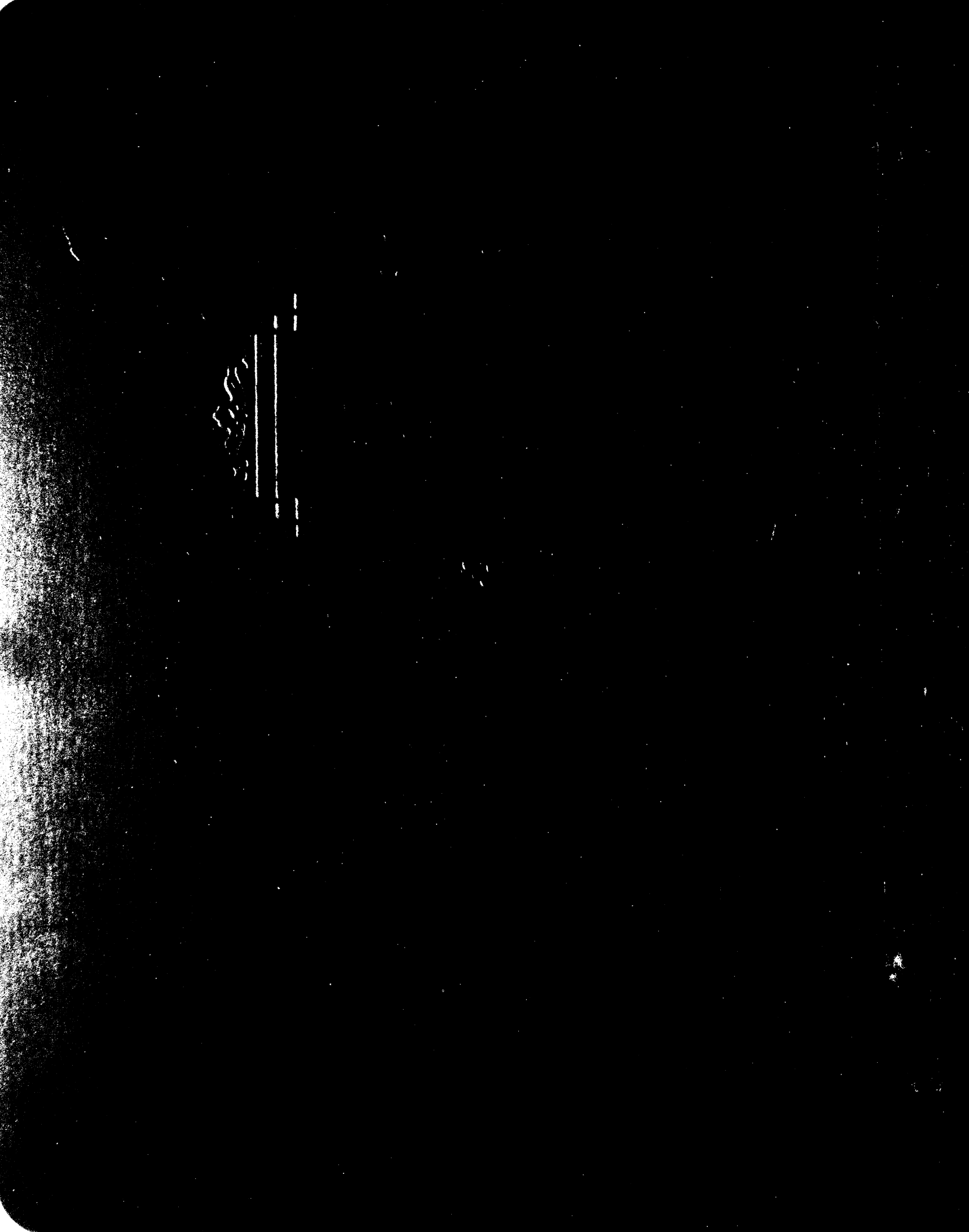


(For.265 Graduate Report)

THE PREFABRICATED HOUSING INDUSTRY
IN THE UNITED STATES

January 23, 1948 G. S. Ranganathan

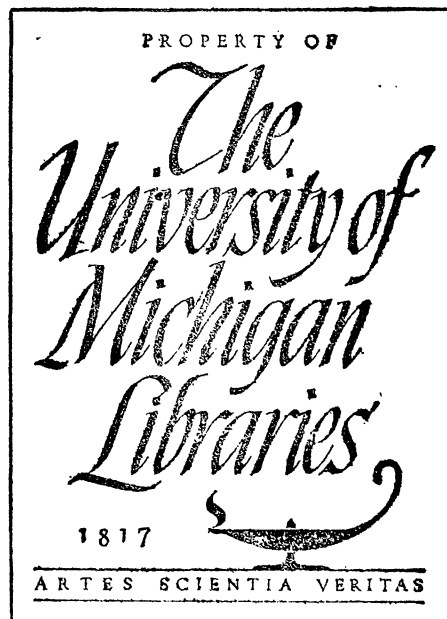
Ranganathan, G. S.



University of Michigan

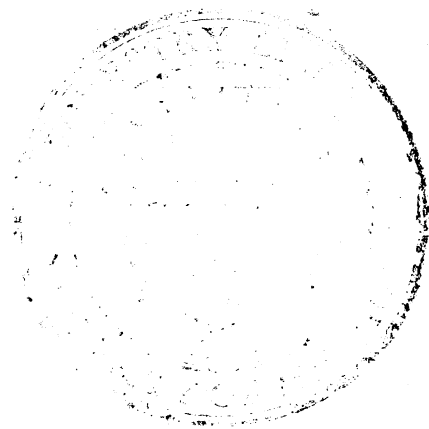
(For. 265, Graduate Report.)

THE PREFABRICATED HOUSING INDUSTRY
IN THE UNITED STATES



January 19, 1948.

G.S.Ranganathan



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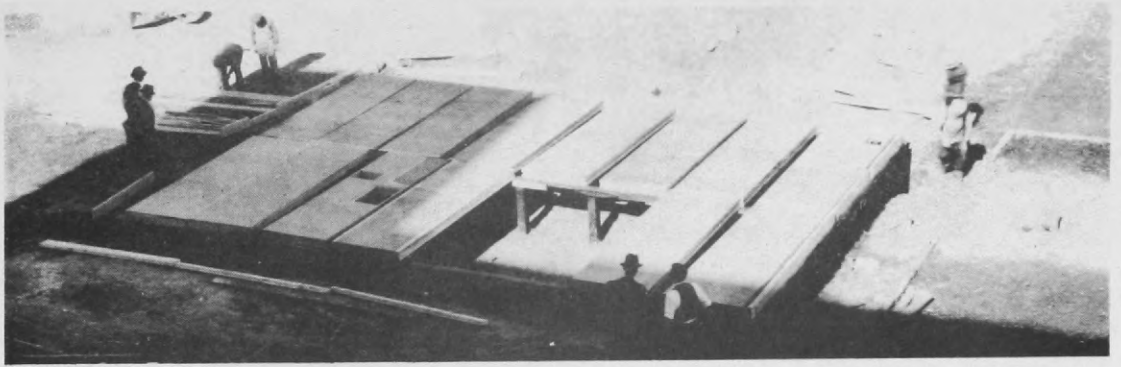
Four Steps In Erection Of Prefabricated Wood House (opp. P 1)
(From Forest Products Laboratory Report)

Wood Panel System Extended (R.F.Luxford)

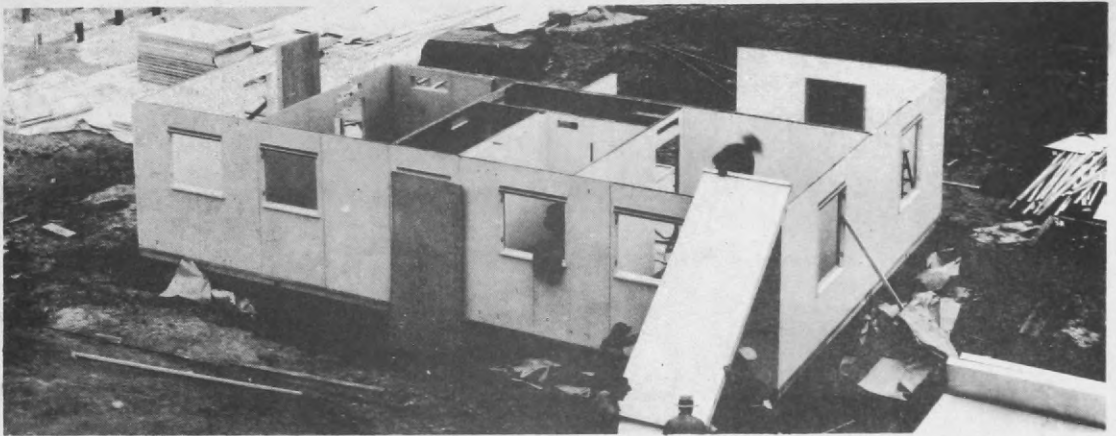
Model Plans - HomeOla

Some Gunnison Homes (photographs)

Four Steps in Erection of Prefabricated Wood House



Floor panels on foundation ready for fitting together with spline connections



First roof panel being put in place. Strips on panel fit into grooves of wall sections for tying roof and walls together



All house panels assembled and garage nearing completion



Z M 32876 F

Panels all in place and house completed

THE PREFABRICATED HOUSING INDUSTRY
IN THE UNITED STATES

Introductory

The idea of prefabricated houses is fairly recent. Though various parts like doors and windows have been manufactured by people in the wood and steel industries for quite some time now, there was no move till recent years to fabricate an entire house within a factory.

In the United States, the initiative was probably first taken by the Forest Products Laboratory in Madison, Wisconsin, when in 1934, after considerable time spent in research, the department of Timber Mechanics in conjunction with the department of Plywood, undertook to build a prefabricated house of stressed-skin plywood. The house that they built was a one-story building. It contained a living room, kitchen, two bedrooms, bathroom, and utility room, as well as an adequate closet space. In it were incorporated the laboratory's latest results in housing research which were based on the various experiments conducted in the departments concerned.

The findings[†] included, among other things, the use of plywood made up with synthetic resin adhesives, and provision of moisture barriers within walls, floor and roof panels. Other interesting features of the new construction were plywood floors with 1/8" hardwood veneer as wearing surface and the use of mineral insulation. The house served both as a method of all wood construction and as a test of its permanency under actual weather conditions. It also afforded a means of obtaining addition-

al research information on various factors such as the efficiency of the moisture barriers and thermal insulation used.

The system was based on the use of standard panels, units that could be made in large quantities in factories, and then ~~and then~~ assembled quickly and without waste on the site. Its ultimate success, naturally, would depend on good workmanship and technique in the construction of these houses units, accurate dimensions of units and efficient paint practice.

Several industrialists made use of the Laboratory's findings to set up plants all over the country. Not all of them built their houses of plywood. There were some that used steel and light metals in their construction with plastics for interiors. The industry however did not meet with much success because the public was not yet ready for prefabricated houses. They were discussed in various magazines, as curiosities usually, and often ridiculed. A large number of plants had to be closed down due to insufficient sales.

During the War, a lot of the data collected by the Forest Products Laboratory and the various concerns that were engaged in the production of these houses, was utilized by the Engineering and Structural departments, to provide temporary building units in the many theaters of War. In England, France, North Africa, India and many other countries such buildings were put up to house men and machines.

Today, with the War over, and in view of the critical situation that exists with regard to housing everywhere, prefabricators have the best opportunity of establishing their industry on a very sound footing. Like every other industry, they too are subject to many limitations right now. Raw materials for their houses cost a lot more than they used to. Sometimes they are not available in sufficient quantities. The prefab-

ricator in spite of these handicaps should be able to turn out houses that cost considerably less than the conventionally built homes.

The public is still prejudiced to a certain extent against ~~prefab~~ prefabricated houses; for several reasons. First and foremost of course, because these houses still cost a large amount of money. Secondly, people still think a prefabricated house is more or less a temporary affair, and one that cannot be expected to last more than a few years. Thirdly, they feel that factory-built homes can not possibly have any great amount of diversity in design; and a house certainly needs individuality. These prejudices may be expected to disappear in due time, when the public are educated by means of reports and bulletins issued by standard research laboratories, that cover, in some detail if necessary, data obtained from tests performed on the houses regarding their strength characteristics, moisture resistance, insulation value of sections used, resistance to decay and such other properties that should convince them the prefab, if properly constructed, is adequately strong and just as durable if not more, than the conventional house.

THE ECONOMICS OF MASS DISTRIBUTION

The success of an industry depends on the soundness of the methods of distribution that are employed, and upon the cooperation of various groups like bankers, mortgage lenders, materials and equipment manufacturers, prospective dealers, prospective purchasers and the general public. Following are some important points[†] involved in the economics of the problem of distribution that any industrialist must face if he believes, as he should, that systematic and coordinated planning is essential for his success.

1) There is no point in making anything unless there is a market for the product. Preliminary studies concerning the market are necessary.

2) The product must be designed to fit the market. This would involve its style and shape, selling price, etc.

3) In the case of prefabricated houses, the most important reason for manufacturing them is because mass-production methods may be used and thereby have houses available for a much larger number of people.

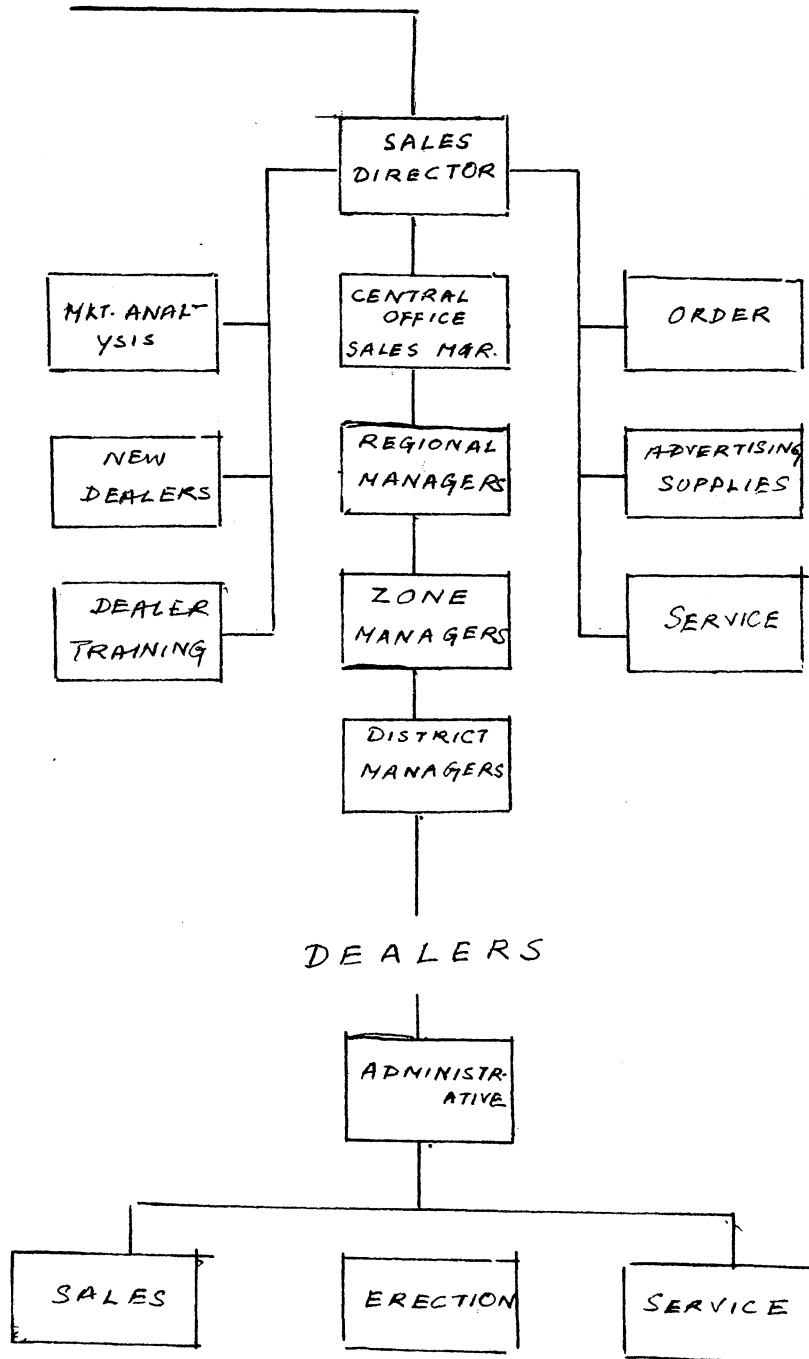
4) Mass-production requires a large investment of capital in plant, specialized equipment such as power-driven conveyors etc. The product must be standardized and capable of being assembled from interchangeable parts.

5) If the conveyors are to work continuously, orders must flow in regularly; distribution methods must be efficient.

6) Mass-distribution is used to diversify sales risk. On the law of averages, the aggregate volume of orders from the dealers will provide the necessary, steady continuous flow to feed the power-conveyors.

Gunnisons Inc. have planned an organization chart towards an efficient management. It is reproduced on the next page.

GUNNISON'S ORGANIZATION CHART



CONDENSATION PROBLEMS IN HOUSES

The condensation of water vapor that occurs during cold weather is the source of many troubles. Water running down from window-sills where the greatest damage may be expected may spoil the finish, damage the plaster, cause buckling of floor boards, loosen wall paper and start decay in extreme cases.

Consistently high humidities will cause wood trim and furniture to pick up moisture. Drawers and doors swell and glue joints may be adversely affected.

Some suggestions for protection †

1) Do not operate humidifiers or water pans in furnaces, or use any other means of intentionally increasing humidity in heated portions of houses in which some rooms may be unheated. Ordinary sources of humidity like cooking, dish washing, bathing and laundry work will maintain considerable moisture in the atmosphere.

2) When frost on windows melts wipe up the water on the sash before it has a chance to soak into the sash.

3) Open windows on bright sunny days and ventilate closed rooms.

4) Install storm sash on all windows; these reduce heat loss considerably and minimize the condensation on the inner surfaces.

5) Absorbent salts like Calcium Chloride may be used sometimes in basements. These should be placed in shallow pans on the floor or on a table near the window. About 2 lbs/100 sq. ft. (floor) should be adequate.

The movement of water vapor is more or less independent of air movement and no general circulation of air is necessary to carry the vapor from its source to the condensing surface. Vapor actually moves by diffusion from points of high vapor pressure to zones of lower pressures. Most building materials like plaster, wood, concrete, most kinds of bricks and building papers are permeable to vapor. The rate of vapor movement from one point to another is proportional to the difference in vapor pressure between the points and inversely proportional to the resistance of the interposed materials. The Forest Products Laboratory after considerable research in this matter tentatively recommends a high vapor resistance on the warm side of a wall and low vapor resistance on the cold side.

The Forest Products Laboratory conducted tests to determine the comparative resistance of various materials to vapor transmission. The results they obtained are given below:†

<u>Material</u>	<u>Loss in grains/sq. ft per hour</u>
Foil surfaced reflective insulation (double faced)	0.153 - 0.093
Roll roofing - smooth surface - 40 to 60#/roll 108 sq. ft.	.093 - .123
Asphalt impregnated and surface coated sheathing, ft. paper glossy surfaced -	
50# 500 sq. ft. roll	..... .153 - .555
35# " "	..... .123 - 1.480
Duplex or laminated papers 30-30-30*	..... .990 - 1.850
Duplex or laminated papers 30-60-30	..... .370 - .617
Duplex papers reinforced	..... .493 - 1.480
Duplex paper coated with metal oxides	..... .370 - .930
Insulation backup paper, treated	..... .617 - 2.462
Gypsum lath with aluminum foil backing	..... .061 - .277
Plaster - wood lath	..... - .790
Plaster - 3 coats lead and oil	..... 2.650 - 2.770
Plaster - 3 coats flat wall paint	..... - 3.080
Plaster - 2 coats aluminum paint	..... - .831

* 30lb paper - 30lb asphalt - 30lb paper

<u>Material</u>	<u>Loss in grains/sq. ft./hr.</u>
Plaster - fiberboard or gypsum lath	14.20 - 14.80
Slaters felt	3.70 - 18.50
Plywood - 1/4" Douglas fir, soybean glue plain	3.08 - 4.620
2 coats asphalt paint	- 0.308
2 coats aluminum paint	- 0.930
1/2" 5 ply Douglas-fir	1.920-1.975
1/4" 3 ply Douglas-fir, art. resin glue	3.08 - 4.620
1/2" 5 ply Douglas fir, art. resin glue	1.975 -2.420
Insulating lath and sheathing - board type	18.50 - 24.65
Insulating sheathing, surface coated	2.19 - 3.050
3/16" compressed fiber board	- 3.640
1" insulating cork boards	-4.400
1/2" and 1" blanket insulation between coated papers	1.38 - 1.440
4" mineral wool - unprotected	- 20.95

Walls finished with such materials as plywood, fiberboard, plasterboard etc, should also have some sort of a vapor barrier in the form of a sheathing paper (generally) . They should be applied vertically on the interior portion of exterior or exposed side walls with edges lapping on the studs after insulation is installed and before thatching. The sheathing paper used in combination with the vapor barrier (the rest of the barrier comprising of the plywood or other material used) should be water resistant, but not very vapor resistant so that the small amount of water vapor that may leak the barrier can escape out.

Some kinds of mineral wool can be made fairly resistant to wetting by water; but of course cannot be regarded as sufficient protection against condensation.

FIRE-RESISTANCE OF PLYWOOD COVERED WALL PANELS

The desirability of installing an insulating material the plywood faces of wall panels to retard the transmission of heat and sound has long been recognized, and the relative fire hazard of the hollow and insulating units has been a matter for serious consideration.

