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BUREAU OF RESEARCH AND ENGINEERING

COMPUTER PROGRAM
FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

VOLUME I
USER'S MANUAL

U.S. Post Office Department
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COMPUTER PROGRAM

FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

VOLUME I

USER'S MANUAL

Project No. 67138

Construction Research Division

Prepared by
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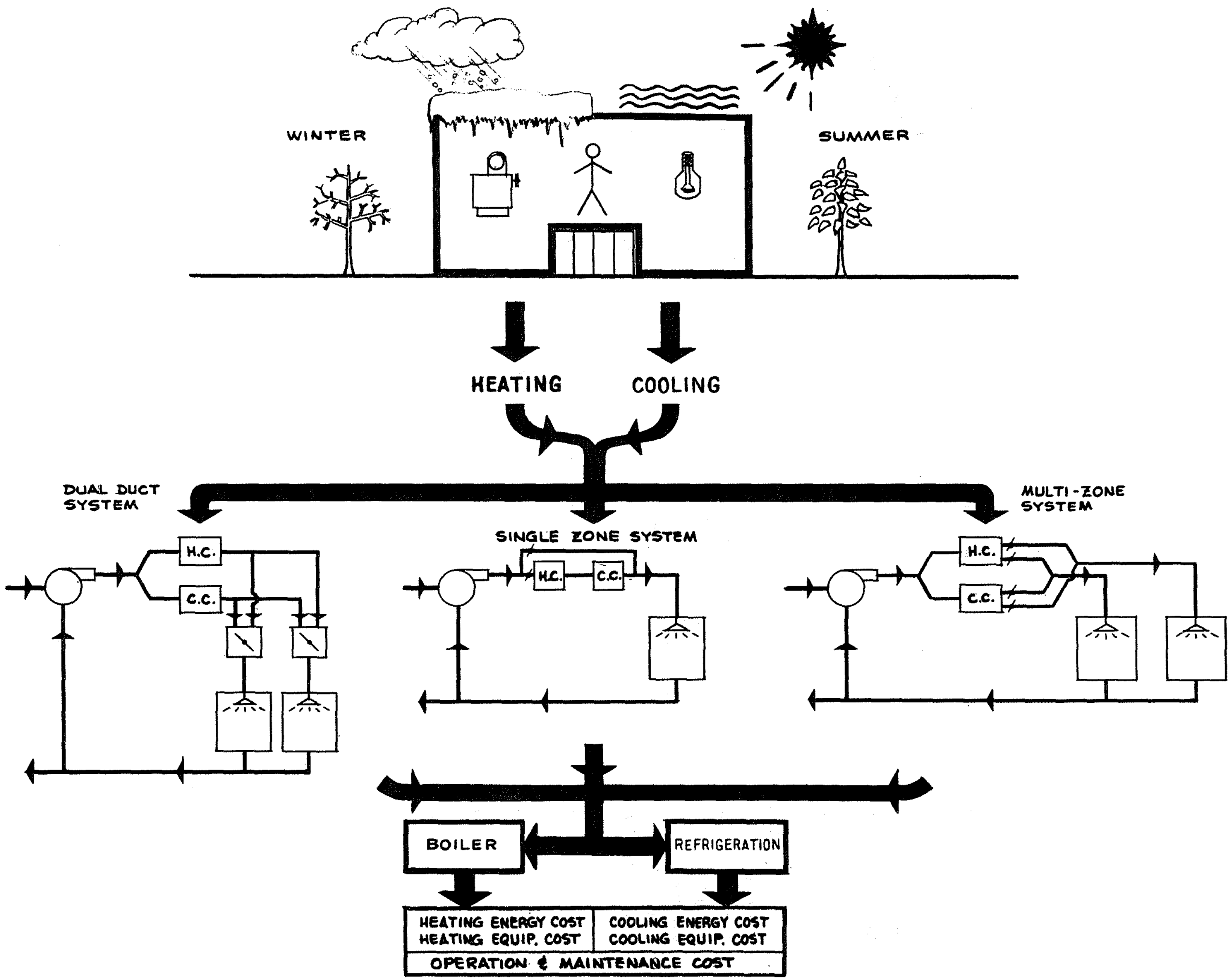
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES



PREFACE

This User's Manual was prepared by the General American Research Division (GARD) of the General American Transportation Corporation as a part of the Post Office Department Contract No. RE 49-67 for the development of a "Computer Program for Analysis of Energy Utilization in Postal Facilities". The project was monitored by Mr. James M. Anders of the POD's Bureau of Research and Engineering. The GARD team that worked on the project was headed by Mr. Metin Lokmanhekim, Manager of Thermal Systems and Computer Applications. Other GARD personnel who contributed to the project includes: Messrs. James Y. Shih, Robert H. Henninger, Charles C. Groth, Stephen J. Lis, Ajit L. Kapil, and Fred H. Bloedow.

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SECTION 1

INTRODUCTION

To maintain pace with the increase in mail volumes and to improve mail delivery, the Post Office Department has developed and is continually developing new concepts for handling mail. This means modification or remodeling of old buildings and construction of new buildings. Also, the fuel and energy consumption for operation of these mail-handling systems and buildings is steadily increasing with each new year. Manufacturers of equipment and producers of utilities, such as gas, oil, coal and electricity, are interested in selling their products for these buildings. It became essential, therefore, that the Post Office Department develop a procedure for selecting equipment and utility systems that:

1) would be objective in its approach,

2) would provide a basis for comparison of the various types of equipment and forms of fuel and energy available, and

3) could be simplified for use by the 15 Post Office Regions.

In 1961-63, the Post Office Department developed and published a procedure for energy and equipment selection that was based on "degree days" and "weighting factors" for providing energy demand and consumption requirements for various types of heating, cooling and energy utilization systems.(1) This proved to be insufficient for good analysis and comparisons of systems and their energy requirements.

In 1967, it was determined that a computer program was necessary that would:

1) simulate the thermal response of a building to all sources of heat gains and losses,

2) account for all non-thermal energy requirements in the facility or on the sites,

3) translate the building operating schedule into total energy demand and consumption costs, and identify the peak capacity requirements of heating and cooling equipment, and

4) allow for an economic analysis that would select the most economical total owning and operating cost equipment and energy source (gas, oil, coal, steam or electricity, or combinations).

The Computer Program for Analysis of Energy Utilization in Postal Facilities will accomplish the above requirements.

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(1) ASHRAE Journal, December, 1965.

The program has been designed to be utilized in the following manner:

1) Pre-design selection of the basic system and energy source. This includes total electric systems, total gas or oil systems (on-site generation), purchased steam-absorption systems and combinations of the above systems and energy sources.

2) During the design stage, utilize various subroutines or sub-programs to evaluate specific design concepts and modifications.

3) During the construction stage, evaluate contractor proposals for modification or deviation from the construction plans and specifications.

4) After completion of the building and its mail-handling systems, use the "ideal building", as finalized by the computer program, to evaluate the maintenance and operation of the facility and the utilities systems. This will completely optimize total owning and operating costs and provide the greatest return on utility dollars.

Also provided with this User's Manual is an accompanying "Engineering Manual". The Engineering Manual provides a complete documentation for all sub-programs, subroutines and the algorithmic expressions used to calculate the building thermal characteristics and the systems simulation included in the program.

The total program consists of seven separate sub-programs, each operating alone and performing a specific function, but with the output of one becoming the input to another. The seven sub-programs include:

1) LOAD CALCULATION SUB-PROGRAM - calculates the hourly heat losses and heat gains for each space within the building for an entire year.

2) PUNCH SUB-PROGRAM - prepares the punched card input data required for the offline Thermal Loads Plot Sub-program.

3) THERMAL LOADS PLOT SUB-PROGRAM - plots the hourly load profiles for any space for any length of time and enables more compatible grouping of spaces into control zones.

4) LOAD EDITING SUB-PROGRAM - aids the engineer in preparing an editted hourly load tape by summing space loads into fan zone loads, thus giving an hourly load tape which can be input directly to the Systems Simulation Sub-program.

5) SYSTEMS SIMULATION SUB-PROGRAM - simulates the operation of the systems and part load operation of heating and cooling equipment components, thus enabling an accurate determination of the building's hourly energy consumption.

6) ECONOMICS ANALYSIS SUB-PROGRAM - calculates the annual owning and operating costs of a building for various combinations of heating and cooling plants.

7) PACKAGED SYSTEMS SIMULATION SUB-PROGRAM - simulates the operation of typical packaged unitary heating/cooling systems used in small Post Office buildings, giving the energy consumption as a function of the part load on the packaged system.

The sequence of using the seven sub-programs depends upon what information the engineer wishes to obtain and if he can initially break the buildings into fan system control zones rather than just spaces. Figure 1 illustrates the paths of sub-program sequencing that can be taken as a function of the engineer's decisions. As the engineer becomes more adept at breaking a building directly into control zones, the need for space load plots and re-grouping of zones will diminish.

As will be seen later, the card input data required by some of the sub-programs cannot be prepared until the output of another sub-program has been examined. For example, the proper grouping of spaces into control zones and then control zones into fan systems required for the Systems Simulation Sub-program probably cannot be done until the results of the Thermal Loads Plot Sub-program are reviewed to establish which spaces have similar load profiles. Neither can monthly energy costs be calculated and inputted to the Economics Analysis Sub-program until the monthly energy consumption summary has been received from the Systems Simulation Sub-program. Nor can the engineer collect the necessary equipment cost data required by the Economics Analysis Sub-program until the Systems Simulation Sub-program tells the engineer the quantity and capacity of the chillers, boilers, cooling towers, etc. Figure 2 illustrates this dependence of input upon output for a large Post Office building analysis. Figure 3 illustrates the same for a small Post Office building analysis where use of all seven sub-programs is probably not required.

For small buildings (below 35,000 square feet), the engineer can elect to use only the Load Calculation Sub-program, the Packaged Systems Simulation Sub-program, and the Economics Analysis Sub-program. If experience indicates no need for economic evaluation of fuels, energy and equipment variations, then the engineer can elect to run only the Load Calculation Sub-program for the peak heating and cooling months to indicate maximum and minimum heating and cooling requirements for good equipment capacity selection.

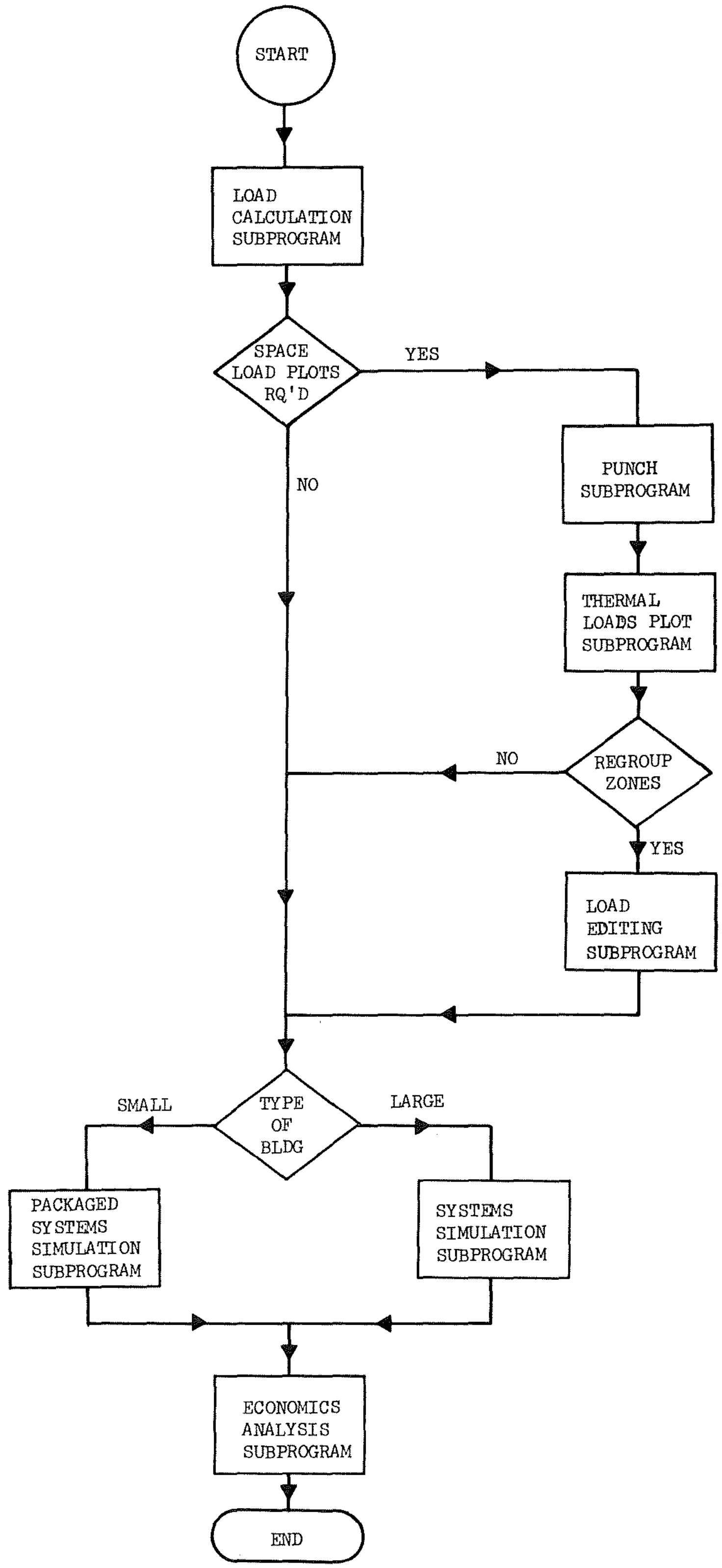


Figure 1 LOGIC FLOW CHART ILLUSTRATING THE SEQUENCE OF USING THE SEVEN SUB-PROGRAMS

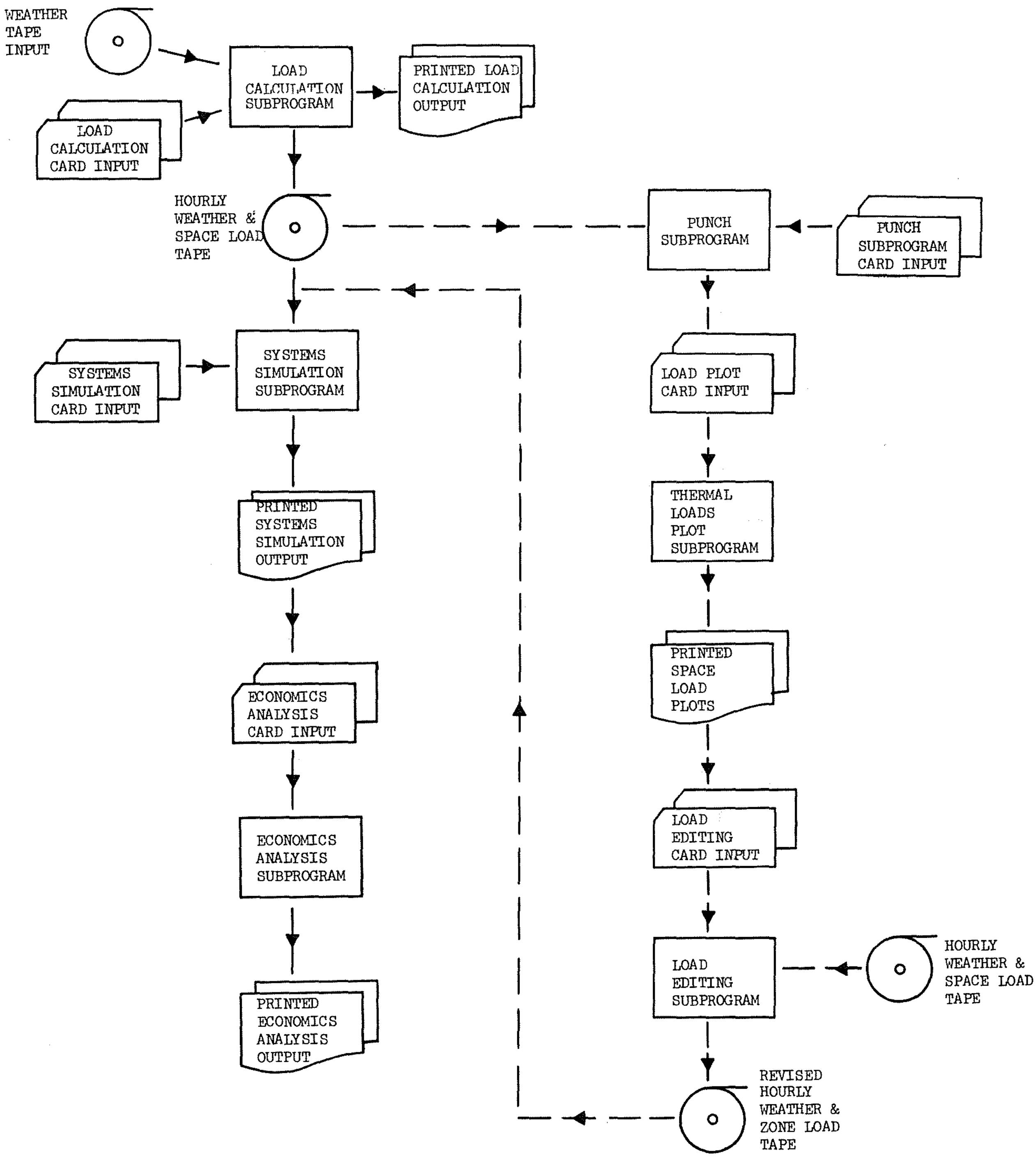


Figure 2 ANALYSIS FOR LARGE POST OFFICE BUILDINGS

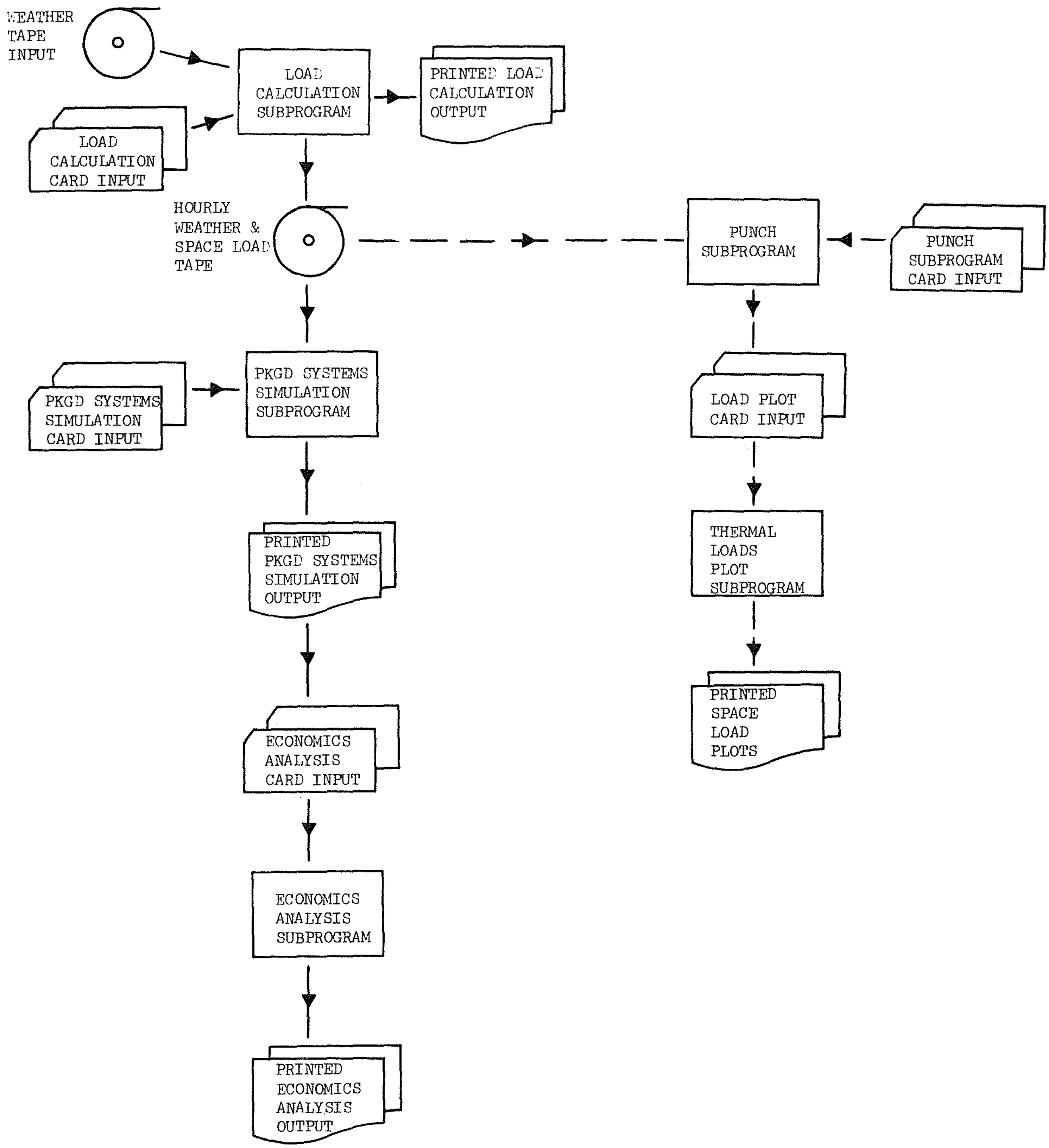


Figure 3 ANALYSIS FOR SMALL POST OFFICE BUILDINGS

To simplify the input of punched card data, only three input formats are used by the program. They include:

1) FORMAT (70A1)

This format allows alphanumeric data to be read, and is used for identifying the name of facility, location, name of engineer, project number and date of run.

2) FORMAT (24F3.2)

This format allows the input of daily schedules for people, equipment and lights. Twenty-four floating point data (decimal numbers) are read from one card. All data must contain a decimal point and appear completely within the specified 3-column field.

Example: 1.0, .02, .25, 0.3, etc.

3) FORMAT (7F10.0)

This format allows seven floating point data (decimal numbers) to be read from one card. All data must contain a decimal point and appear completely within the specified 10-column field.

Coding Forms No. 1, 2 and 3, which are to be used when preparing input data, are illustrated in Figures 4, 5 and 6, respectively. Each line represents the information to be punched on one card. Columns 71 through 80 on Forms 1 and 3, and columns 73 through 80 on Form 2 can be used for comment or identification. The computer ignores anything punched within these columns. Forms 1 and 2 have been specially prepared for the initial input of the Load Calculation Sub-program, where 5 cards of identification, 4 cards of basic data and 82 cards of scheduling information (1 card for codes and 27 cards for each of 3 types of spaces -- work rooms, offices and special equipment areas) are required. Form No. 1 should always be completed and only one is required. A Form No. 2 should be completed for each type of space within the building. If, for example, a building contains only workroom areas and office areas, only two of Form No. 2 should be completed. All remaining Load Calculation Sub-program input data and other sub-program input data should be entered on Form No. 3.

The following sections of this manual describe the details of each of the seven sub-programs enumerated earlier. The main emphasis of each section is on the preparation of the input card data. To help the engineer understand, to some extent, how each sub-program uses the input card data, most sections contain:

1) Logic flow chart

2) Detailed tabular instructions outlining the necessary input data and order

3) Completed example input form

4) Example set of input cards

5) Example of sub-program output.

The detailed tabular instructions summarize the following items:

1) READING ORDER - the order in which the input card occurs in the data deck.

2) COLUMNS - the columns in which the input data are to be punched.

3) INPUT VARIABLE DESCRIPTION - the definition of the input data contained on the card.

4) PROGRAM SYMBOL - the name given to the input variable within the computer program.

5) UNITS - the engineering units of the input data.

6) LIMIT VALUES - the maximum and minimum values of the input variables.

7) CODE - the designation code used to simplify the input of certain information.

8) EXAMPLE - typical input values.

9) COMMENT - any supporting remark which further clarifies the use of the input data.

U. S. P. O. D. CODING FORM NO. 1 FOR
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET — OF —

DATA FIELD (columns 1–70)	IDENTIFICATION FIELD (columns 71–80)

Card	Fields
1	FACILITY NAME (cols 1–35)
2	LOCATION (cols 1–35)
3	ENGINEER (cols 1–35)
4	PROJECT NO. (cols 1–15)
5	DATE (cols 1–15)
6	LATITUDE (1–10), LONGITUDE (11–20), TIME ZONE (21–30), SUM CLE NO (31–40), WIN CLE NO (41–50), BLDG AZIM (51–60)
7	YEAR (1–10), MONTH (11–20), LENGTH (21–30), XMAS PER (31–40), INI TEMP (41–50)
8	PRINT CODE (1–10)
9	SPACE TYP (1–10)

Figure 4 CODING FORM NO. 1

U. S. P. O. D. CODING FORM NO. 2 FOR
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET — OF —

DATA FIELD	IDENTIFICATION FIELD
1–72	73–80

COD PEOPLE SCH (1–10)	COD LIGHT SCH (11–20)	COD EQUIP SCH (21–30)	(31–72)	(73–80)

Columns 1–72 in groups of three, by hour: I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII, XIII, XIV, XV, XVI, XVII, XVIII, XIX, XX, XXI, XXII, XXIII, XXIV ← HOUR (columns 73–80)

PEOPLE SCHEDULE

Day	I–XXIV	
SUNDAY		1
MONDAY		2
TUESDAY		3
WEDNESDAY		4
THURSDAY		5
FRIDAY		6
SATURDAY		7
HOLIDAY		8
XMAS		9

LIGHTING SCHEDULE

Day	I–XXIV	
SUNDAY		1
MONDAY		2
TUESDAY		3
WEDNESDAY		4
THURSDAY		5
FRIDAY		6
SATURDAY		7
HOLIDAY		8
XMAS		9

EQUIPMENT SCHEDULE

Day	I–XXIV	
SUNDAY		1
MONDAY		2
TUESDAY		3
WEDNESDAY		4
THURSDAY		5
FRIDAY		6
SATURDAY		7
HOLIDAY		8
XMAS		9

Figure 5 CODING FORM NO. 2

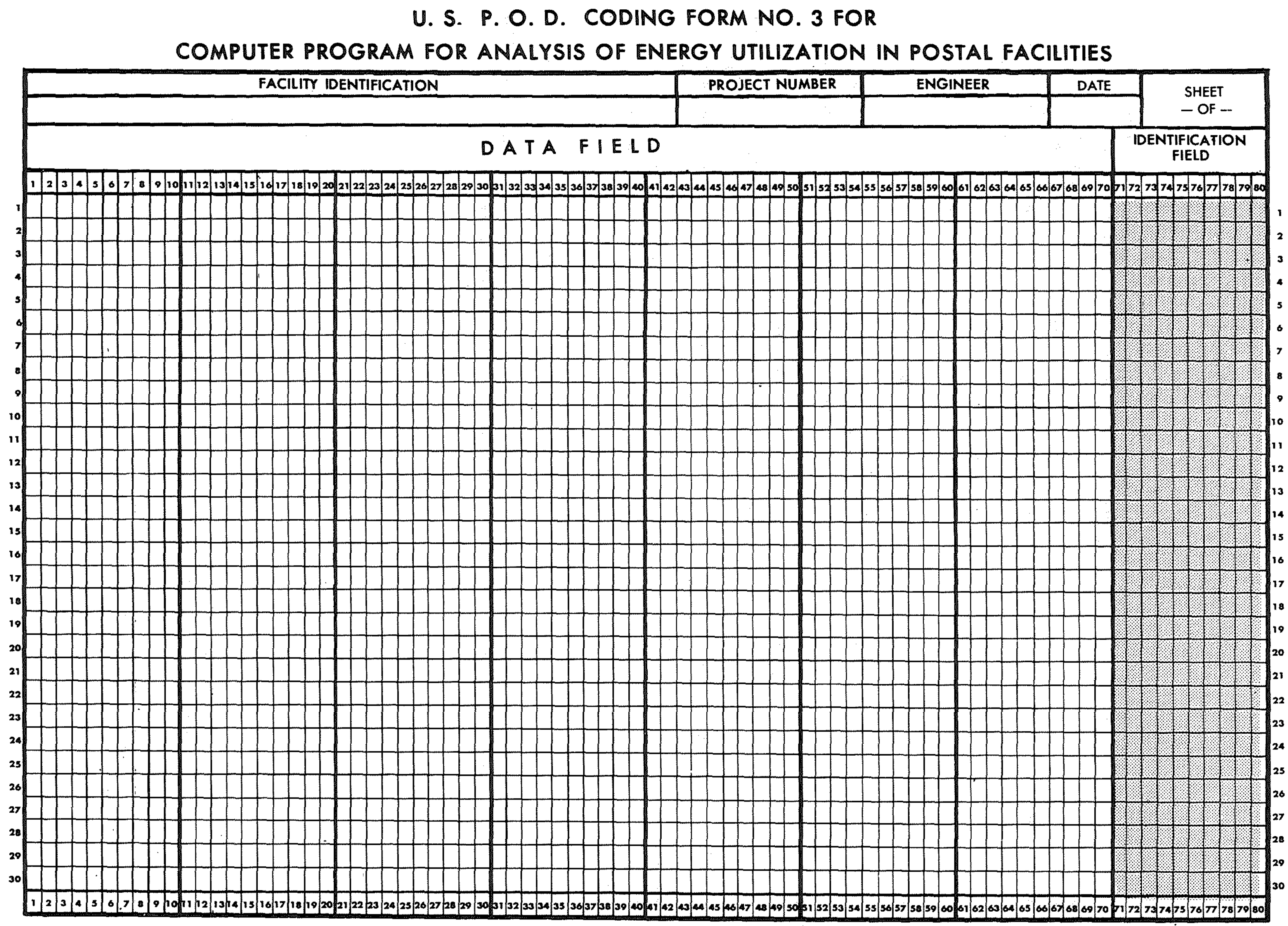


Figure 6 CODING FORM NO. 3

SECTION 2

LOAD CALCULATION SUB-PROGRAM

The Load Calculation Sub-program, a complex of heat transfer, environment, and geometry subroutines, computes the loads, both heating and cooling, imposed upon the building air conditioning system by each space at each hour. The input to the Load Calculation Sub-program reflects building architecture, building structure, the building surroundings, local weather, and the pertinent astronomy of the sun. The output from the Load Calculation Sub-program consists of hourly weather and psychrometric data and hourly sensible loads, latent loads, plenum return air lighting loads and equipment and lighting power consumption for each space.

