normal gases of combustion, at the average temperature for which the chimney was designed, and then the flow of these gases was suddenly stopped. This theoretical draft can never be attained in practice, but it is the basis of all scientific chimney design.

The general formula for the theoretical draft of a chimney, with all observable factors taken into account, is expressed by equation (1).

$$D_t = 6.43\, H\, P_o \left(\frac{W_o}{T_o} - \frac{W_g}{T_c} \right) \qquad (1)$$

where

D_t = theoretical draft in inches of water.
H = height of the chimney above grate bars, in feet.
P_o = pressure of the atmosphere in pounds per square inch.
W_o = weight of air (at 32 deg. fahr.) in pounds per cubic foot.
W_g = weight of the flue gas (at 32 deg. fahr.) in pounds per cubic foot.
T_o = absolute temperature of the air in deg. fahr.
T_c = average, absolute temperature of the gases in the chimney in deg. fahr.

For an atmospheric pressure of 14.7 lb. and a weight of air equal to the weight of the flue gases (at 32 deg. fahr.) of 0.08071 lb. per cubic foot this formula reduces to

$$D_n = 7.63 \left(\frac{1}{T_o} - \frac{1}{T_c} \right) \qquad (2)$$

where

D_n = the normal theoretical draft per foot of height of chimney under usual atmospheric conditions at sea level.

For a temperature of 0 deg. fahr. outside and an average temperature of 600 deg. fahr. in the chimney this reduces to 0.0094 in. of draft per foot of chimney height.

TABLE 1. CORRECTIONS IN INCHES OF WATER PER FOOT OF CHIMNEY TO BE DEDUCTED FROM THE THEORETICAL DRAFT FOR OTHER THAN A 0.08071 LB. PER CUBIC FOOT (AT 32 DEG. FAHR.) DENSITY OF FLUE GAS

Temperature of Flue Gas Deg. Fahr.	Density of Flue Gas in Pounds per Cubic Foot at 32 Deg. Fahr.	Correction Deduction in Inches of Water per Foot of Height
400	0.08071	0
600		
800		
400	0.0820	0.00014
600		0.00011
800		0.00009
400	0.0830	0.00025
600		0.00020
800		0.00017
400	0.0840	0.00036
600		0.00030
800		0.00025
400	0.0855	0.00053
600		0.00043
800		0.00036

The correction factor for changes in atmospheric pressure, ranges from 68 per cent at 10 lb. pressure to 100 per cent at 14.7 lb. pressure, in direct proportions to the pressure.

The corrections for different densities of flue gas are shown in Table 1.

The available draft of a chimney is the theoretical draft after deducting the various losses back to the point of reference, such as at the base of the chimney or the furnace of the boiler. Ordinarily the point at which the available draft is measured is in the furnace directly above the fuel bed.

The losses which must be deducted from the theoretical draft to obtain the available draft at this point are as follows: (1) the velocity and friction losses in the chimney, (2) the velocity and friction losses in the breeching and (3) the velocity and friction losses in the boiler.

The loss due to velocity of the flue gases in the chimney is expressed by equation (3).

$$D_{cv} = 0.1185 \frac{V_c^2}{T_c} = 0.193 \frac{Q^2}{D^4 T_c} = 0.0001222 \frac{W^2 T_c}{D^4} \qquad (3)$$

where

D_{cv} = loss of draft due to velocity in the chimney.
V_c = velocity of the chimney gases in feet per second.
Q = cubic feet of gas flowing per second.
D = diameter of a circular chimney in feet.
W = weight of gases flowing in pounds per second.

All for a flue gas and air weight of 0.08071 lb. per cubic foot (at 32 deg. fahr.) and an atmospheric pressure of 14.7 lb.

The correction factor for different weights of flue gas run from 100 per cent at a weight of 0.08071 lb. per cubic foot (at 32 deg. fahr.) to 109 per cent at a weight of 0.088 lb. per cubic foot in direct proportion to the flue gas weight.

Equation (3) gives the loss due to velocity in the chimney in terms of the velocity, the quantity and the weight of the gases flowing, so that this loss may be figured from either of these factors, which may be known.

The loss of draft due to the friction of the gases in the chimney is expressed by equation (4).

$$D_{cf} = 0.0076 \frac{V_c^2 L}{T_c D} = 0.0123 \frac{Q^2 L}{T_c D^5} = 0.0000078 \frac{W^2 T_c L}{D^5} \qquad (4)$$

where

D_{cf} = loss in draft due to friction in the chimney.
L = length of chimney (in feet) through which the gases pass; all for the standard condition heretofore specified. It will be noted that equation (4) also gives the loss in terms of the velocity, quantity and weight of gases flowing.

Equation (4) is for circular sections. For square sections the friction loss is approximately 62 per cent of that for circular section of a diameter equal to the width of the square when handling the same weight of gases per second.

The loss of draft in the breeching is expressed by equation (5).

$$D_b = 0.000955 \frac{W^2}{D^5_{br}} \qquad (5)$$