F4001A

ENERGY CONSUMPTION

OF RESIDENTIAL BUILDINGS

The Computer program ENCORE
Part 1, User's Manual

by

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CONTENTS

0. INTRODUCTION

This manual explains how to prepare input data for the ENCORE program. The program is based on the "weighting factor method" as described in Chapter 22 of the ASHRAE Handbook of Fundamentals.[1] A detailed description of how the program works is given in the Documentation.[10]

This manual may logically be divided into five main parts:

The first part explains, in general terms, what kind of data that are required, why they are required and where to look for them (most of the data can be found in the ASHRAE Handbook of Fundamentals[1]).

The second part is a detailed description of input data, which explains card by card, column by column, how to prepare the input card deck.

The third part is a description of the output from the program.

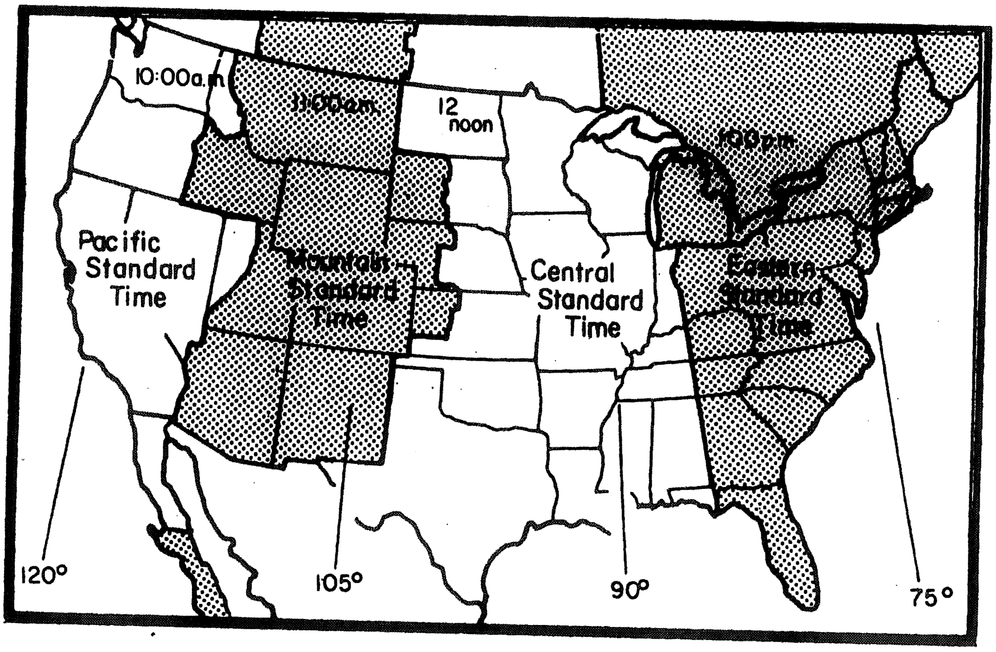
The fourth part is two examples showing the input card decks and the results.

The fifth part is the Appendixes. Appendix A gives the program restrictions, e.g. maximum number of walls, rooms, etc.. Appendix B gives Z-transfer function coefficients of some typical Norwegian wall/floor/ceiling constructions. Appendix C gives a detailed description of how the input weather tape should should look like in order to be accepted by the program. Appendix D gives a detailed description of the data that are written on file for later plotting or other use.

1. GENERAL DESCRIPTION OF INPUT DATA

1.1 Building Location

For solar radiation calculations the program needs information on building latitude, longitude and, to get solar radiation values in Standard Time, the Time Zone (only buildings in the northern hemisphere can be analysed). Longitudes and Time Zones west of Greenwich are positive (e.g. locations in U.S.). Figures 1 and 2 show the Time Zones in U.S. and Europe.



TIME ZONE	TZN
Atlantic	4
Eastern	5
Central	6
Mountain	7
Pacific	8

Figure 1
Time Zones in the United States

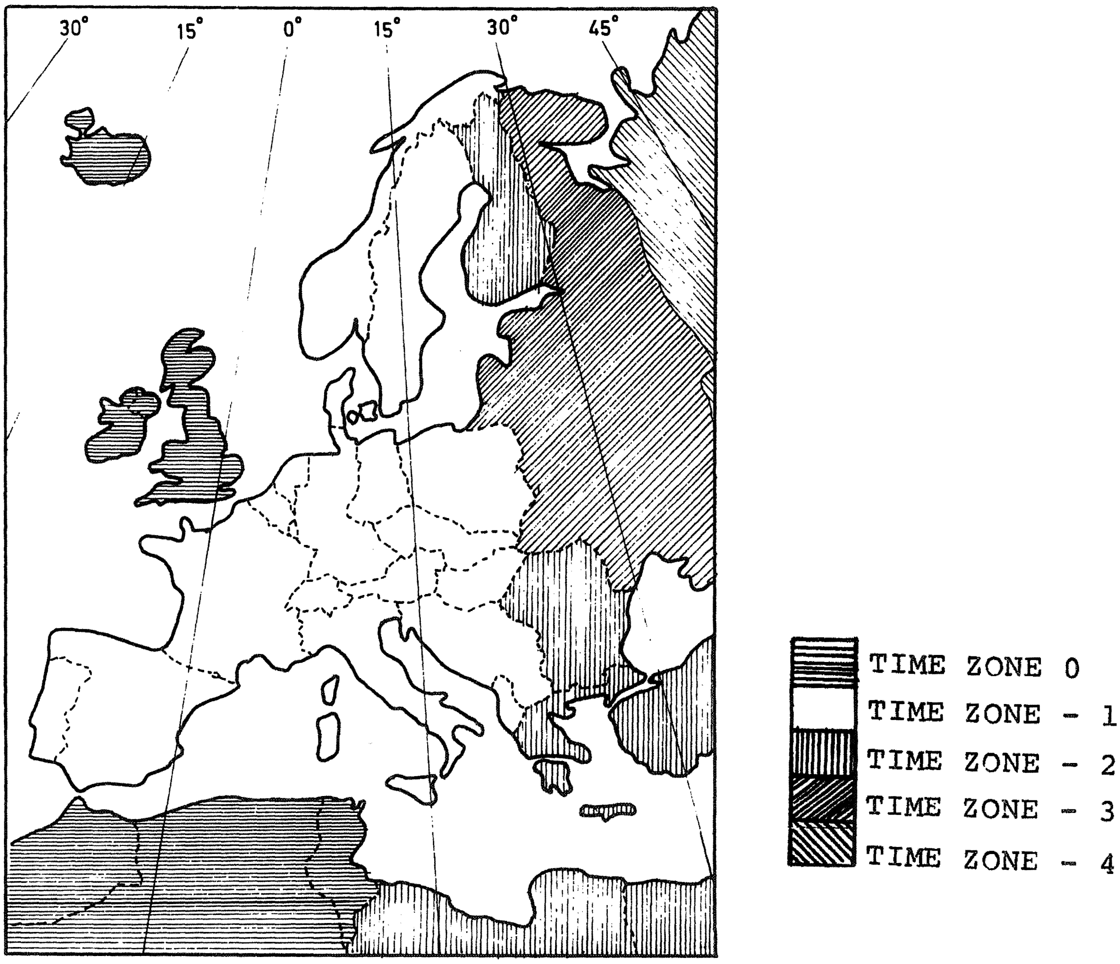


Figure 2
Time Zones in Europe

The sky clearness numbers for summer and winter are also needed for solar radiation calculations. Figure 3 shows clearness numbers for U.S. Data for Europe is not available, but Figure 3 shows the values the numbers possibly may take.

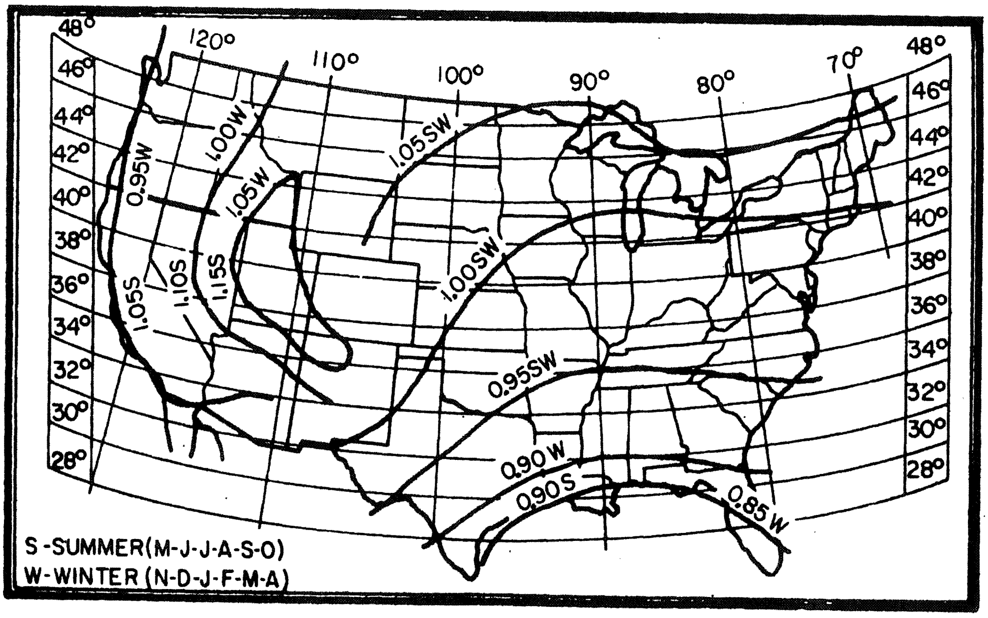


Figure 3

Clearness numbers of non-industrial atmosphere in United States

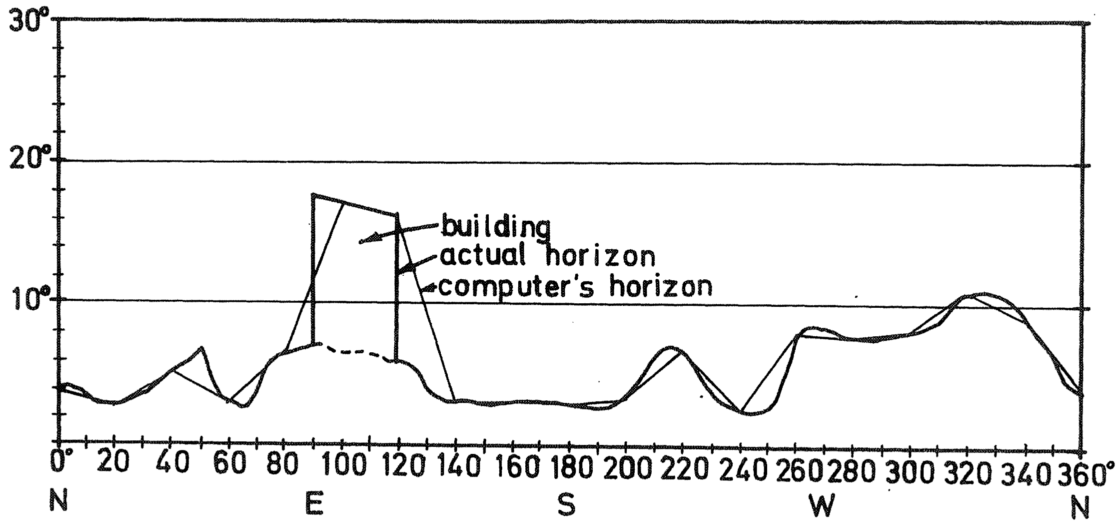


Figure 4

Horizon at the building site

The horizon at the building site is necessary to calculate shading from mountains, hills and other buildings. The program requires the height of the horizon (in degrees) for each 20th degree of the circle starting with 20 degrees east of north and ending with 360 degrees east of north (i.e. north). The height of the horizon between the given values as approximated by linear interpolation as shown in Figure 4.

In most cases the terrain at the nearest meteoroligical site, i.e. the site that has supplied the weather data for the computer run, is different from the terrain at the building site. Therefore it is necessary to modify the wind speed readings from the meteorological site before they are used to calculate the pressure distribution on the building. Both information on the terrain at the building and the meteorological site is needed. The terrain is classified as "flat" (code 1), "suburban" (code 2) or "center of city" (code 3). This is the same classification as used by Davenport[4]. The wind velocity profile, i.e. wind speed as a function of height above ground, is assumed to follow the power law:

$$\frac{V_z}{V_g} = \left(\frac{Z}{Z_g}\right)^{\frac{1}{\alpha}}$$

where:

V_z = wind speed at the height z above ground

V_g = wind speed above the boundary layer (the gradient wind speed)

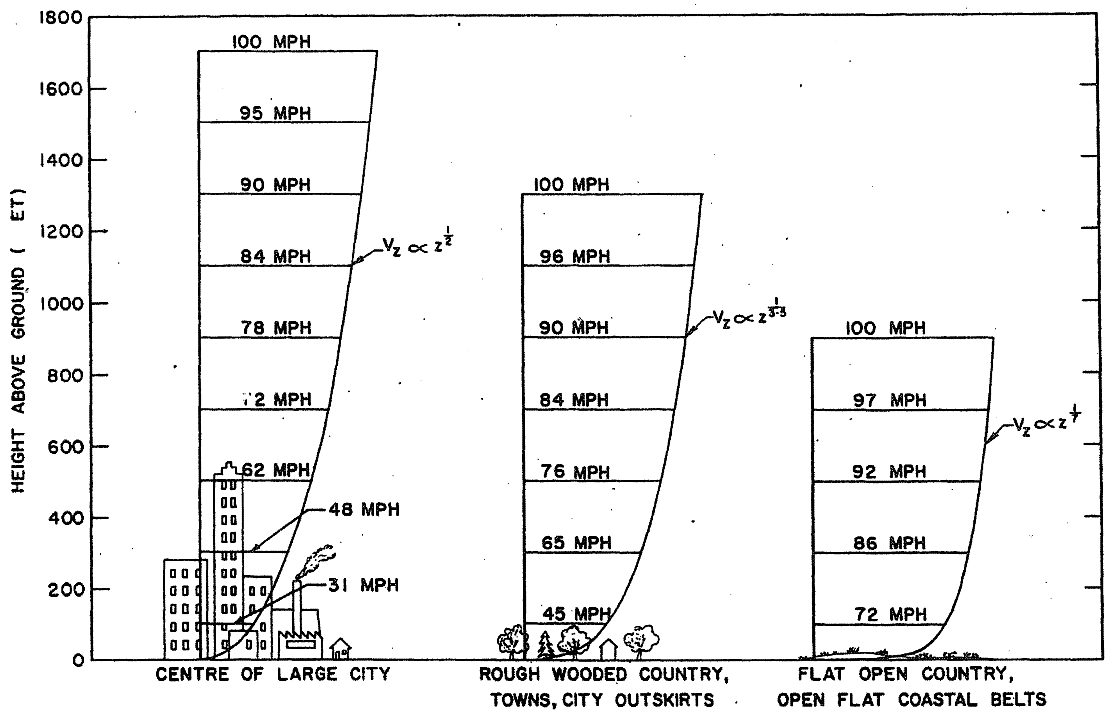
Z_g = thickness of boundary layer

α = exponent

Z_g and α depend on the type of terrain as shown in the following table:

Terrain	Z_g	α
1	275 m	7
2	400 "	3.5
3	520 "	2.5

When the type of terrain at the meteorological and the building sites are given, the measured wind speed is modified by using the above equation twice. First, using it for the meteorological site, the gradient speed V_g is found (wind speed measurements are taken Z = 10 m above ground). Second, using the calculated V_g with Z_g and α for the building site, the wind speed at roof level is found (see Figure 5 which is copied from ref. 4).



VELOCITY PROFILES OVER TERRAIN WITH THREE DIFFERENT ROUGHNESS CHARACTERISTICS FOR UNIFORM GRADIENT WIND VELOCITY OF 100 MPH.

Figure 5

1.2 The building

The wind pressure distribution on a building depends on the building shape. In the program there are stored wind pressure coefficients for eight different building shapes, see Figure 6 and Table 1. Specify the building shape that best approximates the shape of the actual building. Figure 6 also shows the meaning of the expressions "short wall" and "long wall" (wind pressure coefficients for long and short walls usually are different). The dynamic pressure of the wind at the level of the roof edge (i.e. H in Figure 6) is multiplied by the

Shape no.	1	2	3	4	5	6	7	8
H/B	1	1	½	½	½	3/2	3/2	3/2
L/B	1	2	1	2	4	1	2	4

Table 1
Building shapes (see also Figure 6)

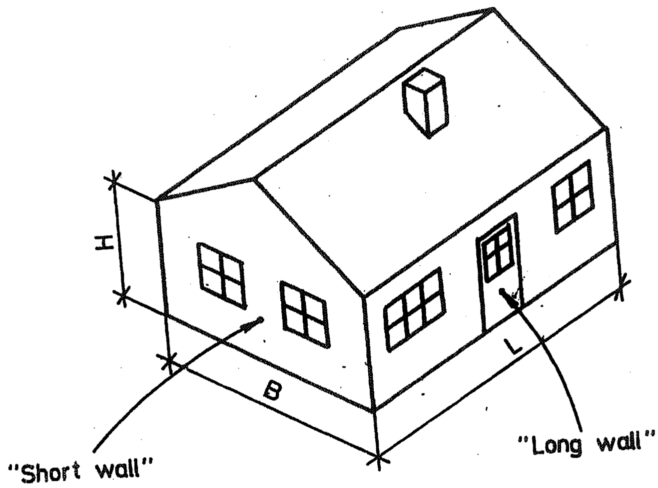


Figure 6
Definition of building shape

pressure coefficients to get the pressure distribution on the building.

The rooms of the building are identified by giving each room a "room number" (see Figure 7). Rooms in this respect means actual rooms or zones where all rooms are having equal temperature (to subdivide such zones is an unnecessary waste of computer time).

As shown in Figure 7 some external, fictitious rooms or "outside pressure point" (numbers 8 to 10) are needed. The outside pressure points are necessary to define external walls and, by means of outside pressure point codes to classify the external walls as "long walls", "short walls" or "roofs" (see Figure 6). It should be noted that outside pressure points are not considered to be real rooms. Therefore outside pressure point numbers must be higher than the number of rooms in the house ! E.g. the house in Figure 7 have 7 rooms, outside pressure points are numbered 8 to 10 (actually outside pressure points are recognized by the computer by having "room numbers" higher than

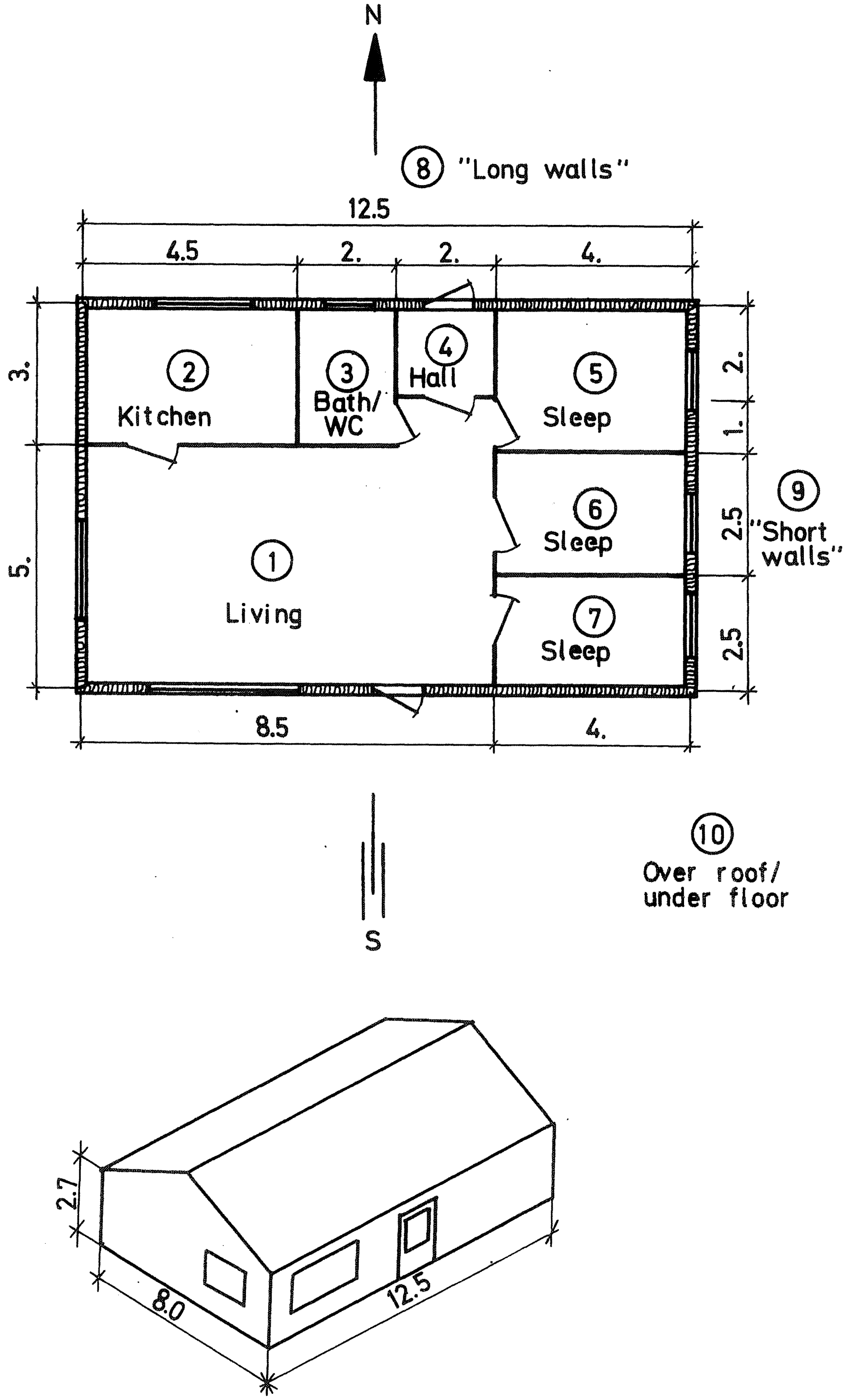


Figure 7
Using room numbers and outside pressure points to describe a building

the number of rooms in the house). As shown in Figure 7 only three outside pressure points are needed; one to represent the "room on the outside" of short walls, one for the "room outside" the long walls and one for the "room outside" the roof panels. In order to get a print-out that is more easily understood some users prefer to have pressure points outside all the facades and roof panels. Also in some cases it is necessary to introduce more than three pressure points in order to avoid more than 20 walls or roof panels connected to a pressure point (each "room" may consist of maximum 15 walls, floors, etc.).

Each room is classified as being of "light" (approx. 145 kg/m^2),"medium" (approx. 345 kg/m^2) or "heavy" (approx. 635 kg/m^2) construction (the weights per square meter are including furniture). Choose the code that best approximates the actual room.

In order to include the stack effect in infiltration calculations the room level is needed. This is the distance from the pressure reference level (usually the ground level is chosen) to a point halfway between floor and ceiling.

The walls, floors, etc. are identified by the rooms, or for external walls, the rooms and the outside pressure points, they separate. Each wall is further described by it's azimuth angle and tilt angle. Wall azimuth angle is the clockwise angle between north and the wall normal as shown in Figure 8. For tilted walls the azimuth angle, is the angle between north and the horizontal projection of the wall normal. Definition of wall tilt angle is shown in Figure 9.

Some times it is useful to see what influence the building orientation makes on the energy consumption. By changing just one input parameter it is possible to "rotate" the building without having to change the wall azimuth angles (they are changed by the computer). A positive rotation (degrees) means that the building is rotated in the clockwise direction (e.g. from north to east).

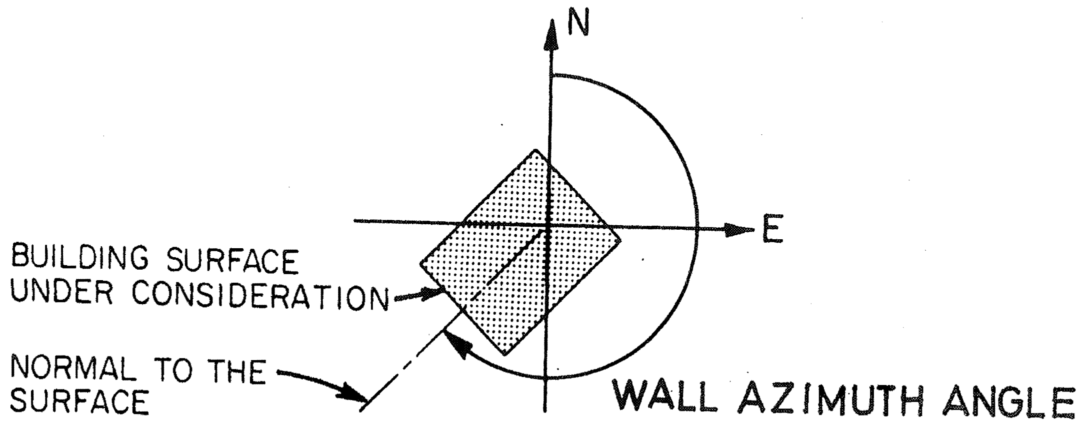


Figure 8
Definition of wall azimuth angle

The construction of each wall is defined by the "wall type number". To each wall type number the user assigns a set of Z-transfer function coefficients, U-value and solar absorbtion coefficient of the outdoor surface of the wall. Transfer function coefficients may be obtained from chapter 22 of the ASHRAE Handbook of Fundamentals[1] (remember to multiply the b-coefficients and the Σc_n by 5.6778 to convert from Btu/ft^2h^oF to $W/m^{2o}C$). Transfer function coefficients may also be obtained by using DBR Computer Program No. 33[9]. Transfer function coefficients for some typical Norwegian wall constructions are given in Appendix B.

The air flow through cracks in external walls can be expressed by the equation:

$$Q = \left(\frac{\Delta p}{R}\right)^n$$

where:

- Q = flow rate (m^3/s)
- Δp= pressure difference across the wall (kg/m^2)
- R = "flow resistance"
- n = flow exponent (between 0,5 and 1,0)

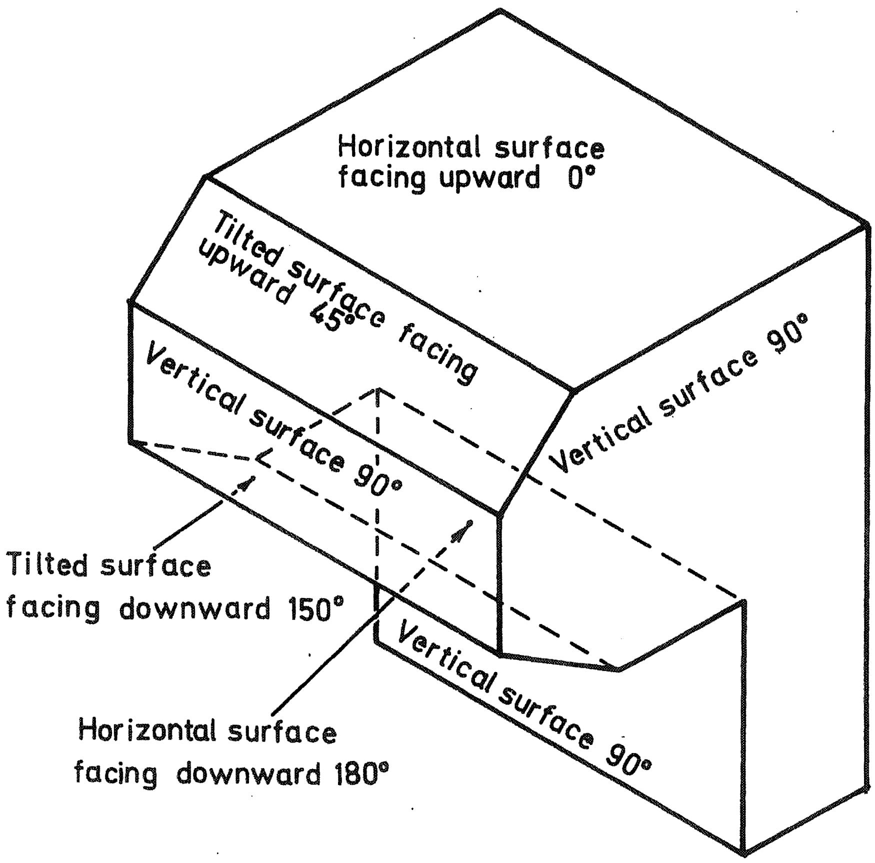


Figure 9

Definition of wall tilt angle

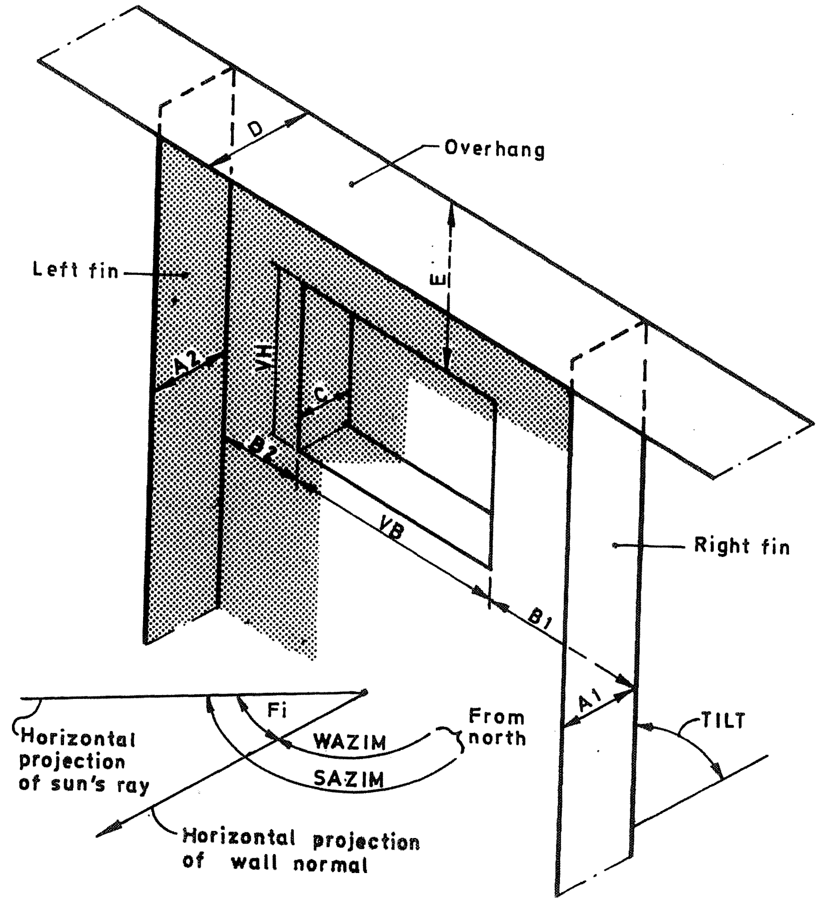
If the flow is laminar n= 1,0, if turbulent n = 0,5. Cracks around windows and doors usually have n = 0,66.

Chapter 25 of the ASHRAE Handbook of Fundamentals gives values for air flow through cracks at different pressure differences. These values are used to find values of R and n to use in the equation above:

> Find the total crack length. Multiply the crack length by the air flow value at a given pressure difference (remember to convert to metric units). Repeat this procedure for all the crack types of the wall and add the results. The air flow through the wall at a given pressure difference is now found (Q in the above equation). For "standard" cracks n=0,66, then the only unknown in the above equation is R.
>
> If $n \neq 0{,}66$ it is necessary to find the air flow through the wall at two pressure differences to get two equations with two unknowns (R and n).

For each external wall R and n are needed by the program. Internal walls are assumed to make no resistance to air flow (doors are open), thus they are not taken into account in the calculations. External walls that are "completely" air tight must be given R = n = 0,0. This way they will be skipped in the calculations in the same way as the internal walls.

If there are windows in an external wall the windows are described by the "window type number", the glass area, the sash, vertical fins and horizontal overhangs, see Figure 10 (internal walls cannot have windows). To each window type number the user assigns U-value with and without shutters, shading coefficient and a code number to tell if the shading device (e.g. venetian blind) is on the inside or outside. The two U-values makes it possible to find the savings one can achieve by covering the windows with insulating shutters during the night. The period during the night when the shutters are closed, as well as the period during the year when shutters are used during the night, is specified in the input.



A1	Width of right fin
A2	Width of left fin
B1	Distance between right fin and window sash
B2	Distance between left fin and window sash
C	Depth of window sash
D	Width of overhang
E	Distance between overhang and window sash
VB	With of window sash
	Height of window sash
SAZIM	Solar azimuth angle in degrees (clockwise from north)
SALT	Solar altitude angle in degrees
WAZIM	Wall azimuth angle in degrees (clockwise from north)

Figure 10
Description of window sash, vertical fins and horizontal overhang

If there are doors in a wall the doors are described by the "door type number" and the door area. To each door type number the user assigns U-value and solar absorption coefficient of the outdoor surface (the latter is not necessary for doors in internal walls).

1.3 The heating system.

The model includes two types of heating systems.

1.31 Electric resistance heaters.

For each room the capacity of the roomheater and the thermostat throttling range (see Figure 11) is given as input.

1.32 Oil fired hot air system.

Due to the fact that the model is not able to calculate airflow between rooms, houses with hot air systems must always be modelled as having one room only ! This simplification is justified by the fact that most hot air systems have only one thermostat and there is no way of controlling the air flow to each room.

The thermostat throttling range (Figure 11) is given as input. The capacity of the heating system is calculated from the burner nozzle capacity and the furnace efficiency (therefore the input field for "the capacity of the room heater" may be left blank).

In order to calculate furnace efficiency as a function of "furnace load factor" (i.e. burner on-time to total time) detailed data for burner, furnace and chimney are needed.

Burner data:

Nozzle capacity (U.S. Gallons per hour)
Air supply ratio, i.e. the amount of air supplied for combustion to the theoretically necessary supply.

Furnace data:

The draft setting at the barometric damper.
Flow ratio, i.e. weight flow of air through furnace at off-cycle to weight flow of flue gases at on-cycle.

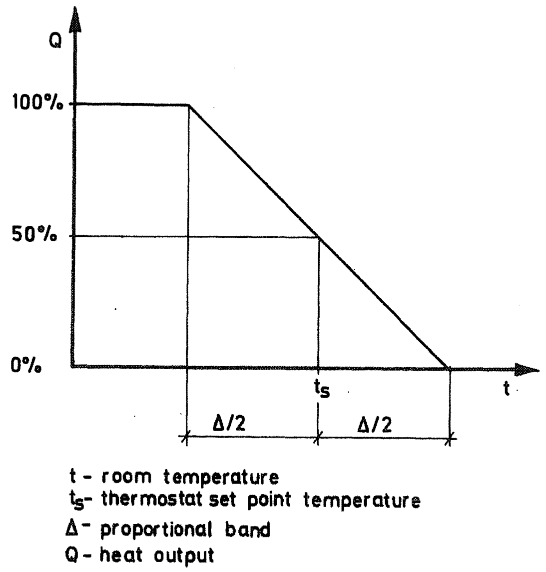


Figure 11
Heat output as a function of room temperature

Number of burner cycles at 50 % furnace load (one burner cycle consist of one on-cycle and one off-cycle).

Steady state on-cycle flue gas temperature (θ_{on} in Figure 12).

Steady state off-cycle "flue gas" temperature (θ_{off} in Figure 12).

Flue gas temperature when air circulation fan shuts off (θ_{fan} in Figure 12).

Time constant for increase in flue gas temperature during on-cycle (time constant is the time it takes to reach 63 % of the steady state value, τ_{on} in Figure 12).

Time constant for decrease in flue gas temperature during off-cycle when the air circulation fan is running.

Time constant for decrease in flue gas temperature during off-cycle when the air circulation fan is not running.

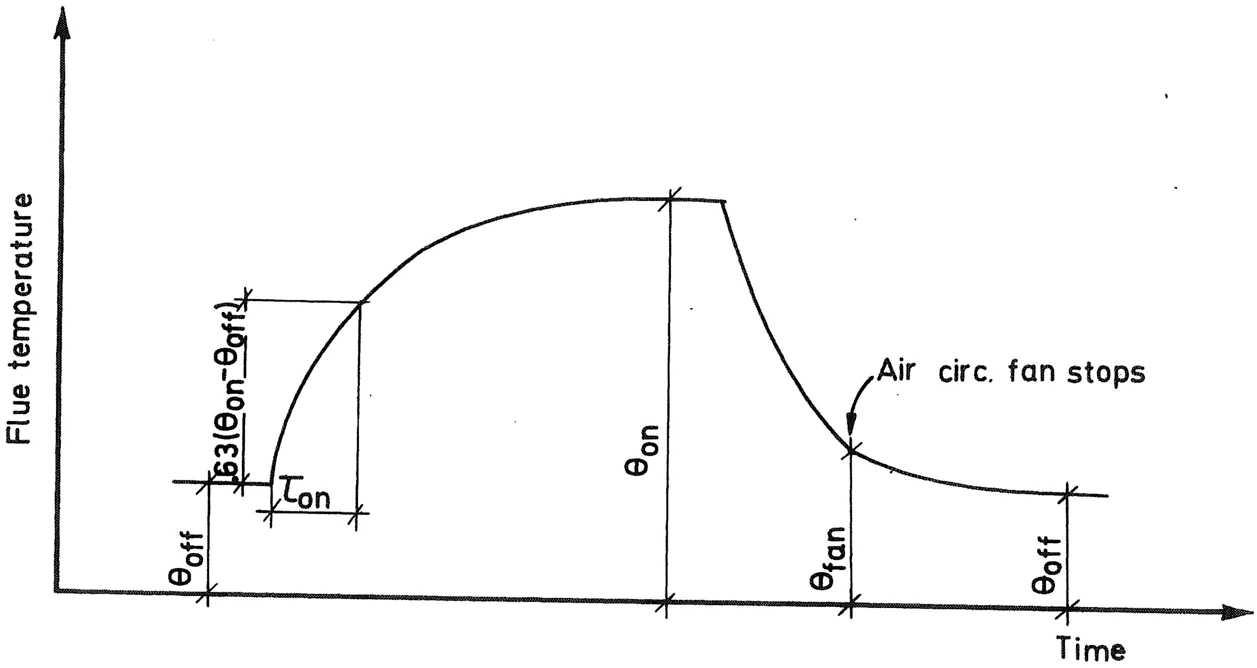


Figure 12
Flue temperature as a function of time during one burner cycle

Chimney and smoke pipe data:

Smoke pipe diameter

Length of smoke pipe

No. of smoke pipe bends

Inside side length of chimney

Length of chimney (length of flow path)

Distance from pressure reference level to top of chimney (h_3 in Figure 13).

Distance from pressure reference level to center of furnace (h_2 in Figure 13).

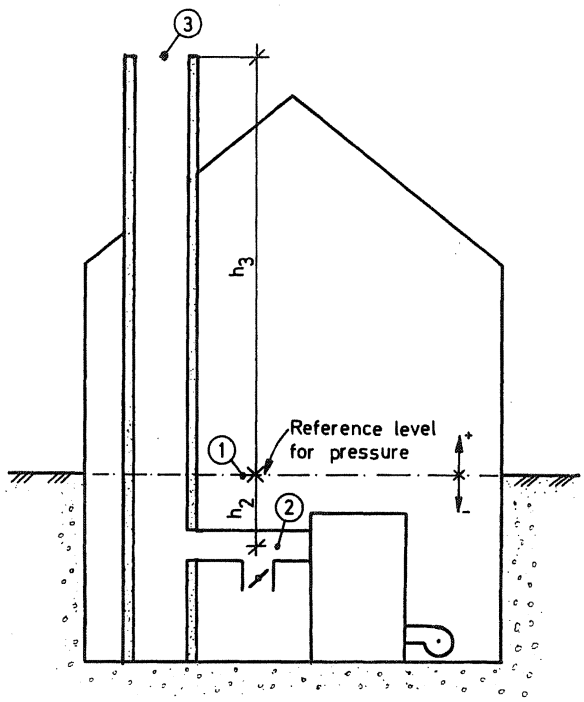


Figure 13
Hot air furnace with smoke pipe and chimney

1.4 The use of the building

The life style of the habitants, or how they are "using" the building, is of major importance for the energy consumption.