2.1 Structure of Load Calculation Sub-program

The Load Calculation Sub-program consists of a set of subroutines, small programs each of which performs an engineering calculation, and a main program which reads the required data, directs the flow of information from one subroutine to another, and writes the output on paper and magnetic tape. For example, control statements in the main program serye such functions as preventing a call to the shadow subroutine before the computer "knows" the building architecture. The descriptions of subroutines are given in the Engineering Manual. The logic flow chart (Figure 7) shows, schematically, the interrelationship of subroutines within the Load Calculation Sub-program. A brief description of each subroutine is given in Table 1.

2.2 The Philosophy of the Numerical Description of Buildings

A complete architectural and thermodynamic description of the building must be punched on computer cards. The most difficult portion of this input job is the numerical architectural description.

For example, suppose that we wish to describe, over the phone, an aspirin bottle. We could say "It's a 100-tablet bottle of Bayer". This would get the picture across. Suppose, however, that we are forbidden to use words -- only numbers. We then are tongue-tied and can do nothing. So, at first glance, it would appear. Yet we're not quite licked.

This situation is just as if you could not see the bottle. Suppose, however, that upon this invisible bottle there landed a visible fly. This would indicate to us where the bottle was, but neither its shape nor its size. We would know merely that there was an invisible object, at a specific place, upon which the insect was resting. Suppose now that a veritable plague of flies descended upon the bottle to rest. Although the bottle would still be invisible, the envelope of flies would delineate its shape and size.

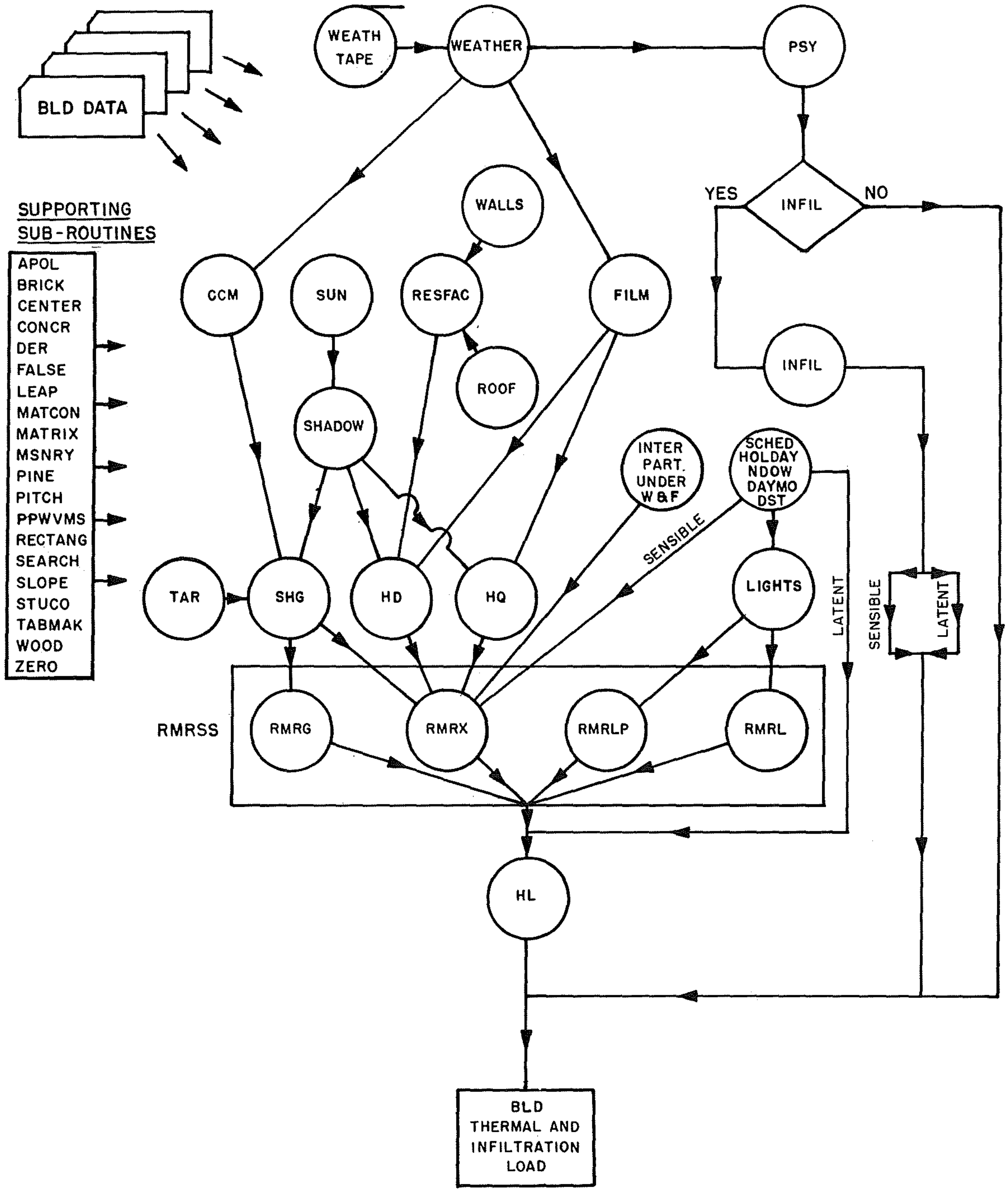


Figure 7 INTERRELATIONSHIP OF LOAD CALCULATION SUB-PROGRAM SUBROUTINES

TABLE 1

LOAD CALCULATION SUB-PROGRAM SUBROUTINES

Name of the Subroutine	Function
APOL	Calculates area and orientation of an irregular surface
CCM	Calculates cloud cover modifier
CENTER	Centers the headings of output
DAYMO	Determines day of month
DST	Determines Daylight Saving Time
FILM	Calculates outside heat transfer film coefficient
HD	Calculates heat gain through slowly responding surfaces (Delayed surfaces)
HL	Calculates sensible and plenum return air heating and cooling load due to a space
HOLDAY	Determines holiday
HQ	Calculates heat gain through quickly responding surfaces (Quick surfaces)
INF	Calculates infiltration air loads due to a space
LEEP	Determines whether the year is a leap-year
NDOW	Determines day of week
PSY and PPWVMS	Calculates psychrometric data
RECTANG	Calculates vertex coordinates of a rectangular surface
RESFAC and DER FALSE MATRIX SLOPE ZERO	Calculates response factors for walls and roofs

TABLE 1 (CONT'D)

Name of the Subroutine		Function
RMRSS	and	Calculates room hourly weighting factors
	RMRG RMRL RMRLP RMRX	
ROOFS	and	Determines thermal and physical properties of a selected roof construction
	MSNRY PITCH WOOD	
SEARCH		Limits shadow pictures to certain times and certain surfaces
SCHED		Determines lighting, people, and equipment schedules
SHADOW	and	Calculates shadow shapes and areas
	MATCON	
SHG		Calculates heat gain through windows
SUN1		Calculates daily data on solar radiation
SUN2		Calculates hourly data on solar radiation
SUN3		Calculates solar data which depends on orientation of a surface
TABMAK		Tabulates output
TAR		Calculates glass absorption and transmission factors
WALLS	and	Determines thermal and physical properties of a selected wall construction
	BRICK CONCR PINE STUCO	
WEATHER		Decodes weather tape

Let us return to the numerical description. Although the form of the bottle defies easy numerical description, the position of a fly can be so described. Descartes showed that three numbers suffice for a fly. Given a plague of flies, n strong, 3n numbers give a fair description of the bottle.

The scheme actually used in the Load Calculation Sub-program is not to smear the building with honey to attract flies, but is equivalent -- we break the structures into a set of plane polygons and specify their vertices. By polygon we mean a closed figure, made up of straight sides, such as a triangle, rectangle, or pentagon. The points where two sides meet, i.e., the corners, are called vertices (see Figure 8). A flat surface may be described numerically by considering its border as made up of the sides of a polygon and specifying the vertices relative to the building coordinate system.

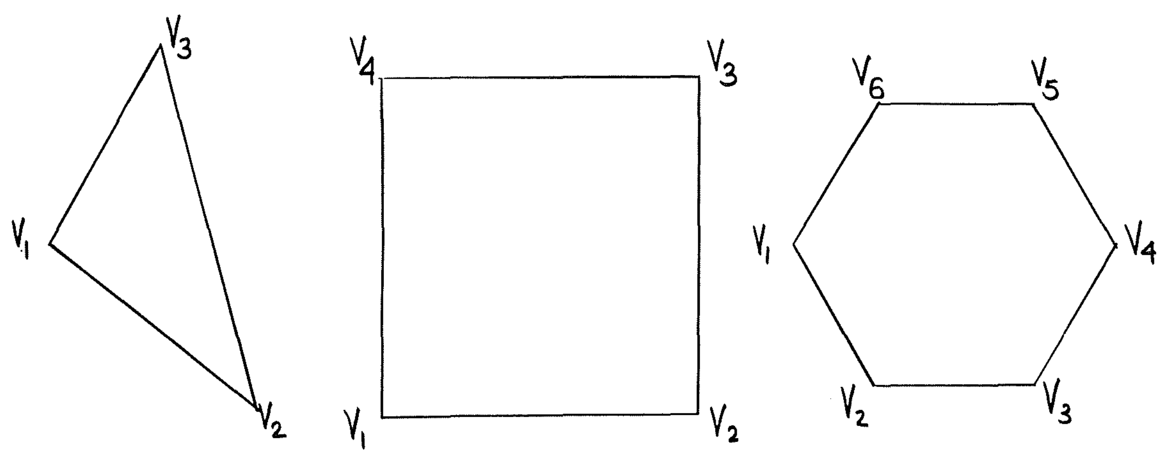


Figure 8 POLYGONS (THE POINTS LABELED V_1, V_2, ETC. ARE THE VERTICES)

Therefore a set of geometric points represents the building architecture. This requires a coordinate system from which to measure the position of a point. Figure 9 shows the recommended coordinate system for a rectangular building. In this right-handed Cartesian coordinate system, the front of the building lies in the xz plane. The origin, as viewed by a person outside of the building, lies at the lower left-hand corner of the building front. The z axis points straight up.

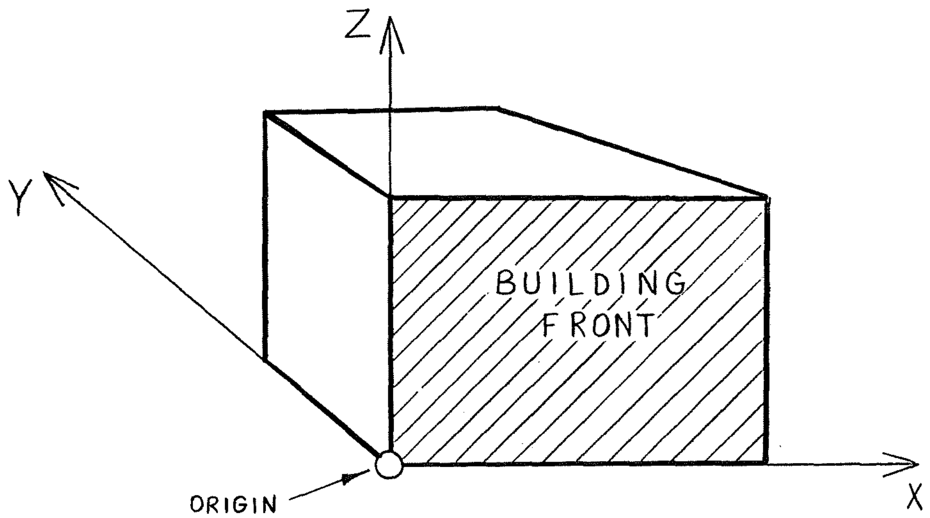


Figure 9 COORDINATE SYSTEM

The vertices of plane polygons which represent building surfaces follow, as shown in Figure 10, in right-handed order about an outward normal.

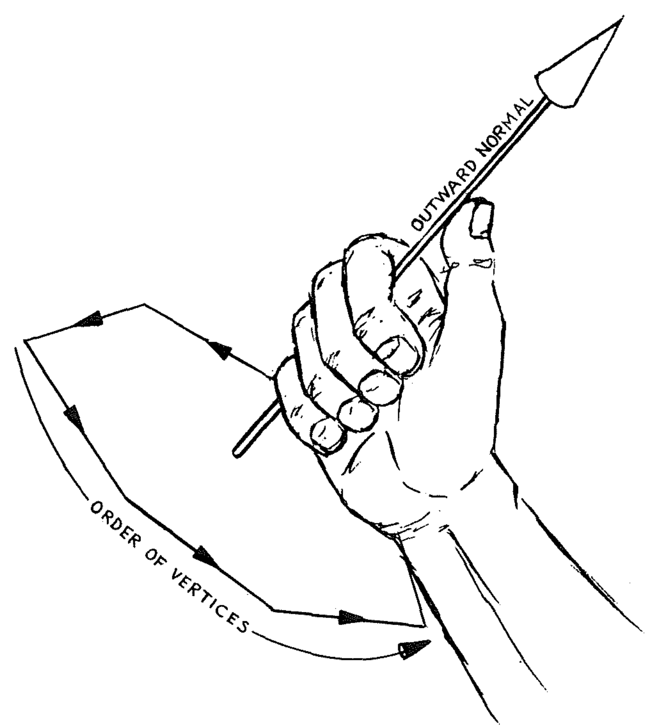
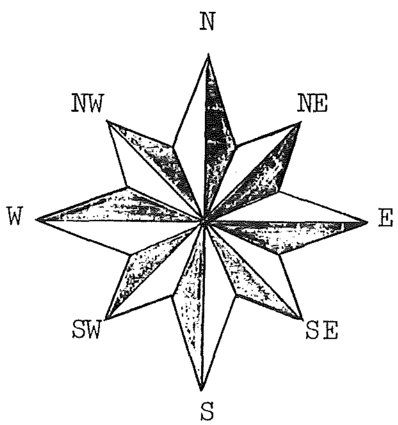


Figure 10 DEFINITION OF RIGHT-HANDED ORDER
OF POLYGON VERTICES

2.2.1 Definitions

Building azimuth angle expresses the orientation of the building coordinate system relative to the points of the compass. It is defined as the angle clockwise from north to the Y-axis, as shown in Figure 11. In case the building does not align with the cardinal points of the compass, interpolation yields the building azimuth. For example, a NW frontal exposure yields a building azimuth of 135°. A SSE frontal exposure yields a building azimuth of 337.5°.



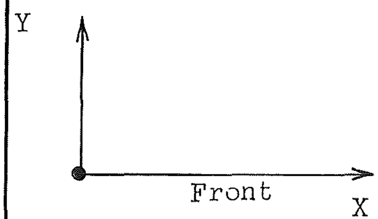
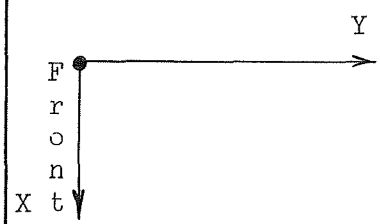
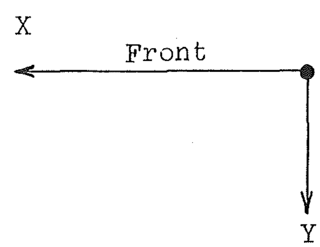
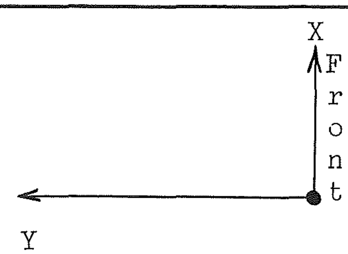
Orientation of Coordinate System relative to compass points	Value of Building Azimuth Angle (°)	Exposure of Building Front
	0	S
	90	W
	180	N
	270	E

Figure 11 BUILDING AZIMUTH ANGLE

Surface tilt angle is defined as the angle between a horizontal plane and the surface in consideration. The value of tilt angle changes between 0° and 180°, as shown in Figure 12.

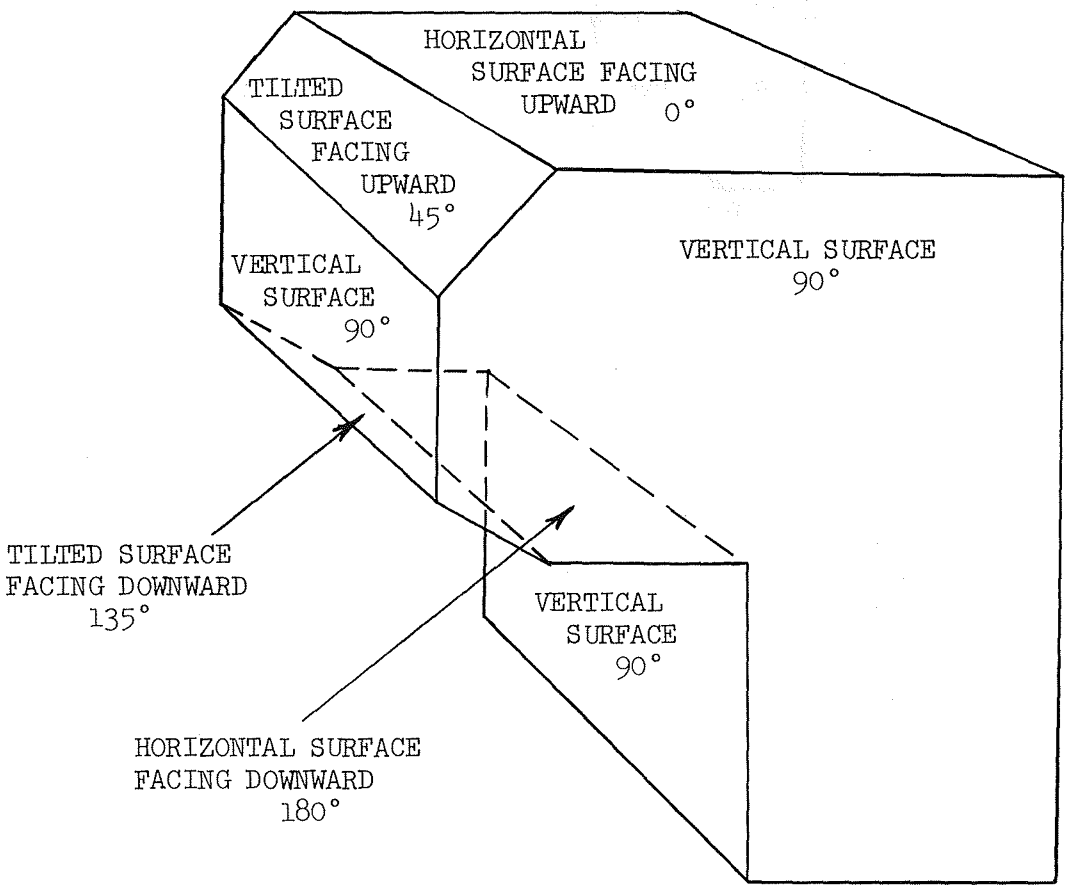


Figure 12 SURFACE TILT ANGLE

Surface azimuth angle is defined as the clockwise angle from the Y-axis to the horizontal projection of the surface outward normal as shown, for vertical surfaces, in Figure 13 and Table 2 .

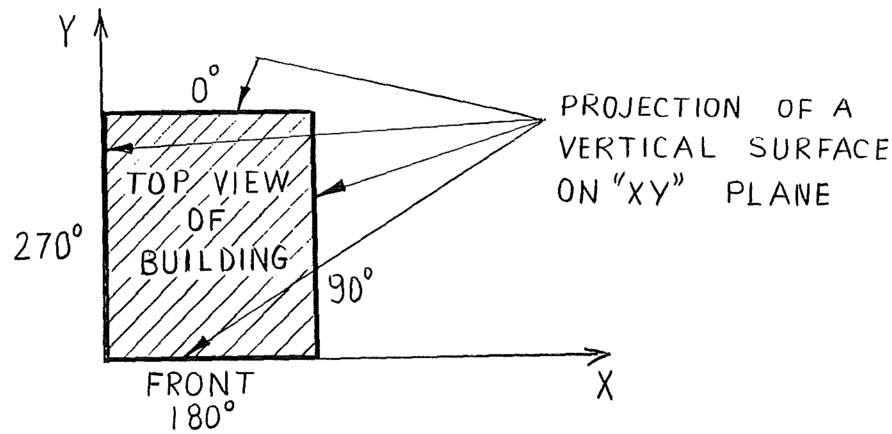


Figure 13 VERTICAL SURFACE AZIMUTH ANGLE

TABLE 2

AZIMUTH ANGLES OF VERTICAL SURFACES

Wall Orientation	Azimuth Angle (°)
Facing direction of Y-axis	0
Facing direction of X-axis	90
Facing opposite the Y-axis	180
Facing opposite the X-axis	270

The width of a rectangle is defined as its horizontal dimension; the height as the dimension on the incline (see Figures 14 through 17).

How do we define the lower left-hand corner, the height, the width and the azimuth angle of a horizontal rectangle whose outward normal has no horizontal projection? Label the vertices, proceeding counterclockwise around the rectangle (walking around the rectangle with the rectangle to your left, the outside world to your right) A, B, C and D. Take the vertex A as the lower left-hand corner, the length of side AD as the height, and the length of side AB as the width. In other words, as you stand at the lower left-hand corner, which was arbitrarily chosen (you might have started labeling at any vertex), and face the center of the rectangle, the height, as defined, falls to your left, the width to your right. Assuming side AB as the projection of a vertical surface, determine the azimuth angle from Figure 13. Figures 14 through 17 show this convention to be consistent, in a limiting sense, with the definition of azimuth, tilt, height, and width.

Spaces and Heat Transfer Surfaces

A room, or group of rooms, which yields a single heating or cooling load, is called a space. Spaces are surrounded by heat transfer surfaces which may be of four types:

1) Interior partitions, underground walls and underground floors, with no heat storage effect

2) Exterior thin walls with no heat storage effect (Quick surfaces)

3) Exterior thick walls with heat storage effect (Delayed surfaces)

4) Windows.

All of these surfaces have this in common: Each can transfer sensible energy in or out of the space. Cases (1), (2) and (4) above include light structures which store no energy. Case (3) above includes heavy structures which store up energy. Stored energy appears in the space some time after it enters the outside of the surface.

Common and Added Shading Surfaces

Shading surfaces are divided into two classes: common and added. This division has been found to increase the usefulness of the program.

Common shade polygons represent surfaces which shade more than one heat transfer surface and prevent the extra labor required to input any shading surface twice. Were "commons" not used, each shading surface would have to be repeated for each heat transfer surface that it shades. To save computer time, the input forms for heat transfer surfaces provide space for the indices of common polygons which shall be deleted

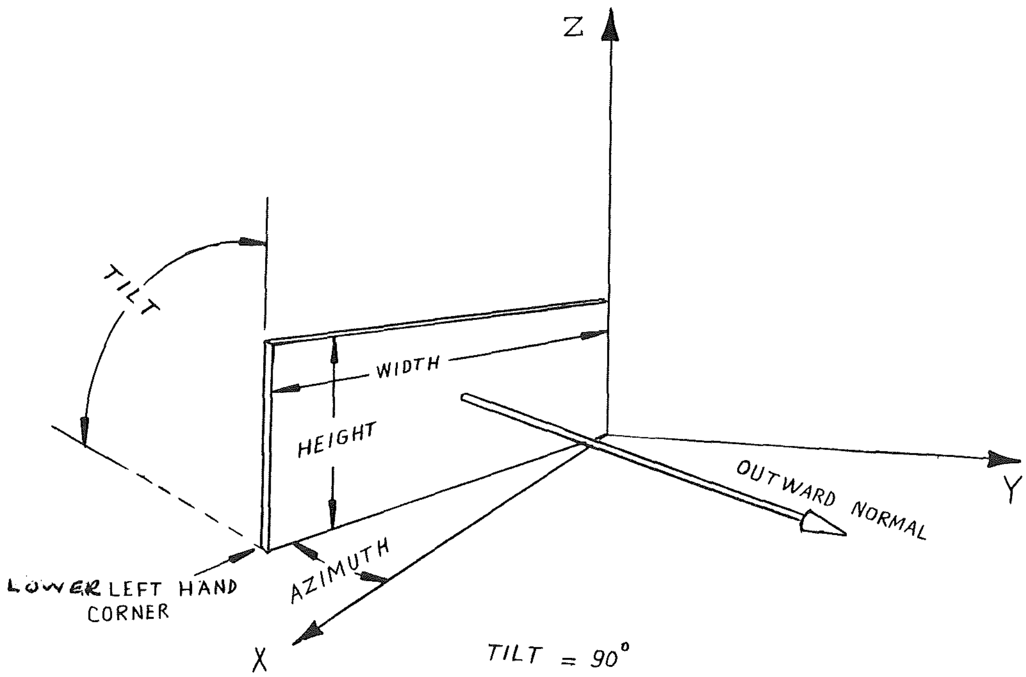


Figure 14 DEFINITION OF HEIGHT, WIDTH, TILT ANGLE, AND AZIMUTH ANGLE OF A RECTANGULAR SURFACE

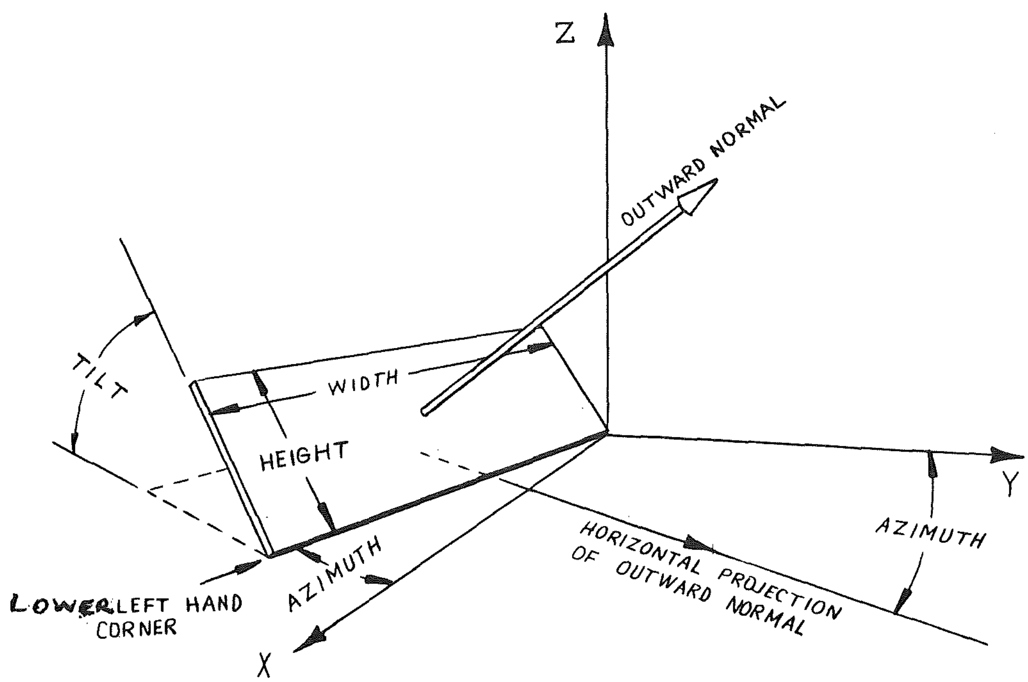


Figure 15 DEFINITION OF HEIGHT, WIDTH, TILT ANGLE, AND AZIMUTH ANGLE OF A RECTANGULAR SURFACE

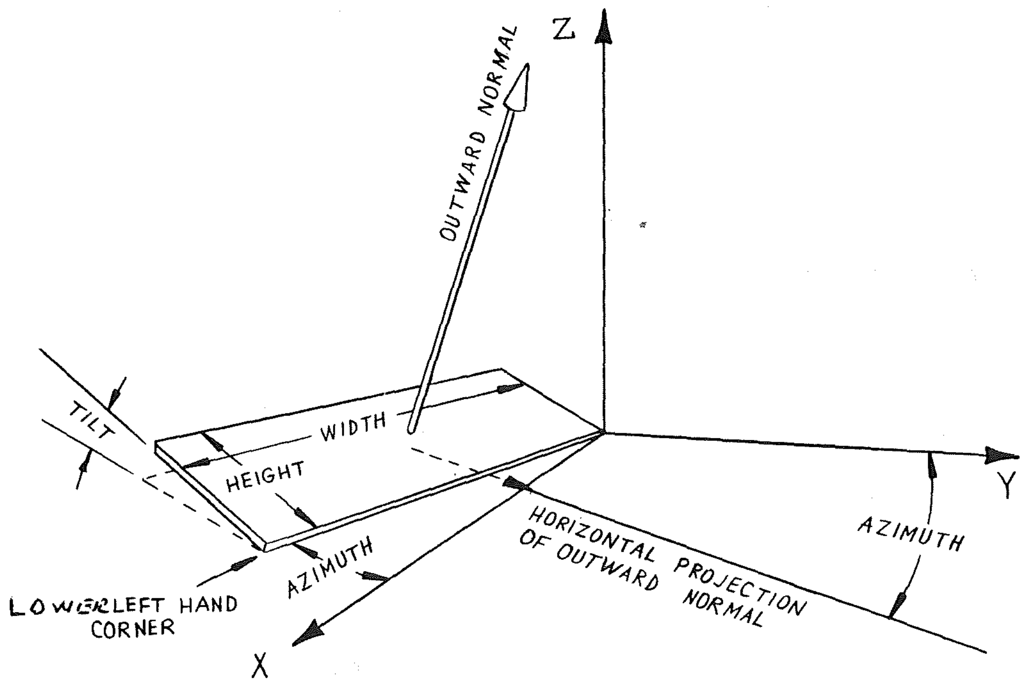


Figure 16 DEFINITION OF HEIGHT, WIDTH, TILT ANGLE, AND AZIMUTH ANGLE OF A RECTANGULAR SURFACE

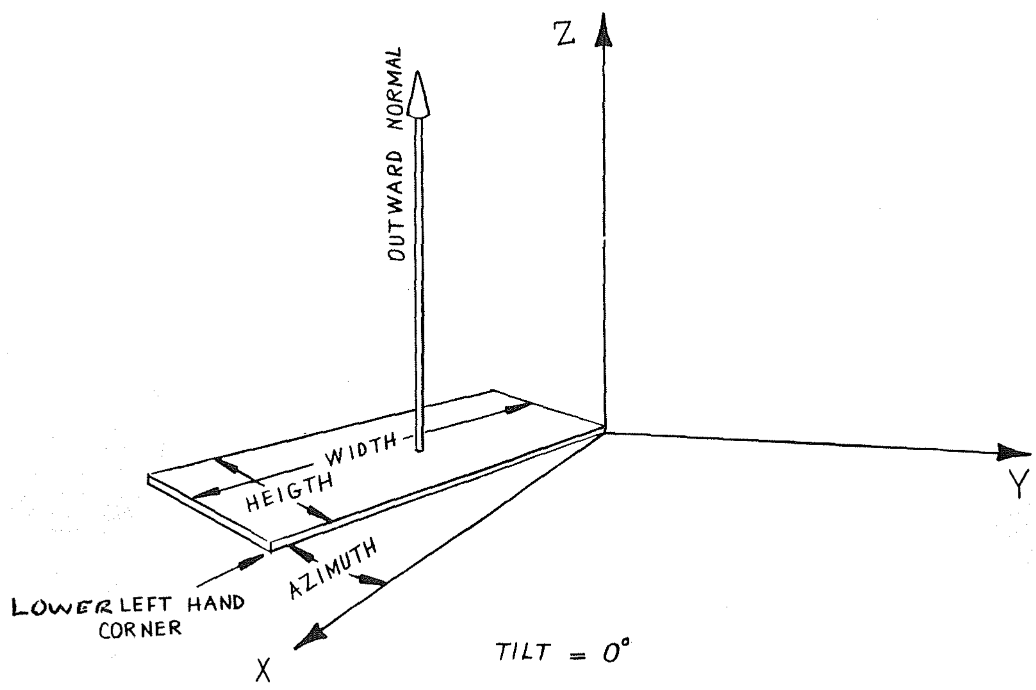


Figure 17 DEFINITION OF HEIGHT, WIDTH, TILT ANGLE, AND AZIMUTH ANGLE OF A RECTANGULAR SURFACE

from the shadow calculation of a particular heat transfer surface. For example, suppose that at the end of the input form for delayed surface 1, there appears the list, 1; 2; 10; 13. The computer program would then assume, without calculation, that neither the 1st, 2nd, 10th, or 13th common polygon shaded the 1st delayed surface. The engineer may use this feature when he knows that certain commons do not cast significant shadows on a heat transfer surface.