Tests made by the Forest Products Laboratory on the fire resistance of untreated plywood present the following facts: †

Effect of glue used

Component plies of plywood glued with all but phenolic resin glues separate and get charred one after the other. The charring of phenolic-resin-bonded plywood results in a flat, checked surface. The charring offers protection to underlying layers of veneer and to some extent even imparts additional fire-resistance.

Effect of plywood thickness

Resistance depends on number of plies and total thickness (more on total thickness). In the case of hollow wall sections resistance is almost directly proportional to total thickness of the two faces.

Effect of distances between faces (width or studding)

Between limits of 1/3-3/8" and 3-5/8" the width of stud or separator in hollow wall panels has no appreciable influence on the fire resistance. However when the space between the faces is filled with sufficient insulation of suitable character to afford long resistance, the combined width of stud and thickness of faces is factor that determines resistance.

Effect of type of insulation

Reflective type consisting of kraft paper, coated on either one both sides with aluminum foil. Shrinkage accompanying charring ruptures the thin metal foil.

Cellulosic type (granular or loose)

Cellulosic Types of Insulation (Granular or Loose)

Fire resistance values for assemblies containing loose Cellulosic insulation are erratic. This may be due to a decrease in thickness produced by shrinkage checks or by portions of the fill falling away when support is no longer provided by the exposed plywood faces.

Blanket types of cellulosic insulation also do not show any outstanding resistance to fire.

Mineral Types of Insulation

Granular insulation is not effective since they tend to flow out when the flames have burned a hole through the exposed plywood face. Fire resistance is considerably increased when a screen is used between studs to retain the insulation.

Tests on single wall units show that the most important factor contributing to fire resistance is the insulation used between the faces of the panels. Reflective insulations ordinarily increase the resistance between 2 and 8 minutes above that of uninsulated wall sections. Cellulosic insulations add from 6 to 40 minutes but are not all dependable. Vermiculite insulation (unsupported) imparts no additional resistance. Nodulated types of mineral wools add from 20 to 40 minutes resistance but cannot be relied upon consistently, owing chiefly to the difficulty of securing uniform distribution in the plywood panel. Some of the mineral wool insulation in the form of batts increase resistance to more than an hour; the amount of additional fire resistance depending on the density at which it is applied in the wall panel. A batt filling installed at a density of 0.8 lb/sq. ft. may be expected to give an increased resistance in the range of 20 to 25 minutes; at 1.0 lb./sq. ft. 25 to 30

minutes; at 1.5 lbs./sq. ft. 30 to 45 minutes; and at 2 lbs./sq. ft. from 35 to 55 minutes.

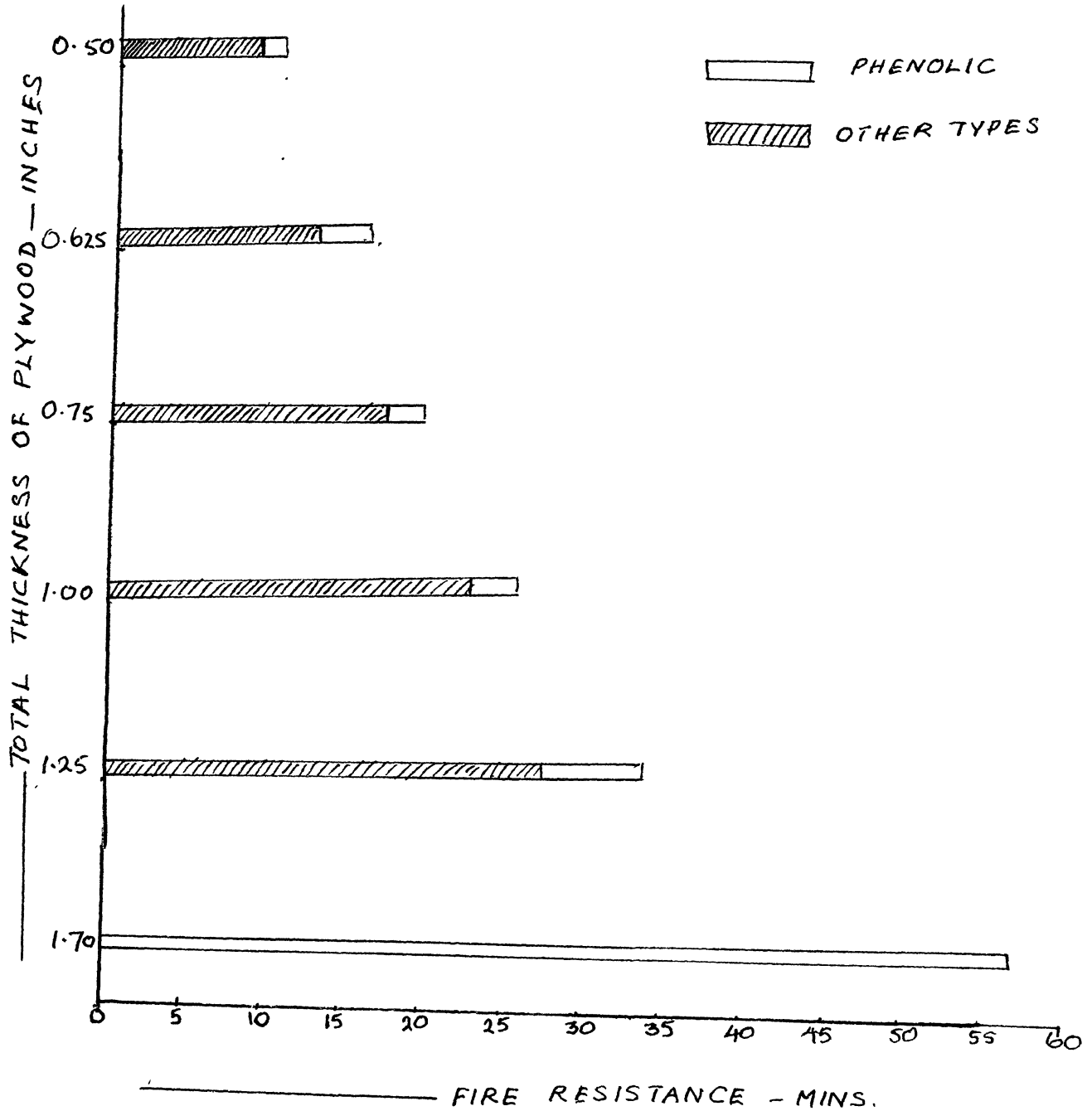
Table below gives the fire resistance of plywood glued with various glues:- †

Glue	Single sheets of plywood			Plywood in unfilled walls, two faces separated by studs			
	Thickness - inches			Total thickness of the two faces in inches			
	1/4	5/8	1-7/10	1/2	3/4	1	1-1/4
<u>Fire Resistance In Minutes</u>							
Soybean (commercial) ..	..	..	..	10	17	21	26
Casein (laboratory) 6.2	13	..	..	10	..	..	..
Animal (laboratory) 6.8	12	..	..	11	..	..	..
Blood, paraformaldehyde, hot pressed, (laboratory) 6	14	..	..	10	..	..	..
Urea resin, cold pressed (laboratory) ..	..	..	..	11	..	..	28
Phenolic resin hot pressed (lab.) 6	16	57	..	12	19	25	34

Fire resistance of plywood wall sections filled with nodulated and loose forms of mineral wood insulation (Planer shavings, shredded paper (untreated etc)). Panels made of 1/4" soybean-glued faces on 3/4-by 1-3/4" studs.

Kind of Insulation	Approximate density of filling	Fire resistance
	Lbs./sq. ft.	Minutes
No insulation	..	10
Expanded mica type	1.2	9

Kind of Insulation	Approximate density of filling Lbs./sq. ft.	Fire resistance Minutes
Notulated types of mineral wool	1.3 - 2.6	31 - 56



GLUES AND GLUING IN PREFABRICATED HOUSE CONSTRUCTION

Modern glues play a very important role in the prefabricated housing industry. During the war the branches of the armed forces made use of the research work done in synthetic resin glues at several standard laboratories for many purposes such as plywood, laminated wood, and wood-to-metal gluing in the construction of P-T boats, landing barges etc. The rigorous tests to which these were subjected during the War besides the various strength tests made at the laboratories have proved beyond any doubt whatsoever that resin glues are the most efficient of any known now. It is therefore not surprising that most prefabricators use synthetic resin adhesives in the construction of their panels.

When plywood is glued to solid wood frames for wall and floor panels the structure as a whole attains a rigidity that is much greater than might be achieved by nailing. Besides, when panels are made with stressed top and bottom coverings, such as plywood glued to joists to form a box girder, framing members can be greatly reduced in size.

Following is a brief description of some of the glues that find use in this industry: †

Casein Glue

It is durable and sufficiently strong under service conditions where the wood remains dry; consequently, may be used for interior work in prefabricated houses. Casein glue joints weaken and fail because of hydrolysis, micro-organism attack, or a combination these causes. These glues can however be made highly resistant to the attack of micro-organisms and their dependability increased by treatment with certain preservative chemicals such as chlorinated phenols.

Room - Temperature - Setting Urea Resin Glues

These glues are formulated to set at temperatures of 70 F and above. The glues are marketed either as dry powders, with separate or incorporated hardeners, or as water suspensions of 60 to 70% solids and supplied with separate hardeners. The powdered glues are prepared for use by mixing with water, or with water and hardener if hardener is supplied separately. The powdered glues usually contain some filler, walnut-shell flour being most commonly used. Mixing directions for the liquid glues usually prescribe the addition of some filler to improving^e their working properties. In general powdered urea-resin glues have longer storage ^{life} ~~forms~~ than the other types. Joints of highest quality are produced with the moisture content of the wood between 8 to 12%. Spreads of 40 to 50 lbs. of wet glue/1000 sq. ft of single glue line are generally recommended.

In general well-made urea-resin glue joints are characterized while new by high original dry strength and high wood failures, and good to fair resistance under laboratory test conditions to continuous soaking in cold water, cyclic soaking and drying exposures of plywood or thin members, continuous high relative humidity, and alternately high and low relative humidity. Significant reduction in glue-joint strength has been observed in joints exposed only to normal room temperatures and humidities over periods of several years. The urea-resin adhesives as a group are low in durability under conditions involving moderately high temperatures, especially when these high temperatures are associated with high humidity. Considerable weakening of glue-joints occurs under dry conditions at 160 F and their rate of strength loss is greater under moist conditions. When exposed to fire they fail because the glue is destroyed at temperatures that char wood allowing the plies to separate.

The effect of high temperatures on the durability of urea-resin glue joints is significant in housing uses because it is probable that temperatures at the glue joint between exterior plywood and studding reaches well over 100 F in some exposures.

Intermediate-Temperature-Setting Phenol Resin Glues

Intermediate-temperature-setting phenol glues have been developed that can be cured at temperatures of 212 F or less. In general phenol glues that set at room temperatures (70 to 80 F) have not been developed for general use. These, like the urea-resin glues are marketed in either powder or liquid form. Glues of this type may be either acidic or alkaline in nature. Acidic glues are undesirable since they have a weakening effect on wood. These glues give good results when the wood glued has a moisture content between 2 to 20%. They are very durable; are highly resistant to dry heat and break down only when temperatures approach their ignition point which is above temperature at which wood chars (415-450 F). Because of this property plywood made with them will not delaminate when exposed to fire. They are not weakened by fungi, bacteria, or other microorganisms; however the adjacent wood may be affected by these forms of decay. Completely cured phenol-resin glue joints are highly resistant to the action of solvents, oils, acids, alkalies, wood-preservedatives, and fire-retardant chemicals.

Intermediate-Setting-Melamine-Resin Glues

These are usually marketed in the form of dry powders. Water, hardener, filler (usually ^lwalnut shell flour) are all used later. The concentration of the glue mixture when ready to be used varies from 60 to 70% solids. Pure melamine glues are almost white. Fillers give them a tan color.

Regarding characteristics, the Melamine glues are ^a similar to the phenol glues. There is not as great a range in allowable moisture content in the wood to be glued as there is with the phenol glues. Best results are obtained when the moisture content is above 6%. Well made melamine glue joints have excellent resistance to high relative humidity, high temperatures, continuous soaking, cyclic soaking and drying, micro-organisms and to most chemicals. Also like the phenol bonded plywood plies do not separate when exposed to fire.

Resorcinol-Resin Glues

These are marketed usually in the form liquids and must be mixed with a hardener, usually formaldehyde or paraformaldehyde, and a filler. When paraformaldehyde is used ~~as hardener~~ a mixture of the hardener and filler is furnished by the manufacturer. Resorcinol glues produce strong glue joints on wood within the range of 2 to 25% moisture content. In durability they compare with the phenol-resin glues.

Gluing Practices

Surfacing

Lumber surfaces should be clean and smooth, and accurately machined. Wood should be surfaced when dry and preferably within a short time before it is glued. If surfaced a considerable time before gluing it should be stored in a humidity-controlled room to prevent changes in its moisture content. Sawn surfaces can be sometimes satisfactorily used, but they are not recommended. Sanding too is not desirable because it tends to produce irregular contours.

Moisture Content of Glued Parts

Most glues are capable of producing good joints over a wide range of

moisture contents. But moisture control is necessary to minimize shrinking and swelling, warping and twisting of structures, and cracks that may develop at panel joints.

Pressure

Adequate and uniform pressures are necessary in order to obtain good joints. Low pressure tend to lower the strength of glue joints, and pressures that are considerably over 200 lbs. crush the wood. The minimum pressure permissible for any assembly is one that will insure close contact of the wood surfaces and hold the members in close contact till the glue has set. Usually 200 lbs./sq. inch. are regarded as an upper limit.

Assembly Time and Working Life of Glue

The working life varies with different glues. It tends to shorten with rising temperatures. In the case of resin glues, the working life becomes lower as storage time increases.

For Urea-resins assembly time is usually limited to a maximum of 20 minutes if entirely closed, and 10 minutes if entirely open. The intermediate-setting-phenol resins permit 1 to 2 hours of closed assembly and have a working life of 2 to 8 hours at 75 F. The melamines are not critical with regard to assembly times, and have a working life of from 2 to 36 hours. The working life of resorcinols is from 3 to 5 hours at 75 F and much reduced at higher temperatures; assembly periods at 70 to 80 F are 30 mins. open to 1 or 2 hours, closed.

Curing of Glue

The curing time of a glue decreases considerably with increase in press-

ing temperature. Casein glues that ordinarily cure at room temperature, cure in a much shorter time at elevated temperatures; in 45 minutes at 120 F, 30 minutes at 150 F, 11 minutes at 180 F and 4 minutes at 220 F (temperatures above 200 are not recommended as some deterioration in strength may result depending on species used.)

The Urea-resins, which require a pressure-period of about 4 hours or more at 75 F, set in a time approximately half for each 10 F rise in temperature. Similarly resorcinol glues that might take 4 to 7 hours to cure at a temperature of 75 F may be cured in as little as 3 minutes at 160 F. The melamine and phenols (intermediate-temperature-setting) that take 3 to 4 hours to set at 120 F will set in 5 minutes at 200 F. These features make it possible to have a rapid gluing assembly in a plant by the use of hot presses.

THE GUNNISON HOMES Inc.

The Gunnison Homes Inc. were the first to apply mass-production methods to produce prefabricated houses.[†] Their plant in New Albany, Indiana sold more than 4500 homes in thirty eight different states before the War. When the War broke out, the Gunnison plant adapted its methods to the production of prefabricated hospital units, which were shipped by plane^{to} various war zones. Now they have resumed peace-time production. In 1944 they became a subsidiary of U.S. Steel Corporation.

The Gunnison Homes follow closely along the early American style of architecture. They come in eight different sizes. The smallest of them being 28' by 24' and the largest, 52' by 24'. (Gunnisons make use of the 4 ft. module in their design) The smallest house includes 2 bathrooms, utility room, kitchen, and living room; and the largest has 3 bedrooms, 2 bathrooms, utility room, kitchen, large living room and dining room. It has besides, large closets situated in various parts of the house. The kitchen contains a 12 ft. wide cabinet with double compartment sink. Beneath this there is ample space (cupboards etc) for utensils, knives, forks etc.

Houses when sold are complete with plumbing, automatic heating, and automatic water heaters. Medicine cabinets and light fixtures are also provided.

Floors, walls, ceilings and roofs are all manufactured in interchangeable standardized panels. The panels are virtually box-girders

bonded together in a single integral part or unit in a hot-press. Phenolic resin adhesives are used as bonding agent. Rockwool bats, chemically treated are sealed into the panels including floor, exterior walls, ceilings and even partitions. (The insulation value of the Rockwool bats equals that of 22" of concrete.)

The Homes can be provided with either a full basement, a partial basement or just the foundation walls.

In addition to the Homes a number of 'Packages' can be purchased as optional feature. The Company uses the term 'Package' to denote completeness. There is a Wing Package which can be added to any of the corner rooms to lengthen them by four feet. There is a front porch, an end porch, a front arcade and an end arcade, all of which are available as extra packages. The several units as may be imagined may be combined in different ways.

Doors, hardware, windows and screens are all installed on the moving conveyor. The panels are then shipped by freight or truck to the owner's lot where they are erected on a concrete foundation, either with or without basement. The panels are locked together with steel connectors and the whole house is then securely bolted to the foundation.

Each house takes one day to be erected, and a week more for the plumbing, exterior panels, heating and other accessories to be installed. The useful life of a Gunnison house according to present standards is estimated to be about 55 years.

Gunnison dealers arrange for mortgage financing. Homes may be sold on monthly payment terms of \$30 to \$60 which includes taxes

And insurance. The buyer gets free service every six months or so.

At the end of the report are included some plates which show
a few
~~some~~ of the Gunnison homes. According to them the shell of each house costs
60% of the total, to construct.

OUTLINE DESCRIPTION OF THE HOMEOLA SYSTEM
OF MODULAR CONSTRUCTION

The HomeOla house^f consists of a series of light weight modular units. A floor frame of structural steel; floor, roof, partition, ceiling and roof panels of light weight stress-skin plywood construction. The design is based on a 4 ft. module, and all units are approximately 4 ft. in width and designed to resist working loads of 2 1/2 times normal, as expressed in 'Performance Standard, Structural and Insulation Requirements for Houses' (National Housing Agency, March 1947).

Exterior Walls

Shop fabricated units 4 ft. wide by story height, consisting of a wooden grid, covered both sides with 1/4" exterior type (water resistant) Douglas fir plywood. Framing includes 2" by 2" border members, one 2" by 2" center grid, one 2" by 2" horizontal stiffener at mid-height, and four lines of 1" by 2" horizontal stiffeners spaced approximately on 16" on center. Units are insulated with 1/2" rigid or non-rigid insulation with an air space on both sides, and vertical vent tracks are provided through the space outside the insulation to relieve moisture vapor pressure should such pressure accumulate. Panels are assembled by means of Resorcinol resin (phenol-formaldehyde base) adhesive, mechanically spread and bonded under pressure in excess of 100 lbs./sq. in. at temperatures over 200 F for not less than 4 minutes, followed by a curing time of at least twelve hours at 150 F.

Partitions

Shop fabricated units 4 ft. wide and ceiling height, are of the same construct-

ion described for exterior walls, except that insulation is not included within the grid.

Floor Construction

Shop fabricated units 4 ft. square are framed with 2" by 2" members, covered on the bottom with 1/4" plywood, and on top with 1/2" plywood. Both surfaces of exterior type plywood of Douglas fir (water resistant). Framing includes border members and two intermediate joists. All edges are grooved for splines. Units are insulated with 1" rigid or non-rigid insulation, placed between the members with an air space on both sides. The top surface is a 1/8" veneer of hardwood or vertical grain fir. Attachments of plywood to grid is by the same method as described for exterior walls.

Ceiling Construction

Ceiling panels consist of 4 by 12 ft. plywood panels in the one story houses, including border members and intermediate joists spaced 16" on center, face grain of the plywood being parallel to the 12 ft. dimension. In the 1 1/2 story houses, ceiling panels are similar to floor panels except that no insulation is incorporated in the completed unit.

Roof Construction

Roof trusses of plywood in 1 1/2 story houses or of steel in single story houses, are spaced 4 ft. on center. Roof units consist of 3/8" plywood with 2" by 2" purlins spaced approximately 14" on center, notched to fit over the trusses, purlins being attached to the plywood by nailing and gluing.

Exterior Finish

Standard exterior finish is as described under 'Exterior Walls'. How-

ever, conventional siding may be field applied.

Materials

All plywood is Douglas fir exterior type. All glue is waterproof in accordance with Commercial Standard CS45 - 42. All framing lumber is Douglas fir (coast region), west coast Hemlock, Larch or Yellow pine #1 grade or better, kiln dried with the moisture content not in excess of 8% at time of assembly; and is dip-treated before assembly at the factory in a 5% solution of pentachlorophenol. Following assembly, all panels are given a roller coat application of a phenolic base, clear, unpigmented primer.

Field Assembly

Foundations are conventional as required, and provided with sufficient anchor bolts. First floor framing is conventional steel beams or channels of correct dimension for span and spacing of 4 ft. on center. Floor units are placed on top of the steel I-beams and connected by hanger-bolts and splines. Wall units are placed on the flange of a Z-bar, electrically welded to the sill and engaging the groove in the bottom of each wall unit. Each unit is then bolted to the sill-member with four 3/8" water-tight bolts; splines are placed in all vertical corners/ joints and corners are closed by wooden posts placed and attached by screws adjoining wall units. No steel connections (through connections) from inside to outside occur above the bottom of the first floor line.

