NEW APPROACHES TO FARMHOUSE DESIGN, CONSTRUCTION AND EQUIPMENT

A paper presented by J. W. Simons,
Assistant Agricultural Engineer,
U. S. Bureau of Agricultural Chemistry & Engineering,
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To those interested in a vitalized southern agriculture comes the challenge of improving the living conditions of the southern farmer and his family. Increased interest in farmhouse design, construction and equipment in the past few years is evidence that agricultural leaders have not overlooked this large and important humanistic problem. New, inexpensive materials, prefabrication, expanded plan services and research activities have contributed and will continue to contribute to the development of this field.

Considering the country as a whole, the trend in design of farmhouses has been toward the urban type. Undoubtedly this has been partly due to the influence of magazines in which plans for urban homes are shown and to plans circulated by materials and equipment manufacturers designed largely for use in towns and cities. Many of these plans, while excellent for some purposes do not provide for the activities carried on in the average farm home which frequently differ radically from those in urban homes. Nor do they take into consideration the fact that equipment which may have influenced the design frequently is not available to farm families because of cost or lack of service facilities. Certainly we must recognize these facts in designing and building houses which will adequately serve the needs of farm families.

Changes in construction and in the use of materials in farmhouses have been influenced far more by urban developments than by any local or general movements to utilize native materials. Those most interested in a widespread program of farm building repair and construction now recognize that one solution of the problem of low-cost buildings is the use of materials which can be obtained from the farm or locally and the contribution by the owner and his farm hands of a large share of the labor required. In such a program not only must new methods be introduced but also the use of old accepted methods should be recommended and urged upon the farmer. Efforts along this line are being undertaken by the Bureau of Agricultural Chemistry and Engineering in cooperation with the University of Georgia, and the University of Wisconsin and by other institutions such as the University of Arkansas and Tuskegee Institute.

For the past four years at Athens our project has placed particular emphasis on the matter of comfort although we have considered such factors as first cost, maintenance, appearance, ease of fabrication, firesafeness, etc. We have learned some interesting things although we have merely "scratched the surface", and there is still the ever present need for more intensive studies of many phases pertaining to farm housing.

To be of practical value the results of farm structures research must be applied to the building and remodeling of actual farmhouses. In the vicinity of Athens we are now doing that by assisting farmers with their house building problems. We furnish the cooperator with plans and specifications, suggest the materials he might use and give limited supervision to the construction of the house. In return, the owner provides us with labor and material records. He also permits those engaged in the research project to make temperature studies and to use his house for a limited time as a demonstration to interested parties. Only a very limited number of farmhouses can be improved by our project and other similar projects through direct cooperation with owners. However, such projects not only provide needed technical information but also serve as proving grounds for developing methods of approaching the general farm building problem on a broad scale.

Let us now examine the results of some of our studies at Athens, and point out the specific application of these results and some of the problems which we are still facing. Inasmuch as a house is built from the ground up it is logical that we should begin with a discussion of the foundation and work upward to include various construction features and their relation to comfort and economy.

The most common floor construction in the South is a wood floor-and-joist system supported by piers. In winter, cold winds blowing under the house result in cold floors and tend to increase fuel consumption. Our studies in the test houses have shown that installing curtain walls between piers resulted in reducing tho fuel consumption on an average of from 12 to 19% depending upon the construction of the balance of the house and the wind velocity. The studies were made with wind velocities ranging from 3 to 9 m.p.h. Curtain walls would increase the cost of a house relatively little and would seem to be a worthwhile expenditure; they would also enhance the appearance of the structure.

Studies of concrete slab floors laid on gravel fills on the ground showed that much more uniform temperatures are maintained than in the case of wood floors supported by piers, and that the heat loss in winter is much less. However, in summer, the cooling process during the night is slower for the concrete floors. It is, therefore, highly desirable to prevent the sun's rays from striking the concrete floor because of its high heat capacity.

Of course there are advantages and disadvantages for both types of floors. Wood floors are easy to build and lumber is readily available at a reasonable cost in most sections. However, they are difficult to finish so as to be easily maintained under farm conditions and are not proof against fire, termites or vermin. As ordinarily built, the pier construction used with wood floors has little resistance to damage by high winds. It is generally agreed, however, that the resilience of a wood floor and its relatively low heat conductivity tend to promote the comfort of persons standing or working on such a floor.

The concrete floor has the advantage of being fire, wind, termite and vermin resistant and is sanitary. The surface may be colored with mineral pigment incorporated with the cement mix, or covered with asphalt tile or wood, thus giving a variety of finishes. In very low-cost construction the floor may be left bare and smoothed to a non-slipping surface, although a covering or finish is highly desirable; often there is objection to a bare concrete floor.