The use of the building is described by schedules. A shedule is 24 numbers giving the value of, for instance the heat gain from lights, for each hour of the day. The program uses the following schedules:

Hot water consumption schedules
Occupancy schedules
Constant light schedules
Variable " "
Equipment schedules
Thermostat setpoint schedules.

The difference between constant light schedules and variable light schedules needs explanation: The constant light schedules give heat gains from lights, and these gains are purely a function of the time of the day, whereas the gains in the variable light schedule will only be "switched on" if the room is occupied and the solar heat gain is less than 4.7 W/m^2 floor area (this value is set in the main program and may easily be changed).

The shedules are input as follows:

First specify a max. quantity. Then for max. five intervals in the day specify a percent of the max. quantity. The intervals must not overlap, but may be disjoint. Hours of the day that are not included by the specified intervals are given the default value "Zero percent of max " (see Figure 14). Note that, in order to save core storage of mini computers, the "percent of max." values are given as integers (real numbers need two words of core storage, whereas integers need only one word).

The thermostat setpoint schedules are exceptions of what is said above. For max. five intervals of the day the setpoints in ^{O}C are specified directly (not "percent of max"). Hours of the day not included by the intervals are given the default value $0^{O}C$ (setpoints are given as integers).

To each room is assigned two sets of occupancy, constant light, variable light and equipment schedules; one for working days and one for holidays (saturdays and sundays included). In the printout schedules for working days are marked with a W and schedules for holidays with a H.

The hot water consumption is the total for the house, one schedule for each day of the week. The same schedule may be used for several days, i.e. it is necessary to specify minimum one maximum seven schedules.

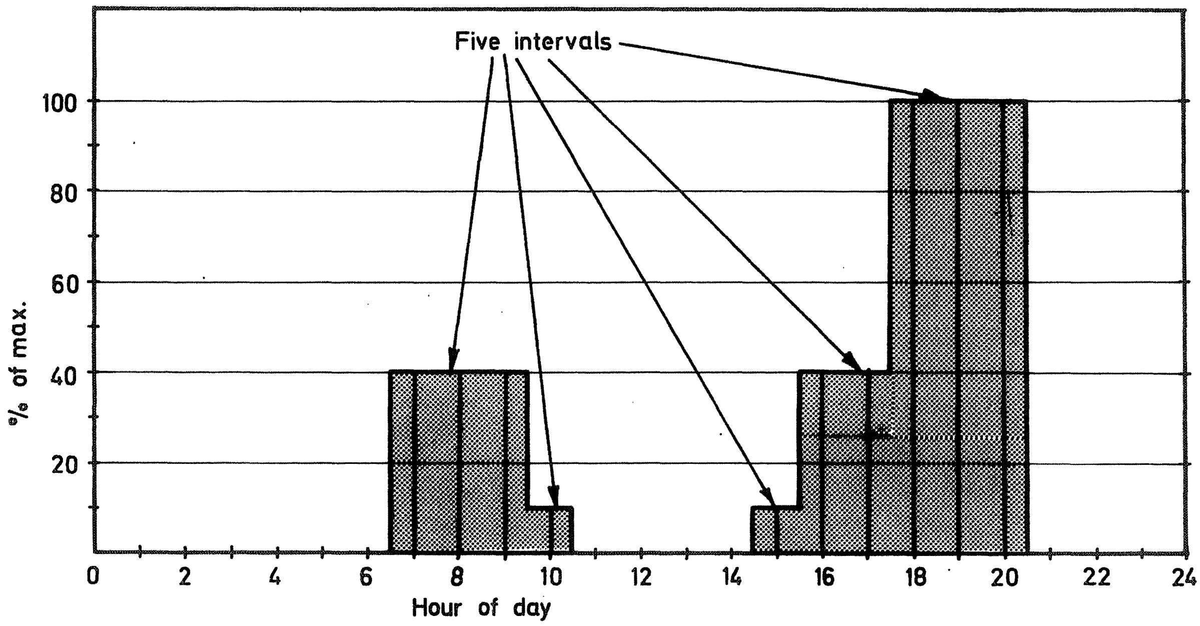


Figure 14
Schedule for internal heat gain

2. DETAILED DESCRIPTION OF INPUT DATA

The following abbreviations are used in the input description:

Card No.	-	the numbers listed are the minimum number of cards.
AN	-	alpha-numeric data, i.e. text. Except for the first two cards, all alpha-numeric text, "headings", occupy 10 columns of the card.
FL	-	floating point number, i.e. number with a decimal point (e.g. 2.4). All floating point numbers occupy 10 columns of the card.
I	-	Integer number, i.e. number without a decimal point (e.g. 2). All integer numbers occupy 5 columns of the card. The number must be right justified in the field of 5 columns !

It should be noted that, except for the first two cards, the only purpose of the alpha-numeric text or "headings" is to make a listing of the input card deck more "comfortable" to read. During the reading of the input card deck the text fields are skipped. Therefore, the user are free to choose his own headings, or leave the text fields blank (not recommended).

Card no.	Column. no.	Format	Comments
1	1 - 80	AN	Job title, line 1
2	1 - 80	AN	Job title, line 2
3	1 - 10	AN	Heading: STATION NO
	11 - 15	I	Synoptic station no.[x]
4	1 - 10	AN	Heading: ROTATION
	11 - 20	FL	Building rotation (degres) relative to azimuth angles given on "wall data cards" (card no. 40). Clockwise rotation positive (e.g. from north to east), counter clockwise rotation negative
5	1 - 5	I	Year of weather data
	6 - 10	I	Start of heating season, day of year
	11 - 15	I	End of heating season, day of year
	16 - 20	I	Detailed output, day of year
	21 - 25	I	1 or 0 : 1 - results are written on file (unit 7) for later plotting[xx] 0 - nothing will be written on file
6			Building location:
	1 - 10	FL	Latitude (degrees)
	11 - 20	FL	Longitude (degrees, west positive)
	21 - 25	I	Time Zone (west positive)

x) See Appendix C

xx) See Appendix D

Card no.	Column. no.	Format	Comments
7 (1st card)	1 - 10	AN	Heading: HORIZON
	11 - 20	FL	Height of horizon (degres) 20 deg. clockwise from north
	21 - 30	FL	" " " " 40 deg. " "
	. . . .	. . . .	. . . .
	71 - 80	FL	140 " " "
8 (2nd card)	1 - 10	FL	" " " " 160 " " "
	11 - 20	"	" " " " 180 " " "
	. . . .	. . . .	. . . .
	71 - 80	FL	" " " " 300 " " "
9 (3rd card)	1 - 10	FL	" " " " 320 " " "
	11 - 20	FL	" " " " 340 " " "
	21 - 30	FL	" " " " 360 " " "
10	1 - 5	I	Terrain at building site (1, 2 or 3): 1 - flat, 2 - suburban, 3 - center of city
	6 - 10	I	Terrain at meteorological site (1, 2 or 3): Same codes as for building site
	11 - 20	FL	Sky clearness number, summer
	21 - 30	FL	" " " , winter
11	1 - 5	I	Building shape (1 to 8)
	6 - 15	FL	Distance from ground to roof edge (m)

Card no.	Column. no.	Format	Comments
12	1 - 10	AN	Heading: SYST TYPE
	11 - 15	I	Heating system type (1 or 2): 1 - oil fired hot air system 2 - electric resistance heaters
13	1 - 10	FL	Hot water heater element capacity (Watts)
	11 - 20	FL	Hot water tank capacity (liters)
	21 - 25	I	Hot water schedule for monday (1 to 7)
	26 - 30	I	" " " " tuesday (")
	. . . . .		. . . . .
	51 - 55	I	" " " " sunday (")
14	1 - 10	AN	Heading: NO.O.ROOMS
	11 - 15	I	Number of rooms (max. 20)
15 (x1st card)	1 - 10	AN	Heading: ROOM NO.
	11 - 15	I	Room no.
16 (2nd card)	1 - 5	I	Room weight code (1, 2 or 3): 1 - light, 2-medium, 3-heavy
	6 - 15	FL	Floor area (m^2)
	16 - 25	FL	Length of room exterior perimeter (m)
	26 - 35	FL	Room level (m). Ground level is zero by definition (+ upwards).
	36 - 45	FL	Capacity of room heater (Watts)
	46 - 55	FL	Thermostat throttling range (°C)

x 4 cards per room. The set of cards consisting of cards nos. 15 to 18 is repeated as many times as there are rooms in the house.

Card no.	Column. no.	Format	Comments
			Working day:
	1 - 5	I	Occupancy schedule no.
17	6 - 10	I	Constant light schedule no.
(3rd card)	11 - 15	I	Variable " " "
	16 - 20	I	Equipment schedule no.
	21 - 25	I	Thermostat setpoint schedule no.
			Holiday:
18	1 - 5	I	
(4th card)	.	.	
	.	.	See "Working day" card comments
	.	.	
	21 - 25	I	
19	1 - 10	AN	Heading: OUT. PRESS
	11 - 15	I	Number of outside pressure points (max.20)
x20	1 - 5	I	Outside pressure point no.
	6 - 10	I	Type of wall (1, 2 or 3): 1 - long wall, 2-short wall, 3-roof
21	1 - 10	AN	Heading: OCCUPANCY
	11 - 15	I	Number of occupancy schedules (max. 15)
22 xx(1st card)	1 - 10	FL	Max. sensible heat released by occupants (Watts)

x One card per pressure point

xx Two cards per occupancy schedule. The set of cards consisting of cards nos. 22 and 23 is repeated as many times as there are occupancy schedules. The first set of cards describes occupancy schedule no. 1, the second set no. 2,etc.

Card no.	Column. no.	Format	Comments
	1 - 5	I	Start (hr)
	6 - 10	I	End (hr)
	11 - 15	I	Percent of max.
	16 - 20	I	Start (hr)
	21 - 25	I	End (hr)
	26 - 30	I	Percent of max.
23	31 - 35	I	Start (hr)
(2nd card)	36 - 40	I	End (hr)
	41 - 45	I	Percent of max.
	46 - 50	I	Start (hr)
	51 - 55	I	End (hr)
	56 - 60	I	Percent of max.
	61 - 65	I	Start (hr)
	66 - 70	I	End (hr)
	71 - 75	I	Percent of max.
			Specifications for max. five periods of the day. Hours not included in these periods will be assigned "zero percent of max."
24	1 - 10	AN	Heading: CON.LIGHT
	11 - 15	I	Number of constant light schedules (max.20)
25	1 - 10	FL	Max. constant light output (Watts)
(1st card)			

Card no.	Column. no.	Format	Comments
26 (2nd card)	1 - 75	I	Similar to card no. 23
27	1 - 10	AN	Heading: VAR. LIGHT
	11 - 15	I	Number of variable light schedules (max.20)
28 (1st card)	1 - 10	FL	Max. variable light output (Watts)
29 (2nd card)	1 - 75	I	Similar to card no. 23
30	1 - 10	AN	Heading: EQUIPMENT
	11 - 15	I	Number of equipment schedules (max.8)
31 (1st card)	1 - 10	FL	Max. equipment heat output (Watts)
32 (2nd card)	1 - 75	I	Similar to card no. 23
33	1 - 10	AN	Heading: THERMOSTAT
	11 - 15	I	Number of thermostat setpoint schedules (max.8)
	1 - 5	I	Start (hr)
	6 - 10	I	End (hr)
	11 - 15	I	Thermostat setpoint (^{o}C)

Card no.	Column. no.	Format	Comments	
x 34	16 - 20	I	Start (hr)	Specifications for max. five periods of the day. Hours not included in these periods will be assigned setpoints 0°C.
	21 - 25	I	End (hr)	
	26 - 30	I	Thermostat setpoint (°C)	
	31 - 35	I	Start (hr)	
	36 - 40	I	End (hr)	
	41 - 45	I	Thermostat setpoint (°C)	
	46 - 50	I	Start (hr)	
	51 - 55	I	End (hr)	
	56 - 60	I	Thermostat setpoint (°C)	
	61 - 65	I	Start (hr)	
	66 - 70	I	End (hr)	
	71 - 75	I	Thermostat setpoint (°C)	
35	1 - 10	AN	Heading: HOT WATER	
	11 - 15	I	Number of hot water consumption schedules (max. 7)	
36 (1st card)	1 - 10	FL	Max. hot water consumption (liters/s)	
37 (2nd card)	1 - 75	I	Similar to card no. 23	

x One card for each thermostat setpoint schedule.

Card no.	Column. no.	Format	Comments
			Window shutter schedule:
	1 - 5	I	Day of the year (spring) when we stop using shutters during the night.
38	6 - 10	I	Day of the year (fall) when we start using shutters during the night.
	11 - 15	I	Hour of the day (evening) when shutters close.
	16 - 20	I	Hour of the day (morning) when shutters open.
39	1 - 10	AN	Heading:NO.O.WALLS
	11 - 15	I	Number of walls (max. 50)
	1 - 5	I	} Room nos. that this wall/floor/roof separates (outside pressure points are regarded as rooms in this respect).
	6 - 10	I	
	11 - 15	I	Wall type (see cards 44, 45, 46 and 47)
	16 - 20	I	Number of windows in the wall
	21 - 25	I	" " doors " "
40	26 - 35	FL	Wall azimuth i.e. the clockwise angle (degrees) between north and the horizontal projection of the wall normal.
(x 1st card)	36 - 45	FL	Tilt angle (degrees), i.e. the angle between a vertical line and the wall normal. Thus vertical walls have 90 deg. tilt angle. Horizontal walls facing upwards have 0 deg. tilt angle. Horizontal walls facing downwards have 180 deg. tilt angle. Note! External walls that should not receive any solar radiation at all, must be given negative tilt angle. (e.g. a floor facing a crawl space)

x) The set of cards consisting of cards nos. 40, 41, 42 and 43 is repeated as many times as there are walls. I.e. this set of cards completely describes one wall with windows and doors.

Card no.	Column. no.	Format	Comments
	46 - 55	FL	Brutto area (m^2), i.e. wall area with areas of windows and doors <u>included</u>.
	56 - 65	FL	Resistance } Constants of infiltration flow equation
	66 - 75	FL	Exponent } Constants of infiltration flow equation
			Note! External walls that should be considered air tight, and internal walls, mus be assigned resistance and exponent values equal to 0.0
	1 - 5	I	Type of window (see card no. 49)
	6 - 15	FL	Window glass area (m^2)
			Note! For this card and the next, see Fig.10
41	16 - 25	FL	Width of window sash (m)
(^{x}2nd card)	26 - 35	FL	Height of window sash (m)
	36 - 45	FL	Depth " " " (m)
	46 - 50	I	1 or 0 1 - window has fins and/or overhang 0 - no fins and/or overhang

^{x}This card is used only if there are windows in the wall

Card no.	Column. no.	Format	Comments
42	1 - 10	FL	Width of right vertical fin (m)
	11 - 20	FL	Distance between right fin and sash (m)
	21 - 30	FL	Width of left vertical fin (m)
(x 3rd card)	31 - 40	FL	Distance between left fin and sash (m)
	41 - 50	FL	Width of horizontal overhang (m)
	51 - 60	FL	Distance between overhang and sash (m)
43	1 - 5	I	Type of door (see card no. 51)
(xx 4th card)	6 - 15	FL	Door area (m^2)
44	1 - 10	AN	Heading: Z-TRANSFER
	11 - 15	I	Number of wall types (max. 10)
45	1 - 10	FL	ΣC_i (sum of c-coefficients
(xxx 1st card)	11 - 20	FL	U-value ($w/m^2\ {}^oC$)
	21 - 30	FL	Solar absorbtion coefficient(outdoor surface)

x This card is used only if the window has fins and/or overhang. The set of cards consisting of cards nos. 41 and 42 is repeated as many times as there are windows in the wall.

xx This card is used only if there are doors in the wall. One card for each door.

xxx The set of cards consisting of cards nos. 45, 46 and 47 is repeated as many times as there are wall types.

Card no.	Column no.	Format	Comments
			b - coefficients (max. 7):
46	1 - 10	FL	b_0
(2nd card)	11 - 20	FL	b_1
	⋮	⋮	⋮
	61 - 70	FL	b_6
			d - coefficients (max. 7):
47	1 - 10	FL	$d_0 = 1.0$
(3rd card)	11 - 20	FL	d_1
	⋮	⋮	⋮
	61 - 70	FL	d_6
48	1 - 10	AN	Heading: WINDOWTYPE
	11 - 15	I	Number of window types (max. 5)
x 49	1 - 10	FL	U-value without shutters ($^W/m^2\ ^oC$)
	11 - 20	FL	" with " (")
	21 - 30	FL	Shading coefficient
	31 - 35	I	0 or 1: 0 - outside shading device 1 - inside " "

x) One card for each window type

Card no.	Column. no.	Format	Comments
50	1 - 10	AN	Heading: DOORTYPES
	11 - 15	I	Number of door types (max. 5)
x 51	1 - 10	FL	U-value (W/m^2 ^{o}C)
	11 - 20	FL	Solar absorbtion coefficient (outdoor surface)
xx 52	1 - 10	FL	Burner nozzle capacity (U.S. Gallons per hour).
	11 - 20	FL	Air supply ratio, i.e. the amount of air supplied for combustion to the theoretically necessary supply
	21 - 30	FL	Draft setting at the barometric damper (kg/m^2)
	31 - 40	FL	Flow ratio, i.e. weight flow of air through furnace at off-cycle to weight flow of flue gases at on-cycle.
	41 - 50	FL	Number of burner cycles at 50 % furnace load
	51 - 60	FL	Steady state on-cycle flue gas temperature (^{o}C)
	61 - 70	FL	Steady state off-cycle "flue gas" temperature (usually the room temperature, e.g. 20^{o}C)
	71 - 80	FL	Flue gas temperature when air circulation fan shuts off (^{o}C)
	1 - 10	FL	Time constant (seconds) for increase in flue gas temperature during on-cycle

x One card for each door type

xx This card is used only if the heating system is "oil fired hot air system" (system type 1, see card no. 12).

Card no.	Column. no.	Format	Comments
x 53	11 - 20	FL	Time constant (seconds) for decrease in flue gas temperature during off-cycle when the air circulation fan is running
	21 - 30	FL	Time constant (seconds) for decrease in flue gas temperature during off-cycle when the air circulation fan is not running
x 54	1 -10	FL	Smoke pipe diameter (m)
	11 - 20	FL	" " length (m)
	21 - 30	FL	Number of smoke pipe bends.
	31 - 40	FL	Inside side length of chimney (m)
	41 - 50	FL	Length of chimney (m)
	51 - 60	FL	Distance from pressure reference level to top of chimney (m)
	61 - 70	FL	Distance from pressure reference level to center of furnace (m)

x This card is used only if the heating system is "oil fired hot air system" (system type 1, see card no. 12).

3. OUTPUT

3.1 Standard output

The output consists of three parts (see the examples):

The first part shows the input data that are used in the calculations.

The second part, which is optional, gives a detailed hour by hour output for one day of the heating season. The user is free to choose the day he wants. The detailed output presents the results in the same way as Chapter 22 of the ASHRAE Handbook of Fundamentals presents the transfer function method. First the heat flows ("gains") through all windows, walls, etc. at a constant room temperature of 20°C are printed. Note that two values for internal walls are printed: The first value shows the heat flow from the room with the highest to the room with the lowest room number. The room with the lowest room number is assumed to have 20°C room temperature, whereas the room with the highest room number are having its real room temperature. The second value shows the heat flow from the room with lowest(real room temperature) to the room with the highest room number (20°C room temperature). After the gains comes a table with the resulting heating or cooling loads at 20°C room temperature. The table shows the total loads and the load components, i.e. loads due to windows, walls, infiltration, etc. Then comes a table with actual heat output and room temperature for each room. These are the heat outputs that correspond to the thermostat setpoint schedule and the thermostat throttling range. At last comes information on the hot water consumption, and if the heating system is a hot air system, the furnace load factor.

The third part is tables of daily and accumulated energy consumption, one table for each month of the year. The tables show energy consumption due to heating, lights and appliances, and hot water heating respectively. If the heating system is a hot air system, the accumulated oil consumption is also shown. The accumulated energy consumptions for the 31st December are the same as the total for the heating season. I.e. the calculation starts the first of January at hr. 0100, stops when the heating season ends in the spring, starts up again when the heating season starts in the fall, and ends the 31st of December at hr. 2400.

3.2 Error messages and warnings

It should be noted that the infiltration calculation, the calculation of the flow up the chimney, and the calculation of the hydraulic friction factor of the smoke pipe and the chimney are calculated by iterative processes. This means that under certain circumstances they may fail to give a solution.

The calculation of the flow up the chimney (a mixture of flue gas and air from the barometric camper inlet) for instance, may fail with certain combinations of outdoor temperature, pressure distribution on the building, tightness of the building, building pressure and temperature in the chimney (i.e. draft). In this case the program makes a "forced solution". That is the flue gases from the furnace are "forced" up the chimney (the barometric damper is closed). In addition the program prints a message:

```
     SUBROUTINE CHMNEY     FLOW IN CHIMNEY NOT FOUND AFTER
  11 ITERATIONS.
```

If this message occurs only a few times during a calculation it has no consequences for the results. But if it occurs frequently it may indicate that the building is too air tight, i.e. the chimney is not capable of giving the necessary draft. This may even cause the whole infiltration calculation to fail, and the program will stop.

4. EXAMPLES

4.1 House with hot air system

The house is shown in Figure 15. It is the same house as shown in Figure 7, but since the heating system is an oil fired hot air system it is modelled as having one room only. The house is built on a crawl space (no basement). Since this is a one-storyed building the reference level is taken as halfway between floor and ceiling. The schedules for internal heat gains are shown in Figure 16. The input card deck is shown in Figure 17, and the output is shown in Figure 18.

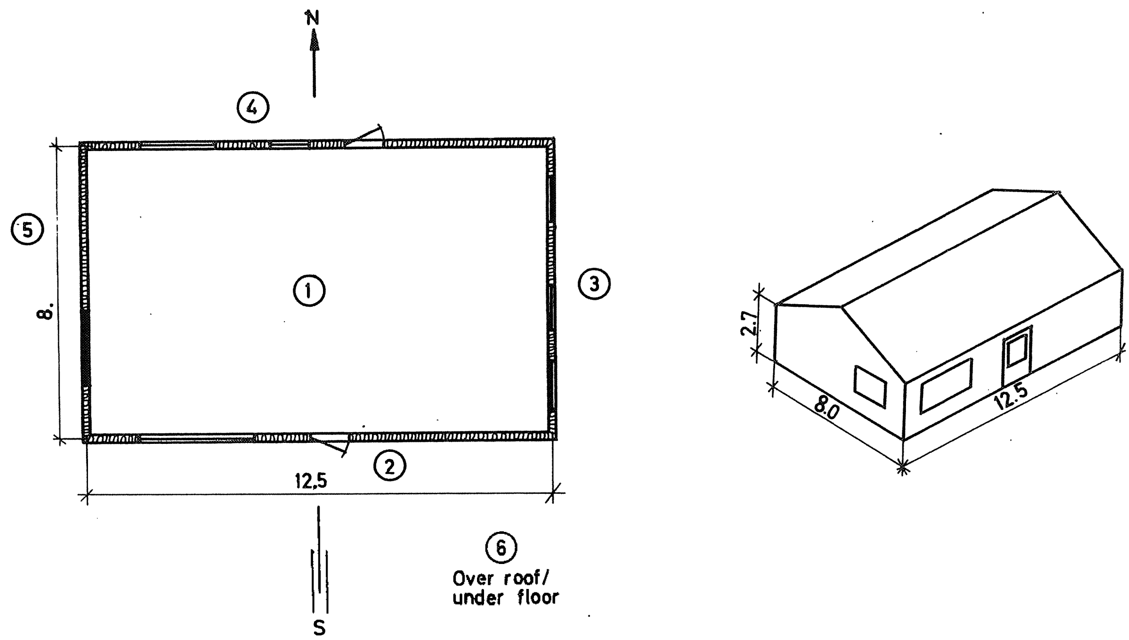


Figure 15

House with hot air system

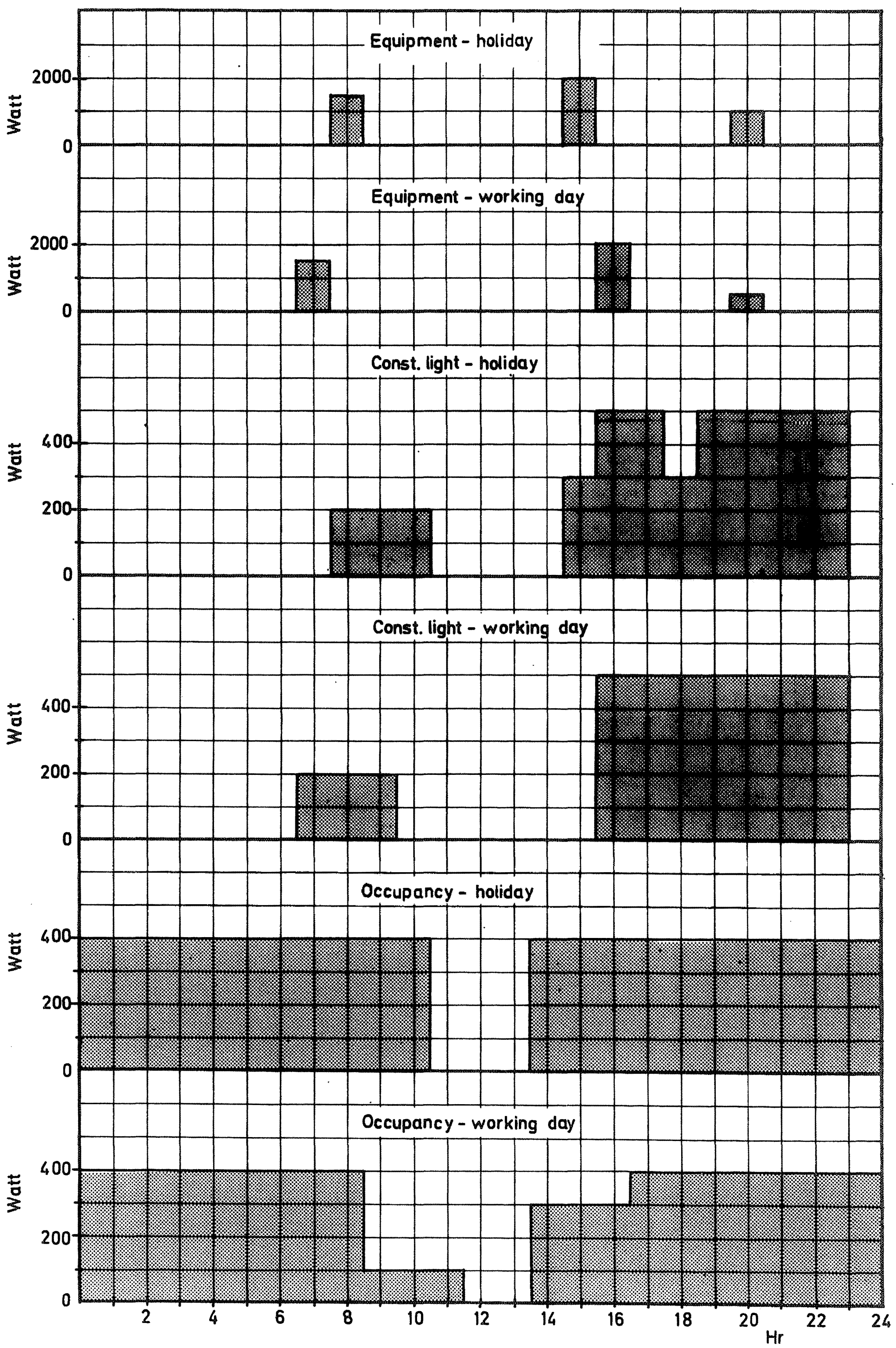


Figure 16

Schedules for internal heat gains

```
     ***  EXAMPLE 1 - ENCORE USER'S MANUAL    ***
     ***  HOUSE WITH HOT AIR SYSTEM           ***
STATION NO  492
ROTATION     0.
 1964  260  127    0    0
  60.    -15.        -1
HORIZ.OSLO   0.        0.        1.        1.        1.5       3.        4.5
   5.        3.        3.        2.5       3.        2.        1.        1.
   1.        1.        0.
    2    2   1.05      1.05
    4    3.
SYSTM TYPE    1
1000.      180.         1    1    1    1    1    1    1
NO.O.ROOMS    1
ROOM NO.      1
    1 100.      41.       0.     10000.      1.5
    1    1    1    1    1
    2    2    1    2    1
OUT.PRESS     5
    2    1
    3    2
    4    1
    5    2
    6    3
OCCUPANCY     2
 400.
    1    8  100    9   11   25   14   16   75   17   24  100
 400.
    1   10  100   14   24  100
CON.LIGHT     2
 500.
    7    9   40   16   23  100
 500.
    8   10   40   15   15   60   16   17  100   18   18   60   19   23  100
```


Figure 17

```
VAR.LIGHT       1
 100.
    1   24   100
EQUIPMENT       2
2000.
    7    7   75    16    16  100    20    20    25
2000.
    8    8   75    15    15  100    20    20    50
THERMOSTAT      1
    1   24   20
HOT WATER       1
   0.
    1   24   100
    0  370   25     0
NO.O.WALLS      7
    1    2    1     2     1 180.         90.         33.75   2000.          .66
    1   6.0        3.1         2.1         .1           0
    1    .9         .6         1.5         .02          0
    1   1.1
    1    5    1     1     0 270.         90.         21.6    2000.          .66
    1   2.4        1.3         2.1         .1
    1    6    2     0     0   0.         -1.        100.
    1    6    2     0     0 180.         25.         50.
    1    6    2     0     0   0.         25.         50.
    1    4    1     2     1   0.         90.         33.75   2000.          .66
    1   2.4        1.3         2.1         .1
    1   .16         .5          .5         .1
    1   2.
    1    3    1     3     0  90.         90.         21.6    2000.          .66
    1   1.44       1.3         1.3         .1
    1   1.44       1.3         1.3         .1
    1   1.44       1.3         1.3         .1
```

```
Z-TRANSFER     2
 .3487446      .4         .6
 .09356209 .23355346 .02159372 .00003546
1.        -.12917745 .00053341
 .077978       .3         .6
 .00052652 .02373843 .04390606 .00957936 .00022729 .00000030
1.        -.92789179 .19580070-.00817364 .00003718
WINDOWTYPE     1
   2.9         .75        .9        1
DOORTYPES      1
   2.5         .6
    .75       1.7         .8          .4        6.       300.        20.        55.
 100.       150.       500.
    .15       2.         2.           .18       6.         5.5       -0.5
```

```
***  EXAMPLE 1 - ENCORE USER'S MANUAL    ***
***  HOUSE WITH HOT AIR SYSTEM            ***

*******************************************************************************

          ----------------------------------------
          I                                      I
          I  HEATING SYSTEM: OIL FIRED HOT AIR   I
          I                                      I
          ----------------------------------------


BUILDING IS ROTATED    0. DEGREES FROM THE AZIMUT ANGLES
GIVEN ON THE "WALL DATA CARDS"


METEOROLOGICAL STATION NO.:  492


WEATHERDATA FOR 1964 IS USED IN SIMULATION

HEATING SEASON STARTS ON DAY NO. 260, ENDS ON DAY NO. 127

BUILDING HAS SHAPE TYPE  4
DISTANCE BETWEEN GROUND AND EDGE OF ROOF:  3.0 M

BUILDING LOCATION 60.0 DEG N AND  -15.0 DEG W (E IF NEG.)  TIME ZONE -1
```

Figure 18

```
TERRAIN AT BUILDING SITE        : 2
    "    " METEOROLOGICAL SITE: 2

CLEARNESS NUMBER, SUMMER: 1.05
    "        "     WINTER: 1.05
```

*** HORIZON ***

DIR.	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360
HOR.	0.	0.	1.	1.	1.	3.	4.	5.	3.	3.	2.	3.	2.	1.	1.	1.	1.	0.

*** HOT WATER HEATER ***

```
TANK CAPACITY                      :   180. LITERS
HEATER ELEMENT CAPACITY            :  1000. WATTS
HOT WATER CONSUMPTION SCHEDULES : MON:1 TUE:1 WED:1 THU:1 FRI:1 SAT:1 SUN:1
```

*** ROOM DATA ***

ROOM NO.	WEIGHT CODE	FLOOR AREA	PERIM. LENGTH	ROOM LEVEL		*************** SCHEDULES *************** OCCUP.	C.LIGHT	V.LIGHT	EQUIP.	THERM.
1	1	100.00	41.00	.0	W	1	1	1	1	1
					H	2	2	1	2	1

OUTSIDE PRESSURE POINTS

POINT NO.	CODE
2	1
3	2
4	1
5	2
6	3

*** OCCUPANCY SCHEDULES ***

NO. 1

400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	100.0	100.0
100.0	.0	.0	300.0	300.0	300.0	400.0	400.0	400.0	400.0
400.0	400.0	400.0	400.0						

NO. 2

400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0
.0	.0	.0	400.0	400.0	400.0	400.0	400.0	400.0	400.0
400.0	400.0	400.0	400.0						

*** CONSTANT LIGHT SCHEDULES ***

NO. 1

.0	.0	.0	.0	.0	.0	200.0	200.0	200.0	.0
.0	.0	.0	.0	.0	500.0	500.0	500.0	500.0	500.0
500.0	500.0	500.0	.0						

NO. 2

.0	.0	.0	.0	.0	.0	.0	200.0	200.0	200.0
.0	.0	.0	.0	300.0	500.0	500.0	300.0	500.0	500.0
500.0	500.0	500.0	.0						

*** VARIABLE LIGHT SCHEDULES ***

LIGHT ON IF ROOM IS OCCUPIED AND SOLAR GAIN LESS THAN 4.7 WATTS/M2 FLOOR AREA

NO. 1

100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
100.0	100.0	100.0	100.0						

*** EQUIPMENT SCHEDULES ***

NO. 1

.0	.0	.0	.0	.0	.0	1500.0	.0	.0	.0
.0	.0	.0	.0	.0	2000.0	.0	.0	.0	500.0
.0	.0	.0	.0						

NO. 2

.0	.0	.0	.0	.0	.0	.0	1500.0	.0	.0
.0	.0	.0	.0	2000.0	.0	.0	.0	.0	1000.0
.0	.0	.0	.0						

*** THERMOSTAT SETPOINT SCHEDULES ***

NO. 1

20	20	20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20	20	20
20	20	20	20						

*** HOT WATER CONSUMPTION SCHEDULES ***

NO. 1

.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
.000	.000	.000	.000						

*** WINDOW SHUTTER SCHEDULES ***

WINDOWS HAVE NO SHUTTERS WHEN DAY OF THE YEAR IS BETWEEN 0 AND 370
THE REST OF THE YEAR SHUTTERS ARE CLOSED FROM 25 IN THE EVENING TO 0 IN THE MORNING

*** WALL DATA ***

WALL NO.	SEPARATES ROOMS	WALL TYPE	NO. OF WINDOWS	NO. OF DOORS	WALL AZIMUT	TILT ANGLE	NET AREA	FLOW RES.	FLOW EXP.
1	1 AND 2	1	2	1	180.0	90.0	25.8	.200+04	.66
2	1 AND 5	1	1	0	270.0	90.0	19.2	.200+04	.66
3	1 AND 6	2	0	0	.0	-1.0	100.0	.000	.00
4	1 AND 6	2	0	0	180.0	25.0	50.0	.000	.00
5	1 AND 6	2	0	0	.0	25.0	50.0	.000	.00
6	1 AND 4	1	2	1	.0	90.0	29.2	.200+04	.66
7	1 AND 3	1	3	0	90.0	90.0	17.3	.200+04	.66

*** HOUSE GEOMETRY ***

ROOM NO.	ROOM IS MADE UP OF WALLS NO.														
1	1	2	3	4	5	6	7	0	0	0	0	0	0	0	0

ROOM NO.	ROOM IS SURROUNDED BY ROOMS NO.														
1	2	5	6	6	6	4	3	0	0	0	0	0	0	0	0

*** LOCATION, AREA AND TYPE OF WINDOWS ***

WINDOW NO.	AREA	TYPE	SEPARATES ROOMS
1	6.0	1	1 AND 2
2	.9	1	1 AND 2
3	2.4	1	1 AND 5
4	2.4	1	1 AND 4
5	.2	1	1 AND 4
6	1.4	1	1 AND 3
7	1.4	1	1 AND 3
8	1.4	1	1 AND 3

*** WINDOW SASH, VERTICAL FINS, AND HORIZONTAL OVERHANG ***

WIN-DOW NO.	* WINDOW SASH *			* RIGHT FIN *		* LEFT FIN *		* OVERHANG *	
	WIDTH	HEIGHT	DEPTH	WIDTH	DIST. TO SASH	WIDTH	DIST. TO SASH	WIDTH	DIST TO SASH
1	3.10	2.10	.10	.00	.00	.00	.00	.00	.00
2	.60	1.50	.02	.00	.00	.00	.00	.00	.00
3	1.30	2.10	.10	.00	.00	.00	.00	.00	.00
4	1.30	2.10	.10	.00	.00	.00	.00	.00	.00
5	.50	.50	.10	.00	.00	.00	.00	.00	.00
6	1.30	1.30	.10	.00	.00	.00	.00	.00	.00
7	1.30	1.30	.10	.00	.00	.00	.00	.00	.00
8	1.30	1.30	.10	.00	.00	.00	.00	.00	.00

*** LOCATION, AREA AND TYPE OF DOORS ***

DOOR NO.	AREA	TYPE	SEPARATES ROOMS
1	1.1	1	1 AND 2
2	2.0	1	1 AND 4

*** WALL TYPES ***

```
NO.  1
B:   .0935621   .2335535   .0215937   .0000355   .0000000   .0000000   .0000000
D: 1.0000000 -.1291774   .0005334   .0000000   .0000000   .0000000   .0000000
C:   .3487446
U:   .4000000
WSABS:   .6000000
NO.  2
B:   .0005265   .0237384   .0439061   .0095794   .0002273   .0000003   .0000000
D: 1.0000000 -.9278918   .1958007 -.0081736   .0000372   .0000000   .0000000
C:   .0779780
U:   .3000000
WSABS:   .6000000
```

*** WINDOW TYPES ***

NO.	U-VALUE1 NO SHUTTERS	U-VALUE2 SHUTTERS	SH.COEF.	SH.TYPE(1=INSIDE,0=OUTSIDE)
1	2.9000	.7500	.90	1

*** DOOR TYPES ***

NO.	U-VALUE	SOLAR ABS.
1	2.5000	.6000

*** HEATING SYSTEM DATA ***

THERMOSTAT THROTTLING RANGE (CELCIUS)	1.5	
CAPACITY OF BURNER NOZZLE (US-GALLONS/HOUR)	.75	
AIR SUPPLIED FOR COMBUSTION TO THEORETICAL AIR REQUIREMENT	1.70	
DRAFT SETTING AT BAROMETRIC DAMPER (MM WATER GAUGE)	.80	
WEIGHT FLOW OF AIR THROUGH THE FURNACE AT OFF-CYCLE TO THE WEIGHT FLOW OF FLUE AT ON-CYCLE	.40	
NUMBER OF BURNER CYCLES PER HOUR AT 50% LOAD	6.	
STEADY STATE ON-CYCLE FLUE TEMP. (C)	300.0	
" " OFF-CYCLE " " "	20.0	
FLUE TEMP. WHEN AIR-CIRCULATION FAN STOPS (C)	55.0	
TIME CONST. FOR INCREASE IN FLUE TEMP. AT ON-CYCLE (SEC)	100.	
" " " DECREASE " " " " " OFF-CYCLE (SEC) WHEN AIR-CIRCULATION FAN IS ON (SEC)	150.	
SAME AS ABOVE, BUT AIR-CIRCULATION FAN IS OFF (SEC)	500.	
SMOKE PIPE DIAMETER (M)	.15	
" " LENGTH (M)	2.00	
NUMBER OF SMOKE PIPE BENDS	2.	
INTERNAL SIDE LENGTH OF CHIMNEY (M)	.18	
LENGTH OF CHIMNEY (M)	6.00	
DISTANCE FROM PRESSURE REF. LEVEL TO TOP OF CHIMNEY (M)	5.50	(UP +)
" " " " " " CENTER OF FURNACE (M)	-.50	(")

DATE: 1/ 1-1964
HOUR: 1

DRY BULB TEMP. : -1.1 CELCIUS
WIND SPEED : .5 M/S
WIND DIRECTION : 20.0 DEG FROM NORTH
CLOUD COVER : 4.0 (0.-8.)

