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FOREST PRODUCTS LABORATORY

In cooperation with the University of Wisconsin

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**FOREST PRODUCTS LABORATORY PREFABRICATION
SYSTEM A NEW DEPARTURE IN ALL-WOOD HOUSING**

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Senior Engineer



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Since its first demonstration at Madison, Wis., in March, when it attracted thousands of visitors, the U. S. Forest Products Laboratory's prefabricated all-wood house system has drawn many inquiries as to whether it was on the market, what it cost, and how it was made.

From the outset the Laboratory made it clear that the demonstration house it built and exhibited represents a system under development, and not a commercial proposition. Nevertheless the wide interest registered from both public and trade sources warrants further description of the system at this stage for evaluation of its possibilities from a service and manufacturing point of view.

It is well to point out, as a preface to such a description, that this house, aside from the plywood in its panels, uses about 5,400 board feet of lumber of various kinds. All lumber, moreover, is used economically because of the system of prefabrication employed. Resultant reductions in cost of building, if this type of housing goes eventually on the market, should aid in its widespread adoption and consequently benefit the entire lumber industry.

That its scheme of assembly is well adapted to the requirement of speed in construction is attested by the Laboratory's experience with it. Figures 1 and 2 graphically demonstrate the rapidity of assembly possible. The house was erected complete in 21 hours by seven men.

Utilizes Built-Up Wood Panel

Like all prefabricated housing systems either under development or already on the market, the Laboratory's has as

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

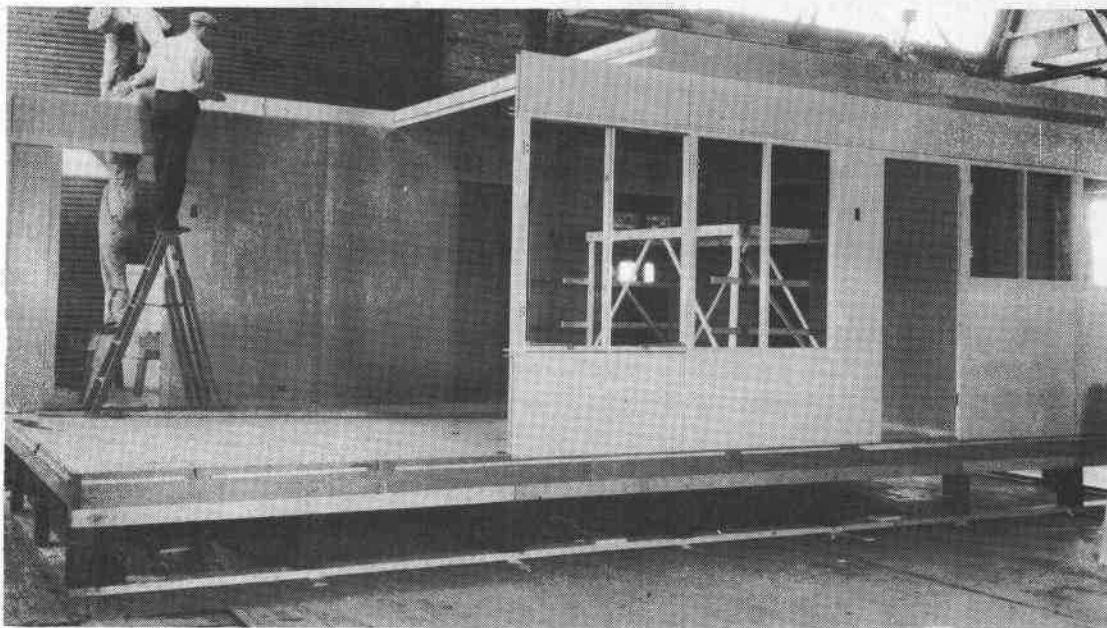


Figure 1.--After 5-1/2 hours this much of the house had been completed.

