Solution: The normal heat transmission through various surfaces shown in load calculations are determined by application of Formula 1.

It is quite obvious from the shape and exposure of this store that the maximum sun load will exist on the west wall. Since the west wall has a large glass area with a negligible time lag, the peak load may be expected at 4:00 p.m. at which time, from Table 4, $I_G = 182$. I_G for south glass at 4:00 p.m. is 2. Because of the small amount of solar radiation transmitted through the south glass, the transmission due to temperature difference has also been included. Assuming time lag in roof and walls to be 2 hours, the corresponding values for I for south and west walls and roof will be those shown in Table 4 for 2:00 p.m. They are respectively 77, 143 and 258. A time lag of 1 hour was assumed for the west door amounting to $I = 192$. By substituting these values in equations 2 and 3 the solar heat load is determined.

To determine the heat gain from the outside air it is necessary first to determine the volume of the outside air to be introduced. Since the show windows are sealed so as not to permit infiltration and since there are only three doors in this store through which infiltration can take place, it is obvious that infiltration of air will be a negligible quantity. The volume of the store is 21,600 cu ft. Good practice indicates that in a store of this character there should be a minimum of from 1 to 1½ outside air changes per hour. On a basis of 1½ air changes the volume of outside air to be introduced would be 32,400 cfh. By reference to Chapter 3 it will be noted that the minimum ventilation requirements are 10 cfm per person. On this basis the ventilation requirements would be 30,000 cfh. Since this will produce approximately 1½ outside air changes per hour, 30,000 cfh will be considered in this application.

To determine load imposed by occupants it will be found from Table 4, Chapter 3 that the average person standing at rest will dissipate 225 Btu sensible heat and 206 Btu latent heat per hour.

NORMAL TRANSMISSION LOAD:

SURFACE	DIMENSIONS	AREA SQ FT	U	TEMP. DIFF. DEG F	BTU PER HOUR
S Glass	2(2 ft 6 in. x 7 ft)+ 2(10 ft x 6 ft)	155	1.13	15	2,627
S Wall	(30 ft x 12 ft)−155	205	0.33	15	1,015
W Wall	(60 ft x 12 ft)−321	399	0.33	15	1,975
W Door	3 ft x 7 ft	21	0.51	15	161
Roof	60 ft x 30 ft	1800	0.26	15	7,020
Floor	26 ft x 54 ft	1404	0.34	5	2,387
N Partition	30 ft x 12 ft	360	0.34	8	979
Total					16,164

SUN LOAD:

SURFACE	DIMENSIONS	AREA SQ FT	F	a	I OR I_G	SHADE FACTOR	BTU PER HOUR
S Wall		205	0.078	0.7	77		862
S Glass		155			2	0.28	87
W Glass	3(14 ft x 6 ft)+ (8 ft x 6 ft)	300			182	0.28	15,288
W Door		21	0.118	0.7	192		333
W Wall		399	0.078	0.7	143		3,113
Roof		1800	0.062	0.9	258		25,914
Total							45,597

OUTSIDE AIR HEAT GAIN:

Sensible heat, $H_s = 0.24 \times 60\ d_o\ Q\ (t_o - t)$ (Formula 4).

$Q = 50 \times 10 = 500$ cfm.

Density of air at 95 F dry-bulb and 75 F wet-bulb for a barometric pressure of 29.92 in. is 0.07089 lb per cubic foot (Table 4, Chapter 1).

Dew-point of outdoor air is 66 F (psychrometric chart).

Partial pressure of vapor is 0.64378 in. Hg. (Pressure of saturated vapor at 66 F, Table 6, Chapter 1).

$W = 0.622 \left(\frac{e}{B - e}\right) = 0.622 \left(\frac{0.64378}{29.92 - 0.64378}\right) = 0.0137$ lb water vapor per pound dry air (Formula 5 a, Chapter 1).

$\frac{1}{1 \text{ plus } 0.0137} = 0.986$ lb dry air per pound outside air.

$d_o = 0.07089 \times 0.986 = 0.0699$ lb dry air per cubic foot outside air.

$H_s = 60 \times 500 \times 0.0699 \times 0.24\ (95\text{-}80) = 7549$ Btu per hour.

Total heat, $H = 60\ d_o\ Q\ (h_o - h)$ (Formula 5).

$h_o = 38.46$ Btu per pound dry air at 75 F wet-bulb (Table 6, Chapter 1).

$h = 31.51$ Btu per pound dry air at 67 F wet-bulb (Table 6, Chapter 1).

$H = 60 \times 0.0699 \times 500\ (38.46 - 31.51) = 14{,}574$ Btu per hour.

Latent heat gain from outside air = 14,574 − 7549 = 7025 Btu per hour.

PEOPLE HEAT GAIN:

$50 \times 225 = 11{,}250$ Btu per hour, sensible heat.

$50 \times 206 = 10{,}300$ Btu per hour, latent heat.

LIGHT HEAT GAIN:

$4200 \times 3.413 = 14{,}335$ Btu per hour.

SUMMARY:

COMPONENT OF LOAD	BTU PER HOUR	
	Sensible	Latent
Normal Transmission Load	16,164	
Sun Load	45,597	
Outside Air Heat Gain	7,549	7,025
People Heat Gain	11,250	10,300
Light Heat Gain	14,335	
Total	94,895	17,325

TOTAL LOAD:

$94{,}895 + 17{,}325 = 112{,}220$ Btu per hour.

PROBLEMS IN PRACTICE

1 ● The outdoor and indoor temperatures are 90 F and 78 F, respectively. What is the amount of heat transmitted per hour through a 7 ft by 4 ft north window?

$H_t = 28 \times 1.13\ (90\text{-}78) = 380$ Btu per hour. (Equation 1, Chapter 8 and Table 13 A, Chapter 5).

2 ● a. If a restaurant has two 10 gal gas-heated coffee urns, what is the cooling load due to them?

b. What is the cooling load due to four 1350 w burners on an electric range?

a. $2 \times 10 \times 1000 = 20{,}000$ Btu per hour (Table 10).

b. $4 \times 1350 = 5400$ w $= 5.4$ kw.
$5.4 \times 3413 = 18{,}430$ Btu per hour (Table 10).

3 ● a. What is the maximum heat transmission for a flat roof located in Pittsburgh (latitude 40 deg) exposed to the sun with the outdoor and indoor tem-