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Handegord, G. O.

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NHBA EXPERIMENTAL PROJECT MARK II, FOREST LAWN, ALBERTA

by

G. O. Handegord

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PREFACE

The Division, as a member of the Research Committee of the National House Builders Association has been assisting in the experimental house program of that Committee. The first experimental house known as Mark I was constructed at Preston, Ontario in 1957 and a second house to the same design was constructed at Dartmouth, N.S. in 1958. Experimental house Mark II was constructed at Forest Lawn, Alberta in 1959. The Division has undertaken to make observations of the performance of these experimental houses, but in some cases these have had to be limited to periodic visits. The Mark II house has been kept under observation by staff from the Prairie Regional Station at Saskatoon and the results are now reported.

The author, a mechanical engineer, is officer-in-charge of the Prairie Regional Station of the Division located at Saskatoon.

Ottawa
January 1962

N. B. Hutcheon
Assistant Director

NHBA EXPERIMENTAL PROJECT MARK II,

FORREST LAWN, ALBERTA

by

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The Mark II House was built by the L. E. Wade Construction Company of Calgary, Alberta, in the fall of 1959 as part of a program sponsored by the National House Builders Association. The house is located at 2527 Sable Drive in the town of Forest Lawn, adjacent to the city of Calgary, and was officially opened on 5 November 1959. Since then it has been occupied by Mr. William White, his wife and family of three preschool children. Mr. White served as superintendent for the Wade Construction Company during the construction of the house.

The Mark II House was constructed to demonstrate and evaluate certain design features that had been proposed by the Research Committee of the National House Builders Association. Following completion of the house, the NHBA requested that the Division of Building Research of the National Research Council assist with this project by having one of its staff observe the performance of the house taking special note of the special features incorporated. As a result of this request, the author visited the house on 11 March 1960, and the house examined in company with Mr. White. The information obtained during this visit established any significant changes made to the original design and indicated any aspects of performance that might be related to the special features of the house.

It was recognized that frequent regular visits could not be made by Division of Building Research personnel from Saskatoon and Mr. White offered to report on any developments which he observed. Arrangements were made to install a recording temperature-humidity instrument which Mr. White agreed to service on a weekly basis. It was thought that this instrument would at least provide some record of the interior environment which might be used in assessing the performance of the heating system or indicating any unusual humidity condition.

A second visit was made to the house in November 1960, to examine the general condition of the house and to discuss its performance with Mr. White. This report has been prepared on the basis of these observations and discussions to provide a record of the features and, to some degree, the performance of the Mark II House. Considerable credit is due to Mr. White for his interest and co-operation in this matter, and his assistance is gratefully acknowledged.

Special Features of the Mark II House

The floor plan of the Mark II House is shown in Fig. 1; views of the front and rear of the completed building are shown in Figs. 4 and 5. Figures 2 and 3, reproduced from the drawings used in the construction of the house, illustrate the various special features which were to have been incorporated. A description of these special features will be described in this report; supplementary information gained through the observations made to date is included where applicable.

Footings

It was originally intended that footings should not be carried below the assumed frost level on the basis that the heat loss from the crawl space would be sufficient to avoid frost heaving problems. Because of the nature of the site, considerable fill was necessary and the resultant foundation walls extend about 5 feet below finish grade. Approximately 3 feet of gravel fill was used in the crawl space area, and the floor of the crawl space was covered with a layer of concrete, 1-1/2 inches thick. No vapour barrier was included in this construction. The foundation walls are of 4-inch concrete block and perimeter insulation of 1-inch thick foamed polystyrene extends from floor level to 18 inches below grade. The centre bearing wall in the crawl space consists of 2- by 4-inch studs at 2-foot centres supported on 4-inch concrete block on a 16- by 6-inch concrete footing 3 feet below the crawl space floor.

In March 1960, examination of the crawl space revealed a slight displacement of the floor adjacent to the centre footing wall, as shown in Fig. 6. In November there appeared to be no increase in this displacement. During both visits the dark appearance of some mortar joints, as shown in Fig. 6, suggested moisture being present, but no other evidence of water seepage was observed. The crawl space was dry and no cracks were noted in the concrete floor.

Floor System

The floor construction was originally planned with nominal 2- by 8-inch joists spaced 24 inches on centres. A special cross-grained plywood, 1/2 inch thick, was used as subflooring and nominal 1- by 4-inch strapping, nailed to the underside of the floor joists at mid-span, served in lieu of conventional cross bridging. Tile was used as finish flooring in the kitchen, bath and hall; painted subfloor was the finish surface in the living room and bedrooms.

Many of the people attending the official opening criticized the floor system as being too "springy", and this has been the chief complaint of the occupants. Excessive deflection of the subflooring may also have been a contributing factor in producing separation at the joints in the plywood flooring sheets (Fig. 7). The high temperatures in the crawl space would also contribute to this separation, notably due to shrinkage of the plywood subfloor. Shrinkage of the joists was reported by the occupant from measurements taken in the crawl space.

Some separation between the base of the wall and the floor was noticed in March 1960 at the end of the stub wall adjacent to the refrigerator, as shown in Fig. 8. Some shrinkage may have occurred in the baseboard, but examination indicated a gap of some 1/2 inch between plate and subfloor. Evidence of possible floor deflection was also noted at the top of the kitchen storage cupboard in Fig. 9. This is a region of fairly heavy floor loading. No increase in these separations were noted in November 1960.

Some checking on the finished surface of the plywood flooring was observed in March 1960, being most severe in the centre bedroom, as shown in Fig. 10. No significant increase in the extent or severity of this checking was noted in November.