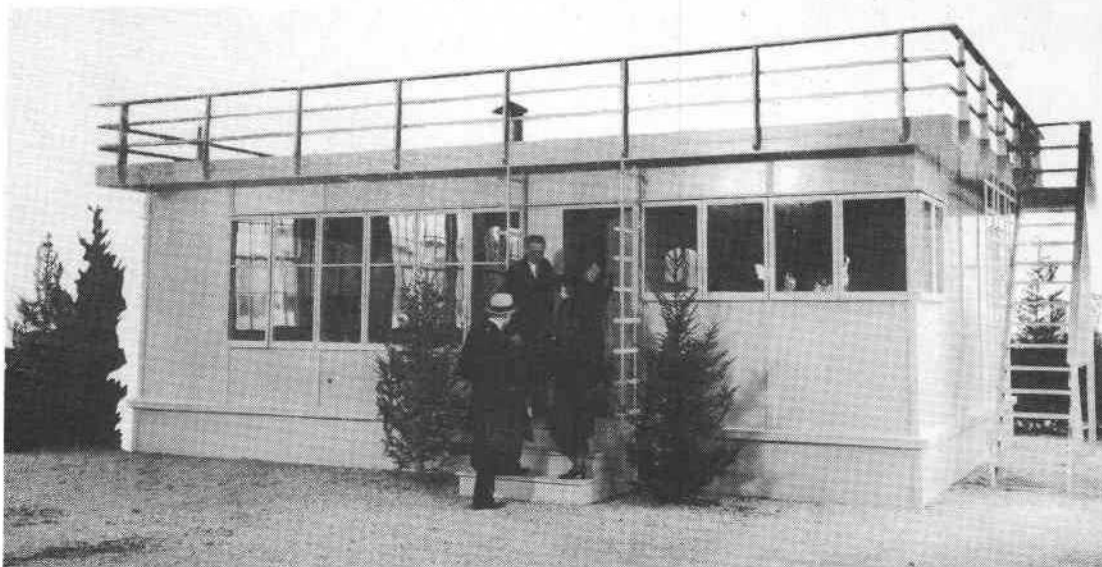


Figure 2.--Twenty-one hours from the time construction was begun the finished house looked like this.

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its basic structural unit a panel. Each panel consists of two plywood faces glued to either side of an inner structural framework to form what is virtually a box girder. The stressed covering principle on which it is built gives it the strength essential for high class construction.

Contrasted with ordinary frame construction, stressed covering opens up a new range of strength and rigidity values with a minimum of material. In the usual floor, for example, subfloor and floor are nailed to relatively deep joists. While the subfloor when laid diagonally stiffens the building to some extent, it contributes little to the strength of the underlying framework. Similarly, ceilings hung on floor joists are additional dead weight.

In the Laboratory's panel, stressed covering incorporates into a single unit joists, subfloor, and ceiling. Weight upon the floor is distributed through the joists to the plywood faces, so that the joists actually support only about one-fourth the load. This unity of action is due to the complete and continuous rigid joint formed by the glue between plywood faces and joists. Such a joint cannot be produced by nailing.

In like manner wall panels were made up of plywood glued to studding or strips.

Wall panels for the demonstration house were built 4 feet by 8 feet of 1/4-inch 3-ply plywood glued on 3/4 by 1-3/8-inch strips, which gives a total wall thickness of 1-7/8 inches. The 1-3/8-inch strips were chosen to conform with the thickness of light stock doors. Top and bottom members of the panel framework were set in 3/4 inch and the outside vertical members the same distance from the edges of the plywood faces, in order to provide the structural joints which will be described.

Floor and roof panels also were built 4 feet wide in conformity with the regular mill width of plywood, and their length in the demonstration house varies from 8 to 14 feet. Because of the strength inherent in this stressed covering type of panel a 2 by 6-inch structural member can be substituted for the usual 2 by 10-inch joist in conventional house construction. The upper face consists of 5/8-inch plywood in five plies, and the lower of 3/8-inch 3-ply stock. Within floor and roof panels a blanket insulator was attached as shown.

Floor panels of this type were tested and found capable of sustaining maximum loads of 300 or more pounds per square foot over a 13 foot 6 inch span. Similarly, wall panels under the pressure of a 60-mile per hour gale would develop a fiber stress in the plywood less than one-third the allowable safe stress for the material.

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Figure 3 illustrates the assembly method for wall, floor, and roof panels.

Mullions Connect Wall Panels

Vertical mullions built up of three pieces glued together are used to connect wall panels. Into parallel grooves of the mullions are fitted the plywood edges of adjacent panels. To protect the plywood edges from moisture and to prevent air infiltration, the grooves are coated with a mastic before the panels are shoved home. Bottom projecting edges of the panel fit over a rabbeted sill member for connection between wall and sill, and similarly the top edges receive a 3/4-inch by 1-3/8-inch member glued to roof panels along wall and partition lines.