HEAT FLOW THROUGH WALLS, ETC. AT 20 C ROOM TEMP. (WATTS),
AND AIR FLOW THROUGH CRACKS IN WALLS (KG/S)
HEAT AND AIR FLOW INTO ROOM/HOUSE POSITIVE

WALL WINDOW DOOR NO.	WINDOWS SOLAR	WINDOWS COND.	WALLS (TWO VALUES FOR INTERNAL WALLS)		DOORS	AIR FLOW THROUGH WALLS AT BURNER ON-CYCLE	AIR FLOW THROUGH WALLS AT BURNER OFF-CYCLE
1	0.	-367.	-182.	0.	-58.	.71757-02	.21259-02
2	0.	-55.	-136.	0.	-105.	.71538-02	.20846-02
3	0.	-147.	-201.	0.	0.	.00000	.00000
4	0.	-147.	-101.	0.	0.	.00000	.00000
5	0.	-10.	-101.	0.	0.	.00000	.00000
6	0.	-88.	-207.	0.	0.	.72414-02	.22473-02
7	0.	-88.	-122.	0.	0.	.71538-02	.20846-02
8	0.	-88.	0.	0.	0.	.00000	.00000

HEATING(NEG.) AND COOLING(POS.) LOADS AT 20 C ROOM TEMP. (WATTS)

ROOM NO.	LOADS DUE TO: WINDOWS	WALLS	DOORS	OCCUP.	EQUIP.	LIGHTS	INF.	TOTAL
1	-665.	-706.	-110.	69.	0.	0.	-215.	-1627.

HEAT OUTPUT AND ROOM TEMPERATURE

ROOM NO.	HEAT OUTPUT (WATTS)	ROOM TEMP. (CELCIUS)
1	2287.	20.6

HOT WATER HEATER (ASSUMING 75 C TEMP.RISE)

HOT WATER DEMAND : 0. WATTS
AVG. ELECTR. INPUT : 0. WATTS
STORED HEAT AT END OF HOUR: 15700. WATTHRS

FURNACE LOAD FACTOR: .10

Similar printout for hrs. 0200 to 2300

DATE: 1/ 1-1964
HOUR: 24

DRY BULB TEMP. : -4.1 CELCIUS
WIND SPEED : .4 M/S
WIND DIRECTION : 48.3 DEG FROM NORTH
CLOUD COVER : 2.5 (0.-8.)

HEAT FLOW THROUGH WALLS, ETC. AT 20 C ROOM TEMP. (WATTS),
AND AIR FLOW THROUGH CRACKS IN WALLS (KG/S)
HEAT AND AIR FLOW INTO ROOM/HOUSE POSITIVE

WALL WINDOW DOOR NO.	WINDOWS SOLAR	WINDOWS COND.	WALLS (TWO VALUES FOR INTERNAL WALLS)		DOORS	AIR FLOW THROUGH WALLS AT BURNER ON-CYCLE	AIR FLOW THROUGH WALLS AT BURNER OFF-CYCLE
1	0.	-419.	-247.	0.	-66.	.72066-02	.21917-02
2	0.	-63.	-184.	0.	-120.	.72090-02	.21962-02
3	0.	-168.	-863.	0.	0.	.00000	.00000
4	0.	-168.	-429.	0.	0.	.00000	.00000
5	0.	-11.	-431.	0.	0.	.00000	.00000
6	0.	-101.	-280.	0.	0.	.72334-02	.22410-02
7	0.	-101.	-166.	0.	0.	.72310-02	.22366-02
8	0.	-101.	0.	0.	0.	.00000	.00000

HEATING(NEG.) AND COOLING(POS.) LOADS AT 20 C ROOM TEMP. (WATTS)

ROOM NO.	LOADS DUE TO: WINDOWS	WALLS	DOORS	OCCUP.	EQUIP.	LIGHTS	INF.	TOTAL
1	-1009.	-2435.	-175.	371.	69.	511.	-279.	-2947.

HEAT OUTPUT AND ROOM TEMPERATURE

ROOM NO.	HEAT OUTPUT (WATTS)	ROOM TEMP. (CELCIUS)
1	3015.	20.5

HOT WATER HEATER (ASSUMING 75 C TEMP.RISE)

HOT WATER DEMAND : 0. WATTS
AVG. ELECTR. INPUT : 0. WATTS
STORED HEAT AT END OF HOUR: 15700. WATTHRS

FURNACE LOAD FACTOR: .13

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH **	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH **	* TOTAL * OIL CONS. LITERS
1/ 1	-2.2	59.	11.	0.	59.	11.	0.	7.4
2/ 1	-2.2	67.	11.	0.	126.	22.	0.	15.9
3/ 1	3.5	45.	11.	0.	171.	32.	0.	21.6
4/ 1	1.4	48.	11.	0.	219.	44.	0.	27.7
5/ 1	1.8	49.	11.	0.	268.	55.	0.	34.0
6/ 1	-5.3	71.	11.	0.	339.	65.	0.	43.0
7/ 1	-8.6	89.	11.	0.	428.	76.	0.	54.2
8/ 1	-6.0	84.	11.	0.	512.	87.	0.	64.8
9/ 1	-2.0	67.	11.	0.	580.	97.	0.	73.3
10/ 1	-1.3	59.	11.	0.	639.	108.	0.	80.8
11/ 1	-3.9	69.	11.	0.	708.	119.	0.	89.6
12/ 1	-4.3	71.	11.	0.	779.	130.	0.	98.7
13/ 1	-7.2	78.	11.	0.	857.	141.	0.	108.5
14/ 1	-6.8	83.	10.	0.	940.	151.	0.	119.0
15/ 1	-6.0	72.	10.	0.	1012.	162.	0.	128.2
16/ 1	-5.8	76.	10.	0.	1088.	172.	0.	137.9
17/ 1	-6.8	76.	10.	0.	1165.	183.	0.	147.6
18/ 1	-8.7	85.	11.	0.	1250.	194.	0.	158.3
19/ 1	-9.5	91.	11.	0.	1341.	205.	0.	169.9
20/ 1	-5.1	76.	10.	0.	1417.	215.	0.	179.5
21/ 1	1.8	48.	10.	0.	1464.	226.	0.	185.6
22/ 1	2.1	42.	10.	0.	1506.	236.	0.	190.9
23/ 1	-.8	53.	10.	0.	1559.	246.	0.	197.6
24/ 1	-.2	53.	10.	0.	1612.	257.	0.	204.3
25/ 1	.6	45.	11.	0.	1657.	268.	0.	210.0
26/ 1	-3.4	61.	11.	0.	1718.	279.	0.	217.7
27/ 1	-7.1	70.	10.	0.	1787.	289.	0.	226.5
28/ 1	-1.5	59.	10.	0.	1847.	300.	0.	234.1
29/ 1	1.8	43.	10.	0.	1890.	310.	0.	239.5
30/ 1	2.7	40.	10.	0.	1930.	320.	0.	244.7
31/ 1	-.2	45.	10.	0.	1975.	331.	0.	250.3

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	* TOTAL * OIL CONS. LITERS
1/ 2	-2.3	56.	11.	0.	2031.	342.	0.	257.4
2/ 2	-2.2	53.	11.	0.	2084.	353.	0.	264.2
3/ 2	1.4	45.	10.	0.	2129.	363.	0.	269.9
4/ 2	-.9	48.	10.	0.	2177.	373.	0.	276.0
5/ 2	-3.8	59.	10.	0.	2236.	384.	0.	283.5
6/ 2	-5.0	56.	10.	0.	2292.	394.	0.	290.5
7/ 2	-3.7	59.	10.	0.	2351.	404.	0.	297.8
8/ 2	3.6	30.	11.	0.	2381.	415.	0.	301.5
9/ 2	.0	35.	11.	0.	2416.	426.	0.	306.0
10/ 2	1.2	36.	10.	0.	2452.	436.	0.	310.6
11/ 2	-1.5	46.	10.	0.	2498.	447.	0.	316.4
12/ 2	-8.9	69.	10.	0.	2568.	457.	0.	325.2
13/ 2	-7.0	76.	10.	0.	2644.	467.	0.	334.8
14/ 2	-4.9	63.	10.	0.	2707.	477.	0.	342.9
15/ 2	-5.3	65.	11.	0.	2771.	488.	0.	351.0
16/ 2	-11.2	82.	11.	0.	2853.	499.	0.	361.6
17/ 2	-10.5	82.	10.	0.	2936.	509.	0.	372.0
18/ 2	-11.1	74.	10.	0.	3010.	519.	0.	381.4
19/ 2	-8.0	73.	10.	0.	3083.	529.	0.	390.6
20/ 2	-6.3	64.	10.	0.	3147.	540.	0.	398.7
21/ 2	-6.2	59.	10.	0.	3205.	550.	0.	406.1
22/ 2	-1.8	49.	11.	0.	3254.	561.	0.	412.3
23/ 2	-2.6	48.	11.	0.	3302.	571.	0.	418.4
24/ 2	-5.3	58.	10.	0.	3361.	581.	0.	425.7
25/ 2	-3.6	55.	10.	0.	3416.	592.	0.	432.8
26/ 2	-1.2	37.	10.	0.	3453.	602.	0.	437.4
27/ 2	-1.0	42.	10.	0.	3494.	612.	0.	442.7
28/ 2	.4	42.	10.	0.	3536.	622.	0.	448.1
29/ 2	1.4	32.	11.	0.	3569.	633.	0.	452.2

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	* TOTAL * OIL CONS. LITERS
1/ 3	1.0	32.	11.	0.	3601.	643.	0.	456.3
2/ 3	1.1	27.	10.	0.	3629.	653.	0.	459.7
3/ 3	.7	33.	10.	0.	3661.	663.	0.	463.8
4/ 3	.7	32.	10.	0.	3694.	674.	0.	467.9
5/ 3	1.1	28.	10.	0.	3722.	684.	0.	471.5
6/ 3	.1	31.	10.	0.	3753.	694.	0.	475.4
7/ 3	-2.6	42.	11.	0.	3795.	704.	0.	480.7
8/ 3	-1.6	43.	11.	0.	3838.	715.	0.	486.1
9/ 3	3.7	22.	10.	0.	3859.	725.	0.	488.8
10/ 3	2.9	18.	10.	0.	3877.	735.	0.	491.1
11/ 3	2.6	19.	10.	0.	3896.	745.	0.	493.5
12/ 3	.9	23.	10.	0.	3920.	755.	0.	496.4
13/ 3	.4	20.	10.	0.	3940.	765.	0.	498.9
14/ 3	-3.2	26.	10.	0.	3966.	775.	0.	502.2
15/ 3	-4.2	29.	10.	0.	3995.	786.	0.	505.9
16/ 3	-3.1	30.	10.	0.	4025.	795.	0.	509.6
17/ 3	-2.9	31.	10.	0.	4056.	805.	0.	513.5
18/ 3	-1.8	33.	10.	0.	4088.	815.	0.	517.7
19/ 3	-4.5	42.	10.	0.	4130.	825.	0.	523.0
20/ 3	-4.4	45.	10.	0.	4175.	835.	0.	528.6
21/ 3	-3.4	53.	10.	0.	4228.	846.	0.	535.2
22/ 3	-1.8	45.	10.	0.	4273.	856.	0.	541.0
23/ 3	-2.4	37.	10.	0.	4311.	866.	0.	545.7
24/ 3	-2.0	37.	10.	0.	4347.	876.	0.	550.3
25/ 3	-.3	27.	10.	0.	4375.	886.	0.	553.7
26/ 3	.1	24.	10.	0.	4399.	896.	0.	556.8
27/ 3	.3	29.	10.	0.	4428.	906.	0.	560.5
28/ 3	1.0	19.	10.	0.	4447.	916.	0.	562.9
29/ 3	1.8	14.	10.	0.	4461.	927.	0.	564.6
30/ 3	1.0	25.	10.	0.	4485.	936.	0.	567.7
31/ 3	.4	23.	10.	0.	4509.	946.	0.	570.6

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	* TOTAL * OIL CONS. LITERS
1/ 4	1.0	17.	10.	0.	4526.	956.	0.	572.8
2/ 4	2.6	12.	10.	0.	4538.	966.	0.	574.3
3/ 4	3.3	7.	10.	0.	4545.	975.	0.	575.2
4/ 4	3.5	7.	10.	0.	4552.	986.	0.	576.1
5/ 4	3.1	13.	10.	0.	4565.	996.	0.	577.7
6/ 4	2.5	17.	10.	0.	4582.	1006.	0.	579.9
7/ 4	2.9	15.	10.	0.	4597.	1015.	0.	581.8
8/ 4	2.0	21.	10.	0.	4618.	1025.	0.	584.5
9/ 4	1.1	34.	10.	0.	4652.	1035.	0.	588.8
10/ 4	3.6	26.	10.	0.	4679.	1045.	0.	592.1
11/ 4	2.9	26.	10.	0.	4704.	1055.	0.	595.4
12/ 4	5.2	14.	10.	0.	4719.	1065.	0.	597.2
13/ 4	7.1	7.	10.	0.	4726.	1075.	0.	598.1
14/ 4	4.5	4.	10.	0.	4730.	1085.	0.	598.6
15/ 4	4.6	10.	10.	0.	4740.	1094.	0.	599.9
16/ 4	3.9	17.	10.	0.	4757.	1104.	0.	602.0
17/ 4	7.9	9.	10.	0.	4766.	1114.	0.	603.1
18/ 4	9.9	6.	10.	0.	4772.	1124.	0.	603.8
19/ 4	11.0	0.	10.	0.	4772.	1134.	0.	603.8
20/ 4	11.8	0.	10.	0.	4772.	1144.	0.	603.8
21/ 4	10.2	0.	10.	0.	4772.	1154.	0.	603.8
22/ 4	10.5	0.	10.	0.	4772.	1163.	0.	603.8
23/ 4	8.2	0.	10.	0.	4772.	1173.	0.	603.8
24/ 4	5.2	3.	10.	0.	4775.	1183.	0.	604.3
25/ 4	3.4	15.	10.	0.	4790.	1193.	0.	606.1
26/ 4	3.7	14.	10.	0.	4804.	1203.	0.	607.9
27/ 4	8.0	7.	10.	0.	4811.	1213.	0.	608.7
28/ 4	8.9	2.	10.	0.	4812.	1223.	0.	609.0
29/ 4	7.7	2.	10.	0.	4814.	1232.	0.	609.2
30/ 4	9.0	5.	10.	0.	4820.	1242.	0.	609.9

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	* TOTAL * OIL CONS. LITERS
1/ 5	9.7	4.	10.	0.	4823.	1252.	0.	610.4
2/ 5	8.3	0.	10.	0.	4823.	1262.	0.	610.4
3/ 5	5.6	0.	10.	0.	4823.	1272.	0.	610.4
4/ 5	6.1	10.	10.	0.	4833.	1282.	0.	611.6
5/ 5	5.7	14.	9.	0.	4847.	1291.	0.	613.4
6/ 5	8.2	9.	9.	0.	4856.	1301.	0.	614.4
16/ 9	11.9	1.	10.	0.	4857.	1311.	0.	614.6
17/ 9	9.9	0.	10.	0.	4857.	1321.	0.	614.6
18/ 9	8.4	1.	10.	0.	4858.	1331.	0.	614.8
19/ 9	7.4	8.	10.	0.	4866.	1341.	0.	615.8
20/ 9	7.4	12.	10.	0.	4878.	1352.	0.	617.3
21/ 9	7.0	13.	10.	0.	4890.	1361.	0.	618.8
22/ 9	7.6	11.	10.	0.	4901.	1371.	0.	620.2
23/ 9	12.1	5.	10.	0.	4906.	1381.	0.	620.8
24/ 9	12.0	0.	10.	0.	4905.	1391.	0.	620.8
25/ 9	11.5	0.	10.	0.	4906.	1401.	0.	620.8
26/ 9	11.2	0.	11.	0.	4906.	1412.	0.	620.8
27/ 9	9.6	0.	11.	0.	4906.	1422.	0.	620.8
28/ 9	10.1	2.	10.	0.	4908.	1432.	0.	621.1
29/ 9	11.4	0.	10.	0.	4908.	1442.	0.	621.1
30/ 9	7.6	4.	10.	0.	4912.	1452.	0.	621.6

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	* TOTAL * OIL CONS. LITERS
1/10	4.4	10.	10.	0.	4921.	1462.	0.	622.8
2/10	7.9	13.	10.	0.	4934.	1472.	0.	624.4
3/10	6.9	7.	11.	0.	4941.	1483.	0.	625.2
4/10	5.5	11.	11.	0.	4952.	1494.	0.	626.6
5/10	6.3	9.	10.	0.	4960.	1504.	0.	627.7
6/10	7.5	9.	10.	0.	4969.	1514.	0.	628.8
7/10	10.0	8.	10.	0.	4977.	1524.	0.	629.7
8/10	10.3	5.	10.	0.	4982.	1534.	0.	630.4
9/10	9.3	6.	10.	0.	4987.	1544.	0.	631.1
10/10	9.6	9.	11.	0.	4996.	1555.	0.	632.2
*** SUBROUTINE CHMNEY *** FLOW IN CHIMNEY NOT FOUND AFTER 11 ITERATIONS								
11/10	7.7	12.	11.	0.	5008.	1565.	0.	633.7
12/10	7.7	11.	10.	0.	5019.	1576.	0.	635.1
13/10	6.6	19.	10.	0.	5038.	1586.	0.	637.6
14/10	6.0	22.	10.	0.	5060.	1596.	0.	640.4
15/10	4.6	23.	10.	0.	5083.	1606.	0.	643.3
16/10	5.9	21.	10.	0.	5104.	1616.	0.	646.0
17/10	6.4	19.	11.	0.	5123.	1627.	0.	648.4
18/10	4.7	18.	11.	0.	5141.	1637.	0.	650.7
19/10	4.2	23.	10.	0.	5164.	1648.	0.	653.5
20/10	9.1	14.	10.	0.	5178.	1658.	0.	655.3
21/10	7.5	12.	10.	0.	5190.	1668.	0.	656.8
22/10	4.6	21.	10.	0.	5211.	1678.	0.	659.5
23/10	6.3	24.	10.	0.	5235.	1688.	0.	662.5
24/10	5.8	24.	11.	0.	5259.	1699.	0.	665.6
25/10	1.8	31.	11.	0.	5290.	1710.	0.	669.5
26/10	-1.2	45.	10.	0.	5335.	1720.	0.	675.1
27/10	-.7	57.	10.	0.	5392.	1730.	0.	682.3
28/10	.3	55.	10.	0.	5447.	1741.	0.	689.2
29/10	-.4	55.	10.	0.	5502.	1751.	0.	696.1
*** SUBROUTINE CHMNEY *** FLOW IN CHIMNEY NOT FOUND AFTER 11 ITERATIONS								
*** SUBROUTINE CHMNEY *** FLOW IN CHIMNEY NOT FOUND AFTER 11 ITERATIONS								
30/10	-.8	40.	10.	0.	5542.	1761.	0.	701.1
31/10	.1	46.	11.	0.	5589.	1772.	0.	707.0

DATE	MEAN DBT DEG C	** DAILY HEATING KWH	ENERGY LIGHTS & APPL. KWH	CONS. ** HOT WATER KWH	** TOTAL HEATING KWH	ENERGY LIGHTS & APPL. KWH	CONS. ** HOT WATER KWH	* TOTAL * OIL CONS. LITERS
1/11	2.1	39.	11.	0.	5628.	1783.	0.	712.0
2/11	3.3	32.	10.	0.	5660.	1793.	0.	716.0
3/11	-.4	38.	10.	0.	5698.	1803.	0.	720.8
4/11	-1.4	56.	10.	0.	5754.	1814.	0.	727.8
5/11	.4	42.	10.	0.	5797.	1824.	0.	733.2
6/11	1.0	43.	10.	0.	5840.	1834.	0.	738.6
7/11	-1.4	50.	11.	0.	5890.	1845.	0.	745.0
8/11	-.0	48.	11.	0.	5937.	1856.	0.	751.0
9/11	-1.9	57.	10.	0.	5995.	1867.	0.	758.3
10/11	-.1	48.	10.	0.	6043.	1877.	0.	764.5
11/11	2.6	35.	10.	0.	6079.	1887.	0.	769.0
12/11	2.7	39.	10.	0.	6117.	1898.	0.	773.9
13/11	.8	46.	10.	0.	6163.	1908.	0.	779.6
14/11	4.8	30.	11.	0.	6193.	1919.	0.	783.4
15/11	4.9	28.	11.	0.	6221.	1930.	0.	787.0
16/11	1.2	43.	10.	0.	6264.	1940.	0.	792.4
17/11	.6	50.	10.	0.	6315.	1951.	0.	798.8
18/11	2.2	40.	10.	0.	6354.	1961.	0.	803.8
19/11	-.8	58.	10.	0.	6412.	1972.	0.	811.1
20/11	-.6	52.	10.	0.	6464.	1982.	0.	817.7
21/11	.6	47.	11.	0.	6511.	1994.	0.	823.7
22/11	1.5	45.	11.	0.	6556.	2005.	0.	829.4
23/11	1.2	45.	10.	0.	6601.	2015.	0.	835.0
24/11	3.1	40.	10.	0.	6640.	2026.	0.	840.1
25/11	2.6	42.	10.	0.	6683.	2036.	0.	845.4
26/11	.5	50.	10.	0.	6732.	2047.	0.	851.7
27/11	2.0	43.	10.	0.	6775.	2057.	0.	857.2
28/11	-.4	56.	11.	0.	6832.	2068.	0.	864.4
29/11	-1.4	56.	11.	0.	6888.	2079.	0.	871.5
30/11	-2.3	63.	10.	0.	6951.	2090.	0.	879.5

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH **	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH **	* TOTAL * OIL CONS. LITERS
1/12	-2.7	62.	10.	0.	7013.	2100.	0.	887.5
2/12	.3	55.	10.	0.	7069.	2111.	0.	894.5
3/12	1.3	48.	10.	0.	7117.	2121.	0.	900.6
4/12	-.5	58.	10.	0.	7174.	2132.	0.	908.0
5/12	-5.0	71.	11.	0.	7245.	2143.	0.	916.9
6/12	-6.7	83.	11.	0.	7328.	2154.	0.	927.4
7/12	1.4	55.	11.	0.	7383.	2165.	0.	934.4
8/12	5.0	42.	11.	0.	7425.	2175.	0.	939.7
9/12	5.8	39.	11.	0.	7464.	2186.	0.	944.7
10/12	1.0	51.	11.	0.	7515.	2196.	0.	951.2
11/12	-.5	58.	11.	0.	7573.	2207.	0.	958.5
12/12	2.9	47.	11.	0.	7620.	2218.	0.	964.5
13/12	1.5	50.	11.	0.	7670.	2229.	0.	970.9
14/12	-2.1	64.	11.	0.	7734.	2240.	0.	979.0
15/12	-2.8	66.	11.	0.	7799.	2251.	0.	987.2
16/12	-4.5	74.	11.	0.	7873.	2261.	0.	996.5
17/12	-2.8	70.	11.	0.	7944.	2272.	0.	1005.4
18/12	-2.6	65.	11.	0.	8009.	2282.	0.	1013.6
19/12	-5.1	75.	11.	0.	8084.	2294.	0.	1023.0
20/12	-3.3	68.	11.	0.	8152.	2305.	0.	1031.7
21/12	-3.8	71.	11.	0.	8223.	2315.	0.	1040.6
22/12	-6.8	85.	11.	0.	8308.	2326.	0.	1051.3
23/12	-7.7	89.	11.	0.	8397.	2337.	0.	1062.5
24/12	-6.8	83.	11.	0.	8480.	2347.	0.	1073.0
25/12	-8.0	86.	11.	0.	8566.	2358.	0.	1083.9
26/12	-11.0	96.	11.	0.	8662.	2370.	0.	1095.8
27/12	-13.5	107.	11.	0.	8769.	2381.	0.	1109.2
28/12	-15.6	118.	11.	0.	8887.	2391.	0.	1124.0
29/12	-9.7	105.	11.	0.	8992.	2402.	0.	1137.4
30/12	-1.1	65.	11.	0.	9057.	2413.	0.	1145.8
31/12	1.3	53.	11.	0.	9110.	2423.	0.	1152.6
		TOTAL FOR THE YEAR:			==========	==========	==========	==========

4.2 House with electric heating

The house is shown is Figure 7. It has a "natural ventilation system". Fresh air enters the house through an opening in the window sash in the sleeping rooms and the living room. Used air is sucked out from the kitchen and the bathroom by means of vertical shafts to the outside (stack effect). In a multiroom model this system is easily simulated by just saying that the room level of the kitchen and bathroom is the same as the top of the vertical shafts, i.e. all the "cracks" in these rooms are located in that level (note that kitchen and bathroom have no fresh air intakes).

The input card deck is shown in Figure 19, and the output is shown in Figure 20.

Another way of simulating the ventilating system would be to introduce a "dummy" room in the level of the top of the shafts. This room should consist of minimum one external wall with the crack that corresponds to the shaft(s), and one internal wall with a high U-value. The latter is necessary to make sure that the temperature of the dummy room is the same as the temperature of the real room which it is a part of.

```
        *** EXAMPLE 2 - ENCORE USER'S MANUAL ***
        *** HOUSE WITH ELECTRIC HEATING      ***
STATION NO  492
ROTATION     0.
 1964  260  127    0    0
  60.     -15.         -1
HORIZ.OSLO   0.        0.        1.        1.        1.5       3.        4.5
   5.        3.        3.        2.5       3.        2.        1.        1.
   1.        1.        0.
    2    2   1.05      1.05
    4   3.0
SYSTM TYPE     2
1000.     180.         1    1    1    1    1    1    1
NO.O.ROOMS     7
ROOM NO.       1
    1  44.5       13.5       0.     5000.       1.5
    1    1    2    3    1
    1    1    2    3    1
ROOM NO.       2
    1  13.5        4.5       4.     1000.       1.5
    2    2    1    1    1
    3    3    1    2    1
ROOM NO.       3
    1   6.         2.        4.      750.       1.5
    6    5    2    3    1
    6    5    2    3    1
ROOM NO.       4
    1   4.         2.        0.      600.       1.5
    6    4    2    3    1
    6    4    2    3    1
ROOM NO.       5
    1  12.         7.        0.     1500.       1.5
    4    5    2    3    1
    4    5    2    3    1
ROOM NO.       6
    1  10.         2.5       0.     1250.       1.5
    5    5    2    3    1
    5    5    2    3    1
```

Figure 19

```
ROOM NO.        7
    1  10.          6.5        0.      1250.        1.5
    5     5     2     3     1
    5     5     2     3     1
U. PRESS.       3
    8     1
    9     2
   10     3
OCCUP.          6
 400.
   17    23   100
 400.
    7     7    50     8     8   100     9    11    25    14    17    75    22    22    25
 400.
    8    10   100    14    16   100    22    22    25
 200.
    1     7   100    23    24   100
 100.
    1     8   100    22    24   100
   0.
    1    24   100
CON. LIGTH      5
 500.
   17    18    60    19    23   100
 200.
    7     9   100    16    18   100
 200.
    8     9   100    15    17   100
  60.
    1    24   100
   0.
    1    24   100
VAR. LIGTH      2
 100.
    1    24   100
   0.
    1    24   100
```

```
EQUIPMENT      3
2000.
   7    7   75   16   16  100   20   20   25
2000.
   8    8   75   15   15  100   20   20   50
   0.
   1   24  100
TERMOSTAT      1
   1   24   20
HOT WATER      1
   0.
   1   24  100
   0  370   25    0
NO.O.WALLS    38
   1    8    1    2    1 180.        90.        22.95
   1   6.        3.1         2.1         .1
   1    .9        .6         1.5         .02
   1   1.1
   1    9    1    1    0 270.        90.        13.5     18700.        .5
   1   2.4       1.3         2.1         .1
   1    2    2    0    1   0.        90.        12.15
   2   2.
   1    3    2    0    0   0.        90.         5.4
   1    4    2    0    1   0.        90.         5.4
   2   2.
   1    6    2    0    1   0.        90.         6.75
   2   2.
   1    7    2    0    1   0.        90.         6.75
   2   2.
   1   10    3    0    0   0.        -1.        44.5
   1   10    3    0    0 180.        25.        34.0
   1   10    3    0    0   0.        25.        10.5
   2    9    1    0    0 270.        90.         8.1
   2    8    1    1    0   0.        90.        12.15
   1   2.4       1.3         2.1         .1
   2    3    2    0    0  90.        90.         8.1
   2   10    3    0    0   0.        -1.        13.5
```

```
Z-TRANSFER     3
 .3487446      .4        .6
 .09356209 .23355346 .02159372 .00003546
 1.        -.12917745 .00053341
 1.7160367   1.809     .6
 .95025575 .75598248 .00979849 .00000002
1.         -.05156129 .00002141
 .077978       .3        .6
 .00052652 .02373843 .04390606 .00957936 .00022729 .00000030
1.         -.92789179 .19580070-.00817364 .00003718
WINDOW U.      1
   2.9         .75       .9        1
DOOR U.        2
   2.5         .6
   2.9         .6
```

```
        *** EXAMPLE 2 - ENCORE USER'S MANUAL ***
        *** HOUSE WITH ELECTRIC HEATING      ***

**********************************************************************

               ---------------------------------------
               I                                     I
               I  HEATING SYSTEM: ELECTRIC           I
               I                                     I
               ---------------------------------------


BUILDING IS ROTATED    0. DEGREES FROM THE AZIMUT ANGLES
GIVEN ON THE "WALL DATA CARDS"


METEOROLOGICAL STATION NO.:  492


WEATHERDATA FOR 1964 IS USED IN SIMULATION

HEATING SEASON STARTS ON DAY NO. 260, ENDS ON DAY NO. 127

BUILDING HAS SHAPE TYPE  4
DISTANCE BETWEEN GROUND AND EDGE OF ROOF:  3.0 M

BUILDING LOCATION 60.0 DEG N AND  -15.0 DEG W (E IF NEG.)  TIME ZONE -1

TERRAIN AT BUILDING SITE      : 2
   "    " METEOROLOGICAL SITE: 2

CLEARNESS NUMBER, SUMMER: 1.05
   "       "      WINTER: 1.05
```

Figure 20

*** HORIZON ***

DIR.	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360
HOR.	0.	0.	1.	1.	1.	3.	4.	5.	3.	3.	2.	3.	2.	1.	1.	1.	1.	0.

*** HOT WATER HEATER ***

TANK CAPACITY : 180. LITERS
HEATER ELEMENT CAPACITY : 1000. WATTS
HOT WATER CONSUMPTION SCHEDULES : MON:1 TUE:1 WED:1 THU:1 FRI:1 SAT:1 SUN:1

*** ROOM DATA ***

ROOM NO.	WEIGHT CODE	FLOOR AREA	PERIM. LENGTH	ROOM LEVEL		**************** SCHEDULES ****************				
						OCCUP.	C.LIGHT	V.LIGHT	EQUIP.	THERM.
1	1	44.50	13.50	.0	W	1	1	2	3	1
					H	1	1	2	3	1
2	1	13.50	4.50	4.0	W	2	2	1	1	1
					H	3	3	1	2	1
3	1	6.00	2.00	4.0	W	6	5	2	3	1
					H	6	5	2	3	1
4	1	4.00	2.00	.0	W	6	4	2	3	1
					H	6	4	2	3	1
5	1	12.00	7.00	.0	W	4	5	2	3	1
					H	4	5	2	3	1
6	1	10.00	2.50	.0	W	5	5	2	3	1
					H	5	5	2	3	1
7	1	10.00	6.50	.0	W	5	5	2	3	1
					H	5	5	2	3	1

*** ROOM HEATERS ***

ROOM NO.	HEATER CAPACITY (WATTS)	THROTTLING RANGE C
1	5000.	1.5
2	1000.	1.5
3	750.	1.5
4	600.	1.5
5	1500.	1.5
6	1250.	1.5
7	1250.	1.5

OUTSIDE PRESSURE POINTS

POINT NO.	CODE
8	1
9	2
10	3

*** OCCUPANCY SCHEDULES ***

1									
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	400.0	400.0	400.0	400.0
00.0	400.0	400.0	.0						
2									
.0	.0	.0	.0	.0	.0	200.0	400.0	100.0	100.0
00.0	.0	.0	300.0	300.0	300.0	300.0	.0	.0	.0
.0	100.0	.0	.0						
3									
.0	.0	.0	.0	.0	.0	.0	400.0	400.0	400.0
.0	.0	.0	400.0	400.0	400.0	.0	.0	.0	.0
.0	100.0	.0	.0						

NO. 4									
200.0	200.0	200.0	200.0	200.0	200.0	200.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
.0	.0	200.0	200.0						
NO. 5									
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	.0	.0
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
.0	100.0	100.0	100.0						
NO. 6									
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0						

*** CONSTANT LIGHT SCHEDULES ***

NO. 1									
.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
.0	.0	.0	.0	.0	.0	300.0	300.0	500.0	500.0
500.0	500.0	500.0	.0						
NO. 2									
.0	.0	.0	.0	.0	.0	200.0	200.0	200.0	.0
.0	.0	.0	.0	.0	200.0	200.0	200.0	.0	.0
.0	.0	.0	.0						
NO. 3									
.0	.0	.0	.0	.0	.0	.0	200.0	200.0	.0
.0	.0	.0	.0	200.0	200.0	200.0	.0	.0	.0
.0	.0	.0	.0						

```
NO.  4
   60.0    60.0    60.0    60.0    60.0    60.0    60.0    60.0    60.0    60.0
   60.0    60.0    60.0    60.0    60.0    60.0    60.0    60.0    60.0    60.0
   60.0    60.0    60.0    60.0
NO.  5
     .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
     .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
     .0      .0      .0      .0
```

*** VARIABLE LIGHT SCHEDULES ***

LIGHT ON IF ROOM IS OCCUPIED AND SOLAR GAIN LESS THAN 4.7 WATTS/M2 FLOOR AREA

```
NO.  1
  100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
  100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0   100.0
  100.0   100.0   100.0   100.0
NO.  2
     .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
     .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
     .0      .0      .0      .0
```

*** EQUIPMENT SCHEDULES ***

```
NO.  1
     .0      .0      .0      .0      .0      .0  1500.0      .0      .0      .0
     .0      .0      .0      .0      .0  2000.0      .0      .0      .0   500.0
     .0      .0      .0      .0
NO.  2
     .0      .0      .0      .0      .0      .0      .0  1500.0      .0      .0
     .0      .0      .0      .0  2000.0      .0      .0      .0      .0  1000.0
     .0      .0      .0      .0
NO.  3
     .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
     .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
     .0      .0      .0      .0
```

*** THERMOSTAT SETPOINT SCHEDULES ***

NO. 1

20	20	20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20	20	20
20	20	20	20						

*** HOT WATER CONSUMPTION SCHEDULES ***

NO. 1

.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
.000	.000	.000	.000						

*** WINDOW SHUTTER SCHEDULES ***

WINDOWS HAVE NO SHUTTERS WHEN DAY OF THE YEAR IS BETWEEN 0 AND 370
THE REST OF THE YEAR SHUTTERS ARE CLOSED FROM 25 IN THE EVENING TO 0 IN THE MORNING

*** WALL DATA ***

WALL NO.	SEPARATES ROOMS	WALL TYPE	NO. OF WINDOWS	NO. OF DOORS	WALL AZIMUT	TILT ANGLE	NET AREA	FLOW RES.	FLOW EXP.
1	1 AND 8	1	2	1	180.0	90.0	15.0	.000	.00
2	1 AND 9	1	1	0	270.0	90.0	11.1	.187+05	.50
3	1 AND 2	2	0	1	.0	90.0	10.1	.000	.00
4	1 AND 3	2	0	0	.0	90.0	5.4	.000	.00
5	1 AND 4	2	0	1	.0	90.0	3.4	.000	.00
6	1 AND 6	2	0	1	.0	90.0	4.7	.000	.00
7	1 AND 7	2	0	1	.0	90.0	4.7	.000	.00
8	1 AND 10	3	0	0	.0	-1.0	44.5	.000	.00
9	1 AND 10	3	0	0	180.0	25.0	34.0	.000	.00

10	1 AND 10	3	0	0	.0	25.0	10.5	.000	.00
11	2 AND 9	1	0	0	270.0	90.0	8.1	.000	.00
12	2 AND 8	1	1	0	.0	90.0	9.7	.000	.00
13	2 AND 3	2	0	0	90.0	90.0	8.1	.000	.00
14	2 AND 10	3	0	0	.0	-1.0	13.5	.000	.00
15	2 AND 10	3	0	0	.0	25.0	13.5	.200+04	.50
16	3 AND 8	1	1	0	.0	90.0	5.2	.000	.00
17	3 AND 4	2	0	0	90.0	90.0	5.4	.000	.00
18	3 AND 1	2	0	1	90.0	90.0	.7	.000	.00
19	3 AND 10	3	0	0	.0	-1.0	6.0	.000	.00
20	3 AND 10	3	0	0	.0	25.0	6.0	.200+04	.50
21	4 AND 8	1	0	1	.0	90.0	3.4	.000	.00
22	4 AND 5	2	0	0	90.0	90.0	5.4	.000	.00
23	4 AND 10	3	0	0	.0	-1.0	4.0	.000	.00
24	4 AND 10	3	0	0	.0	25.0	4.0	.000	.00
25	5 AND 8	1	0	0	.0	90.0	10.8	.000	.00
26	5 AND 9	1	1	0	90.0	90.0	6.7	.187+05	.50
27	5 AND 6	2	0	0	180.0	90.0	10.8	.000	.00
28	5 AND 1	2	0	1	90.0	90.0	.7	.000	.00
29	5 AND 10	3	0	0	.0	-1.0	12.0	.000	.00
30	5 AND 10	3	0	0	.0	25.0	12.0	.000	.00
31	6 AND 9	1	1	0	90.0	90.0	5.3	.187+05	.50
32	6 AND 7	2	0	0	180.0	90.0	10.8	.000	.00
33	6 AND 10	3	0	0	.0	-1.0	10.0	.000	.00
34	6 AND 10	3	0	0	180.0	25.0	10.0	.000	.00
35	7 AND 9	1	1	0	90.0	90.0	5.3	.187+05	.50
36	7 AND 8	1	0	0	180.0	90.0	10.8	.000	.00
37	7 AND 10	3	0	0	.0	-1.0	10.0	.000	.00
38	7 AND 10	3	0	0	180.0	25.0	10.0	.000	.00

*** HOUSE GEOMETRY ***

ROOM NO.	ROOM IS MADE UP OF WALLS NO.														
1	1	2	3	4	5	6	7	8	9	10	18	28	0	0	0
2	3	11	12	13	14	15	0	0	0	0	0	0	0	0	0
3	4	13	16	17	18	19	20	0	0	0	0	0	0	0	0
4	5	17	21	22	23	24	0	0	0	0	0	0	0	0	0
5	22	25	26	27	28	29	30	0	0	0	0	0	0	0	0
6	6	27	31	32	33	34	0	0	0	0	0	0	0	0	0
7	7	32	35	36	37	38	0	0	0	0	0	0	0	0	0

ROOM NO.	ROOM IS SURROUNDED BY ROOMS NO.														
1	8	9	2	3	4	6	7	10	10	10	3	5	0	0	0
2	1	9	8	3	10	10	0	0	0	0	0	0	0	0	0
3	1	2	8	4	1	10	10	0	0	0	0	0	0	0	0
4	1	3	8	5	10	10	0	0	0	0	0	0	0	0	0
5	4	8	9	6	1	10	10	0	0	0	0	0	0	0	0
6	1	5	9	7	10	10	0	0	0	0	0	0	0	0	0
7	1	6	9	8	10	10	0	0	0	0	0	0	0	0	0

*** LOCATION, AREA AND TYPE OF WINDOWS ***

WINDOW NO.	AREA	TYPE	SEPARATES ROOMS
1	6.0	1	1 AND 8
2	.9	1	1 AND 8
3	2.4	1	1 AND 9
4	2.4	1	2 AND 8
5	.2	1	3 AND 8
6	1.4	1	5 AND 9
7	1.4	1	6 AND 9
8	1.4	1	7 AND 9

*** WINDOW SASH, VERTICAL FINS, AND HORIZONTAL OVERHANG ***

WINDOW NO.	WINDOW SASH WIDTH	WINDOW SASH HEIGHT	WINDOW SASH DEPTH	RIGHT FIN WIDTH	RIGHT FIN DIST. TO SASH	LEFT FIN WIDTH	LEFT FIN DIST. TO SASH	OVERHANG WIDTH	OVERHANG DIST TO SASH
1	3.10	2.10	.10	.00	.00	.00	.00	.00	.00
2	.60	1.50	.02	.00	.00	.00	.00	.00	.00
3	1.30	2.10	.10	.00	.00	.00	.00	.00	.00
4	1.30	2.10	.10	.00	.00	.00	.00	.00	.00
5	.50	.50	.10	.00	.00	.00	.00	.00	.00
6	1.30	1.30	.10	.00	.00	.00	.00	.00	.00
7	1.30	1.30	.10	.00	.00	.00	.00	.00	.00
8	1.30	1.30	.10	.00	.00	.00	.00	.00	.00

*** LOCATION, AREA AND TYPE OF DOORS ***

DOOR NO.	AREA	TYPE	SEPARATES ROOMS
1	1.1	1	1 AND 8
2	2.0	2	1 AND 2
3	2.0	2	1 AND 4
4	2.0	2	1 AND 6
5	2.0	2	1 AND 7
6	2.0	2	3 AND 1
7	2.0	1	4 AND 8
8	2.0	2	5 AND 1

*** WALL TYPES ***

NO. 1

B:	.0935621	.2335535	.0215937	.0000355	.0000000	.0000000	.0000000
D:	1.0000000	-.1291774	.0005334	.0000000	.0000000	.0000000	.0000000
C:	.3487446						
U:	.4000000						
WSABS:	.6000000						

NO. 2

B:	.9502558	.7559825	.0097985	.0000000	.0000000	.0000000	.0000000
D:	1.0000000	-.0515613	.0000214	.0000000	.0000000	.0000000	.0000000
C:	1.7160367						
U:	1.8090000						
WSABS:	.6000000						

NO. 3

B:	.0005265	.0237384	.0439061	.0095794	.0002273	.0000003	.0000000
D:	1.0000000	-.9278918	.1958007	-.0081736	.0000372	.0000000	.0000000
C:	.0779780						
U:	.3000000						
WSABS:	.6000000						

*** WINDOW TYPES ***

NO.	U-VALUE1 NO SHUTTERS	U-VALUE2 SHUTTERS	SH.COEF.	SH.TYPE(1=INSIDE,0=OUTSIDE)
1	2.9000	.7500	.90	1

*** DOOR TYPES ***

NO.	U-VALUE	SOLAR ABS.
1	2.5000	.6000
2	2.9000	.6000

DATE: 1/ 1-1964
HOUR: 1

DRY BULB TEMP. : -1.1 CELCIUS
WIND SPEED : .5 M/S
WIND DIRECTION : 20.0 DEG FROM NORTH
CLOUD COVER : 4.0 (0.-8.)