Bearing partitions are nailed to the floor units connected by screws or nails to wall units. Second floor steel beams in 1 1/2 story houses are attached to the walls and bearing partitions by four 3/8" water-tight bolts through steel plates welded to the ends, and are

recessed and wood plugged on the outside to prevent condensation. Second floor units in 1 1/2 story houses are attached the steel beams the same as first floor units. Steel trusses in single story houses are fitted with a metal plate and a means of bolted connection to two contiguous wall-panels. At gable ends, a continuous plate, grooved for spline connection to the wall above, is nailed to the top of the first story wall panels. Second story gable and walls (end walls) have splined connection to the lower wall plate and splines are placed in joints between units. A continuous wood plate at the top of the eave walls is also provided on single story houses. The joint between plate and gable-end wall units is sealed by mastic. Roof units are attached to trusses by means of nailing or clips.

Limitations

The HomeOla Corporation provides that all elements of construction, finish and equipment other than floor, ceiling, roof construction, heating, wiring, and plumbing as is described to be different from the conventional shall comply with with the Minimum Construction Requirements of the Federal Housing Administration for the District in which the house is erected. All pre-cut structural members shall be considered conventional and shall comply with applicable local requirements.

The next few pages will be devoted to tables containing data from strength tests made on HomeOla wall, floor and ceiling units; also from tests on their insulation value.

TABLE I

Assembly Name	Working Uniform Transverse Live Load	Design Uniform Transverse Live Load	Ultimate (Test) to Destruction Transverse Load
Floor Beams	40#/sq. ft. (18000 per sq. in. stress)	100#/sq. ft.	
Floor Panel	45#/sq. ft.	113#/sq. ft.	868#/sq. ft.

1) From 'Review and Report on Structural Tests on Standard HomeOla Stressed Plywood Panels as performed at the National Bureau of Standards, August to November 1946, by Prof. A.L. Whittemore.'

TABLE II

Assembly Name	Working Uniform Transverse Live Load	Ultimate Transverse Live Load	Working Load Under Uniform Compression	Ultimate Load Under Uniform Compression
Exterior Wall	25#/sq. ft. (2)	180#/sq. ft.	600#/lin. ft.	6030#/lin. ft.
Roof Panels	40#/sq. ft.	224#/sq. ft.	... Not Applicable ...	...

2) This figure of 25# is generally conceded adequate for side walls in buildings not over 25 ft. in height for erection in areas subject to winds of high velocity including tornados, hurricanes etc.

TABLE III

Assembly Name	CONCENTRATED LOAD		IMPACT	
	Loading	Defect	Weight & Drop	Defect
Floor Panel	1000# on 1" round disc	None	60# sand bag 6' - 0"	None (3)
Wall Panel	...	..	60# sand bag 6' - 0"	None (3)
Roof Panel	650# on 1" round disc	None	...(4)	...

(3) This drop is three times the required distance for testing floors for permanent residences.

(4) 3/8" panels will hold 3/4" galvanized nail attachment of wood shingle so that a force of 85 lbs. is required to raise the butt of a 16" shingle 8".

Condensation In Walls and Roofs

The tests were conducted in the Climatometer of the Engineering Research Section of Pennsylvania State College. The data reproduced here were compiled by the Technical Office - National Housing Agency, Washington, D.C.

The wall panels tested were standard HomeOla CA panels, no paint applied to interior or exterior except the regular factory applied roller coating of clear synthetic resin sealer. During the test period commencing March 27th and ending April 18, 1947, panels were set up as an enclosure and subjected to a steady state of temperature and humidity conditions as expressed below:

Outside of enclosure	.....	<u>R.H.</u> 78%	<u>Temperature</u> Zero F
Inside of enclosure	.....	38%	70 F
Vapor pressure differential	...	....	<u>.125 lbs./sq. in.</u>

On April 18th the panels were opened for inspection and the results were observed. The report of this inspection was: No evidence of condensation. In addition to visual inspection, psychrometric readings were taken in wall cavities, and were as expressed below:

<u>Average Outside Skin Temperature</u>	<u>Average Air Dew Point</u>	<u>Safety Range</u>
8° F	5° F	3° F

During the continuation of the tests commencing April 25th to May 7, 1947, more serious conditions were imposed:

Outside of enclosure	<u>R.H.</u> 78%	<u>Temperature</u> Zero F
Inside of enclosure	38%	80 F
Vapor Pressure differential	....	<u>.178 lbs./sq. in.</u>

On May 7, the panels were again opened for inspection, and reported as follows: No evidence of condensation top or bottom. Inside wall surfaces seem cold. Wall surfaces straight and true.

Temperature differentials noted:

<u>Top</u>	<u>Bottom</u>	<u>Difference</u>
24 F	21 F	3 F

Summary 'Visual inspection alone does not appear to give positive indication of pending trouble. The application of two coats of paint to Douglas fir plywood appear to give excellent performance as a vapor barrier'.

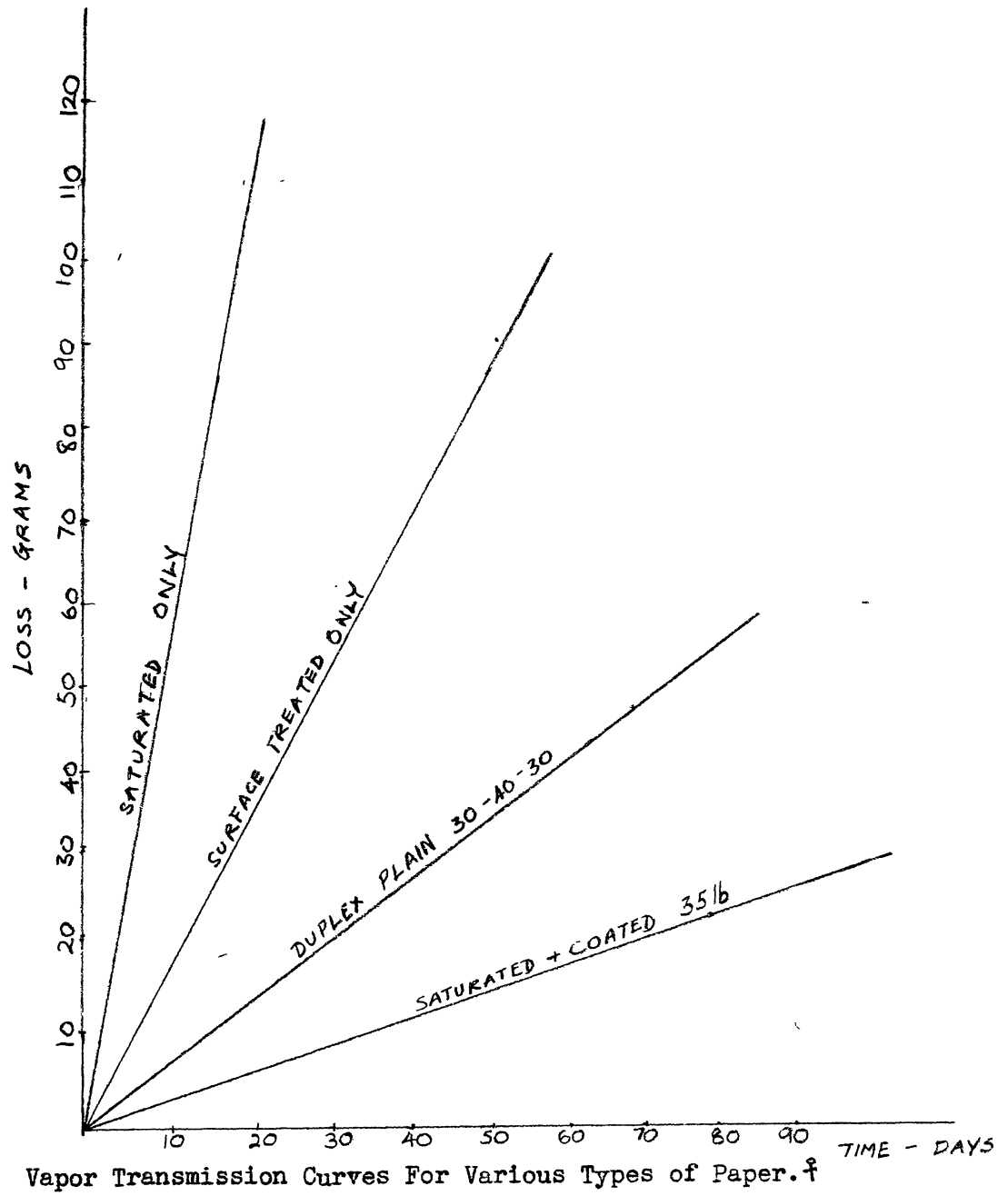
TABLE IV

Insulation Values

<u>Floors</u>	<u>Walls</u>	<u>Roof</u>
U .16	U .21	U .115

Figures included above are standard assemblies prepared in accordance with ASHVE Guide Book by B.G. Andrews, Kimberly-Clark Corporation, Neenah, Wisc.

Houses built of HomeOla modular parts are available as single family-units, and also as duplexes, and in models ranging from 1k to 5 bedrooms, both in 1 and 1 1/2 story design.



SOME EXTRACTS FROM CODES AND REGULATIONS PERTAINING
TO THE CONSTRUCTION OF PREFABRICATED HOUSES IN THE U.S.

General: The erection of prefabricated buildings or[✓] the use of prefabricated assemblies shall conform to the requirements of the code (Southern Standard Building Code 1946-1947, Section 1708 and 1703; and Building Officials Conference of America - Basic Code, Art. 19, Prefabricated Construction Report of Basic Code Committee, October 13, 1946.) except as otherwise provided for in this section.

Loads: Live, dead and wind loads requirements shall conform to the following when such building or assembly does not fulfill the requirements of this Ordinance as to structural standards.

Floor Loads; Uniformly distributed loads - 40 lbs./sq. ft. shall be required.

Floor Live Loads; Where the rise is less than 30, roof shall be designed for a vertical live loads of not less than 20 lbs./sq. ft. of horizontal projection. Where the rise is greater than 30, the roof shall be designed for wind load only.

Wind Pressure; Every exterior wall shall be capable of withstanding horizontal loads of 25 lbs./sq. ft. acting either inward or outward*

* This figure has been established for southern coastal regions subject to hurricanes, tropical disturbances, and are occasionally winds attaining exceptionally high velocity, and are about 50% in excess of those required for inland regions for buildings of less than 30 ft. in height.

Tests: Every manufacturer of prefabricated construction seeking permits, shall file with the (building official) true copies of a certificate stating that tests have been made on the particular type of prefabricated construction, showing the live and wind load capacities in pounds per square foot uniformly distributed, as required by this Section, together with a detailed description of the panels tested.

(Roofs shall be designed to withstand loads outward normal to the surface, equal to $1 \frac{1}{4}$ times the horizontal load specified for the wall,)

CONCLUSION

In concluding this report I might say something about a few of the other types of construction that are employed in the prefabricated building industry.

The Fuller House: Soon after the War ended there were a series of articles in several magazines regarding the Fuller House. The House was to be circular in design, with a shell of Aluminum or light steel. It was supported on a mast, capable of revolving in order to make use of Solar heating as far as possible. The rooms were formed by radial partitions; and the living room took up the entire outer circumference. The design was, as may be imagined, quite unconventional, and the approximate cost about \$10,000. The Management, however, said they were confident they could sell about 10,000 houses a year. The plant was to be on the order of an automobile factory. But due to insufficient funds they never got under way.

Quonset Huts: These have been used in various places as temporary dwelling units. The construction is essentially very simple, and consists of a semi-circular shell (front elevation) of galvanized iron sheets.

Cinder-Block Houses: These cannot entirely be called prefabricated houses because the method of erection is not very different from the conventional method of erecting brick or stone houses. However they are easier to assemble and take much less time. The blocks are joined together by means of mechanical connectors (like timber connectors). They can be dismantled very easily and can be reused with very little loss. Hence their resale value may be expected to be quite high. Due to the porosity of the cinder-

Blocks, in cold or damp climates adequate moisture barriers should be provided. Plywood panels can easily be nailed to the blocks.

Constructions of Cinder-blocks have several advantages over most other types due to the great diversity in design that may be employed. They should lend themselves particularly adaptable to modern designs in Architecture; besides they can be easily replaced if damaged and cost less to repair than houses of plywood panels. A resin coating may be given to the exterior surface of the blocks in regions where high relative humidities are common.

Concrete-Shell: Recently, there were some articles in the Architecture Forum and the Life Magazine about a man who had patented a device of constructing concrete shells for houses. He did this by pouring a mixture of concrete (with light aggregate) over an inflated balloon of reinforced rubber. When the concrete set (in 5 or 6 hours) the balloon was deflated and removed. The shell is formed with windows and doors and may be reinforced if desired. This type of construction on account of its simplicity and low cost should find great use as restaurants and cafeterias and gas stations.

Trailer-Houses: These are fairly small and compact. Most of them are of stressed-skin plywood. They are low priced. A large number of trailer-houses were put up the T.V.A. for their employees. During peace time the manufacture of these houses would depend to a great extent on the automobile factories and the highways. In America where people have the means to travel the industry may be considered fairly stable.

The majority of prefabricated houses in the U.S. are made of wood; either entirely of stressed-skin plywood panels or with an exterior of siding of half-round logs (These are usually cabins that are meant to be occupied only part of the year. They are not generally provided with insulation.)

The houses that are built are almost always of conventional design, the aim of the prefabricator being, it would appear, to make houses that don't look any different from regular contractor-built houses. This, though aesthetically lamentable (for the ordinary, contractor-built home is nothing but a hash of some ancient designs made by architects ages ago, entirely unsuited to modern times and totally lacking in imagination) is perhaps sound business sense. For the person buying a house will want to be certain that his house has a fairly high resale value; and houses of modern design do not have a good resale value because people are skeptical of anything that looks different from the thousands of other houses they are used to seeing around them.

It will be a matter of years, however, before most of the houses in this country are prefabricated. The majority of people, it is to be expected, will buy houses that cost only half as much and are just as good as the houses built by contractors. Those who can afford to engage architects will still be able to do so, but even those houses could be built by the prefabricator in most cases, for in the long run he will be able to supply the architect with most of the materials he might wish to use. Prefabrication on a nationwide scale will also bring about the conservation and effective use of valuable building materials.

In India today the need for houses is greater than ever before, and people are very much at the mercy of unscrupulous contractors. A prefabricated housing industry would help alleviate the housing shortage considerably. I believe that such an industry could do a great deal if backed by the Government.

At present, in India, most of the houses are built of either stone, brick or concrete. Wood, though ~~it~~ it could be used if properly treated to withstand the heavy tropical rains, would take a ~~long time~~ a long time to overcome the prejudice that is attributed to its durability. Plywood panels can be used for the interior finish.

Quonset huts are being used to a certain extent in India. During the War they were used as hospital units and temporary barracks. The other types of construction described can easily be applied to conditions in India.

SOME MANUFACTURERS OF PREFABRICATED HOUSES

Allied Housing Associates, Inc., Langhorne, Penna.
American Houses, Inc., 570 Lexington Ave., New York, N.Y.
Capital Prefabricators, Inc., Box 821, Austin, Texas.
Dorr Associates, 505 N. Michigan Ave., Chicago, Ill.
Factory Built Homes, Inc., McDonough, N.Y.
Flury & Crouch, Inc., 4600 Georgia Ave., West Palm Beach, Fla.
Fuller Houses, Inc., Wichita, Kan.
General Housing Co., 2121 N. Beckly, Dallas, Texas.
Gunnison Homes, Inc., New Albany, Ind.
HomeOla Corporation, 9 S. Clinton St., Chicago 6, Ill.
Horsley Structures Inc., Eugene, Ore.
Johnson Quality Homes, Inc., 270 41st st., Brooklyn 32, N.Y.
Latisteel, Inc., 2272 E. Foothill Blvd., Pasadena 8, Cal.
Lincoln Industries, Inc., Marion, Va.
Palace Corp., Flint, Mich.
Precision Built Homes Corp., Trenton, New Jersey.
Strathmoore Co., 14000 Grand River Ave., Detroit 27, Mich.
United States Housing Co., 1629 K St., N.W., Washington 6, D.C.
Wingfoot Homes, Inc., 1144 E. Market St., Akron, O.

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(Fire Resistance Tests)

F.P.L. Report R 1025 (Plywood as a structural Covering for Framex)walls
and Wall Units).

Floor Panels With Stress Skin Plywood R 1026

How to minimize Condensation in Houses R 1421

Fortune Magazine April, 1946.

Condensation Problems in Modern Buildings R 1195 (Forest Products)

Fabricated Wall panels with Plywood Coverings R 1099 "

Prefabricated Homes (Library Reprint) Educational Service Department
No. 26

Glues and Gluing in Prefabricated House Construction G.N. Arneson

Comparative ~~Transmission~~ ~~to~~ ~~Vapor~~ resistance of some Commercial Building
Papers to Vapor Transmission By Teesdale (F.P.L.)

HomeOla Corporation's Data on Houses.

The Prefabricated House : Graff, Matern & Williams

All-wood Panel System of Construction is Extended

By R. F. LUXFORD, *Engineer*
and

AUGUST SMERDA, Jr., *Junior Forest Products Technologist,*
Forest Products Laboratory, Forest Service,*
U. S. Department of Agriculture

IN ITS research program on modern structures and wood fabrication, the Forest Products Laboratory designed and built during 1935 an experimental prefabricated house in which plywood was the principal material of construction. This house is of a one-story type with a flat roof and has casement windows throughout.**

Like most prefabricated structures, the house has as 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. With this type of construction the load is immediately distributed through the framework to the plywood faces so that the joists or studs actually support only about one-quarter of the bending load.

This action is possible because of the complete and continuous rigid joint formed by the glue between the plywood faces and the framework.

System Is Flexible

This panel system of prefabricated construction can easily be altered to permit many types of construction. As an illustration of its flexibility of design a new wall section including double-hung windows was recently constructed and is described here for the first time.

Details of design whereby panel construction can be used for two stories and pitched roofs are also shown.

Figure 1 is an exterior view of the new wall section. The overall thickness of the wall panel is $2\frac{1}{4}$ inches. The window sash are only one inch in thickness, whereas the minimum thickness in usual commercial windows is $1\frac{3}{8}$ inches. For relatively small windows, however, they should prove satisfactory with reasonable care in manufacture. The weight pockets were eliminated by the use of one of the new types of window balances.

Each of the vertical mullions that form part of a door or window frame has two parallel grooves into which the edges of the plywood panels are fitted. This part is continuous the full height of the wall panel, and carries the load from the floor above to the foundation (fig. 1). The center parting strip is made of hardwood rather than of the usual soft pine and thereby affords the use of a thinner piece which reduces the required overall thickness of the window frame. The door frame has the same overall thickness as the window frame and is sufficient to accommodate a $1\frac{3}{4}$ inch inside door. There is also space for a 1 inch screen door provided the inside door is equipped with a special short knob.

Plywood Sheets Adjacent

The mullion at the junction of the two panels extends from the unexposed face of the interior plywood to $\frac{7}{8}$ inch beyond the outer face. Consequently no part of the mullion extends into the room and hence the edges of the plywood sheets are adjacent to each other. This arrangement eliminates the batten-strip effect and when the edges of the panels are rounded the attractiveness of the rooms is increased.

Since the mullions do not project into the room it was necessary to extend them $\frac{7}{8}$ inch beyond the outer surface of the building in order to obtain mullions of sufficient size to support the floor loads. This gives the appearance of more structural strength than when the mullions extend partly beyond both the inner and outer wall surfaces with

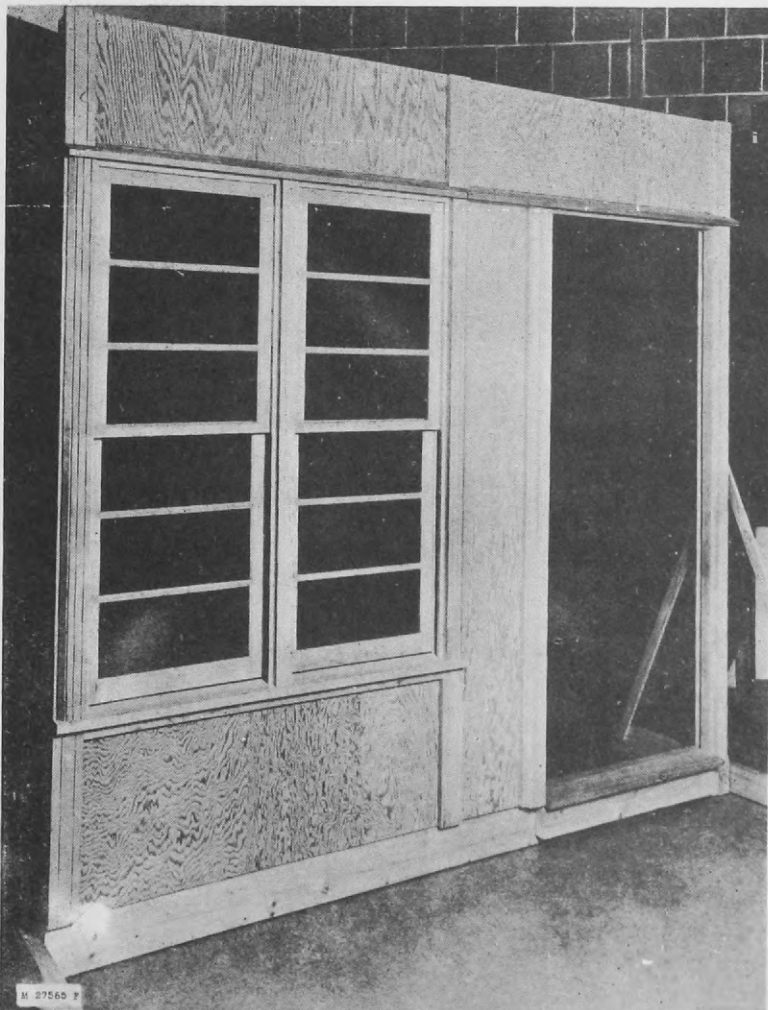


Figure 1. Exterior view of prefabricated wall section.

