complete discussion of free area ratio and its effect on system performance, see Reference 14.

The equations for the heating requirements of a snow-melting system have been derived and thoroughly explained in Reference 15. The general equation for slab output, q_o, is

$$q_o = q_s + q_m + R_A(q_e + q_h) \quad (15)$$

where

q_s = sensible heat transferred to snow, Btu per (hour) (square foot).
q_m = heat of fusion, Btu per (hour) (square foot).
R_A = ratio of snow-free area to total area, dimensionless.
q_e = heat of vaporization, Btu per (hour) (square foot).
q_h = heat transfer by convection and radiation, Btu per (hour) (square foot).

The sensible heat, q_s, to raise the temperature of the snow to 32 F is

$$q_s = 2.6s\ (32 - t_a) \quad (16)$$

where

s = rate of snowfall, see Table 5, inches of water equivalent per hour.
t_a = air temperature, Fahrenheit.

The heat of fusion, q_m, to melt the snow is

$$q_m = 746s \quad (17)$$

The heat of vaporization, q_e, (mass transfer) is

$$q_e = 1074(0.0201v + 0.055)(0.185 - p_{av})R_A \quad (18)$$

where

p_{av} = vapor pressure of moist air, inches of mercury.

The heat transfer, q_h, (convection and radiation) is

$$q_h = 11.4(0.0201v + 0.055)(t_f - t_a)R_A \quad (19)$$

where

v = wind velocity, miles per hour.
t_f = water film temperature, Fahrenheit.

In addition to determining the four heating requirements, it is necessary to make allowance for back and edge losses. These losses vary from 30 to 50 percent, depending upon the slab construction.

The equation for the required fluid temperature to provide an output q_o has been derived in Reference 15. For construction similar to Fig. 19, the equation is

$$t_m = 0.5q_o + t_f \quad (20)$$

where

t_m = mean fluid temperature (antifreeze solution), Fahrenheit.

Equation 20 will suffice for 1 in. IPS as well as ¾ in. — see Fig. 19.

Values for s for certain cities are given in Table 5. Using the values for s given in Table 5, the appropriate values for t_a and v, the values for q_o may be found in Table 6. In preparing Table 6, only values of p_{av} for relative humidities of 80 percent were used. The variation in q_o and t_m

TABLE 5. SNOWFALL DATA FOR VARIOUS CITIES[a]

City	Number of Readings with Maximum Temperature in 6-Hour Period below Freezing at Various Snowfall Rates				Total Readings Taken	Assumed Design Rate of Snowfall[b]
	Snowfall Rate in Equivalent Inches of Water per Six Hours.					
	0.00 to 0.24	0.25 to 0.49	0.50 to 0.74	0.75 to 0.99		s
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
Albany, N. Y.	2052	29	5	1	3720	0.16
Asheville, N. C.	463	5	1	0	3536	0.08
Billings, Mont.	1640	4	0	0	3532	0.08
Bismarck, N. D.	2838	0	0	0	3720	0.08
Boise, Idaho	1300	3	0	0	3720	0.08
Boston, Mass.	1323	11	4	2	3720	0.16
Buffalo, N. Y.	1871	23	3	1	3720	0.16
Burlington, Vt.	2390	9	0	0	3720	0.08
Caribou, Maine	1363	19	1	0	1672	0.16
Chicago, Ill.	1498	3	0	1	2976	0.08
Cincinnati, Ohio	1045	3	0	0	3720	0.08
Cleveland, Ohio	1569	2	0	0	3720	0.08
Columbus, Ohio	1351	4	1	0	3720	0.08
Denver, Col.	1207	4	0	0	3720	0.08
Detroit, Mich.	1830	5	2	0	3720	0.08
Evansville, Ind.	916	5	1	1	3720	0.08
Hartford, Conn.	1514	44	9	3	3720	0.25
Kansas City, Mo.	1189	12	2	1	3720	0.16
Madison, Wisc.	2370	5	2	0	3720	0.08
Minneapolis, Minn.	2703	7	0	0	3720	0.08
Oklahoma City, Okla.	613	8	4	0	3720	0.16
Omaha, Neb.	1795	8	1	0	3720	0.16
Philadelphia, Pa.	891	10	2	1	3720	0.16
Pittsburgh, Pa.	1365	6	2	0	3720	0.08
Portland, Maine	2054	33	4	1	3720	0.16
St. Louis, Mo.	1088	5	0	1	3720	0.08
Salt Lake City, Utah	1482	5	0	0	3720	0.08
Spokane, Wash.	1545	11	1	0	3720	0.16
Washington, D. C.	533	7	2	1	3348	0.16
New York, N. Y.[c]						0.16

[a] Data from *U. S. Weather Bureau*. Based on readings taken 1:30 a.m., 7:30 a.m., 1:30 p.m., and 7:30 p.m. daily from November 15 to February 15 from 1940 to 1949. (Where the total readings are less than 3720 the period of record is less than 10 years.) The difference between Col. 6 and the sum of readings in Cols. 2, 3, 4, and 5 is the number of readings with a maximum temperature (in the 6-hr period) above freezing.

[b] The design rate is found as follows: Proceed to left (on line from any city) from Column 5 until the column containing the tenth reading is found. Assume that the larger value in the heading of the selected column is an *average maximum* value, and should be multiplied by 2 to obtain the maximum rate for a 6-hour period. This maximum rate divided by 6 is the design rate per hour. This is equivalent to dividing the larger value in the heading of the selected column by 3.

For example: For Albany, N. Y. Columns 5 and 4 total six readings, and consequently the tenth reading is in Column 3, which has the larger value of 0.49 in the column heading. Dividing 0.49 by 3, the design water equivalent of 0.16 inches per hour is found, as listed in Column 7.

[c] New York City record was not used in this tabulation since the records for that station were not comparable with those of the other stations.

for humidities of 75, 80, 85 and 90 percent are given in Reference 14, and may be calculated by solving Equations 21 and 22.

$$\frac{dt_m}{dp_{av}} = -537\ (0.0201v + 0.055)\ A_r \quad (21)$$