HEAT FLOW THROUGH WALLS, ETC. AT 20 C ROOM TEMP. (WATTS),
AND AIR FLOW THROUGH CRACKS IN WALLS (KG/S)
HEAT AND AIR FLOW INTO ROOM/HOUSE POSITIVE

WALL WINDOW DOOR NO.	WINDOWS SOLAR	WINDOWS COND.	WALLS (TWO VALUES FOR INTERNAL WALLS)		DOORS	AIR FLOW THROUGH WALLS AT BURNER ON-CYCLE	AIR FLOW THROUGH WALLS AT BURNER OFF-CYCLE
1	0.	-367.	-106.	0.	-58.	.00000	.00000
2	0.	-55.	-79.	0.	2.	.47515-02	.00000
3	0.	-147.	3.	4.	2.	.00000	.00000
4	0.	-147.	3.	2.	2.	.00000	.00000
5	0.	-10.	1.	1.	2.	.00000	.00000
6	0.	-88.	2.	2.	2.	.00000	.00000
7	0.	-88.	2.	2.	-105.	.00000	.00000
8	0.	-88.	-90.	0.	2.	.00000	.00000
9	0.	0.	-68.	0.	0.	.00000	.00000
10	0.	0.	-21.	0.	0.	.00000	.00000
11	0.	0.	-57.	0.	0.	.00000	.00000
12	0.	0.	-69.	0.	0.	.00000	.00000
13	0.	0.	4.	3.	0.	.00000	.00000
14	0.	0.	-27.	0.	0.	.00000	.00000
15	0.	0.	-27.	0.	0.	-.94062-02	.00000
16	0.	0.	-37.	0.	0.	.00000	.00000
17	0.	0.	2.	3.	0.	.00000	.00000
18	0.	0.	0.	0.	0.	.00000	.00000
19	0.	0.	-12.	0.	0.	.00000	.00000
20	0.	0.	-12.	0.	0.	-.94062-02	.00000
21	0.	0.	-24.	0.	0.	.00000	.00000

22	0.	0.	2.	2.	0.	.00000	.00000
23	0.	0.	-8.	0.	0.	.00000	.00000
24	0.	0.	-8.	0.	0.	.00000	.00000
25	0.	0.	-76.	0.	0.	.00000	.00000
26	0.	0.	-47.	0.	0.	.47515-02	.00000
27	0.	0.	4.	4.	0.	.00000	.00000
28	0.	0.	0.	0.	0.	.00000	.00000
29	0.	0.	-24.	0.	0.	.00000	.00000
30	0.	0.	-24.	0.	0.	.00000	.00000
31	0.	0.	-38.	0.	0.	.47515-02	.00000
32	0.	0.	4.	5.	0.	.00000	.00000
33	0.	0.	-20.	0.	0.	.00000	.00000
34	0.	0.	-20.	0.	0.	.00000	.00000
35	0.	0.	-38.	0.	0.	.47515-02	.00000
36	0.	0.	-76.	0.	0.	.00000	.00000
37	0.	0.	-20.	0.	0.	.00000	.00000
38	0.	0.	-20.	0.	0.	.00000	.00000

HEATING(NEG.) AND COOLING(POS.) LOADS AT 20 C ROOM TEMP. (WATTS)

ROOM NO.	LOADS DUE TO: WINDOWS	WALLS	DOORS	OCCUP.	EQUIP.	LIGHTS	INF.	TOTAL
1	-377.	-233.	-30.	0.	0.	0.	-101.	-740.
2	-97.	-114.	1.	0.	0.	0.	0.	-210.
3	-7.	-36.	2.	0.	0.	0.	0.	-41.
4	0.	-22.	-69.	0.	0.	10.	0.	-81.
5	-60.	-112.	2.	35.	0.	0.	-101.	-237.
6	-58.	-45.	1.	17.	0.	0.	-101.	-185.
7	-60.	-101.	2.	17.	0.	0.	-101.	-243.

HEAT OUTPUT AND ROOM TEMPERATURE

ROOM NO.	HEAT OUTPUT (WATTS)	ROOM TEMP. (CELCIUS)
1	1003.	20.4
2	274.	20.3
3	99.	20.6
4	117.	20.5
5	313.	20.4
6	258.	20.4
7	301.	20.4

HOT WATER HEATER (ASSUMING 75 C TEMP.RISE)

HOT WATER DEMAND	:	0. WATTS
AVG. ELECTR. INPUT	:	0. WATTS
STORED HEAT AT END OF HOUR	:	15700. WATTHRS

Similar printout for hrs. 0200 to 2300

DATE: 1/ 1-1964
HOUR: 24

DRY BULB TEMP. : -4.1 CELCIUS
WIND SPEED : .4 M/S
WIND DIRECTION : 48.3 DEG FROM NORTH
CLOUD COVER : 2.5 (0.-8.)

HEAT FLOW THROUGH WALLS, ETC. AT 20 C ROOM TEMP. (WATTS),
AND AIR FLOW THROUGH CRACKS IN WALLS (KG/S)
HEAT AND AIR FLOW INTO ROOM/HOUSE POSITIVE

WALL WINDOW DOOR NO.	WINDOWS SOLAR	WINDOWS COND.	WALLS (TWO VALUES FOR INTERNAL WALLS)		DOORS	AIR FLOW THROUGH WALLS AT BURNER ON-CYCLE	AIR FLOW THROUGH WALLS AT BURNER OFF-CYCLE
1	0.	-419.	-143.	0.	-66.	.00000	.00000
2	0.	-63.	-106.	0.	2.	.47515-02	.00000
3	0.	-168.	7.	8.	2.	.00000	.00000
4	0.	-168.	4.	4.	2.	.00000	.00000
5	0.	-11.	2.	3.	2.	.00000	.00000
6	0.	-101.	3.	4.	2.	.00000	.00000
7	0.	-101.	2.	4.	-120.	.00000	.00000
8	0.	-101.	-384.	0.	2.	.00000	.00000
9	0.	0.	-292.	0.	0.	.00000	.00000
10	0.	0.	-91.	0.	0.	.00000	.00000
11	0.	0.	-78.	0.	0.	.00000	.00000
12	0.	0.	-93.	0.	0.	.00000	.00000
13	0.	0.	6.	5.	0.	.00000	.00000
14	0.	0.	-116.	0.	0.	.00000	.00000
15	0.	0.	-116.	0.	0.	-.94062-02	.00000
16	0.	0.	-50.	0.	0.	.00000	.00000
17	0.	0.	4.	4.	0.	.00000	.00000
18	0.	0.	1.	1.	0.	.00000	.00000
19	0.	0.	-52.	0.	0.	.00000	.00000
20	0.	0.	-52.	0.	0.	-.94062-02	.00000
21	0.	0.	-33.	0.	0.	.00000	.00000

22	0.	0.	3.	4.	0.	.00000	.00000
23	0.	0.	-35.	0.	0.	.00000	.00000
24	0.	0.	-34.	0.	0.	.00000	.00000
25	0.	0.	-103.	0.	0.	.00000	.00000
26	0.	0.	-64.	0.	0.	.47515-02	.00000
27	0.	0.	6.	6.	0.	.00000	.00000
28	0.	0.	0.	1.	0.	.00000	.00000
29	0.	0.	-104.	0.	0.	.00000	.00000
30	0.	0.	-103.	0.	0.	.00000	.00000
31	0.	0.	-51.	0.	0.	.47515-02	.00000
32	0.	0.	4.	6.	0.	.00000	.00000
33	0.	0.	-86.	0.	0.	.00000	.00000
34	0.	0.	-86.	0.	0.	.00000	.00000
35	0.	0.	-51.	0.	0.	.47515-02	.00000
36	0.	0.	-103.	0.	0.	.00000	.00000
37	0.	0.	-86.	0.	0.	.00000	.00000
38	0.	0.	-86.	0.	0.	.00000	.00000

HEATING(NEG.) AND COOLING(POS.) LOADS AT 20 C ROOM TEMP. (WATTS)

ROOM NO.	WINDOWS	WALLS	DOORS	OCCUP.	EQUIP.	LIGHTS	INF.	TOTAL
1	-551.	-914.	-50.	110.	0.	386.	-115.	-1135.
2	-154.	-360.	2.	27.	68.	35.	0.	-382.
3	-11.	-129.	2.	0.	0.	0.	0.	-138.
4	0.	-85.	-111.	0.	0.	56.	0.	-139.
5	-95.	-346.	2.	134.	0.	0.	-115.	-421.
6	-92.	-193.	2.	71.	0.	0.	-115.	-328.
7	-95.	-300.	2.	73.	0.	0.	-115.	-435.

(LOADS DUE TO: WINDOWS, WALLS, DOORS, OCCUP., EQUIP., LIGHTS, INF.)

HEAT OUTPUT AND ROOM TEMPERATURE

ROOM NO.	HEAT OUTPUT (WATTS)	ROOM TEMP. (CELCIUS)
1	1168.	20.4
2	311.	20.3
3	157.	20.4
4	153.	20.4
5	445.	20.3
6	353.	20.3
7	447.	20.2

HOT WATER HEATER (ASSUMING 75 C TEMP.RISE)

HOT WATER DEMAND : 0. WATTS
AVG. ELECTR. INPUT : 0. WATTS
STORED HEAT AT END OF HOUR: 15700. WATTHRS

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/ 1	-2.2	62.	11.	0.	62.	11.	0.
2/ 1	-2.2	70.	11.	0.	132.	21.	0.
3/ 1	3.5	45.	11.	0.	177.	32.	0.
4/ 1	1.4	49.	11.	0.	226.	43.	0.
5/ 1	1.8	53.	11.	0.	279.	54.	0.
6/ 1	-5.3	72.	11.	0.	350.	64.	0.
7/ 1	-8.6	89.	11.	0.	439.	75.	0.
8/ 1	-6.0	84.	11.	0.	524.	86.	0.
9/ 1	-2.0	68.	11.	0.	592.	97.	0.
10/ 1	-1.3	60.	11.	0.	652.	107.	0.
11/ 1	-3.9	71.	11.	0.	723.	118.	0.
12/ 1	-4.3	73.	11.	0.	796.	129.	0.
13/ 1	-7.2	79.	11.	0.	875.	140.	0.
14/ 1	-6.8	82.	11.	0.	957.	150.	0.
15/ 1	-6.0	74.	11.	0.	1031.	161.	0.
16/ 1	-5.8	76.	11.	0.	1107.	172.	0.
17/ 1	-6.8	77.	11.	0.	1184.	182.	0.
18/ 1	-8.7	85.	11.	0.	1269.	193.	0.
19/ 1	-9.5	91.	11.	0.	1360.	204.	0.
20/ 1	-5.1	76.	11.	0.	1436.	215.	0.
21/ 1	1.8	49.	11.	0.	1484.	225.	0.
22/ 1	2.1	45.	11.	0.	1529.	236.	0.
23/ 1	-.8	58.	11.	0.	1587.	247.	0.
24/ 1	-.2	55.	11.	0.	1642.	257.	0.
25/ 1	.6	48.	11.	0.	1690.	268.	0.
26/ 1	-3.4	62.	11.	0.	1752.	279.	0.
27/ 1	-7.1	73.	10.	0.	1825.	289.	0.
28/ 1	-1.5	61.	11.	0.	1886.	300.	0.
29/ 1	1.8	43.	11.	0.	1929.	311.	0.
30/ 1	2.7	40.	11.	0.	1969.	322.	0.
31/ 1	-.2	46.	11.	0.	2016.	332.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/ 2	-2.3	59.	11.	0.	2075.	343.	0.
2/ 2	-2.2	57.	11.	0.	2132.	353.	0.
3/ 2	1.4	46.	11.	0.	2178.	364.	0.
4/ 2	-.9	50.	11.	0.	2228.	375.	0.
5/ 2	-3.8	56.	10.	0.	2284.	385.	0.
6/ 2	-5.0	61.	10.	0.	2345.	395.	0.
7/ 2	-3.7	62.	11.	0.	2407.	406.	0.
8/ 2	3.6	37.	10.	0.	2443.	416.	0.
9/ 2	.0	40.	11.	0.	2484.	427.	0.
10/ 2	1.2	41.	10.	0.	2524.	437.	0.
11/ 2	-1.5	50.	10.	0.	2574.	448.	0.
12/ 2	-8.9	74.	10.	0.	2648.	458.	0.
13/ 2	-7.0	80.	10.	0.	2728.	468.	0.
14/ 2	-4.9	69.	11.	0.	2797.	479.	0.
15/ 2	-5.3	71.	11.	0.	2868.	490.	0.
16/ 2	-11.2	87.	10.	0.	2955.	500.	0.
17/ 2	-10.5	85.	10.	0.	3040.	510.	0.
18/ 2	-11.1	80.	10.	0.	3121.	521.	0.
19/ 2	-8.0	79.	10.	0.	3199.	531.	0.
20/ 2	-6.3	70.	10.	0.	3269.	541.	0.
21/ 2	-6.2	66.	10.	0.	3335.	552.	0.
22/ 2	-1.8	55.	11.	0.	3390.	562.	0.
23/ 2	-2.6	55.	11.	0.	3444.	573.	0.
24/ 2	-5.3	64.	10.	0.	3508.	583.	0.
25/ 2	-3.6	60.	10.	0.	3569.	593.	0.
26/ 2	-1.2	44.	10.	0.	3613.	604.	0.
27/ 2	-1.0	47.	10.	0.	3660.	614.	0.
28/ 2	.4	46.	11.	0.	3706.	625.	0.
29/ 2	1.4	38.	10.	0.	3745.	635.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/ 3	1.0	37.	10.	0.	3782.	645.	0.
2/ 3	1.1	33.	10.	0.	3815.	656.	0.
3/ 3	.7	37.	10.	0.	3852.	666.	0.
4/ 3	.7	38.	10.	0.	3890.	676.	0.
5/ 3	1.1	30.	10.	0.	3920.	686.	0.
6/ 3	.1	34.	10.	0.	3954.	696.	0.
7/ 3	-2.6	43.	10.	0.	3997.	707.	0.
8/ 3	-1.6	45.	10.	0.	4042.	717.	0.
9/ 3	3.7	27.	10.	0.	4070.	727.	0.
10/ 3	2.9	22.	10.	0.	4092.	737.	0.
11/ 3	2.6	22.	10.	0.	4114.	747.	0.
12/ 3	.9	26.	10.	0.	4140.	757.	0.
13/ 3	.4	25.	10.	0.	4165.	767.	0.
14/ 3	-3.2	35.	10.	0.	4200.	778.	0.
15/ 3	-4.2	40.	10.	0.	4239.	788.	0.
16/ 3	-3.1	39.	10.	0.	4278.	798.	0.
17/ 3	-2.9	38.	10.	0.	4316.	808.	0.
18/ 3	-1.8	39.	10.	0.	4355.	818.	0.
19/ 3	-4.5	47.	10.	0.	4402.	828.	0.
20/ 3	-4.4	52.	10.	0.	4454.	838.	0.
21/ 3	-3.4	57.	11.	0.	4511.	849.	0.
22/ 3	-1.8	49.	10.	0.	4560.	859.	0.
23/ 3	-2.4	44.	10.	0.	4604.	869.	0.
24/ 3	-2.0	43.	10.	0.	4647.	879.	0.
25/ 3	-.3	35.	10.	0.	4682.	889.	0.
26/ 3	.1	32.	10.	0.	4714.	899.	0.
27/ 3	.3	35.	10.	0.	4749.	909.	0.
28/ 3	1.0	27.	10.	0.	4777.	920.	0.
29/ 3	1.8	21.	10.	0.	4797.	930.	0.
30/ 3	1.0	29.	10.	0.	4826.	940.	0.
31/ 3	.4	32.	10.	0.	4858.	950.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/ 4	1.0	25.	10.	0.	4883.	960.	0.
2/ 4	2.6	17.	10.	0.	4901.	970.	0.
3/ 4	3.3	13.	10.	0.	4913.	979.	0.
4/ 4	3.5	15.	10.	0.	4928.	989.	0.
5/ 4	3.1	19.	10.	0.	4947.	1000.	0.
6/ 4	2.5	23.	10.	0.	4969.	1010.	0.
7/ 4	2.9	20.	10.	0.	4989.	1020.	0.
8/ 4	2.0	23.	10.	0.	5012.	1030.	0.
9/ 4	1.1	32.	10.	0.	5045.	1040.	0.
10/ 4	3.6	26.	10.	0.	5071.	1050.	0.
11/ 4	2.9	26.	11.	0.	5097.	1061.	0.
12/ 4	5.2	18.	10.	0.	5116.	1071.	0.
13/ 4	7.1	6.	10.	0.	5122.	1081.	0.
14/ 4	4.5	6.	10.	0.	5128.	1091.	0.
15/ 4	4.6	13.	10.	0.	5140.	1101.	0.
16/ 4	3.9	18.	10.	0.	5159.	1111.	0.
17/ 4	7.9	12.	10.	0.	5171.	1121.	0.
18/ 4	9.9	5.	10.	0.	5176.	1131.	0.
19/ 4	11.0	1.	10.	0.	5176.	1141.	0.
20/ 4	11.8	0.	10.	0.	5176.	1151.	0.
21/ 4	10.2	0.	10.	0.	5176.	1161.	0.
22/ 4	10.5	0.	10.	0.	5176.	1171.	0.
23/ 4	8.2	2.	10.	0.	5179.	1181.	0.
24/ 4	5.2	14.	10.	0.	5193.	1191.	0.
25/ 4	3.4	21.	10.	0.	5214.	1201.	0.
26/ 4	3.7	17.	10.	0.	5232.	1211.	0.
27/ 4	8.0	7.	10.	0.	5239.	1221.	0.
28/ 4	8.9	5.	10.	0.	5244.	1232.	0.
29/ 4	7.7	6.	10.	0.	5250.	1242.	0.
30/ 4	9.0	8.	10.	0.	5258.	1252.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/ 5	9.7	4.	10.	0.	5261.	1262.	0.
2/ 5	8.3	2.	10.	0.	5263.	1272.	0.
3/ 5	5.8	3.	10.	0.	5266.	1282.	0.
4/ 5	6.1	14.	10.	0.	5280.	1292.	0.
5/ 5	5.7	18.	10.	0.	5297.	1303.	0.
6/ 5	8.2	9.	10.	0.	5307.	1312.	0.
16/ 9	11.9	2.	10.	0.	5308.	1323.	0.
17/ 9	9.9	2.	10.	0.	5310.	1333.	0.
18/ 9	8.4	5.	10.	0.	5316.	1343.	0.
19/ 9	7.4	11.	11.	0.	5327.	1354.	0.
20/ 9	7.4	13.	11.	0.	5340.	1365.	0.
21/ 9	7.0	15.	10.	0.	5355.	1375.	0.
22/ 9	7.6	13.	10.	0.	5368.	1385.	0.
23/ 9	12.1	3.	10.	0.	5371.	1396.	0.
24/ 9	12.0	0.	10.	0.	5372.	1406.	0.
25/ 9	11.5	0.	10.	0.	5372.	1416.	0.
26/ 9	11.2	0.	11.	0.	5372.	1427.	0.
27/ 9	9.6	2.	10.	0.	5374.	1437.	0.
28/ 9	10.1	4.	10.	0.	5378.	1447.	0.
29/ 9	11.4	2.	10.	0.	5380.	1458.	0.
30/ 9	7.6	7.	10.	0.	5387.	1468.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/10	4.4	15.	10.	0.	5402.	1478.	0.
2/10	7.9	14.	10.	0.	5416.	1488.	0.
3/10	6.9	10.	10.	0.	5426.	1499.	0.
4/10	5.5	14.	10.	0.	5441.	1509.	0.
5/10	6.3	12.	10.	0.	5452.	1519.	0.
6/10	7.5	11.	11.	0.	5463.	1530.	0.
7/10	10.0	10.	11.	0.	5473.	1540.	0.
8/10	10.3	4.	10.	0.	5478.	1551.	0.
9/10	9.3	10.	11.	0.	5488.	1562.	0.
10/10	9.6	14.	11.	0.	5502.	1572.	0.
11/10	7.7	20.	11.	0.	5522.	1583.	0.
12/10	7.7	21.	11.	0.	5543.	1594.	0.
13/10	6.6	23.	11.	0.	5566.	1605.	0.
14/10	6.0	23.	11.	0.	5589.	1615.	0.
15/10	4.6	24.	11.	0.	5613.	1626.	0.
16/10	5.9	22.	11.	0.	5635.	1637.	0.
17/10	6.4	18.	11.	0.	5653.	1648.	0.
18/10	4.7	19.	11.	0.	5672.	1658.	0.
19/10	4.2	22.	11.	0.	5694.	1669.	0.
20/10	9.1	15.	11.	0.	5710.	1679.	0.
21/10	7.5	16.	10.	0.	5725.	1690.	0.
22/10	4.6	24.	11.	0.	5750.	1700.	0.
23/10	6.3	25.	11.	0.	5775.	1711.	0.
24/10	5.8	26.	11.	0.	5801.	1722.	0.
25/10	1.8	26.	11.	0.	5827.	1732.	0.
26/10	-1.2	36.	10.	0.	5863.	1743.	0.
27/10	-.7	44.	11.	0.	5907.	1754.	0.
28/10	.3	44.	11.	0.	5951.	1764.	0.
29/10	-.4	44.	11.	0.	5996.	1775.	0.
30/10	-.8	37.	10.	0.	6033.	1785.	0.
31/10	.1	42.	11.	0.	6075.	1796.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/11	2.1	37.	11.	0.	6112.	1807.	0.
2/11	3.3	32.	11.	0.	6143.	1818.	0.
3/11	-.4	39.	10.	0.	6182.	1828.	0.
4/11	-1.4	53.	11.	0.	6235.	1839.	0.
5/11	.4	43.	11.	0.	6278.	1850.	0.
6/11	1.0	45.	11.	0.	6323.	1860.	0.
7/11	-1.4	55.	11.	0.	6379.	1871.	0.
8/11	-.0	53.	11.	0.	6432.	1882.	0.
9/11	-1.9	62.	11.	0.	6493.	1892.	0.
10/11	-.1	54.	11.	0.	6547.	1903.	0.
11/11	2.6	41.	11.	0.	6588.	1914.	0.
12/11	2.7	43.	11.	0.	6632.	1924.	0.
13/11	.8	50.	11.	0.	6682.	1935.	0.
14/11	4.5	35.	11.	0.	6717.	1946.	0.
15/11	4.9	32.	11.	0.	6749.	1957.	0.
16/11	1.2	45.	11.	0.	6794.	1967.	0.
17/11	.6	53.	11.	0.	6846.	1978.	0.
18/11	2.2	41.	11.	0.	6887.	1989.	0.
19/11	-.8	59.	11.	0.	6946.	2000.	0.
20/11	-.6	54.	11.	0.	7000.	2010.	0.
21/11	.6	51.	11.	0.	7051.	2021.	0.
22/11	1.5	48.	11.	0.	7099.	2032.	0.
23/11	1.2	47.	11.	0.	7146.	2043.	0.
24/11	3.1	42.	11.	0.	7189.	2053.	0.
25/11	2.6	42.	11.	0.	7231.	2064.	0.
26/11	.5	50.	11.	0.	7281.	2074.	0.
27/11	2.0	44.	11.	0.	7325.	2085.	0.
28/11	-.4	58.	11.	0.	7383.	2096.	0.
29/11	-1.4	59.	11.	0.	7441.	2107.	0.
30/11	-2.3	63.	11.	0.	7504.	2117.	0.

DATE	MEAN DBT DEG C	** DAILY ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH	** TOTAL ENERGY CONS. ** HEATING KWH	LIGHTS & APPL. KWH	HOT WATER KWH
1/12	-2.7	64.	11.	0.	7568.	2128.	0.
2/12	.3	56.	11.	0.	7624.	2139.	0.
3/12	1.3	52.	11.	0.	7676.	2150.	0.
4/12	-.5	57.	11.	0.	7733.	2160.	0.
5/12	-5.0	72.	11.	0.	7805.	2171.	0.
6/12	-6.7	85.	11.	0.	7890.	2182.	0.
7/12	1.4	56.	11.	0.	7946.	2192.	0.
8/12	5.0	42.	11.	0.	7988.	2203.	0.
9/12	5.8	36.	11.	0.	8024.	2214.	0.
10/12	1.0	49.	11.	0.	8073.	2225.	0.
11/12	-.5	57.	11.	0.	8130.	2235.	0.
12/12	2.9	49.	11.	0.	8179.	2246.	0.
13/12	1.5	50.	11.	0.	8229.	2257.	0.
14/12	-2.1	63.	11.	0.	8292.	2268.	0.
15/12	-2.8	69.	11.	0.	8361.	2278.	0.
16/12	-4.5	77.	11.	0.	8438.	2289.	0.
17/12	-2.8	73.	11.	0.	8512.	2300.	0.
18/12	-2.6	64.	11.	0.	8576.	2311.	0.
19/12	-5.1	75.	11.	0.	8651.	2321.	0.
20/12	-3.3	69.	11.	0.	8720.	2332.	0.
21/12	-3.8	70.	11.	0.	8790.	2343.	0.
22/12	-6.8	83.	11.	0.	8873.	2354.	0.
23/12	-7.7	87.	11.	0.	8960.	2364.	0.
24/12	-6.8	82.	11.	0.	9042.	2375.	0.
25/12	-8.0	85.	11.	0.	9127.	2386.	0.
26/12	-11.0	94.	11.	0.	9221.	2397.	0.
27/12	-13.5	104.	11.	0.	9325.	2407.	0.
28/12	-15.6	112.	11.	0.	9437.	2418.	0.
29/12	-9.7	99.	11.	0.	9536.	2429.	0.
30/12	-1.1	65.	11.	0.	9601.	2439.	0.
31/12	1.3	52.	11.	0.	9653.	2450.	0.

TOTAL FOR THE YEAR: ==

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6. APPENDIXES

6.1 Appendix A. Program restrictions.

When preparing data for the program the user must be aware of the restrictions listed below. The restrictions are due to core storage allocation (array declarations) in the program. The program does not check the input to see if the limits are exceeded!

Max. no. of walls	50
" " " rooms	20
" " " walls in a room	15
" " " windows	20
" " " doors	20
" " " wall types	10
" " " window types	5
" " " door types	5
" " " occupancy schedules	15
" " " const. light schedules	20
" " " var. light schedules	20
" " " equipment schedules	8
" " " hot water cons. schedules	7
" " " thermostat setpoint schedules	8

6.2 Appendix B. Z-transfer function coefficients of some typical Norwegian wall/floor/roof constructions

The ENCORE program calculates heat flow through building components using the "transfer function method" as described in Chapter 22 of the ASHRAE Handbook of Fundamentals.[1] It is carried out using sol-air temperature to represent outdoor conditions, and an assumed constant indoor air temperature (variations in indoor air temperature are taken care of later on). Furthermore it is assumed that both indoor and outdoor surface heat transfer coefficients are constant. Thus, the heat gain through a wall, floor or roof is given by:

$$q_\tau = A \left[\sum_{n=o} b_n \, t_{\tau - n\Delta} - \sum_{n=1} \frac{d_n q_{\tau - n\Delta}}{A} - t_r \sum_{n=o} c_n \right]$$

where:

A = indoor surface area of wall, floor or roof (m^2)

q_τ = heat gain by the room through indoor surfaces of a wall, floor or roof (Watts)

τ = time

Δ = time interval

n = summation index (each summation has as many terms as there are nonnegligible values of the coefficients)

$t_{\tau-n\Delta}$ = sol-air temperature at time $\tau - n\Delta$ (^oC)

t_r = constant indoor room temperature (^oC)

b_n, c_n, d_n = transfer function coefficients

The transfer function coefficients b's and d's, as well as U-value and $\sum_{n=0} c_n$, are listed in Tables B2 and B3 for various wall, floor and roof constructions. The thermal properties of the various layers that make up roofs, floors and walls are listed in Table B1. The transfer function coefficients for different constructions can be calculated using the computer program outlined in Reference 9. Approximate values can be obtained, however, by selecting a set of transfer function coefficients from Tables B2 or B3 for a construction that is nearly the same as the construction under consideration and multiplying the b's and c's by the ratio of the U-value of the construction under consideration over the U-value of construction that was selected from Table B2 or B3.

Table B.1 Thermal properties and code numbers of layers used in calculations of coefficients for wall, floor and roof transfer functions

Description	Code No.	Thickness m	Conductivity W/(m°C)	Density kg/m³	Spec.heat J/(kg°C)	Resistance (m²°C)/W
Outside surface resistance	1					0.04
Inside " "	2					0.13
Air space resistance	3					0.17
2"x2" studs c/c 600 mm and 50 mm mineral wool	4	0.05	0.05	75.	980.	
2"x4" studs c/c 600 mm and 100 mm mineral wool	5	0.1	0.055	95.	1000.	
2"x2" horizontal battens c/c 900 mm and 50 mm min.wool	6	0.05	0.047	60.	930.	
2"x8" joists c/c 600 mm and 100 mm mineral wool	7	0.1	0.05	75.	980.	
2"x8" joists c/c 600 mm and 150 mm mineral wool	8	0.15	0.05	75.	980.	
2"x8" joists c/c 600 mm and 175 mm mineral wool	9	0.175	0.05	75.	980.	
2"x8" joists c/c 600 mm and 200 mm mineral wool	10	0.2	0.05	75.	980.	
100 mm mineral wool	11	0.1	0.041	35.	840.	
4" bricks	12	0.108	0.7	1800.	800.	

Table B.1 Continued

Description	Code No.	Thickness m	Conductivity W/(m^oC)	Density kg/m^3	Spec.heat J/(kg^o)	Resistance ($m^{2o}C$)/W
100 mm l.w.concrete blocks	13	0.1	0.26	700.	1500.	
150 mm " " "	14	0.15	0.26	700.	1500.	
200 mm " " "	15	0.2	0.26	700.	1500.	
250 mm " " "	16	0.25	0.26	700.	1500.	
100 mm h.w. concrete	17	0.1	1.75	2300.	880.	
150 mm " "	18	0.15	1.75	2300.	880.	
200 mm " "	19	0.2	1.75	2300.	880.	
100 mm l.w. concrete	20	0.1	0.2	500.	1500.	
150 mm " "	21	0.15	0.2	500.	1500.	
200 mm " "	22	0.2	0.2	500.	1500.	
12 mm asphalt treated fiber board	23	0.012	0.058	350.	840.	
13 mm plaster board	24	0.013	0.2	800.	840.	
28 mm wood	25	0.028	0.14	500.	2500.	

Table B.2 Transfer function coefficients for exterior walls, floors and roofs (continued)

Description [1)]	Code nos. of layers		Coefficients b_n and d_n [2)]. Time interval = 1.0 hr							U	$\sum_{n=0}^{\infty} C_n$
			n=0	n=1	n=2	n=3	n=4	n=5	n=6		
200 mm h.w. concrete	1, 19, 2	b	0.007252	0.172498	0.217459	0.028411	0.000252				
		d	1.000000	-1.143274	0.271005	-0.006665	0.000004			3.518	0.42587
100 mm h.w. concrete	1, 17, 4,	b	0.007640	0.101335	0.074220	0.004713	0.000014				
and 50 mm mineral wool	2	d	1.000000	-0.825775	0.069690	-0.001093				0.774	0.18792
150 mm h.w. concrete	1, 18, 4,	b	0.000820	0.031446	0.053992	0.010790	0.000222				
and 50 mm mineral wool	2	d	1.000000	-1.065150	0.203238	-0.009645	0.000023			0.757	0.09727
200 mm h.w. concrete	1, 19, 4,	b	0.000063	0.007785	0.028186	0.013269	0.000938	0.000008			
and 50 mm mineral wool	2	d	1.000000	-1.317412	0.417116	-0.032559	0.000654			0.741	0.05025
4" brick, 100 mm mine-	1, 12, 11,	b	0.000000	0.000183	0.002260	0.003526	0.001061	0.000063	0.000001		
ral wool, 4" brick	12, 2	d	1.000000	-1.930909	1.160403	-0.222442	0.013776	-0.000127		0.343	0.00709
Wood floor with 100 mm	1, 23, 7,	b	0.003243	0.063079	0.059174	0.004930	0.000024				
mineral wool	25, 2	d	1.000000	-0.756503	0.093037	-0.000377				0.388	0.13045
Wood floor with 150 mm	1, 23, 8,	b	0.000213	0.015196	0.036154	0.010077	0.000322	0.000001			
mineral wool	25, 2	d	1.000000	-1.035015	0.264934	-0.008306	0.000021			0.280	0.06196
Wood floor with 175 mm	1, 23, 9,	b	0.000046	0.006710	0.024328	0.010928	0.000685	0.000005			
mineral wool	25, 2	d	1.000000	-1.177474	0.374065	-0.022627	0.000127			0.245	0.04270
Ventilated wood roof	1, 7, 24,	b	0.068750	0.239406	0.039904	0.000202					
with 100 mm min. wool	2	d	1.000000	-0.227086	0.005450					0.447	0.34826

1) Construction is defined by code numbers for various layers. The thermal properties of layers designated by code numbers are given in Table B.1.

2) U, b's and c's are in W/(m^2°C), and d is dimensionless.

Table B.2 Transfer function coefficients for exterior walls, floors and roofs

Description [1]	Code nos. of layers	Coefficients b_n and d_n [2]. Time interval = 1.0 hr	n=0	n=1	n=2	n=3	n=4	n=5	n=6	U	$\sum_{n=0}^{\infty} C_n$
Frame wall with 100 mm mineral wool	1, 23, 5 24, 2	b	0.026599	0.190682	0.071833	0.001703	0.000001				
		d	1.000000	-0.358803	0.016105	-0.000031				0.442	0.29082
Frame wall with 150 mm mineral wool	1, 23, 5, 6, 24, 2	b	0.002837	0.060754	0.061630	0.006291	0.000051				
		d	1.000000	-0.621991	0.060392	-0.001098	0.000001			0.301	0.13156
Frame wall with 100 mm min. wool and 4" brick on the outside	1, 12, 5, 24, 2	b	0.000065	0.009382	0.035919	0.018021	0.001429	0.000014			
		d	1.000000	-1.158408	0.329089	-0.028173	0.000604	-0.000001		0.453	0.06483
100 mm l.w. concrete blocks	1, 13, 2	b	0.023011	0.309997	0.224691	0.013230	0.000031				
		d	1.000000	-0.768822	0.085988	-0.000503				1.803	0.57096
150 mm l.w. concrete blocks	1, 14, 2	b	0.000261	0.028869	0.095107	0.039655	0.002295	0.000013			
		d	1.000000	-1.241234	0.393494	-0.028388	0.000267			1.339	0.16620
200 mm l.w. concrete blocks	1, 15, 2	b	0.000001	0.001313	0.015813	0.023887	0.006962	0.000400	0.000004		
		d	1.000000	-1.713647	0.924433	-0.175066	0.009835	-0.000116		1.065	0.04838
250 mm l.w. concrete blocks	1, 16, 2	b	0.000000	0.000032	0.001379	0.005986	0.005391	0.001224	0.000070		
		d	1.000000	-2.186060	1.678546	-0.546365	0.073271	-0.003504	0.000047	0.884	0.01408
100 mm h.w. concrete	1, 17, 2	b	0.338172	1.093784	0.160852	0.000304					
		d	1.000000	-0.648451	0.010315					4.403	1.59311
150 mm h.w. concrete	1, 18, 2	b	0.057708	0.502883	0.255826	0.007977	0.000004				
		d	1.000000	-0.890946	0.101962	-0.000205				3.911	0.82440

1) Construction is defined by code numbers for various layers. The thermal properties of layers designated by code numbers are given in Table B.1.