Added shade polygons represent surfaces which shade only one heat transfer surface and prevents the task of deleting a common for all but one heat transfer surface.

The usual classification of some shading surfaces appears in Table 3 and is illustrated in Figure 18. There is no hard rule for classification, so the engineer must use judgement. In case of doubt as to whether a shading surface casts significant shadows upon more than one heat transfer surface, that shading surface should, to be safe, be treated as common.

TABLE 3

USUAL CLASSIFICATION OF SHADING SURFACES

Type of Surface	Classification
Roof overhang	Common
Adjacent Building	Common
Window setback	Added
Window overhang	Added
Tree or water tower	Common
Parapet	Added
Penthouse	Common

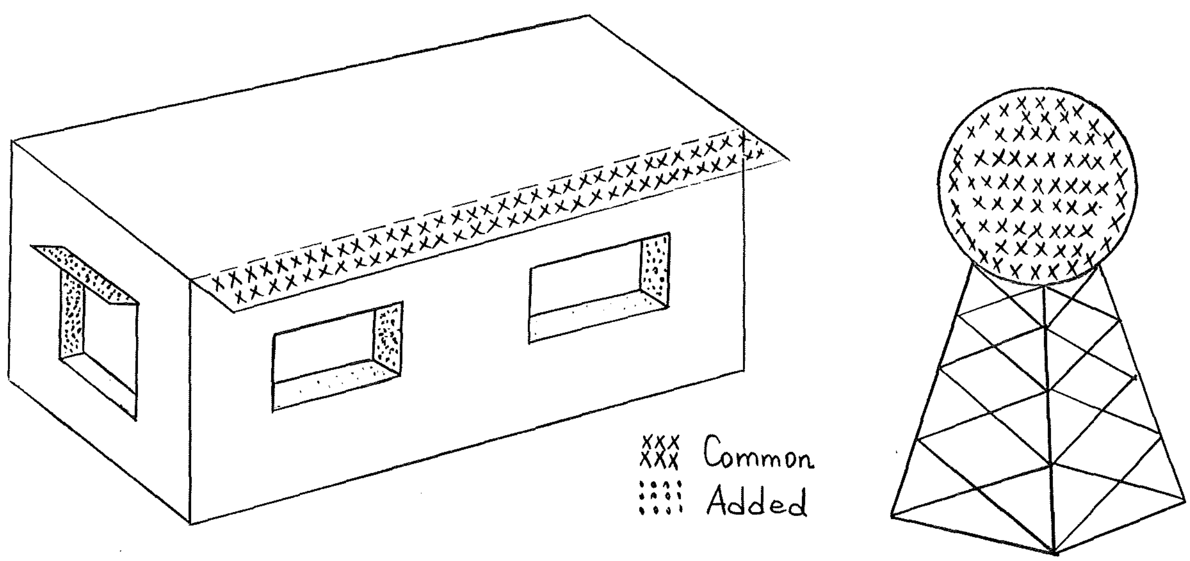


Figure 18 COMMON AND ADDED SHADING SURFACES

2.2.2 Surfaces with Windows

Often a window lies in the middle of a surface. If the perimeter of the surface is input as the perimeter of a polygon, the region over the window will be counted twice, once as a window and once as part of a delayed heat transfer surface (Figure 19). This error should be avoided by one of the following methods:

1) Use a cut to convert the surface into a doughnut-shaped polygon, of 8 vertices, which surrounds but does not enclose the window (Figure 20).

2) Divide the surface into several smaller surfaces, none of which enclose the window (Figure 21).

It is important that window setback be reflected in the coordinates of the polygon representing the window. For example, a front window set back 1 foot would have y coordinates which are 1 foot greater than the y coordinates of the surface into which the window is set.

2.2.3 Choice of 1st Vertex of a Heat Transfer Surface

The following is of utmost importance:

Where a polygon has a concave portion of its boundary, i.e., where it has a "dent" in it, always choose the 1st vertex so that the first 3 vertices are convex (see Figure 22). This means that, if you walk from vertex 1 to vertex 2 on the outside of the surface, you must make a left turn to get to vertex 3. This convention is necessary because it affects coordinate transformations inside the shadow subroutine. This convention applies to delayed surfaces, quick surfaces, and windows.

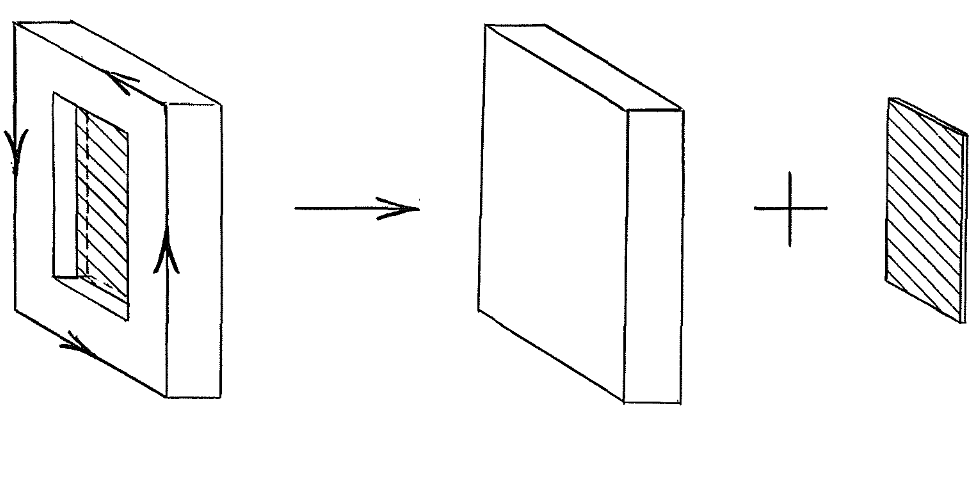


Figure 19 INCORRECT REPRESENTATION OF SURFACE WITH WINDOWS

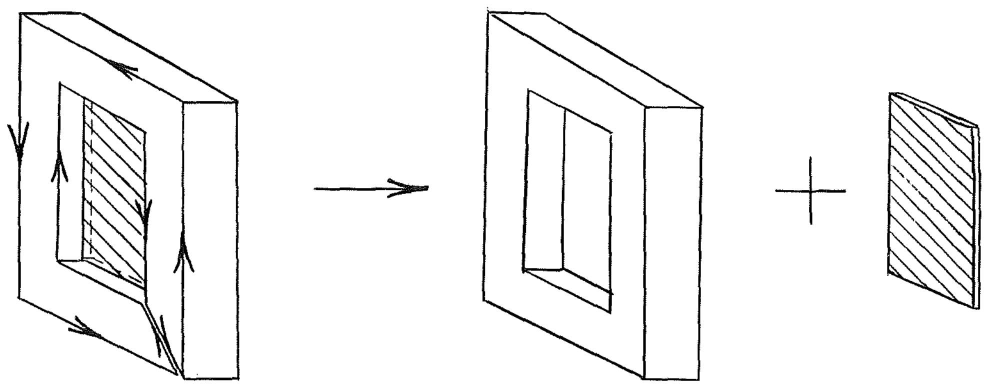


Figure 20 CORRECT USE OF A CUT TO REPRESENT SURFACE WITH A WINDOW

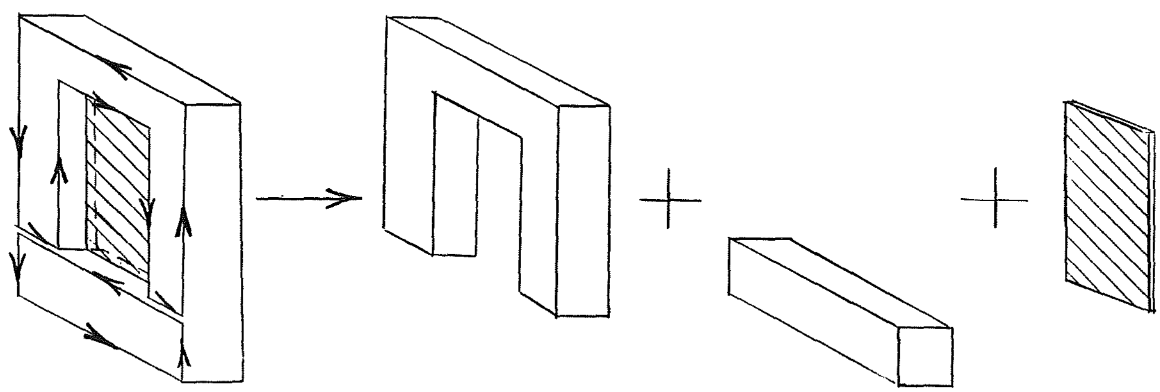


Figure 21 CORRECT USE OF MULTIPLE POLYGONS TO REPRESENT A SURFACE WITH A WINDOW

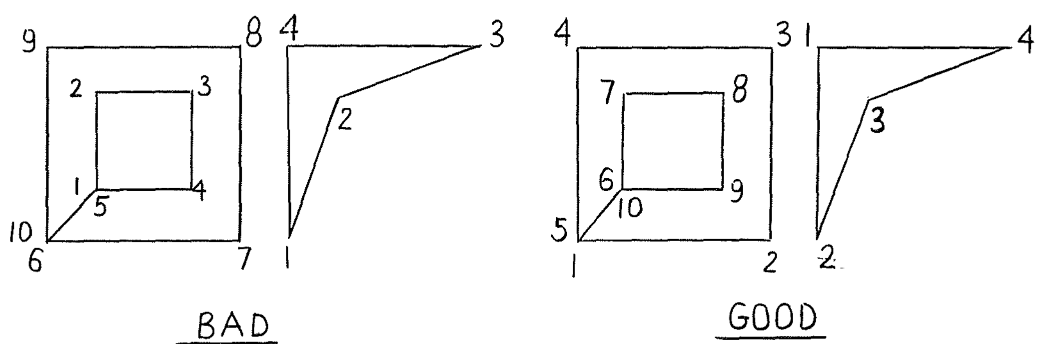


Figure 22 CHOICE OF 1ST VERTEX OF A HEAT TRANSFER SURFACE

2.3 Geometric Aspects of Building Heat Transfer Surface Data Take-off

Architects' blueprints are often accompanied by an isometric or perspective rendering. If such a three-dimensional drawing is not available, one should be drawn for the purpose of conceptualizing the shape of the building. As an example of heat transfer surface geometric data take-off, let us take the rectangular two-story building of Figure 23. The procedure follows:

1) Set up coordinate system, mark the coordinate axes and dimensions on isometric and floor plan sketches and number your spaces (Figure 24).

2) From the isometric sketch, derive main plane polygons (Figure 25).

3) a. In order that polygons do not cross space boundaries, subdivide the main plane polygons into smaller polygons, each of which contacts only one space. Make sure, also, that none of these lesser polygons include two types of surface (Quick and glass, Quick and Delayed, etc.). Then tag each of these lesser polygons with a code letter (D for Delayed, Q for Quick and W for Window) and an index (by index, we mean a number) (Figure 26).

   b. If the building has heat-transferring interior partitions (an interior partition is considered as heat-transferring if the temperatures of the spaces to which the partition is connected are different from each other), underground walls and underground floors, use code letters I, UF and UW for interior partitions, underground floors, and underground walls, respectively, and repeat Step 3.a for them.

4) On <u>Work Form No. 1</u> (see Table 4), for each space, list the indices of D, Q, W, I, UF and UW-type polygons.

   It should be noted that:

   > If it is necessary, the number of polygons attached to a space may be increased. This is controlled by dimension statement in the computer program.

5) Tag each vertex of delayed, quick and window-type polygons with an index. Most vertices occur in more than one polygon, but each vertex receives only one index (Figure 27).

6) On Work Form No. 2 (see Table 5), for delayed, quick and window-type polygons, list the indices of that polygon's vertices in counterclockwise order as seen from the outside of the building.

It should be noted that:

If it is necessary, the number of the vertices of a plane polygon may be increased. This is controlled by dimension statement in the computer program.

If three successive vertices of a polygon lie in a straight line, the middle one may be omitted.

7) Enter each vertex coordinate on Work Form No. 3 (see Table 6).

2.3.1 A Special Provision of Load Calculation Sub-program for Rectangular Heat Transfer Surfaces

For rectangular heat transfer surfaces (Delayed, Quick and Window-type), we need not input all the vertices of each surface. The Load Calculation Sub-program has a special provision which requires only one vertex, the height, the width, and the orientation. The procedure for rectangles follows.

Repeat Steps 1 through 5 of Section 2.3.

6) For each rectangle, enter on Work Form No. 4 (see Table 7) the following:

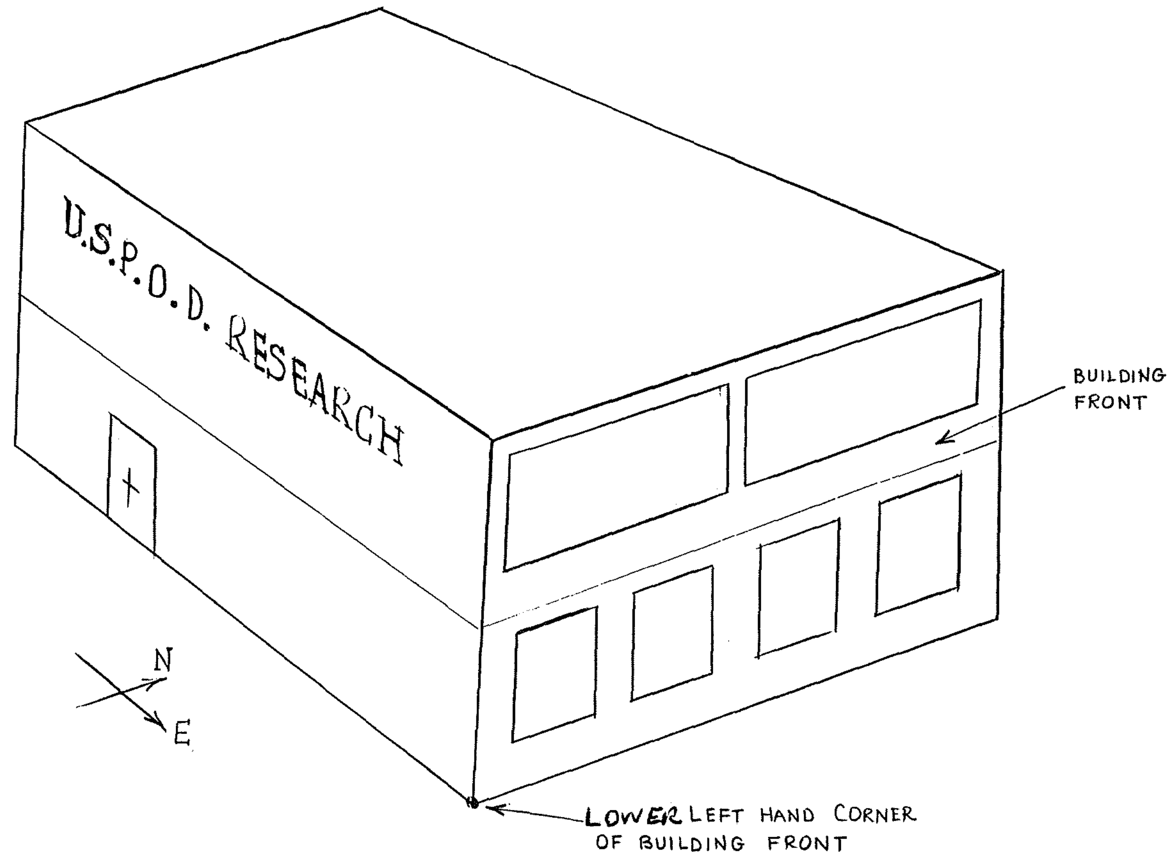
a) x, y, z coordinates of the lower left-hand corner of the rectangle as seen from outside of the building.

b) the height and width of the rectangle.

c) the azimuth and tilt angles of the rectangle.

IT SHOULD BE NOTED THAT:

THE PROCEDURES DESCRIBED IN SECTIONS 2.3 AND 2.3.1, DEPENDING UPON APPLICATION, MAY BE USED ALONE OR MIXED, FOR SIMPLIFICATION.



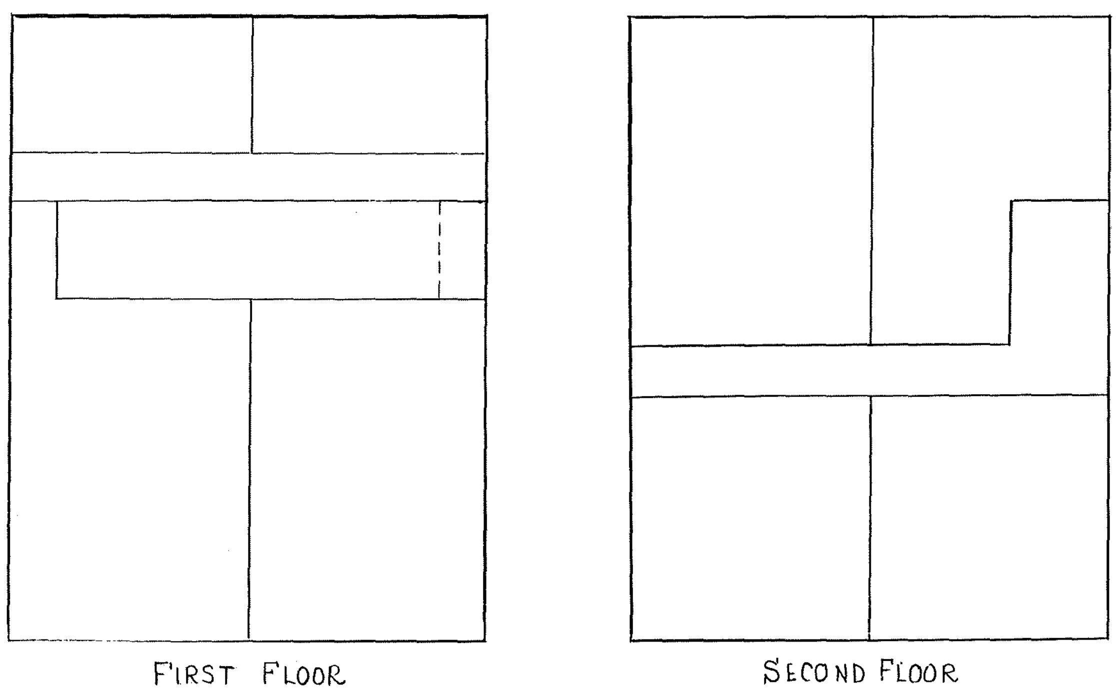


Figure 23 ISOMETRIC LINE SKETCH AND FLOOR PLANS OF EXAMPLE BUILDING

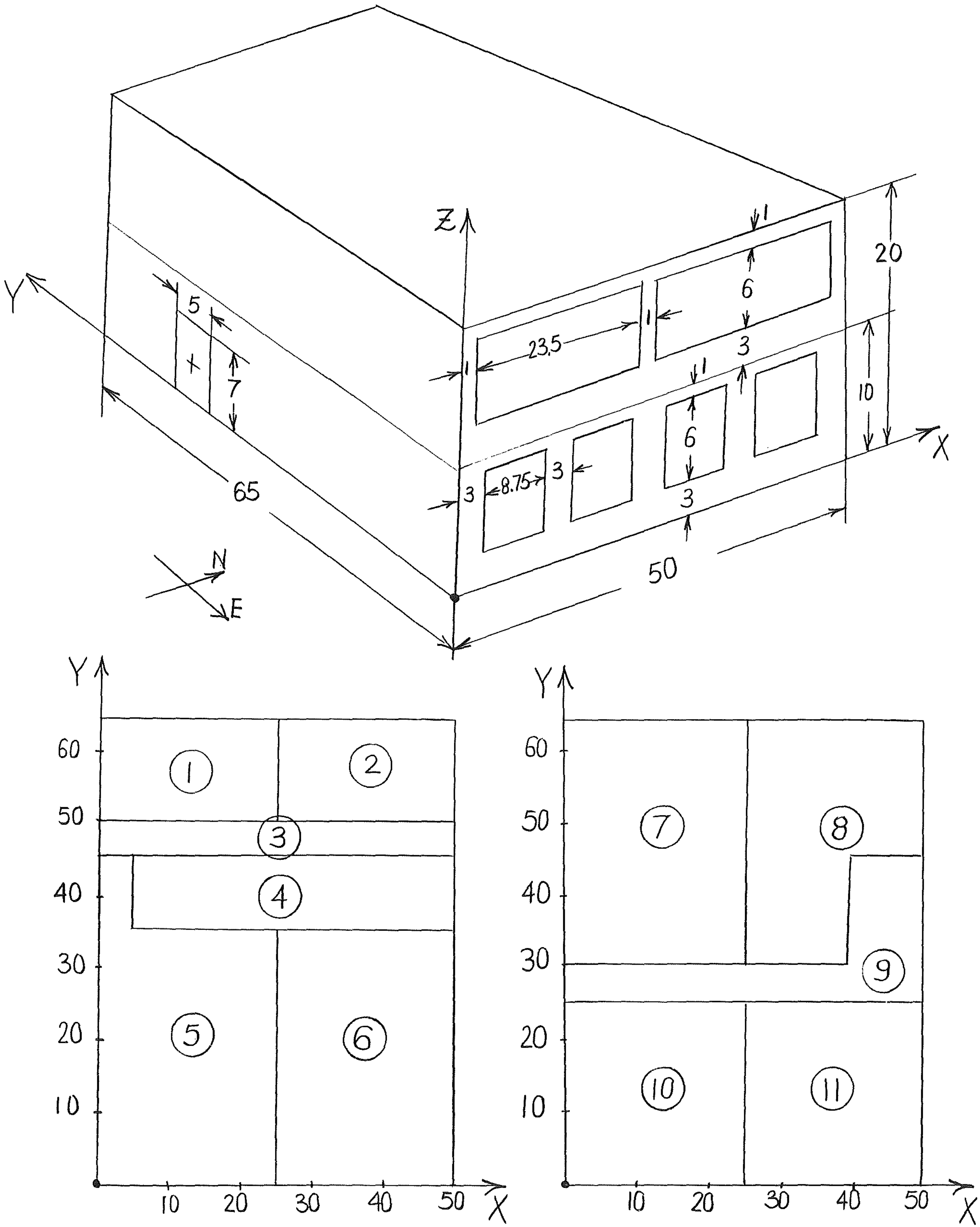


Figure 24 ISOMETRIC LINE SKETCH AND FLOOR PLANS OF EXAMPLE BUILDING WITH COORDINATE SYSTEM, MAIN DIMENSIONS AND SPACE NUMBERS