Windows

Fixed windows were used throughout the house, with factory sealed double-glazed units installed as shown in detail in Fig. 3. The occupants reported no serious condensation difficulties during the first winter although some slight deterioration of the wood stops had occurred. By November 1960 the caulking compound had become hard and brittle and more severe condensation at the sill had been observed. In December 1960 during intentional humidification of the centre bedroom, some condensation between panes in the sealed units was reported.

Attic Ventilation

Perforated hardboard was used as a soffit to permit entry of outside air for ventilation of the attic space. A special continuous ridge vent was installed as an exhaust vent.

It was reported in March 1960 that under certain conditions snow tended to enter the attic through the ridge vent and the vent had been blocked off for the most part following this experience (Fig. 2). The attic appeared to be dry and free from condensation in March except for some frost near the top of the north gable end. The occupant had observed no signs of serious condensation during the winter.

Wall Construction

Nominal 2- by 4-inch framing members spaced 24 inches o.c. were used in the exterior wall construction. Interior finish consists of 1/2-inch thick gypsum board and 5/16-inch cross-grained fir plywood provides a combined sheathing siding, with vertical fir battens spaced 2 feet for appearance and for joint concealment. No sheathing paper was used. The exterior plywood and battens were finished with three coats of stain. Insulation consists of 2-inch thick rock wool batts protected by an additional polyethylene vapour barrier. Interior partitions are of nominal 2- by 3-inch framing at 24 inches o.c.

The wall construction had performed quite satisfactorily except for excessive checking in the exterior plywood finish. There had been no obvious evidence of condensation within the wall, and no cracking had occurred in the interior plasterboard, except for a few hairline cracks at corners and wall ceiling intersections.

Roof System

A special type of king post truss spaced at 2-foot centres was employed as the basic roof structure, (Fig. 2) and this system appeared to have performed satisfactorily. Roof sheathing consisted of 3/8-inch cross-grained plywood, 14 feet in length, applied so as to extend from ridge to eave without horizontal joints. No reinforcing was used at the joints between the plywood roof sheets; these were simply caulked and painted. The roofing used was a special liquid coating called "Permaclad", and was applied according to the suppliers' directions.

The special roof coating appeared to perform satisfactorily until the weekend of 2 July 1960 when a hail storm occurred, followed by rain. Under these conditions, serious leaks developed at the joints in the plywood roofing. The occupant observed that rain water, entering through the roof, found its way across the polyethylene vapour barrier to the exterior walls, and down the exterior walls between the vapour barrier and the insulation. Water was observed at window heads with a considerable amount entering at this point in the master bedroom. A large puddle formed on the floor beneath this window and the drapes became wet and badly stained. Subsequent examination of the attic by the occupant indicated a few wet spots in the wood shaving insulation, but no serious staining of the ceiling occurred.

Following this experience, and after examination of the roof, asphalt shingles were applied. A sample of the sheathing taken from the roof after the storm indicated that the original "Permaclad" coating had become very brittle and had apparently lost its bond to the wood.

Heating and Ventilation System

The heating system used in the Mark II House was a modified form of a "crawl space plenum" system with a down-flow gas-fired forced warm air furnace discharging heated air directly into the crawl space. It differed from the conventional crawl space plenum system in that no duct work was used to direct or distribute warm air in the crawl space and the warm air was discharged to the living space through a series of holes drilled in the subfloor around the perimeter of the house rather than through conventional registers. These holes were concealed behind the baseboard which was spaced 3/4 inch from the face of the wall, as shown in the detail in Fig. 3. It was intended that strips of 3/4-inch by 3/4-inch lumber could be dropped into this space to cover some of the holes to permit balancing of the system. The occupant thought that sufficiently uniform distribution was obtained without resorting to this technique.

Registers were provided near the ceiling in all bedrooms, kitchen, and utility room, to allow the air to return through the hall, kitchen and living room, and be taken into the return air plenum of the furnace through two registers located near the ceiling in the furnace closet.

Ventilation was provided for in the design with two ducts formed in the ceiling joist spaces and extending from the furnace plenum to the eaves at the front and rear of the house. These ducts were installed as shown in the detail in Fig. 2. Both ducts were equipped with manually operated dampers for control of the amount of ventilation. The exhaust of air from the house was provided for by a bathroom exhaust fan and by two ceiling vents, one in the master bedroom and one in the living room, which were equipped with manually operated doors as shown in Fig. 3 and connected by ducts to the outside. It was intended that the outside air intakes and ceiling vents could be opened in winter to provide a means for moisture removal and could be opened in winter to provide a means for moisture removal and could similarly be employed in summer to gain the benefits of night cooling. In winter, except for a short period after occupancy, only the vent in the master bedroom was kept open. This was found necessary because of the discomfort from cold down drafts from the vents, presumably during "off" periods of the fan or under certain wind conditions. The tenant preferred a cooler bedroom and this vent was closed only infrequently. It was also found that cold air issued from the combustion air register at the base of the furnace closet in the kitchen under certain conditions, and this was closed off to avoid discomfort to those sitting at the kitchen table. The outside air intake vents were left open at all times, both summer and winter.

The occupants appeared to be very satisfied with the performance of the heating system, although initially the noise of operation of the fan was objectionable. Information regarding the proper adjustment of warm air furnaces was sent to the occupant in March 1960, so that the control settings and fan speed could be modified if necessary. The occupant also stated that at first his wife found the floor somewhat too warm but this feature was most desirable from the standpoint of small children. The occupants thought that dust and lint were more apparent than in other houses of their experience.