There are several problems in connection with the use of concrete slab floors in low-cost farmhouses about which various authorities do not agree. It would seem that this one subject should provide an excellent opportunity for some intensive research. The question of economical moisture-proofing is one deserving much consideration. Another question is that of the minimum thickness for a floor slab with the proper amount of reinforcing which will be economical to use.

Figure 1 shows a type of floor which we believe to be fairly economical on level sites. This was laid recently in a house in Jackson County. A one course, $3\frac{1}{2}$-inch slab, reinforced with No. $12\frac{1}{2}$ gage woven wire was placed over a six-inch gravel fill. The site is well drained and, therefore, there should be little difficulty due to moisture. This particular floor will be covered with asphalt tile.

In our initial studies in occupied farm dwellings we found that those houses having the loosest construction were the most comfortable in summer, but of course they were the most uncomfortable in winter. Also, those houses with the least massive construction had

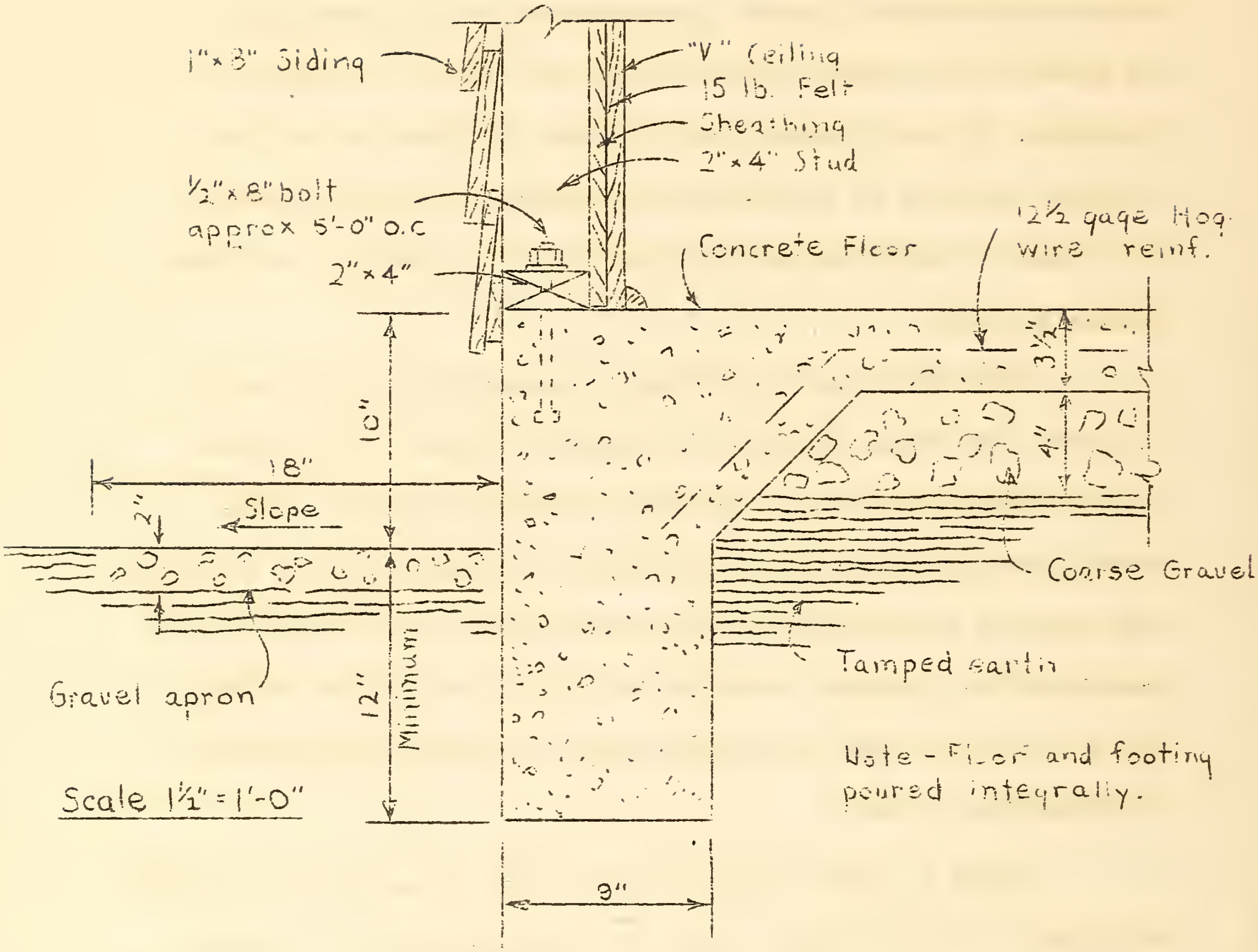

Figure 1 - Detail - Concrete Slab Floor Construction

the advantage in summer of more rapid cooling at night. These results were borne out by the studies in the test houses. Particularly striking were the results obtained under winter conditions. In these tests one type of construction used was typical of the average farmhouse; lapped weatherboarding on the exterior, studs and V-ceiling on the interior. It was found that with this wall construction the fuel consumption increased about 56% when the wind velocity increased from 3 to 9.7 m.p.h. It was also noted that the two three-room experimental houses, although built on the same plan and of similar materials with a difference in age of less than two years, did not require the same amount of fuel. Fuel consumption in the older house was approximately one-third more, with equal temperatures being maintained in both houses.

In another series of tests all exterior joints in the siding and the cracks around the windows were caulked and doors were weather-stripped to provide tight construction without changing the heat transmission characteristics of the structure. This procedure reduced infiltration of air through the walls, windows and doors and resulted in an average reduction in fuel consumption of from 23 to 39 percent with the wind velocity ranging from 3.0 to 9.0 m.p.h. The percentage reduction would also be influenced by the amount of heat lost through the floor and ceiling.

In sections of the country farther north, where winter cold is the main problem, the obvious thing to do is to seal the outside wall as tightly as possible in order to take advantage of the air space within the wall. In areas farther south, where summer heat presents the main problem, the walls should be constructed somewhat loosely. However, in this particular section where both summer and winter extremes of temperature are encountered, a type of construction is needed which will be effective in both cold and hot weather and provide a reasonable degree of comfort throughout the year.

Such a type of construction might employ a relatively loose exterior wall covering such as lapped weatherboarding or vertical boards and battens. The sheathing would be placed on the interior, and be covered with building paper and V-ceiling or other interior wall finish. This construction would allow some air movement within the wall and provide some means of escape for absorbed heat in summer. In winter infiltration of air through the wall into the house would be kept at a minimum, and the $1\frac{1}{2}$-inch thickness of wood or equivalent material would provide a fair degree of heat insulation.