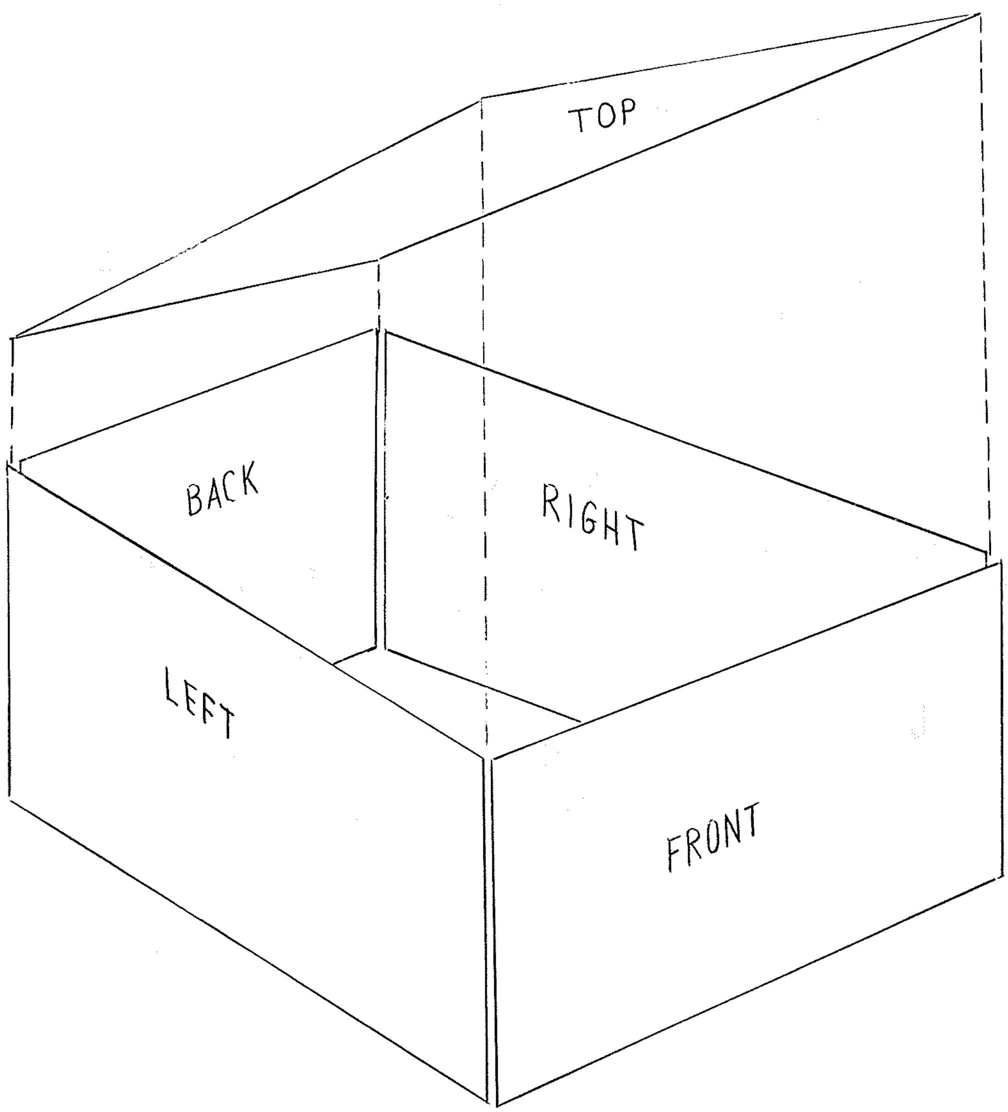


Figure 25 MAIN PLANE POLYGONS

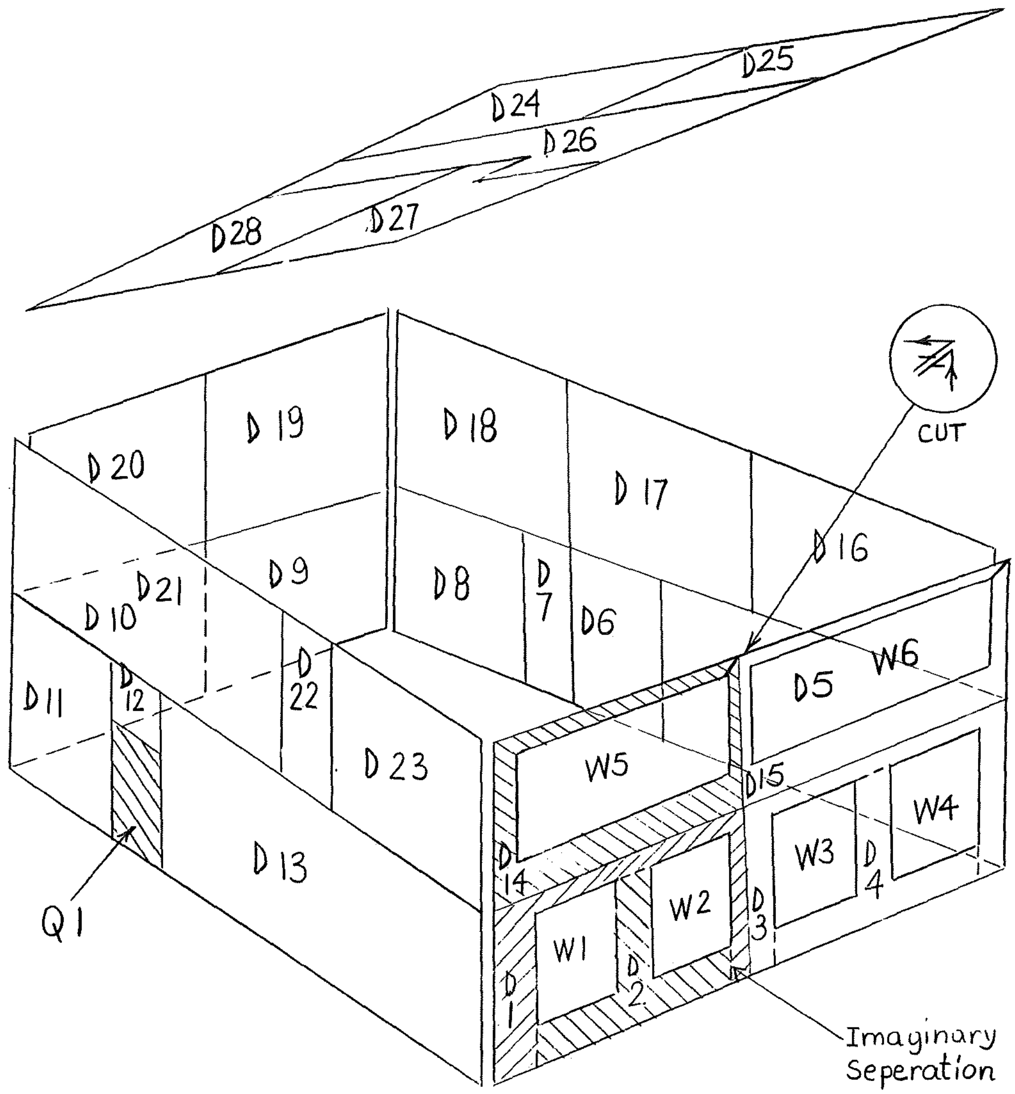


Figure 26 NUMBERED PLANE POLYGONS WHICH CONTACT ONE SPACE ONLY, AND REPRESENT ONLY ONE TYPE OF HEAT TRANSFER SURFACE

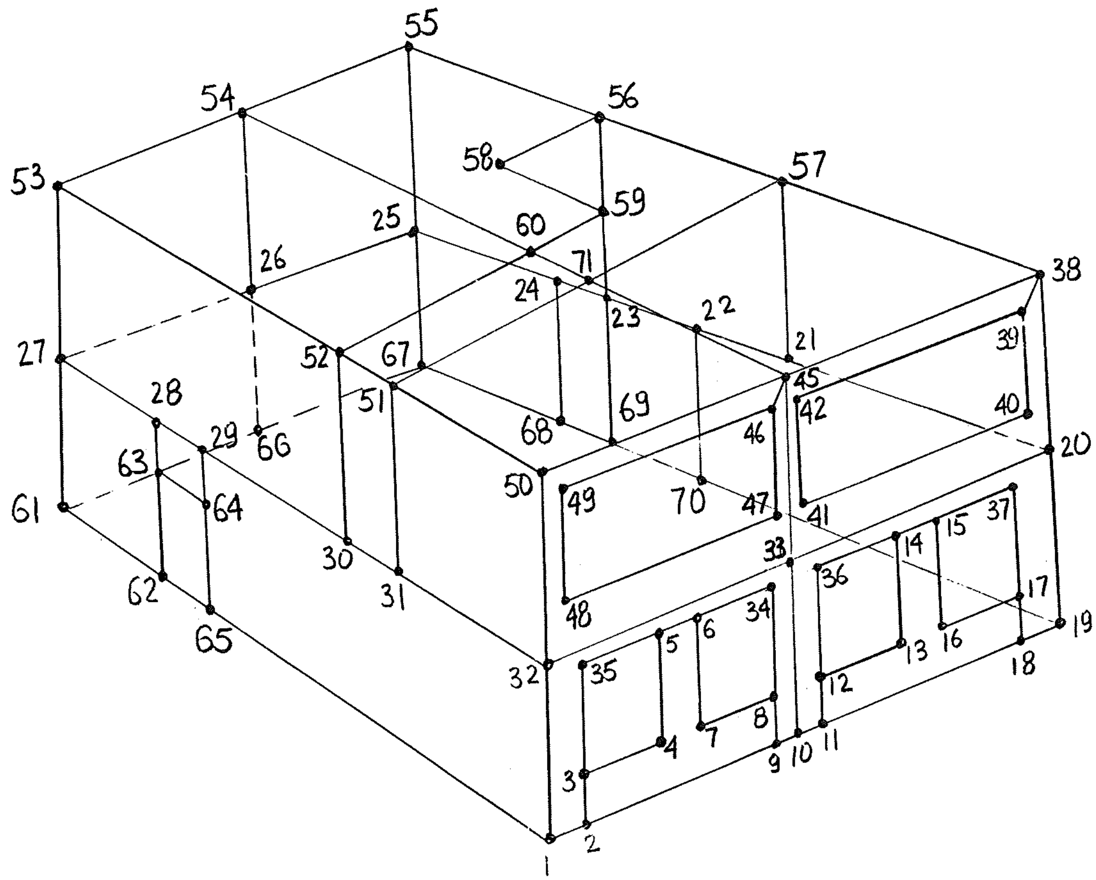


Figure 27 NUMBERED VERTICES OF PLANE POLYGONS WHICH REPRESENT DELAYED, QUICK AND WINDOW-TYPE SURFACES

TABLE 4

WORK FORM NO. 1

LIST OF THE INDICES OF DIFFERENT
TYPE SURFACES ATTACHED TO SPACES

SPACE NO.	INDICES OF																							
	DELAYED SURFACES				QUICK SURFACES				WINDOWS				INTERN.H.T. SURFACES				UNDERGROUND WALLS				UNDERGROUND FLOORS			
3	7	12			1																			
5	1	2	13						1	2														
10	14	23	27						5															
¦																								

TABLE 5

WORK FORM NO. 2

THE VERTEX INDEX ASSIGNMENT OF THE POLYGONS

	VERTEX →	1	2	3	4	5	6	7	8	9	10
	POLYGON INDX ↓	ASSIGNED VERTEX INDEX									
DELAYED	D-1	1	2	35	34	9	10	33	32		
	D-14	32	33	45	46	47	48	49	46	45	50
		¦									
		¦									
QUICK	Q-1	62	63	64	65						
WINDOW	W-1	3	4	5	35						
	W-5	48	47	46	49						
INTERNAL											
UNDERGROUND WALLS											
UNDERGROUND FLOORS											

TABLE 6

WORK FORM NO. 3

COORDINATES OF VERTICES

VERTEX INDEX	X	Y	Z
1	0.0	0.0	0.0
38	50.0	0.0	20.0
⋮			
⋮			

TABLE 7

WORK FORM NO. 4

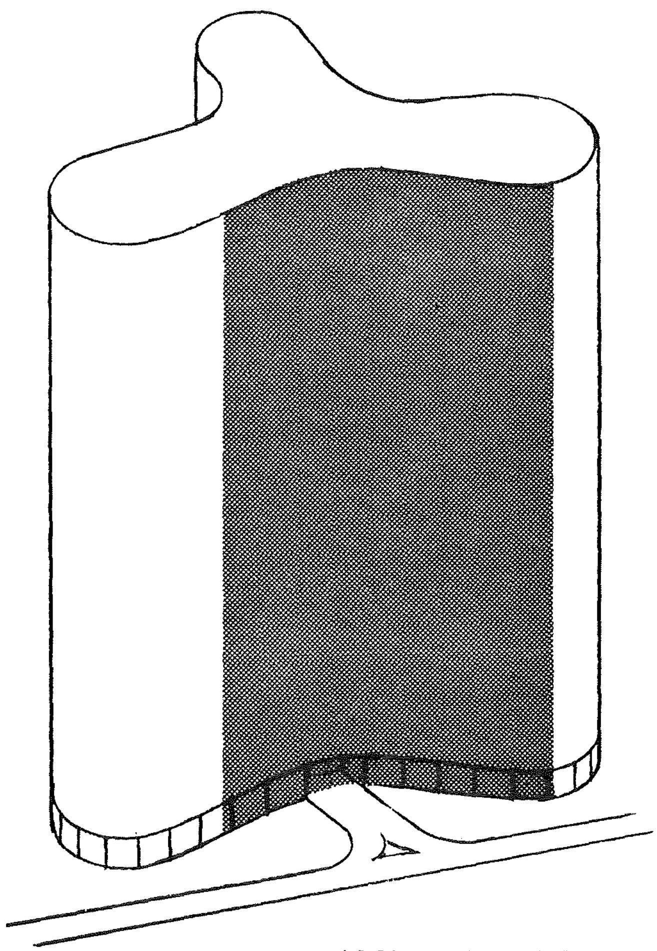
DATA FOR RECTANGULAR POLYGONS

POLYGON INDEX	XCORN	YCORN	ZCORN	HEIGHT	WIDTH	AZIMUTH	TILT
D-5	50.0	0.0	0.0	10.0	35.0	90.0	90.0
W-1	3.0	0.0	0.0	6.0	8.75	180.0	90.0
D-28	0.0	30.0	20.0	35.0	25.0	180.0	0.0
⋮							

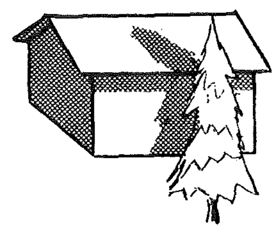
2.4 Shade Input

Let us consider what we mean by the shading problem. There usually are, on a building and in the vicinity of a building, several surfaces which cast shadows upon the building. These shadows reduce the direct solar radiation striking the external surfaces of the building. For this reason, the shading surfaces must be specified for any rational evaluation of air conditioning loads.

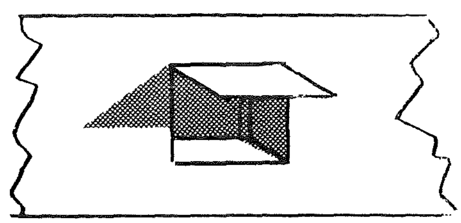
Shading surfaces, as shown in Figure 28, are exemplified by trees, hills and cliffs, adjacent buildings, parapets, domes, overhangs, awnings, window setbacks, and outcroppings of the home building.



Building Shaded by its own Outcroppings



Roof and Tree



Window Overhang and Setback

Figure 28 TYPICAL SHADING SURFACES

The shade input represents all such structures as a series of plane polygons. Even curved surfaces lend themselves to such a representation (see Figure 29). However, a curved surface requires several polygons. The fidelity of such a representation for a curved surface depends upon the number of polygons used.

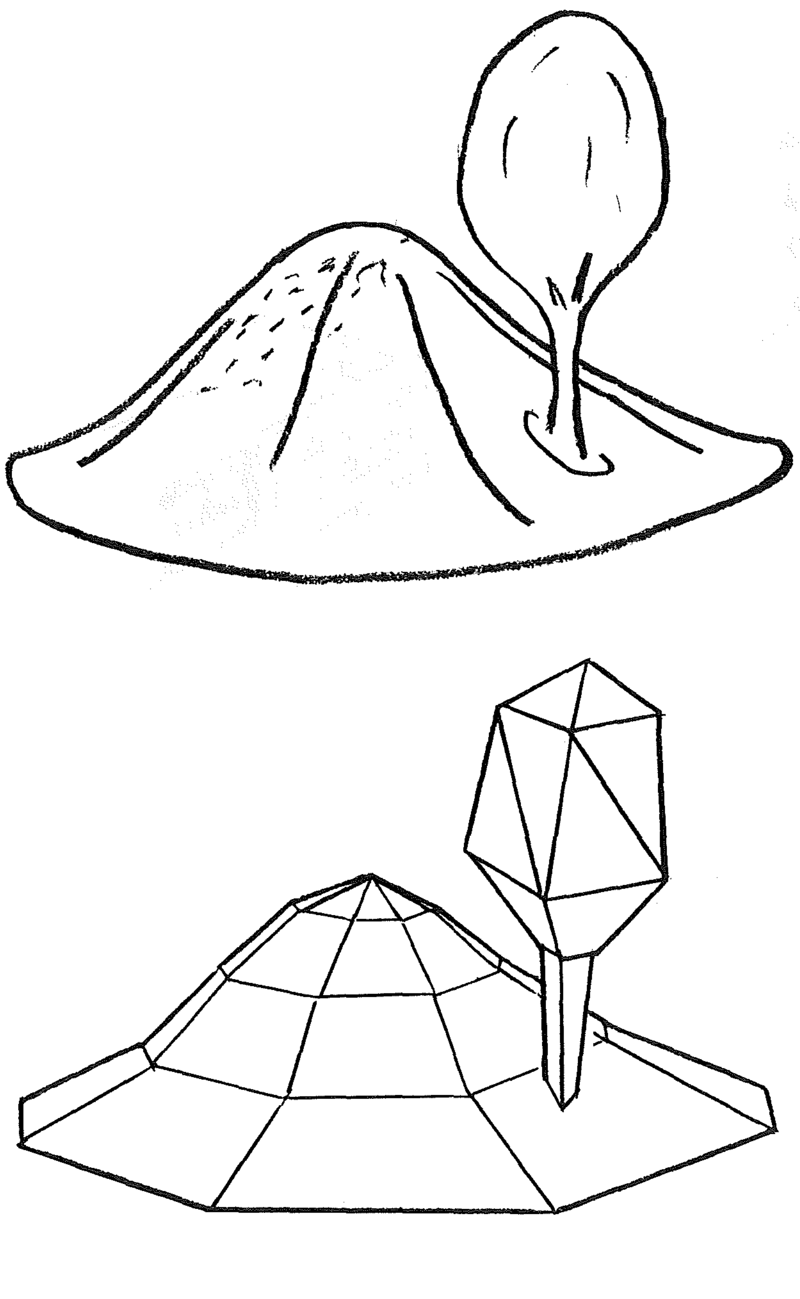
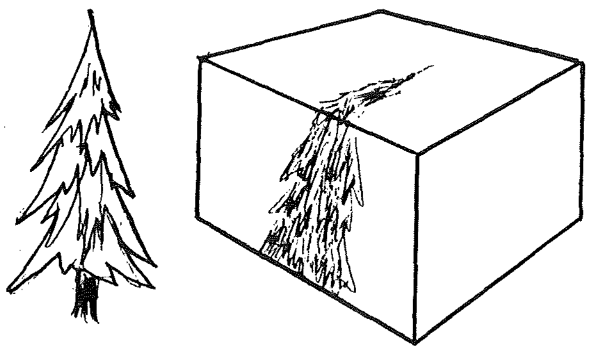
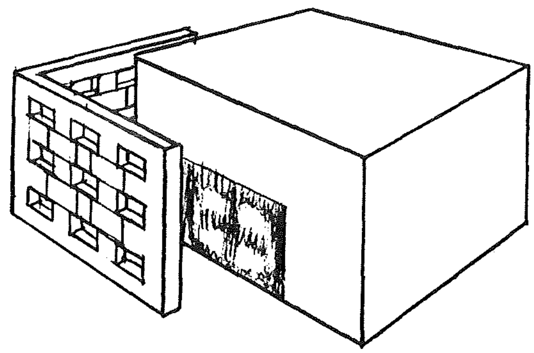


Figure 29 REPRESENTATION OF A HILL AND A TREE BY A NUMBER OF POLYGONS

In some cases, a certain amount of light can filter through perforations in a shading surface. As examples of such transmissive structures, we can mention trees and gratings as shown in Figure 30. These non-opaque structures require a number between 0.0 (transparent) and 1.0 (opaque) to specify how much light gets through.



Tree



Decorative Wall

Figure 30 BUILDINGS SHADED BY TRANSMISSIVE STRUCTURES

2.4.1 Geometric Aspects of Building Shading Surface Data Take-off

Building shading surface geometric data take-off procedure resembles that for heat transfer surfaces, which is explained in Sections 2.3 and 2.3.1. In Step 3, the code letter S should be used for tagging a shading polygon.

To demonstrate different methods for describing shading polygons, let's describe the gable roof with overhang of Figure 31.

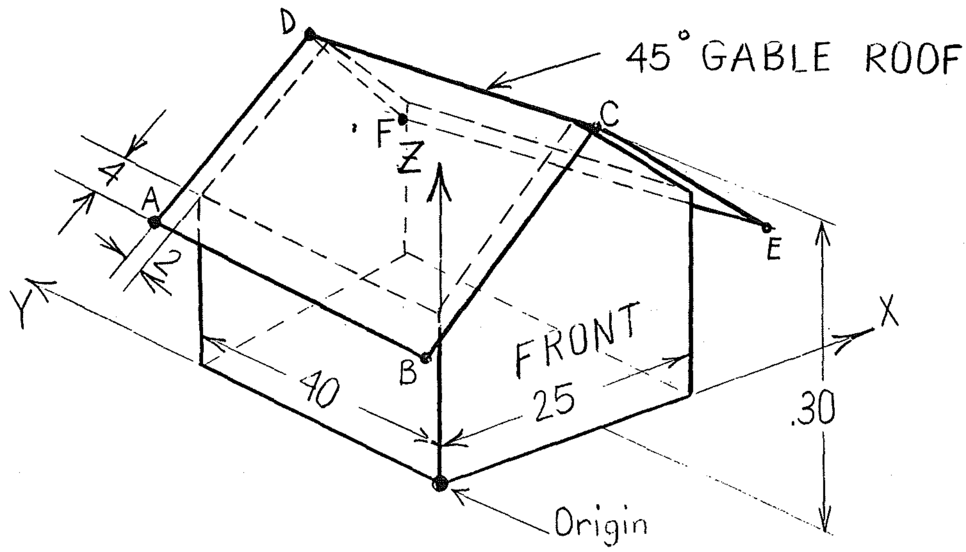


Figure 31 GABLE ROOF WITH OVERHANG

Firstly, we must realize that, by the use of polygons, there are several ways of describing the roof overhang. This means that the engineer has a decision to make, and in order to make this decision, he must understand the polygons method very thoroughly. Through such understanding, he may use the computer program with an expertise resulting in correct computation of shadows, minimization of input labor, and conservation of both computer time and core storage. To achieve some of this understanding, let us investigate three methods of representing the roof overhang.

Method 1

A minimum of two polygons may be used to represent the roof overhang. These are the two rectangles ABCD and DCEF. Each has four vertices. The coordinates of vertices, which may be calculated from Figure 31 or read directly from an orthographic projection, are given in Table 8.

TABLE 8

COORDINATES OF ROOF VERTICES

Vertex	X	Y	Z
A	-2.828	42.000	14.672
B	-2.828	-2.000	14.672
C	12.500	-2.000	30.000
D	12.500	42.000	30.000
E	27.828	-2.000	14.672
F	27.828	42.000	14.672

In this method, each of the two shade polygons input coincides with a heat transfer surface, namely, the roof itself. This raises a problem: depending upon how the last decimal places are handled, the polygons ABCD and DCEF may completely shade the roof. One way around this problem would be to reduce the Z coordinates of the vertices by a small amount to insure that the "shading roof" is below the "heat gathering roof".

By this scheme, the two Z values would be, perhaps, 14.670 and 29.998 rather than 14.672 and 30.000. The change of 2/1000ths of a foot would not significantly affect the accuracy of the computation, but would guarantee that the roof would see light.

Method 2

Another way to avoid the superposition of a shading surface and a heat transfer surface in the case of the gable overhang is to avoid the middle portion of the roof, as shown in Figure 32, and input only the overhanging portion of the roof.

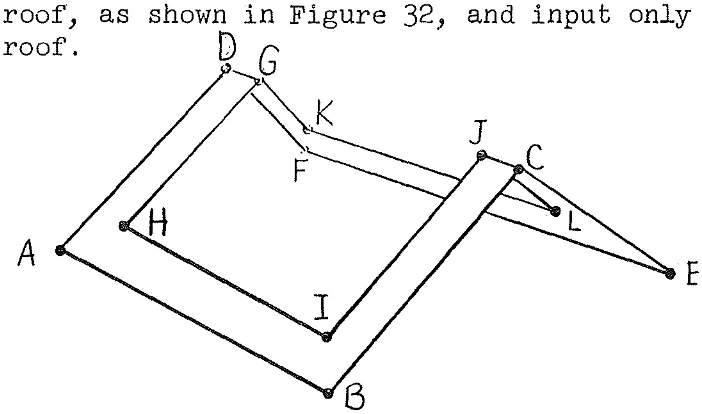


Figure 32 GABLE ROOF - OVERHANG ONLY

Here again, a minimum of two polygons will suffice. These are the octagons (eight-sided polygons) ABCJIHGD and EFDGKLJC. The coordinates of vertices are given in Table 9.

TABLE 9

COORDINATES OF ROOF VERTICES

Vertex	X	Y	Z
A	-2.828	42.000	14.672
B	-2.828	-2.000	14.672
C	12.500	-2.000	30.000
D	12.500	42.000	30.000
E	27.828	-2.000	14.672
F	27.828	42.000	14.672
G	12.500	40.000	30.000
H	0.000	40.000	17.500
I	0.000	0.000	17.500
J	12.500	0.000	30.000
K	25.000	40.000	17.500
L	25.000	0.000	17.500

Method 3

It is a geometric theorem that eight numbers are needed to specify the size and position of a rectangle in space. Where two sides of the rectangle are known to be horizontal, only seven numbers are required. For such rectangles, we have been giving 12 numbers (3 coordinates, each of 4 vertices), so it seems reasonable that the data could be simplified. As explained in Section 2.3.1, there is a provision in the Load Calculation Sub-program for such simplified data for rectangles. The data for this method is given in Table 10.

TABLE 10

COORDINATES OF LOWER LEFT-HAND CORNERS, HEIGHT, WIDTH, AZIMUTH AND TILT ANGLES OF ROOF SHADING POLYGONS

POLYGON	XCORN	YCORN	ZCORN	HEIGHT	WIDTH	AZIMUTH	TILT
ABCD	-2.828	42.000	14.672	21.7	44.0	270.0	45.0
EFDC	27.828	-2.000	14.672	21.7	44.0	90.0	135.0

In this method also the Z coordinates of the lower left-hand corner should be reduced as described under Method 1, and when using this method, the number of vertices of a polygon is set equal to one in the coding form. This is a code to notify the computer that simplified data for a rectangle will follow.

In the three methods described above, Tables 8 and 9 are the equivalent of Table 6, and Table 10 is equivalent of Table 7. The data from these tables is easily transferred through input forms (see Section 2.5) to coding forms.

2.5 Input Forms

In practice, the engineer who prepares the input for the computer program can skip most of the steps outlined in subsections 2.3 and 2.3.1. He will transfer the pertinent data, by inspection, directly from the blueprints to the input forms. Such intuitive facility comes from experience.

The input forms which follow in Figures 33 through 39 are self-explanatory. However, it should be noted that they require not only the geometric data, such as the vertex coordinates, but also the other necessary information which is required by the Load Calculation Sub-program. The order of input to the program is explained in the next section.

NUMBER OF POLYGONS

Fill in only before first common polygon or before the first of a list of added polygons. Enter the number of common polygons or the number of additions. Otherwise, leave blank.

NUMBER OF VERTICES	TRANS-MITTANCE

Enter 1.0 here if a rectangle follows and simplified input is desired.

VERTEX COORDINATES

If 1.0 has been entered above, enter only one vertex (lower left-hand corner). If not, enter each vertex in the polygon.

X	Y	Z

DATA FOR RECTANGLES

Fill in these entries only if 1.0 has been entered above.

HEIGHT	WIDTH	AZIMUTH	TILT

Figure 33 SHADE INPUT FORM

NUMBER OF D SURFACES

Fill in only before first delayed surface. Otherwise, leave blank.

ABSORP-TIVITY	GROUND RE-FLECTIVITY

Enter 1.0 here if a rectangle follows and simplified input is desired.

NUMBER OF VERTICES	NUMBER OF X DIVISIONS	NUMBER OF Y DIVISIONS	NUMBER OF CSS DELAYED	NUMBER OF SS ADDED	SURF.ROUGH-NESS INDEX	INDEX FOR TYPE

VERTEX COORDINATES

If 1.0 has been entered above, enter only one vertex (lower left-hand corner). If not, enter each vertex in the polygon.

X	Y	Z

DATA FOR RECTANGLES

Fill in these entries only if 1.0 has been entered above.

HEIGHT	WIDTH	AZIMUTH	TILT

INDICES OF COMMON SHADING POLYGONS KNOWN TO BE UNIMPORTANT FOR THIS DELAYED SURFACE. THESE INDICES MUST BE ENTERED IN ASCENDING ORDER.

If number of additions entered above is 0.0, start the next delayed surface or, if this is the last delayed surface, start the quick surfaces. If, however, the number of additions is some number larger than 0.0, follow this form with that number of shade input forms and place an added polygon in each.

Figure 34 DELAYED SURFACES INPUT FORM

NUMBER OF Q SURFACES

Fill in only before first quick surface. Otherwise, leave blank.

ABSORP-TIVITY	GROUND RE-FLECTIVITY	HEAT TRANS. COEFFICIENT

Enter 1.0 here if a rectangle follows and simplified input is desired.

NUMBER OF VERTICES	NUMBER OF X DIVISIONS	NUMBER OF Y DIVISIONS	NUMBER OF CSS DELAYED	NUMBER OF SS ADDED	SURF.ROUGH-NESS INDEX

VERTEX COORDINATES

If 1.0 has been entered above, enter only one vertex (lower left-hand corner). If not, enter each vertex in the polygon.

X	Y	Z

DATA FOR RECTANGLES

Fill in these entries only if 1.0 has been entered above.

HEIGHT	WIDTH	AZIMUTH	TILT

INDICES OF COMMON SHADING POLYGONS KNOWN TO BE UNIMPORTANT FOR THIS QUICK SURFACE. THESE INDICES MUST BE ENTERED IN ASCENDING ORDER.

If number of additions entered above is 0.0, start the next quick surface or, if this is the last quick surface, start the windows. If, however, the number of additions is some number larger than 0.0, follow this form with that number of shade input forms and place an added polygon in each.

Figure 35 QUICK SURFACES INPUT FORM

NUMBER OF WINDOWS

← Fill in only before first window. Otherwise, leave blank.

SHADING CO-EFFICIENT	FORM FACTOR WDW - SKY	FORM FACTOR WDW- GROUND	GROUND RE-FLECTIVITY

Enter 1.0 here if a rectangle follows and simplified input is desired.

NUMBER OF VERTICES	NUMBER OF X DIVISIONS	NUMBER OF Y DIVISIONS	NUMBER OF CSS DELAYED	NUMBER OF SS ADDED	NUMBER OF PANES	INDEX FOR TYPE

VERTEX COORDINATES

If 1.0 has been entered above, enter only one vertex (lower left-hand corner). If not, enter each vertex in the polygon.

X	Y	Z

DATA FOR RECTANGLES

Fill in these entries only if 1.0 has been entered above.

HEIGHT	WIDTH	AZIMUTH	TILT

INDICES OF COMMON SHADING POLYGONS KNOWN TO BE UNIMPORTANT FOR THIS WINDOW. THESE INDICES MUST BE ENTERED IN ASCENDING ORDER.