The thermohygrograph records for the heating periods in the spring and fall of 1960 indicated that relative humidity conditions within the house were similar to those of houses of the same general character and occupancy in Saskatoon. During zero and subzero weather, minimum humidities of 20 to 25 per cent were experienced as shown in Fig. 11. This figure is a reproduction of the instrument record for the coldest period during the time of observation. Figure 12 is a similar chart for a period of milder weather in November 1960. In each of these figures the mean hourly outside temperature has also been plotted as a dotted curve, based on information supplied by the Meteorological Office at the City of Calgary Airport.

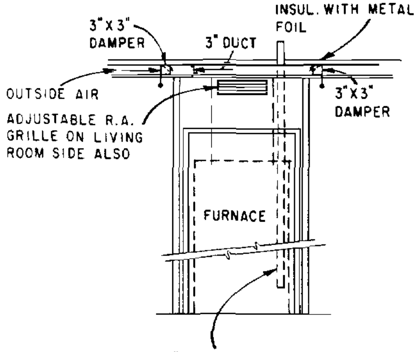
The most significant feature of the records shown in Figs. 11 and 12 is in relation to the frequency of the temperature control cycle. In most houses with basements, with conventional forced warm air, gas fired systems, the "on" and "off" cycle of the furnace, as exemplified by the temperature variation, involves a period of from 20 to 40 minutes, whereas a period of from 3 to 4 hours for each cycle may be noted for the Research House. This is the type of performance that has been noted in a house with a gravity hot water system in Saskatoon and indicates the effect of high heat storage capacity. In the house with hot water heating this is due to the mass of the system and water, whereas in the Mark II House it may be due to the thermal capacity of the concrete slab and floor system. This is not necessarily a disadvantage of the system and it may be observed that the amplitude of temperature variation of approximately $\pm 2F^{\circ}$ is similar to that obtained in conventional houses even with a shorter cycle.

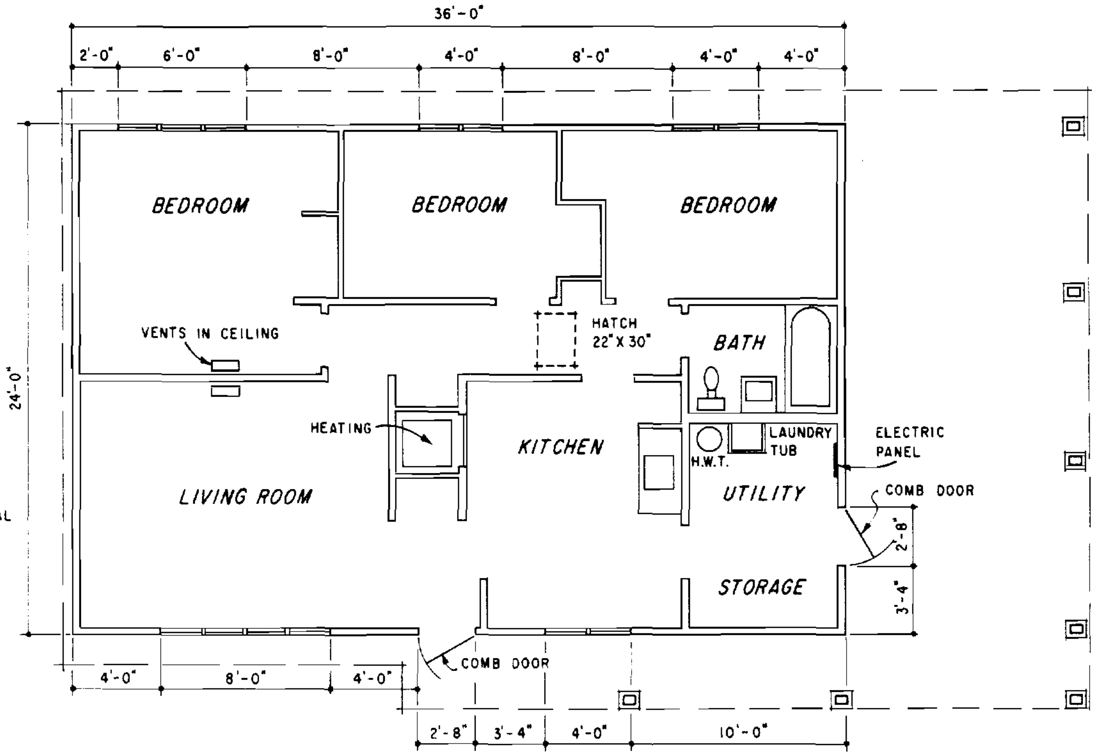
Operation of the system during hot summer weather required the occupant to control the operation of the fan manually and to use drapes to reduce solar gain. Normally, drapes were drawn on those windows facing the sun during the course of the day and the furnace fan was turned on at noon and left in operation until the environment became chilly. This usually occurred at sunset or thereabouts. Doors were also opened during periods when cool breezes prevailed.

A reproduction of the record of interior temperature and humidity during one of the warmest outside conditions is shown in Fig. 13, together with the average hourly outside temperature. This record suggests that the procedure followed by the occupants resulted in satisfactory conditions being maintained although it is difficult to draw any specific conclusions regarding the inherent merit of the system without comparison with other conventional houses under the same weather conditions. The occupant thought that the conditions were superior to those in other houses of his experience.

