$A_r = 1$; commercial areas (e.g., sidewalks around stores, etc.) may be designed with $A_r = 0.5$; and private driveways, or areas where low installation costs are imperative, may be designed with $A_r = 0$. For a more complete discussion of free area ratio and its effect on system performance, see Reference 6.

The equations for the heating requirements of a snow melting system have been derived and thoroughly explained in Reference 7. The general equation for slab output, q_o, is

$$q_o = q_s + q_m + A_r(q_e + q_h) \tag{7}$$

where

q_s = sensible heat transferred to snow, Btu per (hour) (square foot).
q_m = heat of fusion, Btu per (hour) (square foot).
A_r = 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).

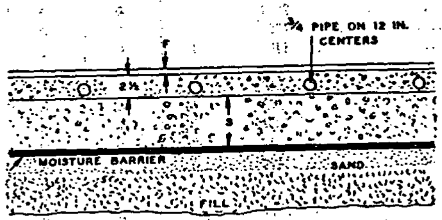

FIG. 16. DETAIL OF SNOW MELTING PANEL

F = Depth of Finish Coat—Assumed as ½ in. of concrete. Finish Coat may be asphalt but then cover slab should be reduced from 3 in. Depth of slab should always keep thermal resistance equal to 3 in. of concrete.
S = Depth required by structural design.

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

$$q_s = 2.6s\ (32 - t_a) \tag{8}$$

where

s = rate of snowfall, see Table 3, inches of water equivalent per hour.
t_a = air temperature, Fahrenheit.

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

$$q_m = 746s \tag{9}$$

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

$$q_e = 1074(0.0201v + 0.055)(0.185 - p_{av})A_r \tag{10}$$

where

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

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

$$q_h = 11.4(0.0201v + 0.055)(t_f - t_a)A_r \tag{11}$$

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 7. For construction similar to Fig. 16, the equation is

$$t_m = 0.5q_o + t_f \tag{12}$$

where

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

Equation 12 will suffice for 1 in. IPS as well as ¾ in. — see Fig. 16.

TABLE 4. HEAT OUTPUT AND FLUID TEMPERATURE FOR SNOW MELTING SYSTEMS

s Rate of Snowfall	A_r		t_a = 0 F, Velocity v 5	10	15	t_a = 10 F, Velocity v 5	10	15	t_a = 20 F, Velocity v 5	10	15	t_a = 30 F, Velocity v 5	10	15
0.08	1.0	q_o	151	205	260	127	168	209	102	128	154	75	84	94
		t_m	108	135	162	97	117	138	85	97	110	70	75	79
	0.0	q_o	66	66	66	64	64	64	62	62	62	60	60	60
		t_m	66	66	66	65	65	65	64	64	64	63	63	63
0.16	1.0	q_o	218	273	327	193	233	274	165	191	217	135	144	154
		t_m	142	169	198	129	149	170	117	129	142	100	105	109
	0.0	q_o	133	133	133	129	129	129	125	125	125	121	121	121
		t_m	99	99	99	97	97	97	95	95	95	93	93	93
0.25	1.0	q_o	292	347	401	265	305	346	235	261	287	203	212	221
		t_m	179	206	234	165	186	206	151	163	176	134	139	144
	0.0	q_o	208	208	208	202	202	202	195	195	195	188	188	188
		t_m	137	137	137	134	134	134	131	131	131	127	127	127

Note: This table is based on a relative humidity of 80 percent for all air temperatures.
s = Rate of snowfall, inches of water equivalent per hour (See Table 3).
A_r = Free area ratio.
q_o = Slab output, Btu per (hour) (square foot).
t_a = Air temperature, Fahrenheit.
t_m = Fluid temperature, Fahrenheit. Based on construction as shown in Fig. 16.
v = Wind velocity, miles per hour.

Values for s for certain cities are given in Table 3. Using the values for s given in Table 3, the appropriate values for t_a and v, the values for q_o may be found in Table 4. In preparing Table 4, only values of p_{av} for relative humidities of 80 percent were used. The variation in q_o and t_m for humidities of 75, 80, 85 and 90 percent are given in Reference 6, and may be calculated by solving Equations 13 and 14.

$$\frac{dt_m}{dp_{av}} = -537\ (0.0201v + 0.055)\ A_r \tag{13}$$

$$\frac{dq_o}{dp_{av}} = -1074\ (0.0201v + 0.055)\ A_r \tag{14}$$

When selecting the heat exchanger, it will be necessary to allow for the thermal properties of the anti-freeze solution. The manufacturer should be given data on the type and concentration of anti-freeze, the tempera-