2) U, b's and c's are in $W/(m^2 °C)$, and d is dimensionless.

Table B.2 Transfer function coefficients for exterior walls, floors and roofs (continued)

Description [1)]	Code nos. of layers		Coefficients b_n and d_n [2)]. Time interval = 1.0 hr							U	$\sum_{n=0}^{\infty} C_n$
			n=0	n=1	n=2	n=3	n=4	n=5	n=6		
Ventilated wood roof	1, 8, 24	b	0.008436	0.096150	0.058024	0.002868	0.000006				
with 150 mm min. wool	2	d	1.000000	-0.500823	0.036436	-0.000274				0.309	0.16548
Ventilated wood roof	1, 10,24	b	0.000675	0.026593	0.043138	0.008027	0.000160				
with 200 mm min. wool	2	d	1.000000	-0.785745	0.122619	-0.004042	0.000012			0.236	0.07859

1) Construction is defined by code numbers for various layers. The thermal properties of layers designated by code numbers are given in Table B.1.

2) U, b's and c's are in $W/(m^2 {}^{o}C)$, and d is dimensionless.

Table B.3 Transfer function coefficients for interior partitions, floors and ceilings

Description [1)]	Code nos. of layers		Coefficients b_n and d_n [2)]. Time interval = 1.0 hr							U	$\sum_{n=0}^{\infty} c_n$
			n=0	n=1	n=2	n=3	n=4	n=5	n=6		
Frame partion with 13 mm plaster boards	2, 24, 3, 24, 2	b	0.872064	0.779525	0.013498						
		d	1.000000	-0.067603	0.000052					1.786	1.66509
Frame partion with 50 mm min. wool and 13 mm plaster boards	2, 24, 4, 24, 2	b	0.162158	0.398854	0.045833	0.000109					
		d	1.000000	-0.160750	0.004416					0.719	0.60695
100 mm l.w. concrete blocks	2, 13, 2	b	0.011310	0.181018	0.159032	0.012553	0.000048				
		d	1.000000	-0.906526	0.142685	-0.001544				1.551	0.36396
150 mm l.w. concrete blocks	2, 14, 2	b	0.000120	0.015609	0.059017	0.029072	0.002111	0.000017			
		d	1.000000	-1.378930	0.515661	-0.048746	0.000684	-0.000001		1.195	0.10595
200 mm l.w. concrete blocks	2, 15, 2	b	0.000000	0.000672	0.009085	0.015494	0.005223	0.000361	0.000004		
		d	1.000000	-1.851343	1.111651	-0.245484	0.017191	-0.000273	0.000001	0.972	0.03084
100 mm h.w. concrete	2, 17, 2	b	0.130025	0.475217	0.084114	0.000222					
		d	1.000000	-0.802578	0.021272					3.153	0.68958
150 mm h.w. concrete	2, 18, 2	b	0.021626	0.209603	0.121329	0.004591	0.000003				
		d	1.000000	-1.033101	0.157032	-0.000458				2.893	0.35715
200 mm h.w. concrete	2, 19, 2	b	0.002660	0.069704	0.097407	0.014566	0.000155				
		d	1.000000	-1.285158	0.365857	-0.011655	0.000009			2.672	0.18449
Wood floor with 100 mm mineral wool	2, 25, 3 7, 24, 2	b	0.001421	0.041902	0.059169	0.009444	0.000143				
		d	1.000000	-0.850480	0.157258	-0.004734	0.000008			0.371	0.11208

1) Construction is defined by code numbers for various layers. The thermal properties of layers designated by code numbers are given in Table B.1.

2) U, b's and c's are in W/(m^2 °C), and d is dimensionless.

Table B.3 Transfer function coefficients for interior partitions, floors and ceilings (continued)

Description [1]	Code nos. of layers		Coefficients b_n and d_n [2] Time interval = 1.0 hr							U	$\sum_{n=0}^{\infty} c_n$
			n=0	n=1	n=2	n=3	n=4	n=5	n=6		
Wood floor with 150 mm mineral wool	2, 25, 3, 8, 24, 2	b	0.000084	0.009078	0.031619	0.013062	0.000839	0.000006			
		d	1.000000	-1.130657	0.353139	-0.026105	0.000312			0.271	0.05323
Wood floor with 200 mm mineral wool	2, 25, 10, 24, 2	b	0.000005	0.001952	0.012988	0.011413	0.001802	0.000048			
		d	1.000000	-1.374132	0.572550	-0.073140	0.002377	-0.000011		0.221	0.02821
100 mm l.w. concrete floor deck	2, 20, 2	b	0.016985	0.218029	0.154297	0.008810	0.000019				
		d	1.000000	-0.790841	0.093999	-0.000571				1.316	0.39814
150 mm l.w. concrete floor deck	2, 21, 2	b	0.000242	0.022814	0.069733	0.027006	0.001413	0.000007			
		d	1.000000	-1.246059	0.396645	-0.028407	0.000249			0.990	0.12122
200 mm l.w. concrete floor deck	2, 22, 2	b	0.000001	0.001222	0.013029	0.017784	0.004635	0.000231	0.000002		
		d	1.000000	-1.701287	0.906556	-0.167598	0.008923	-0.000094		0.794	0.03690

1) Construction is defined by code numbers for various layers. The thermal properties of layers designated by code numbers are given in Table B.1.

2) U, b's and c's are in $W/(m^2 \, ^\circ C)$, and d is dimensionless.

6.3 Appendix C. Description of weather tape

In order to be accepted by the ENCORE program the weather tape should be as described below.

The records must be in unformatted (binary) form.

First record:

ISTNR	IAAR

where:

ISTNR - synoptic no. of the meteorological station

IAAR - year of weather data

The information in the first record is checked against input data to the ENCORE program to make shure that correct weather data are used in the calculations.

One record for each day of the year:

MND	IDATO	ISNO	TEMP(1)	SKYDK(1)	SKYTP(1)	VHAST(1)	VRETN(1)	TEMP(2)	...	VHAST(24)	VRETN(24)

where:

MND - month

IDATO - day of the month

ISNO - thickness of snow cover (cm)

TEMP(1),.....,TEMP(24) - dry bulb temperatures at hrs 0100 to 2400

SKYDK(1),....,SKYDK(24) - cloud cover in parts of eight (i.e. 1/8, 2/8,...,8/8) at hrs 0100 to 2400

SKYTP(1),....,SKYTP(24) - cloud type as 0. (cirrus, cirrostratus), 1. (stratus) and 2. (other) at hrs 0100 to 2400

VHAST(1),....,VHAST(24) - wind speed in m/s at hrs 0100 to 2400

VRETN(1),....,VRETN(24) - wind direction (degrees clockwise from north) at hrs 0100 to 2400

6.4 Appendix D. Description of output file

The following data are written unformatted (binary) on file(unit 7) for later plotting or other use. One record for each hour of the year:

IDAY	MONTH	IHOUR	DBT	WSPEED	CLC	ER(1)	RTEMP(1)	....	ER(K)	RTEMP(K)

where:

IDAY - day of the month
MONTH - month
IHOUR - hour of the day
DBT - outdoor dry bulb temperature
WSPEED - wind speed
CLC - cloud cover
ER(1) - heat output in room no. 1
RTEMP(1) - room temperature in room no. 1

ER(K) - heat output in room no. K
RTEMP(K) - room temperature in room no. K

6.5 Appendix E. How to run the program on Univac 1100 series computers

Assuming that the object code of the program is contained in the disk file PROG, the weather data in the file WEATH, and results for later plotting are to be stored in PLOT, the following card deck is necessary to run the program:

```
"RUN .........
"ASG,A  PROG
"ASG,A  WEATH
"USE 8.,WEATH.
"ASG,A  PLOT
"USE 7.,PLOT.
"XQT PROG.ENCORE

      data cards


"FIN
```

As can be seen above the weather data input and the plot output have internal unit numbers 8 and 7 respectively. The program uses standard unit numbers for card reader and line printer (5 and 6 respectively).

Tidligere publikasjoner i samme serie.

1 Stasjonær varmestrøm. Brukerbeskrivelse av datamaskinprogrammet STAST Av Guttorm Megård.

2 Saint-Venant torsjon. Brukerbeskrivelse av datamaskinprogrammet SAINT/VENANT Av Guttorm Megård.

3 Ikke-stasjonær varmestrøm. Brukerbeskrivelse av datamaskinprogrammet ENDIM Av Guttorm Megård.

4 Datamaskinprogrammer 1974. En oversikt over programmer ved NBI Av Guttorm Megård, 1974.

5 Ikke-stasjonær varmestrøm. Brukerbeskrivelse av datamaskinprogrammet ISTAST Av Guttorm Megård.

6 Beregning av rotasjonsskallkonstruksjoner. Brukerbeskrivelse av datamaskinprogrammet RSKALL Av J. Caspar Falkenberg. 1973. A4. Kr. 25,-.

7 Ventilasjonsberegninger. Brukerbeskrivelse av datamaskinprogrammet VEBER Av Bjørn T. Larsen, 1974.

8 Varmeledning med latent varme. Brukerbeskrivelse av datamaskinprogrammet VALAT Av Guttorm Megård, 1974.

9 Forankring av hus mot vindkrefter. Brukerbeskrivelse av datamaskinprogrammet VIFA Av Magnus Enerud, 1974.

10 Beregning av kontinuerlig bjelke med krumning i eget plan Brukerbeskrivelse av datamaskinprogrammet BUE Av Leif K. Lunke.

11 Vedlikehold og skriving av tidsskriftsirkulasjonslister. Brukerbeskrivelse av datamaskinprogrammet SIRK av Geir Aarflot og Anne Tveter Knoop.

Air Infiltration Centre
Old Bracknell Lane, Bracknell,
Berkshire, Great Britain, RG12 4AH

EDB
PROGRAM
BIBLIOTEK

NORGES BYGGFORSKNINGSINSTITUTT 1977

NBI

Energy Consumption of Residential Buildings

The Computer program ENCORE
Part 2, Documentation

By Bjørn Tore Larsen

F4001A

ENERGY CONSUMPTION OF RESIDENTIAL BUILDINGS

The Computer program ENCORE

Part 2, Documentation

by

Bjørn Tore Larsen

Norwegian Building Research Institute
Oslo 1977

CONTENTS

0. INTRODUCTION

This manual gives a fairly detailed documentation of all the subroutines of the ENCORE program. It also gives a detailed description of all the variables in common blocks (all the key variables of the program are stored in common blocks).

Before reading this manual the reader is advised to read Chapter 1 of the ENCORE Users' Manual (Ref. 10) which explains in general terms how the program works.

CALCUL

The routine where the hour by hour simulation takes place.

INPUT

BLANK COMMON (See Appendix A)

COMMON BLOCKS E, G, H, DUMP, PLOT, CLIMA, SHADE (See Appendix A)

OUTPUT

BLANK COMMON (See Appendix A)

COMMON BLOCKS E, G, H, DUMP, PLOT, CLIMA, SHADE (See Appendix A)

Printout of daily energy consumption

CALCULATION SEQUENCE

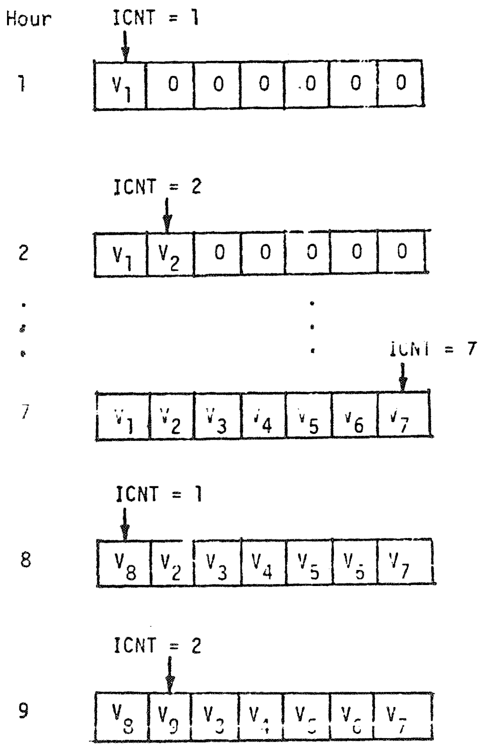


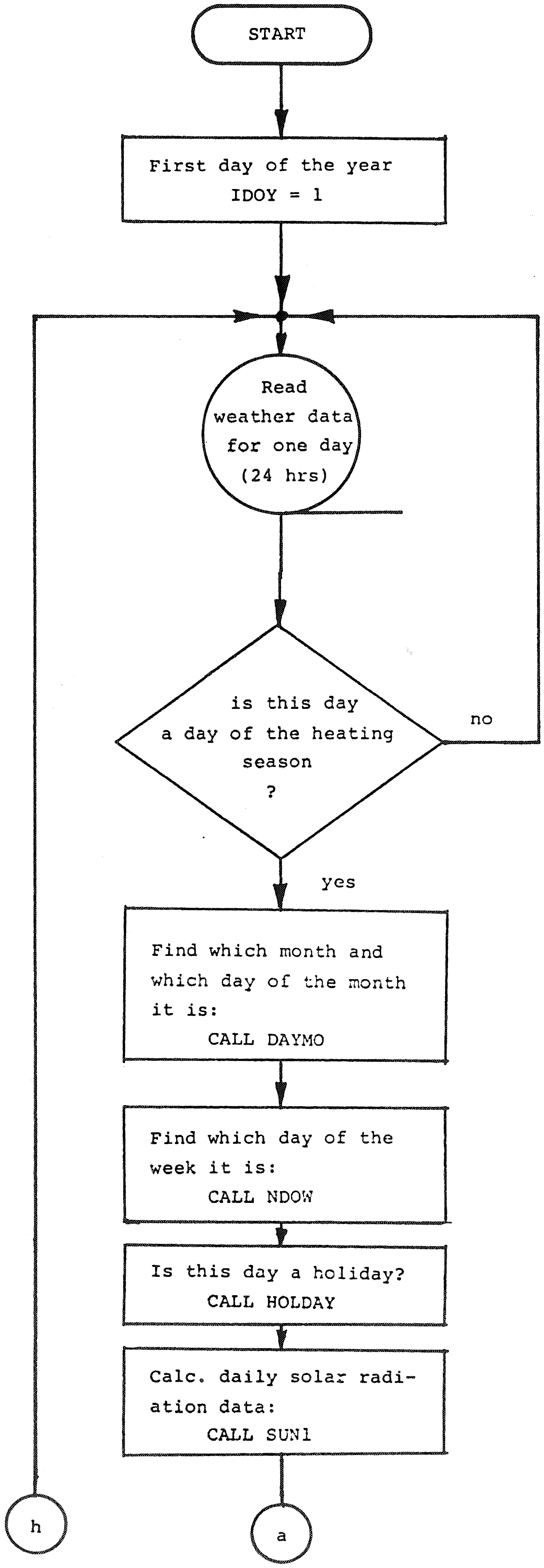
Figure 1

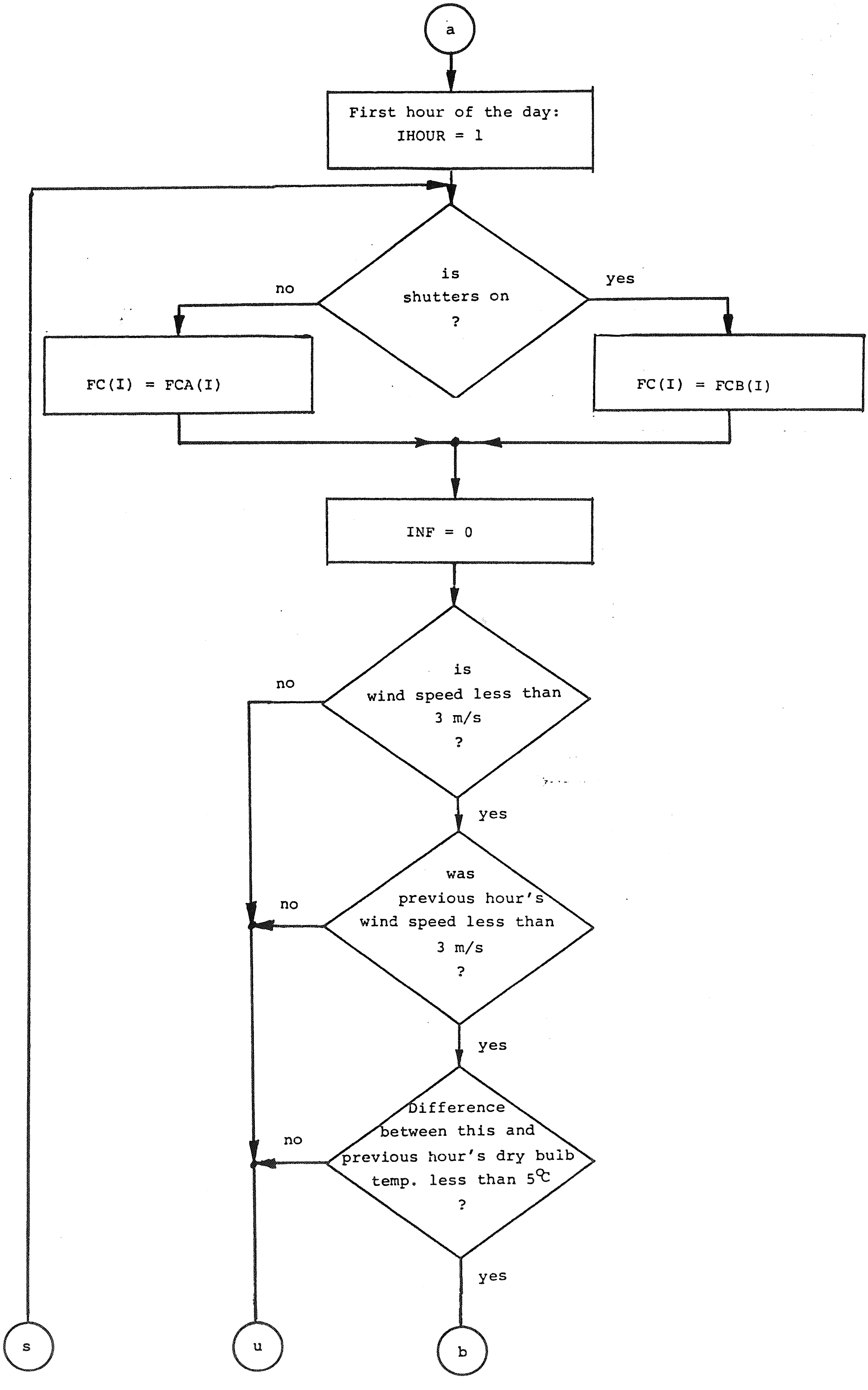
In non steady state heat transfer calculations the value of a variable, e.g. the heat flow through a wall, is a function of the present and the previous excitations(i.e. inside and outside temperature), and, in the formulation used in this program, it's own history. Therefore, it is necessary to store the present and a certain number of previous values. Figure 1 shows an array with room for the present and the previous 6 values. Every time the calculation proceeds one step forward in time the "oldest" value is not needed any more, and it is replaced by the new present value.

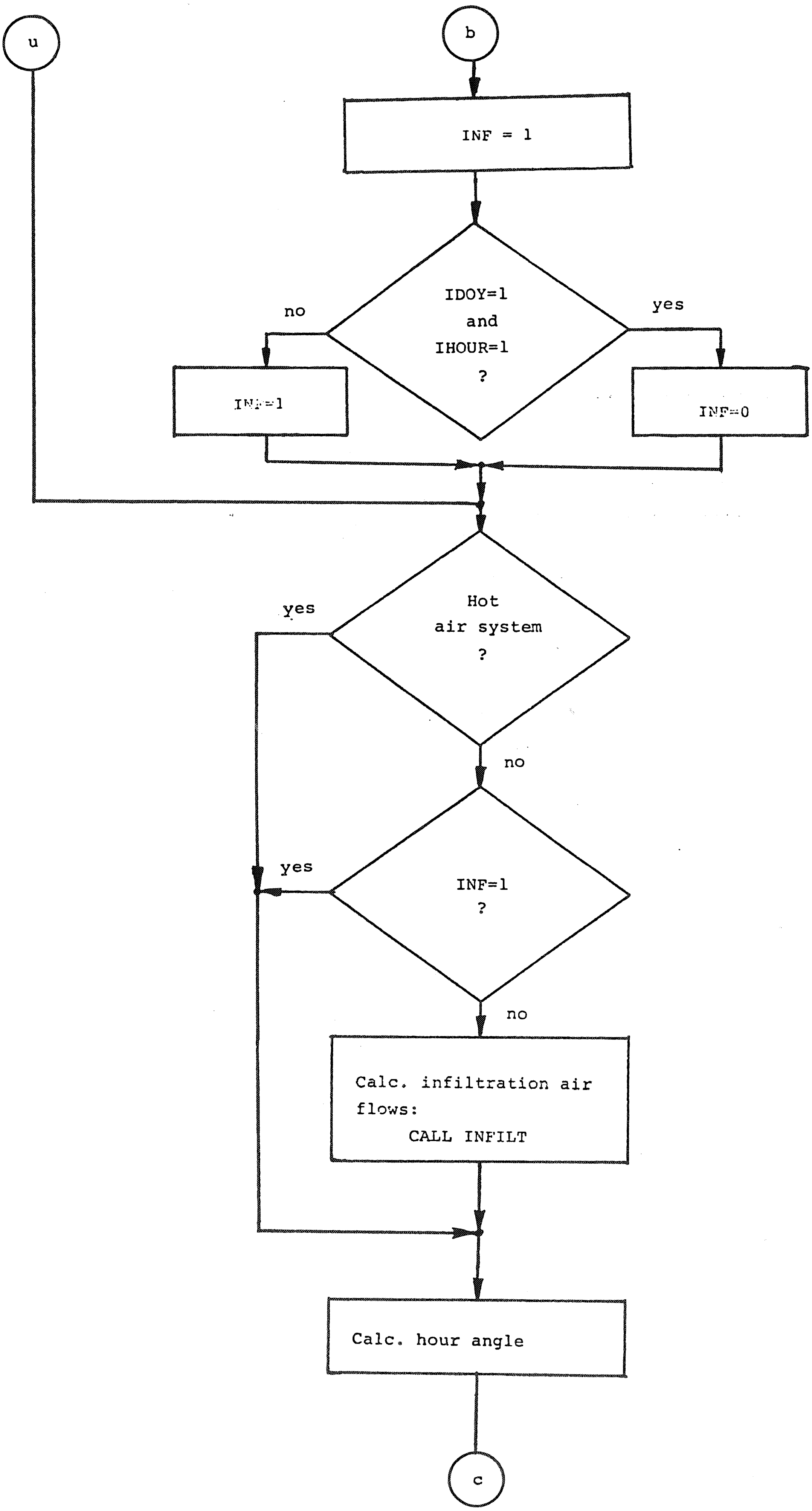
A pointer, ICNT in Figure 1, keeps track of the location where the present value is stored. In this routine there are 3 pointers:

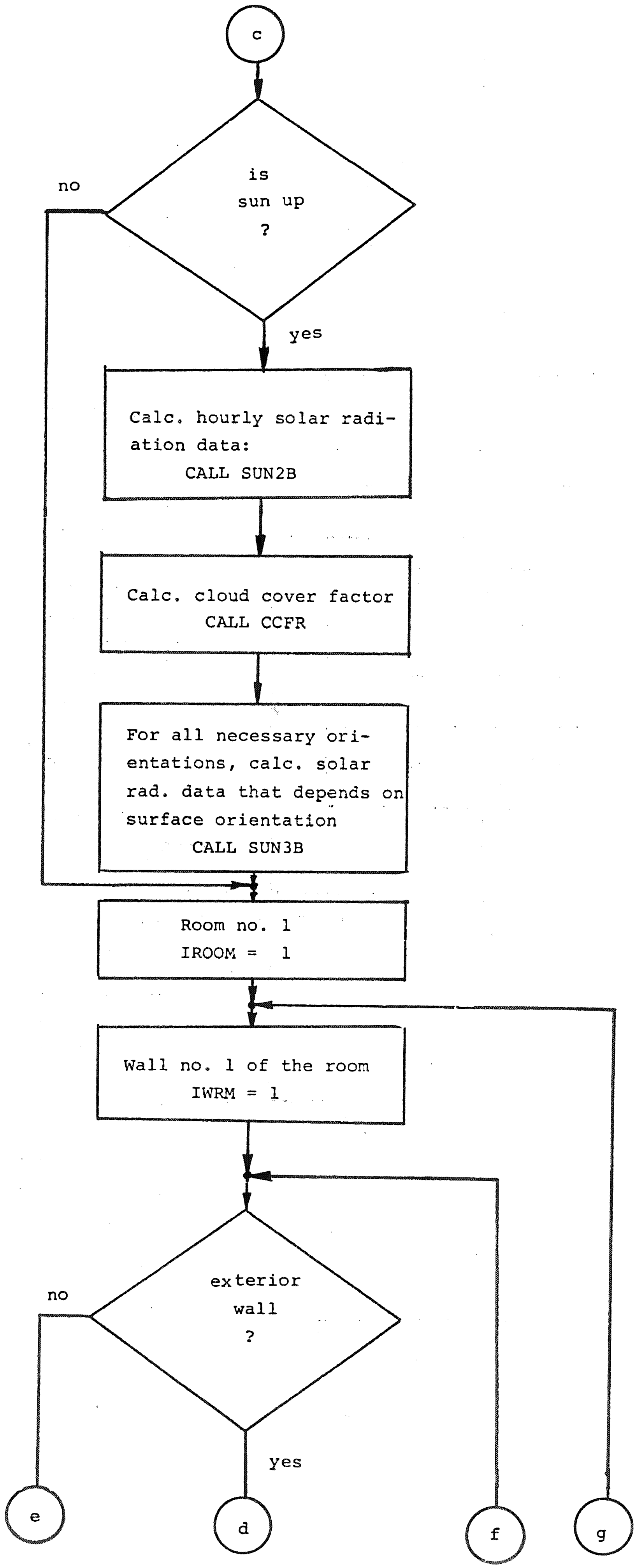
JCNT for arrays where the present and 1 previous value is stored
KCNT " " " " " 2 " values are stored
ICNT " " " " " " 6 " " " "

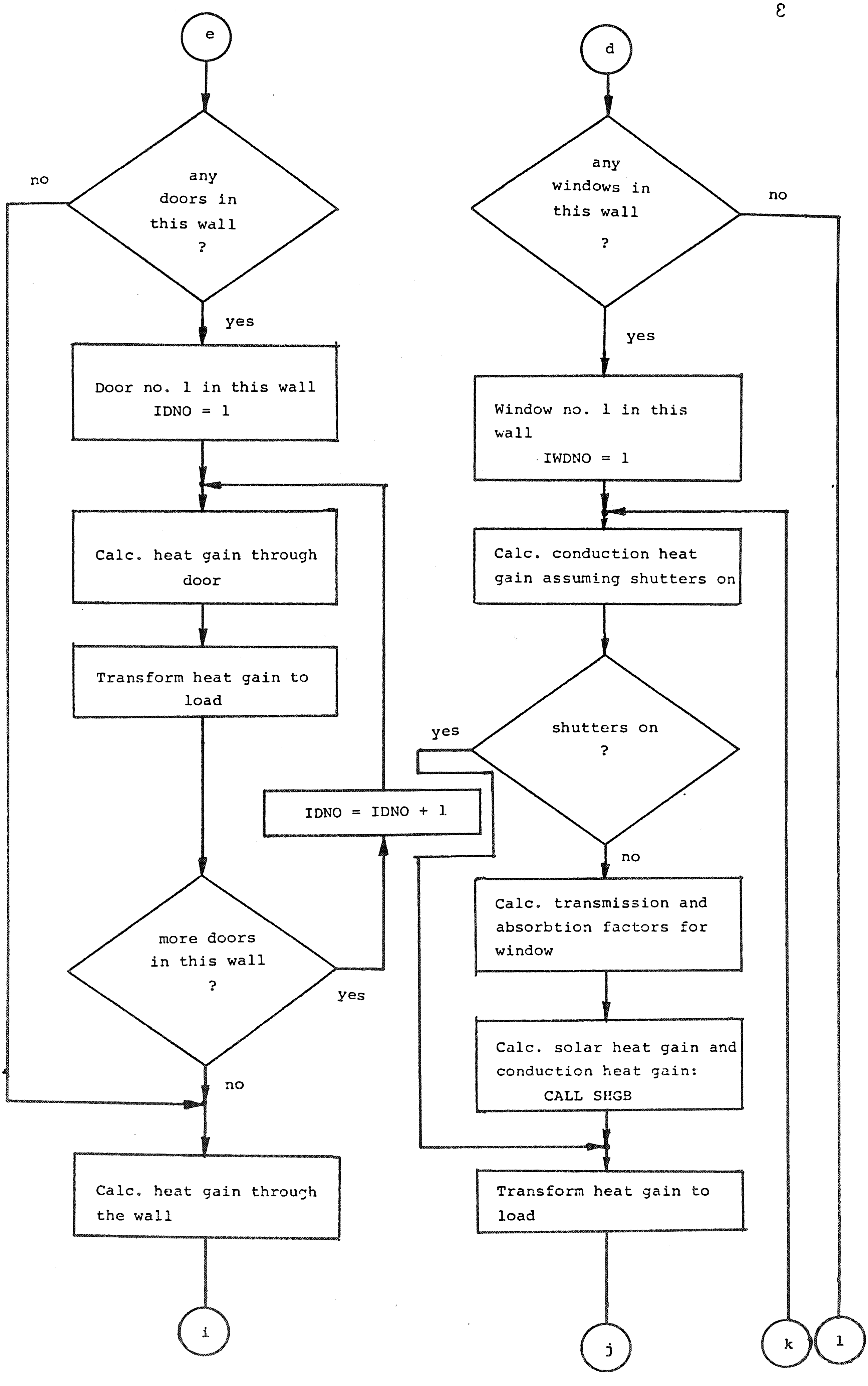
The calculation sequence is as described in the following flow chart.

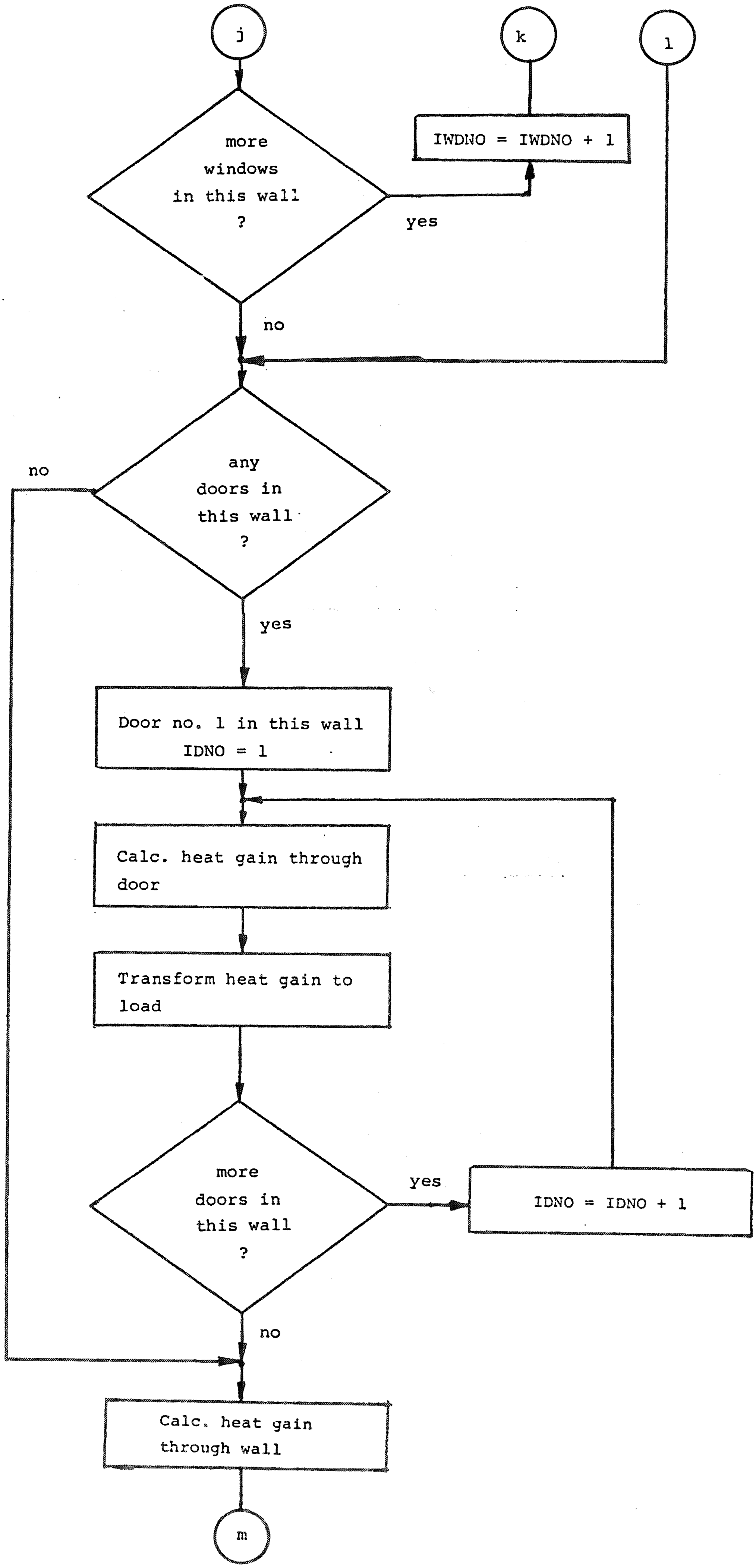


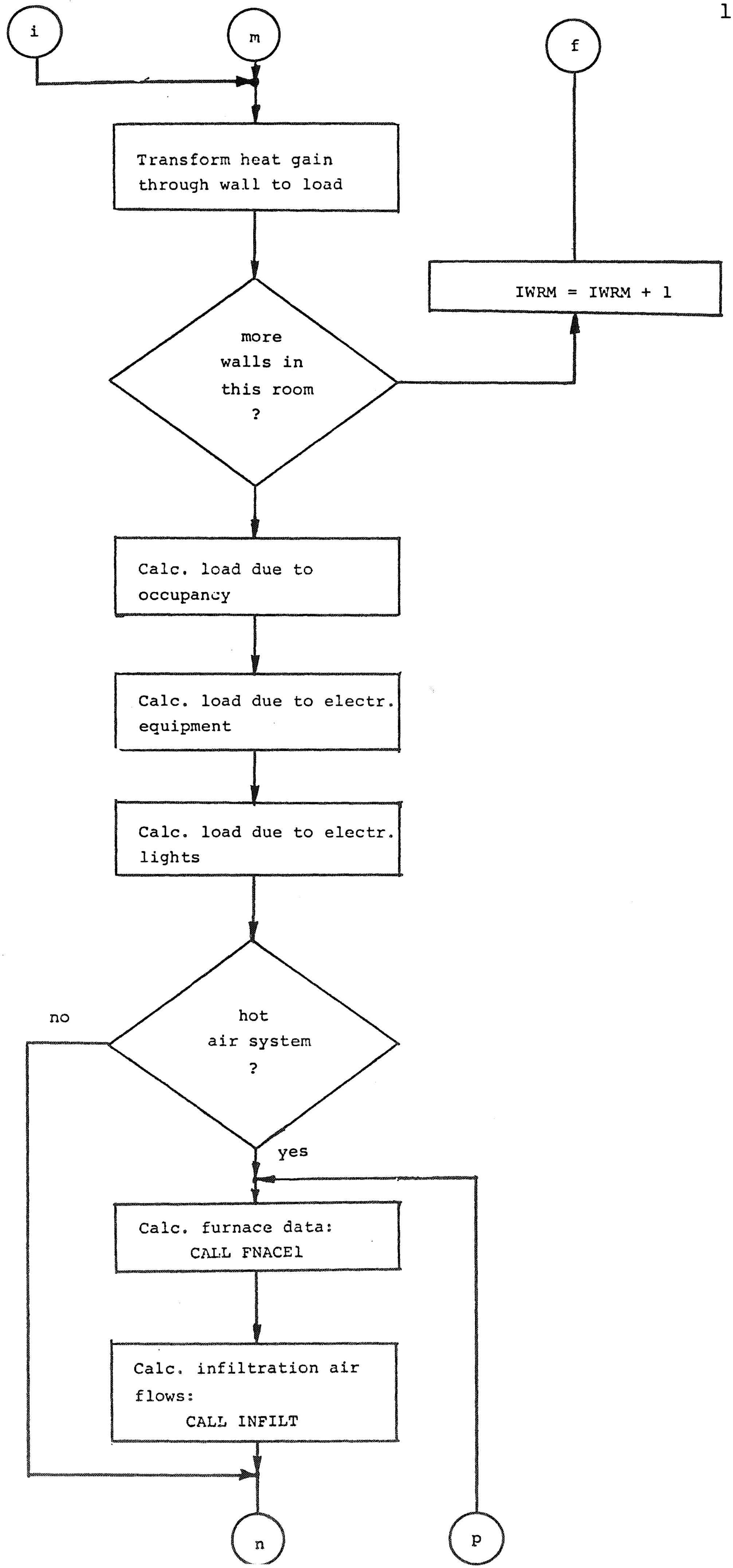

a
First hour of the day:
IHOUR = 1
is
shutters on
?
no
yes
FC(I) = FCA(I)
FC(I) = FCB(I)
INF = 0
is
wind speed less than
3 m/s
?
no
yes
was
previous hour's
wind speed less than
3 m/s
?
no
yes
Difference
between this and
previous hour's dry bulb
temp. less than 5°C
?
no
yes
s
u
b