DETAIL OF FURNACE DAMPERS & VENTILATION

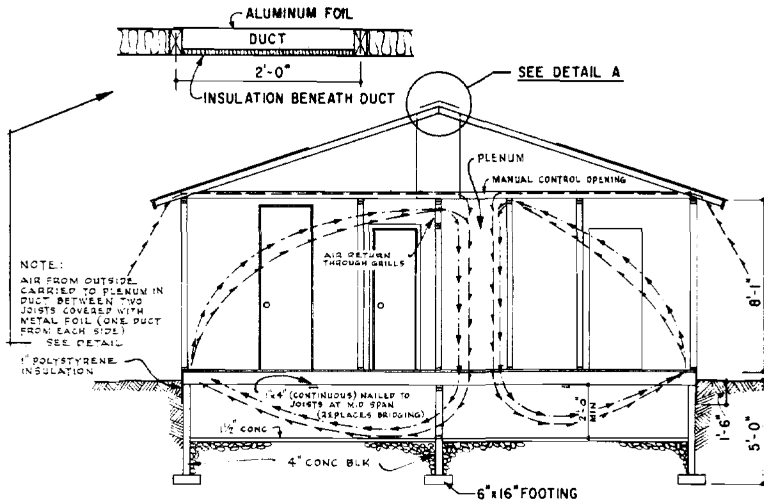
SEE FIG. 2 FOR CEILING VENT DETAILS



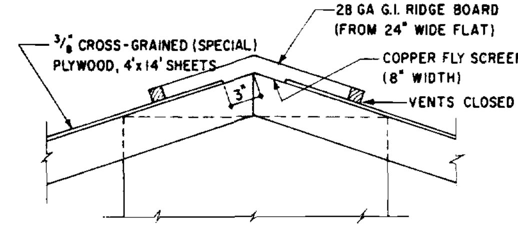


FLOOR PLAN

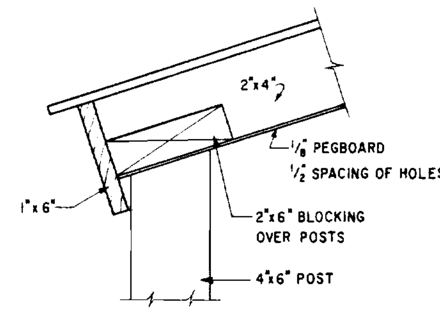
FIGURE 1



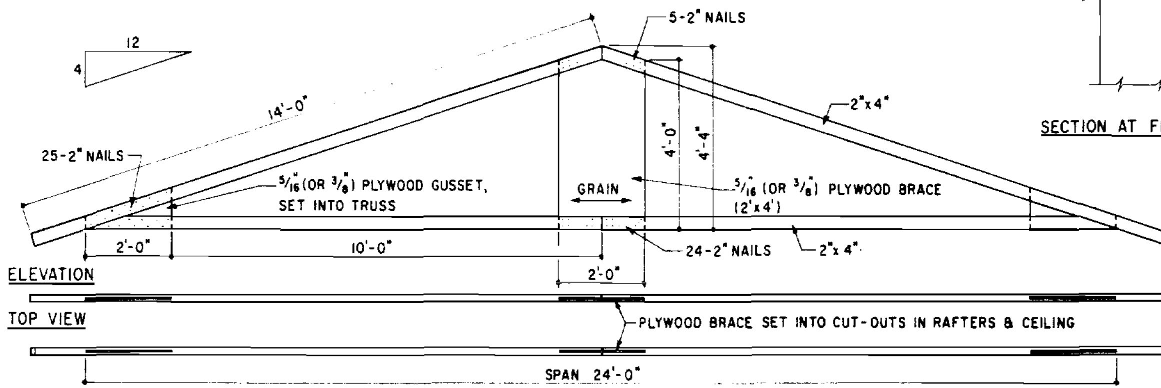
AIR FLOW DIAGRAM - HEATING & VENTILATION