If number of additions entered above is 0.0, start the next window or, if this is the last window, start the internal heat transfer surfaces. If, however, the number of additions is some number larger than 0.0, follow this form with that number of shade input forms and place an added polygon in each.

Figure 36 WINDOWS INPUT FORM

NUMBER OF INTERN.H.T. SURFACES

AREA	HEAT TRANSFER COEFFICIENT	INDEX OF SPACE ON ONE SIDE	INDEX OF SPACE ON OTHER SIDE

Figure 37 INTERNAL HEAT TRANSFER SURFACES INPUT FORM

NUMBER OF UGW OR UGF

AREA	HEAT TRANSFER COEFFICIENT

Figure 38 UNDERGROUND WALLS AND UNDERGROUND FLOORS INPUT FORM

NUMBER OF SPACES

NUMBER OF DELAYED SURFACES	NUMBER OF QUICK SURFACES	NUMBER OF WINDOWS	NUMBER OF INTERNAL PARTITIONS	NUMBER OF UNDERGROUND WALLS	NUMBER OF UNDERGROUND FLOORS

FLOOR AREA	VOLUME	WEIGHT OF FLOOR	TEMPERATURE	NUMBER OF PEOPLE	ACTIVITY LEVEL

VENTILATION INDEX	USE INDEX	CODE FOR LIGHTG.LOAD	CODE FOR EQUIP.LOAD	CODE FOR INFILTRATN

WATT/FT^2 LIGHTG.LOAD

← If code for lighting load equal to 0.0, use this.

LIGHTING LOAD

← If code for lighting load equal to 1.0, use this.

WATT/FT^2 EQUIP.LOAD

← If code for equipment load equal to 0.0, use this.

EQUIPMENT LOAD

← If code for equipment load equal to 1.0, use this.

Figure 39 SPACES INPUT FORM - PAGE 1

INDICES OF DELAYED SURFACES						

INDICES OF QUICK SURFACES						

INDICES OF WINDOWS						

INDICES OF INTERNAL HEAT TRANSFER SURFACES						

INDICES OF UNDERGROUND WALLS						

INDICES OF UNDERGROUND FLOORS						

Figure 39 SPACES INPUT FORM - PAGE 2

2.6 Input to Load Calculation Sub-program

2.6.1 Input in the Computer Card Form

Summary of input information for the Load Calculation Sub-program is given in Table 11. The values of some essential data and codes are given in Figures 40 through 42 and Tables 12 through 18.

2.6.2 Input in the Computer Tape Form

Hourly load calculation procedure requires the hourly values of the following weather data.

Dry-bulb temperature
Dew point temperature or wet-bulb temperature
Total cloud amount
Cloud type
Wind velocity
Atmospheric pressure.

The hourly values of the data listed above can be obtained, as Form 1440, either in punch card or magnetic tape form, from the National Weather Record Center, NWRC, Asheville, N. C. Detailed information on these data may be found in:

(1) Reference Manual WBAN Hourly Surface Observations 144, April 1966.

(2) Reference Manual WBAN Solar Radiation - Hourly 280, April 1967.

(3) Tape Reference Manual, Airways Surface Observations, TDF 14.

In the Load Calculation Computer Sub-program, magnetic tape form of data is used. When you give an order for a selected tape, that is, a selected weather station according to the city in which the building is to be located, obtain 10 years of data in such a way that the weather year which you are going to use is among these 10 years and should satisfy your design criteria.

2.7 Output from Load Calculation Sub-program

2.7.1 Mandatory Output

Figures 43, 44, 45 and 46 are the mandatory outputs of the Load Calculation Sub-program.

2.7.2 Optional Output

In the case where wall and roof construction values are to be selected by computer, Figures 47 and 48 may be printed. In the case where hourly values of outside weather data and loads for each space are required, Figures 49 and 50 may be printed. Also, for a given surface, for a given time, pictorial output of shadow may be printed (Figure 51).

TABLE 11

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
LC-1	1 to 35	Facility Name	IDEN1	-	-	-	P.O. and V.M.	Not more than 35 characters
LC-2	1 to 35	Facility location	IDEN2	-	-	-	Chicago, Ill.	Not more than 35 characters
LC-3	1 to 35	Name of engineer	IDEN3	-	-	-	M. Lokmanhekim	Not more than 35 characters
LC-4	1 to 15	Project number	IDEN4	-	-	-	61311	Not more than 15 characters
LC-5	1 to 15	Date	IDEN5	-	-	-	18 October 1969	Not more than 15 characters
LC-6	1 to 10	Latitude	STALAT	Degree	-90.0 to 90.0	-	42.0	-
	11 to 20	Longitude	STALON	Degree	0.0 to 360.0	-	88.0	-
	21 to 30	Time zone number	TZN	-	4.0 to 8.0	-	6.0	See Figure 40 and Table 12 on page 65.
	31 to 40	Clearness number for summer	CNS	-	0.90 to 1.05	-	0.98	See Figure 41 on page 65.
	41 to 50	Clearness number for winter	CNW	-	0.90 to 1.05	-	0.98	See Figure 41 on page 65.
	51 to 60	Building azimuth	BAZ	Degree	0.0 to 360.0	-	270.0	-
LC-7	1 to 10	Weather year	YEAR	-	-	-	1949.0	-
	11 to 20	Month at which study to be started	ONTH	-	1 to 12	-	11.0	-
	21 to 30	Length of study	ENGTH	Day	1 to 365	-	7.0	See Table 13 on page 66.
	31 to 40	Length of Christmas schedule	XMAS	Day	1 to 365	-	100.0	-
	41 to 50	Estimated initial wall and roof outside surface temperature	TDB	°F	-50.0 to 150.0	-	80.0	-
LC-8	1 to 10	Code for printing hourly space thermal and infiltration loads	CPRINT	-	0.0 to 1.0	0.0 Printing is not wanted 1.0 Printing is wanted	1.0	-
LC-9	1 to 10	Number of different types of schedules	TYPS	-	1.0 to 3.0	-	2.0	1st type- Work room areas 2nd type- Office areas 3rd type- Special areas

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
THE READING ORDERS 10, 11, 12 and 13 INCLUSIVE SHOULD BE REPEATED "TYPS" TIMES.								
LC-10	1 to 10	Code for people schedule	CFKSCH	-	0.0 or 1.0	0.0 Schedule is not applicable 1.0 Schedule is applicable	1.0	If equal to 0.0, skip reading order 11; go to 12.
	11 to 20	Code for lighting schedule	CLTSCH	-	0.0 or 1.0	0.0 Schedule is not applicable 1.0 Schedule is applicable	1.0	If equal to 0.0, skip reading order 12; go to 13.
	21 to 30	Code for equipment schedule	CEQSCH	-	0.0 or 1.0	0.0 Schedule is not applicable 1.0 Schedule is applicable	1.0	If equal to 0.0, skip reading order 13; go to 14.
THE FOLLOWING READING ORDER SHOULD BE REPEATED 9 TIMES: 1st card for Sunday, 2nd card for Monday, 3rd card for Tuesday, 4th card for Wednesday, 5th card for Thursday, 6th card for Friday, 7th card for Saturday, 8th card for Holiday, and 9th card for Christmas.								
LC-11	1 to 72	People schedule	SCHFIK	-	0.0 to 1.0	-	0.5	Each card includes schedule for 24 hours starting from 1:00 A.M.
THE FOLLOWING READING ORDER SHOULD BE REPEATED 9 TIMES: 1st card for Sunday, 2nd card for Monday, 3rd card for Tuesday, 4th card for Wednesday, 5th card for Thursday, 6th card for Friday, 7th card for Saturday, 8th card for Holiday, and 9th card for Christmas.								
LC-12	1 to 72	Lighting schedule	SCHLIT	-	0.0 to 1.0	-	1.0	Each card includes schedule for 24 hours starting from 1:00 A.M.
THE FOLLOWING READING ORDER SHOULD BE REPEATED 9 TIMES: 1st card for Sunday, 2nd card for Monday, 3rd card for Tuesday, 4th card for Wednesday, 5th card for Thursday, 6th card for Friday, 7th card for Saturday, 8th card for Holiday, and 9th card for Christmas.								
LC-13	1 to 72	Equipment schedule	SCHEQ	-	0.0 to 1.0	-	0.75	Each card includes schedule for 24 hours starting from 1:00 A.M.
LC-14	1 to 10	Number of common shading surfaces	FNSP	-	0.0 to --	-	0.0	If equal to 0.0, skip reading orders 15, 16, and 16'; go to 17.
THE READING ORDERS 15 AND 16 (OR 16' OR 16 + 16') INCLUSIVE SHOULD BE REPEATED "FNSP" TIMES.								
LC-15	1 to 10	Number of vertices in Ith surface	FNVSP	-	1.0 or 3.0 to --	1.0 Short form for a rectangle	3.0	If equal to 1.0, use reading order 16; otherwise use 16'.
	11 to 20	Transmittance of Ith surface	PSP	-	0.0 to 1.0	0.0 Opaque 1.0 Clear	0.5	-
LC-16	1 to 10	Coordinates of lower left-hand corner of Ith rectangular surface when viewed from outside	XCORN	Ft	-	-	50.0	-
	11 to 20		YCORN	Ft	-	-	10.0	-
	21 to 30		ZCORN	Ft	-	-	5.0	-
	31 to 40	Height of Ith surface	H	Ft	-	-	15.0	-
	41 to 50	Width of Ith surface	W	Ft	-	-	50.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
	51 to 60	Azimuth angle of Ith surface	A	Degree	0.0 to 360.0	-	45.0	-
	61 to 70	Tilt angle of Ith surface	B	Degree	0.0 to 180.0	-	90.0	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVSP" TIMES.								
LC-16'	1 to 10	Coordinates of Jth vertex of Ith surface	XSP	Ft	-	-	15.0	-
	11 to 20		YSP	Ft	-	-	20.0	-
	21 to 30		ZSP	Ft	-	-	0.0	-
LC-17	1 to 10	Number of different types of delayed surfaces	FNRF	-	0.0 to --	-	2.0	If equal to 0.0, skip reading orders 18 through 29; go to 30.
THE READING ORDERS 18, AND 19 (OR 19' + 20) INCLUSIVE SHOULD BE REPEATED "FNRF" TIMES.								
LC-18	1 to 10	Code for the properties of the layers of surface	FKNOW	-	0.0 to 1.0	0.0 Properties are not known 1.0 Properties are known	1.0	If equal to 0.0, use reading order 19; skip 19' and 20. If equal to 1.0, skip reading order 19; use 19' and 20.
LC-19	1 to 10	Code for being wall or roof	CODWOR	-	0.0 or 1.0	0.0 Wall 1.0 Roof	0.0	-
	11 to 20	Code for outside surface type	ES	-	1.0 to 6.0 Wall 1.0 to 3.0 Roof	-	2.0	See Tables 14 and 15 on page 66.
	21 to 30	Maximum overall heat transfer coefficient	UMAX	Btu/hr,ft^2, °F	-	-	0.34	-
	31 to 40	Thickness of insulation	TINS	Inch	0.0 to --	-	1.0	-
	41 to 50	Code for selection of winter or summer condition	COLD	-	1.0 or 2.0	1.0 Winter 2.0 Summer	2.0	-
LC-19'	1 to 10	Number of layers of Ith surface	FNOL	-	1.0 to --	-	5.0	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNOL" TIMES. (Note: First and last cards should include information for outside and inside layers respectively.)								
LC-20	1 to 10	Thickness of the Jth layer of Ith surface	XL	Ft	-	-	0.333	If layer has no thermal mass, set equal to 0.0.
	11 to 20	Thermal conductivity of the Jth layer of Ith surface	XK	Btu/hr,ft^2, °F	-	-	0.770	If layer has no thermal mass, set equal to 0.0.

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
	21 to 30	Density of the Jth layer of the Ith surface	D	lb/ft^3	-	-	125.0	If layer has no thermal mass, set equal to 0.0.
	31 to 40	Specific heat capacity of the Jth layer of Ith surface	SH	Btu/lb,°F	-	-	0.22	If layer has no thermal mass, set equal to 0.0.
	41 to 50	Thermal resistivity of the Jth layer of Ith surface	RES	Hr,ft^2,°F/ Btu	-	-	0.00	If layer has thermal mass, set equal to 0.0.
LC-21	1 to 10	Number of delayed heat transfer surfaces in the building	FNDB	-	0.0 to --	-	28.0	If equal to 0.0, skip reading orders 22 through 29 ; go to 30.
THE READING ORDERS 22, 23, 24 (OR 24' OR 24 + 24'), 25, 26, 27 (OR 27' OR 27 + 27') INCLUSIVE SHOULD BE REPEATED "FNDB" TIMES.								
LC-22	1 to 10	Absorptivity of outside of Ith surface	ABD	-	0.0 to 1.0	-	0.35	See Table 16 on pages 67, 68, 69.
	11 to 20	Reflectivity of ground facing Ith surface	ROGD	-	0.0 to 1.0	-	0.30	See Table 17 on page 69.
LC-23	1 to 10	Number of vertices of Ith surface	FNVD	-	1.0 or 3.0 to --	1.0 Short form for a rectangle	1.0	If equal to 1.0, use reading order 24; otherwise use 24'
	11 to 20	Number of X divisions of Ith surface	FNXD	-	1.0 to --	-	15.0	-
	21 to 30	Number of Y divisions of Ith surface	FNYD	-	1.0 to --	-	10.0	-
	31 to 40	Number of common shading surfaces deleted from Ith surface	FNDD	-	0.0 or less than or equal to FNSP	-	2.0	If equal to 0.0 or FNSP, skip reading order 25.
	41 to 50	Number of added shading surfaces to Ith surface	FNAD	-	0.0 to --	-	3.0	-
	51 to 60	Surface roughness index	FISD	-	1.0 to 6.0	-	2.0	See Table 14 on page 66.
	61 to 70	Index for type of Ith surface	FIRF	-	1.0 to FNRF	-	1.0	-
LC-24	1 to 10	Coordinates of lower left-hand corner of Ith rectangular surface when viewed from outside	XCORN	Ft	-	-	18.5	-
	11 to 20		YCORN	Ft	-	-	23.7	-
	21 to 30		ZCORN	Ft	-	-	1.3	-
	31 to 40	Height of Ith surface	H	Ft	-	-	10.0	-
	41 to 50	Width of Ith surface	W	Ft	-	-	15.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
	51 to 60	Azimuth angle of Ith surface	A	Degree	0.0 to 360.0	-	0.0	-
	61 to 70	Tilt angle of Ith surface	B	Degree	0.0 to 180.0	-	25.5	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVD" TIMES.								
LC-24'	1 to 10	Coordinates of Jth vertex of Ith surface	XVD	Ft	-	-	25.5	-
	11 to 20		YVD	Ft	-	-	18.5	-
	21 to 30		ZVD	Ft	-	-	0.0	-
LC-25	1 to 10 : 61 to 70	Index of Jth common shading surface deleted from Ith surface	FIDD	-	1.0 to FNSP	-	2.0, 5.0,......	If number of deletions is greater than seven, use more than one computer card.
THE READING ORDERS 26 AND 27 (OR 27' OR 27 + 27') INCLUSIVE SHOULD BE REPEATED "FNAD" TIMES.								
LC-26	1 to 10	Number of vertices of Jth surface added to Ith surface	FNVAD	-	1.0 or 3.0 to --	1.0 Short form for a rectangle	8.0	If equal to 1.0, use reading order 27, otherwise use 27'.
	11 to 20	Transmittance of Jth surface added to Ith surface	PAD	-	0.0 to 1.0	0.0 Opaque 1.0 Clear	0.8	-
LC-27	1 to 10	Coordinates of lower left-hand corner of Jth rectangular surface added to Ith surface when viewed from outside	XCORN	Ft	-	-	12.0	-
	11 to 20		YCORN	Ft	-	-	11.0	-
	21 to 30		ZCORN	Ft	-	-	10.0	-
	31 to 40	Height of Jth surface added to Ith surface	H	Ft	-	-	5.0	-
	41 to 50	Width of Jth surface added to Ith surface	W	Ft	-	-	6.0	-
	51 to 60	Azimuth angle of Jth surface added to Ith surface	A	Degree	0.0 to 360.0	-	35.0	-
	61 to 70	Tilt angle of Jth surface added to Ith surface	B	Degree	0.0 to 180.0	-	90.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVAD" TIMES.								
LC-27'	1 to 10	Coordinates of Kth vertex of Jth surface added to Ith surface	XAD	Ft	-	-	15.0	-
	11 to 20		YAD	Ft	-	-	23.0	-
	21 to 30		ZAD	Ft	-	-	12.0	-
LC-28	1 to 10	Total number of pictorial outputs desired	FLOOKD	-	0.0 to --	-	5.0	If equal to 0.0, skip reading order 29; go to 30.
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FLOOKD" TIMES.								
LC-29	1 to 10	Month	FMLOKD	-	1.0 to 12.0	-	7.0	-
	11 to 20	Hour of the day	FILOKD	-	1.0 to 24.0	-	11.0	-
	21 to 30	Surface index	FJLOKD	-	1.0 to FNDB	-	3.0	-
LC-30	1 to 10	Number of Quick heat transfer surfaces in the building	FNQB	-	0.0 to --	-	1.0	If equal to 0.0, skip reading orders 31 through 38; go to 39.
THE READING ORDERS 31, 32, 33 (OR 33' OR 33 + 33'), 34, 35, 36 (OR 36' OR 36 + 36') INCLUSIVE SHOULD BE REPEATED "FNQB" TIMES.								
LC-31	1 to 10	Absorptivity of outside of Ith surface	ABQ	-	0.0 to 1.0	-	0.3	See Table 16 on pages 67, 68, 69.
	11 to 20	Reflectivity of ground facing Ith surface	ROGQ	-	0.0 to 1.0	-	0.4	See Table 17 on page 69.
	21 to 30	Heat transfer coefficient	UQI	Btu/hr,ft^2,°F	-	-	1.65	-
LC-32	1 to 10	Number of vertices of Ith surface	FNVQ	-	1.0 or 3.0 to --	-	4.0	If equal to 1.0, use reading order 33; otherwise use 33'.
	11 to 20	Number of X divisions of Ith surface	FNXQ	-	1.0 to --	-	10.0	-
	21 to 30	Number of Y divisions of Ith surface	FNYQ	-	1.0 to --	-	5.0	-
	31 to 40	Number of common shading surfaces deleted from Ith surface	FNDQ	-	0.0 or less than or equal FNSP	-	0.0	If equal to 0.0 or FNSP, skip reading order 34.
	41 to 50	Number of added shading surfaces to Ith surface	FNAQ	-	0.0 to --	-	3.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
	51 to 60	Surface roughness index	FISQ	-	1.0 to 6.0	-	4.0	See Table 14 on page 66.
LC-33	1 to 10	Coordinates of lower left-hand corner of Ith rectangular surface when viewed from outside	XCORN	Ft	-	-	25.0	-
	11 to 20		YCORN	Ft	-	-	15.0	-
	21 to 30		ZCORN	Ft	-	-	20.0	-
	31 to 40	Height of Ith surface	H	Ft	-	-	10.0	-
	41 to 50	Width of Ith surface	W	Ft	-	-	5.0	-
	51 to 60	Azimuth angle of Ith surface	A	Degree	0.0 to 360.0	-	360.0	-
	61 to 70	Tilt angle of Ith surface	B	Degree	0.0 to 180.0	-	90.0	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVQ" TIMES.								
LC-33'	1 to 10	Coordinates of Jth vertex of Ith surface	XVQ	Ft	-	-	25.0	-
	11 to 20		YVQ	Ft	-	-	20.0	-
	21 to 30		ZVQ	Ft	-	-	10.0	-
LC-34	1 to 10 : 61 to 70	Index of Jth common shading surface deleted from Ith surface	FIDQ	-	1.0 to FNSP	-	3.0, 4.0, ...	If number of deletion is greater than seven, use more than one computer card.
THE READING ORDERS 35 AND 36 (OR 36' OR 36 + 36') INCLUSIVE SHOULD BE REPEATED "FNAQ" TIMES.								
LC-35	1 to 10	Number of vertices of Jth surface added to Ith surface	FNVAQ	-	1.0 or 3.0 to --	1.0 Short form for a rectangle	8.0	If equal to 1.0, use reading order 36; otherwise use 36'.
	11 to 20	Transmittance of Jth surface added to Ith surface	PAQ	-	0.0 to 1.0	0.0 Opaque 1.0 Clear	0.8	-
LC-36	1 to 10	Coordinates of lower left-hand corner of Jth rectangular surface added to Ith surface when viewed from outside	XCORN	Ft	-	-	12.0	-
	11 to 20		YCORN	Ft	-	-	11.0	-
	21 to 30		ZCORN	Ft	-	-	10.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
	31 to 40	Height of Jth surface added to Ith surface	H	Ft	-	-	5.0	-
	41 to 50	Width of Jth surface added to Ith surface	W	Ft	-	-	6.0	-
	51 to 60	Azimuth angle of Jth surface added to Ith surface	A	Degree	0.0 to 360.0	-	35.0	-
	61 to 70	Tilt angle of Jth surface added to Ith surface	B	Degree	0.0 to 180.0	-	90.0	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVAQ" TIMES.								
LC-36'	1 to 10	Coordinates of Kth vertex of Jth surface added to Ith surface	XAQ	Ft	-	-	12.0	-
	11 to 20		YAQ	Ft	-	-	0.0	-
	21 to 30		ZAQ	Ft	-	-	1.0	-
LC-37	1 to 10	Total number of pictorial outputs desired	FLOOKQ	-	0.0 to --	-	2.0	If equal to 0.0, skip reading order 38; go to 39.
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FLOOKQ" TIMES.								
LC-38	1 to 10	Month	FMLOKQ	-	1.0 to 12.0	-	11.0	-
	11 to 20	Hour of the day	FILOKQ	-	1.0 to 24.0	-	9.0	-
	21 to 30	Surface index	FJLOKQ	-	1.0 to FNQS	-	5.0	-
LC-39	1 to 10	Number of windows in the building	FNWB	-	0.0 to --	-	6.0	If equal to 0.0, skip reading orders 40 through 47; go to 48.
THE READING ORDERS 40, 41, 42 (OR 42' OR 42 + 42'), 43, 44, 45 (OR 45' OR 45 + 45') INCLUSIVE SHOULD BE REPEATED "FNWB" TIMES.								
LC-40	1 to 10	Internal shading coefficient	SHACO	-	0.0 to 1.0	-	0.5	See ASHRAE Guide Book.
	11 to 20	Form factor between Ith window and sky	FFWS	-	0.0 to 1.0	-	0.4	-
	21 to 30	Form factor between Ith window and ground	FFWG	-	0.0 to 1.0	-	0.4	-
	31 to 40	Reflectivity of ground facing Ith window	ROGW	-	0.0 to 1.0	-	0.30	See Table 17 on page 69.

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
LC-41	1 to 10	Number of vertices of Ith window	FNVW	-	1.0 or 3.0 to --	1.0 Short form for a rectangle	8.0	If equal to 1.0, use reading order 42; otherwise use 42'.
	11 to 20	Number of X divisions of Ith window	FNXW	-	1.0 to --	-	15.0	-
	21 to 30	Number of Y divisions of Ith window	FNYW	-	1.0 to --	-	10.0	-
	31 to 40	Number of common shading surfaces deleted from Ith window	FNDW	-	0.0 or less than or equal FNSP	-	0.0	If equal to 0.0 or FNSP, skip reading order 43.
	41 to 50	Number of added shading surfaces to Ith window	FNAW	-	0.0 to --	-	5.0	-
	51 to 60	Number of panes of Ith window glass	FNPW	-	1.0 or 2.0	1.0 Single pane 2.0 Double pane	1.0	-
	61 to 70	Index for type of Ith window glass	FGLASW	-	1.0 to 8.0	-	1.0	See Table 18 and Figure 42 on page 70.
LC-42	1 to 10	Coordinates of lower left-hand corner of Ith rectangular window when viewed from outside	XCORN	Ft	-	-	8.5	-
	11 to 20		YCORN	Ft	-	-	22.7	-
	21 to 30		ZCORN	Ft	-	-	2.0	-
	31 to 40	Height of Ith window	H	Ft	-	-	10.0	-
	41 to 50	Width of Ith window	W	Ft	-	-	15.0	-
	51 to 60	Azimuth angle of Ith window	A	Degree	0.0 to 360.0	-	90.0	-
	61 to 70	Tilt angle of Ith window	B	Degree	0.0 to 180.0	-	25.5	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVW" TIMES.								
LC-42'	1 to 10	Coordinates of Jth vertex of Ith window	XVW	Ft	-	-	25.0	-
	11 to 20		YVW	Ft	-	-	5.0	-
	21 to 30		ZVW	Ft	-	-	10.0	-
LC-43	1 to 10 : 61 to 70	Index of Jth common shading surface deleted from Ith window	FIDW	-	1.0 to FNSP	-	3.0,6.0,......	If number of deletions is greater than seven, use more than one computer card.

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
THE READING ORDERS 44 AND 45 (OR 45' OR 45 + 45') INCLUSIVE SHOULD BE REPEATED "FNAW" TIMES.								
LC-44	1 to 10	Number of vertices of Jth surface added to Ith window	FNVAW	-	1.0 or 3.0 to --	1.0 Short form for a rectangle	1.0	If equal to 1.0, use reading order 45; otherwise use 45'.
	11 to 20	Transmittance of Jth surface added to Ith window	PAW	-	0.0 to 1.0	0.0 Opaque 1.0 Clear	0.0	-
LC-45	1 to 10	Coordinates of lower left-hand corner of Jth rectangular surface added to Ith window when viewed from outside	XCORN	Ft	-	-	22.0	-
	11 to 20		YCORN	Ft	-	-	10.0	-
	21 to 30		ZCORN	Ft	-	-	10.0	-
	31 to 40	Height of Jth surface added to Ith window	H	Ft	-	-	15.0	-
	41 to 50	Width of Jth surface added to Ith window	W	Ft	-	-	26.0	-
	51 to 60	Azimuth angle of Jth surface added to Ith window	A	Degree	0.0 to 360.0	-	85.0	-
	61 to 70	Tilt angle of Jth surface added to Ith window	B	Degree	0.0 to 180.0	-	90.0	-
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNVAW" TIMES.								
LC-45'	1 to 10	Coordinates of Kth vertex of Jth surface added to Ith window	XAW	Ft	-	-	25.0	-
	11 to 20		YAW	Ft	-	-	18.0	-
	21 to 30		ZAW	Ft	-	-	12.0	-
LC-46	1 to 10	Total number of pictorial outputs desired	FLOOKW	-	0.0 to --	-	0.0	If equal to 0.0, skip reading order 47; go to 48.
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FLOOKW" TIMES.								
LC-47	1 to 10	Month	FMLOKW	-	1.0 to 12.0	-	1.0	-
	11 to 20	Hour of the day	FILOKW	-	1.0 to 24.0	-	12.0	-
	21 to 30	Window index	FJLOKW	-	1.0 to FNWB	-	5.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
LC-48	1 to 10	Number of internal heat transfer surfaces in the building	FNIHTS	-	0.0 to --	-	0.0	If equal to 0.0, skip reading order 49; go to 50.
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNIHTS" TIMES.								
LC-49	1 to 10	Area of Ith surface	AIHTS	Ft^2	-	-	100.0	-
	11 to 20	Heat transfer coefficient of Ith surface	FIHTS	Btu/hr, ft^2, °F	-	-	0.9	-
	21 to 30	Indices of spaces connected to Ith surface	SPC1	-	-	-	11.0	-
	31 to 40		SPC2	-	-	-	9.0	-
LC-50	1 to 10	Number of underground walls in the building	FNUWB	-	0.0 to --	-	1.0	If equal to 0.0, skip reading order 51; go to 52.
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNUWB" TIMES.								
LC-51	1 to 10	Area of Ith wall	AUW	Ft^2	-	-	50.0	-
	11 to 20	Heat transfer coefficient of Ith wall	FUW	Btu/hr, ft^2, °F	-	-	1.5	-
LC-52	1 to 10	Number of underground floors in the building	FNUFB	-	0.0 to --	-	0.0	If equal to 0.0, skip reading order 53; go to 54.
THE FOLLOWING READING ORDER SHOULD BE REPEATED "FNUFB" TIMES.								
LC-53	1 to 10	Area of Ith floor	AUF	Ft^2	-	-	25.0	-
	11 to 20	Heat transfer coefficient of Ith floor	FUF	Btu/hr, ft^2, °F	-	-	2.0	-
LC-54	1 to 10 : 61 to 70	Ground temperature	TGRND	°F	-	-	30.0, 35.0, ...	First data is for the first month of study. If length of study is greater than seven months, use second computer card. If FNUWB + FNUFB equal to 0.0, skip this reading order.
LC-55	1 to 10	Number of spaces in the building	FNS	-	1.0 to --	-	11.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
THE READING ORDERS 56, 57, 58, 59 (OR 59' OR 59 + 59'), 60 (OR 60' OR 60 + 60'), 61, 62, 63, 64, 65 and 66 INCLUSIVE SHOULD BE REPEATED "FNS" TIMES.								
LC-56	1 to 10	Number of delayed surfaces in the Ith space	FND	-	0.0 to FNDB	-	3.0	If equal to 0.0, skip reading order 61.
	11 to 20	Number of quick surfaces in the Ith space	FNQ	-	0.0 to FNQB	-	2.0	If equal to 0.0, skip reading order 62.
	21 to 30	Number of windows in the Ith space	FNW	-	0.0 to FNWB	-	3.0	If equal to 0.0, skip reading order 63.
	31 to 40	Number of internal surfaces in the Ith space	FINT	-	0.0 to FNIHTS	-	0.0	If equal to 0.0, skip reading order 64.
	41 to 50	Number of underground walls in the Ith space	FNUW	-	0.0 to FNUWB	-	2.0	If equal to 0.0, skip reading order 65.
	51 to 60	Number of underground floors in the Ith space	FNUF	-	0.0 to FNUFB	-	1.0	If equal to 0.0, skip reading order 66.
LC-57	1 to 10	Floor area of Ith space	FLORA	Ft^2	-	-	100.0	-
	11 to 20	Volume of Ith space	VOL	Ft^3	-	-	1000.0	-
	21 to 30	Weight of floor of Ith space	WOF	lb/ft^2	-	-	80.0	-
	31 to 40	Temperature of Ith space	TSPAC	°F	-	-	75.0	-
	41 to 50	Number of people in Ith space	FOLK	-	-	-	5.0	-
	51 to 60	Activity level in the Ith space	HASSL	Btu/hr	400.0 to 1350.0	-	550.0	-
LC-58	1 to 10	Ventilation index of Ith space	VENT	-	0.0 or 1.0	0.0 No return through ceiling plenum 1.0 Return through ceiling plenum	1.0	-
	11 to 20	Use index of Ith space	UINDEX	-	1.0 or 2.0 or 3.0	1.0 Workroom area 2.0 Office area 3.0 Special area	2.0	-
	21 to 30	Code for lighting load of Ith space	CODLIT	-	0.0 or 1.0	0.0 Lighting load is unknown 1.0 Lighting load is known	0.0	If equal to 0.0, use reading order 59; otherwise, use 59'.
	31 to 40	Code for equipment load for Ith space	CODEQ	-	0.0 or 1.0	0.0 Equipment load is unknown 1.0 Equipment load is known	1.0	If equal to 0.0, use reading order 60; otherwise, use 60'.
	41 to 50	Code for infiltration of Ith space	CODINF	-	0.0 or 1.0	0.0 Infiltration is not considered 1.0 Infiltration is considered	0.0	-

TABLE 11 (Con't)

LOAD CALCULATION SUB PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
LC-59	1 to 10	Watts per foot square floor area lighting load of Ith space	WPFSL	Watts	-	-	4.0	-
LC-59'	1 to 10	Lighting power of Ith space	PLITE	KW	-	-	0.5	-
LC-60	1 to 10	Watts per foot square floor area equipment load of Ith space	WPFSE	Watts	-	-	2.0	-
LC-60'	1 to 10	Equipment power of Ith space	QEQ	KW	-	-	1.0	-
LC-61	1 to 10 : 61 to 70	Indices of delayed surfaces of Ith space	FID	-	0.0 to FND	-	3.0,4.0,......	If number of indices is greater than seven, use more than one computer card.
LC-62	1 to 10 : 61 to 70	Indices of quick surfaces of Ith space	FIQ	-	0.0 to FNQ	-	1.0,2.0,......	If number of indices is greater than seven, use more than one computer card.
LC-63	1 to 10 : 61 to 70	Indices of windows of Ith space	FIW	-	0.0 to FNW	-	15.0,22.0,.....	If number of indices is greater than seven, use more than one computer card.
LC-64	1 to 10 : 61 to 70	Indices of internal surfaces in Ith space	FFIHTS	-	0.0 to FINT	-	11.0,22.0,.....	If number of indices is greater than seven, use more than one computer card.
LC-65	1 to 10 : 61 to 70	Indices of underground walls in Ith space	FIUW	-	0.0 to FNUW	-	6.0,7.0,......	If number of indices is greater than seven, use more than one computer card.
LC-66	1 to 10 : 61 to 70	Indices of underground floors in Ith space	FIUF	-	0.0 to FNUF	-	9.0,12.0,.....	If number of indices is greater than seven, use more than one computer card.