There are other aspects of design and construction which have particular reference to summer conditions. For example, we have found that anything which we do in attempting to promote comfort in low-cost housing has little effect so long as solar radiation is permitted to enter the house through windows and doors. In our studies ordinary roller window shades reduced the daytime average of air temperature from 3 to 4 degrees and the average temperature of the wall, ceiling and floor surfaces about one degree. However, for some people, the reduction in air movement tends to offset the reduction in temperature. Although an analysis has not been completed, a preliminary inspection of the data and observations of the investigators indicate that the use of slatted blinds on the outside of windows and doors is much more effective and has the added advantage of permitting the entrance of air. The disadvantage in the use of exterior blinds is the inconvenience of operating them, especially when full length screens are used. The effectiveness of various types of window shading has also been the object of other investigators 1/

1/ Houghten, F. C. et al. Studies of Solar Radiation Through Bare and Shaded Windows. Journal of the American Society of Heating and Ventilating Engineers Vol. 40: 101-108.

The use of high ceilings has been quite customary in the past in the southern states although the present tendency, particularly in low-cost houses, is to reduce ceiling heights. In the experimental houses, all of which are of one-story construction, we found that there was no appreciable difference in air or surface temperature when comparing ceiling heights of eight and ten feet. It is obvious that houses with the lower ceiling heights would be cheaper to build and easier to heat in winter.

Attic ventilation by natural means is a subject of some discussion. Our studies have shown that gable louvers of the size ordinarily used are of little benefits in producing greater comfort in the rooms below. The use of such louvers together with an opening two inches wide running the full length of the cornice resulted in some reduction in ceiling-surface temperature. It is felt that the entire area of the gables should be louvered to be really effective, however, we have conducted no tests to substantiate this belief.

The kitchen is probably the most uncomfortable room in farm homes in the south where wood-burning ranges are used for cooking. We have had fairly good results in one-story houses with the use of a large grille, which can be closed in the winter, installed in the ceiling directly over the stove. With such an installation sufficient exhaust area must be provided from the attic. Since cross ventilation is also an aid in solving the problem of hot kitchens, more thought should be given to this factor in designing farmhouses. In one occupied house the range was located in one end of a combination kitchen-dining room. There was no cross ventilation in this portion of the room so that extremely high temperatures were experienced, particularly during periods of meal preparation. It was decided that the best remedy for the situation was to cut a door, with transom above, through the partition into an adjacent bedroom. Although analysis of data has not been completed, both the investigators and occupants of the house agreed that the installation produced very desirable results and was more than worth the cost. While not considered good practice to connect a bedroom with the kitchen in this manner, something must be sacrificed occasionally in order to produce greater comfort.

