Practical rates of combustion run from 5 lb. per sq. ft. of grate in small heating boilers to 40 lb. per sq. ft. of grate in large power boilers depending upon the fuel and draft.

2. Square feet of heating surface which determines the capacity of the boiler for transferring heat from fuel to heating medium. This may be divided into prime heating surface (in direct contact with the fuel bed and its direct radiation) and secondary heating surfaces in contact with the heated gases, only.

In an ordinary three-pass boiler, from 60 to 80 per cent of the total heat is transferred by the surface in the first pass, which means that approximately this one-third of the surface transmits at a rate of from four to five times that of the remaining two-thirds of the surface. All or a part of the other two-thirds may be and is frequently more or less omitted as it is seen that this can be done without decreasing the capacity more than 30 per cent or the efficiency more than 20 per cent. Any omission of this surface increases stack temperatures and decreases the efficiency of the boiler.

A long-established rule for the rating of high-pressure boilers on the basis of their heating surface is to allow 10 sq. ft. of heating surface per boiler horsepower of 34.5 lb. of water evaporated from and at 212 deg. fahr. per hour. This means $\frac{33465}{10}$ B.t.u. per hour sq. ft. of heating surface. On this basis the rating of heating boilers would equal 3346.5 multiplied by the square feet of heating surface in B.t.u. per hour.

Heating boilers are seldom rated on this basis as the ratio of prime to secondary surface, the design and arrangement of surface are so different in the various types of boilers and there is no well-established practice as to stack temperatures and efficiencies upon which uniform ratings may be based. While this basis is still used for the nominal rating of high-pressure boilers it is not in effect since usual practice is to operate at from 150 to 300 per cent of this normal rating, which may be successfully done, with proper arrangement of furnace and heating surface, without serious loss in efficiency.

3. The capacity of the fire-box for fuel and the capacity of the combustion chamber for proper combustion at the full boiler rating. The capacity for fuel must be sufficient for the necessary charge to run from one firing period to another without forming too deep a bed of fuel and ash on the grate to permit the passage of sufficient air for proper combustion with the available draft and at the same time leave sufficient space for proper combustion. In the case of oil fuel the capacity of combustion chamber should be sufficient so that the flame does not impinge upon the walls or heating surface.

4. In adjusting the boiler to the load care must be exercised to see that all of the conditions to be met are taken into account and proper factors of safety are allowed for heating-up the building.

A heating boiler designed for the maximum conditions will be operating under a comparatively low load factor for the greater part of the time and may be correspondently inefficient and uneconomical, unless properly designed to meet these conditions. In the smaller plants this is hard to overcome without either having a boiler too large for economy or too small to properly heat the building up in a reasonable time. This is sometimes attempted by having the normal capacity of the boiler about 80 per cent of that required for maximum conditions. In order to make this successful the boiler plant must be adapted to operate successfully on at least 50 per cent overload for short periods.

In larger plants the boilers may be divided into two or three units, so that one unit may be operated during mild weather, one or two units during average weather and the entire plant during extreme weather which arrangement is ideal for flexibility and economy.

In office buildings, factories and other work places, it is not generally considered so necessary to have the temperature up to normal at the beginning of the working period as it is in schools, churches, theatres and other places of assemblages where the occupants are sitting still, and for this reason the relative capacity of the heating system may be less.

In school buildings and other buildings where the heating of the air for ventilation is a large part of the load, this factor may be greatly reduced by recirculating this air during the heating-up period, so that while the entire normal average load on the building may be from two to three times as much for heating the air as for supplying the direct radiation the heating-up load for the air may be reduced to from one-half to one-third of its normal value so that the total load may not be more than twice the direct radiation load. By continuous recirculation arranged to vary the amount of air taken in from the outside from 100 per cent at an outside temperature of 65 deg. to 25 per cent at an

outside temperature of 6 deg. the boiler capacity required for heating the air may be held practically constant at about 25 per cent of that required for 100 per cent of air from the outside.

The following factors of safety are recommended in the selection of boilers:

For school buildings where recirculation is not to be employed 50 per cent to 100 per cent.
For school buildings where full recirculation is to be employed 25 per cent to 50 per cent.
For buildings heated periodically 50 per cent to 100 per cent.
For other buildings 25 per cent to 50 per cent.

5. In figuring the total load on the boilers the equivalent of the piping system in square feet of radiation must be added to the actual radiation and all other heat-using elements must also be added for. In the absence of exact data from 10 per cent to 15 per cent is usually added for the average piping systems. The capacity of a boiler should state what it is capable of doing under certain conditions; the normal capacity under normal conditions and the maximum capacity under maximum conditions. The draft requirements of a boiler are for forcing the air through the grates and fuel bed and for creating the necessary velocity and overcoming friction in passing the gases through the gas passages of the boiler. Boiler ratings should give these two factors of the draft requirements under several load conditions. As a rough guide the loss in draft through the passage of the boiler from the furnace to the smoke outlet (under full load) ranges from 0.05 to 0.15 in. water depending upon the size and type of boiler.

A reliable simple formula for the chimney capacity of heating boilers is:

$$C = K A \sqrt{H}$$

where

C = pounds of coal to be burned per hour.
K = 10 for small chimneys and up to 15 for large ones.
A = cross sectional area of chimney in square feet.
H = height of chimney in feet above the grates.

IMPORTANCE OF DRAFT

The capacity a boiler is capable of developing depends more upon the amount of draft available than upon any other factor. Assuming that a chimney is smoke tight and well built according to the Ordinance for Construction of Chimneys, 1921 (recommended by the *National Board of Fire Underwriters* and approved by the Society), the intensity of the draft depends upon the height of the chimney, and the quantity or amount of draft depends principally upon the effective area of the chimney. According to their height, heating chimneys are divided into three classes, the erratic, uncertain and reliable. Chimneys less than 36 ft. high are erratic in their action. The head produced by such a low height is so small that the least unfavorable condition or interference practically puts the chimney out of commission.

Chimneys between 36 ft. and 64 ft. in height are in the doubtful zone, sometimes good and sometimes bad. The head produced by this relatively low height is frequently offset by slight unfavorable conditions that may be difficult to locate. Chimneys over 64 ft. in height are usually