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

**Shown in WOOD CONSTRUCTION, issue of May, 1935.

New Methods Applied to Double-hung Windows, Pitched Roofs and Two-story Houses. Results of Research Program in Wood Fabrication

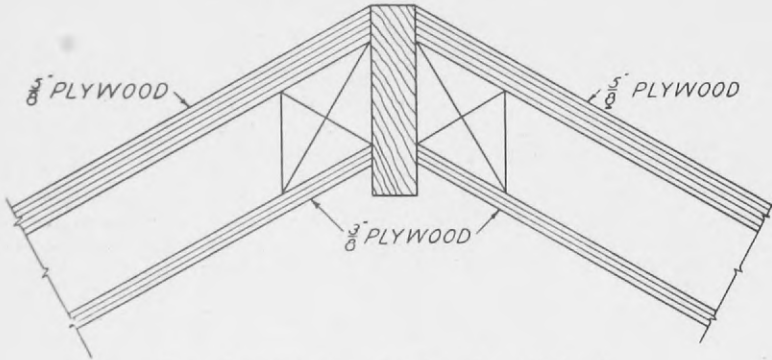


Figure 2. Connections of roof panels at ridgeboard.

a less extension from the outer surface.

By filling the wall opening, which is $1\frac{3}{4}$ inches wide, with a loose insulating material, a wall very resistant to the transfer of heat or cold is obtained. In fact, it is somewhat better than the conventional type of construction consisting of wood siding, wood sheathing, paper, lath and plaster, plus $\frac{1}{2}$ inch of blanket insulation. A house constructed of plywood panels is also more resistant to air infiltration than the con-

ventional construction, because there are no cracks through which the wind can pass.

Pitched Roofs

Most prefabricated houses are modernistic in design with the usual flat roofs. Houses constructed with prefabricated panels lend themselves more readily to modern design than do houses with pitched roofs and they are also more economical. However, the inclusion of both flat and pitched roofs in the field of prefabricated construction makes possible a wider range in architectural effects. A pitched roof with the resulting attic also provides storage space which is considerably lacking in a flat-roof house, and particularly so when the house is without a basement.

Houses with pitched roofs can be easily constructed with the type of panels employed by the Forest Products Laboratory. Figure 4 illustrates a suggested joint between the roof and attic floor panels. This joint consists essentially of a triangular strip "A" approximately 2 by 3 by $3\frac{1}{2}$ inches in cross section securely nailed to the top story wall ceiling panel, and a triangular strip "B" approximately 2 by 2 by $2\frac{3}{4}$ inches in cross section securely nailed to the roof panel. After the roof panels are assembled, strip "B" bearing against strip "A" keeps the roof panels firmly in place. When the erection is completed strip "B" is nailed to strip "A" to prevent the roof from being lifted by heavy winds. The connection at the roof board is of the conventional type as illustrated in figure 2.

The thrust exerted by the roof loads must be resisted through the floor panels. Since the panels are not continuous from roof line to roof line, but extend only from one roof line to a bearing partition, it is necessary to have a tie between the panels. Splines are used between all panels to cause them to deflect together under load. Through adequate nailing these same splines are utilized to obtain the proper tie in the direction of the thrust. The splines extend $\frac{1}{2}$ inch into the floor panel joists and are $1\frac{7}{8}$ inches high.

Two-Story Houses

In prefabricated houses there is a decided tendency toward one-story homes. It is, however, both practical and feasible to erect two-story houses with prefabricated panels as constructed by the Forest Products Laboratory. A connection between the first and second stories at the outside wall is shown in figure 3. This figure includes portions of the wall of the first floor, the floor panel between the first and second stories and a portion of the wall of the

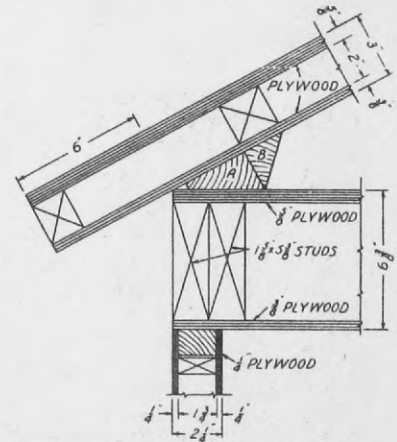


Figure 4. Joint connections for pitched roof.

second floor. In this illustration the several parts are slightly separated.

Essentially the construction resembles the platform type of conventional frame construction in that the second-story floor panel rests upon the first-story wall panels and the second-story wall panels are placed directly on top of the floor panels. The wall panels are grooved by extending the plywood faces beyond the edges of the framework $1\frac{1}{4}$ inches forming a groove $1\frac{1}{4}$ by $1\frac{3}{4}$ inches. A strip which will exactly fit this groove is nailed to the top and the bottom of the floor panel along its outer end, and the wall panels fitted over these strips as shown in figure 3.

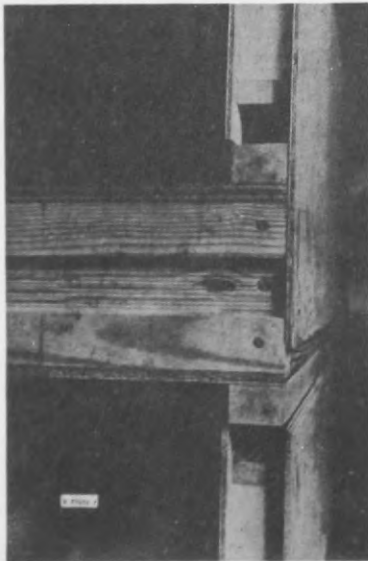


Figure 3. Portions of first-story wall panel, floor panel and second-story wall panel, which are slightly separated to show how parts fit together.

- PLANS -
MODEL 21 HOME-OLA
STANDARD PLANS

The house described in these plans is manufactured by the HomeOla Corporation of Chicago, Illinois, and the fabrication materials and methods not indicated herein are more completely described in a General Ruling, dated June 28, 1946, numbered 119, and the amendment dated Sept. 26, 1946, as issued by the Office of the Assistant Commissioner, Underwriting, Federal Housing Administration, Washington, D. C.

Elements of construction in the field may vary from one locality to another due to local ordinances and the different individual property standards of F.H.A. District Offices. There are, in addition, certain modifications and "extras" to the basic plan which are sometimes provided by the erector.

Provisions for these variations are provided for and listed on the specifications. By means of a group of circles, blanks, or other devices on the plans these variations may also be indicated in red pencil or inked notation.

The plans for major additions to the basic structure, such as, garages, breezeways, etc., should accompany these drawings and all changes in window or door locations should be entered on the plans in red pencil. If the house is not located on the lot as the elevations show, this change can be indicated on the plot plan.

TO THE APPLICANT

Intelligent use of this set of plans and the submission of complete information will greatly assist the evaluator in making a prompt and adequate commitment. Do not fail to remove any sheets which have no bearing upon this submission, (i.e. remove basement plan sheet if this submission is based on a Model 21 to be erected on a rim.)

DEC. 1946

21 - 1

SPECIFICATIONS

Series 20 Model 21

DRAWINGS AND SPECIFICATIONS: 1 - The following specifications, including the Federal Housing Administration technical ruling 119, and the drawings shall apply only to the material and parts furnished by the HomeOla Corporation. All other materials and construction, equipment, and finish shall comply with the F.H.A. minimum construction requirements for the district in which the house is erected.

2 - The builder shall submit the plans and elevations applicable and shall also fill in all blanks on the specification pages 21-11, 21-12, 21-13, 21-14, which refer to the materials and constructions he is to furnish.

WOOD PARTS: LUMBER: 1 - All lumber used in the construction of HomeOla parts shall be douglas fir, west coast hemlock, larch, or yellow pine and shall be free from knots or knot holes in excess of 3/8" in diameter, pitch pockets not exceeding 4", no defects, and shall have a moisture content of not more than ten per cent at time of assembly.

2 - Plwood: All plywood used shall be douglas fir exterior grade according to commercial standard CS45-42 with the exception of the face veneer of the panels used to form the floor surface, which shall be vertical grain fir, birch, maple veneer, or a type of plastic surface as indicated in the specification for floor panels.

2a - All wood parts, except kitchen cabinets to receive a spray or dip coat of a water repellent toxic dip containing not less than five per cent by weight of highly chlorinated phenol or other suitable and equivalent toxic.

3 - FLOOR PANELS: Floor panels are 48"x48" net and 2-3/8" thick and consist of a framework of nominal 2"x2" lumber (1-5/8"x1-5/8" net) around the edges of the panel and two intermediate 2"x2" nominal joists. The top surface of this panel is 1/2" plywood of oak, vertical grain fir, or 120# Inderon. In the spaces between the wooden framework is either 1" rigid or 1" non-rigid insulation. The bottom surface of the panel is a single piece of 48"x48" resin-bonded 1/4" douglas fir plywood. The panel is assembled by one of the following procedures:

A. By induction heating, using high frequency generating equipment and using a glue similar to, or equal to, that defined for use in the manufacture of douglas fir plywood by the provisions of commercial standard CS45-45

B. By means of cold press gluing, using a resorcinol resin adhesive with or without infra-red acceleration.

C. By means of hot plate pressing, using a glue similar or equal to Exterior, defined for use of the manufacturer of Douglas Fir Plywood in Commercial Standard CS45-45.

In all cases, a bonding pressure of at least 20 P.S.I. is employed, and the strength of the glued joint is at least equal to the specification for the testing of Exterior grade Douglas Fir plywood by the provisions of Commercial Standard CS45-45.

Floor panels have been designed in accordance with, and in order to meet the provisions of Commercial Standard CS125-45. Calculated heat loss (U value) is .125.

Designed uniform live load per square foot is 40 lbs.

All panels are milled to size upon completion. The floor panels are sanded to a finished net thickness of 2-3/8" plus or minus 1/32". Attach the floor panels to the steel beams with four 1/4"x1-3/4"

HomeOla
D. S. CLINTON
CHICAGO, ILL.

12-21-46

21-2

hanger bolts. (See details) Connect the panels by 1/4"x1" wooden splines.

4 - EXTERIOR WALL PANELS: Exterior wall panels are 48"x97-1/2" net and 2-1/8" thick and consist of a framework of nominal 2"x2" lumber (1-5/8" net) around the edge of the panel, one vertical 2"x2" nominal stud, one 2"x2" nominal, and four 1"x2" nominal horizontal stiffeners. Surfaces of this panel are covered with 1/4" resin-glued fir plywood. In the open spaces within the framework is either 1/2" rigid or 1/2" non-rigid insulation. The panel is assembled and glued by means of the same procedures as floor panels.

5 - PARTITION PANELS: The construction of these bearing panels is identical to the construction of exterior wall panels except that they contain no insulation and have an average width of 48" and a height of 7'9".

6 - ROOF FRAMING MEMBERS: The roof framing members consist of steel trusses 4'-0" O.C. The two sections of each truss are fabricated in the shop and bolted with a center tie member in the field to form a complete truss. Main members are J. and L. Otiscoloy steel, analysis: (carbon 15% max., manganese .90 to 1.40, phosphorous .08 to 1.30, silicon .10 max. copper .30 to .50. All other steel ASTM A7-42. See details for truss and stress diagram HB-X.

7 - PLATES, SILLS, AND STRINGERS: Gable wall sill plate, rake moulding, eave moulding, etc, may be found in the drawings which fully describe the size, position, location, and method of assembly of these parts.

8 - ROOF SECTIONS: Roof panels consist of 3/8" three ply Exterior grade douglas fir plywood to which has been nailed and glued 2"x2" pur-lins with 5d nails 6" o.c. and resorcinol resin glue. They are 16" on center and notched to fit over the truss members.

9 - INTERIOR AND EXTERIOR TRIM: This consists of base moulding, door jambs, casings, drip moulding, eave moulding, rake moulding, and battens. The size and installation can be determined from the drawings.

10 - WINDOWS: All wood shall conform to the specifications for lumber and shall have the same coat of chemical preservative. They shall have the inside sash horizontal sliding, the other fixed to include the following: Frame, KD head jambs and sill members are milled from 1-3/4" x 3-3/4" fir to form an integral member with interior trim, parting stops and outside casing in one piece. Prefit sash, 1-1/8" thick, rabbited for glazing, complete with 3/8" muntins, grooved for sliding, 3" bottom rail, 2" top and side rails. Hard oak or maple sill tracks.

11 - FIRST FLOOR CEILING SECTIONS: The ceiling sections are made up of 1/4" Exterior grade douglas fir plywood and 2"x2" nominal framing members glued and nailed to the plywood.

12 - NON-BEARING PARTITIONS: These are made as millwork, KD, storage wall cabinets. Sides, tops, bottoms and doors are of 3/4" fir plywood. Sides are rabbited to receive tops and bottoms. 2"x2" nominal jambs are installed at doors.

13 - KITCHEN CABINETS: See plans and details for layout of kitchen cabinets. They are constructed as follows: KD: sides, bottoms, doors, partitions, tops, shelves of 3/4" fir plywood. Jambs of doors are 1 x 2 fir. Sides are rabbited to receive bottoms and shelves. Drawers slide on hardwood runners. Back for base cabinet is 1/4" plywood, splash back 3/4" plywood.

14 - DOORS: All exterior doors are 1-3/4" thick fir according to CS73-43 for Douglas fir doors. Design F182 with 2 muntins. Interior doors of rooms are 1-3/8" thick fir according to SC73-38 for Douglas fir doors, 1, 2, or 3 panel design,

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21-3

METAL PARTS. STRUCTURAL STEEL: 1 - The structural steel is fabricated from channels and "I" beams according to the details and drawings. The sills, continuous around the house, are channels, all structural steel ASTM Specification A7-42. The beams are 4' on center and are fabricated from junior "I" beams 6" at 4.4 lbs. per foot. The center girder is an "I" beam. All parts are fabricated to permit field erection with a few bolts, to receive the hanger bolts securing the first floor panels, and the bolts to wall panels.

PLUMBING: The plumbing parts consist of an assembled water, drain, and vent unit fabricated in accordance with BSM 66 U.S. Bureau of Standards. All pipe throughout this unit is copper type M or L, U.S. Govt. Spec. W W -T-799 and A.S.T.M. Spec B-88-33. All fittings are solder type of cast bronze, wrought copper, or forged brass, made according to Federal spec QQ-B-691-3, May 1932, section 4 part 5, composition 2, for steam bronze mixture: 84-86% copper, 4-6% tin, 4-6% zinc, 4-6% lead. Fittings are made to conform to the American standard; soldered joint fittings for plumbing equipment as published by American Standards Association. Joints are soldered joints, using a petroleum base flux and a Mueller Brass Company #50 solder, or equal, or a silver solder. Units (water, drainage and vent) are tested under water with 75# of air. No piping is run in outside walls. All water pipes are insulated for noise vibration.

1. **WATER:** Water connection to unit is 3/4". Unit includes a 1/2" stop valve; composition disk, positive seating, drainable seat, swivel disk, steam bronze metal, according to Federal spec. QQ-B-691-3 Composition 2, for shut-off at the entrance; from the shut-off valve, all lines are 1/2" which include 1/2" lines to W.C., tub, lavatory, kitchen sink (with air chambers on lavatory and kitchen sink), and hot water heater and plugged T's at end of lines for future connections.

2. **DRAINAGE:** Soil, waste, vent, and revent pipes are of copper with cast bronze drainage type fittings, 4" W.C. soil and vent, 2" lavatory waste and vent, and 2" waste and vents for the bath tub and kitchen sink. Vent stack through second floor and roof is a galvanized iron pipe or C.I. with 5" increaser through roof, including lead flashing. Lavatory and kitchen sink waste connects to "P" traps. Bath tub has 4"x8" cast bronze drum trap with cleanout. Connections to fixtures are galvanized steel nipples and fittings except to W.C. which is a cast iron "Y"

3. **FIXTURES INCLUDE THE FOLLOWING:** 1 - 5" Porcelain enameled cast iron, or steel, built in apron tub, complete with connected drain and overflow, chain and rubber stopper, overrim wall mounted chromium plated and renewable seats, double bath tub filler. 1 Vitreous china close coupled round front washdown closet combination complete with float valve, single acting trip lever handle, 3/8" angle supply and stop, bolt caps, floor bolts, white coated seat and cover. 1 18"x15" Porcelain enameled cast iron wall hung lavatory, complete with 3/8" supplies, 1-1/4" drain and P trap, chain and rubber stopper. 1 porcelain enamel cast iron or steel single compartment flat rim sink with ledge, enameled inside painted outside, complete with 1-1/2" drain and P trap, basket type strainer, 1/2" supplies, ledge type, chromium plated, renewable seat, double faucet with swing spout. 1 20 gallon electric hot water heater. Tank 12 gauge ASTM A7-42 steel galvanized. Thermostat 15A 230V A.C. non inductive load iron fireman #W301-3 element. 1500W

220V A.C. Chromatox immersion heater type TSF-115 2 plugs for cleanout and pressure release valve where required (to be purchased and installed locally). All as approved by Underwriters.

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21-4

HEATING: See addendo for heating equipment.

ELECTRICAL: 1 - Includes conduit for entrance service 1" dia. thin wall conduit, service entrance head, connectors. Entrance wires are 3 #8 type "SN" (New type "T") 60 C - 140 F 600 Volt synthetic insulated wire. Main service switch for single phase service with branch circuits. 30 AMP 125-230 volts A.C. 3 pole solid neutral toggle type main switch operated with door closed. Bakelite lead front plate. 30 amp 125 volt single fuse branches. Plug type fuses, 3 main poles, 2 main fuses, 4 branch fuses, switches with fusible mains, surface mounting type. Wiring from the fuse box to the two circuits, each of 1,000 watts or less, is #14 2" Romex as approved by the National Board of Fire Underwriters. Wire from distribution box, on separate fuses, to hot water heater

2. **OUTLETS:** Outlets and switches are standard bakelite, or metal surface type fittings, as approved by the underwriters' laboratories.

3. **Electrical Fixtures:** Kitchen and bath wall brackets "Lightolier" #7374 lgth 4-3/4" x 7-1/4" x 7-3/8" all metal chromium finish complete with opaque glass shade, pull chain switch and outlet. All other brackets Lightolier #7372 lgth 6-1/2 x 3-1/2 x 4-1/4" chromium finish, complete with pull chain switch and outlet.

HARDWARE: 1. Exterior doors: Cylinder lock, 5 pin tumbler, 2 knobs, zinc finish, "Zamol" zinc alloy finish, "Vimcar" #14-s.

2. Interior doors: Latch and 2 knobs, threadless spindles, "Zamol" zinc alloy.

3. Hinges: steel dull brass finish.

4. Cabinet and storage door knobs, cast aluminum.

5. Bath accessories: tumbler holder, towel bar holder, paper holder, soap dish are ceramic.

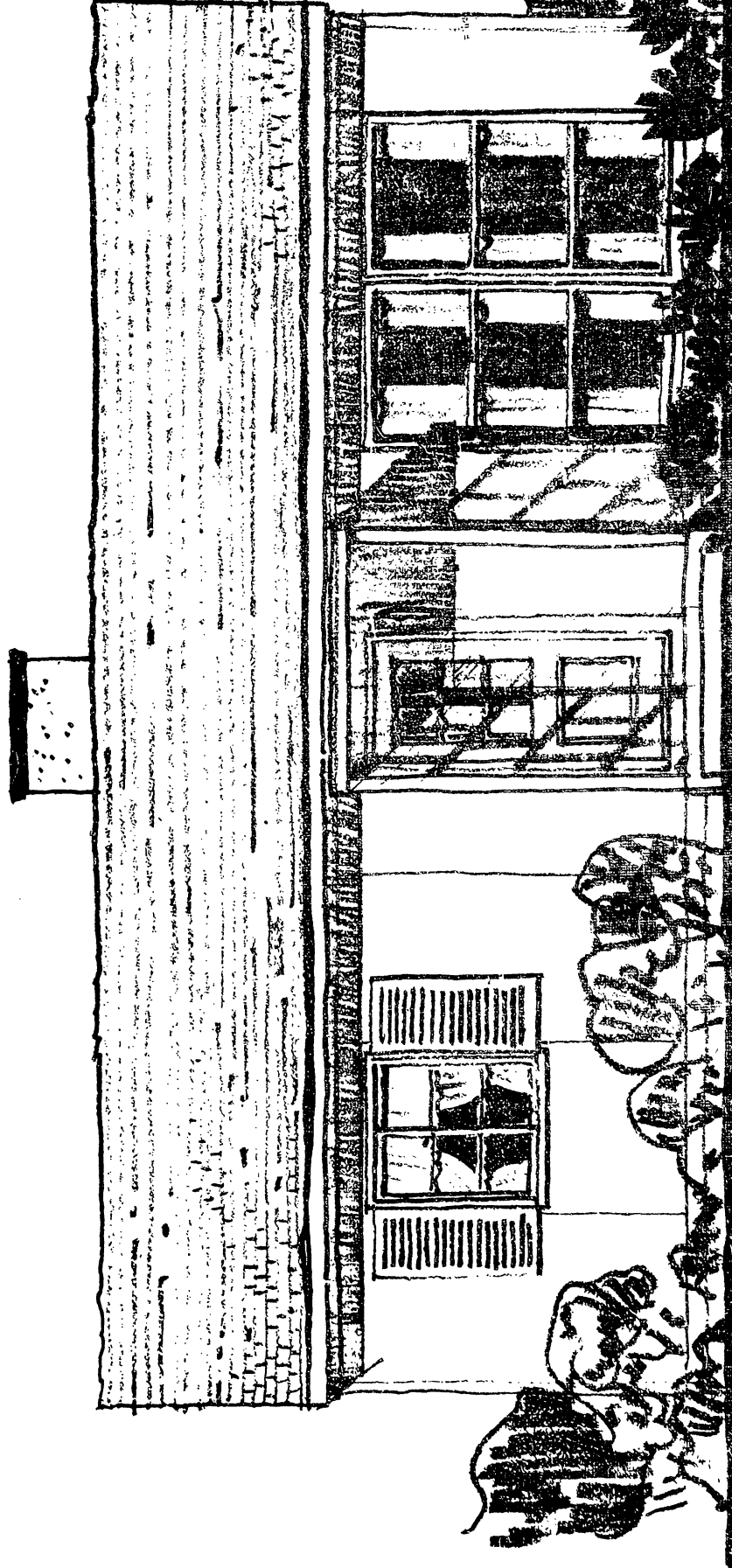
INSULATION: Insulation as previously described, is 1/2" rigid in wall panels, 1" rigid or batt type in floor panels, Over ceilings is 1" thick Kimsul or equal all furnished by Homeola.