Other phases of our research have particular reference to winter conditions. The problem of reducing stratification or air temperature variation from floor to ceiling has been a matter of some concern to many engineers. The use of various types of heating units and forced air circulation, have been studied. Some of the heating installations, especially those utilizing forced air, undoubtedly have some influence on stratification. However, we believe that in most of these studies little thought has been given to the heat transmission and infiltration characteristics of the construction. The customary practice is to assume approximately 2 percent change in temperature from that at the five-foot level for each foot above or below this level. In a house having a ceiling height of eight feet with a temperature of 72 degrees at the five-foot level, the temperature variation from floor to ceiling, using the allowance mentioned would be 11½ degrees. In our studies in the test houses temperature differences between floor and ceiling as great as 65 degrees were measured with most of the differences falling between 20 and 40 degrees. Figure 2 is a curve showing stratification or air temperature difference from floor to ceiling plotted against fuel consumption rates illustrating the relation which we found between these two factors. It will be noted that the higher the fuel rate the greater was the stratification. In terms of a fixed temperature at the breathing level this means that the greater the heat loss the greater is the amount of fuel that will be required; in turn, greater fuel consumption, produces more pronounced stratification. One effective method of reducing stratification, therefore, is to reduce the heat loss from the house by various means.

The use of cotton seed hulls for insulation has been one of the phases of our project in which many people have expressed a great interest. In our winter tests we found that a 3 5/8 - inch thickness of hulls on the ceiling of the three-room test houses produced an average reduction in fuel consumption of from 16 to 25 percent, depending upon the amount of infiltration through the walls and the heat loss through the floor. In the one room houses having very high heat transmission characteristics the highest reduction was about 37

