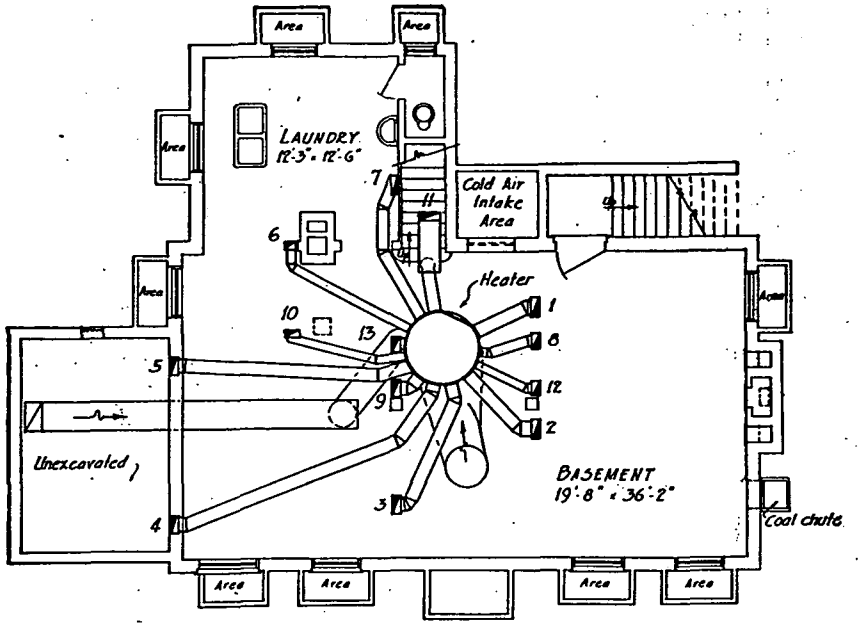

FIG. 8. BASEMENT PLAN, RESEARCH RESIDENCE

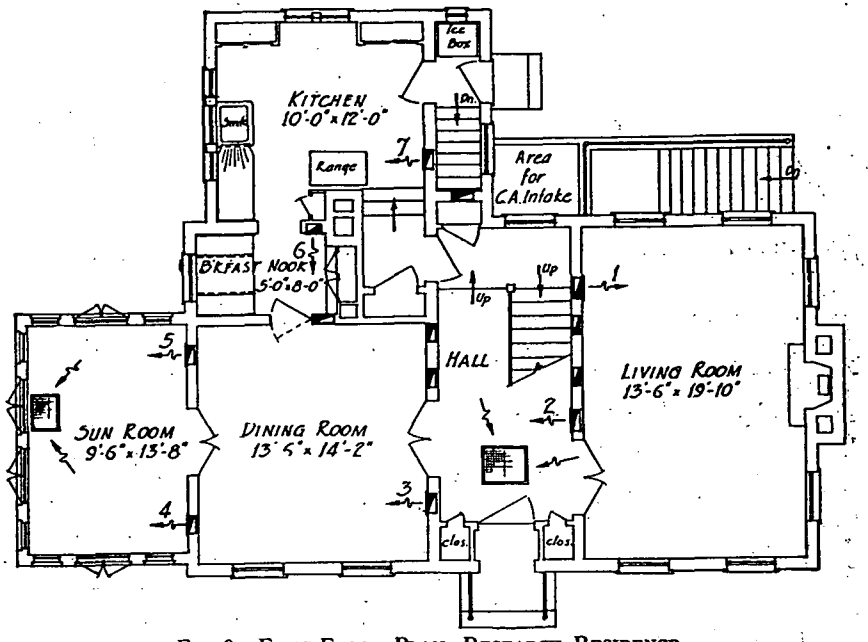

FIG. 9. FIRST-FLOOR PLAN, RESEARCH RESIDENCE

approximate nearest to the 175-F register warm-air temperature are—combustion rate, 7 lb; warm-air register temperature, 173 F; efficiency of the furnace, 58.5 per cent. The third factor is efficiency, which, in turn, is a function of the combustion rate varying with it as shown by the efficiency curve of Fig. 6. The fourth factor is the heat value per pound of fuel burned, which was 12,790 Btu, but is not shown on the curves since it was constant for all combustion rates.

From the relation existing between these factors it is found (Fig. 6) that the capacity of the furnace under test is 147,750 Btu per hour for the total grate, which gives the capacity at the furnace bonnet per square foot of grate as 51,300 Btu and per square inch of grate as 356 Btu per hour.

Suppose it is desired to select a furnace to deliver air to the rooms at a register temperature approximating 160 F rather than 175 F. Referring to the curves, the relation is—combustion rate, 5.5 lb; register warm-air temperature 160 F; and efficiency of the furnace 62 per cent. Under this condition the capacity of the furnace at the furnace bonnet per square foot of grate area is 43,300 Btu per hour, and per square inch of grate it is 300 Btu per hour. From these performance values, the grate area for any plant requirement will be, (allowing 20 per cent heat loss between furnace and registers):

$$\text{Grate area (175 F register temperature), square inches } \frac{1.2\ H}{356} = 0.0034H^* \quad (7)$$

$$\text{Grate area (160 F), square inches } = \frac{1.2\ H}{300} = 0.0040H^* \quad (8)$$

It is not always possible to obtain performance curves, and the following method is suggested as being a close check. An addition of 2 per cent of the furnace capacity is proposed for each unit that the heating surface-grate area ratio of the furnace exceeds 20. This addition is based on tests of four types of furnaces having various ratios of heating surface to grate area, at the University of Illinois.

Let E = efficiency of the furnace.
f = fuel value of the coal, Btu per pound.
p = pounds of coal burned per square foot grate per hour.
R = ratio of heating surface to grate area.
H = total heat requirements of the house.

$$\text{Grate area, square inches} = \frac{1.2 \times 144\ H}{Efp\ [1 + 0.02\ (R - 20)\ ]} \text{ for all inside air} \quad (9)$$

For coal having a heat value of 12,000 Btu, a furnace having 60 per cent efficiency, and 6-lb coal burned per square foot grate per hour, and 20 sq ft of heating surface for 1 sq ft of grate this becomes:

$$\text{Grate area, square inches} = \frac{1.2 \times 144\ H}{0.60 \times 12{,}000 \times 6} \text{ for all inside air} \quad (10)$$

*Let H = Btu heat loss from the entire house per hour = summation of all room losses $H_1 + H_2$ + etc. + the Btu necessary to heat the fresh air, if any, at intake. This fresh air loss in Btu per hour will be approximately 1.27 times the cubic feet of air admitted through the intake per hour on a zero day. For systems which recirculate all the air this value will be zero. For systems which have a fresh air intake, controlled by damper, this value might well be approximated, since this loss will probably be reduced to a minimum on a zero day. Assume for such cases, that the building loss is increased by 25 per cent, and that there is the usual 20 per cent loss between furnace and registers.