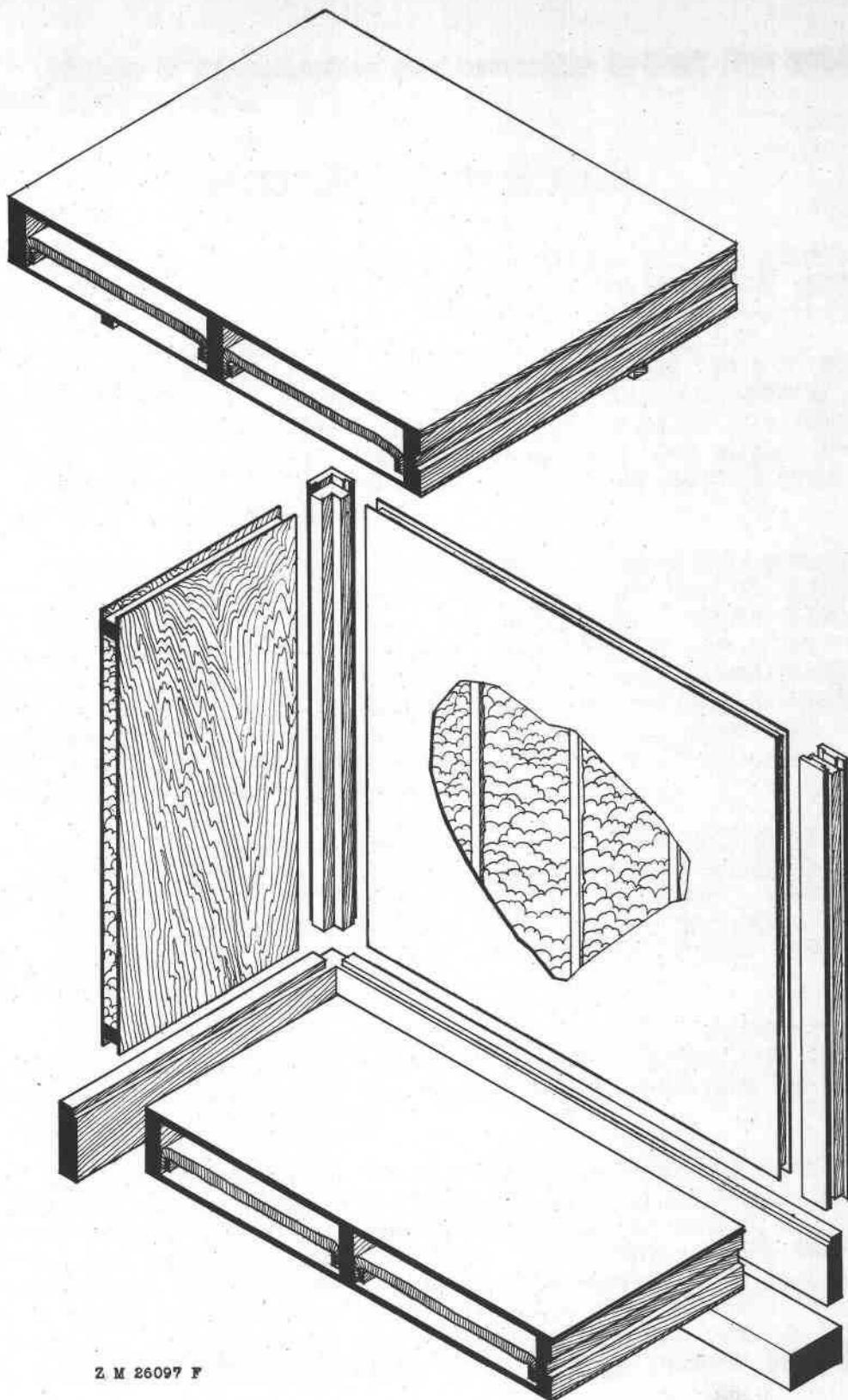
Lateral edges of floor and roof panels are grooved to permit a spline connection for the distribution of weight to adjacent panels. A window system with sash larger than the opening, so that the window is hung outside the plane of the casing, was used. Head jambs, and sill are completely assembled on the typical window panels, with hinges attached, ready to receive the sash. The closure between sash and casing is sealed with a spring bronze weather strip. A wooden drip cap provides protection at the head.

Finished hardwood floors were laid in sections 4 feet square connected by T-shaped strips screwed to the subfloor, with the flanges of the T holding the squares down. Gum flooring was used in the bedrooms and oak in the living room. A special wood plastic developed by the Laboratory was used for the bathroom floor.

The structure as erected includes all the combinations of panels which might obtain in even a large house, so that the connection problems and the necessary variations in panels could be studied in full scale.