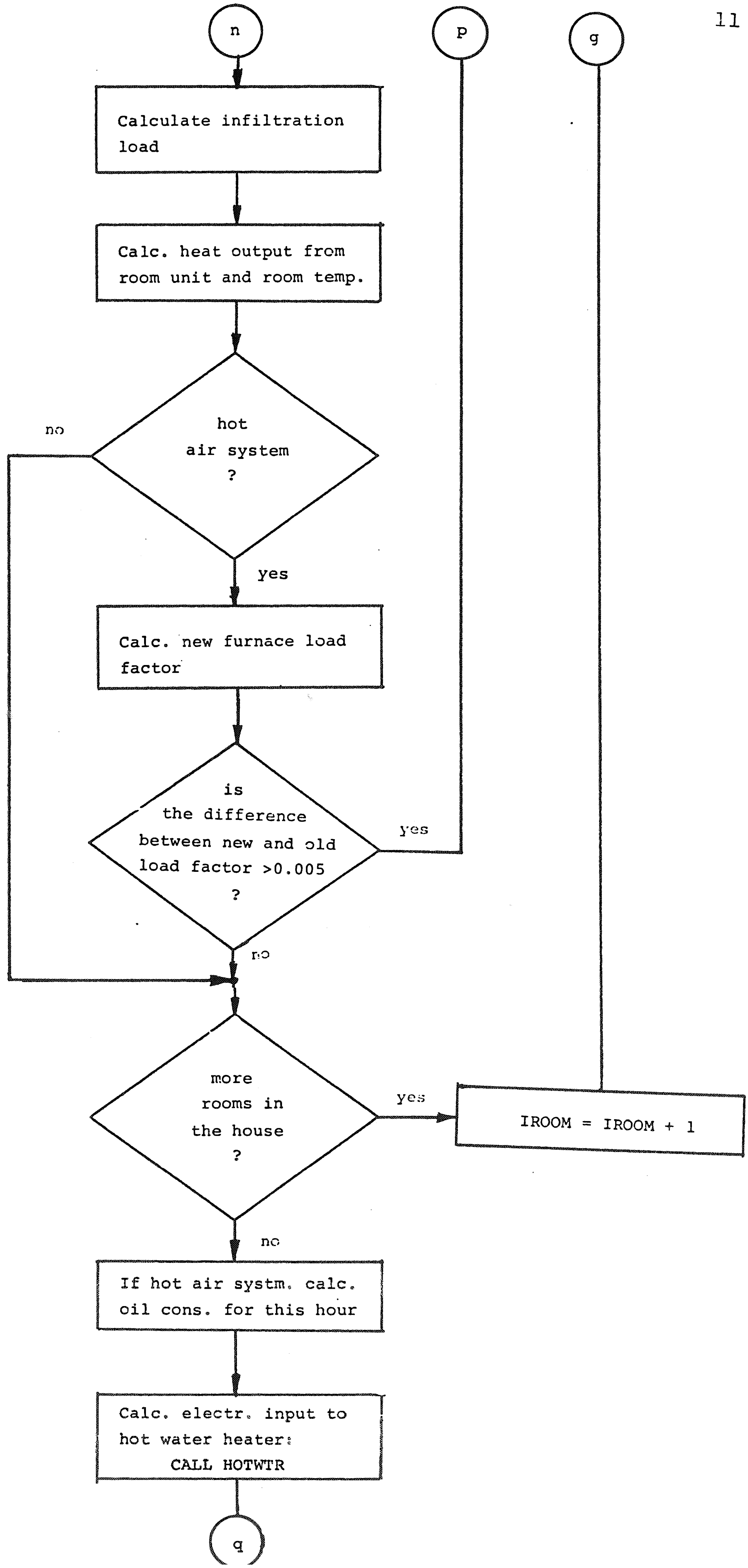

u
b
INF = 1
IDOY=1
and
IHOUR=1
?
no
yes
INF=1
INF=0
Hot
air system
?
yes
no
INF=1
?
yes
no
Calc. infiltration air
flows:
CALL INFILT
Calc. hour angle
c

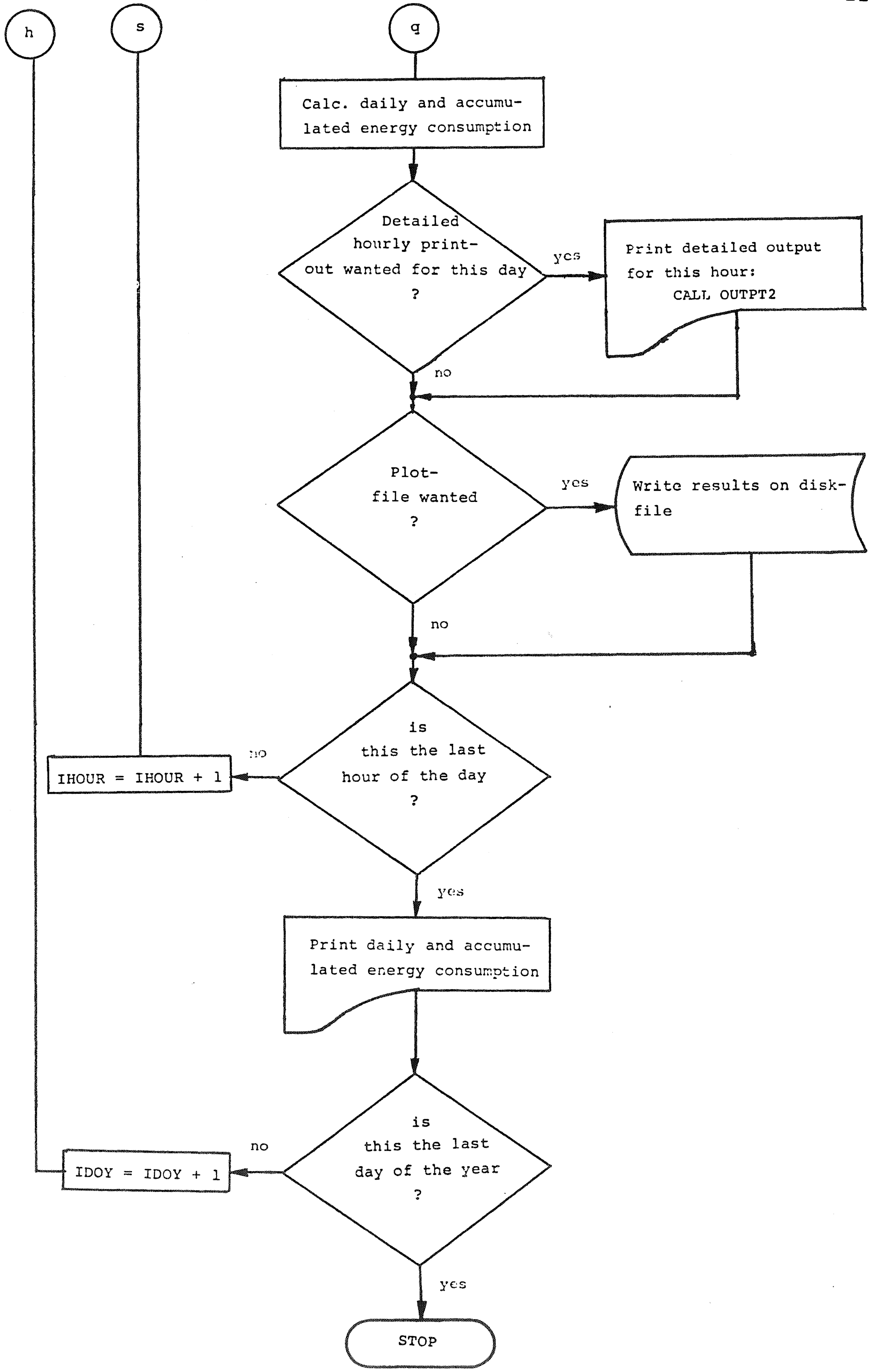

c
is
sun up
?
no
yes
Calc. hourly solar radi-
ation data:
CALL SUN2B
Calc. cloud cover factor
CALL CCFR
For all necessary ori-
entations, calc. solar
rad. data that depends on
surface orientation
CALL SUN3B
Room no. 1
IROOM = 1
Wall no. 1 of the room
IWRM = 1
exterior
wall
?
no
yes
e
d
f
g


e
any doors in this wall ?
no
yes
Door no. 1 in this wall
IDNO = 1
Calc. heat gain through door
Transform heat gain to load
IDNO = IDNO + 1
more doors in this wall ?
yes
no
Calc. heat gain through the wall
i
d
any windows in this wall ?
no
yes
Window no. 1 in this wall
IWDNO = 1
Calc. conduction heat gain assuming shutters on
shutters on ?
yes
no
Calc. transmission and absorbtion factors for window
Calc. solar heat gain and conduction heat gain:
CALL SHGB
Transform heat gain to load
j
k
l


j
k
l
more windows in this wall ?
yes
IWDNO = IWDNO + 1
no
any doors in this wall ?
no
yes
Door no. 1 in this wall
IDNO = 1
Calc. heat gain through door
Transform heat gain to load
more doors in this wall ?
yes
IDNO = IDNO + 1
no
Calc. heat gain through wall
m


i
m
f
Transform heat gain through wall to load
IWRM = IWRM + 1
more walls in this room ?
Calc. load due to occupancy
Calc. load due to electr. equipment
Calc. load due to electr. lights
no
hot air system ?
yes
Calc. furnace data: CALL FNACE1
Calc. infiltration air flows: CALL INFILT
n
p


n
p
g
Calculate infiltration load
Calc. heat output from room unit and room temp.
hot air system ?
no
yes
Calc. new furnace load factor
is the difference between new and old load factor >0.005 ?
yes
no
more rooms in the house ?
yes
IROOM = IROOM + 1
no
If hot air systm. calc. oil cons. for this hour
Calc. electr. input to hot water heater:
CALL HOTWTR
q


h
s
q
Calc. daily and accumulated energy consumption
Detailed hourly print-out wanted for this day ?
yes
Print detailed output for this hour: CALL OUTPT2
no
Plot-file wanted ?
yes
Write results on disk-file
no
is this the last hour of the day ?
no
IHOUR = IHOUR + 1
yes
Print daily and accumulated energy consumption
is this the last day of the year ?
no
IDOY = IDOY + 1
yes
STOP

CARDIN

A subroutine which reads the input card deck and produces a print-out that shows how the input data was interpreted.

INPUT

Input card deck

Output

BLANK COMMON (See Appendix A)

COMMON BLOCKS H, DUMP, PLOT, CLIMA, SHADE (See Appendix A)

Printout that shows how the input data was interpreted.

CALCULATION SEQUENCE

1. The routine reads the input card deck and stores information in single variables and arrays contained in the Common Blocks given above. The routine also produces a printout that shows how the input data was interpreted (see chapter 4 of the User's Manual).

2. The only calculation made by this routine is the calculation of a factor that transforms measured wind speed at the nearest meteorological site to wind speed at roof level at the building site.

   There are three different types of terrain:

   1. Flat open country
   2. Rough wooded country, towns, city outskirts
   3. Centre of large cities

   This is the same classification as used in Reference 4.

   The wind velocity profile, i.e. wind speed as a function of the height above ground, is assumed to follow the power law:

   VZ/VG = (Z/ZG) ** ALFA

Where:

VZ = wind speed at height Z above ground

VG = wind speed above the boundary layer (the gradient wind speed)

ZG = thickness of boundary layer

ALFA = exponent

ZG and ALFA depend on the type of terrain as shown in Table 1:

Terrain	ZG	ALFA	1/ALFA
1	280 m	.143	7.
2	400 m	.286	3.5
3	520 m	.400	2.5

Table 1
ZG and ALFA for different types of terrain

3. Calculate the gradient wind speed from the measured wind speed at the meteorological site (measurements are made 10 m above ground):

VG = VM/((10./ZGM)** ALFAM)

Where:

ALFAM = exponent for meteorological site
VM = wind speed at the meteorological site
ZGM = thickness of boundary layer at the meteorological site

4. Calculate wind speed at roof level at the building site:

VR = VG * (HR/ZGB)** ALFAB

Where:

ALFAB = exponent for meteorological site
HR = distance between ground and edge of roof
ZGB = thickness of boundary layer at the building site

5. To get VR when VG is given, multiply VG by:

```
WCOEF = ((ZGM/10.)** ALFAM)*((HR/ZGB)** ALFAB)
```

CCFR

A subroutine to calculate cloud cover and cloud cover factor according to D. G. Stephenson and K. Kimura (Reference 12). The value of CCF, Cloud Cover Factor, is defined as follows:

$$CCF = ITHC/ITH$$

where

ITHC: Total solar radiation on a horizontal surface under a cloudy sky of given cloud amount and types of cloud

ITH: Total solar radiation calculated for a horizontal surface under a cloudless sky at the same solar hour as of ITHC

<u>INPUT</u>

IDOY	Day of the year	
ICT	Cloud type index =	0 Cirrus, Cirrostratus (high clouds) 1 Stratus (low clouds) 2 Other
ICLD	Total cloud amount (0 - 10)	

<u>OUTPUT</u>

CC Cloud cover

CCF Cloud cover factor

<u>CALCULATION SEQUENCE</u>

1. If ICT = 0 then X = ICC
   If ICT = 2 then X = 0.5*ICC
   Otherwise X = 0.

2. Cloud cover
   CC = ICLD - 0.5*X

3. Cloud cover factor

CCF = P + Q*CC + R*CC**2

where P, Q, and R are found in the following table

Season	P	Q	R
spring (90<IDOY≤150)	1.06	0.012	-0.0084
summer (150<IDOY≤259)	0.96	0.033	-0.0106
autumn (250<IDOY≤330)	0.95	0.030	-0.0108
winter (IDOY<330 or IDOY≤90)	1.14	0.003	-0.0082

The value of P, which is essentially the cloudless sky factor, depends upon the proportion of direct to diffuse sky radiation in reference to the standard ASHRAE values published in the 1972 Handbook of Fundamentals. If the value of P is unity, this proportion of direct to diffuse solar radiation is such that the solar radiation evaluated for a horizontal surface under a cloudless sky should be equal to the value obtained by the methd described in the 1972 ASHRAE Handbook of Fundamentals. If the value of P is different from unity, the direct to diffuse proportion is different from the standard values.

CHMNEY

A subroutine which simulates the hydraulics of a chimney and smoke pipe with barometric damper.

INPUT

FTMP	Temp. of flue gases from furnace, $^{\circ}K$
GF	Weight flow of flue gases from furnace, kg/s
WSPEED	Wind speed, m/s
RTMP	Indoor temp., $^{\circ}K$
OUTTMP	Outdoor temp., $^{\circ}K$
P1	Building pressure, kg/m^2
ZETA	Static pressure loss coefficient for furnace at off-cycle when barometric damper is closed

COMMON BLOCK H (See Appendix A)

OUTPUT

GCH	Weight flow of gases in smoke pipe and chimney, kg/s
DGDP1	The derivative of the chimney flow with respect building pressure, m^2/s

CALCULATION SEQUENCE

Note! The following is copied from Reference 11, and the symbols are not the same as those used in the subroutine.

Figure A1 shows a furnace, smoke pipe with barometric damper, and a chimney. The following derivations are needed to describe the flow from point 2, immediately upstreams of the branch to the barometric damper, to point 3, the top of the chimney. Heat loss from smoke pipe and chimney is not taken into account.
When the barometric damper is open, i.e. the damper is operating, the static pressure at point 2 is:

$$P_2 = P_1 - \rho_{in}\, g h_2 - d_r \qquad \text{(A 1)}$$

where:

P_1 = static pressure in the house at reference level (point 1)

ρ_{in} = density of the room air

g = gravitational acceleration

h_2 = vertical distance between reference level and point 2.

d_r = draft setting of the barometric damper.

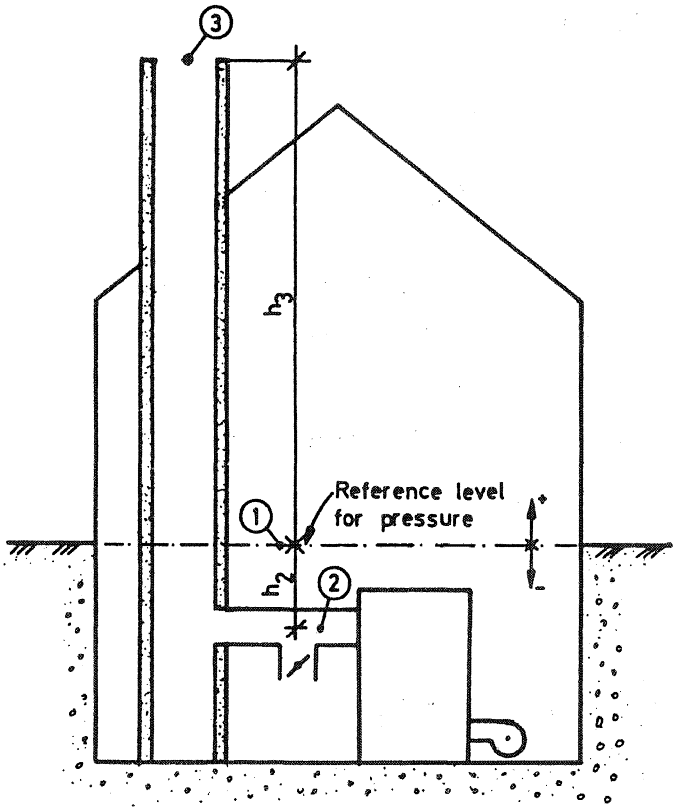


FIGURE A1

Model to find the flow up the chimney

When the outside static pressure at reference level is taken as zero, the static pressure at point 3 is given by:

$$P_3 = c\rho_{out}\frac{V_w^2}{2} - \rho_{out}\, gh_3 \qquad (A2)$$

where: c = wind pressure coefficient

ρ_{out} = density of outside air

V_w = wind speed

h_3 = vertical distance between reference level and point 3

Bernoulli's equation from point 2 to point 3:

$$P_1 - d_r - \rho_{in}gh_2 + \rho_{ch}\frac{V_2^2}{2} + \rho_{ch}gh_2$$
$$= c\rho_{out}\frac{V_w^2}{2} - \rho_{out}gh_3 + \rho_{ch}\frac{V_3^2}{2} + \rho_{ch}gh_3 + \Delta E \qquad (A\ 3)$$

where: ρ_{ch} = density of gas in smoke pipe and chimney

V_2 = gas velocity at point 2

V_3 = " " " " 3

ΔE = friction loss between 1 and 2

An energy balance for the point where the smoke pipe and the branch to the barometric damper is connected gives:

$$T_{ch} = \frac{G_f T_f + G_d T_c}{G_{ch}} \qquad (A\ 4)$$

where: G_f = weight flow of gas from furnace

G_{ch} = " " " " up the chimney

G_d = " " " air from the barometric damper inlet

T_f = absolute flue gas temperature

T_{ch} = absolute temperature of chimney gas

T_c = absolute room air temperature

The condition of mass balance gives:

$$G_d = G_{ch} - G_f \qquad (A\ 5)$$

combining equations A4 and A5:

$$T_{ch} = \frac{G_f}{G_{ch}} (T_f - T_c) + T_c \qquad (A\ 6)$$

The density of the chimney gas is given by the gas equation:

$$\rho_{ch} = \frac{P_{atm}}{R\ T_{ch}} \qquad (A7)$$

It is quite adequate to use standard atmospheric pressure and gas constant for air in this equation.

The friction loss from point 1 to point 3 is given by:

$$\Delta E = \left[\left(f_s \frac{\ell_s}{d_s} + \zeta_{br} + n_b\right) \frac{8}{g^2 \pi^2 d_s^4} + f_{ch} \cdot \frac{\ell_{ch}}{a} \frac{1}{2 g^2 a^4} \right] \frac{G_{ch}^2}{\rho_{ch}} \qquad (A8)$$

where: f_s = hydraulic friction factor for smoke pipe

ℓ_s = smoke pipe length

d_s = smoke pipe diameter

ζ_{br} = "straight-through" dynamic loss coefficient for the branch to the barometric damper

n_b = number of smoke pipe bends. It is assumed that the dynamic loss coefficient for a bend is equal to 1.0

f_{ch} = hydraulic friction factor for chimney

ℓ_{ch} = chimney length

a = internal side length of the chimney

Eq. (A6), (A7), (A8) and (A3) give a third order equation with G_{ch} as the unknown. The three solutions are found in mathermatical handbooks. Only one of them is acceptable. The condition for an acceptable solution is that $G_{ch} \geq 0$. In addition it has to be checked if $G_{ch} - G_f > 0$. If this is not so, it means that the barometric damper is closed. The flow through the furnace, smoke pipe, and damper is then given by:

$$P_1 - \rho_{in}\, g h_2 - \frac{1}{2}\,\frac{G_{ch}^2}{g^2\, \rho_f\, A_3^2} - \rho_f\, g\,(h_3 - h_2) + \rho_{out}\,(g h_3 - C\frac{v_w^2}{2})$$

$$= \left[(f_{sp}\,\frac{\ell_{sp}}{d_{sp}} + n_b + \zeta_f)\,\frac{8}{g^2\pi^2\, d_{sp}^4} + f_{ch}\,\frac{\ell_{ch}}{a}\,\frac{1}{2\, g^2 a^4}\right]\frac{G_{ch}^2}{\rho_f} \qquad (A9)$$

Where: A_3 = chimney area

ζ_f = dynamic loss coefficient for the furnace

ρ_f = density of flue gas

The condition for use of Eq. (A9) may occur during off-cycle at low furnace load.

Figure A2 shows some results obtained by this calculation procedure.

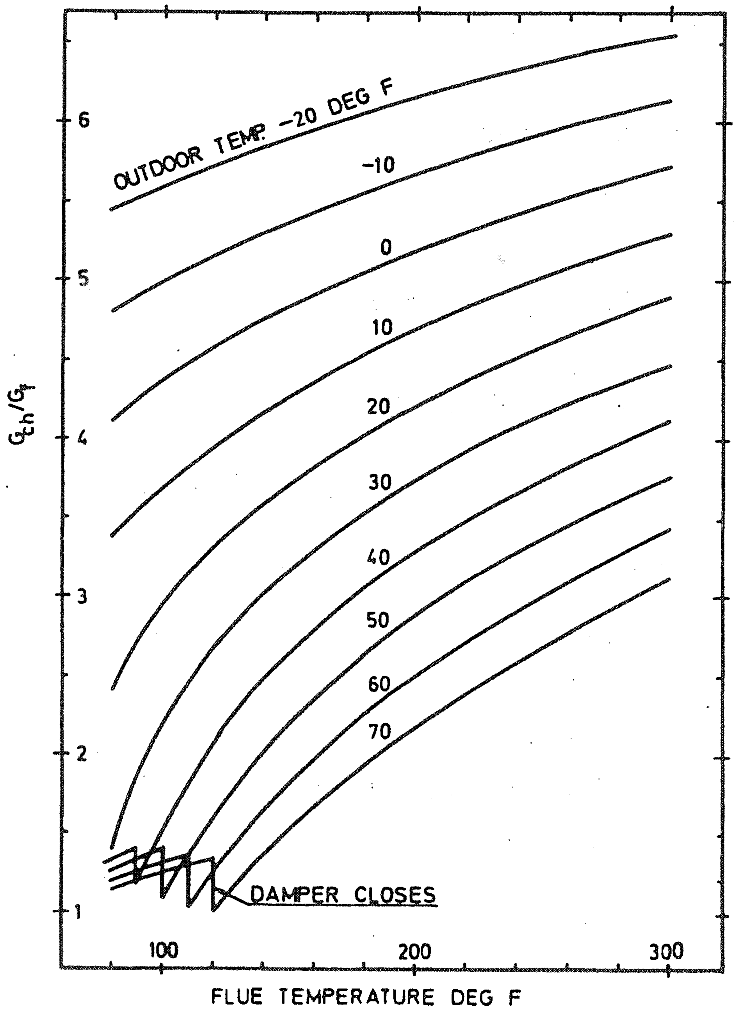


FIGURE A 2
Weight flow up a 20 ft high chimney as a function of flue gas and outdoor temperature.

When G_{ch} is found, the derivative of G_{ch} with respect to the indoor pressure P_1 is calculated. The reason for this is that G_{ch} is included in the infiltration calculation which is a Newton-Raphson iteration.

DAYMO

A calendar subroutine which identifies the day of the month and the month of the year.

INPUT

LEAP Leap year index = $\begin{cases} 0 & \text{Non-leap year} \\ 1 & \text{Leap year} \end{cases}$

IDOY Day of the year, from start of year

OUTPUT

IDAY Day of the month

MONTH Month of the year

CALCULATION SEQUENCE

1. If IDOY < 31, MONTH = 1 and IDAY = IDOY

2. If 31 < IDOY $\leq$ (59 + LEAP), MONTH = 2, IDAY = IDOY - 31

3. If (59 + LEAP) < IDOY $\leq$ (90 + LEAP), MONTH = 3,
   IDAY = IDOY - 59 - LEAP

4. If (90 + LEAP) < IDOY $\leq$ (120 + LEAP), MONTH = 4,
   IDAY = IDOY - 90 - LEAP

5. If (120 + LEAP) < IDOY $\leq$ (151 + LEAP), MONTH = 5,
   IDAY = IDOY - 120 - LEAP

6. If (151 + LEAP) < IDOY $\leq$ (181 + LEAP), MONTH = 6,
   IDAY = IDOY - 151 - LEAP

7. If (181 + LEAP) < IDOY $\leq$ (212 + LEAP), MONTH = 7,
   IDAY = IDOY - 181 - LEAP

8. If (212 + LEAP) < IDOY $\leq$ (243 + LEAP), MONTH = 8,
   IDAY = IDOY - 212 - LEAP

9. If (243 + LEAP) < IDOY ≤ (273 + LEAP), MONTH = 9,
IDAY = IDOY - 243 - LEAP

10. If (273 + LEAP) < IDOY ≤ (304 + LEAP), MONTH = 10,
IDAY = IDOY - 273 - LEAP

11. If (304 + LEAP) < IDOY ≤ (334 + LEAP), MONTH = 11,
IDAY = IDOY - 304 - LEAP

12. If (334 + LEAP) < IDOY, MONTH = 12,
IDAY = IDOY - 334 - LEAP

FCFAC

A subroutine to calculate reduction factors, due to heat loss to the surroundings, for "V-factors" of the room transfer function. The routine also calculates the room's total heat conduction to the surroundings. See Chpt. 22, part II of the ASHRAE Handbook of Fundamentals, 1972.

INPUT/OUTPUT

BLANK COMMON (See Appendix A)

CALCULATION SEQUENCE

1. For each room the routine calculates the total heat conduction to the surroundings:

$$Q_{total} = U_{window} A_{window} + U_{exterior\ wall} A_{eksterior\ wall.} + U_{door} A_{door}$$

   Two different Q_{total} are calculated: one which applies when windows do not have shutters, and one when they have.

2. The reduction factors, or Fc-faktors, for the "V-factors" are given by (Si - units):

$$F_c = 1.0 - \frac{0.01156}{L_F} \cdot Q_{total}$$

   where: L_F = Length of room exterior perimeter

   As for Q_{total} two different F_c - factors are calculated.

3. A test is made to see if $1.0 > F_c > 0.7$. If F_c does not fall within these limits the program stops and prints a message. This situation is usually caused by bad input (it is possible to get around the test by "adjusting" the room exterior perimeter length).

FFACT

A function which calulates the hydraulic friction factor for flow in pipes.

INPUT

REY	Reynold's number
ROUGH	Wall roughness of pipe, m
DIA	Pipe diameter, m

OUTPUT

FFACT	The hydraulic friction factor

CALCULATION SEQUENCE

1. If Reynold's number is less than 3000 the flow is laminar, and the friction factor is given by:

   FFACT = 64.0/REY

2. If Reynold's number is greater than 3000 the flow vill be in the transitional or the fully turbulent regime. The friction factor is then given by the expression:

   1.0/SQRT(FFACT) = - 0.86 * ALOG (ROUGH/(DIA * 3.7)
   + 2.51/(REY * SQRT(FFACT)))

   To solve for FFACT it is necessary to use an iteration procedure. The Newton Raphson's method of the form f(x)=0 is used to solve for:

   X = 1.0/SQRT(FFACT)

   Initial value (first approximation):

   X = 3.162

   Let A = ROUGH/(DIA*3.7)
   B = 2.51/REY

3. Using exponentials instead of logarithms gives (y = f(x) = 0) :

```
Y = (A+B*X) ** (-0.86) - EXP(X)
```

4. The derivative of Y with respect to X :

```
DYDX = - 0.86 * B * (A+B * X) ** (-1.86)-EXP(X)
```

5. Correction to X :

```
DELTAX = - Y/DYDX
```

6. A new and better value of X is given by:

```
X = X + DELTAX
```

7. If the absolute value of DELTAX is greater than 0.1 then go back to step 3 and do the steps 3 to 6 over again (usually 3 to 6 iterations are enough).

8. Calculate the friction factor :

```
FFACT = 1.0/(X * X)
```

FILLUP

A subroutine which generates hourly values of the schedules for internal heat gains and thermostat set points.

INPUT

IIN(15)	Array containing schedule input data for maximum five periods of the day.
IGROUP	Identification of schedule:

IGROUP = 1	Occupancy schedule
IGROUP = 2	Const. light schedule
IGROUP = 3	Var. light schedule
IGROUP = 4	Equipment schedule
IGROUP = 5	Thermostat schedule
IGROUP = 6	Hot water schedule

N	Schedule number of the group
L	Maximum number of schedules in the group
M	Hours per day (i.e. 24)

OUTPUT

K(L,M)	Array containing hourly schedule values expressed as "percent of max".

CALCULATION SEQUENCE

The array IIN contains schedule input data on the form "From hr., to hr., percent of max, from hr., to hr., percent of max, ... etc. for maximum five periods of the day. From this input FILLUP produces hourly values (24 values) of the form "percent of max.". Each call of the routine produces one line in the array K (i.e. K(N,M) where M is from 1 to 24).

FNACE1

A subroutine which simulates an oil fired hot air furnace using fuel oil no. 2

INPUT/OUTPUT

COMMON Block G (see Appendix A)

COMMON Block H (" " ")

CALCULATION SEQUENCE

Note! The following is copied from Reference 11, and the symbols are not the same as those used in the subroutine.

The purpose of the following derivations is to find the furnace loss as a function of the furnace load. This loss includes the flue gas loss during on-cycles and the loss due to air flow through the furnace at off-cycles.

If the burner is started and left on long enough for the flue gas to reach a constant temperature, and then turned off the flue gas temperature as a

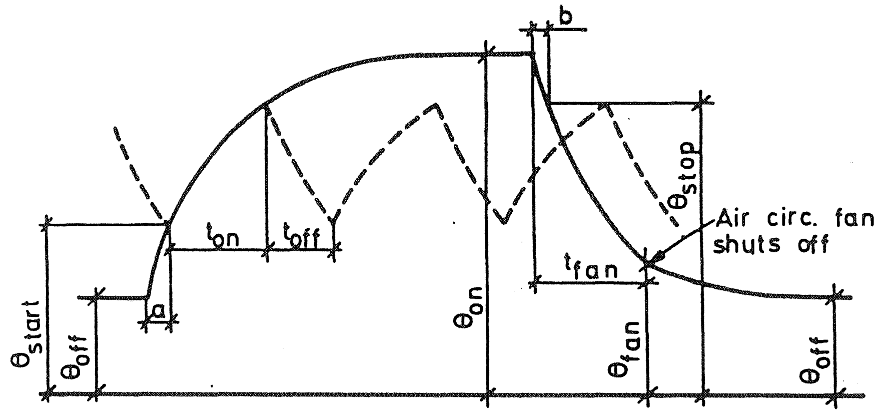


FIGURE B1
Flue gas temperature during on-and off-cycle for an oil fired hot air furnace.

function of time will be something like the continous curve in figure B1. The general case, with the burner going on and off at regular intervals, will be something like the dashed curve.

The number of burner cycles per hour varies according to the furnace load. It is obvious that the number of cycles at no load is zero, and that the number of cycles at full load is one (burner on all the time). Somewhere between these two extremes the number of cycles will have a maximum. U.Bonne et al [7,8] have found that the maximum occurs at 50 % load. Their work indicates that the number of cycles per hour as a function of furnace load factor, i.e. on-time to total time, can be expressed by the following equation:

$$n = x + (n_{50} - 0{,}5) \cdot \left[1 - (2x - 1)^2\right] \qquad \text{(B1)}$$

where: x = furnace load factor ($0 \leq x \leq 1$)

n_{50} = number of cycles at 50 % furnace load ($x = 0{,}5$)

One cycle consists of one on-cycle and one off-cycle. The length of these in seconds are given by:

$$t_{on} = \frac{3600\ x}{n} \qquad \text{(B2)}$$

$$t_{off} = \frac{3600}{n} - t_{on} \qquad \text{(B3)}$$

It is assumed that the flue gas temperature during on- and off-cycle can be represented by exponential functions. In the general case the on-cycle temperature is given by (see figure B1):

$$\theta = (\theta_{on} - \theta_{off})\,(1 - e^{-\frac{t + a}{\tau_{on}}}) + \theta_{off} \qquad \text{(B4)}$$

where: t = elapsed time from the moment the burner started

τ_{on} = time constant

The "a" in Eq. (B4) is found by using it with $t = 0$ and $\theta = \theta_{start}$.

The off-cycle temperature, when the air circulation fan is running, is given by:

$$\theta = \theta_{on} - (\theta_{on} - \theta_{off})\,(1 - e^{-\frac{t + b}{\tau_{off1}}}) \qquad \text{(B5)}$$

where: t = elapsed time from the moment the burner shut off

τ_{off1} = time constant.

The "b" in Eq. (B5) is found by using it with $t=0$ and $\theta = \theta_{stop}$. The time, t_{fan}, from the burner shuts off to the time when the circulation fan shuts off is found by using Eq. (B5) with $\theta = \theta_{fan}$.

The off-cycle temperature, when the air circulation fan is not operating, is given by:

$$\theta = \theta_{fan} - (\theta_{fan} - \theta_{off}) \cdot (1 - e^{-\frac{t - t_{fan}}{\tau_{off2}}}) \qquad \text{(B6)}$$

where: t = same as t in Eq.(B5)

τ_{off2} = time constant

The temperature θ_{end} at the end of the off-cycle, as calculated by Eq. (B6) or (B5) has to be the same as the temperature at the start of the on-cycle. Actual calculations are started by assuming θ_{start}. If θ_{end} deviates to much from θ_{start}, the calculations are done over again with $\theta_{start} = \theta_{end}$. The process is repeated as many times as necessary to get the two temperatures equal.

If other constituents than carbon and hydrogen are neglected for fuel oil no 2, the amount of flue gas per weight unit of fuel is given by:

$$G_{flue} = 0{,}0144 \cdot \alpha(8c + 24\ h) + 1 \qquad \text{(B7)}$$

where: c = % carbon by weight in the fuel

h = % hydrogen " " " "

α = amount of air supplied for combustion to the amount of air theoretically required

The weight of water wapor formed by combustion of one weight unit of fuel is given by:

$$G_{H_2O} = \frac{8,5}{100} h \qquad (B8)$$

When the capacity of the burner nozzle is given, the flue loss per on-cycle is:

$$L_{on} = \int_0^{t_{on}} \frac{k}{3600} \gamma \cdot Cp \cdot \left[0,0144 \cdot \alpha \cdot (8c + 24 h) + 1\right] (\theta - \theta_{off})\, dt$$

$$+ \frac{k}{3600} \cdot \gamma \cdot \frac{8,5}{100} h \cdot W \cdot t_{on} \qquad (B9)$$

where: k = capacity of burner nozzle (gph)
γ = spesific weight of fuel
W = heat of vaporization of water at room temperature (θ_{off}).
c_p = specific heat of flue gas

The barometric damper will always try to keep constant draft over the furnace. In this case, at steady state operation, the weight flow of flue gas will be constant. Even at off-cycle, when the furnace is cooling down, the mass flow of air through the furnace will be fairly constant if the main resistance to air flow is the air intake of the burner. In this case the off-cycle loss per cycle is:

$$L_{off} = \int_0^{t_{off}} DkG_{flue}\, C_p\, (\theta - \theta_{off})\, dt \qquad (B10)$$

where: D = air flow through the furnace at off-cycle to the flow of flue gas at on-cycle.

When both L_{on} and L_{off} are found the furnace efficiency is simply given by:

$$\eta = 1 - \frac{(L_{on} + L_{off})\, n}{k \cdot HHV \cdot x} \qquad (B11)$$

where: HHV = higher heating value of fuel

Other losses, such as heat loss from the furnace, are not taken into account as they give a positive heat input to the house.

Curves for furnace efficiency as a function of load, calculated with Eq. (B11), are shown in Figure B 2. The figure shows clearly how important it is to keep the off-cycle air flow through the furnace as low as possible.

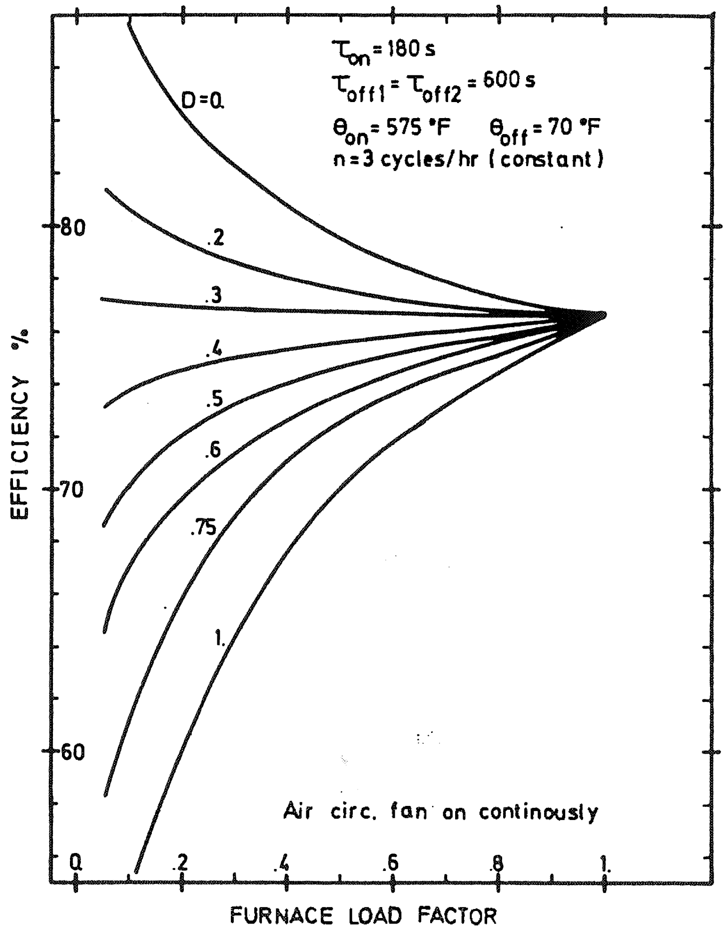


FIGURE B2.
Furnace efficiency as a function of furnace load factor.

HOLDAY

A subroutine which, except for easter, identifies the Norwegian national holidays.

INPUT

MO	Month of the year
JAY	Day of the month
NDAY	Day of the week (Sunday = 1, etc.)

OUTPUT

JOL Holiday indicator = { 0 Not holiday; 1 Holiday }

CALCULATION SEQUENCE

1. Set JOL equal to 1 for the following situations:

   If MO = 1 and JAY = 1
   MO = 5 and JAY = 1
   MO = 5 and JAY = 17
   MO = 12 and JAY = 25
   MO = 12 and JAY = 26

2. Otherwise set JOL equal to 0.

HOTWTR

A subroutine which simulates an electric hot water heater with storage (see Figure 1). The thermostat will try to keep the water heater completely charged all the time.

INPUT

QHWT	Average hot water demand for the hour in question,W
QSMAX	Maximum heat storage capacity of the water heater,Wh
QINMAX	Maximum electric power input to the water heater,W
QS	Stored heat in the water heater at the beginning of the hour,Wh

OUTPUT

QS	Stored heat in the water heater at the end of the hour,Wh
QIN	Average electric power input for the hour in question,W
IQ	0 if the heater was able to meet the demand, 1 if not.