DETAIL A - RIDGE VENT

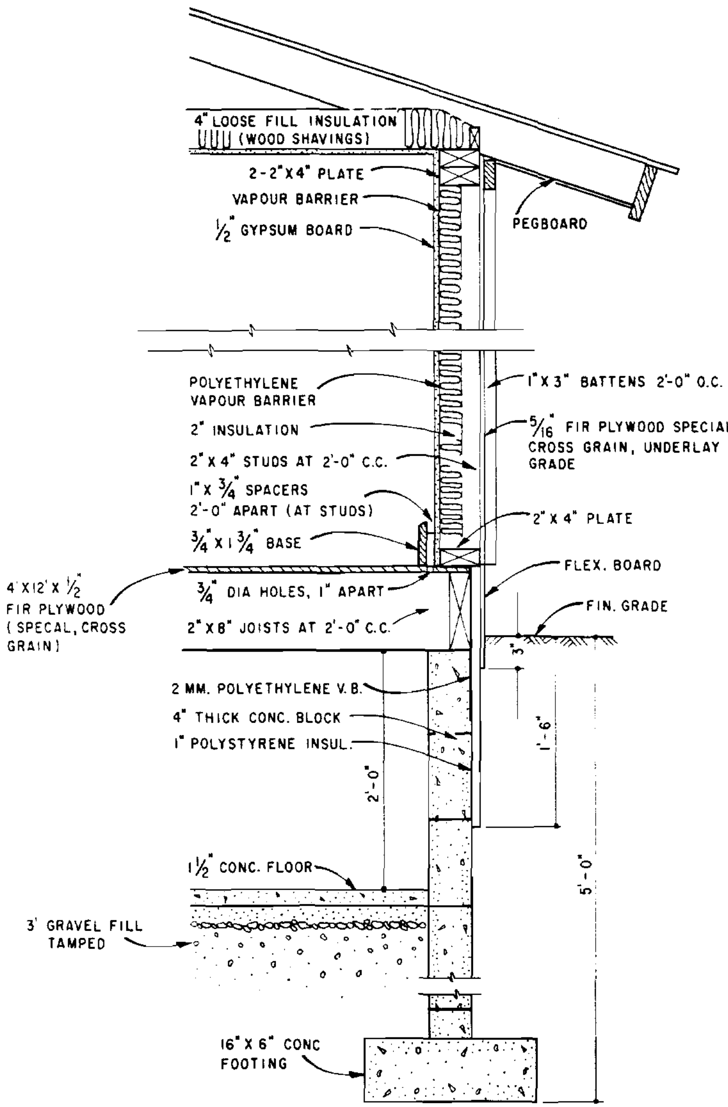


SECTION AT FRONT OVERHANG

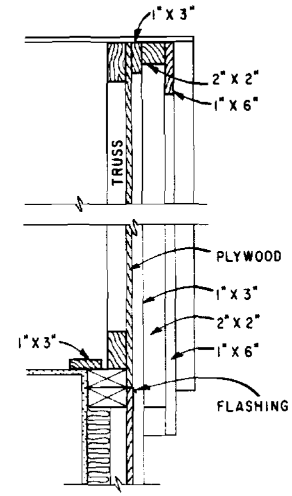


ROOF TRUSS DETAILS

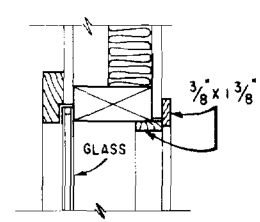
FIGURE 2



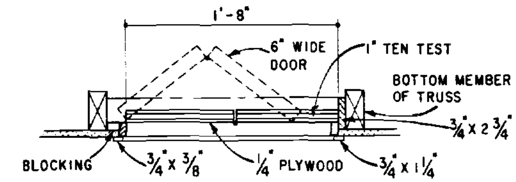
SECTION THRU EXTERIOR WALL



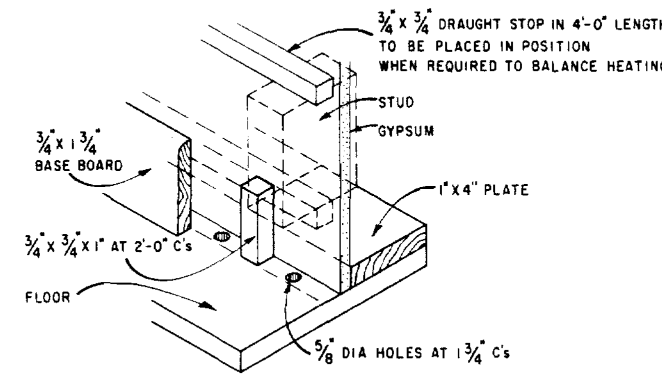
GABLE DETAIL



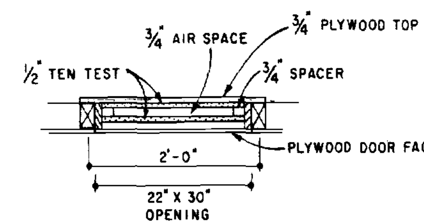
DOUBLE GLAZING DETAIL



CEILING VENT DETAIL



SKETCH SHOWING CIRCULATION HOLES



DETAIL OF HATCH IN CEILING
IN HALLWAY

FIGURE 3

Figure 4 Mark II House -- front view,
11 March 1960.

Figure 5 Mark II House -- rear view,
11 March 1960.

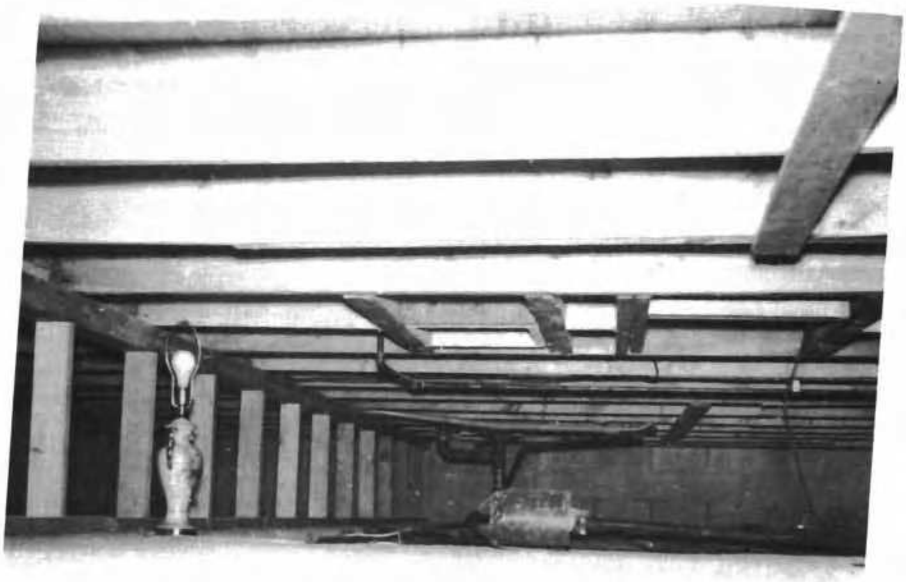


Figure 6 Crawl space of Mark II House.

Figure 7 Separation of plywood flooring sheets -- Mark II House.