SHEET METAL WORK: O.G. Gutters and downspouts (one for each side) and eave soffit member are fabricated as detailed of 20 ga. galv. steel.

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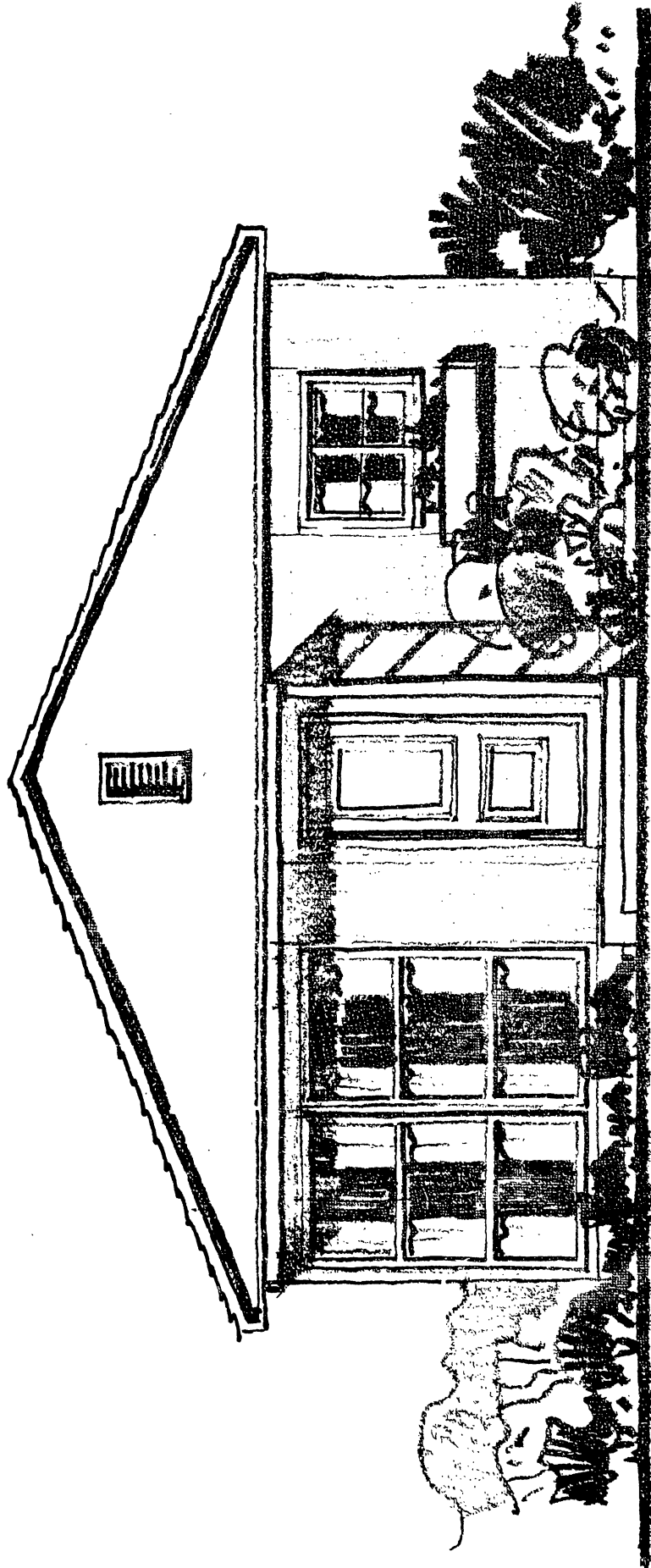
12-21-46

21-5



SUGGESTED OPTIONAL FRONT ELEVATION FOR
ANY HOME OLA IN SERIES 20 SHOWING USE
OF TWO PICTURE WINDOWS AND ADDITION OF
SHUTTERS AND HOOD

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CHICAGO, ILL.

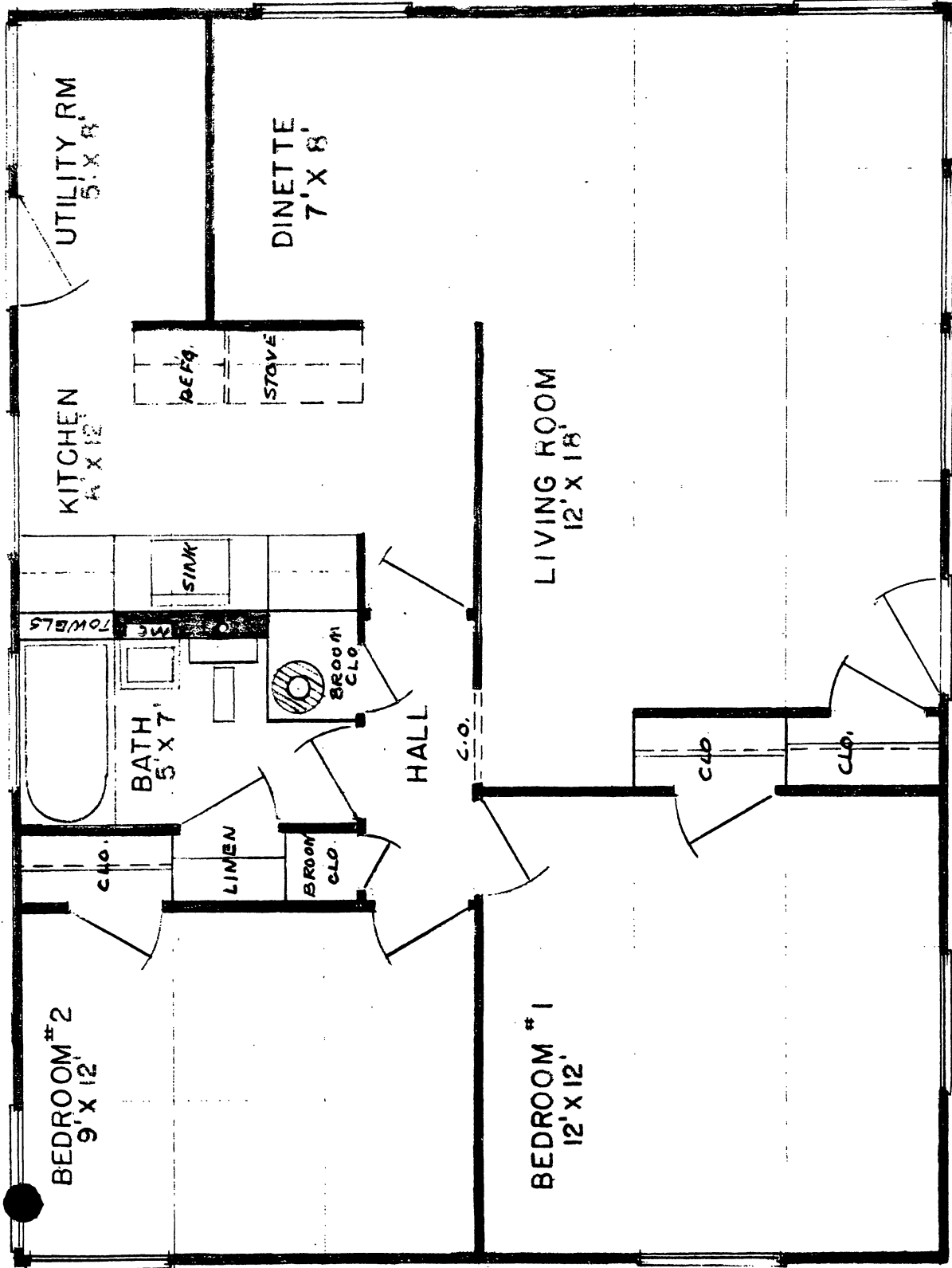


**SUGGESTED OPTIONAL 24' FRONT ELEVATION
FOR ANY HOME OLA IN SERIES 20 OR 30
SHOWING USE OF TWO PICTURE WINDOWS AND
ADDITION OF HOOD AND FLOWER BOX**