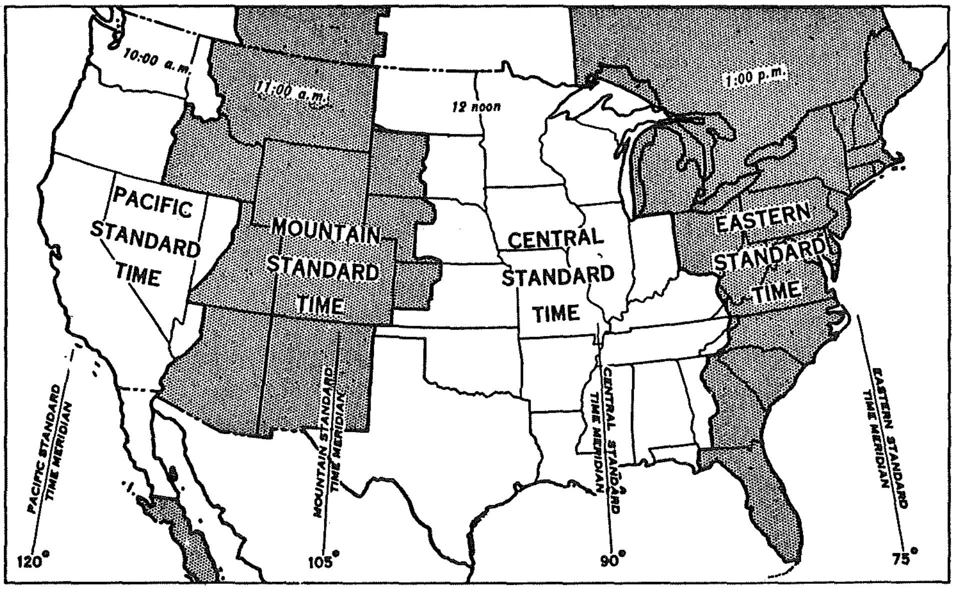


Figure 40 TIME ZONES IN THE UNITED STATES

TABLE 12

TIME ZONE NUMBERS IN U.S. FOR STANDARD TIME

TIME ZONE	TZ No.
Atlantic	4
Eastern	5
Central	6
Mountain	7
Pacific	8

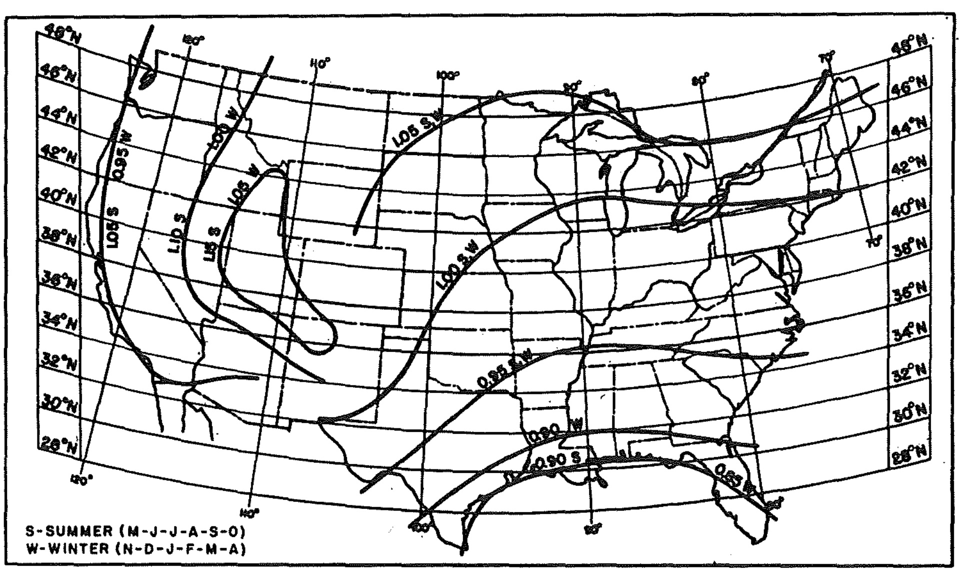


Figure 41 CLEARNESS NUMBERS OF NON-INDUSTRIAL ATMOSPHERE IN UNITED STATES

TABLE 13 UPPER LIMIT FOR LENGTH OF STUDY AS FUNCTION OF STARTING MONTH

STARTING MONTH	UPPER LIMIT FOR LENGTH
January	365
February	334
March	306
April	275
May	245
June	214
July	184
August	153
September	122
October	92
November	61
December	31

TABLE 14 CODE FOR WALL EXTERIOR SURFACE

CODE	MEANING
1	Stucco
2	Brick and rough plaster
3	Concrete
4	Clear pine
5	Smooth plaster
6	Glass, white paint on pine

TABLE 15 CODE FOR ROOF SURFACE TYPE

CODE	MEANING
1	Flat masonry roof
2	Wood or metal construction, flat roof
3	Pitched roof

TABLE 16

BUILDING MATERIALS, SOLAR ABSORPTIVITY

Material	Solar Absorptivity
BRICKS	
Clay, cream, glazed	0.36
Clay, Fleton, dark portion	0.63
Clay, Felton, light portion	0.40
Lime clay, French	0.46
Gault, cream	0.36
Light buff	0.516
Light buff but darker than above	0.60
Mottled purple	0.77
Red	0.699
Red, common and tiles	0.68
Red, darker, glazed	0.766
Red, wire-cut	0.52
Stafford blue	0.89
Stock, light fawn	0.57
White glazed	0.26
White glazed (2 specimens)	0.25-0.27
TILES	
Clay, purple (dark)	0.82
Clay, dark purple, machine-made	0.81
Red	0.67
Red, hand-made	0.60
Red, light, Dutch	0.43
Red, light, machine- ade	0.66
Red, light, machine-made	0.62
Concrete, uncolored	0.65
Concrete, black	0.91
Concrete, dark	0.91
Concrete, brown	0.85
Concrete, brown, very rough	0.88
ASPHALT	
New, 3 specimens	0.91
New, 3 specimens	0.91
New, another specimen	0.93
Pavement	0.852
Pavement, free from dust	0.928
Pavement, weathered, 3 specimens	0.82
	0.83
	0.89

TABLE 16 (CONT'D)

BUILDING MATERIALS, SOLAR ABSORPTIVITY

Material	Solar Absorptivity
ROOFING	
Bituminous felt, aluminized	0.40
Bituminous felt	0.88
Bituminous felt	0.89
Bitumin-covered, brown	0.87
Sheet, green	0.86
Sheet, black matte surface	0.97
Sheet, black matte surface	0.97
ASBESTOS CEMENT	
Aged	0.75
Aged 6 months	0.61
Aged 12 months	0.71
Aged 6 years, very dirty	0.83
Red	0.69
Red	0.74
Washed with soap and water	0.40
White	0.61
White (2 samples)	0.49-0.42
LIMESTONE	
Anston	0.60
Bath	0.53
Clipsham	0.46
Indiana	0.571
Ketton	0.42
Portland	0.36
Steetley	0.33
SAND-LIME	
Light-red	0.55
Red	0.68
White, fine sand	0.41
White, coarse sand	0.50
MARBLE	
White	0.44
Ground, unpolished	0.465
Cleavage	0.592
GRANITE	
Reddish	0.55
FELDSPAR	
$K_2O\ Al_2O_3 \cdot 6SiO_2$	0.606
MORTAR SCREENED	0.73

TABLE 16 (CONT'D)

BUILDING MATERIALS, SOLAR ABSORPTIVITY

Material	Solar Absorptivity
SANDSTONE	
Grey, Bristol pennant	0.76
Polmaise, light fawn	0.54
Stancliffe, light grey	0.62
Woolton, red	0.73
WHITEWASH	
On galvanized iron	0.22
On galvanized iron	0.22
On galvanized iron	0.26
On galvanized iron, a very thick layer	0.20
SLATE	
Blue grey	0.87
Blue, grey	0.85
Clay, dark	0.933
Greenish, grey, rough	0.88
Grey, dark	0.90
Grey, dark, fairly rough	0.90
Grey, dark, fairly rough	0.90
Grey, dark, smooth	0.89
Purple	0.86
Silver-grey, Norwegian	0.79

TABLE 17

REFLECTANCE OF GROUND SURFACES
FOR VISIBLE RADIATION

SURFACE	REFLECTANCE
Forest, green	.03 - .10
Grass, dry	.15 - .25
Wheat fields	.07
Green fields	.10 - .15
Bare ground	.10 - .20
Bare ground, very white	.03 - .06
Dark field soil	.07 - .10
Bright field soil	.10 - .16
Concrete, light color	.10 - .50
Bituminous concrete	.05 - .10
Dark rock	.07 - .15
Bright rock	.15 - .40
Snow, fresh	.95
Ocean	.03 - .07

TABLE 18

CODE FOR THICKNESS TIMES
EXTINCTION COEFFICIENT

CODE	MEANING
1	1/8" sheet
2	$k^* \ell$ = 0.10
3	$k^* \ell$ = 0.15
4	$k^* \ell$ = 0.20
5	$k^* \ell$ = 0.40
6	$k^* \ell$ = 0.60
7	50% transparent H.A. plate
8	$k^* \ell$ = 1.00

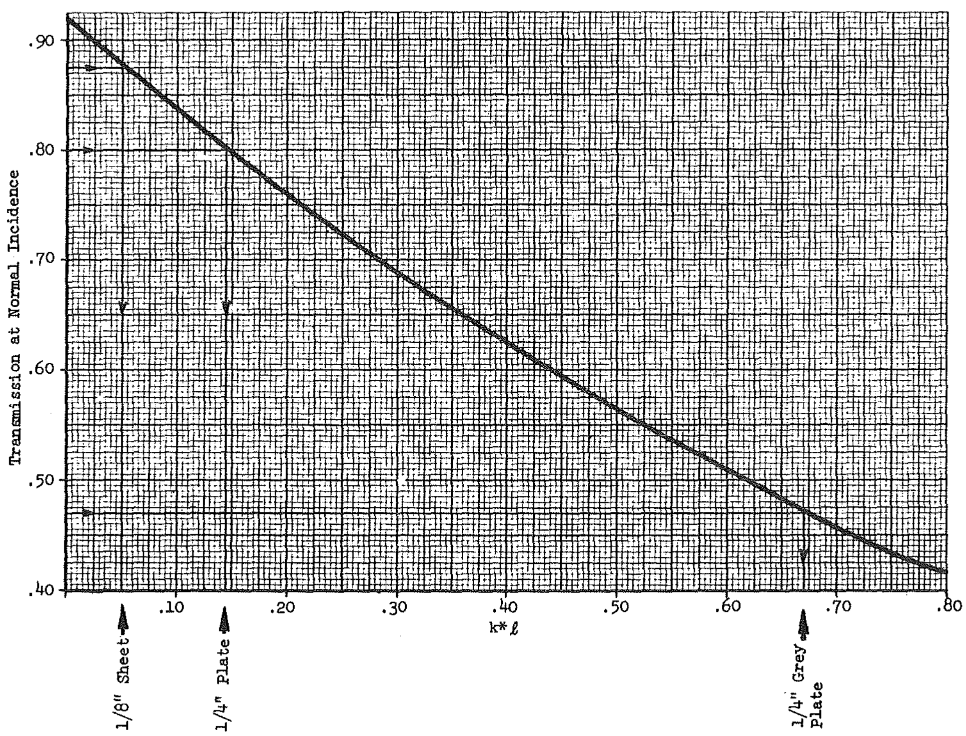


Figure 42 $k^* \ell$ VS TRANSMISSION AT NORMAL INCIDENCE FOR SINGLE SHEET GLASS

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ANALYSIS OF ENERGY UTILIZATION OF

POST OFFICE AND VEHICLE MAINTENANCE

FACILITY

AT CHICAGO, ILLINOIS

ENGINEER    = M. LOKMANHEKIM
PROJECT NO = 61311
DATE        = 18 NOV, 1969
```

Figure 43 MANDATORY OUTPUT NO. 1

```
IN THIS RUN

= U. S. WEATHER BUREAU 1440 WEATHER TAPE OF STATION 14819 IS USED.

= THE FIRST DATA OBTAINED FROM WEATHER TAPE IS FOR 0TH HOUR OF 11/01/1949.

= THE LENGTH OF THIS STUDY IS    7 DAYS.

= THE INITIAL OUTSIDE SURFACE TEMPERATURE IS 30 DEGREES FAHRENHEIT.
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Figure 44 MANDATORY OUTPUT NO. 2

BUILDING THERMAL AND INFILTRATION LOADS SUMMARY

COOLING DESIGN HOUR	TEMPERATURE DEGREES FAHRENHEIT DB	TEMPERATURE DEGREES FAHRENHEIT WB	HUM. RAT. LBS WATER PER LB DRY-AIR	PRESSURE INCHES OF MERCURY	PLENUM LOAD BTU PER HOUR	BUILDING THERMAL AND INFILTRATION LOADS BTU PER HOUR: SENSIBLE RAD.+TRAN.+INTER. +PEOPLE	SENSIBLE INF.	LATENT PEOPLE	LATENT INF.	TOTAL LOAD BTU PER HOUR
7449 9.HOUR OF 7 NOV.	44	41	.004882	29.34	0	11578	0	0	0	11578

HEATING DESIGN HOUR	TEMPERATURE DEGREES FAHRENHEIT DB	HUM. RAT. LBS WATER PER LB DRY-AIR	PRESSURE INCHES OF MERCURY	BUILDING THERMAL AND INFILTRATION SENSIBLE LOAD BTU PER HOUR
7302 6.HOUR OF 1 NOV.	28	.000000	29.34	-47107

Figure 45 MANDATORY OUTPUT NO. 3

SPACE MAXIMUM AND MINIMUM HEATING AND COOLING LOADS SUMMARY

SP.NO	MAX. HEAT. BTU/HOUR	HOUR	MIN. HEAT. BTU/HOUR	HOUR	MAX. COOL. BTU/HOUR	HOUR	MIN. COOL. BTU/HOUR	HOUR
1	-1610	9.HOUR OF 1 NOV.	-476	22.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
2	-1611	9.HOUR OF 1 NOV.	-521	22.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
3	-402	9.HOUR OF 1 NOV.	-123	22.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
4	-403	9.HOUR OF 1 NOV.	-138	23.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
5	-4479	5.HOUR OF 1 NOV.	-75	15.HOUR OF 7 NOV.	3003	9.HOUR OF 7 NOV.	59	9.HOUR OF 4 NOV.
6	-4081	5.HOUR OF 1 NOV.	-20	15.HOUR OF 7 NOV.	3216	9.HOUR OF 7 NOV.	8	11.HOUR OF 1 NOV.
7	-8158	9.HOUR OF 1 NOV.	-2801	21.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
8	-6571	9.HOUR OF 1 NOV.	-2340	22.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
9	-3632	9.HOUR OF 1 NOV.	-1295	22.HOUR OF 7 NOV.	IN THIS SPACE NO COOLING IS REQUIRED FOR THE PERIOD OF STUDY			
10	-8265	6.HOUR OF 1 NOV.	-34	8.HOUR OF 5 NOV.	2690	9.HOUR OF 7 NOV.	323	8.HOUR OF 6 NOV.
11	-8265	6.HOUR OF 1 NOV.	-41	8.HOUR OF 5 NOV.	2669	9.HOUR OF 7 NOV.	298	8.HOUR OF 6 NOV.

Figure 46 MANDATORY OUTPUT NO. 4

WALL SPECIFICATIONS- EXTERIOR- CONCRETE
MAX. OVERALL U= .405 BTU/HR-FT2-F

WINTER CONDITIONS OUTSIDE

STD. ASHRAE WALL SELECTION IS AS FOLLOWS

LAYER	DESCRIPTION	THKNS FT.	CONDTVTY B/HR-FT-F	DNSTY LB/FT3	SP HT B/LB-F	RESISTANCE HR-FT2-F/B
1	6.000 IN. CONCRETE, SAND + GRAVEL AGGREGATE (NOT DRIED) 140 LB/FT3	.500	1.042	140.00	.250	0.00
2	0.500 IN. CEMENT MORTAR	0.000	0.000	0.00	0.000	.10
3	8.000 IN. CONCRETE, SAND + GRAVEL AGGREGATE (NOT DRIED) 140 LB/FT3	.667	1.042	140.00	.250	0.00
4	.625 IN. GYPSUM PLASTER, LIGHTWEIGHT AGGREGATE	.052	.130	45.00	.200	0.00
5	INSIDE SURFACE STILL AIR	0.000	0.000	0.00	0.000	.68

OVERALL U= .435 BTU/HR-FT2-F

Figure 47 OPTIONAL OUTPUT NO. 1

ROOF SPECIFICATIONS- PITCHED ROOF
MAX. OVERALL U= .211 BTU/HR-FT2-F

SUMMER CONDITIONS OUTSIDE

STD. ASHRAE ROOF SELECTION IS AS FOLLOWS

LAYER	DESCRIPTION	THKNS FT.	CONDTVTY B/HR-FT-F	DNSTY LB/FT3	SP HT B/LB-F	RESISTANCE HR-FT2-F/B
1	.500 IN. ROOFING, ASBESTOS-CEMENT SLATE SHINGLES	.042	.833	120.00	.200	0.00
2	.063 IN. BUILDING PAPER , VAPOR-PERMEABLE FELT	.005	.087	44.00	.324	0.00
3	.781 IN. BUILDING BOARD, PLYWOOD	.065	.067	34.00	.650	0.00
4	AIR SPACE	0.000	0.000	0.00	0.000	.85
5	.750 IN. INSULATING MAT#L, ACOUSTICAL TILE (WOOD OR CANE FIBERBOARD	.063	.035	15.00	.200	0.00
6	INSIDE SURFACE, STILL AIR	0.000	0.000	0.00	0.000	.92

OVERALL U= .215 BTU/HR-FT2-F

Figure 48 OPTIONAL OUTPUT NO. 2

```
****************************************************************************
*                                                                          *
*                                                                          *
*                       IN THE FOLLOWING PAGES                             *
*                                                                          *
*                                                                          *
*            THE FIRST LINE OF EACH PRINTED BLOCKS GIVES                   *
*                                                                          *
*   TIME              = HOURS, STANDARD TIME FROM FIRST HOUR OF JANUARY    *
*   SUN INDEX         = IF EQUAL TO ONE SUN IS DOWN, IF EQUAL TO ZERO SUN IS UP *
*   DRY-BULB TEMP.    = DEGREES FAHRENHEIT                                 *
*   WIND VELOCITY     = KNOTS                                              *
*   HUMIDITY RATIO    = LBS WATER PER LB DRY-AIR                           *
*   PRESSURE          = INCHES OF MERCURY                                  *
*   ENTHALPY          = BTU PER LB DRY-AIR                                 *
*   DENSITY           = LBS DRY-AIR PER CUBIC FOOT                         *
*                                                                          *
*          THE FOLLOWING LINES OF EACH PRINTED BLOCKS GIVES                *
*                                                                          *
*   SPACE NUMBER                                                           *
*   SPACE SENSIBLE LOAD = BTU PER HOUR                                     *
*   SPACE LATENT LOAD   = BTU PER HOUR                                     *
*   PLENUM RETURN AIR LIGHTING LOAD     = BTU PER HOUR                     *
*   SPACE LIGHTING AND EQUIPMENT POWER = KILOWATTS                         *
*                                                                          *
*                                                                          *
****************************************************************************
*         NOTE = THE LOADS EXCLUDES OUTSIDE VENTILATION AIR LOADS          *
****************************************************************************
```

Figure 49 OPTIONAL OUTPUT NO. 3

7449	0	44	4	.004882	29.94	15.84	.076607
1		-983.92		0.00	0.00		0.00
2		-996.78		0.00	0.00		0.00
3		-247.26		0.00	0.00		0.00
4		-251.55		0.00	0.00		0.00
5		3003.36		0.00	0.00		0.00
6		3216.31		0.00	0.00		0.00
7		-5610.95		0.00	0.00		0.00
8		-4553.75		0.00	0.00		0.00
9		-2517.65		0.00	0.00		0.00
10		2689.95		0.00	0.00		0.00
11		2668.51		0.00	0.00		0.00

Figure 50 OPTIONAL OUTPUT NO. 4

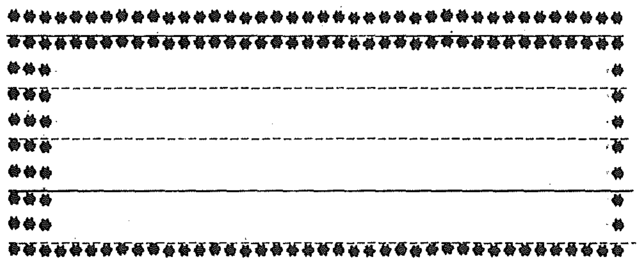

Figure 51 OPTIONAL OUTPUT NO. 5

SECTION 3

PUNCH SUB-PROGRAM

The Punch Sub-program is provided to facilitate easy preparation of the input card deck required for the Thermal Loads Plot Sub-program. The plotting program outlined in Section 4 is an offline plotting program that is not for use on the large computer which would be used for running the other sub-programs, but rather is for use on a smaller computer such as an IBM 1130, which is capable of accepting only punched cards and not magnetic computer tape as input.

The Punch Sub-program reads through the output tape which was generated by the Load Calculation Sub-program and punches the deck of cards required for plotting the hourly space loads for the spaces indicated by the engineer. See Figure 52 for a logic flow chart of the Punch Sub-program.

3.1 Input Forms

The only input card information which must be prepared by the engineer is that indicated in Table 19. The first card (PN-1) in the data deck indicates how many plots are desired. The remainder of the data deck is made up of plot control cards (PN-2), one for each space plot and each indicating how many days of space load data the engineer wants plotted.

3.2 Output Forms

The output of the Punch Sub-program is a deck of cards which is ready to be used directly by the Thermal Loads Plot Sub-program. If only one space plot is to be made, the output deck would consist of card PN-1 and a plot control card (Card PN-2) followed by a group of cards which summarize the hourly space loads for the indicated space and indicated length of time. If more than one space plot is to be made, there would be as many of the above card sets in the output deck as there were spaces to be plotted. Figures 53 and 54 illustrate a completed input form and input punched cards for one space plot and Figure 55 shows the associated output card deck that was received from the Punch Sub-program.

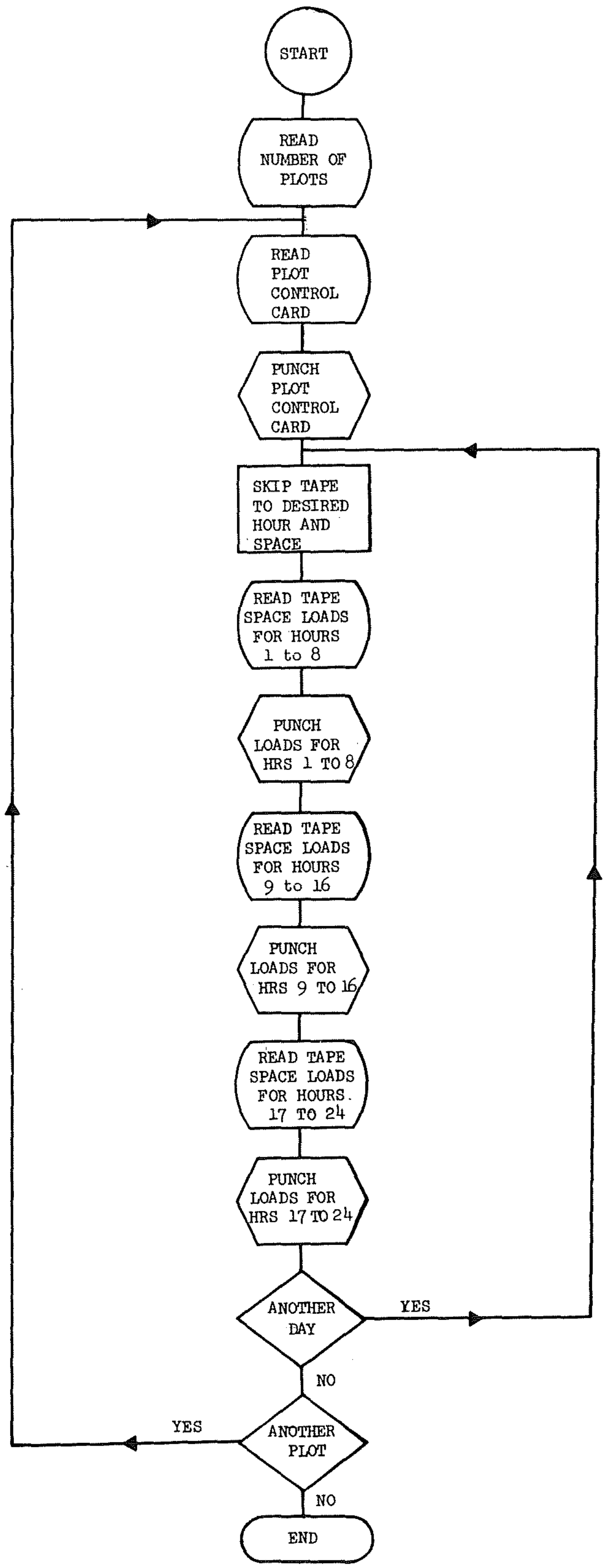

Figure 52 LOGIC FLOW CHART OF PUNCH SUB-PROGRAM

TABLE 19 PUNCH SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
PN-1	1 to 10	Number of plots to be made	NPLOT				5.	
PN-2	1 to 10	Space number for which plot is to be made	NSPACE				5.	
	11 to 20	Number of days to be plotted	LENGTH		Maximum of 366		7. for a week	366. Indicates a leap-year
	21 to 30	Day of week at which the plot is to begin	NDAY	Day	See CODE	1 Sunday 2 Monday 3 Tuesday 4 Wednesday 5 Thursday 6 Friday 7 Saturday	3. for Tuesday	
	31 to 40	Day of month at which plot is to begin	IDAY	Day			5.	
	41 to 50	Month at which plot is to begin	MONTH	Month	See CODE	1 January 2 February 3 March 4 April 5 May 6 June 7 July 8 August 9 September 10 October 11 November 12 December	6. for June	
	51 to 60	Year at which plot is to begin	IYEAR	Year			1969.	

