Circulation is accelerated if the drop to the furnace is through a round inclined pipe with, say, two 45-deg. elbows rather than through a vertical drop and two 90 deg. elbows. The top of the shoe should never enter the casing above the level of the grate in the furnace. To accomplish this the shoe must be wide.

## FURNACE

The size of furnace should, of course, be such as will provide the necessary air heating capacity, usually expressed in square inches of

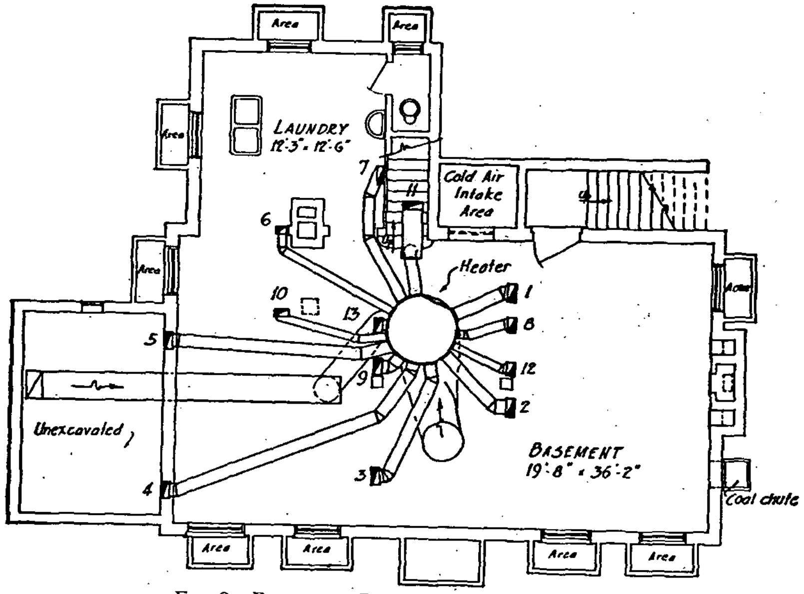


FIG. 8. BASEMENT PLAN RESEARCH RESIDENCE

leader pipe area, and at the same time provide a grate of the proper area to burn the necessary fuel at a reasonable chimney draft. The total leader pipe area required is easily obtained by finding the sum of the leader pipe areas as already designated.

The grate area will depend on several factors of which four are very important. First of all, the air temperature at the register for which the plant has been designed must be determined. Usually, this temperature is taken as 175 deg. fahr. Second in importance is the combustion rate, *which must always correspond with the register air temperature*, as is shown by reference to a set of typical furnace performance curves (Fig. 6) for a cast-iron circular radiator furnace with a 23-in. diameter grate and 50-in. diameter casing. The conditions shown on these curves which seem to approximate nearest to the 175 deg. register warm-air temperature are—combustion rate 7 lb., warm-air register temperature 173 deg., 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 B.t.u., 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 B.t.u. per hour for the total grate, which gives the capacity at the furnace bonnet per square foot of grate as 51,300 B.t.u. and per square inch of grate as 356 B.t.u. per hour.

Suppose it is desired to select a furnace to deliver air to the rooms at a register temperature approximating 160 deg. rather than 175 deg.

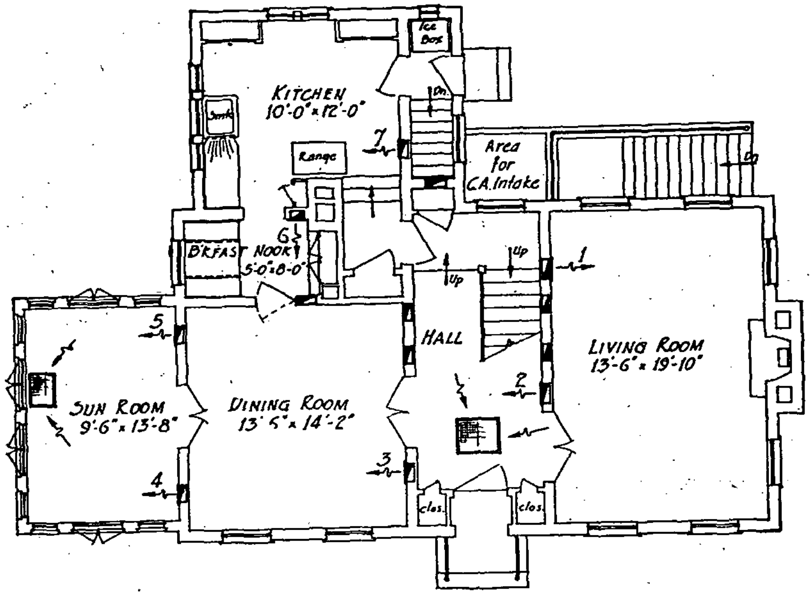


FIG. 9. FIRST FLOOR PLAN RESEARCH RESIDENCE

Referring to the curves, the relation is—combustion rate 5.5 lb., register warm-air temperature 160 deg. 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 B.t.u. per hour, and per square inch of grate it is 300 B.t.u. 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):

$$\text{Grate area (175 deg. register temperature), square inches } \frac{1.2\ H}{356} = 0.0034H^1 \quad (7)$$

$$\text{Grate Area (160 deg.), square inches } = \frac{1.2\ H}{300} = 0.0040H^1 \quad (8)$$

[1]Let $H$ = B.t.u. heat loss from the entire house per hour = summation of all room losses $H_1 + H_2$ + etc. + the B.t.u. necessary to heat the fresh air if any, at intake. This fresh air loss in B.t.u. will be