ture, is exposed to moisture damage—such as swelling, mold or discoloration.

Visible condensation may occur also in summer. It is often seen on basement concrete walls and floors which are cooled by the earth and which being massive, tend to hold a constant temperature from day to day while the weather dew-point temperature rises. When no water vapor is released in the space, the dew point tends to equal that of the outside (though it is likely to lag when there is slight ventilation). At times the dew-point temperature rises above the temperature of walls and floors and condensation results. If the basement is decorated the trouble may be serious. As an operating problem, the solution may be to reduce ventilation at times of high weather dew point, to warm the walls, or to dehumidify

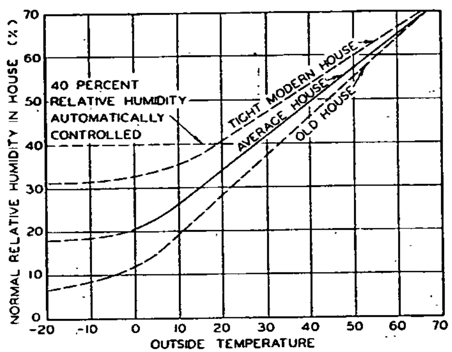

Fig. 5. Relative Humidity in Dwellings

the space. Warming the walls, a slow process at best, is generally accomplished in favorable climates by excess ventilation. In a climate having low temperature at night, it may be feasible to ventilate only at night and thus reduce the moisture content of hygroscopic materials which will then act as a desiccant to retard the dew-point rise during the day. In basement walls and floors insulation should be applied in the concrete or on its outside. Insulation placed on the inside of such walls eliminates visible condensation but fosters concealed condensation. The control of the latter will be discussed. A practical and fully effective technique for such control has, however, not been developed. Usually, sub-surface dwellings should be designed for occupancy and should be dehumidified.

A similar situation is seen in dwellings with concrete floor slabs laid on the ground where such slabs are not a part of the heating system. In a northern climate where high dew-point temperatures occur in summer, condensation or very high relative humidity may damage rugs which are themselves contributors to the trouble since they reduce the floor slab temperature. Slab floors above grade are not so serious a problem as floor slabs on grade but their response to air temperature change is slow. Faster warming is accomplished by the removal of rugs and abundant ventilation at proper times. In their design, floor slabs should have as low specific heat and as high thermal resistance as is consistent with other requirements. Suitable insulation below the slab, especially well drained gravel, will help

somewhat. A top surface cover of insulating value that is unaffected by water on its lower side would be desirable in the less favorable northern climates.

The avoidance of interior visible condensation is partly a construction and partly an operating problem. It is accomplished by reducing the interior dew-point temperature or by raising the surface temperatures that are below the dew-point, or both. The dew-point temperature may be lowered by giving attention to the sources of the moisture, and in winter, may be controlled by ventilation, or possibly by some moisture absorption process. The temperatures of the inside room surfaces in winter may be increased by adding insulation to outside walls, by double glazing of windows, by circulating warm air over the surface, or perhaps by direct heating of the surface. The most expedient method of overcoming a surface condensation difficulty will depend upon special conditions surrounding the problem.

CONCEALED CONDENSATION IN HEATED BUILDINGS

Water vapor produced in a building necessarily raises the vapor pressure above that outside thus providing the force that causes its diffusion into exterior walls. The amount of vapor pressure rise in the building depends on the amount of vapor produced and inversely on its chance to escape. The resulting balance may be expressed in terms of relative humidity if the inside temperature is 70 F. The relative humidity in heated buildings covers nearly all of the possible range. In zero weather it may be only 10 percent in an office, and 85 percent in an industrial plant where humidification is required for a process, or where vapor release is incidental to a process. In residences the relative humidity in cold winter weather ranges from 10 percent to 60 percent, the latter figure applying to a very small, crowded and unventilated dwelling. A 40 percent level is considered representative of a substantial number of modern tightly constructed small houses although the average house relative humidity is probably below 25 percent. Surveys in residences show that the relative humidity increases as would be expected in warmer weather. Fig. 5 represents the results of one such survey.[6]

When water vapor is allowed to enter a wall and condensation occurs on its outer cold elements, it appears as frost or liquid. If the weather temperature rises frequently, frost melts and becoming liquid, is likely to penetrate capillary materials like wood, or run down when the surface is non-absorbing or is already saturated with water. In weather that is continuously cold for a long period, the frost may build back into a cavity or fibrous insulation and, when it reaches a warmer plane, will run to lower, cooler levels where it forms a mass of ice. Water seepage to the weather side may occur harmlessly in masonry walls when the weather is above freezing but water seepage into the building must obviously be avoided. In typical frame construction with wood sheathing which has large water absorbing capacity, seepage is rare and occurs only after a long period of steady cold weather. More generally, moisture accumulates in wood sheathing and siding through the colder months and reaches a peak in late winter, after which the drying of spring and summer completes the annual cycle. The average winter temperature and its duration are factors in the condensation problem. In Fig. 6 the map of the United States is divided into condensation zones based on winter weather conditions. The solid lines separating the zones follow state lines, and are those recommended by the