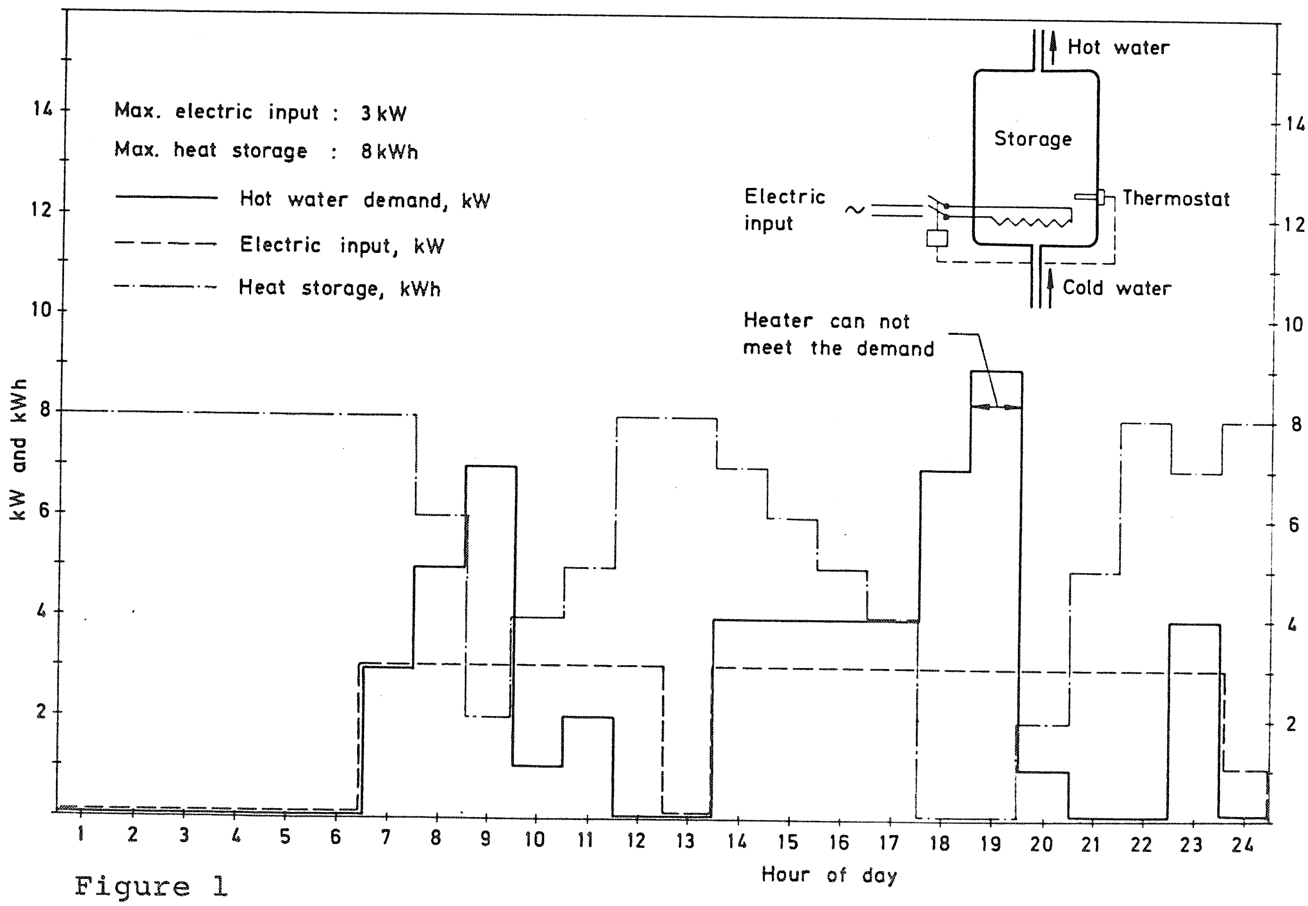


Figure 1

Simulation of hot water heater with storage

CALCULATION SEQUENCE

1. CASE 1:

   The water heater contains the maximum possible amount of heat (QSMAX) at the beginning of the hour:

   a) QHWT is less or equal to QINMAX:

      QIN = QHWT

      QS = QSMAX (as before)

   b) QHWT is greater than QINMAX:

      QIN = QINMAX

      QS = QSMAX - (QHWT - QINMAX)

2. CASE 2:

   The water heater is not completely charged at the beginning of the hour (QS < QSMAX):

   a) QHWT is less than QINMAX:

      QIN = QHWT + (QSMAX - QS)

      QS = QSMAX

      If QIN calculated above turns out to be greater than QINMAX then:

      QIN = QINMAX

      QS = QSOLD + (QINMAX - QHWT)

   b) QHWT is greater than QINMAX:

      QIN = QINMAX

      QS = QS-(QHWT - QINMAX)

3. If any of the above calculation make QS negative it means that the demand could not be met. In this case:

      QIN = QINMAX

      QS = 0

      IQ = 1

Fig. 1 shows an example of how the electrical input and the amount of stored heat will vary according to the hot water demand.

INFILT

A subroutine which calculates air flow through cracks in the external walls of a house. It is assumed that there are no pressure losses inside the house, i.e. all the internal doors are open.

INPUT

WDIR	Wind direction, degrees clockwise from north
WSPD	Wind speed at the nearest meteorological site, m/s
TOUT	Outdoor temperature, ^{o}C
TIN	Indoor temperature, ^{o}C
HIO(50)	Array containing the distances (m) between the reference level and the cracks for the different walls of the house (h in Figure 2).
IERR	Should be set to 0 before calling the routine

OUTPUT

SUMG	The algebraic sum of all the air flows through the cracks in the walls, kg/s
IERR	0 if the iteration process (Newton Raphson's method) to find inside air pressure does converge. If it does not converge, IERR is set to 1.
WFLOW(50,2)	The weight flows of air through the different walls of the house:

WFLOW(n,1) furnace is on
WFLOW(n,2) " " off

BLANK COMMON (See Appendix A)

COMMON BLOCKS F, G and H (See Appendix A)

CALCULATION SEQUENCE

1. Transform indoor and outdoor temperature to degrees Kelvin:

```
TO = TOUT + 273.
TI = TIN  + 273.
```

2. Transform wind speed at the meteorological site, WSPD, to wind speed at the building site:

   WSPEED = WCOEF * WSPD

3. For each external surface calculate the wind's angle of attack, WANG, relative to surface azimuth angle, WAZ:

   WANG = |WAZ - WDIR|
   if WANG > 180. then WANG = 360.- WANG

Shape no.	1	2	3	4	5	6	7	8
H/B	1	1	½	½	½	3/2	3/2	3/2
L/B	1	2	1	2	4	1	2	4

Table 1
Building shapes (see also Figure 1)

4. Find the proper column, K, of Table 2 ("long walls"), Table 3 ("short walls") or Table 4 (roofs). "Long walls" and "short walls" are defined in Figure 1:

   K = WANG/45. + 1.51

   NOTE! For the walls the correct rows of Table 2 or Table 3 are already found by the input routine CARDIN. The row for the long walls is stored in array FWCPA, the row for the short walls in SWPCA.

5. For roof surfaces with tilt angle, TILT, find the correct row, ISLOPE, of Table 3:

   ISLOPE = TILT/15. + 1.51
   If ISLOPE > 4 then ISLOPE = 4

6. Store the correct pressure coefficient in the array C:

   If the surface, I, is a long wall:

   C(I) = FWPCA(K)

   If the surface is a short wall:

   C(I) = SWPCA(K)

If the surface is a roof:

C(I) = RPCA(ISLOPE, K)

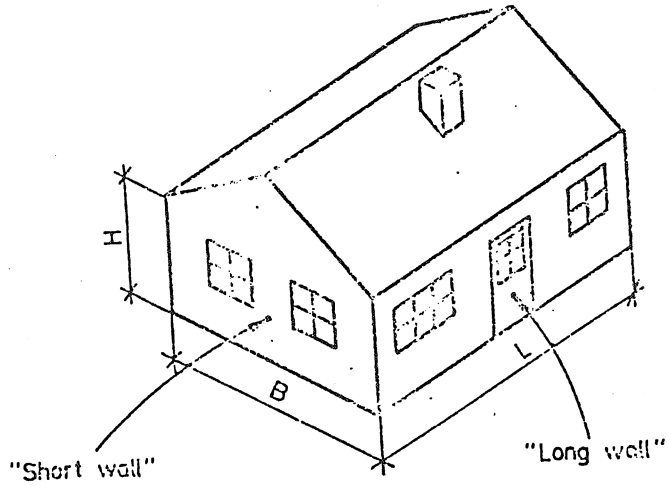


Figure 1
Definition of building shape

Build. shape	Angle of attack				
	0°	45°	90°	135°	180°
1	0.8	0.4	-0.8	-0.6	-0.6
2	0.8	0.4	-0.7	-0.8	-0.6
3	0.7	0.4	-0.7	-0.6	-0.4
4	0.7	0.4	-0.5	-0.7	-0.5
5	0.7	0.4	-0.3	-0.7	-0.6
6	0.7	0.4	-0.8	-0.7	-0.7
7	0.8	0.4	-0.7	-0.8	-0.6
8	0.8	0.5	-0.5	-0.8	-0.7

Table 2
Pressure coefficients for long walls

Build. shape	Angle of attack				
	0°	45°	90°	135°	180°
1	0.7	0.4	-0.8	-0.6	-0.6
2	0.8	0.4	-0.7	-0.6	-0.2
3	0.8	0.4	-0.8	-0.5	-0.4
4	0.7	0.3	-0.9	-0.6	-0.2
5	0.8	0.3	-0.9	-0.5	-0.2
6	0.7	0.4	-0.8	-0.6	-0.7
7	0.7	0.3	-0.7	-0.7	-0.4
8	0.8	0.2	-0.8	-0.7	-0.3

Table 3
Pressure coefficients for short walls

Roof angle	Angle of attack				
	0°	45°	90°	135°	180°
0°	-0,8	-0,8	-0,6	-0,8	-0,8
15°	-0,9	-0,9	-0,6	-0,8	-0,7
30°	-0,8	-0,5	-0,6	-0,8	-0,6
45°	0.	-0,1	-0,7	-0,8	-0,7

Table 4
Pressure coefficients for roofs.

The factors in Tables 1, 2 and 3 are average numbers obtained from Reference 6.

7. The expression for the weight flow of air through a crack is derived in the following which is copied from Reference 11.

The amount of air flowing through a crack in an outside wall depends on the size of the crack and the pressure difference between inside and outside. In most cases the resistance to air flow within the house is negligible. For the purpose of infiltration calculations the house can then be regarded as a box, as shown in Figure 1.

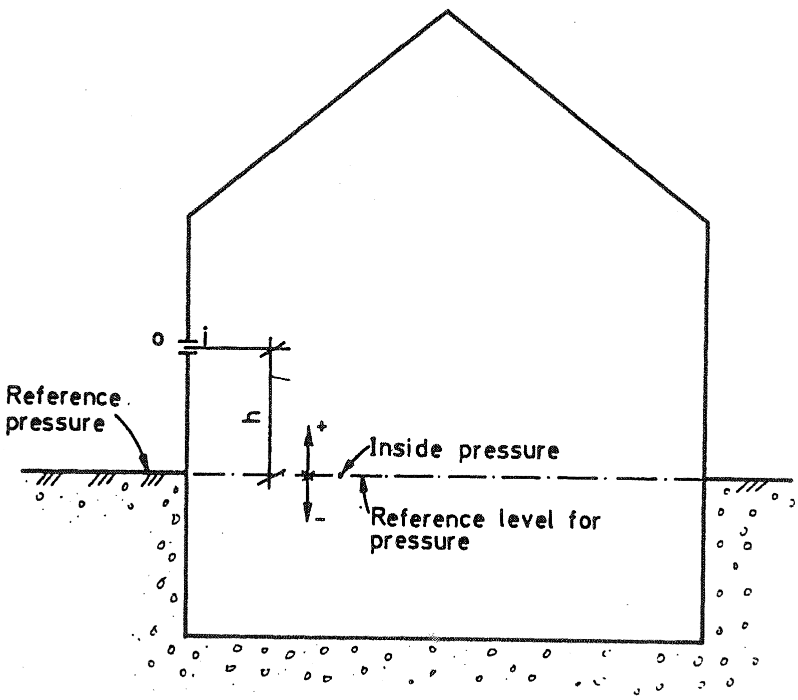


FIGURE 1
Infiltration model

The air flow through the crack between o and i in Figure 1 is given by,

$$Q_{oi} = \left(\frac{P_o - P_i}{R_{oi}} \right)^n \qquad (2)$$

where:

R_{oi} = "resistance" of the crack
P_o = static pressure at o
P_i = " " " i
n = flow exponent (usually n = 0,66)

The resistance, R, can be derived from data given in handbooks. ASHRAE Handbook of Fundamentals[1] for instance, gives air flow per unit lenth of crack, or unit area of wall, for a set of pressure differences. Values for different types of windows, doors and walls are given. To find R, first multiply the handbook value by the length of the crack, or area of the wall, then use Eq. (2) and solve for R (n = 0,66).

The static pressure at point o in Figure 1 is given by:

$$P_o = c\rho_o \frac{v_w^2}{2} - \rho_o gh \qquad (3)$$

where:

c = wind pressure coefficient
ρ_o = density of outdoor air
v_w = wind speed
g = gravitational acceleration
h = distance between reference level and crack

The static pressure at point i is given by:

$$P_i = x - \rho_i gh \qquad (4)$$

where:

x = inside pressure at reference level
ρ_i = density of indoor air

The density of air is given by the gas equation:

$$\rho = \frac{P_{atm}}{R_g T} \qquad (5)$$

where:

P_{atm} = atmospheric pressure
R_g = gas constant for air
T = absolute temperature

Using Eq. (2), (3), (4) and (5) the weight flow from o to i can be expressed as:

$$G_{oi} = \left\{ \frac{P_{atm} g}{R_{oi}^{n} R_g T_{o,i}} \quad \frac{P_{atm}}{R_g} \left[\frac{c}{2} \frac{V_v^2}{T_o} - gh \left(\frac{1}{T_o} - \frac{1}{T_i} \right) \right] - x \right\}^{n} \qquad (6)$$

where:

$T_{o,i}$ = T_o when the air flow is from o to i

$T_{o,i}$ = T_i when the air flow is from i to o

Positive direction of air flow is from outside to inside.

In an actual simulation a crack, such as the one in Figure 1, will represent all the cracks in an external wall of a room. This equivalent crack should be located halfway between floor and ceiling.

8. In the expression for the weight flow through a crack, Eq. (6) above, the inside pressure X is unknown. To find X the Newton Raphson's method is used:

   a. The previous hour's values are used as initial values

   b. For each external wall having cracks calculate the weight flow of air through the cracks using Eq. (6) above. Also calculate the derivative of the weight flow with respect to X

      i.e. $\frac{dGoi}{dx}$

c. Calculate the algebraic sum, SUMG, of all the weight flows. Also calculate the algebraic sum, SUMDG, of all the derivatives.

d. If the house has a hot air system, call the subroutine CHMNEY to get the weight flow of gases up the chimney. This routine also returns the derivative of the weight flow with respect to X. Add the weight flow and the derivative to SUMG and SUMDG respectively.

e. The correction to X is given by:

$$DX = - SUMG/SUMDG$$

f. A new and better value of X is now given by:

$$X = X + DX$$

g. The solution is reached when the absolute value of SUMG has become less than a predetermined small value, (condition of mass balance). If not so, steps b. to f. is done over again until the solution is reached (if the solution is not reached after 20 iterations the program will stop and print a message).

LEEP

A subroutine which determines whether a year is a leap year or not.

INPUT

JAHR Year AD

OUTPUT

LEEP Leap year index = $\begin{cases} 0 & \text{Not leap year} \\ 1 & \text{Leap year} \end{cases}$

CALCULATION SEQUENCE

If (JAHR - 1900) is evenly divisible by 4, then LEEP = 1, otherwise LEEP = 0

MAIN PROGRAM

INPUT

None

OUTPUT

BLANK COMMON (See Appendix A)
COMMON BLOCK H (" " ")

CALCULATION SEQUENCE

1. The nominator z-transfer coefficients for transformation of heat gains by radiation to cooling load are assigned values as given in the following table:

	Light 1) Structure	Medium 2) Structure	Heavy 3) Structure
v_o	0.224	0.197	0.187
v_1	-0.044	-0.067	-0.097

1) Approx. 145 kg of building material per sq. meter of floor area (furniture included)

2) Approx. 345 kg/m^2

3) Approx. 635 kg/m^2

2. The nominator Z-transfer coefficients for transformation of heat gains by conduction to cooling load are assigned values as given in the following table:

	Light Structure	Medium Structure	Heavy Structure
v_o	0.703	0.681	0.676
v_1	-0.523	-0.551	-0.586

3. The nominator Z-transfer coefficients for transformation of heat gains from incadecent lights exposed in the room air to cooling load are assigned values as given in the following table:

	Light Structure	Medium Structure	Heavy Structure
v_0	0.0	0.0	0.0
v_1	0.50	0.50	0.50
v_2	-0.32	-0.37	-0.41

4. The nominator Z-transfer coefficients for deviation of space temperature from an assumed constant value of 20^{o}C are given in the following table (the heating/cooling loads are calculated using 20^{o}C room temperature). The coefficients have the dimension W/(m^{2o}C):

	Light Structure	Medium Structure	Heavy Structure
x_0	9.539	10.277	10.504
x_1	-9.823	-10.731	-11.072
x_2	0.284	0.454	0.568

The x coefficients given in the table are for a room with zero heat conductance to the surrounding spaces and are normalized to unit floor area. To get the x_j coefficients for a room with a total conduktance K between room air and surroundings and infiltration rate Vl_t it is necessary to make the following corrections:

1) Multiply each x_j value by room floor area
2) To x_0 add: $K + cp \cdot Vl_\tau$
3) To x_1 add: $K + cp \cdot Vl_{\tau-1} \cdot b_1$

where: cp = specific heat of air (J/kg)

b_1 = one of the common denominator factors given in the table below

$Vl_\tau, Vl_{\tau-1}$ = infiltration rate (kg/s) for the present and previous hour

5. The common denominator Z-transfer coefficients to be used with all the nominator coefficients above are assigned values as given in the following table:

	Light Structure	Medium Structure	Heavy Structure
b_o	1.0	1.0	1.0
b_1	-0.82	-0.87	-0.93

6. How to use these coefficients is explained in Chapter 22 of the 1972 ASHRAE Handbook of Fundamentals /1/. For example to find the cooling load, Q_τ, at time τ when the heat gain, Q_τ, is given in the form of time series, i.e. the value of the heat gain at equally-spaced points in time (one hour interval), the following calculation is necessary:

$$Q_\tau = V_o q_\tau + v_1 q_{\tau-1} + v_2 q_{\tau-2} + \ldots\ldots\ldots -b_1 Q_{\tau-1}$$

7. The array RPCA is assigned values for wind pressure coefficients for roofs (see Table 4 of the documentation of the INFILT subroutine).

8. The subroutine CARDIN which reads the input card deck is called.

9. The subroutine CALCUL where the hour by hour simulation takes place is called.

NDOW

A subroutine which determines the day of the week.

INPUT

JR	Year AD
MO	Month of the year
JAY	Day of the month

OUTPUT

NDOW Week day indicator =
- 1 if Sunday
- 2 if Monday
- 3 if Tuesday
- 4 if Wednesday
- 5 if Thursday
- 6 if Friday
- 7 if Saturday

CALCULATION SEQUENCE

1. Let JST(1) = 31, JST(2) = 59, JST(3) = 90, JST(4) = 120
   JST(5) = 151, JST(6) = 181, JST(7) = 212, JST(8) = 243
   JST(9) = 273, JST(10) = 304, JST(11) = 334, JST(12) = 365

2. Let N = Integer part of JR/4

   ND = N - 485
   IY = 2, IAAD = 2
   If ND = 0, go to (4)
   If ND is less than 0, ND = -ND and IADD = -2

3. Repeat the following steps ND times

   IY = IY - LADD

   If IY is greater than 7, IY = IY - 7
   If IY is equal to 0, IY = 7
   If IY is less than 0, IY + 7

4. Let MD = JR - N * 4

```
If MD is equal to 0, IWK = IY
                  1, IWK = IY + 2
                  2, IWK = IY + 3
                  3, IWK = IY + 4
```

If IWK is greater than 7, IWK = IWK - 7

5. Repeat the following for j = 1 through 12.

   If MO is equal to j, let JDAY = JST(j) - 31 + JAY - 1

6. If MD is equal to 0 and MO is greater than 2, JDAY = JDAY + 1

7. NTX = Integer part of JDAY/7
   NDX = JDAY - 7 * NTX + IWK

   If NDX is greater than 7, let NDS = NDX - 7

8. Let NDOW = NDX

OUTPT 2

A subroutine which prints detailed hour by hour results from the simulation.

INPUT

WFLOW(50,2)	The weight flows of air through the different walls (cracks) of the house: WFLOW (n,1) when furnace is on WFLOW (n,2) when furnace is off
IHOUR	Hour of the day
IDAY	Day of the month
MONTH	Month of the year
IDWEEK	Day of the week (Sunday = 1, etc.)
JOL	Holiday Indicator { 0 Not Holiday; 1 Holiday
ICNT	Pointer to the location of the present hour value in arrays containing data for the present and the previous six hours (i.e. seven values are stored).
JCNT	Pointer to the location of the present hour value in arrays containing data for the present and the previous hour.
KCNT	Pointer to the location of the present hour value in arrays containing data for the present and the previous three hours.
FLF	Furnace load factor ($0. \leq FLF \leq 1.0$)
WSPEED	Wind speed at the meteorological site, m/s
WDIR	Wind direction, degrees clockwise from north

BLANK COMMON (See Appendix A)

COMMON BLOCK E (See Appendix A)

OUTPUT

Printout of detailed hour by hour results from the simulation as shown in Chapter 4 of the User's Manual.

REDFAC

A subroutine which calculates the sunlit area factor of a window shaded by the window sash, vertical fins and a horizontal overhang (see Fig. 1).

Sunlit area factor means sunlit area enclosed by the window sash divided by the total area enclosed by the sash.

NOTE!
It is assumed that fins and overhang have "infinite" lengths.

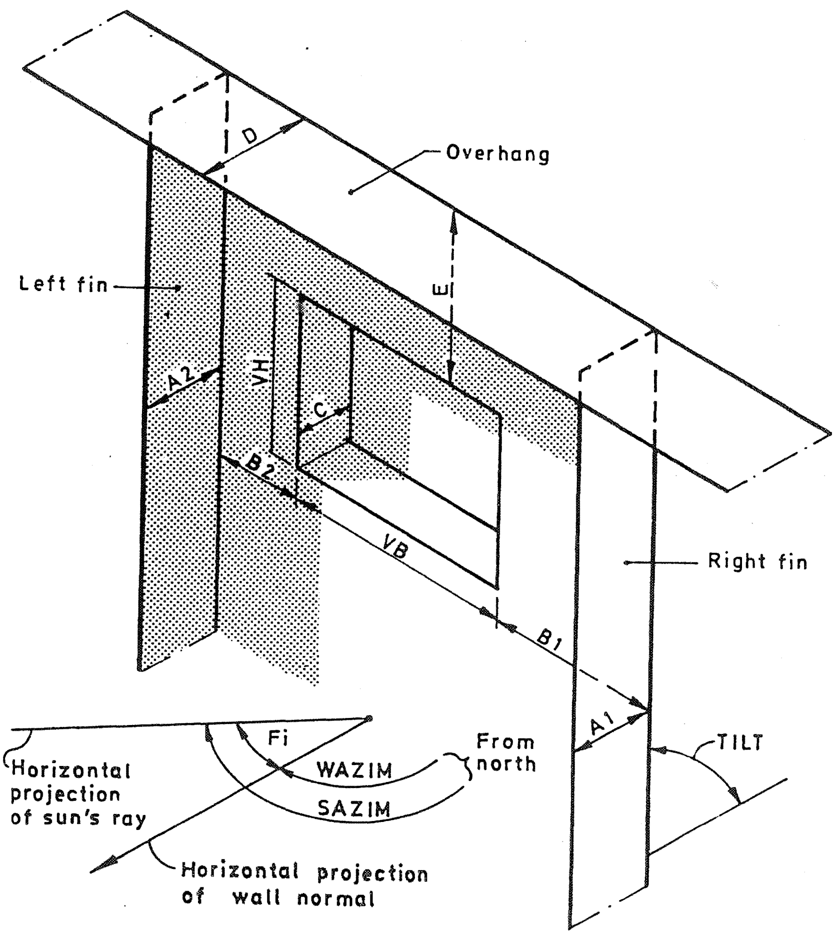


Figure 1
Window with fins and overhang

INPUT

A1	Width of right fin (see Fig. 1)
A2	Width of left fin (see Fig. 1)
B1	Distance between right fin and window sash (see Fig. 1)
B2	Distance between left fin and window sash (see Fig. 1)
C	Depth of window sash (see Fig. 1)

D	Width of overhang (see Fig. 1)
E	Distance between overhang and window sash (see Fig. 1)
VB	With of window sash (see Fig. 1)
VH	Height of window sash (see Fig. 1)
SAZIM	Solar azimuth angle in degrees (clockwise from north)
SALT	Solar altitude angle in degrees
WAZIM	Wall azimuth angle in degrees (clockwise from north)
ETA	Cosine of the solar angle of incidence
TILT	Wall tilt angle in degrees (vertical walls 90 degrees)

OUTPUT

REDFAC	Sunlit area factor. ($0.0. \leq$ REDFAC ≤ 1.0, 0.0 if the window is completely shaded, 1.0 if it is not shaded at all).

CALCULATION SEQUENCE

1. If ETA ≤ 0.0 the sun is not shining on the wall. No calculations are necessary (return from subroutine).

2. Calculate the difference between solar and wall azimuth angle and decide if window is shaded by right or left fin.

$$FI = SAZIM - WAZIM$$

If FI ≤ 0.0 then A = A1 and B = B1 (Fig. 1)

If FI > 0.0 then A = A2 and B = B2 (Fig. 1)

Two special cases may occur

a) If SAZIM ≤ 90 degrees and WAZIM ≥ 270 degrees then

$$FI = 360 + FI$$

$$A = A2$$

$$B = B2$$

b) If SAZIM ≥ 270 degrees and WAZIM ≤ 90 degrees then

$$FI = 360 - FI$$

$$A = A1$$

$$B = B1$$

From this point on the absolute value of FI is used in the calculations.

3. If (TILT + OMEGA) $\geq$ 180 degrees then the window is completely shaded. I.e. REDFAC = 0.0 and no further calculations are necessary.

4. Calculate shading by horizontal overhang (Fig. 2)

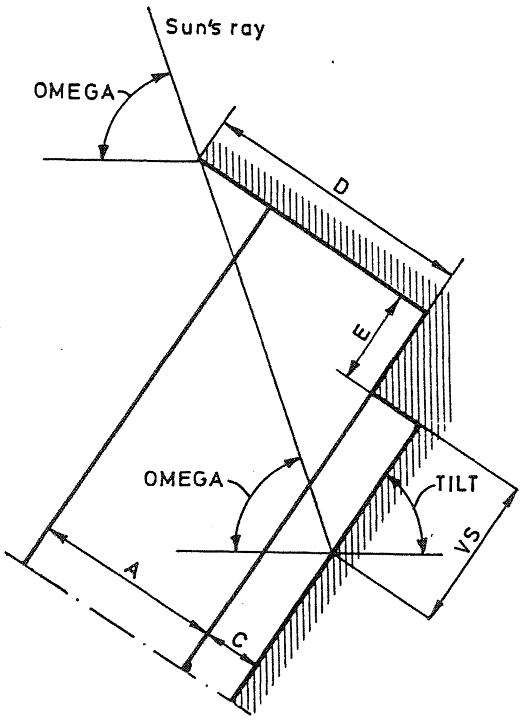


Figure 2
Shading by horizontal overhang

No shadow from overhang if TILT + OMEGA $\leq$ 90.0

In this case the window is shaded by the lower horizontal part of the window sash (Fig. 3).
The width of the shadow is given by
VS = C/TAN(TILT + OMEGA)

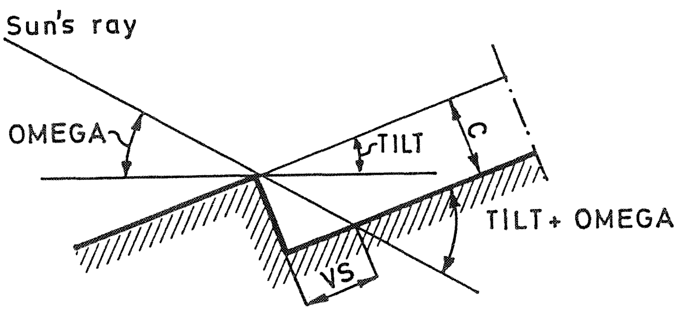


Figure 3
Shading by the lower horizontal part of the window sash

If TILT + OMEGA > 90.0

VS = - (D + C)/TAN(TILT + OMEGA) - E

If VS < - C/TAN(TILT + OMEGA) then the window is shaded by the upper horizontal part of the window sash. VS is then given by

VS = - C/TAN(TILT + OMEGA)

5. Calculate shading by vertical fins. (Fig. 4 a and b)

From Fig. 4 a and b we get

HS = (A+C) * TAN(FI)/(SIN(TILT) + COS(TILT) * TAN(OMEGA))-B

Also calculate

HS1 = C * TAN(FI)/(SIN(TILT) + COS(TILT) * TAN(OMEGA))

IF HS < HS1 then the window is shaded by the vertical part of the window sash and

HS = HS1

IF FI happens to be equal to or very close to 90.0 or 270.0 degrees we get

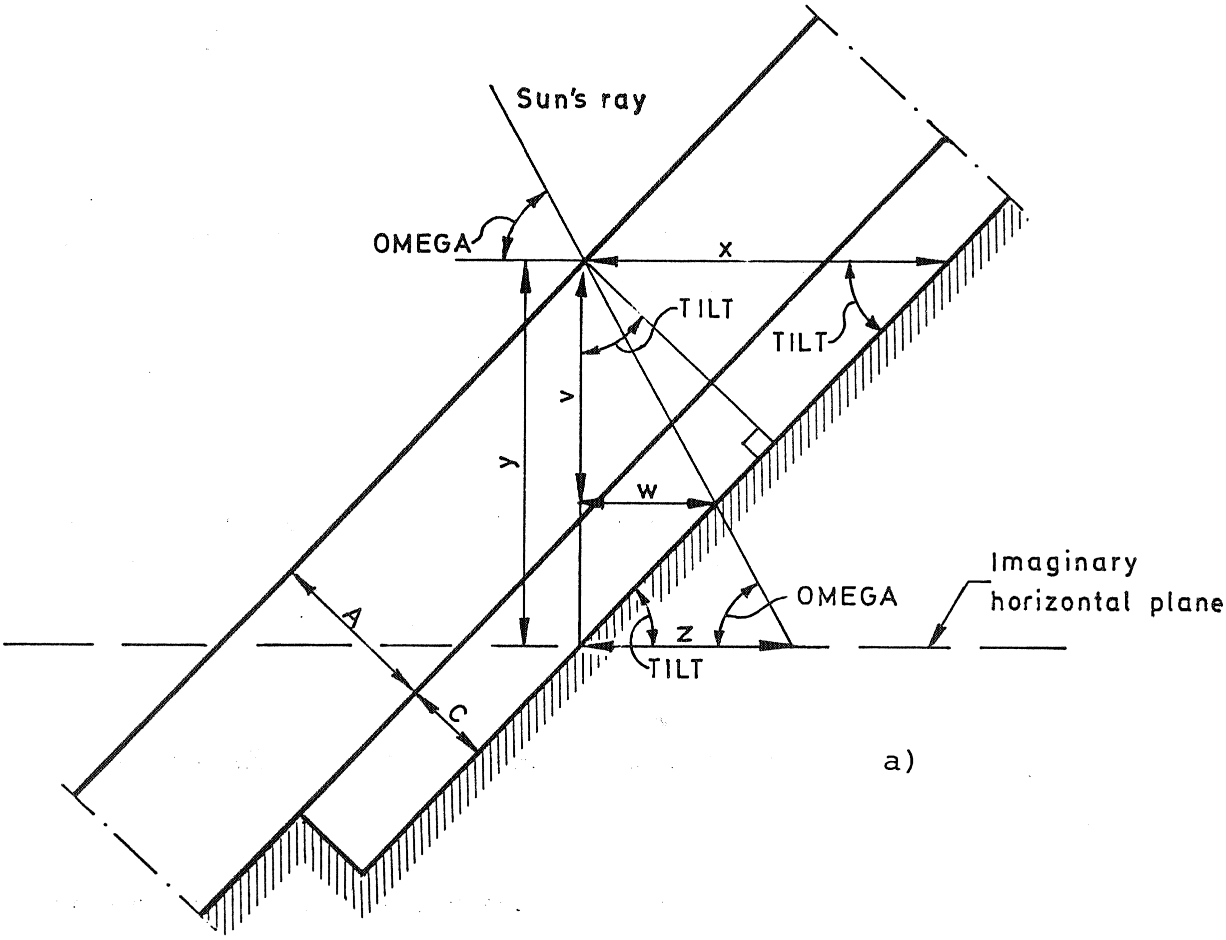
HS = (A+C)/(COS(TILT) * TAN(SALT)) - B

HS1 = C/(COS(TILT) * TAN(SALT))

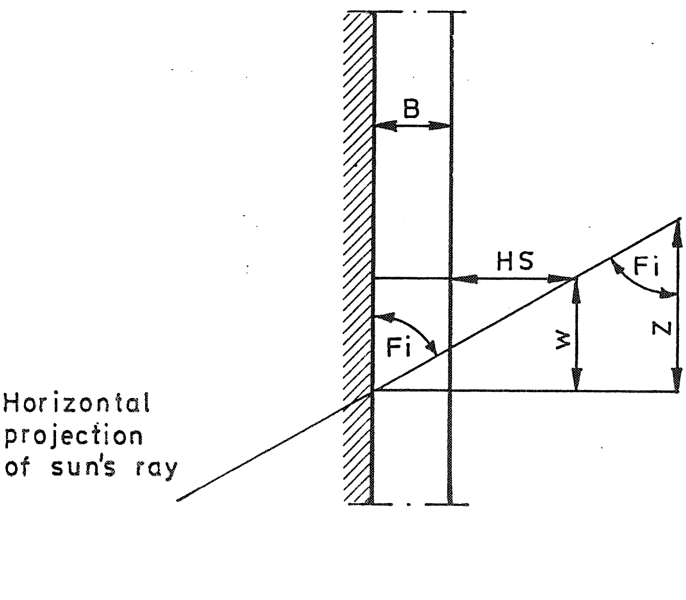
6. Calculate sunlit area factor

REDFAC = (VH - VS) * (VB - HS)/(VH * VB)

If VS ≥ VH or HS ≥ VB then REDFAC = 0.0



a)



b)

Figure 4a) and b)
Shading by vertical fins

SHGB

A subroutine which calculates solar heat gain through single pane windows.

INPUT

RDIR	Intensity of direct solar radiation normal to window, W/m^2
RDIF	Intensity of diffuse solar radiation falling on window, W/m^2
RO, RI	Thermal resistance at outside surface and inside surface, $m^2 {}^oC/W$
SHAW	Sunlit area factor
SC	Shading coefficient if the window is shaded by drapes or blinds
TDIR, TDIF	Transmission factors of direct and diffuse radiation
ADIRO	Absorption factor of direct solar radiation through window pane
ADIFO	Absorption factor of diffuse radiation through window pane
Note:	When the value of SC is given, these Transmission and Absorption factors should be for the standard 1/8" thick double strength glass.
T	Space temperature, ^oC
TDB	Ambient outside air temperature, ^oC

<u>OUTPUT</u>

QRAY Radiant heat gain through glass, W/m^2

QCON Conductive heat gain through glass, W/m^2

<u>CALCULATION SEQUENCE</u>

1. Calculate inward flowing fraction of the radiation absorbed by the window pane

   FO = RO * U

2. Calculate components of solar load

   a) Direct

   QDIR = SHAW * RDIR

   b) Diffuse

   QDIF = RDIF

   c) Transmitted

   QTRANS = QDIF * TDIF + QDIR * TDIR

   d) Absorbed

   QABS = QDIF * ADIFO * FO + QDIR * ADIRO * FO

3. Calculate solar heat gain through glass

   QRAY = SC * (QTRANS + QABS)

4. Calculate heat conduction through glass

   QCON = U * (TDB-T)

SOLTAB

A subroutine which finds the necessary number of different solar radiation values that are needed to calculate energy consumption of a given building.

INPUT

BLANK COMMON

OUTPUT

NORAD Number of different combinations of azimuth and tilt angles. The program will handle max. 20 combinations.

AZTILT(20,2) Azimuth (AZTILT(n,1)) and tilt angles (AZTILT(n,2)) for max. 20 combinations.

CALCULATION SEQUENCE

The routine examines the azimuth and tilt angles of all the external surfaces to find the number of unique combinations of azimuth and tilt angles.

SUN1

A subroutine to calculate the daily solar radiation data.

INPUT

IDOY Day of Year, 1 to 366

TL Tangent of Latitude angle

OUTPUT

SUNRAS Hourly angle (radians) when solar altitude is zero

DEABC(1) Tangent of declination angle, TAN δ

DEABC(2) Equation of time, ET, hours

DEABC(3) Apparent solar constant, A, BTU/hr-sq ft

DEABC(4) Atmospheric extinction coefficient, B

DEABC(5) Sky diffuse factor, C

Table 1 lists, as function of date, five variables related to solar radiation. These variables are declination angle, δ; the equation of time, ET; the apparent solar constant, A; the atmospheric extinction coefficient, B; and sky diffuse factor, C

DATE	δ DEGREES	ET HOURS	A Btu per (hr)(sq ft)	B AIR MASS^{-1}	C
Jan. 21	-20.0	-.190	390	0.142	0.058
Feb. 21	-10.8	-.230	385	0.144	0.060
Mar. 21	0.0	-.123	376	0.156	0.071
Apr. 21	11.6	.020	360	0.180	0.097
May 21	20.0	.060	350	0.196	0.121
June 21	23.45	-.025	345	0.205	0.134
July 21	20.6	-.103	344	0.207	0.136
Aug. 21	12.3	-.051	351	0.201	0.122
Sept. 21	0.0	.113	365	0.177	0.092
Oct. 21	-10.5	.255	378	0.160	0.073
Nov. 21	-19.8	.235	387	0.149	0.063
Dec. 21	-23.45	.033	391	0.142	0.057

Table 1

Values of δ, ET, A, B and C for northern hemisphere

Table 1 could be stored in the computer memory, but this would necessitate an interpolation procedure. In order to avoid such a problem and to save computer core, Tanδ, ET, A, B and C are expressed in Fourier Series form and the values are calculated as a function of the day of the year, d, from the following truncated Fourier series.

$$\left.\begin{array}{l}\text{Tan } \delta \\ \text{ET} \\ \text{A} \\ \text{B} \\ \text{C}\end{array}\right\} = \begin{array}{l} A_0+A_1*\text{Cos}(\omega\ d) + A_2*\text{Cos}(2*\omega*d) + A_3*\text{Cos}(3*\omega*d) \\ \quad +B_1*\text{Sin}(\omega*d) + B_2*\text{Sin}(2*\omega*d) + B_3*\text{Sin}(3*\omega*d)\end{array}$$

where

$$\omega = 2*\pi/366. = 0.01721$$

$$d = \text{IDOY}$$

The proper Fourier coefficients are given in Tabel 2

	A_0	A_1	A_2	A_3	B_1	B_2	B_3
Tanδ	-.00527	-.4001	-.003996	-.00424	.0672	0.0	0.0
ET	0.696×10^{-4}	.00706	-0.0533	-0.00157	-0.122	-0.156	-.00556
A	368.44	24.52	-1.14	-1.09	.58	-0.18	.28
B	.1717	-.0344	.0032	.0024	-.0043	0.0	-.0008
C	.0905	-.0410	.0073	.0015	-.0034	.0004	-.0006

Table 2
Fourier coefficients

CALCULATION SEQUENCE

1. Calculate Tanδ, ET, A, B and C using the following equation where I varies from 1 to 5 and coefficients take on values shown in Table 2

$$\text{DEABC(I)} = A_0 + A_1 * \text{C1} + A_2 * \text{C2} + A_3 * \text{C3} + B_1 * \text{S1} + B_2 * \text{S2} + B_3 * \text{S3}$$

where

$$C1 = \cos(\omega * d)$$

$$SI = \sin(\omega * d)$$

and by trigometric identity

$$C2 = \cos(2 * \omega * d) = C1*C1-S1*S1$$

$$C3 = \cos(3\ \omega * d) = C1*C2-S1*S2$$

$$S2 = \sin(2 * \omega * d) = 2*S1*C1$$

$$S3 \quad \sin(3 * \omega * d) = C1*S2+S1*C2$$

2. Calculate sun rise angle

$$SUNRAS = \cos^{-1}(-TL*DEABC(1))$$ (NOTE! Cos^{-1} is the same as arccos)

which is obtained from general equation

$$\sin(h) = \sin(\delta)*\sin(L)+\cos(\delta)*\cos(L)*\cos(t)$$

(this equation is RAYCOS(3); see subroutine SUN2 for derivation)

where

H = solar altitude, radians
L = latitude, radians
t = hour angle, radians

and where SUNRAS is gotten by setting h=0, and solving for t.