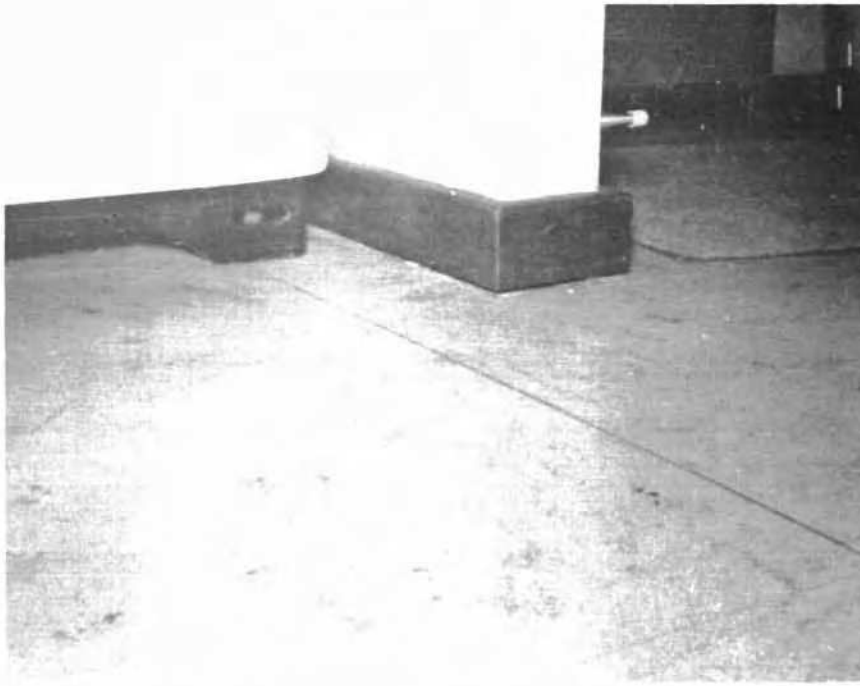


Figure 8 Separation between base of wall and floor -- Mark II House.

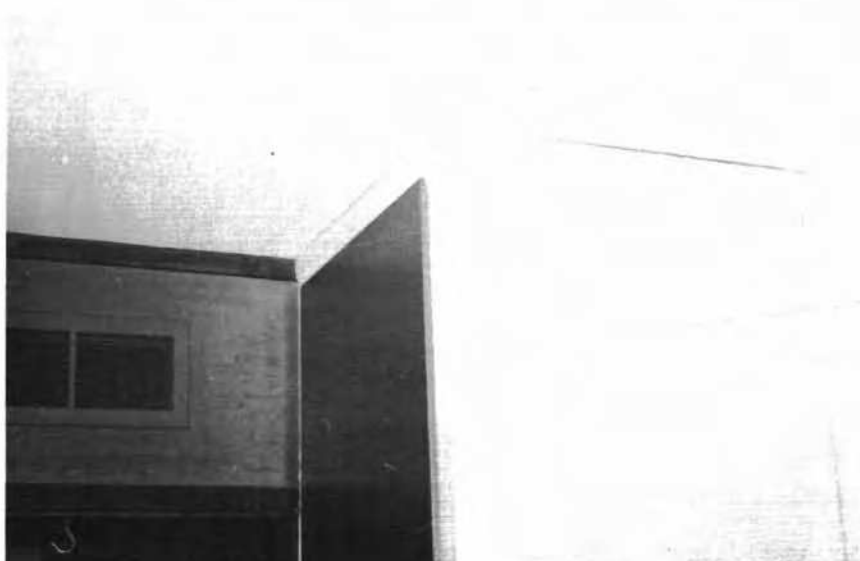


Figure 9 Separation at top of kitchen cupboard -- Mark II House.

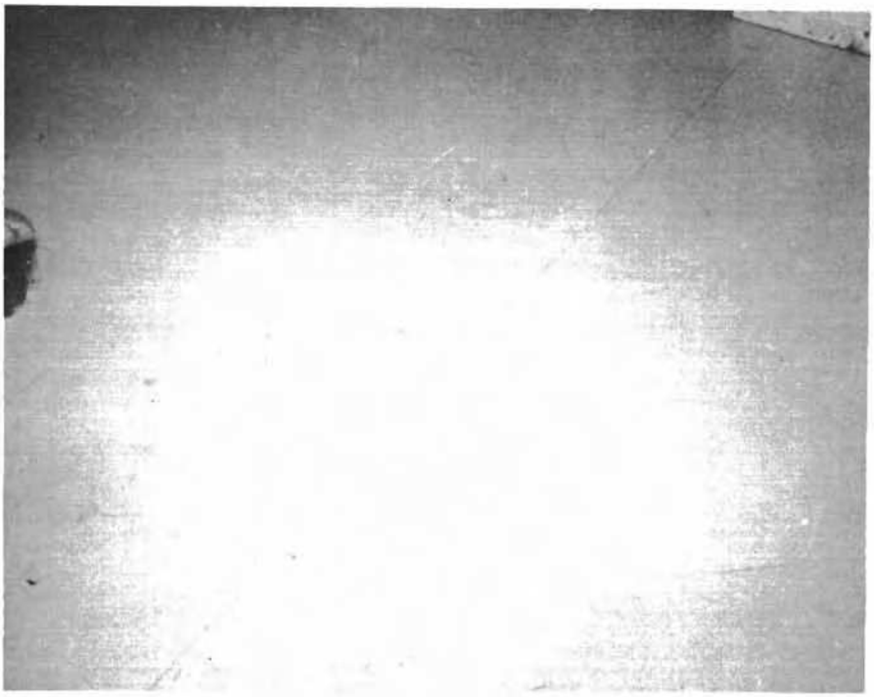


Figure 10 Checking of plywood flooring -- Mark II House.