HomeOla

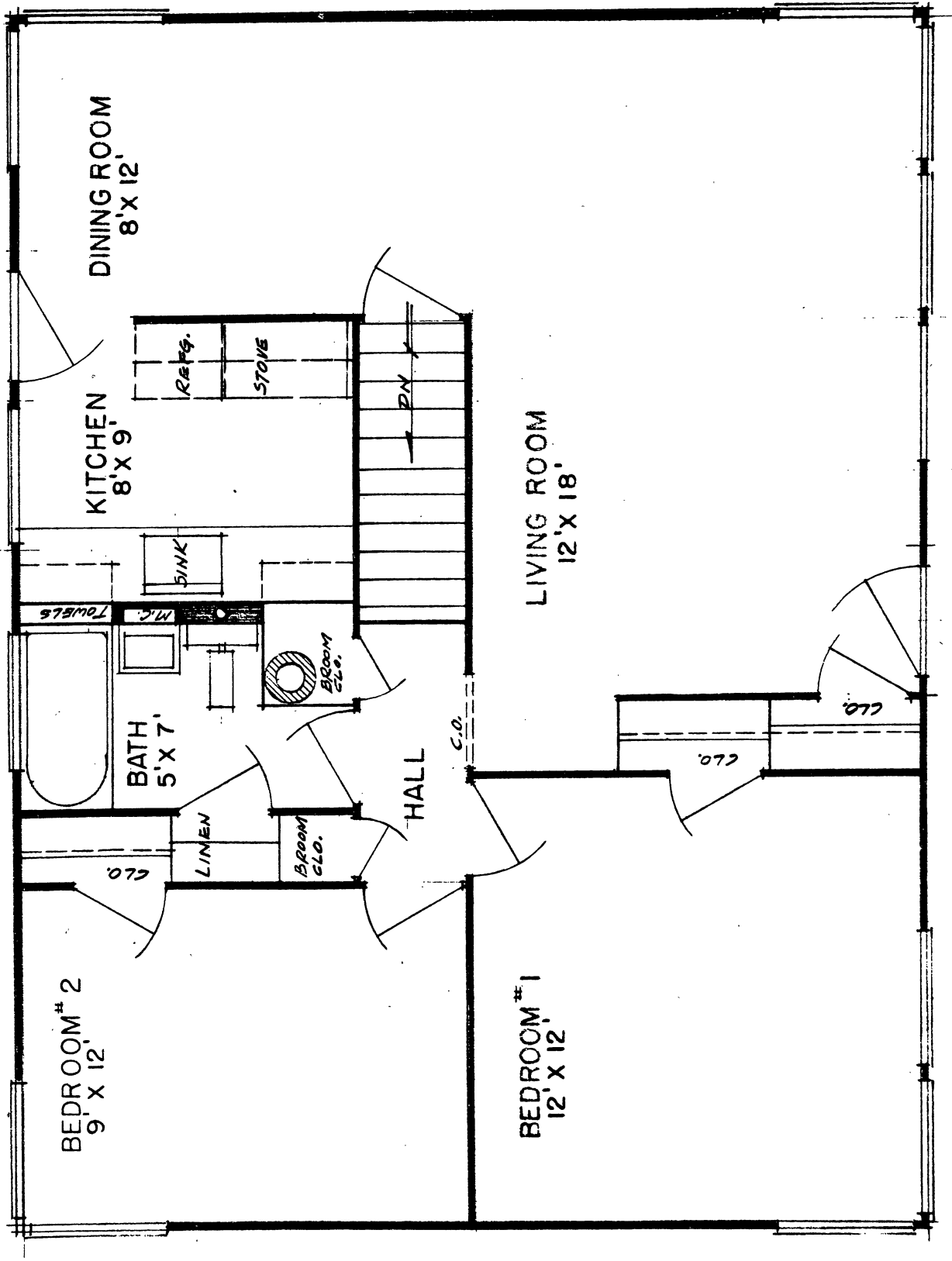
**P. S. CLINTON
CHICAGO, ILL.**

20-100

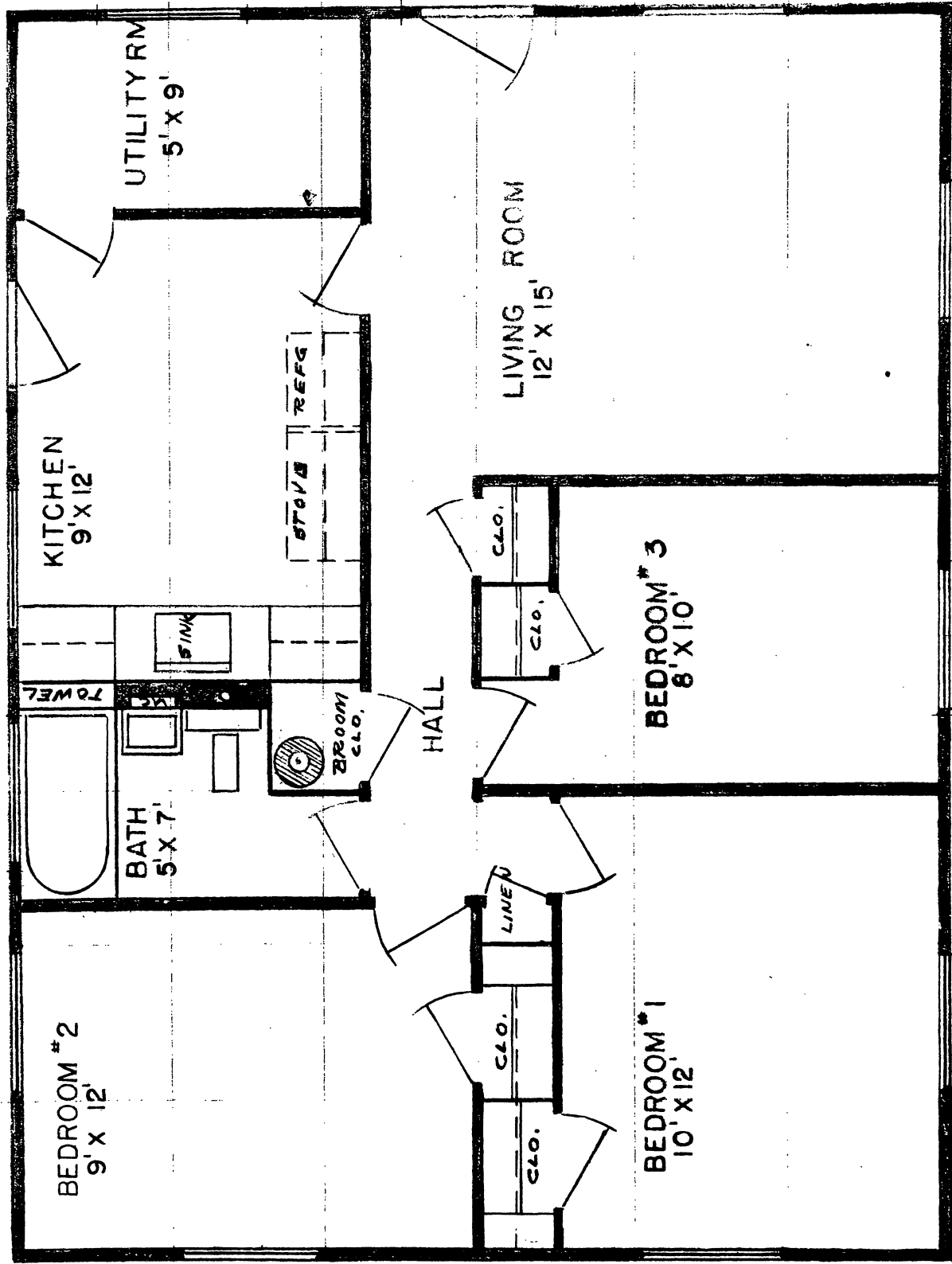


SERIES 20 MODEL 21

WITH UTILITY ROOM

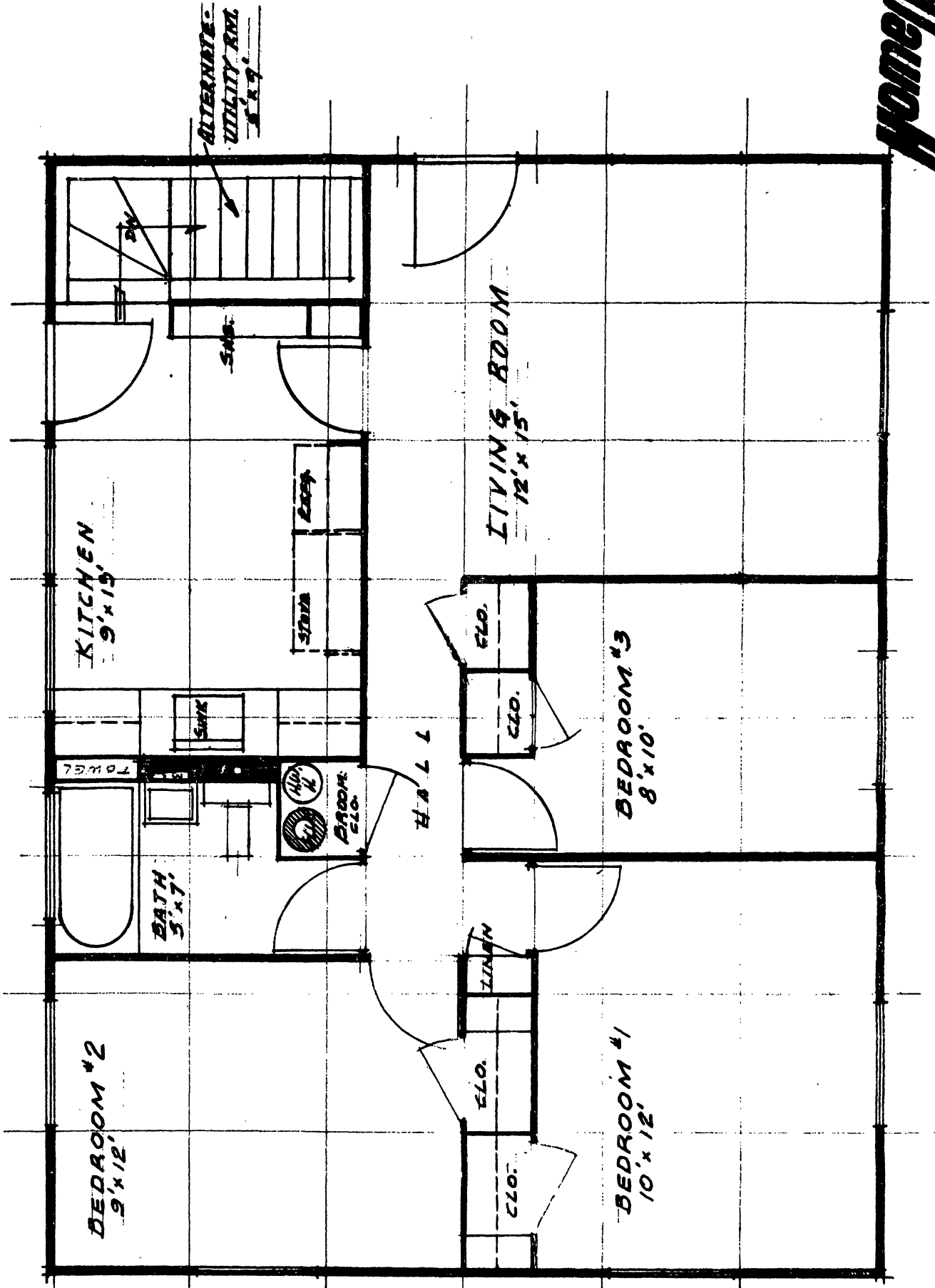


SERIES 20 MODEL 21
VIII BASEMENT

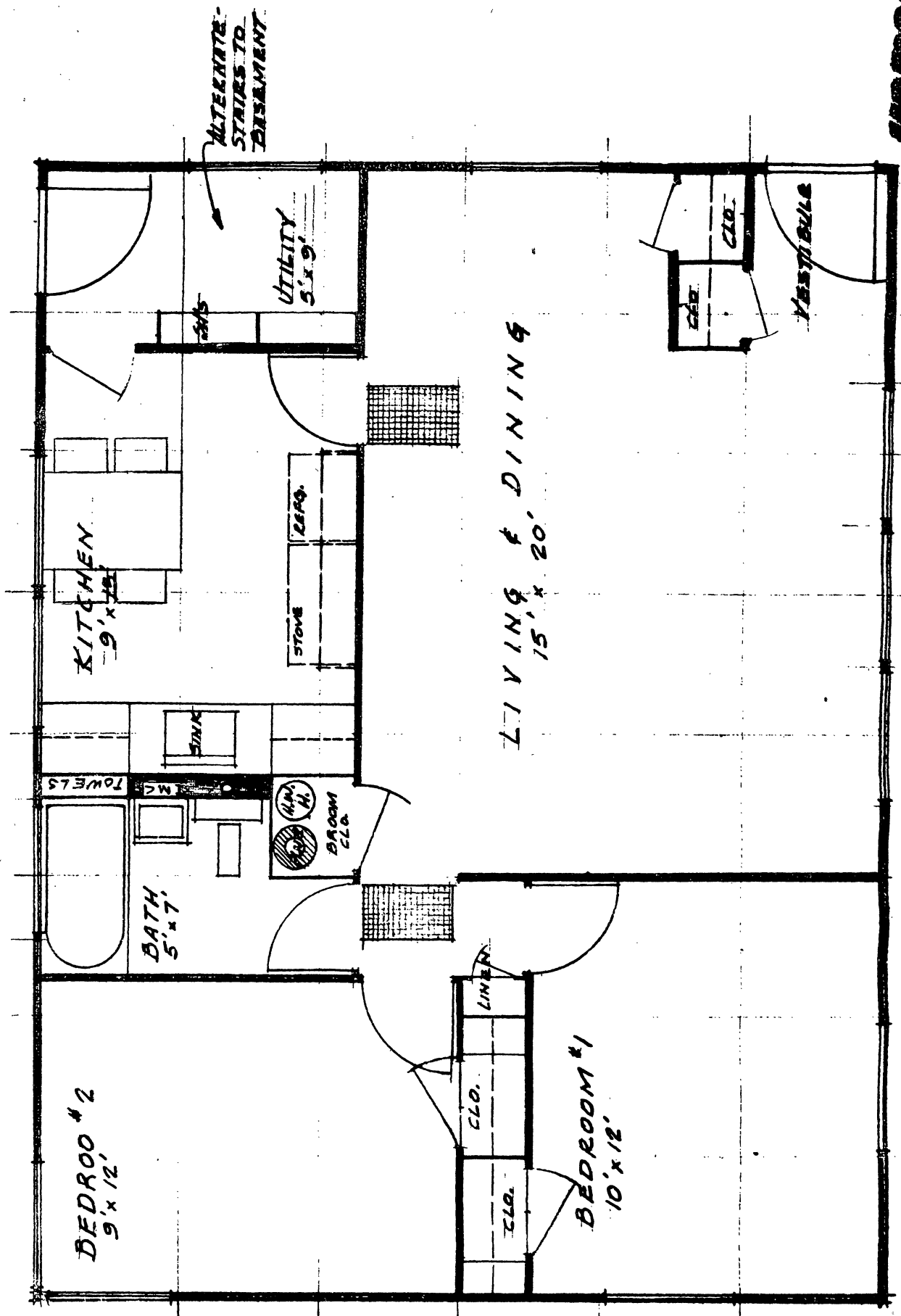


SERIES 20 MODEL 22

WITH UTILITY ROOM

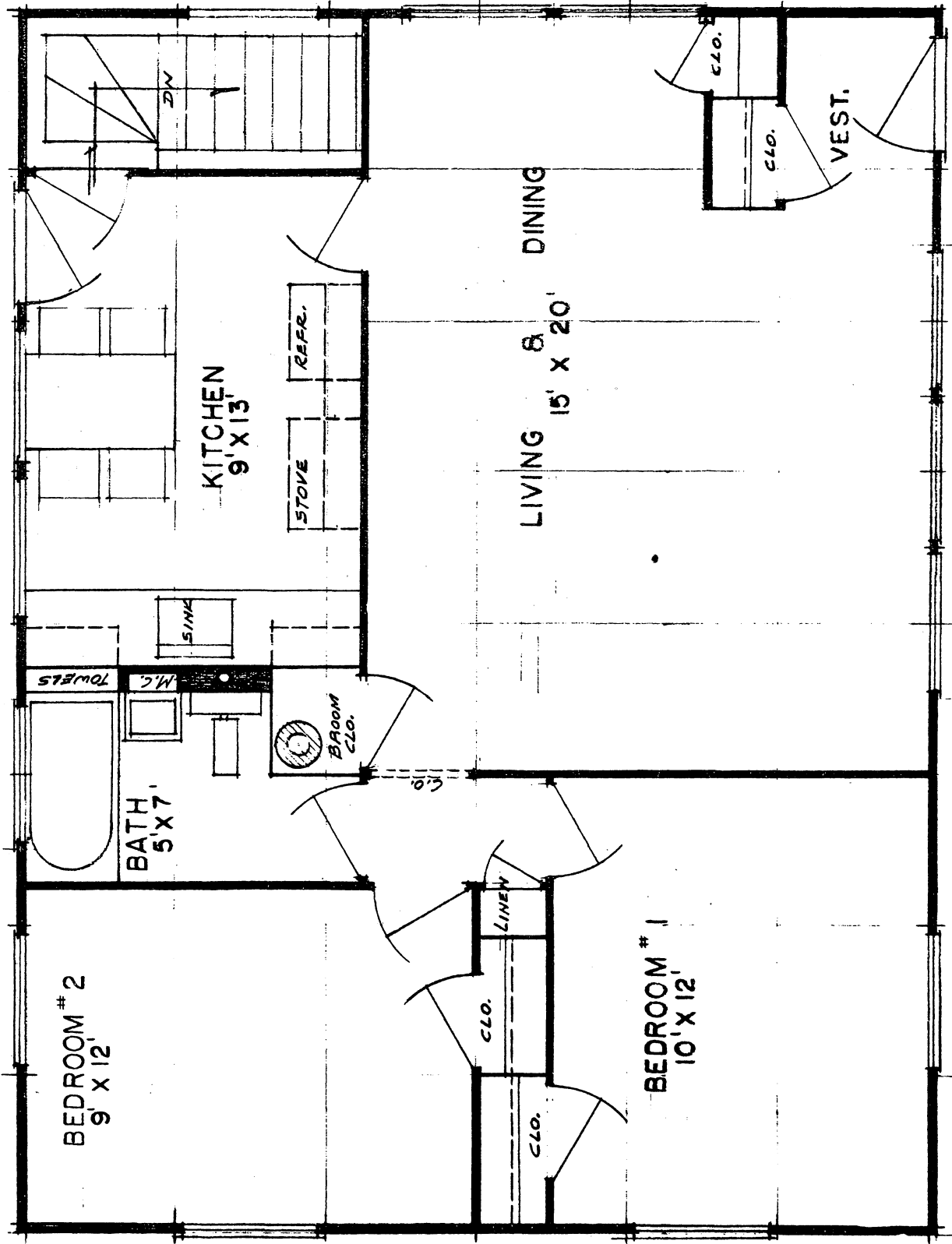


SERIES 20 MODEL 22
WITH BASEMENT

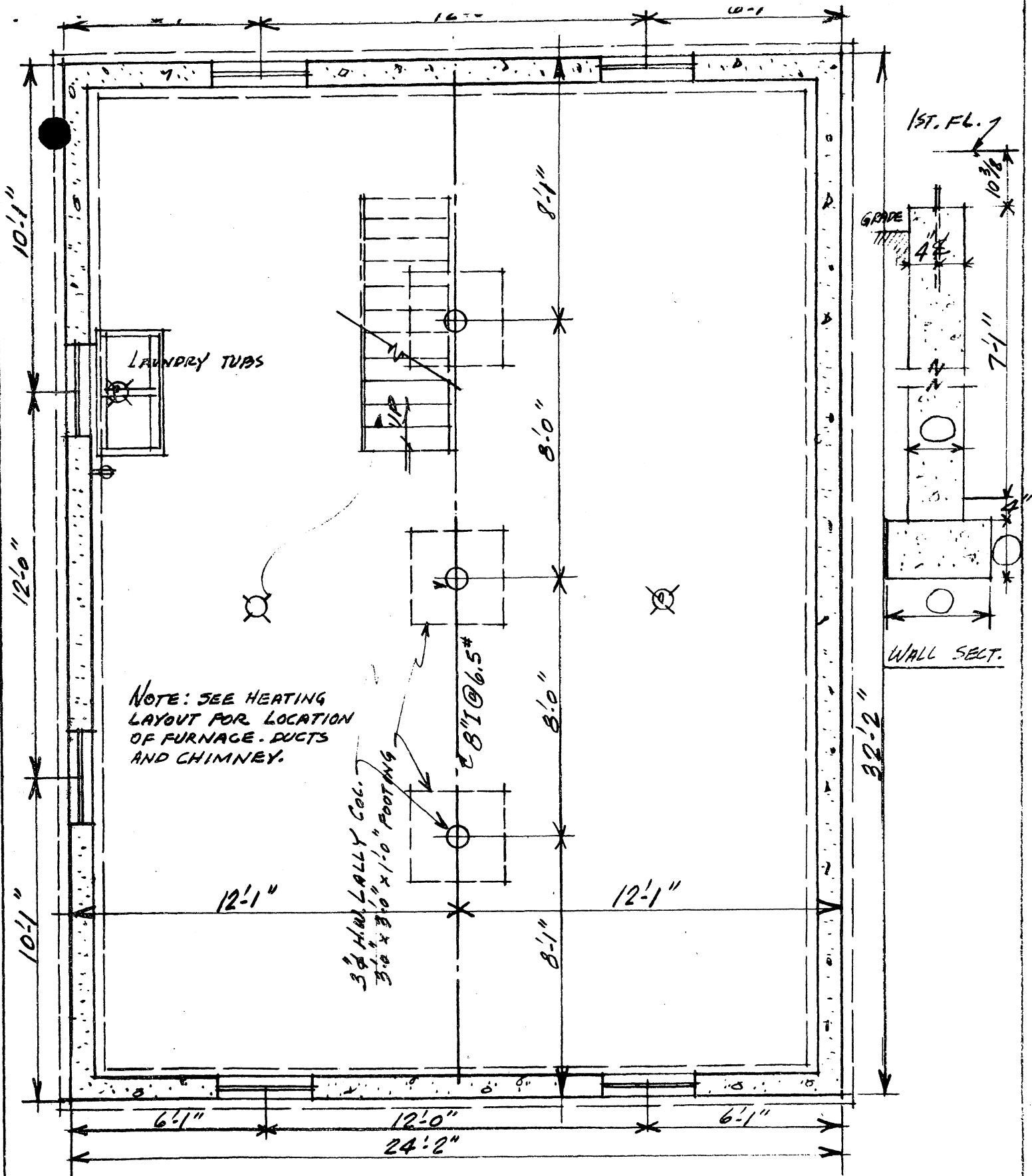


SERIES 20 MODEL 23
WITH UTILITY ROOM

Wagner
 E. CLINTON
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 23-100



SERIES 20 MODEL 23
 WITH BASEMENT

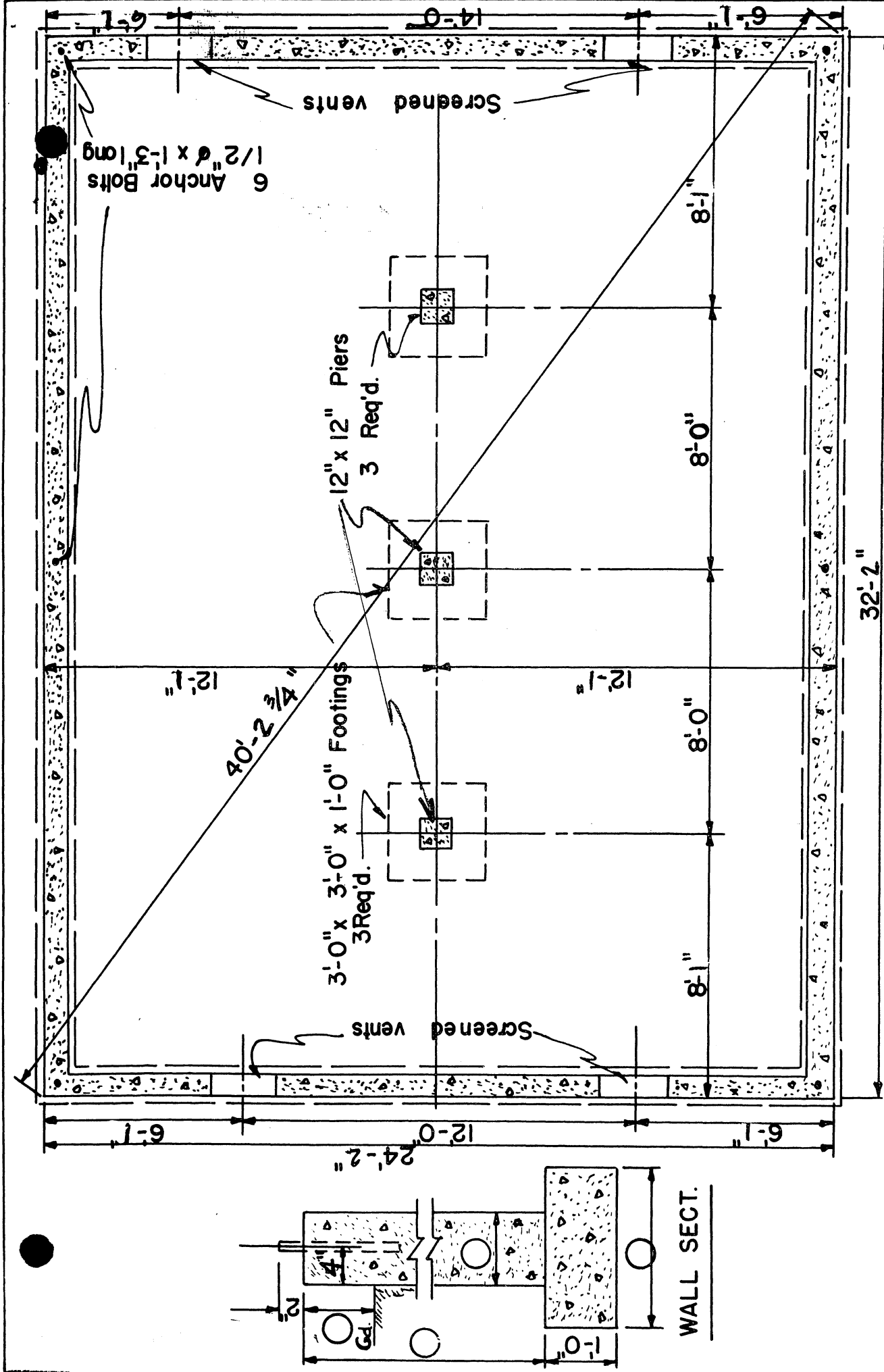


NOTE: INDICATE LOCATION OF COAL BIN - DL TANK - GAS OUTLET - CHIMNEY & FOOTING - OTHER ADDITIONS.

BASEMENT PLAN SCALE 1/4" = 1'-0"

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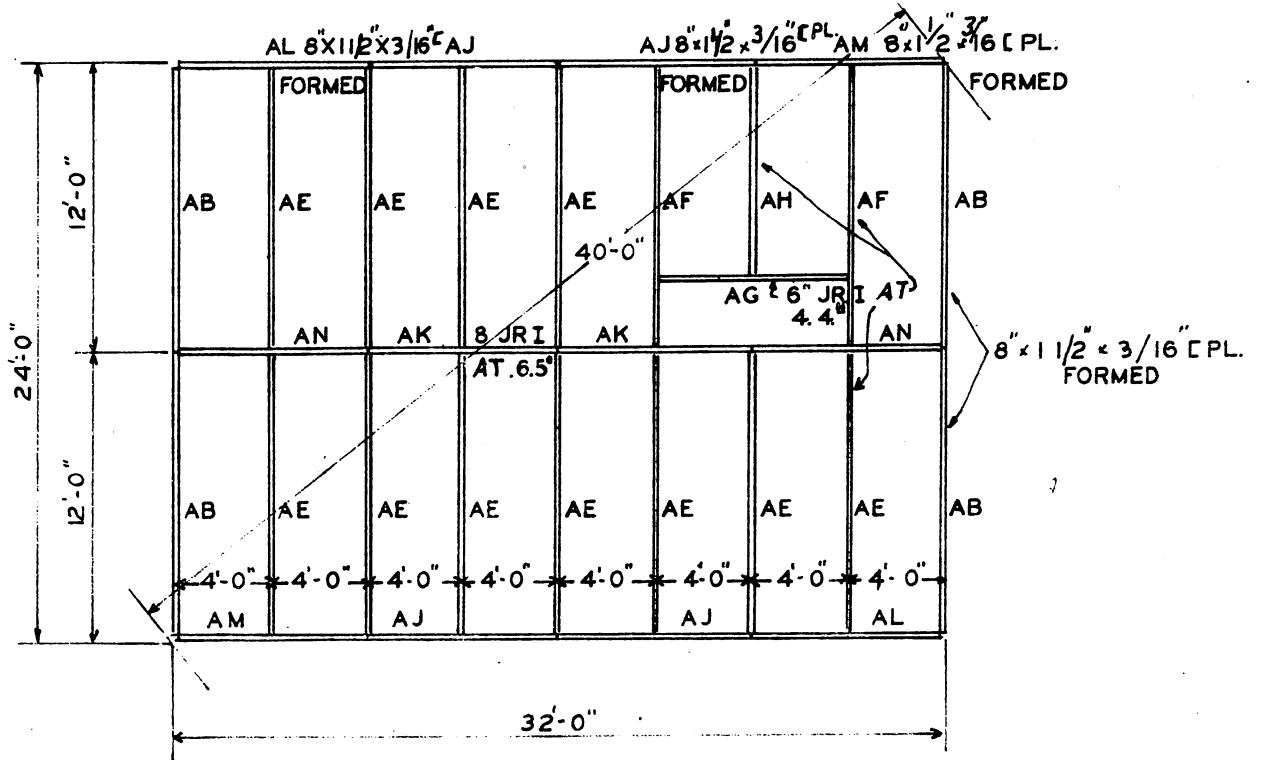
REV.	3/13/47
21-20	



RIM FOUNDATION PLAN

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- Scale 1/4" = 1'-0"
- Wall material: Description _____
- Footings _____
- Steps or Porch foundation: Description _____
- Chimney found: Desc. _____
- Vents, 6.5" house _____



FIRST FLOOR FRAMING

BA	BA	BA	BA	20-BF HOLES FOR PLUMBING	BA	BA	BA
"	"	"	20-BD	20-BE	"	"	"
"	"	"	BA	BA	BC BB UNIT FOR BASEMENT	BC BB	"
"	"	"	"	"	BA	BA	"
"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"

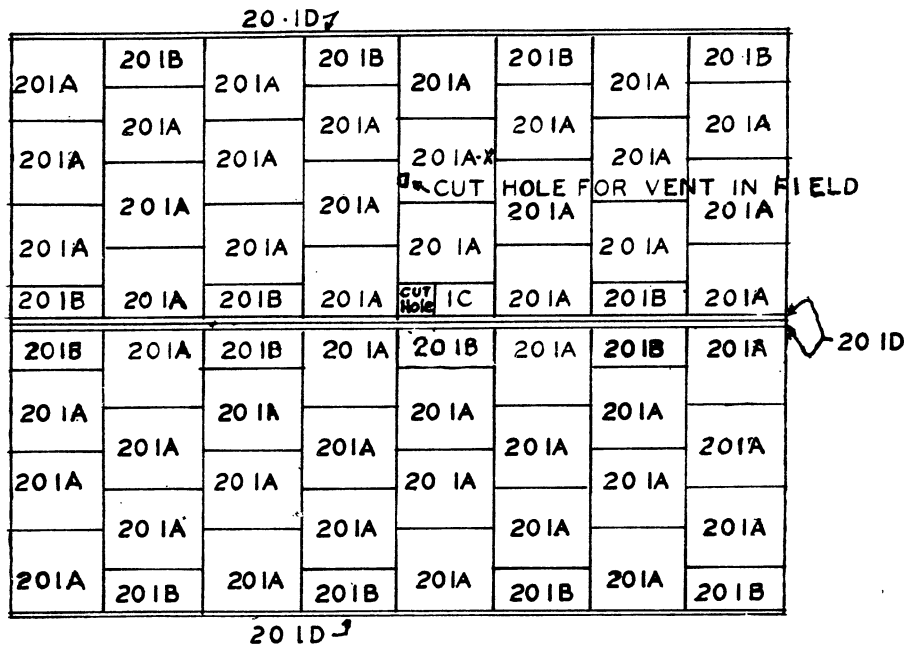
FIRST FLOOR PANEL ASSEMBLY

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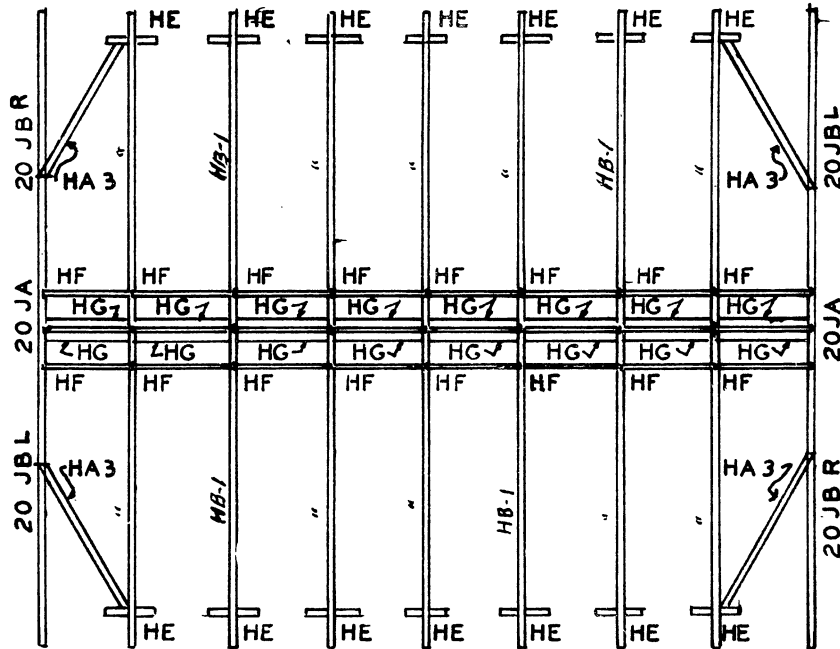
1/8" = 1'-0"