A simple electric wiring plan was adopted for the demonstration house. Under a water table built around the outer base of the house a conduit was attached which supplies all wiring for exterior wall panels. Into each panel the necessary connections were inserted before assembly. To supply wiring to inside partitions conduits were run underneath the floor panels. Connections for power appliances, radio, and telephone were similarly installed in panels before assembly.

Where the panels would be pierced by conduits or pipes they were reinforced by glued-in blocks.



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Figure 3.--A standard assembly of panels with a corner mullion and standard mullion. Cut-away views show insulation in place.

A Considerably higher degree of insulating efficiency is obtainable with this type of panel, which is filled with loose insulation material, than with frame construction consisting of wood siding, wood sheathing, and lath and plaster interior. The plywood panel is about equal to the above type of frame construction with 1/2-inch flexible insulation added, but would be superior as regards air infiltration.

The roof and floor panels of the type used, including 1/2-inch flexible insulation, are far superior in insulating value to many common types of floors and roofs.

Because this house was built merely to demonstrate a new idea in prefabrication, it was placed upon a timber foundation. A concrete, stone, or concrete-block foundation could readily be installed beneath it with such additional features as basement furnace room and utility room. The demonstration house was, however, erected with hot-air heating unit in the living room and with a utility room between kitchen and bathroom for economy in installing plumbing fixtures and other appliances.

The plan of the house includes a living room, two bedrooms, kitchen, bath, and utility room; all in the space of 21 by 29 feet. Built-in features include a coat closet which screens the front entrance from the living room; a simple vanity and clothes closet in the master bedroom; a clothes closet in other bedroom; and essential cabinets in the kitchen, all made of lumber and plywood. These features are only incidental to the structural system and could be replaced by a wide variety of movables. In figure 4 is shown the floor and room arrangement, together with all equipment and fixtures provided. To present an appropriate and attractive interior, the demonstration home was furnished in modern style within the limitations of a moderate budget.

Technical Production Requirements

Behind all systems of house prefabrication, whether in wood, steel, or other materials, lies the same general idea -- namely, to put the difficult, intricate part of the work inside the factory, thus reducing the time and expense of assembly on the site to a minimum and providing masses of the population with acceptable housing at a price within their reach. As one writer puts it, the objective is "to make home ownership as common in America as automobile ownership is today."

The footage of dimension material as well as plywood involved in a program of several hundred thousand four-to-six-room houses of the type here considered forms indeed an

