIONAL BUILDER, October, 1971

"Who's Building the Modulars and How Many?," HOUSE & HOME, June, 1971

"Who's Who in Industrialized Building," PROFESSIONAL BUILDER, October, 1971