12-19-46

21-24



ROOF PANEL ASSEMBLY



TRUSS & GABLE PANEL ASSEMBLY

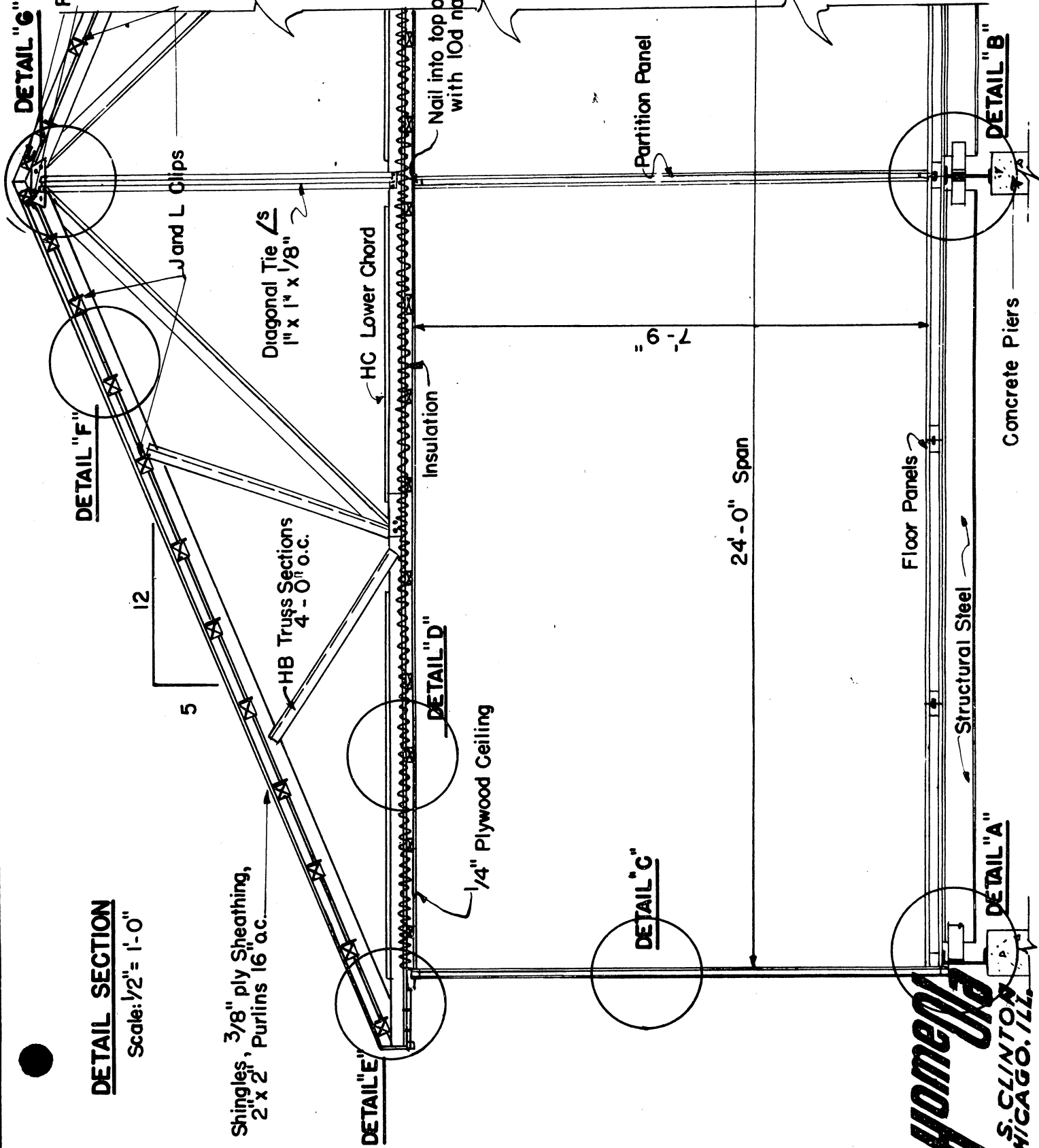
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12-20-46
1/8" = 1'-0"
21-24A

DETAIL SECTION

Scale: 1/2" = 1'-0"

Shingles, 3/8" ply Sheathing,
2" x 2" Purlins 16" o.c.



11-6-46
21-25

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Concrete Piers

Structural Steel

Floor Panels

24'-0" Span

7'-6"

Partition Panel

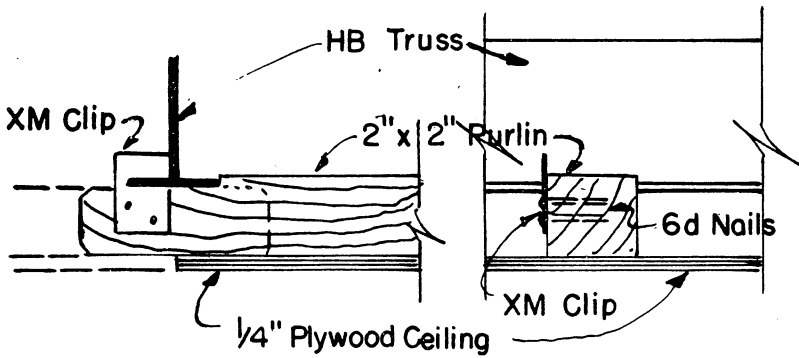
Nail into top of Partition
with 10d nails 12" o.c.

HC Lower Chord

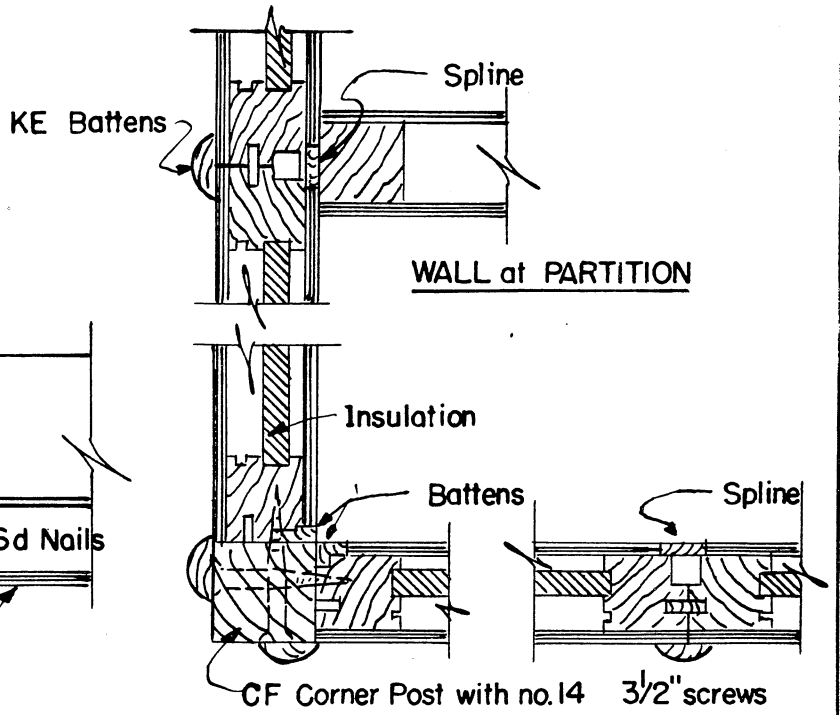
Diagonal Tie
1" x 1 1/4" x 1/8"

J and L Clips

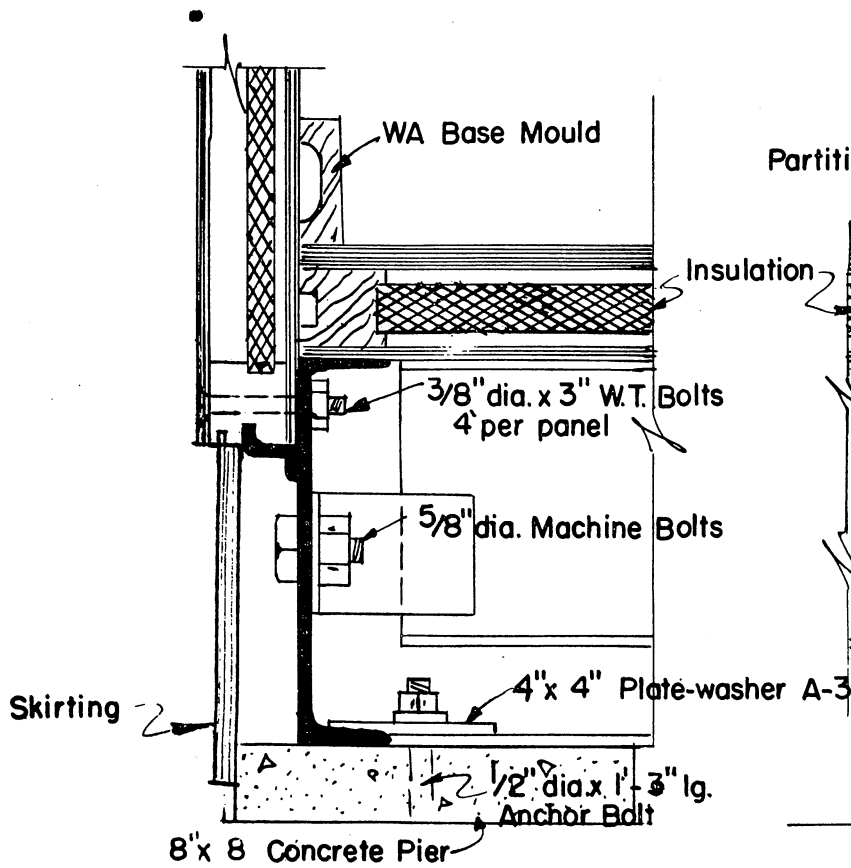
Ridge
2 1/2" x 1/4" x 1/8"



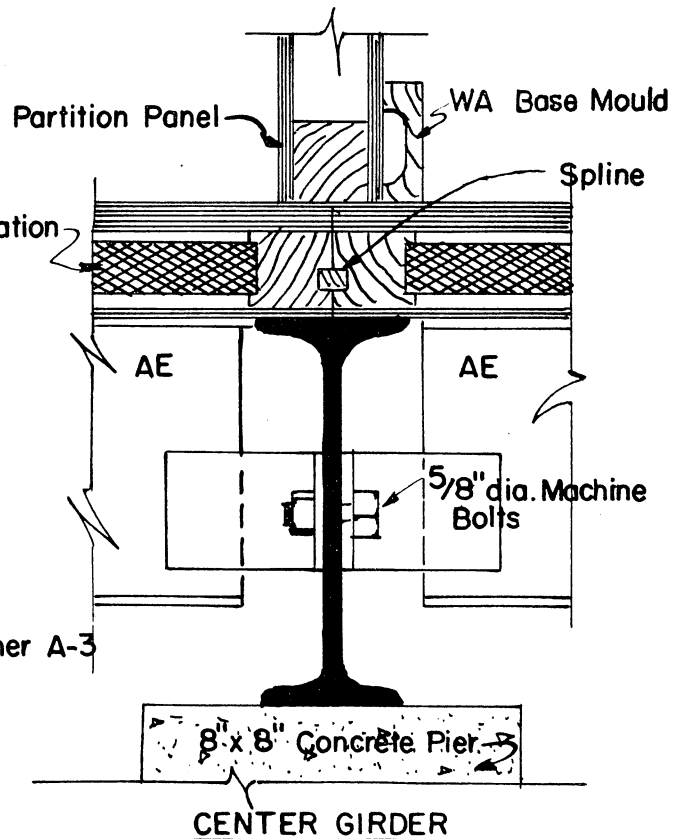
CEILING at TRUSS
SKETCH "D"



WALL at PARTITION
CORNER WALL JOINT
SKETCH "C"



WALL at SILL
SKETCH "A"



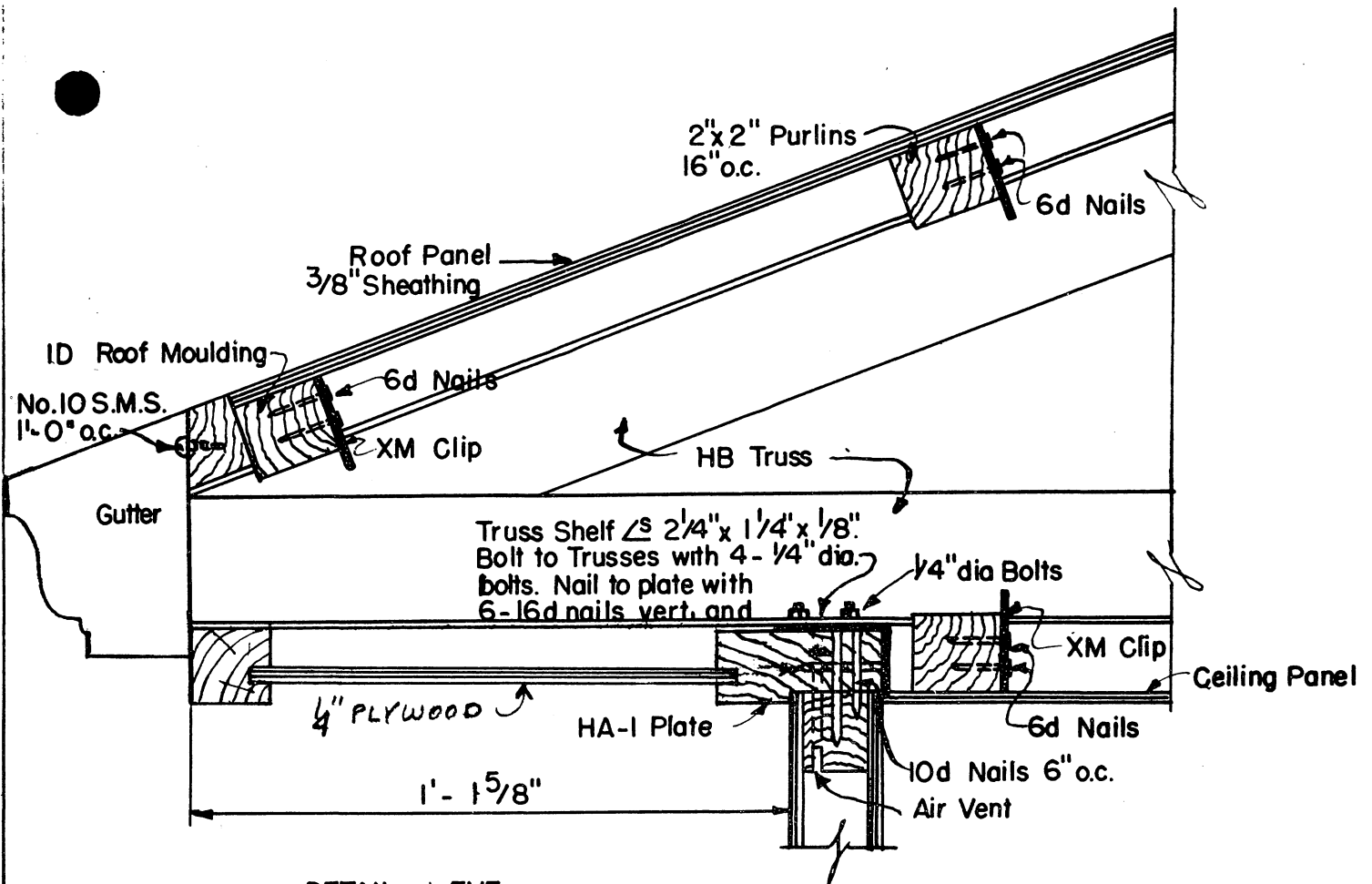
CENTER GIRDER
SKETCH "B"

Scale: 3" = 1'-0"

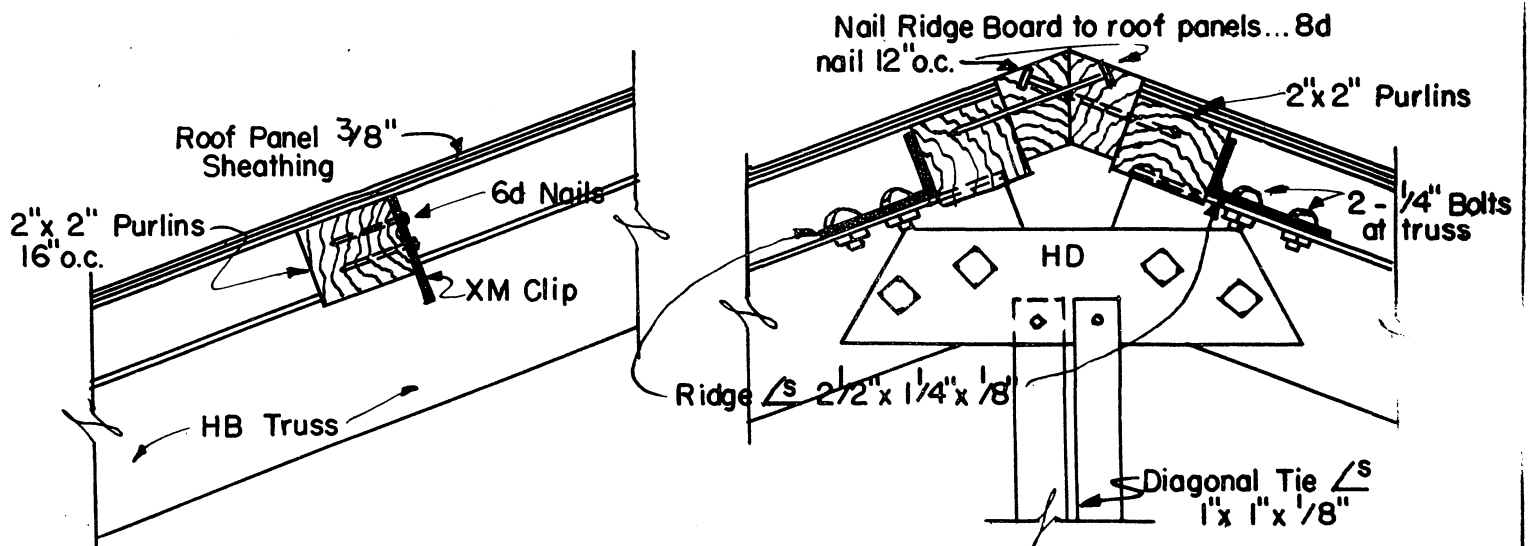
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12-7-46

21-26



DETAIL at EVE
SKETCH "E"



ROOF PANEL at TRUSS

SKETCH "F"

DETAIL at RIDGE

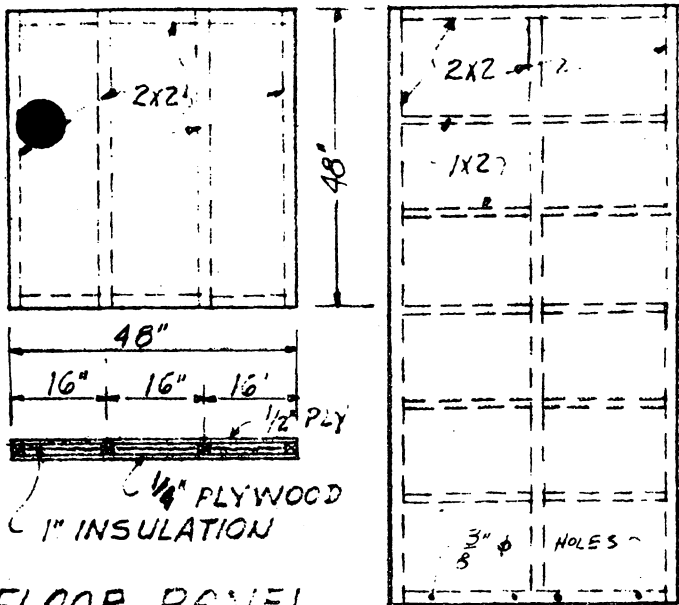
SKETCH "G"

Scale: 3" = 1'-0"

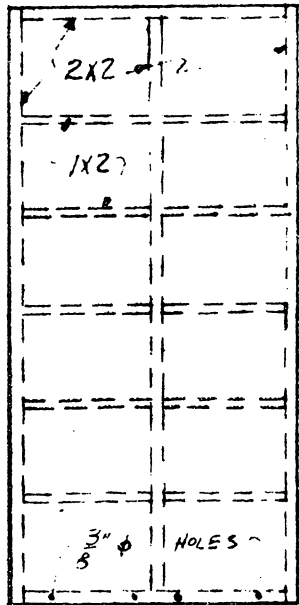
Home
Old
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11 - 7 - 46