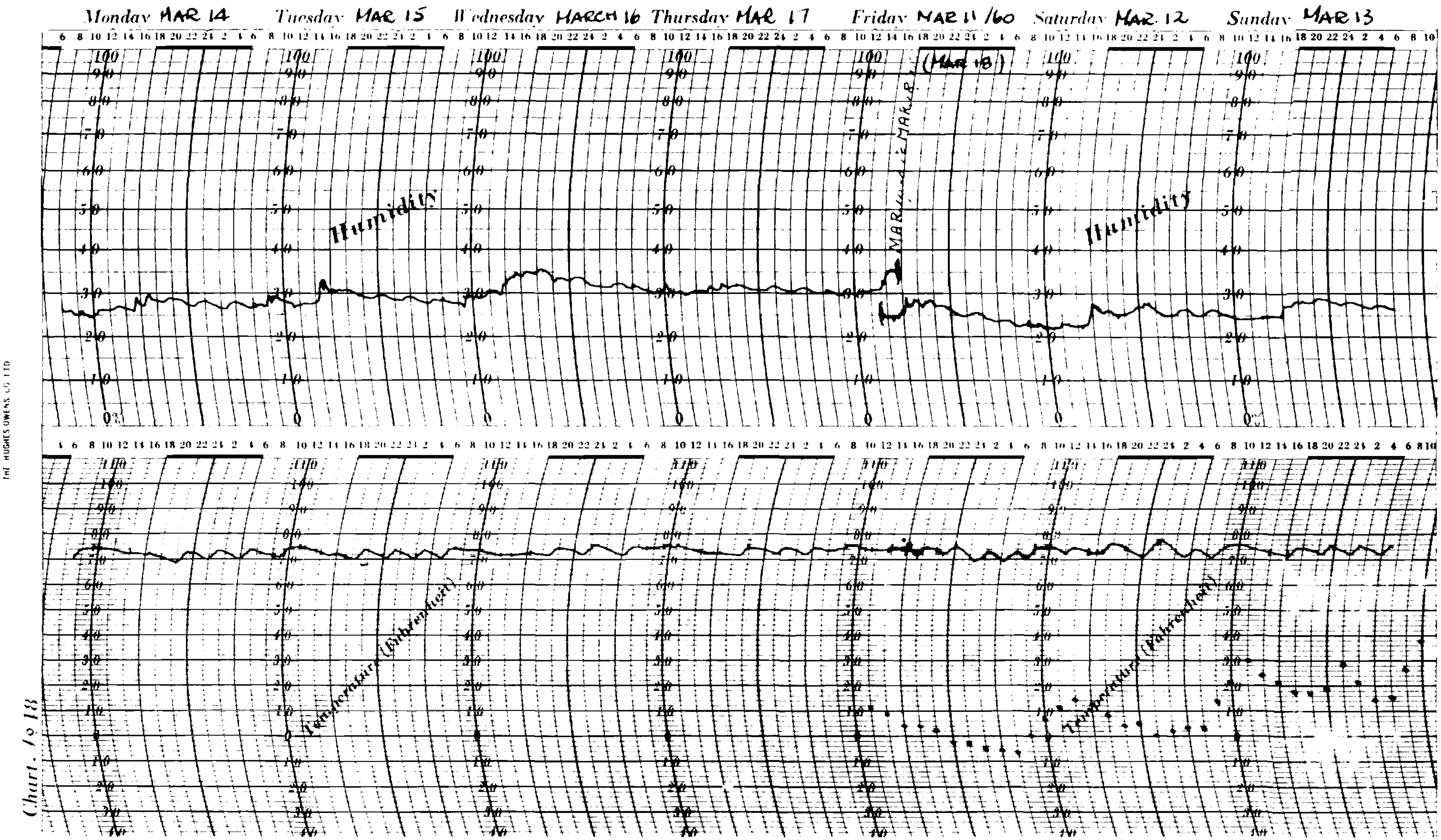


Figure 11 Thermohygrograph records, 11 to 18 March 1960 -- Mark II House. Dotted curve on lower chart indicates outdoor temperature.