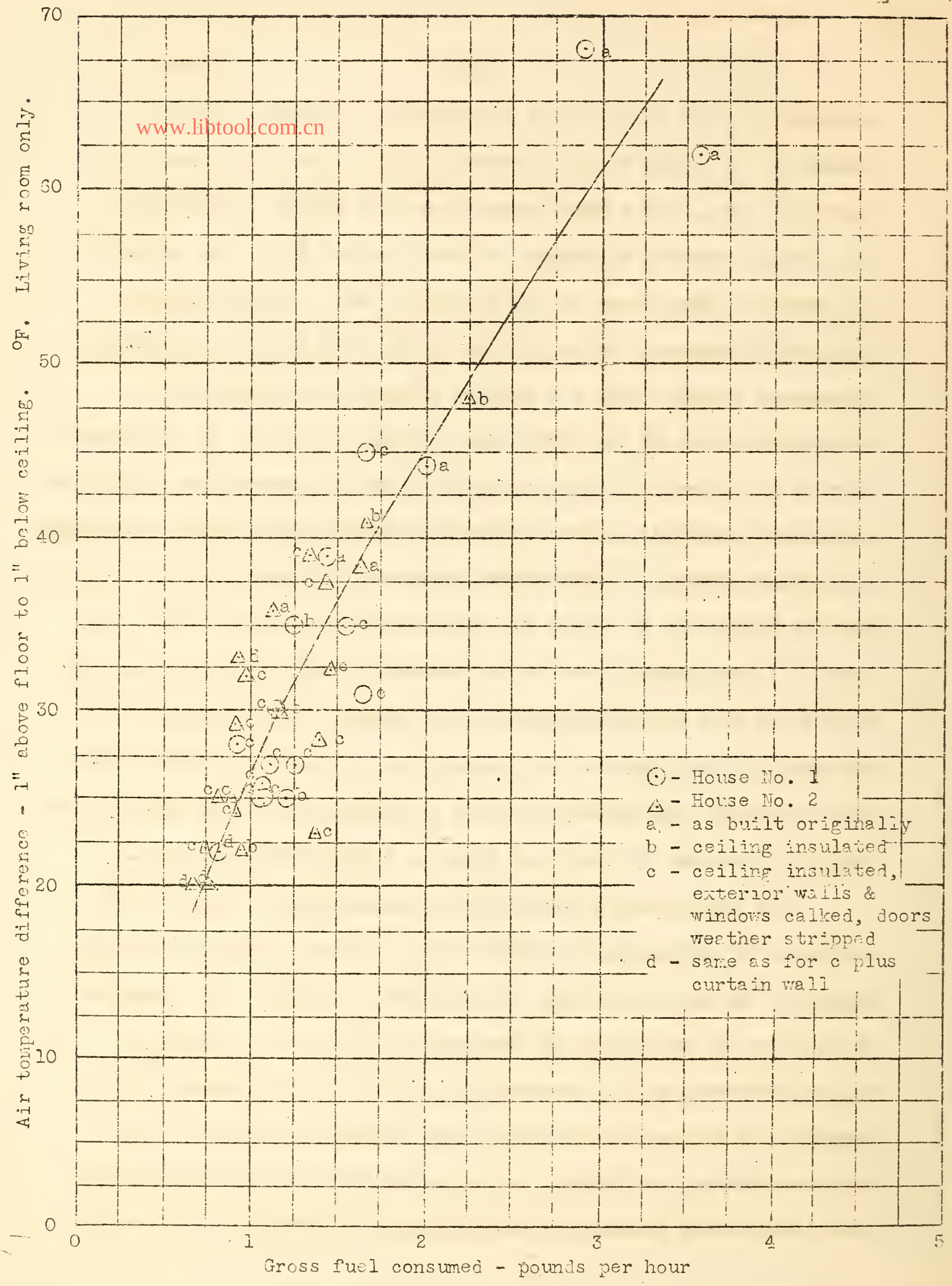

Figure 2 - Relation of fuel consumption to air temperature difference - floor to ceiling. Three room houses. Winter tests.

percent.

Our studies revealed that in summer insulation had little effect on air temperatures within the house under normal living conditions. However, the ceiling surface temperatures were reduced noticeably during the day. Although no method has been devised for determining the exact effect upon the human body of lowering temperatures of surrounding surfaces, it is known that cooler surfaces result in increased bodily comfort.

Resistance to fire is an important quality in an insulating material. For this reason, we are now recommending treatment with an ammonium sulphate solution which renders the hulls reasonably fire-resistant.

Further study of various treatments is being made in an effort to improve the effectiveness and to determine the permanency of the treatment.

In normal seasons the cost of cottonseed hulls is around ten dollars per ton. With a density of ten or eleven pounds per cubic foot and a layer thickness of 3-5/8 inches the cost per square foot of ceiling area would be about 1-3/4 cents. Ammonium sulphate required for the treatment costs less than one cent per square foot making the total cost of materials slightly less than 2-3/4 cents per square foot.

In touching on the subject of heating equipment it might be well to emphasize the fact that very little attention has been given to the development of low-cost heating equipment which will provide satisfactory heat when using fuel obtained from the farm. This is, indeed, a problem warranting serious consideration. The elimination of the inefficient fireplace and much of the heavy masonry required would be a big step forward, as affecting house design, cost and comfort.

There is the question of how much one can afford to spend for heating equipment. The average five room house being built by the FSA costs around $1400 to $1500, a figure which is near the limit the farmer can pay. Of this amount $50 to $70 is spent in constructing the fireplace and chimney, which in most cases comprises the heating system for the house. These houses might be considered as very near the minimum standard for construction, finish and equipment; therefore it would seem impossible, and certainly undesirable to spend less on the house in order to provide better heating equipment. Yet there is no question but that the farmer and his family should have better heating facilities than they now have.

Until we do have better heating systems, the only thing we can do is to utilize some improvements on existing ones. In our studies in the experimental houses, we have found that where an air-circulating heater is employed, registers in the partitions near the floor and near the ceiling provide much more uniform heating if the interior doors are open; however they are fairly satisfactory with interior doors closed. Registers near the ceiling in conjunction with a cold-air return under the floor were tried, but this arrangement, in addition to being more expensive, was not as satisfactory as the registers alone. Another arrangement which might be even cheaper would be to provide only the registers near the ceiling or transoms above the door and allow the colder air to return through open doors. While our tests have not included cheaper types of heaters, some improvement in stratification would no doubt be obtained with wall registers when common stoves are used.

Although our studies at Athens have revealed much information which I have not been able to give in this paper, I have tried to present to you in general terms those results which have the greatest practical application at this time. As stated before, there are many problems yet to be solved and we must intensify our efforts in order that some of these questions will be answered before a huge program of farm housing has to be undertaken. Certainly that day cannot be far off, for needed improvements in farm buildings have been postponed again and again. When the defense industries slacken production, the field of farm housing will provide opportunity for productive employment of men and the utilization of potential natural and industrial resources while making the difficult transition from emergency to normal conditions.