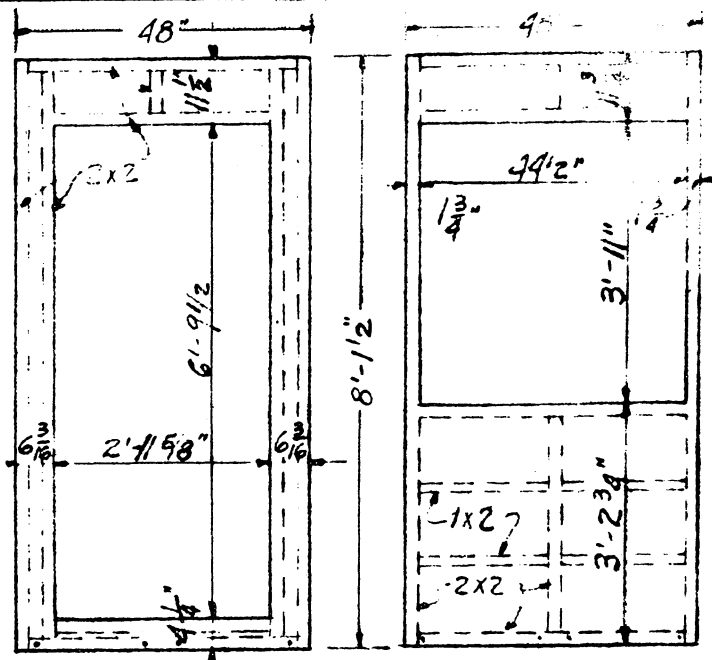
21-27



FLOOR PANEL

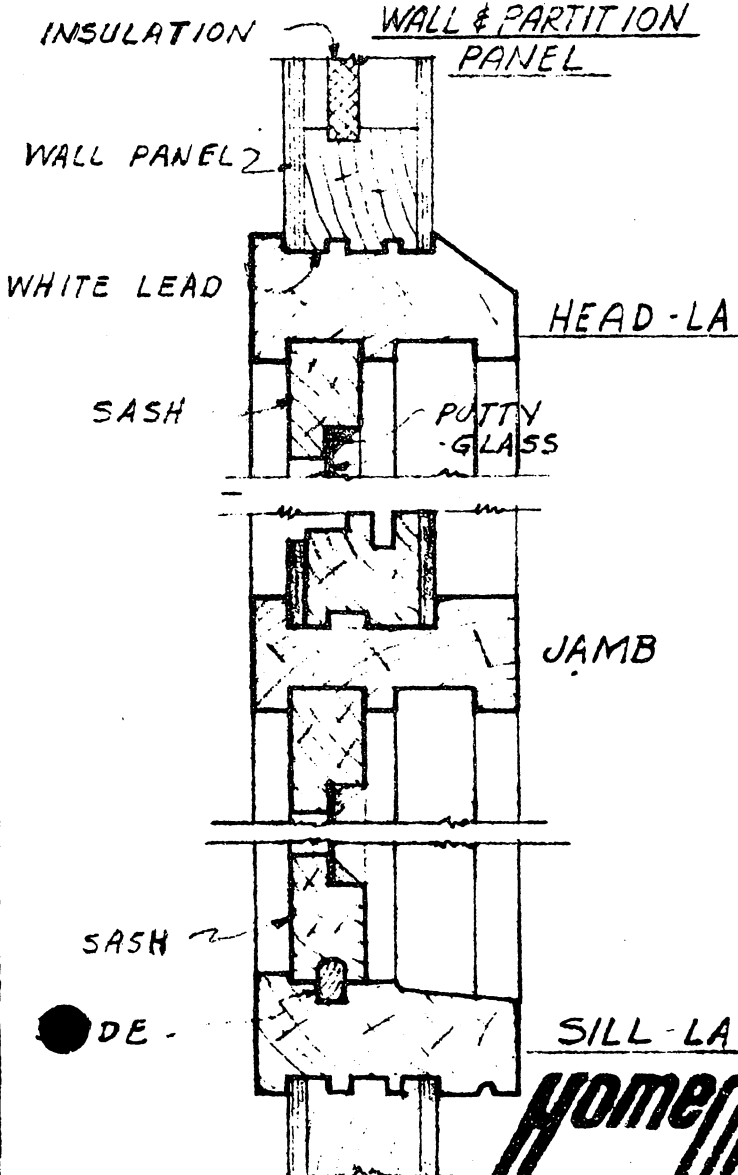


WALL & PARTITION PANEL

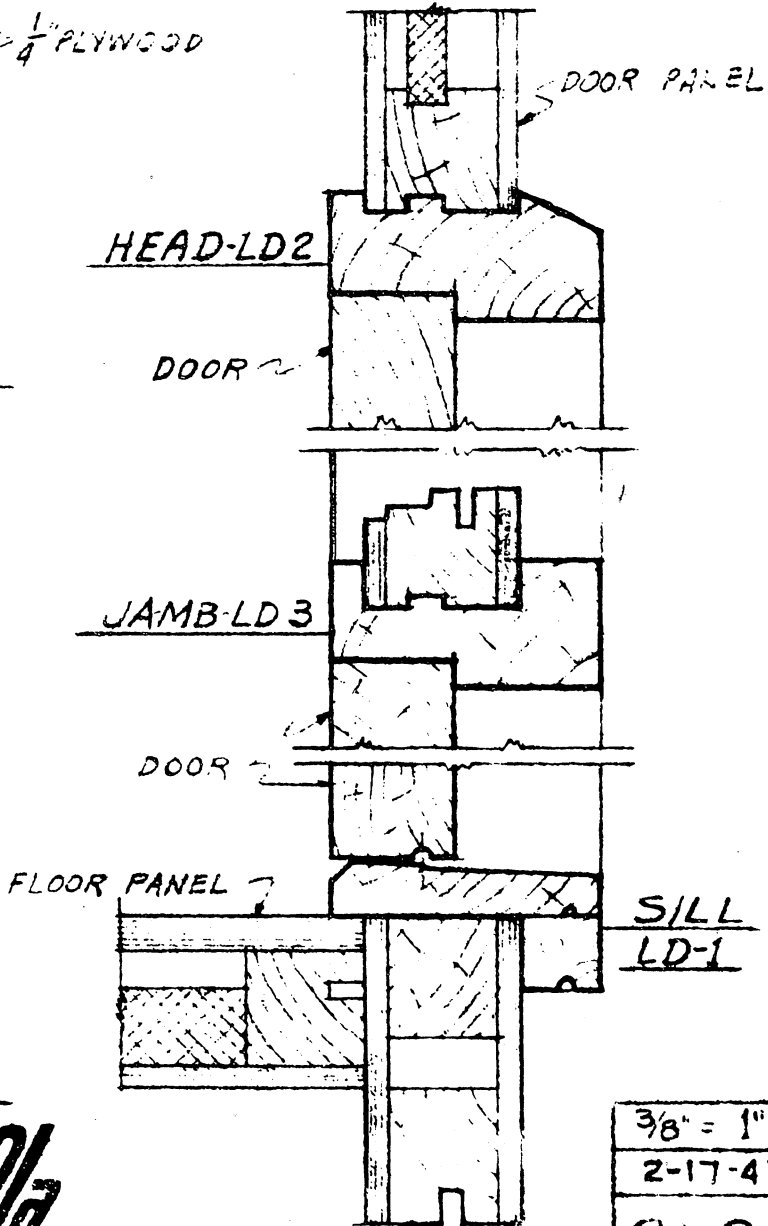


DOOR PANEL-CH

WINDOW PANEL-CC



WINDOW DETAIL



DOORWAY DETAIL

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3/8" = 1"
2-17-47
21-28

LEAD FLASHING

5"

4"

NOTE: ALL WATER SUPPLIES 1/2" TO FIXTURES

2" DRAIN & VENTS FOR TUB, LAVATORY & KIT. SINK

C.I. VENT

WATER HEATER IF ON 1ST FLOOR

4" COPPER

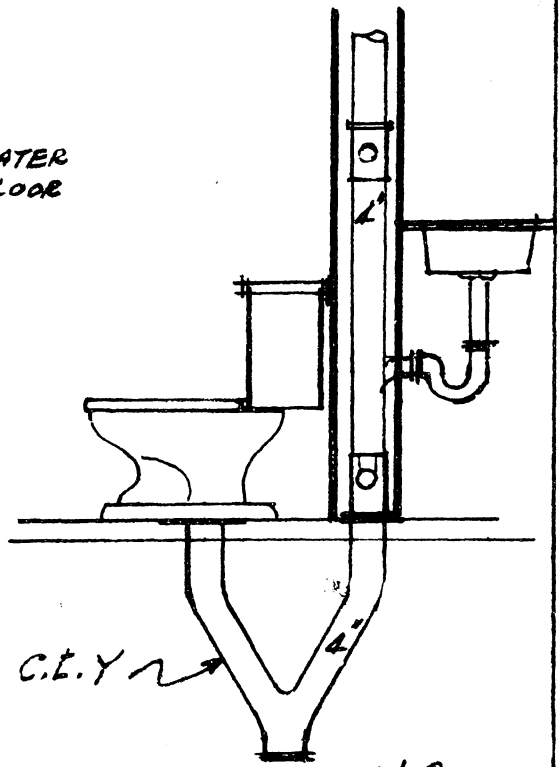
4' x 8' C.I. DRUM TRAP

2" DRAIN PITCH 1/4" - 1'-0" DRAINAGE FITTINGS

3/4" WATER SUPPLY & VALVE

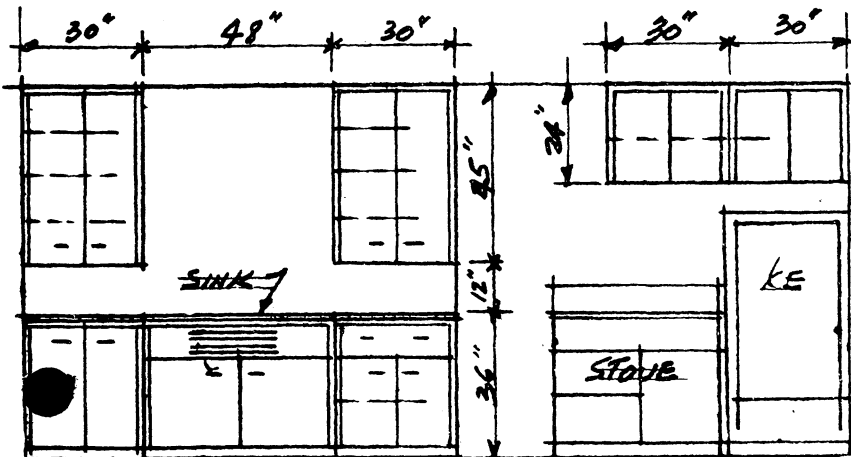
C.I.V.

ELEV. OF BATHROOM & PLUMBING



C.I.V.

SECTION AT W.C.



KITCHEN CABINETS SCALE 1/4" = 1'-0"

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Olga
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REV.
 3/14/47

21-30

National **HOMES**



NATIONAL HOMES CORPORATION

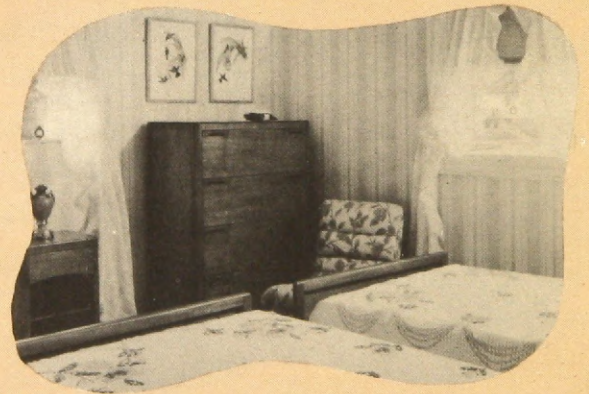
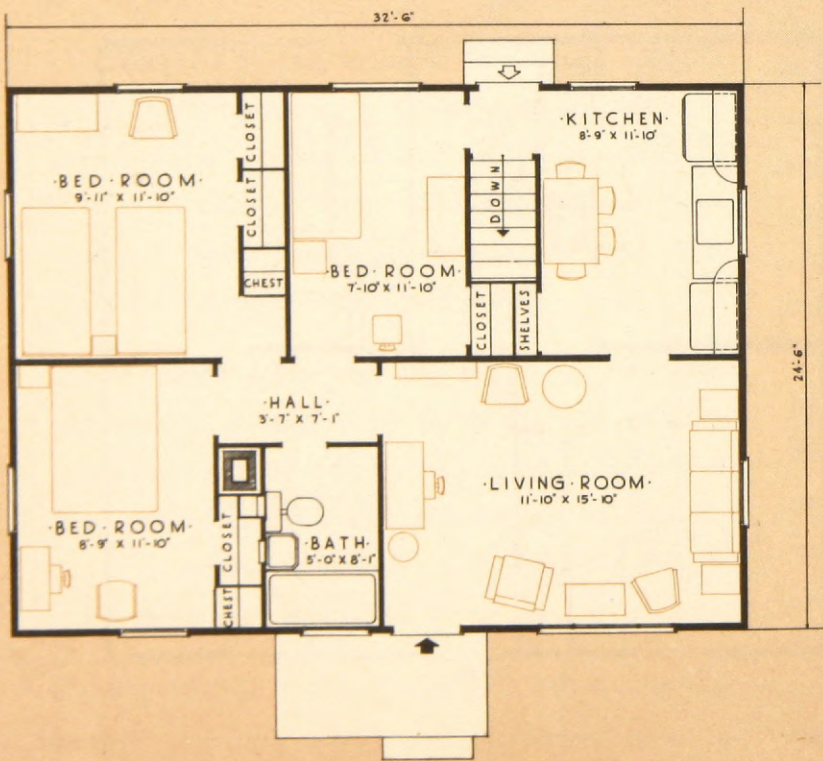
LAFAYETTE, INDIANA, U. S. A.



DESIGN 6L

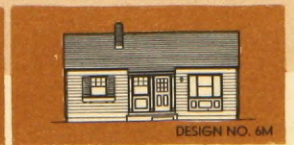
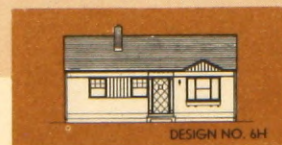
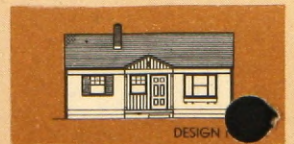
The Vernon

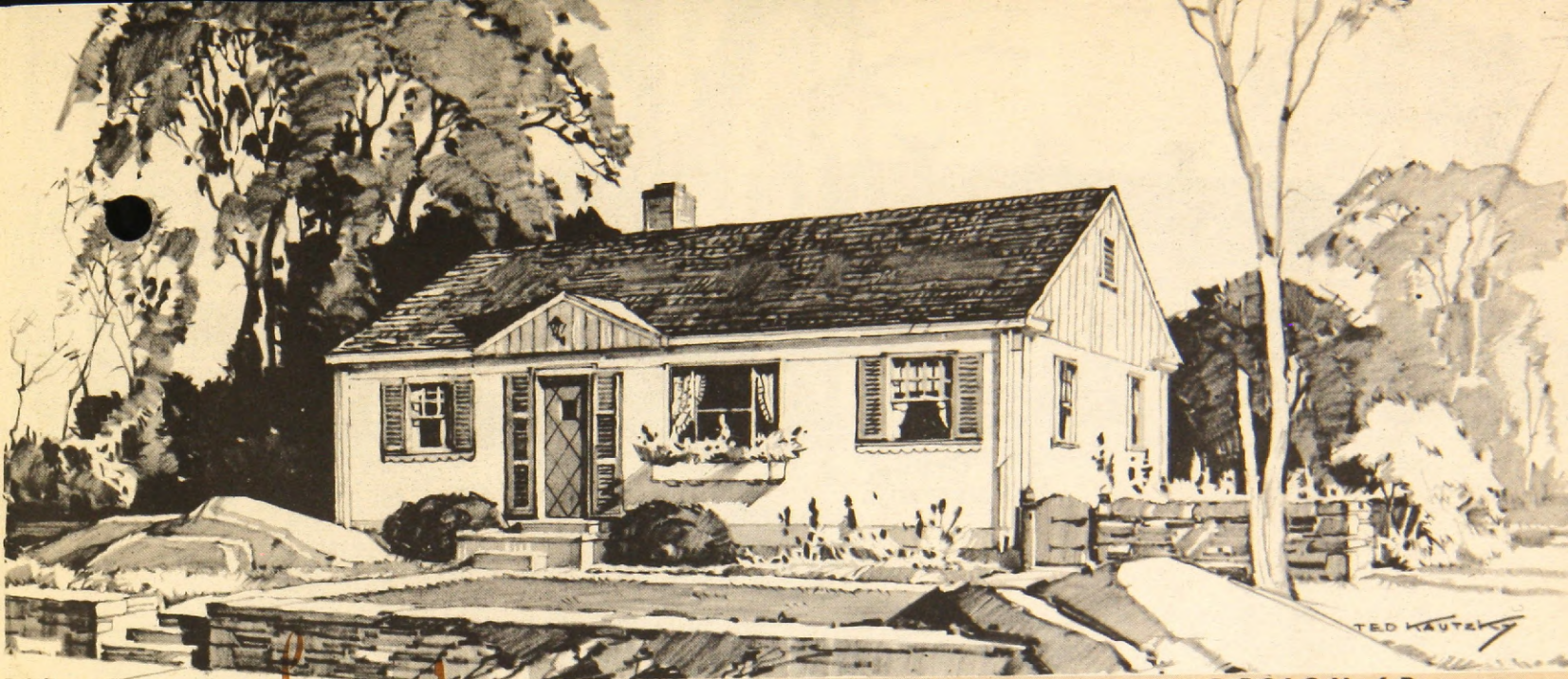
An efficient one-floor plan arrangement of three bedrooms for those requiring the seemingly impossible—a cozy home that nestles comfortably into the minimum size lot. THE VERNON plan, as shown, is RIGHT HAND; however, the plan is reversible. Any one of the three beautiful exteriors of traditional architectural design, 6H (Page 5), 6L (above), and 6M (Page 6), as illustrated, may be used for this plan, 24'-6" x 32'-6" in overall dimensions.



Here is a design of compact and restful charm. Each room of THE VERNON, with its abundant light and ventilation, is of ample size to serve its purpose and arranged to fit into the typical scheme of family living. Roomy, ceiling-height closets (with an extra one for the master's bedroom), chests of drawers, easy-to-reach shelves, modern bath, and an efficiently equipped kitchen with ample space for dining arrangement, makes this plan, THE VERNON, tops in living at low cost.

THE VERNON

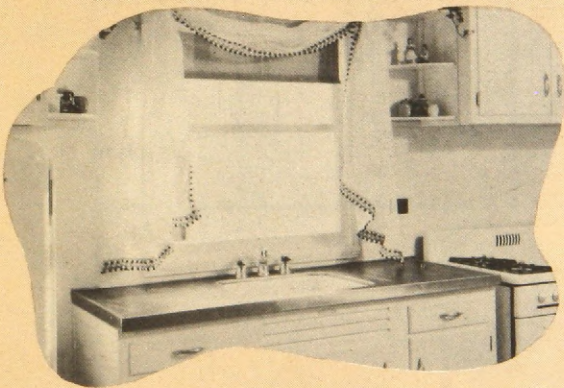




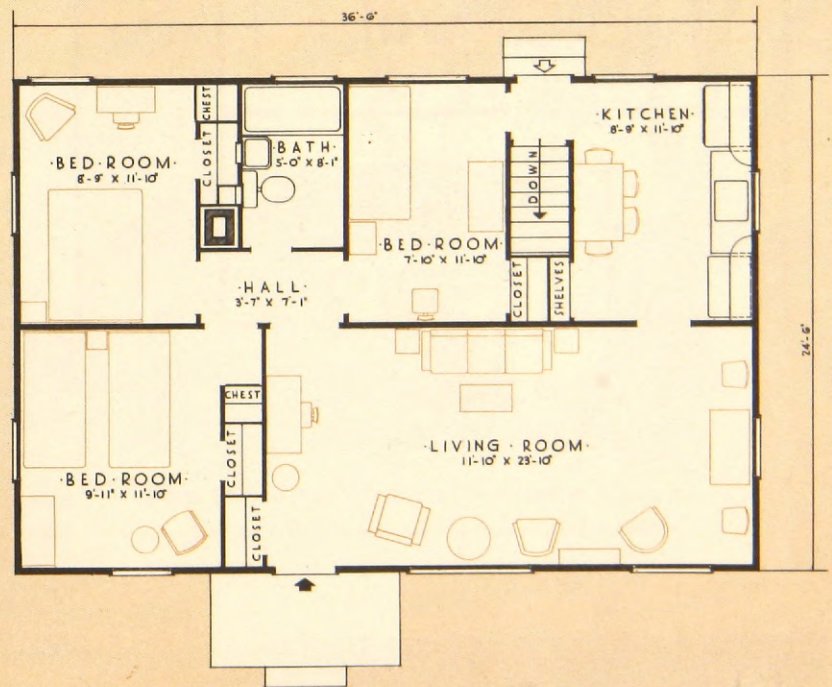
DESIGN 6R

The Longfellow

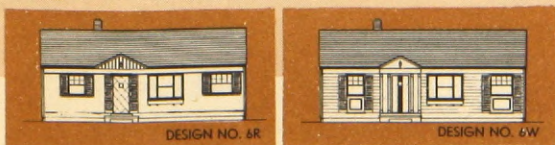
A splendidly balanced one-floor arrangement including all essentials for restful, quiet, convenient and flexible living. The "ALL PURPOSE" room adjoining the kitchen may be a sewing room, study, dining room, or, as suggested, a bedroom. Either of the two beautiful traditional architectural designs, 6R (above) or 6W (Page 6), may be used for this efficient plan, which is 24'-6" x 36'-6" in size. The plan, as illustrated, is RIGHT HAND; however, it is reversible.



The spacious living room of THE LONGFELLOW, generously lighted by its many windows, invites pleasant and enjoyable living. This plan is characterized by modern, convenient arrangement throughout. Ample dining space is provided in the sparkling, efficient kitchen, designed for less work and fewer steps. The built-in shelves unit is useful for storing china and other frequently needed articles. Kitchen design is thoroughly modern in every respect. Well proportioned rooms, large, ceiling-height closets, chests of drawers, and modern, full-sized bath—features which are distinctive of all NATIONAL HOMES—make this, THE LONGFELLOW, truly a home of grace and comfort for the American family.



THE LONGFELLOW



National **HOMES**



NATIONAL HOMES CORPORATION

LAFAYETTE, INDIANA, U. S. A.

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THE UNIVERSITY OF MICHIGAN

TO RENEW PHONE 764-1494

DATE DUE

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