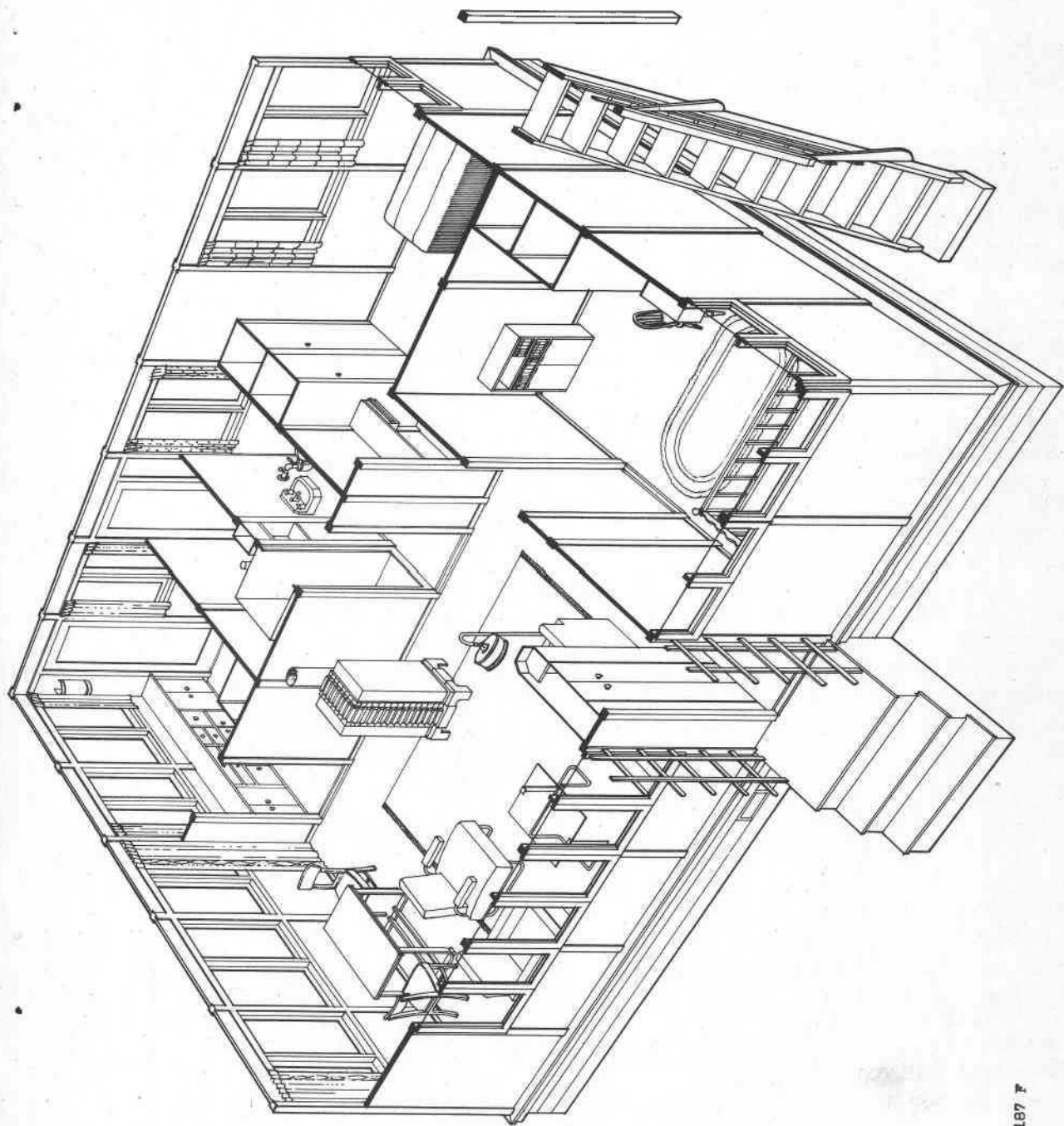


Figure 4.--Perspective drawing of completed house with roof removed, showing floor arrangement and built-in features.

interesting prospect. But the point should not be overlooked that mass ownership of such things as automobiles today hinges not alone on cheap mass production but on all of that plus increasing precision control in manufacture. Accuracy of fitted parts means real performance, satisfaction in use, fundamental desirability, the difference between success and failure.

The degree to which the woodworking factory can meet close tolerances in moisture condition and machining of the wood, can satisfy exact requirements in gluing, and can insure adequate provision against long-time weathering will determine whether the prefabricated all-wood house is to be a modern reality or just another experiment.

The Forest Products Laboratory believes that, with the start that has been made, all such problems can be mastered. Its own machines have produced panels and mullions that fit and that show no cumulative error of dimension as one part follows the other in enclosing the house. The material has been seasoned and conditioned in accord with the best technical rules and practice, and the method of painting, with two aluminum priming coats, has been verified by six years of test on experimental paint fences.

For some purposes, the demonstration house might recommend itself as an investment, just as it stands, but the larger and more vital question is whether it and thousands to follow it will carry wood's fullest and most adequate contribution to the housing needs of the nation. This question deserves an early answer in the affirmative.

Research and Development Needs

The architectural question of variety versus monotony in appearance of large groups of the prefabricated type of house can be eliminated at the outset, since the basic idea in this development is not a unit house but a system of building units. The substitution of wall, floor, and roof panels for smaller traditional integers such as bricks, boards, or slates actually insures wide flexibility in design of individual houses and admits of any size, number, and arrangement of rooms desired.

A remark often heard in viewing the demonstration house is, "It's got a flat roof!" So it has, with stairs and a railing, and so have 75 percent of the houses shown on plans submitted in a recent nation-wide General Electric contest to determine the best type of modern American home. The reason is economy, efficient utilization of space, an extra opportunity for the family to take the sun and air. Nevertheless, to please all tastes and all purses, study might well be undertaken looking to the adaptation of roof units to a standard or variable pitch and to various types of prepared waterproof covering.

Similarly, the Laboratory engineers look forward to the opportunity of comparing and testing out different materials and methods of panel insulation and determining the most practical permanent treatment of exterior and interior surfaces, as well as adjusting construction details to full production and service requirements. It is felt, however, that a substantial beginning has been made toward the realization of a mass-production all-wood house on a strict economy basis, with adequate provision for an American standard of comfort and convenience. Active interest of the wood industries has stimulated development of the project to this point and is counted on to see it through to a definite and favorable outcome.