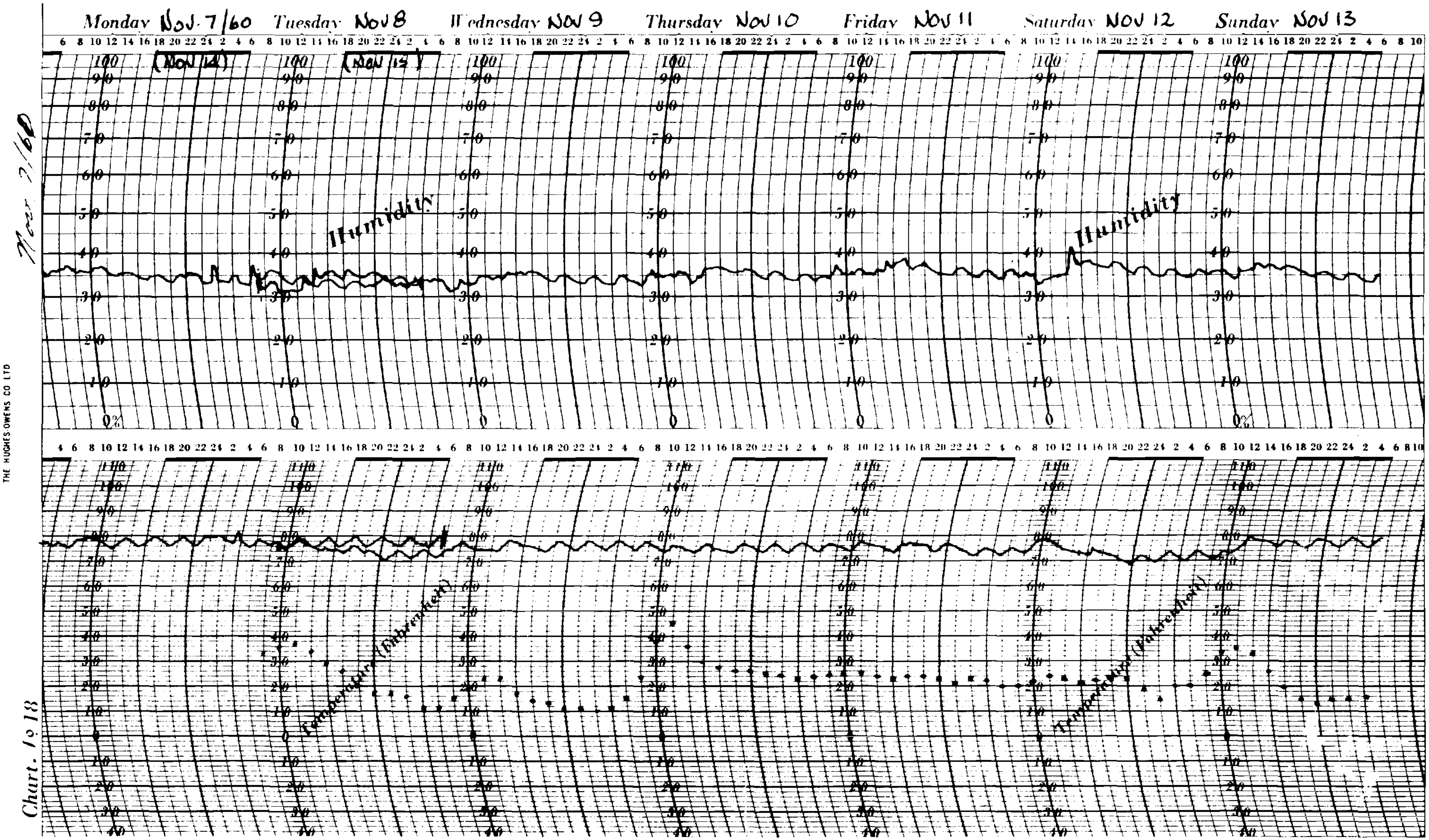


Figure 12 Thermohygrograph records, 7 to 15 November 1960 -- Mark II House. Dotted curve on lower chart indicates outdoor temperature.

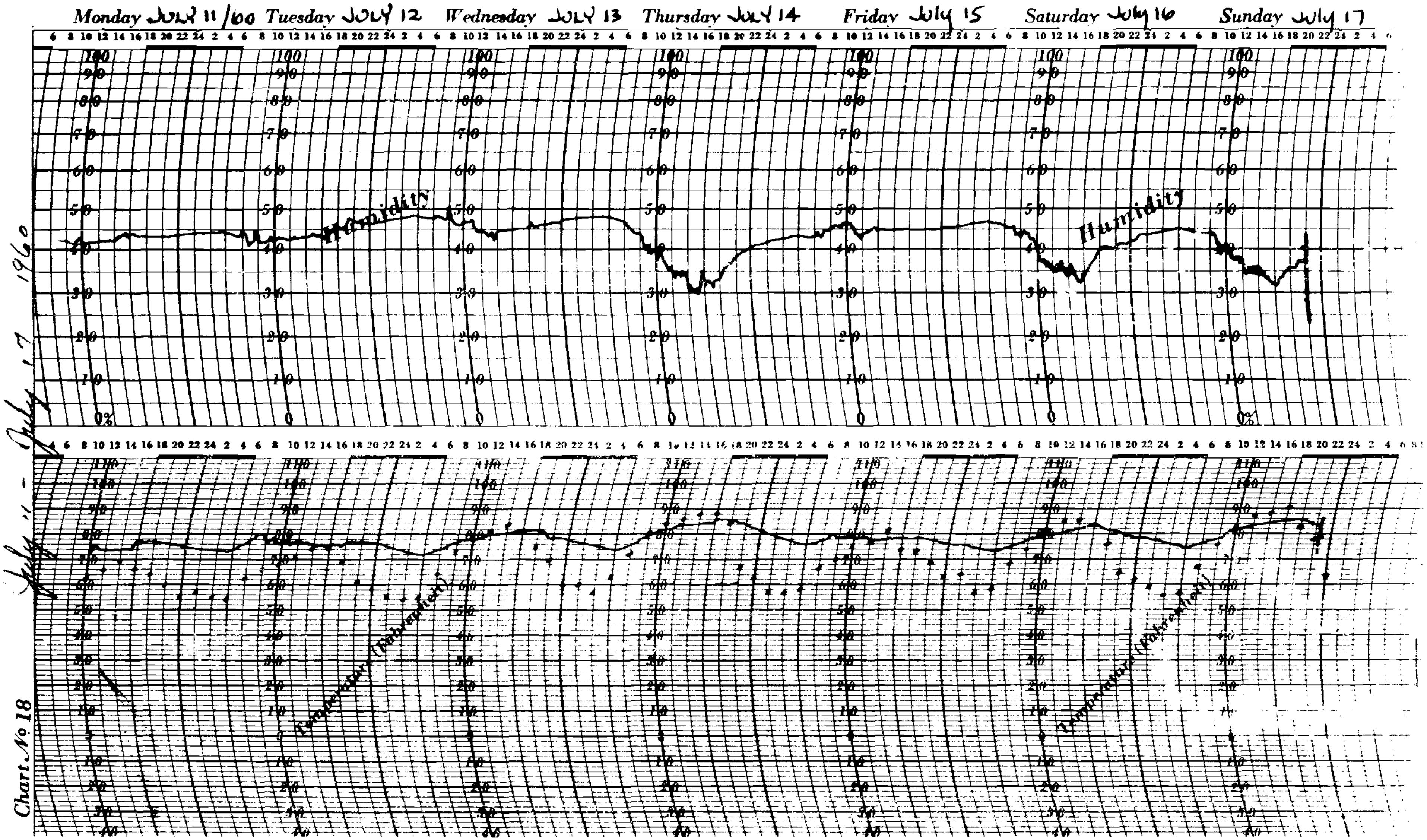


Figure 13 Thermohygrograph records, 11 to 17 July 1960 -- Mark II House. Dotted curve in lower chart indicates outdoor temperature.