NOTE: ONE OF CARD PN-2 IS REQUIRED FOR EACH SPACE PLOT TO BE MADE.

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COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

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U. S. POST OFFICE AND V. M. F.	60311	R. HENNINGER	4/10	1 – OF – 1

DATA FIELD (columns 1–70) — **IDENTIFICATION FIELD** (columns 71–80)

Line	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80
1	1.							RHH PN-1
2	1.	1.	1.	12.	8.	1968.		RHH PN-2
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Figure 53 TYPICAL INPUT FORM FOR PUNCH SUB-PROGRAM

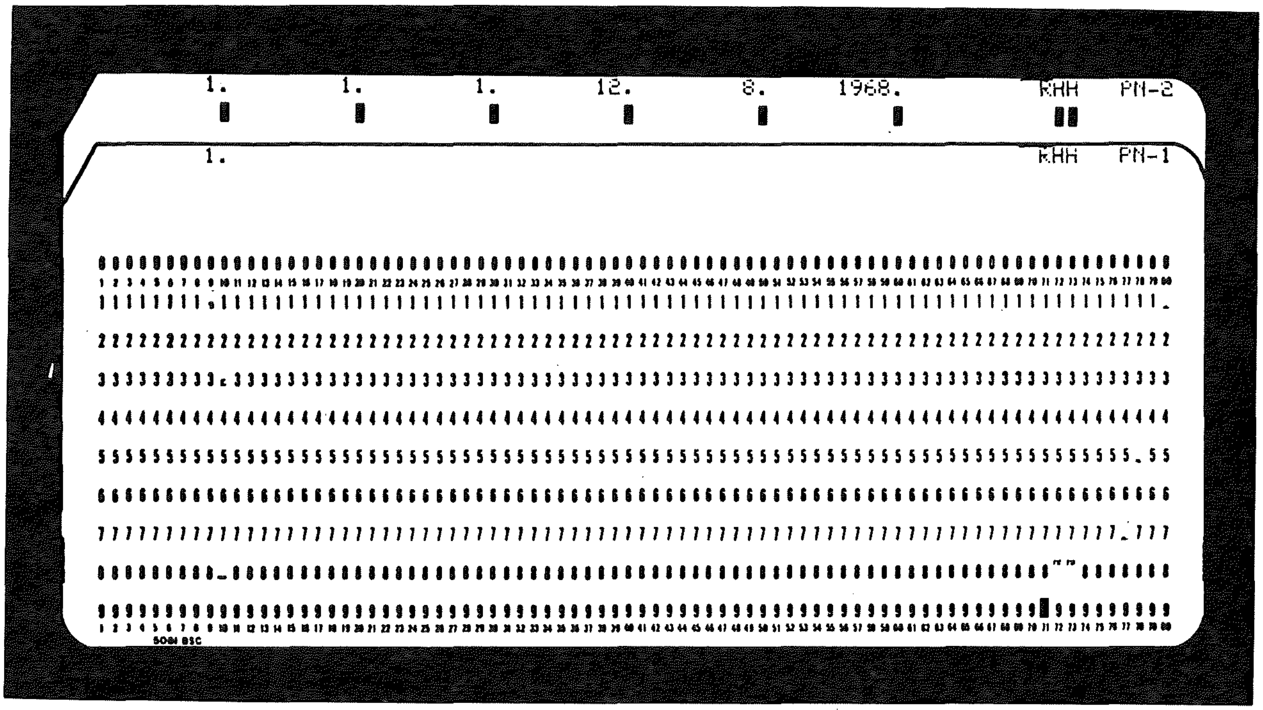

Figure 54 TYPICAL INPUT CARD DECK FOR PUNCH SUB-PROGRAM

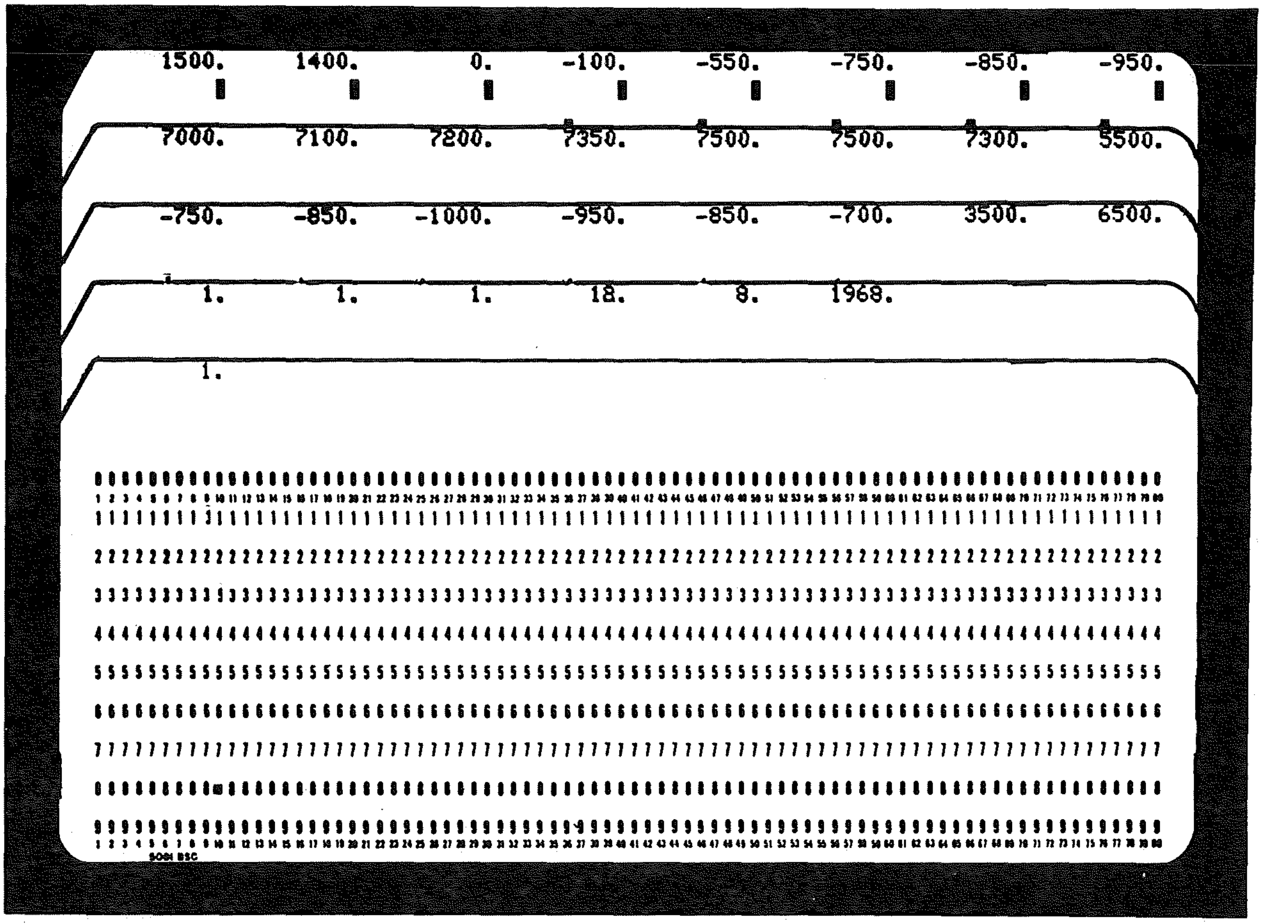

Figure 55 TYPICAL OUTPUT CARD DECK FOR PUNCH SUB-PROGRAM

SECTION 4

THERMAL LOADS PLOT SUB-PROGRAM

When comparing several spaces in a building, it may be desirable to group spaces into zones, each controlled by a single thermostat. To determine which spaces are to be grouped most efficiently, it is necessary that that the thermal loads for each space be compatible. A convenient way to make comparisons is by plotting the respective thermal loads for each space. To facilitate this, the Thermal Loads Plot Sub-program takes hourly thermal load data and plots these data for a day, a week, a month, or a year. This Plot Sub-program (an offline program) can be used when there is doubt as to whether or not the spaces have been grouped into zones in a compatible manner, or it can be used to establish the load profiles of certain spaces in the building. Figure 56 illustrates schematically the inner workings of the Thermal Loads Plot Sub-program.

4.1 Input Forms

All input data required by the Thermal Loads Plot Sub-program are read from punched cards. The engineer need not prepare any of this card input. The output card deck from the Punch Sub-program is the only input required for the Thermal Loads Plot Sub-program. See Figure 55, page 81 for a typical Thermal Loads Plot Sub-program input deck.

4.2 Output Forms

The Thermal Loads Plot Sub-program determines which of the plots are desired from the plot control card (Card PN-2). If the number of days to be plotted equals 1, a single day of hourly data is plotted as shown in Figure 57. When the number of days to be plotted equals 7, a week of data is plotted as shown in Figure 58. When the number of days to be plotted is greater than 7, but equal to or less than 31, a month of data is plotted as shown in Figure 59. When the number of days to be plotted is greater than 31, but less than or equal to 366, a year of data is plotted continuously. A leap year is detected by the number of days to be plotted being set equal to 366 and automatically gives FEBRUARY 29 days. The plot shown in Figure 57 is a result of the input card deck shown in Figure 55, page 81.

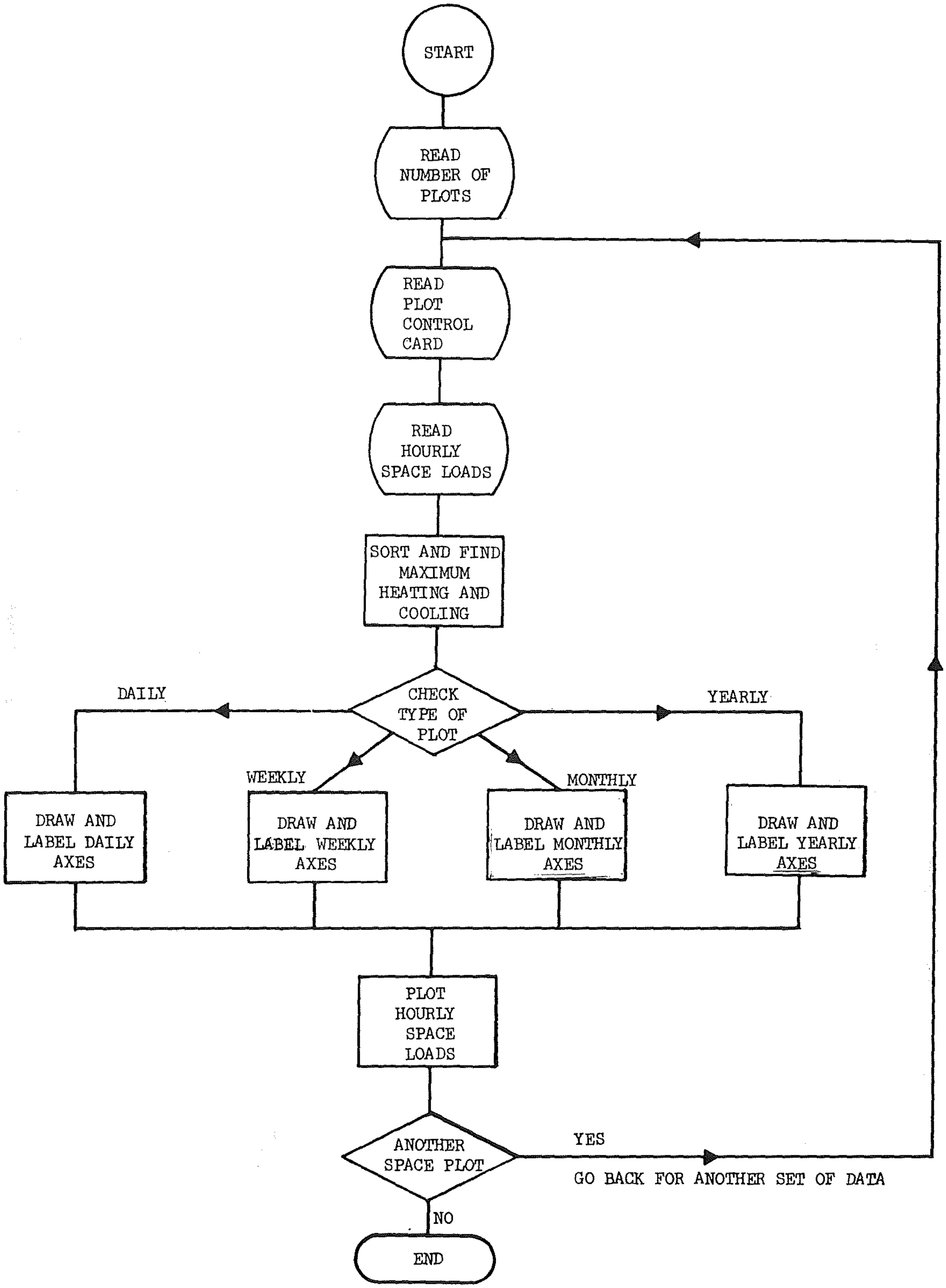

Figure 56 LOGIC FLOW CHART OF THERMAL LOAD PLOT SUB-PROGRAM

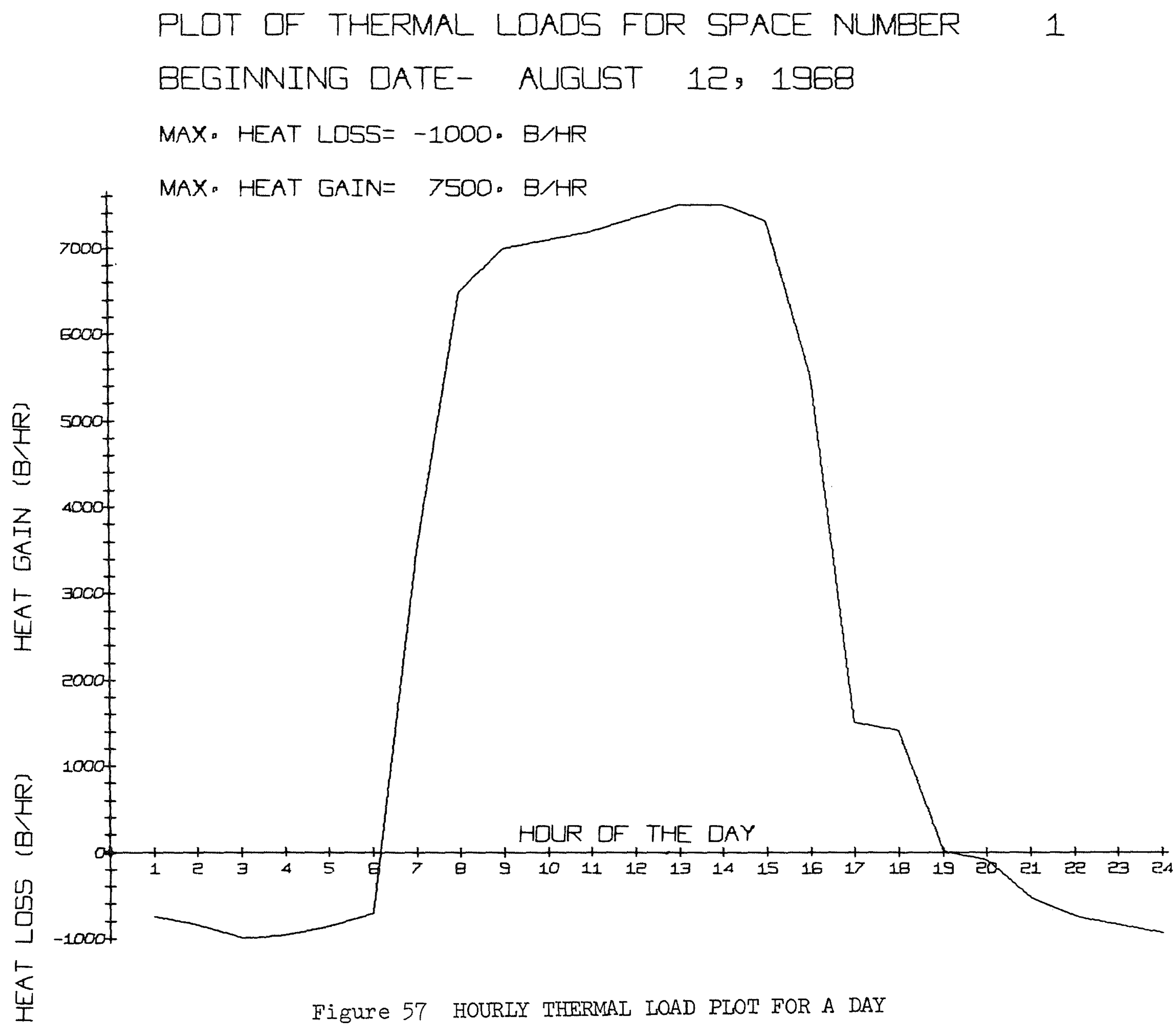

Figure 57 HOURLY THERMAL LOAD PLOT FOR A DAY

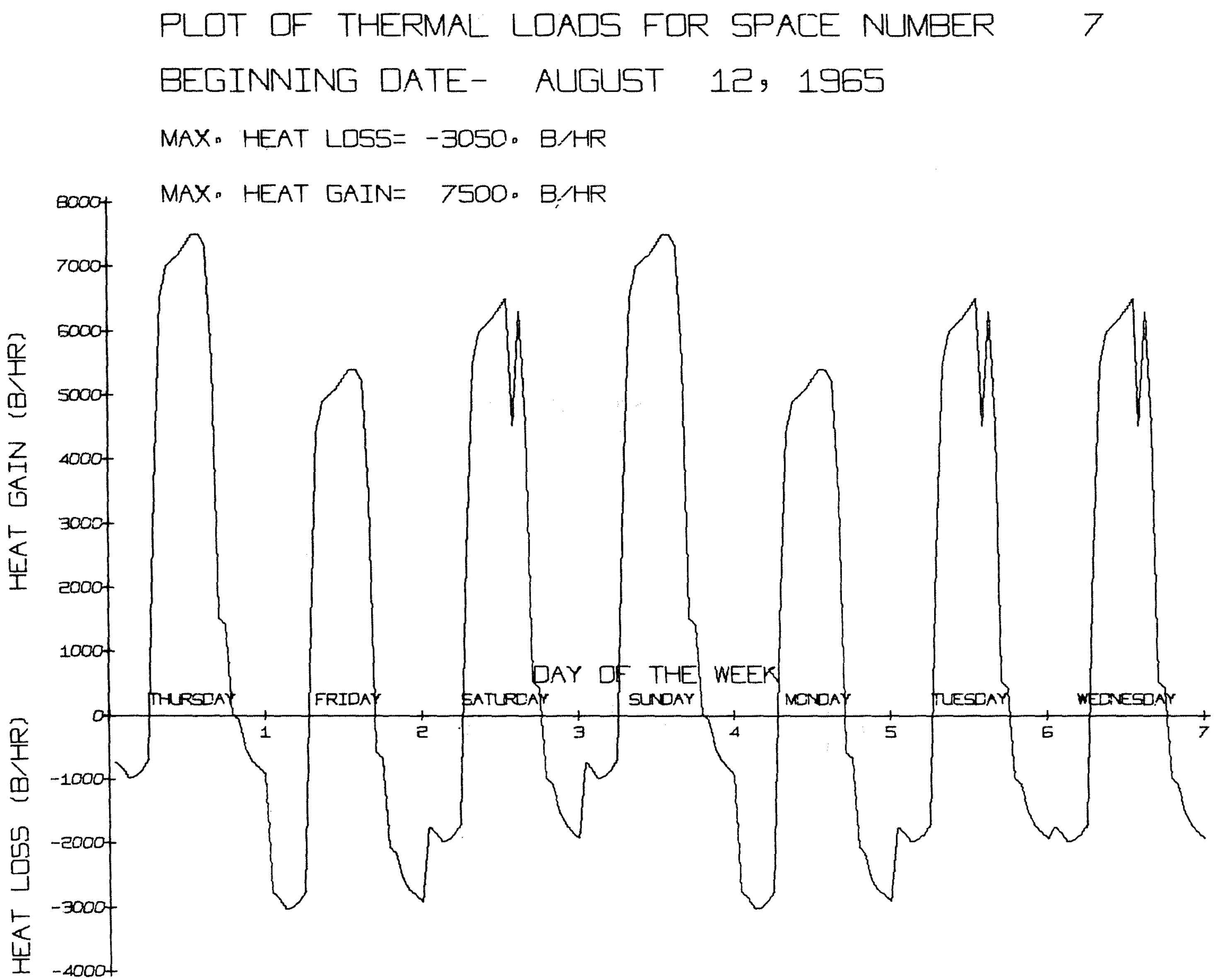

Figure 58 HOURLY THERMAL LOAD PLOT FOR A WEEK

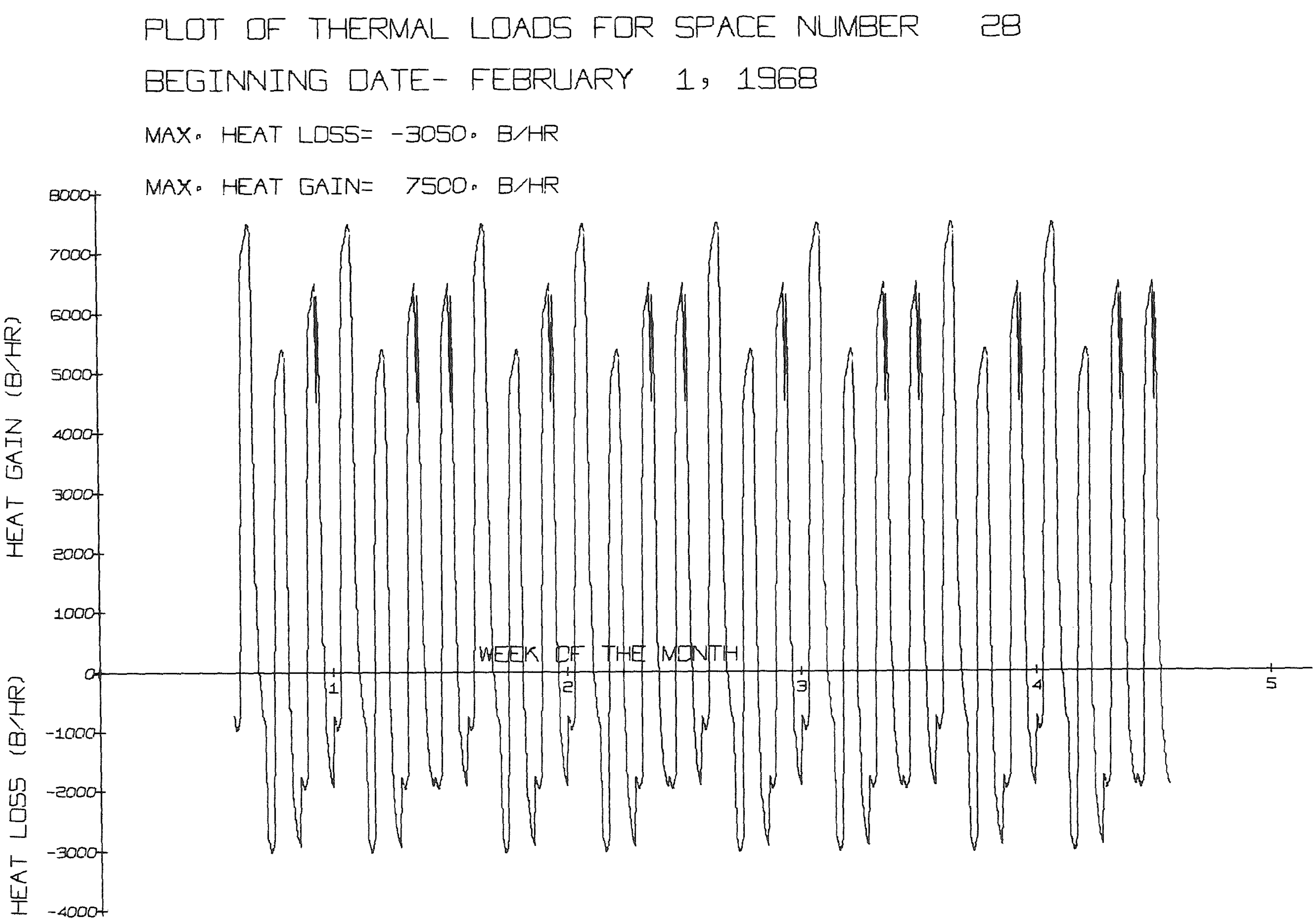

Figure 59 HOURLY THERMAL LOAD PLOT FOR A MONTH

SECTION 5

LOAD EDITING SUB-PROGRAM

If, after examining the space plots from the Thermal Loads Plot Sub-program, the engineer desires to regroup spaces into fan zones or regroup zones into fan systems, the Load Calculation Sub-program output tape then must be revised or editted and a new load tape produced which contains hourly fan zone loads in proper sequence. If, however, the engineer initially subdivided his building into fan zones, numbered the zones such that the zones of any particular fan system have consecutive numbers and the Thermal Loads Plot Sub-program plots indicate that no change in the grouping of zones is necessary, the Load Editing Sub-program can be by-passed. The Load Calculation output tape can then be used directly as the input tape to the Systems Simulation Sub-program. The sole purpose of the Load Editing Sub-program is to reassemble the Load Calculation Sub-program output tape such that the loads are fan zone loads and are in proper sequence.

5.1 Input Forms

The input information required for the Load Editing Sub-program can be prepared with the help of Table 20. A typical input deck would consist of one of Reading Order Card LE-1, as many of Reading Order Card LE-2 as there are fan systems, and as many of Reading Order Cards LE-3 as there are total fan zones in the building. All of the Reading Order Cards LE-2 must appear together in the card deck, as do the Reading Order Cards LE-3. The sequencing of Reading Order Cards LE-2 and LE-3 is as follows:

Fan 1	Zone 1
Fan 1	Zone 2
Fan 1	Zone 3
.	.
.	.
Fan 2	Zone 1
Fan 2	Zone 2
Fan 2	Zone 3
Fan 2	Zone 4
.	.
.	.
.	.
.	.

The input form and punched cards required to describe the following building system are shown in Figures 60 and 61.

Number of Spaces that building was initially subdivided into = 13

Number of Fan Systems in building = 2

Number of Zones on Fan System 1 = 2

Number of Zones on Fan System 2 = 3

Number of Spaces making up Zone 1 on Fan System 1 = 2

Number of Spaces making up Zone 2 on Fan System 1 = 3

Number of Spaces making up Zone 1 on Fan System 2 = 1

Number of Spaces making up Zone 2 on Fan System 2 = 3

Number of Spaces making up Zone 3 on Fan System 2 = 4

Spaces making up Zone 1 on Fan System 1 = Nos. 3, 9

Spaces making up Zone 2 on Fan System 1 = Nos. 1, 4, 5

Spaces making up Zone 1 on Fan System 2 = No. 2

Spaces making up Zone 2 on Fan System 2 = Nos. 10, 11, 12

Spaces making up Zone 3 on Fan System 2 = Nos. 6, 7, 8, 13

5.2 Output Forms

The output of the Load Editing Sub-program is a tape of the same format as the output tape of the Load Calculation Sub-program, but containing zone loads instead of space loads. The hourly information appearing on the output tape for each zone includes:

(1) Hourly sensible zone load, Btu/hr

(2) Hourly latent zone load, Btu/hr

(3) Hourly plenum heat from lights, Btu/hr

(4) Hourly zone electrical consumption by internal lights and motors, KW.

THESE ZONE LOADS INCLUDE ONLY THERMAL AND INFILTRATION LOADS AND EXCLUDE VENTILATION AIR LOADS.