NOTE!
This subroutine calculates the apparent solar constant, A, in BTU/hr-sq ft. In programs using SI-units A should be transformed to W/m^2 immediately after the call of the routine.
Actually, in the ENCORE program neither A nor B as calculated by this routine is used. Immediately after the call of the routine they are replaced by values given by Lunelund (Reference) whose values are derived from measurements made in Scandinavia

SUN2B

A subroutine to calculate the hourly solar radiation data.

INPUT

H	Hour angle,radians (calculated in main program)	
DEABC(1)	Tangent of declination angle	Calculated in SUN1
DEABC(2)	Equation of time, hours	
DEABC(3)	Apparent solar constant, W/m^2	
DEABC(4)	Atmospheric extinction coefficient	
DEABC(5)	Sky diffuse factor	
SL	Sin of latitude angle	
CL	Cosine of latitude angle	
CN	Clearness number	

OUTPUT

RAYCOS(1)	Direction cosine of sun in x-cirection (EAST)
RAYCOS(2)	Direction cosine of sun in y-direction (NORTH)
RAYCOS(3)	Direction cosine of sun in z-direction (UPWARD)
RDN	Intensity of direct normal solar radiation, W/m^2
BS	Brightness of sky, W/m^2

CALCULATION SEQUENCE

1. Calculate direction cosines of sun

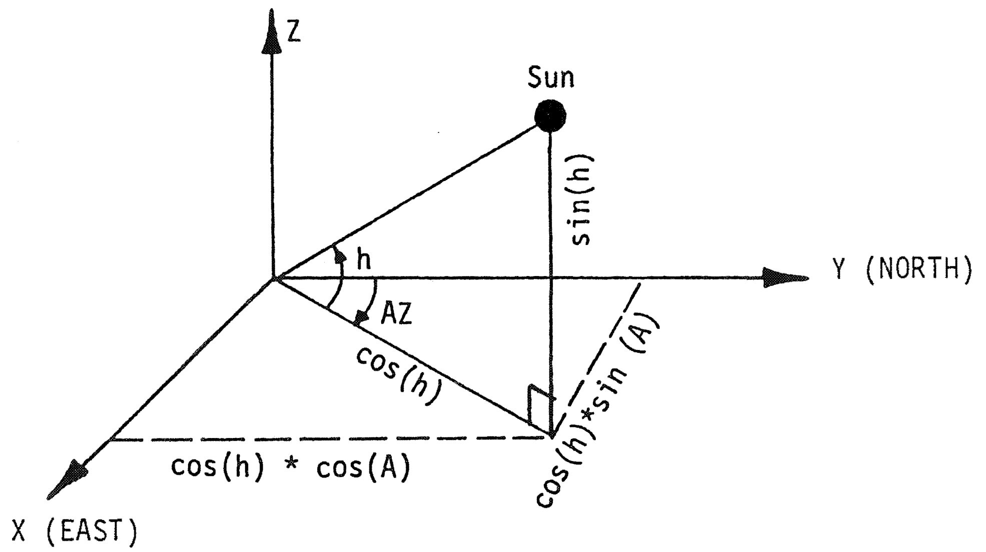


Figure 1
Coordinate system used in the calculations

From the schematic presented above, the direction cosines are as follows:

RAYCOS(1) = cos(e) = cos(h)* sin(AZ)
RAYCOS(2) = cos(n) = cos(h)* cos(AZ)
RAYCOS(3) = SIN(h)

where h = altitude of sun measured from horizontal, degrees

AZ = azimuth of sun measured from north towards east, degrees

From spherical trigonometry , the following relationships hold

$$\sin(h) = \sin(\delta)*\sin(L)+\cos(\delta)*\cos(L)*\cos(t)$$
$$\cos(AZ) =(\sin(\delta)*\cos(L)-\cos(\delta)*\sin(L)*\cos(t))/\cos(h)$$
$$\sin(AZ) = -(\cos(\delta)*\sin(t))/\cos(h)$$

where δ = declination of sun, degrees
L = station latitude, degrees
t = hour angle of sun measured from south towards west, degrees

Substitution gives

RAYCOS(1) = -cos(δ)*sin(t)

RAYCOS(2) = sin(δ)*cos(L)-cos(δ)*sin(L)*cos(t)

RAYCOS(3) = sin(δ)*sin(L)+cos(δ)*cos(L)*cos(t)

2. Calculate intensity of direct normal solar radiation

a) If RAYCOS(3) is $\leq$ 0.001, sun has not risen yet, and therefore set

RAYCOS(3) = 0.0
RDN = 0.0
BS = 0.0

b) If RAYCOS(3) is greater than 0.001, sun is up, and therefore

RDN = DEABC(3)*CN*EXP(-DEABC(4)/RAYCOS(3))
BS = DEABC(5)*RDN/(CN*CN)

Value of clearness number, CN, for US can be gotten from Figure 2

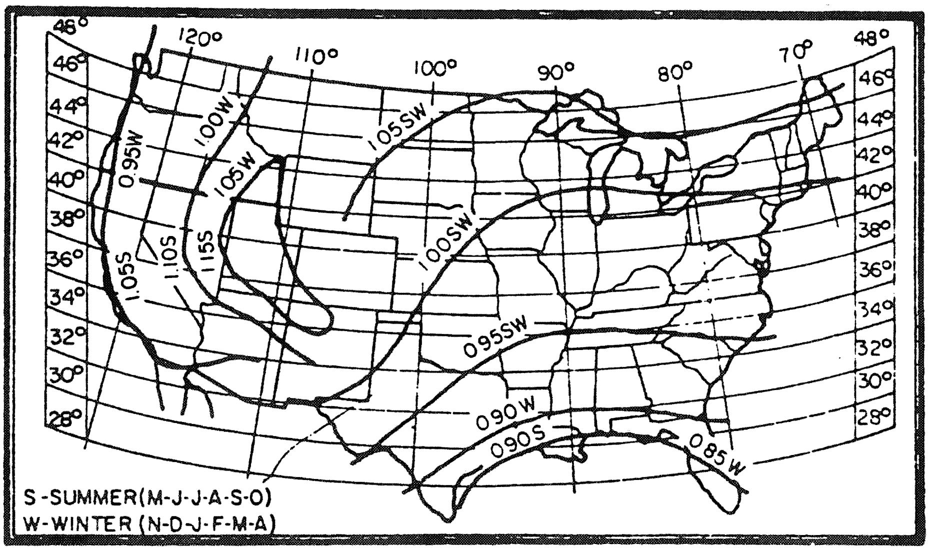


Fig. 2 Clearness numbers of non-industrial atmosphere in United States
Clearness numbers for Europe is not available, but Figure 2 gives a good indication on possible values

SUN3B

A subroutine which calculates solar data depending upon orientation of a surface. Values for cloudy days are calculated according to D. G. Stephenson and K. Kimura (Reference 12).

INPUT

WT	Surface tilt angle from horizontal, radians
WA	Surface azimuth angle, radians, clockwise from north
RAYCOS	Direction cosines of sun's ray
RDN	Intensity of direct normal solar radiation, W/m^2 (already corrected for cloud cover)
BS	Brightness of sky (diffuse sky radiation on horizontal surface), W/m^2
ROG	Ground reflectivity
CC	Cloud cover
CCF	Cloud cover factor

OUTPUT

GAMMA	Cosine of angle between zenith and outward normal of surface
ETA	Cosine of the solar angle of incidence, η
RDIR	Intensity of direct solar radiation on surface, W/m^2
RDIF	Intensity of diffuse radiation on surface, W/m^2
RTOT	Intensity of total radiation on surface, W/m^2
BG	Brightness of ground, W/m^2

For a pictorial illustration of the various angles referred to in SUN3, see Figures 1 and 2.

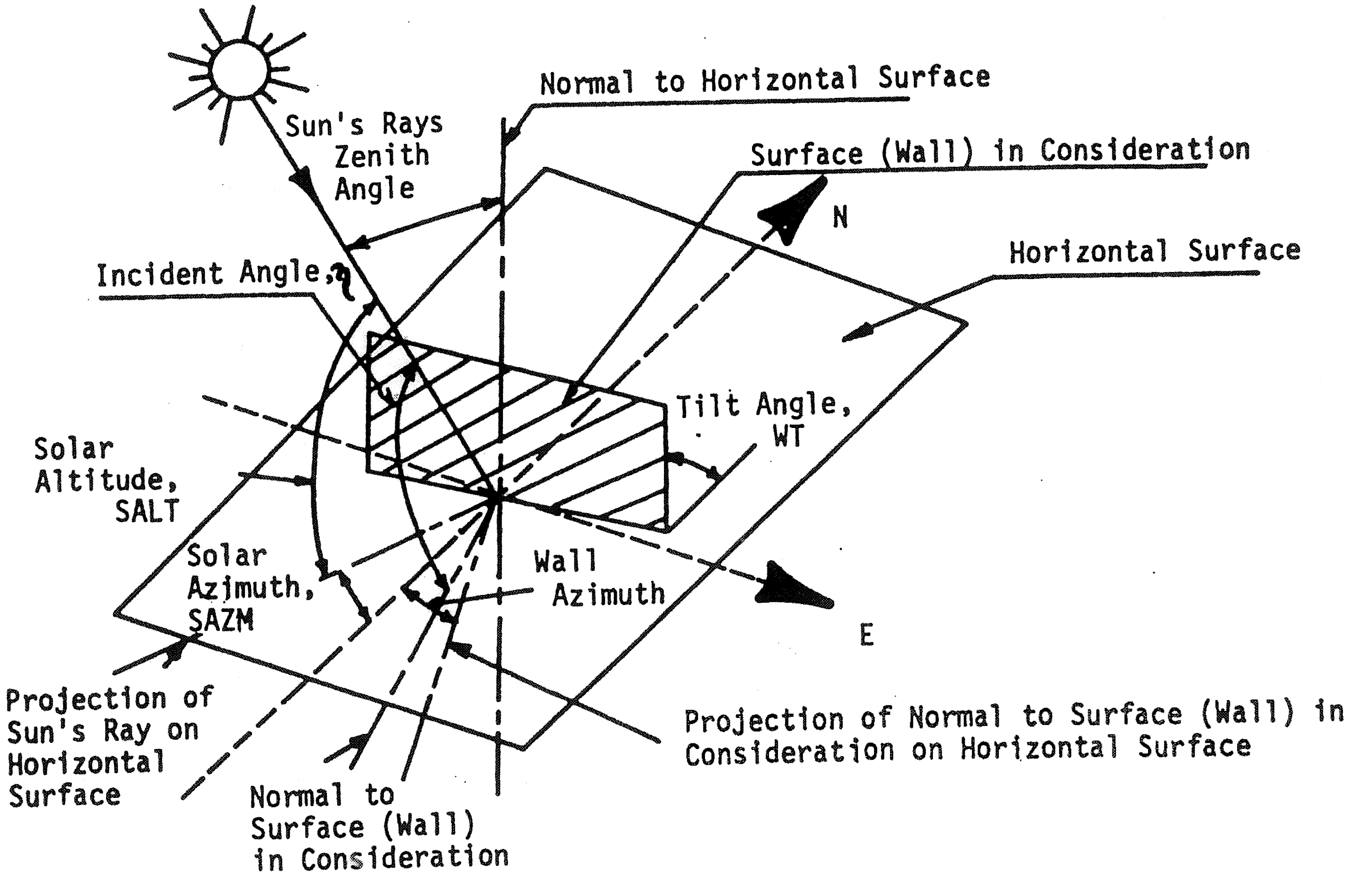


Figure 1

Definition of angles

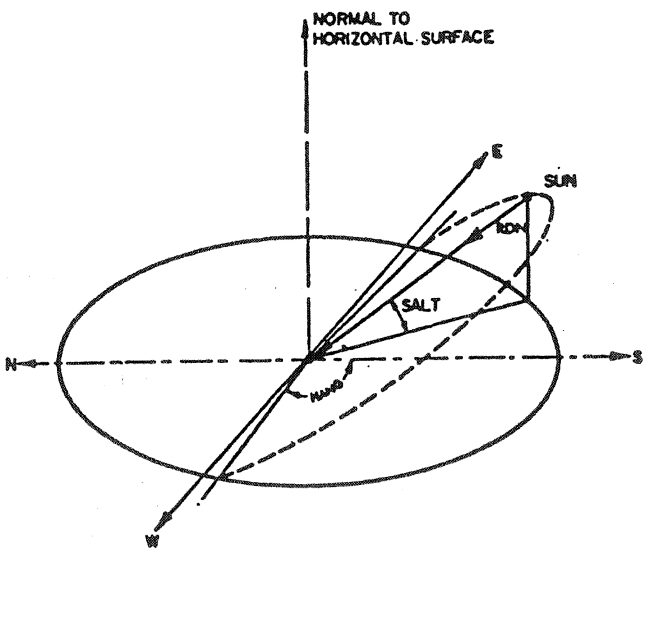


Figure 2

Schematic showing apparent path of
sun and hour angle

CALCULATION SEQUENCE

1. Calculate brightness of ground under a cloudless sky

   BG = ROG*(BS+RDN*RAYCOS(3))

2. Calculate the factors YY and RK

   Let X = RAYCOS(3)
   YY = 0.309-0.137*X 0.394*X*X
   RK = X/(DEABC(5)+X)+(CN-1.)/(1.-YY)

3. Calculate the intensity of direct, diffuse and total radiation on a horizontal surface under a cloudless sky

   Direct: RDIRH = RDN*RAYCOS(3)
   Diffuse: RDIFH = BS
   Total: RTOTH = RDIRH+RDIFH

4. Calculate the intensity of direct radiation on a horizontal surface under a cloudy sky

   RDIRHC = RTOTH*RK*(1.-CC/10.)

5. Calculate the direction cosines (α, β and γ) of the normal to the surface. By definition

$$\alpha = \cos(WT) = CWT$$
$$\beta = \sin(WA)\ \sin(WT) = SWA\ SWT$$
$$\gamma = \cos(WA)\ \sin(WT) = CWA\ SWT$$

Since most building surfaces have tilt angles that are generally either 0^{o} (roofs) or 90^{o} (walls) and azimuth angles that generally coincide with the four cardinal directions of the compass (0^{o}, 90^{o}, 180^{o} and 270^{o}) much computer computation time can be saved by checking for these conditions and setting the values of the sin(WT), cos(WT), sin(WA) and cos(WA) directly instead of letting the computer software evaluate the sine and cosine.

Therefore, the following preliminary checks have been made part of SUN3B.

a) If WT = 0.0 RAD (0^{o}), surface is horizontal facing upward

CWT = cos (0) = 1.0

SWT = sin (0) = 0.0

b) If WT = 1.5708 RAD (90^{o}), surface is vertical

CWT = cos (90) = 1.0

SWT = sin (90) = 0.0

c) For all other tilt angles

CWR = cos (WT)

SWT = sin (WT)

d) If WA = 0.0 RAD (0^{o})

CWT = cos (0) = 1.0

SWT = sin (0) = 0.0

e) If WA = 1.5708 RAD (90^{o})

CWT = cos (90) = 0.0

SWT = sin (90) = 1.0

f) If WA = 3.1416 RAD (180^{o})

CWT = cos (180) = -1.0

SWT = sin (180) = 0.0

g) If WA = 4.7114 RAD (270^{o})

CWT = cos (270) = 0.0

SWT = sin (270) = -1.0

h) For all other azimuth angles

CWT = cos (WA)

SWT = sin (WA)

6. Calculate ETA, the cosine of the incident radiation on the surface

$$ETA = \cos(\eta) = \alpha * RAYCOS(3) + \beta * RAYCOS(1) + \gamma * RAYCOS(2)$$

7. Calculate the intensity of the direct normal solar radiation for cloudy and cloudless sky

a) If ETA $\leq$ 0.0, sun is not up yet

RDIR = 0.0
RDIRC = 0.

b) If ETA>0.0, sun is up

RDIR = RDN*ETA
RDIRC = RDIR*RDIRHC/RDIRH

8. Calculate the intensity of diffuse radiation for a cloudless sky

a) If WT $\leq$ 0.7854 RAD (45°) surface is oriented toward sky

RDIF = BS

b) If WT > 2.35619 RAD (135°), surface is oriented toward ground

RDIF = BG

c) If WT between 45° and 135°, diffuse radiation is estimated using curve shown in Figure 3 .

If ETA < -0.2,
y = 0.45

If ETA $\geq$ -0.2,
y = 0.55 + 0.437*ETA + 0.313*ETA**2

Then RDIF = y*BS + 0.5*BG

9. Calculate total radiation incident upon surface under a cloudless sky

RTOT = RDIR + RDIF

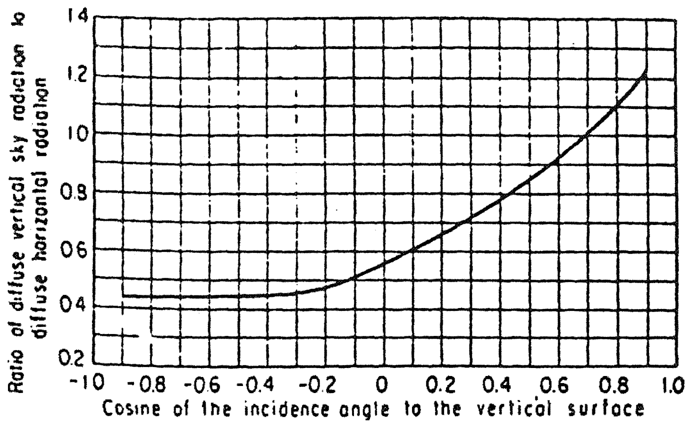


Figure 3 Ratio of diffuse sky radiation incident upon a vertical surface to that incident upon a horizontal surface during clear days

10. Calculate the intensity of diffuse radiation on a horizontal surface under a cloudy sky

RDIFHC = RTOTH*(CCF-RK*(1.-CC/10.))

11. Calculate the intensity of diffuse and total radiation for a cloudy sky

Diffuse: RDIFC = RDIF*RDIFHC/RDIFH
Total: RTOTC = RDIRC+RDIFC

12. If CC>0.5 then

RDIF = RDIFC
RDIR = RDIRC
RTOT = RTOTC

3. REFERENCES

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APPENDIX A

Variables in common blocks

A.1 Variables in blank common

IWALL(50,5) — Contains data for maximum 50 walls. For each wall, K, the following data are stored:

(K,1) = the room on one side of the wall

IWALL(K,2) = the room on the other side of the wall

IWALL(K,3) = wall type (construction type)

IWALL(K,4) = no. of windows in the wall

IWALL(K,5) = no. of doors in the wall

WALL(50,5) — Contains data for maximum 50 walls. For each wall, K, the following data are stored:

WALL(K,1) = wall orientation i.e. the clockwise angle between north and the wall normal

WALL(K,2) = wall tilt angle

WALL(K,3) = wall net area (areas of windows and doors not included)

WALL(K,4) = flow resistance for the cracks in the wall

WALL(K,5) = flow exponent for the cracks in the wall

WINDOW(20) — Contains the areas of maximum 20 windows

IWINDO(20) — Contains the type of maximum 20 windows

)W(20,3) — Contains data on windows. For each wall having windows the following data are stored:

NOW(K,1) = wall no.

NOW(K,2) = first window in this wall

NOW(K,3) = last window in this wall

If there is only one window in a wall NOW(K,2) = NOW(K,3).

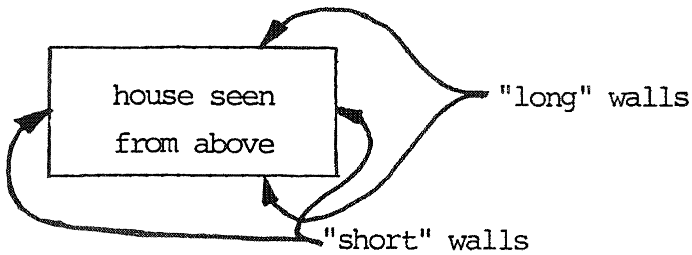
Number of windows in a wall is given by:

n = NOW(K,3) - NOW(K,2) + 1

The windows in each wall will always be in consecutive order, i.e. if a wall has three windows they will have the numbers: j, j + 1, j + 2.

NOD(20,3)	Same as NOW except that NOD contains data on doors
IWIR(20,15)	The walls each room (max. 20) are made up of. Each room can have maximum 15 walls. If room no. K has 6 walls, then: IWIR(K,1), IWIR(K,2), ..., IWIR(K,6) will be non-zero.
ISR(20,15)	The rooms on the "other side" of the walls in IWIR, i.e. the rooms that surround each room.
DOOR(20)	Contains the areas of maximum 20 doors.
IDOOR(20)	Contains the type of maximum 20 doors.
NOWIR(20)	No. of walls in each room.
WDATA(5,3)	Data for maximum 5 window types. For each window type, K, the following data are stored: WDATA(K,1) = window U-value, no shutters WDATA(K,2) = window U-value, with shutters WDATA(K,3) = window shading coefficient
DDATA(5)	U-values for maximum 5 door types
DZWALL(10,7)	"d-coefficients" of the z-transfer functions for maximum 10 wall types (for definition of "d-coefficients", see Chpt. 22 in ASHRAE Handbook of Fundamentals). Each wall type may have up to 7 "d-coefficients".
BZWALL(10,7)	"b-coefficients" of the z-transfer functions for maximum 10 wall types.
CZWALL(10)	Sum of the "c-coefficients" of the z-transfer functions for maximum 10 wall types.
UWALL(10)	U-value for maximum 10 wall types
WSABS(10)	Solar absorbtivity for maximum 10 wall types
DSABS(5)	Solar absorbtivity for maximum 5 door types

ISCD(5)	Shading type code for maximum 5 window types: ISCD = 1 inside shading devices ISCD = 0 outside shading -"-
FCA(20)	Reduction factors for room "v-coefficients" (max. 20 rooms) when windows do not have shutters (see Chpt. 22 in ASHRAE Handbook of Fundamentals).
FCB(20)	Similar to FCA, but windows have shutters.
FCA1(20)	Total conductivity to the surroundings for each room (max. 20), when windows do not have shutters.
FCB1(20)	Similar to FCA1, but windows have shutters.
FWPCA(5)	Wind pressure coefficients for the "long walls" of the house for 5 different angles of attack: 0°, 45°, 90°, 135°, 180°
SWPCA(5)	Similar to FWPCA, except that these are coefficients for the"short walls" of the house.



RPCA(4,5)	Wind pressure coefficients for 4 different roof angles (0°, 15°, 30°, 45°) and 5 different angles of attack (0°, 45°, 90°, 135°, 180°). If roof angle is more than 45°, the values for walls are used. In calculations using FWPCA, SWPCA, RPCA interpolation is used. I.e. for angles of attack between 22.5° and 67.5° the values for 45° is used,for roof angles between 7.5° and 22.5° the value for 15° is used and so on.

ICTP(20)	Data for max. 20 outside pressure points: Long walls : ICTP(i) = 1 Short walls: ICTP(i) = 2 Roofs : ICTP(i) = 3
RNAME(40)	Name of computer run (the two first cards in the input card deck).
IPERS(15,24)	Maximum 15 schedules for heat gain from people. The array contains values that are per cents (integers) of values given in PERS. With schedule no. 2 the heat gain from people at 12 hr is given by: $Q = PERS(2) * IPERS(2,12)/100.$
PERS(15)	See description of IPERS above.
ICLSCH(20,24)	Maximum 20 schedules for heat gain from "constant" lights. "Constant" means that the lighting level depends only on the schedule, i.e. time of the day. ICLSCH contains values that are per cents of values given in RCL.
RCL(20)	See description of ICLSCH above.
IVLSCH(20,24)	Maximum 20 schedules for heat gain from "variable" lights. "Variable" means that the lights are on if: a) The room is occupied and b) Solar heat gain through windows is less than RLCRIT w/m^2 floor area. RLCRIT is given a value in the CARDIN routine. IVLSCH contains values that are per cents of values given in RVL.
RVL(20)	See description IVLSCH above.
IEQUIP(8,24)	Maximum 8 schedules for heat gain from electrical equipment.

The array contains values that are per cents of values given in EQUIP.

EQUIP(8) — See description of IEQUIP above.

IWATER(7,24) — Maximum 7 schedules for hot water consumption.

The array contains values that are per cents of values given in WATER.

WATER(7) — See description of IWATER above.

ITHERM(8,24) — Maximum 8 schedules for thermostat setpoints. The array contains deg C stored as integers.

IWCODE(20,5) — For maximum 20 rooms the array contains information on which schedules to use for working days. For room no. K these schedules are used:

```
IWCODE(K,1)  =  occupancy schedule
IWCODE(K,2)  =  const.light   "
IWCODE(K,3)  =  var.    "     "
IWCODE(K,4)  =  equipment     "
IWCODE(K,5)  =  thermostat setpoint schedule
```

IHCODE(20,5) — Similar to IWCODE, except that it contains schedules for holidays. Sundays and Saturdays are also considered as holidays.

IRCODE(20) — Weight codes for maximum 20 rooms:

```
IRCODE(K)  =  1 : light weight constr.
IRCODE(K)  =  2 : medium   "     "
IRCODE(K)  =  3 : heavy    "     "
```

The definition of light, medium and heavy is the same as in Chpt. 22 in ASHRAE Handbook of Fundamentals.

FLAREA(20) — Floor areas for max. 20 rooms.

PERIM(20)	Perimeter length for maximum 20 rooms.
RLEVEL(20)	Room level relative to the "pressure reference level" (usually the ground) for maximum 20 rooms. If the ground is used as reference level, then RLEVEL contains distances between ground and a point halfway between floor and ceiling in the room. Positive direction is upwards by definition.
ISDAY1 ISDAY2 IHOUR1 IHOUR2	Shutter data: Shutters are on if day of the year (IDOY) and hour of the day (IHOUR) are as follows: IDOY $\leq$ ISDAY or IDOY $\geq$ ISDAY2 and IHOUR $\geq$ IHOUR1 or IHOUR $\leq$ IHOUR2.
RLCRIT	See description of IVLSCH above.
WCOEF	Coefficient that relates the wind speed measured 10 m above ground at meteorological site and the wind speed at the building site at the level of the edge of the roof. To get the wind speed at the building site multiply wind speed at meteorological site by WCOEF.
JAHR	Year of weatherdata used in the calculations
RLAT	Building lattitude
RLONG	Building longitude
ITZN	Building time zone
CN1	Clearness number, summer
CN2	Clearness number, winter

VZRM1(3,2)	Z-transfer coefficients for transforming heat gains by radiation to cooling load. ("v-factors" in Chpt. 22 of ASHRAE Handbook of Fundamentals). VZRM1(1,i) = light weight constr. VZRM1(2,i) = medium " " VZRM1(3,i) = heavy " "
VZRM2(3,2)	Z-transfer coefficients for transforming conductive heat gains to cooling load. Similar to VZRM1.
VZRM3(3,2)	Z-transfer coefficients for transforming heat gain from incandescent lights, exposed in the room air to cooling load. Similar to VZRM1. Values for VZRM1, VZRM2, and VZRM3 are given in: ASHRAE Procedures for Determining Heating and Cooling Loads for Computerized Energy Calculations.
WZRM(3)	Denominator coefficients to be used with the nominator coefficients VZRM1, VZRM2 or VZRM3. WZRM(1) = light weight constr. WZRM(2) = medium " " WZRM(3) = heavy " "
GZAIR(3,3)	Z-transfer coefficients for the "room air transfer function". GZAIR(1,i) = light weight constr. GZAIR(2,i) = medium " " GZAIR(3,i) = heavy " " GZAIR are nominator coefficients. WZRM are the corresponding denominator coefficients.
NROOM	No. of rooms in the building.
NWALL	No. of walls " "
NOCCUP	No. of occupancy schedules

LIGHT1	No. of constant light schedules
LIGHT2	No. of variable " "
NEQUIP	No. of equipment schedules
NTHERM	No. of thermostat setpoint schedules
NWATER	No. of hot water consumption schedules
IWALLT	No. of wall types
IWINDT	No. of window types
IDOORT	No. of door types
NOPT	No. of outside pressure points
ISHAPE	Building shape ($1 \leq$ ISHAPE ≤ 8)
ISTART	The day of the year when the heating season starts in the fall
IEND	The day of the year when the heating season ends in the spring
ISYSTM	Heating system type ISYSTM = 1 hot air oil fired system ISYSTM = 2 electr. resistance heaters in each room
ERMAX(20)	Maximum capacity (heat output) of the room heaters (max. 20 rooms)
TRANGE(20)	Proportional bands of the room thermostats (max. 20 rooms)
QSMAX	Heat storage of hot water heater
QINMAX	Maximum capacity of hot water heater element

IDHTW(7) Which hot water consumption schedule to use for each day of the week

IDHTW(1) = the schedule for Sundays and holidays

IDHTW(2) = the schedule for Monday

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etc.

A.2 Variables in common block E

GWALL(50,7,2)	Heat gains through walls (max.50) for the present and the previous 6 hours. The necessity of the third dimension of the array is due to the fact that internal walls separate two rooms (A and B, say). When calculating the room gains and room loads the temperature of the room in question is assumed to be 20^{o}C whereas the surrounding rooms have their actual temperatures. Thus the heat gain from room A to room B will usually not be the same as the heat gain from room B to room A. GWALL(i,j,1) will be the gain to the room with the lowest room number. GWALL (i,j,2) will be the gain to the room with the highest room number.
RLWALL(50,2,2)	The heating loads due to the corresponding gains stored in GWALL. Loads for the present and the previous hour are stored (second dimension of the array).
RLWIND(20,2)	Loads due to windows (max.20) for the present and the previous hour.
GWINDC(20,2)	Gains due to conduction through windows (max. 20) for the present and the previous hour.
RLDOOR(20,2,2)	Loads due to doors (max.20) for the present and the previous hour. For explanation of the third dimension of the array see GWALL.
GDOOR(20,2)	Gains due to doors (max. 20) for the present and the previous hour.
RTEMP(20,7)	Room temperatures (max. 20 rooms) for the present and the previous 6 hours.
RLROOM(20,3)	Total room loads (max. 20 rooms) for the present and the previous 2 hours.

DEABC(5)	Constants for solar radiation calculations (see documentation of subroutine SUN1).
RAYCOS(3)	Present hour direction cosines of the direct solar beam.
AZTILT(20,2)	Azimuth and tilt angles for max. 20 surfaces: AZTILT(K,1) = azimuth angle AZTILT(K,2) = tilt angle
RIN(120)	Hourly weather data for one day. I.e. 24 values of dry bulb temperature, cloud cover, cloud type, wind speed, and wind direction (the values for hour 01 come first, the the values for hour 02, and so on).
DBT(7)	Outside dry bulb temp. for the present and the previous 6 hours.
RADDIR(20,7)	Direct solar radiation falling on max. 20 surfaces having different orientations. Values for the present and the previous 6 hours are stored.
RADDIF(20,7)	Similar to RADDIR, but diffuse radiation.
CLC(7)	Cloud cover factors for the present and the previous 6 hours.
FC(20)	When windows have shutters on, FC is equal to FCB, otherwise FC is equal to FCA (FCA and FCB are stored in blank common).
AOIN(20)	Present hour values of the cosines of the angles of incidence between the direct solar beam and the surfaces stored in AZTILT.
GWINDS(20,2)	Solar heat gain through windows (max.20) for the present and the previous hour.

RLOCC(20,2)	Room loads (max. 20 rooms) due to occupancy for the present and the previous hour.
RLIGHT(20,2)	Similar to RLOCC, but loads due to lights.
RLEQP(20,2)	Similar to RLOCC, but loads due to electrical equipment.
VL(20,3)	VL is equal to 1.0 if variable lights are on (otherwise VL is zero). Data for the present and the previous 2 hours are stored: VL(2,1) = 1.0 means that variable lights in room no. 2 are on for the present hour.
ER(20,2)	Heat output of room heaters (max. 20 rooms) for the present and the previous hour.
RT1(20)	When calculating room heat gains and loads the temperatures of the surrounding rooms are needed. However, when starting the calculation for a given hour these are not known yet. As a first approximation the previous hour's temperatures are used (they are stored in RT1). When new room temperatures are found, they are compared with the temperatures stored in RT1. If the largest difference is more than a certain limit, the newly calculated temperature are stored into RT1 and a new calculation is made. This goes on until the largest difference becomes less than the limit.
QINF(20,2)	Infiltration loads for each room (max.20) for the present and the previous hour.
HOTW	Hot water demand for the present hour.
QHWT	Electrical power input to the hot water heater for the present hour.
QS	Amount of heat stored in the hot water heater at the end of the present hour.

A.3 Variables in common block G

FLF	Furnace load factor FLF = on-time/total time
CYCLES	No. of cycles/hr
TON	On-time per cycle (sec.)
TOFF	Off-time per cycle (sec.)
ONTMP	Average flue gas temperature during on-cycle
OFFTMP	Average "flue gas" temperature during off-cycle
GFON	Weight flow of flue gases during on-cycle
GFOFF	Weight flow of "flue gases" during off-cycle
ONLSS	Loss per on-cycle
OFFLSS	Loss per off-cycle
ZETAF	Static pressure loss coefficient of the furnace
HHV	Higher heating value of fuel oil
PON	Building pressure (relative to outside air pressure) during furnace on-cycle
POFF	Building pressure during furnace off-cycle

A.4 Variables in common block H

RN50	No. of burner cycles at 50% furnace load (FLF = 0.5 see description of common block G)
SSTON	Steady state on-cycle flue gas temperature
SSTOFF	Steady state off-cycle "flue gas" temperature
ONTC	Time constant for increase of flue gas temperature during on-cycle
OFFTC1	Time constant for decrease of flue gas temperature during off-cycle when air circulation fan is on
OFFTC2	Similar to OFFTC1, but air circulation fan is off
SPDIA	Smoke pipe diameter
CHSL	Inside side length of chimney
DRAFT	Draft setting at barometric damper
DFACT	Weight flow of air through the furnace at off-cycle divided by the weight flow of flue gases at on-cycle
GPH	Burner nozzle capacity (U.S.Gallons per hour)
SPLGTH	Length of smoke pipe
BENDS	No. of smoke pipe bends
CHLGTH	Chimney length (for use in pressure loss calculations)
TOP	Distance between pressure reference level and top of chimney
BOTTOM	Distance between pressure reference level and center of furnace

FANTMP	Flue gas temperature when air circulation fan shuts off
CBAIR	Air supplied for combustion divided by the theoretically necessary supply

A.5 Variables in common block DUMP

IDOUT	The day of the year when the user wants detailed hour by hour printout.

A.6 Variables in common block PLOT

IPLOT	IPLOT = 1 if the user wants to store data in file 7 for later plotting. For each hour of the heating season the following data are written to the file:

day of the month
month
hour of the day
outdoor dry bulb temperature
wind speed
cloud cover
heat output in room no. 1
room temperature in room no. 1

heat output in room no. K
room temperature in room no. K

A.7 Variables in common block CLIMA

ISYNOP	Synoptic station number of the meteorological station that has supplied the input weather tape.

A.8 Variables in common block SHADE

HORIZ(18)	The height of the horizon (degrees) in the directions 20^{o}, 40^{o}, 60^{o}, ..., 360^{o} degrees clockwise from north.
FIAOV(20,9)	Measures that describe the window sash, vertical fins, and horizontal overhang for each window (max. 20). For window no. K the following data are stored:

FIAOV(K,1) = width of right vertical fin

FIAOV(K,2) = distance between right fin and sash

FIAOV(K,3) = width of left vertical fin

FIAOV(K,4) = distance between left fin and sash

FIAOV(K,5) = width of horizontal overhang

FIAOV(K,6) = distance between overhang and sash

FIAOV(K,7) = depth of sash

FIAOV(K,8) = width of sash

FIAOV(K,9) = height of sash

APPENDIX B

Program restrictions

When preparing data for the program the user must be aware of the restrictions listed below. The restrictions are due to core storage allocation (array declarations) in the program. The program does not check the input to see if the limits are exceeded!

Max.	no.	of	walls	50
"	"	"	rooms	20
"	"	"	walls in a room	15
"	"	"	windows	20
"	"	"	doors	20
"	"	"	wall types	10
"	"	"	window types	5
"	"	"	door types	5
"	"	"	occupancy schedules	15
"	"	"	const. light schedules	20
"	"	"	var. light schedules	20
"	"	"	equipment schedules	8
"	"	"	hot water cons. schedules	7
"	"	"	thermostat setpoint schedules	8

APPENDIX C

Description of weather tape

In order to be accepted by the ENCORE program the weather tape should be as described below.

The records must be in unformatted (binary) form.

First record:

ISTNR	IAAR

where:

ISTNR - synoptic no. of the meteorological station

IAAR - year of weather data

The information in the first record is checked against input data to the ENCORE program to make shure that correct weather data are used in the calculations.

One record for each day of the year:

MND	IDATO	ISNO	TEMP(1)	SKYDK(1)	SKYTP(1)	VHAST(1)	VRETN(1)	TEMP(2)	...	VHAST(24)	VRETN(24)

where:

MND	- month
IDATO	- day of the month
ISNO	- thickness of snow cover (cm)
TEMP(1),.....,TEMP(24)	- dry bulb temperatures at hrs 0100 to 2400
SKYDK(1),....,SKYDK(24)	- cloud cover in parts of eight (i.e. 1, 2, 3, ...8) at hrs 0100 to 2400
SKYTP(1),....,SKYTP(24)	- cloud type as 0. (cirrus, cirrostratus), 1. (stratus) and 2. (other) at hrs 0100 to 2400
VHAST(1),....,VHAST(24)	- wind speed in m/s at hrs 0100 to 2400
VRETN(1),....,VRETN(24)	- wind direction (degrees clockwise from north) at hrs 0100 to 2400

APPENDIX D

Description of output file

The following data are written unformatted (binary) on file(unit 7) for later plotting or other use. One record for each hour of the year:

IDAY	MONTH	IHOUR	DBT	WSPEED	CLC	ER(1)	RTEMP(1)	....	ER(K)	RTEMP(K)

where:

IDAY	-	day of the month
MONTH	-	month
IHOUR	-	hour of the day
DBT	-	outdoor dry bulb temperature
WSPEED	-	wind speed
CLC	-	cloud cover
ER(1)	-	heat output in room no. 1
RTEMP(1)	-	room temperature in room no. 1

ER(K)	-	heat output in room no. K
RTEMP(K)	-	room temperature in room no. K