TABLE 20 LOAD EDITING SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
LE-1	1 to 10	Number of fan systems in building	KMAX				2.	
	11 to 20	Total number of spaces in building	ISBMX				13.	Get from Load Calculation Sub-Progam
LE-2	1 to 10	Number of zones on fan system No. ___	JMAX(K)				2.	A Card LE-2 will be required for each fan system in the building.
	11 to 20	Number of spaces to be grouped into Zone 1	ISPMX(K,J)				2.	If a fan system has more than 6 zones, then Card LE-2A will have to be used also.
	21 to 30	" " " 2	"				3.	All Cards LE-2 will be together in the deck, the order of the cards being the same as the numerical order of the fan system number.
	31 to 40	" " " 3	"					
	41 to 50	" " " 4	"					
	51 to 60	" " " 5	"					
	61 to 70	" " " 6	"					
LE-2A	1 to 10	Number of spaces to be grouped into Zone 7	"					If a fan system has more than 13 zones, use as many of Card LE-2A as are necessary.
	11 to 20	" " " 8	"					
	21 to 30	" " " 9	"					
	31 to 40	" " " 10	"					
	41 to 50	" " " 11	"					
	51 to 60	" " " 12	"					
	61 to 70	" " " 13	"					

TABLE 20 (CONT'D) LOAD EDITING SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
LE-3	1 to 10	Space No. to be grouped into Zone No.___ of fan system No.___	FANZ(K,J,L)				3.	A Card LE-3 will be required for each zone in the building.
	11 to 20	" " "	"				9.	If more than six spaces are to be grouped into a fan zone, then more than one Card LE-3 will have to be used for that fan zone.
	21 to 30	" " "	"					
	31 to 40	" " "	"					All Cards LE-3 will be together in the deck, the order of the cards being first by numerical order of fan system number and then by zone number.
	41 to 50	" " "	"					
	51 to 60	" " "	"					
	61 to 70	" " "	"					

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FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET
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DATA FIELD / IDENTIFICATION FIELD

Line	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80 (Identification Field)
1	2.	13.						RHH LE1-1
2	2.	2.	3.					RHH LE2-2
3	3.	1.	3.	4.				RHH LE2-3
4	3.	9.						RHH LE3-4
5	1.	4.	5.					RHH LE3-5
6	2.							RHH LE3-6
7	10.	11.	12.					RHH LE3-7
8	6.	7.	8.	13.				RHH LE3-8

Figure 60 TYPICAL INPUT FORM FOR LOAD EDITING SUB-PROGRAM

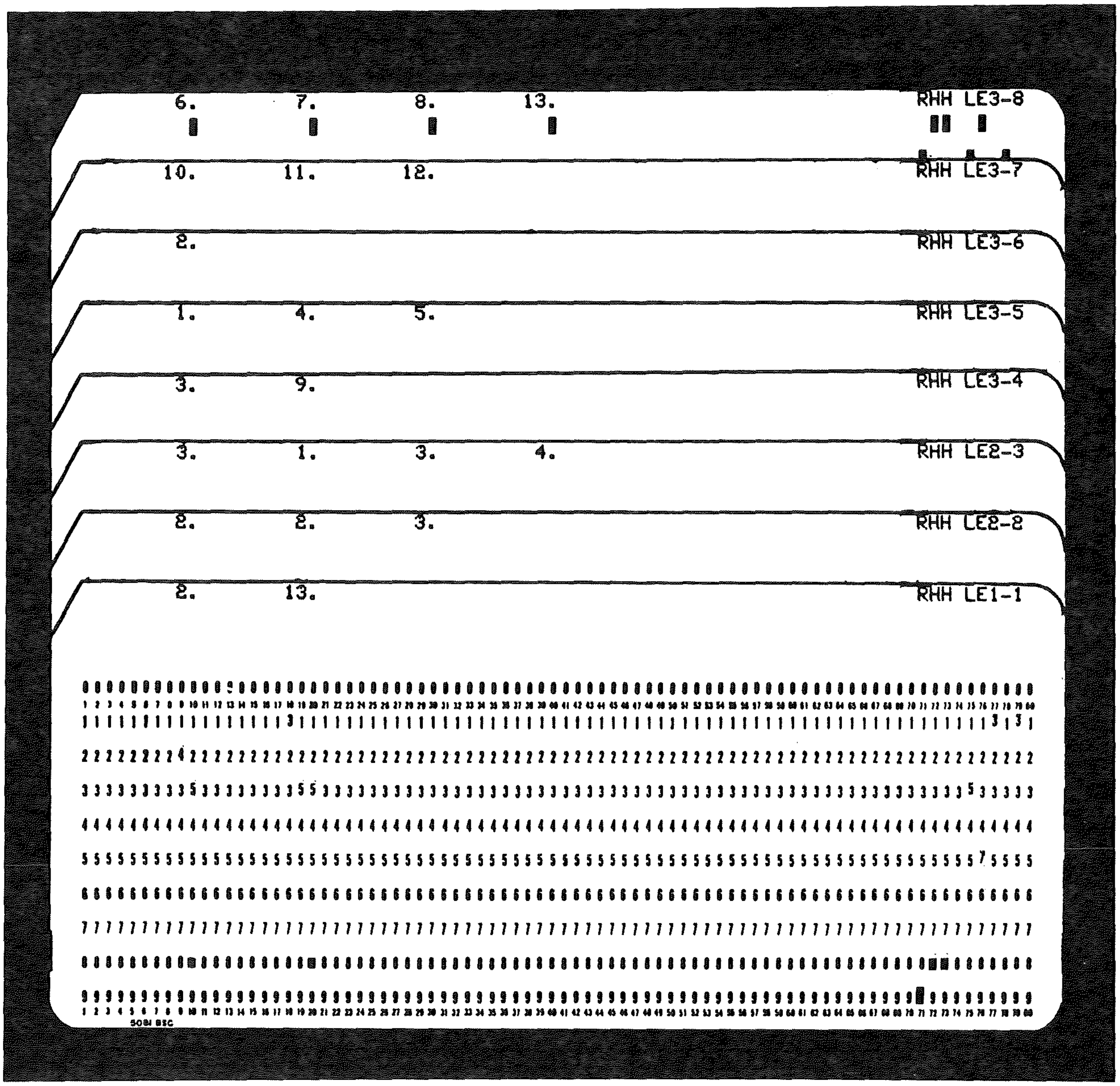


Figure 61 TYPICAL INPUT CARD DECK FOR LOAD EDITING SUB-PROGRAM

SECTION 6

SYSTEMS SIMULATION SUB-PROGRAM

The hourly space loads calculated by the Load Calculation Sub-program are not necessarily the heating and/or cooling loads that are transferred through the fan systems and back to the heating and cooling plants. Due to outside air requirements and the limitations imposed by various component control schedules, the building's hourly heating and/or cooling requirement can be different from the summation of the hourly heating and/or cooling space loads. The Systems Simulation Sub-program is required, therefore, to perform two functions. First, translate the hourly space loads, including the ventilation air requirements, by means of the individual performance characteristics of each fan system, into the actual hourly thermal requirements imposed upon the heating and cooling plants, and second, convert these hourly thermal requirements into energy requirements based upon the part-load characteristics of the heating and cooling plant equipment.

The Systems Simulation Sub-program is able to simulate the operation of the following system components:

1) Heating/Cooling Systems

   a) Single zone system

   b) Multi-zone system

   c) Dual-duct system

   d) Single zone with subzone reheat system

   e) Unit ventilator system

   f) Unit heater system

   g) Floor panel heating system

2) Refrigeration Machines

   a) Hermetic reciprocating water chiller

   b) Hermetic centrifugal water chiller

   c) Open centrifugal water chiller

   d) Steam absorption water chiller

   e) Steam turbine-driven open centrifugal water chiller combination.

3) Source of Heating Energy

   a) Gas-fired/hot water or steam boiler

   b) Oil-fired/hot water or steam boiler

   c) Purchased steam/steam or hot water

   d) Electrically-fired/hot water boiler, steam boiler or strip heaters.

4) Heat Conservation Refrigeration Machines

   a) Hermetic reciprocating water chiller

   b) Hermetic centrifugal water chiller.

5) Reheat Coils used in Single Zone/Reheat Systems

   a) Gas-fired/hot water or steam reheat coil

   b) Oil-fired/hot water or steam reheat coil

   c) Purchased steam/hot water or steam reheat coil

   d) Electric resistance reheat coil or electrically-fired/ hot water or steam reheat coil.

6) On-site Generation Engine-Generator Sets

   a) Natural gas engine-generator set

   b) Diesel fuel engine-generator set.

7) Supplemental Heat Source used in Chilled Water Line of Heat Conservation System

   a) Gas-fired/hot water

   b) Oil-fired/hot water

   c) Electric resistance/hot water

   d) City water

   e) Well water.

8) Snow-melting Systems

   a) Liquid

   b) Electric

The System Simulation Sub-program is actually made up of 15 smaller programs or subroutines. (See Table 21 for a description of these subroutines.) Subroutine SYSIM directs the flow of logic through the subprogram and controls the order in which calculations are to be performed. The sequence of the calculations is as follows. First, the zone air flows are sized using the peak hourly heating and cooling zone loads. Next, the central heating and cooling plant components are sized based upon the peak building heating and cooling loads. Then, an hour-by-hour analysis of the building's heating/cooling systems is performed. Each heating/cooling system is examined each hour and the hourly heating and/or cooling loads calculated and summed to give the building's heating and/or cooling requirements. At the end of an hour's calculation, after the last heating/cooling system has been examined and any snow-melting load accounted for, the EQUIP subroutine is called upon to convert the hourly building thermal requirements into hourly heating, cooling and on-site generation (if applicable) energy requirements. This series of calculations is done repeatedly for every hour of each month, thus establishing the monthly energy requirements for the building equipment combination in question. An annual summary of the energy consumption is then printed out as a permanent record.

The sequence of calculations outlined above is the same for a heat conservation equipment combination, except that (1) zone air flows are sized differently, (2) other supplemental heating requirements must be accounted for and (3) specialized treatment of the double-bundled condenser refrigeration machines is necessary. Figures 62 to 64 depict schematically the workings of the SYSIM, EQUIP and HTCON subroutines and Figure 65 illustrates the interrelationship of all 15 subroutines.

6.1 Input Forms

The System Simulation Sub-program requires two forms of input, magnetic tape and punched cards. The tape is that which is produced by the Load Calculation Sub-program or Load Editing Sub-program and is in such format that it can be used directly by the System Simulation Sub-program. The card input data must be prepared by the engineer. When a snow-melting system is to be included in the systems analysis, the engineer must acquire from the National Weather Record Center, Ashville, N.C. a copy of the WBAN Summary of Day Deck 345 for the city and year under consideration. This can be done at the same time the weather data for the Load Calculation Sub-program is ordered. The 345 card deck would then be placed at the end of the Systems Simulation Sub-program card input deck. See Table 22 for instructions to prepare Systems Simulation Sub-program card input.

The makeup of a typical input deck is illustrated in Figure 66. An actual completed input form and punched card deck are shown in Figures 67 to 71.

6.2 Output Forms

Several forms of output are received from the Systems Simulation Sub-program. Output 1 is a title page indicating the name of facility, project number and engineer's name. Output 2 summarizes the characteristics of all heating/cooling systems within the building. Output 3 summarizes the zone supply air quantities for each zone in the building. Output 4 summarizes the equipment component capacities. Output 5 summarizes the monthly energy consumption of the building. See Figures 72 to 79 for examples of each of these outputs. Outputs 4 and 5 are repeated for each equipment combination that is run through the Systems Simulation Sub-program. When a heat conservation system is encountered for the first time, outputs 2 and 3 are printed along with outputs 4 and 5, since air flow quantities are sized again for heat conservation systems.

TABLE 21

SYSTEM SIMULATION SUB-PROGRAM SUBROUTINES
AND THEIR FUNCTION

NAME OF THE SUBROUTINE	FUNCTION
SYSIM	Controls the operation of the entire Systems Simulation Sub-program by executing the subroutines in their proper order.
FSIZE	Sizes the air flor quantities for each fan zone.
HTCON	Simulates the operation of the heat conservation system.
SZRHT	Simulates the operation of single zone/reheat fan system.
SZMZD	Simulates the operation of single zone, multi-zone and dual-duct fan systems.
UVENT	Simulates the operation of unit ventilator and unit heater systems.
FHEAT	Simulates the operation of floor panel heating systems.
PSYCH	Calculates the psychrometric properties of moist air.
EQUIP	Simulates the operation of heating and cooling central systems and on-site generation systems.
RECIP	Simulates the operation of reciprocating water chillers.
CENT	Simulates the operation of hermetic centrifugal water chillers.
ABSOR	Simulates the operation of steam absorption water chillers.
STTUR	Simulates the operation of steam turbines.
SNOW	Simulates the operation of snow-melting systems.
ENGYC	Prints out annual energy consumption summary in a form similar to POD Form No. 2215.

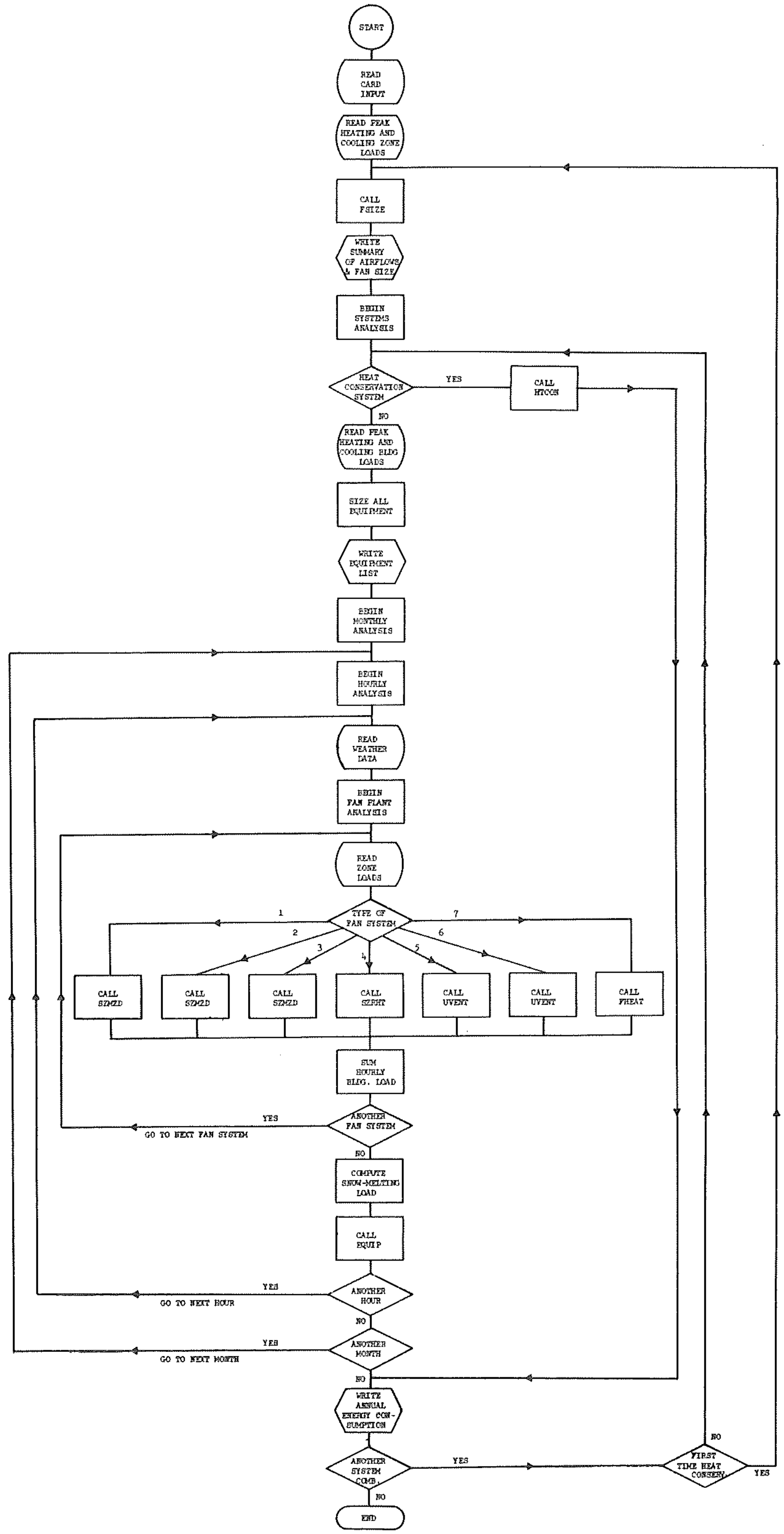


Figure 62 LOGIC FLOW CHART OF SYSTEMS SIMULATION SUB-PROGRAM (SYSIM SUBROUTINE)

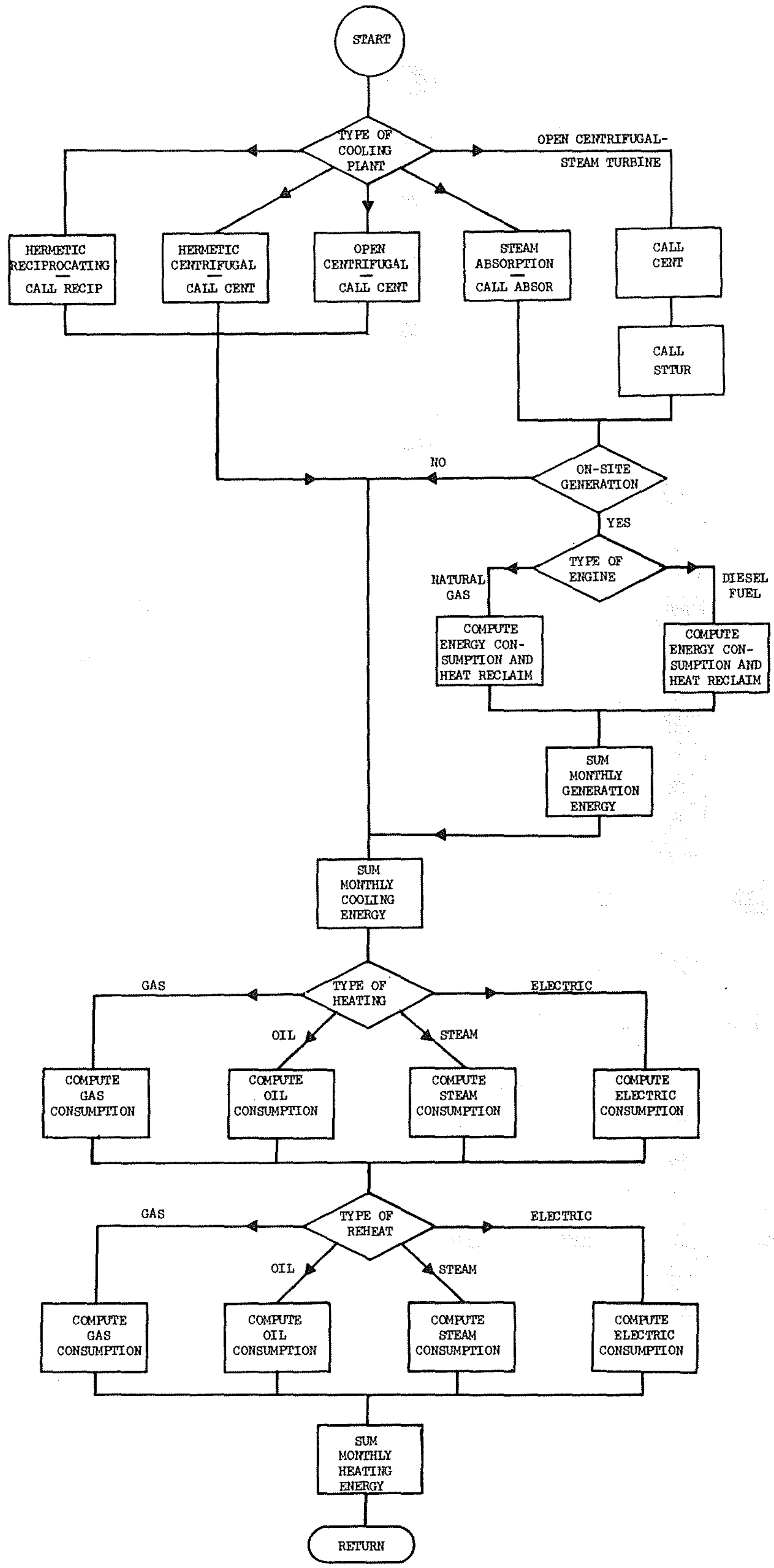


Figure 63 LOGIC FLOW CHART OF EQUIP SUBROUTINE

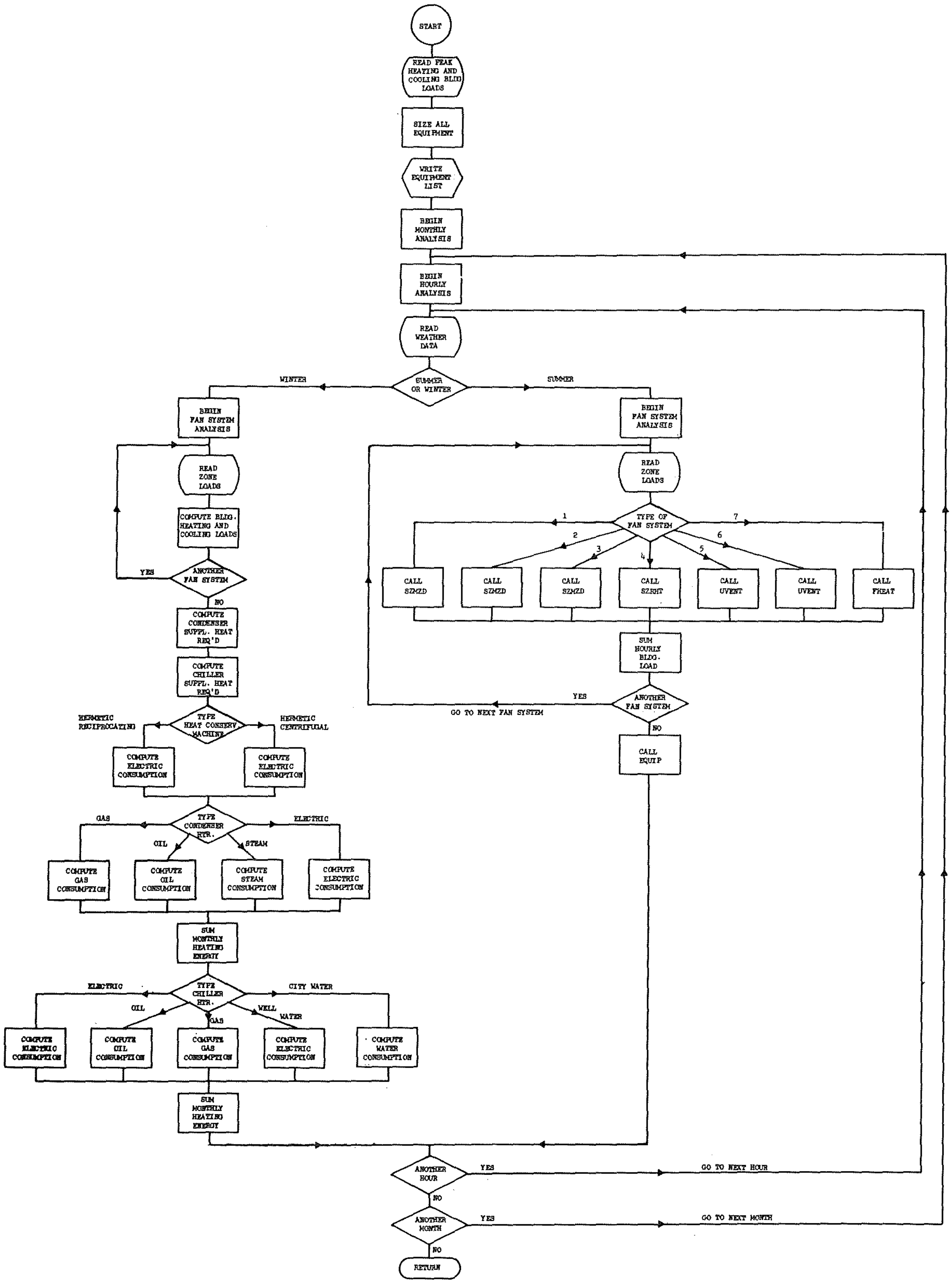
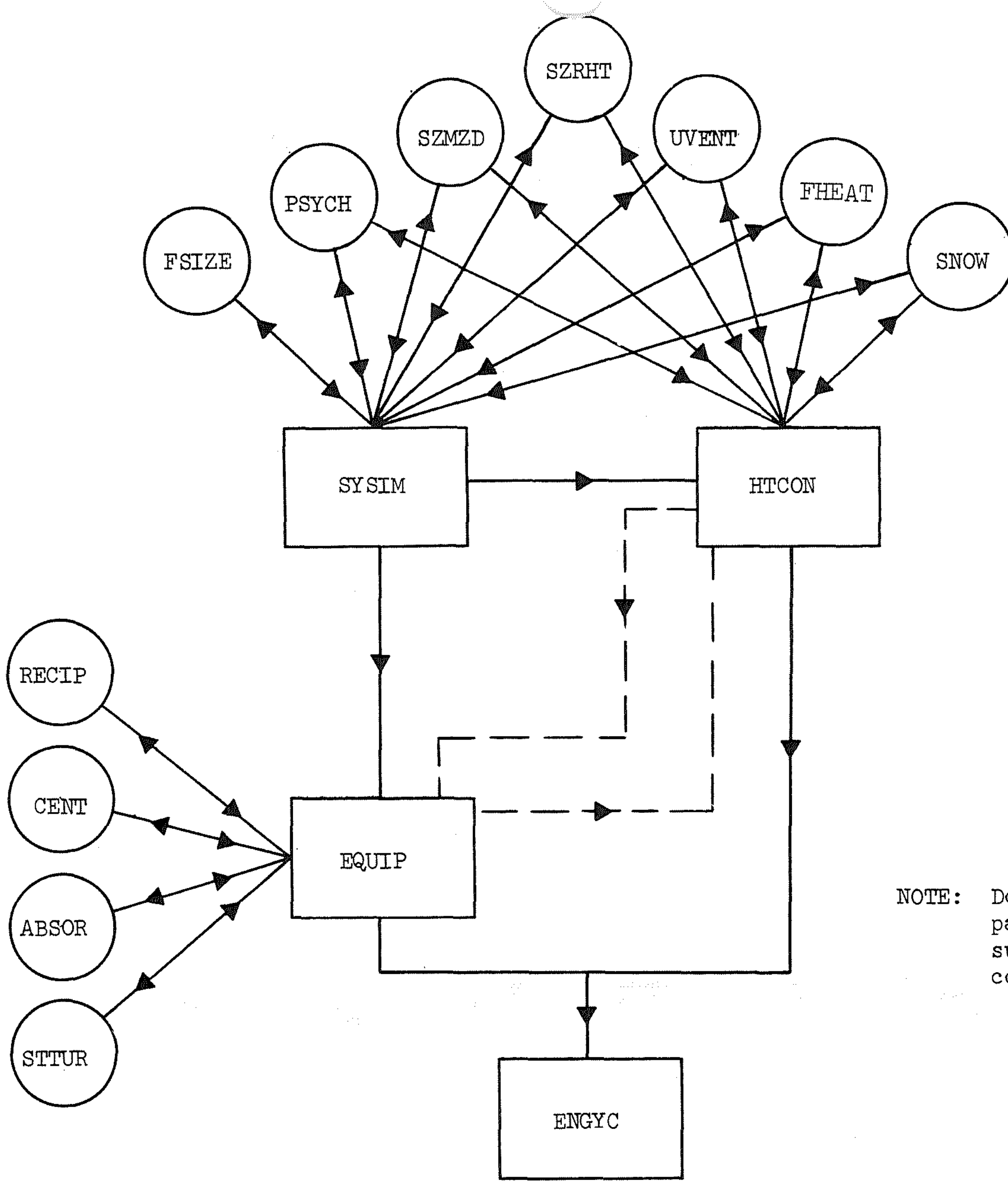


Figure 64 LOGIC FLOW CHART OF HTCON SUBROUTINE



NOTE: Dotted line indicates path of logic taken for summer operation of heat conservation machines.

Figure 65 INTERRELATIONSHIP OF SYSTEMS SIMULATION SUB-PROGRAM SUBROUTINES

TABLE 22 SYSTEMS SIMULATION SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
SS-1	1 to 10	Building changeover temperature	TCO	°F			60.	Above this O.A. temp., only cooling available; below, only heating available.
SS-2	1 to 10	Chilled water set point temperature	TLCHL	°F			44.	
SS-3	1 to 10	Cooling tower water low limit temperature	TECMN	°F			75.	
SS-4	1 to 10	Maximum condenser water temp. allowable	TLCNM	°F			115.	For heat conservation systems only
SS-5	1 to 10	Heating value of diesel fuel	HVDF	Btu/gal			150000.	
SS-6	1 to 10	Heating value of heating oil	HVHO	Btu/gal			140000.	
SS-7	1 to 10	Design temperature of well or city water returning to source	TCLMN	°F			50.	For heat conservation systems only
SS-8	1 to 10	City water temperature	TCWIN	°F			60.	
SS-9	1 to 10	Well water temperature	TWWIN	°F			60.	
SS-10	1 to 10	Pressure of low pressure steam	PESTM	psig			10.	Used for steam absorption chillers and steam heating coils
SS-11	1 to 10	Temperature of low pressure steam	TESTM	°F			200.	
SS-12	1 to 10	Pressure of high pressure steam	PPS	psig			250.	Usually purchased steam used for driving steam turbines
SS-13	1 to 10	Temperature of high pressure steam	TPS	°F			400.	
SS-14	1 to 10	Fan and pump motor efficiency	EFF	%			80.	Allows motor sizing and accounting for fan heat added to air
SS-15	1 to 10	Speed of steam turbine	RPM	rpm			3600.	
SS-16	1 to 10	Total head of chilled water pumps	HDCLP	feet			40.	
SS-17	1 to 10	Total head of condenser water pumps	HDCNP	feet			40.	
SS-18	1 to 10	Total head of boiler water pumps	HDBLP	feet			40.	
SS-19	1 to 10	Total head of well water pumps	HDWWP	feet			40.	

TABLE 22 (CONT'D) SYSTEMS SIMULATION SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
SS-20	1 to 10	Power of external lights	PWOL	KW			10000.	Parking lot and dock lighting
SS-21	1 to 10	Number of boilers	NUMB				2.	
SS-22	1 to 10	Minimum part load cutoff for chillers	FFLMN	%			20.	Below this point, chillers are turned off.
SS-23	1 to 10	Type of snow-melting system	KSNOW			0 None 1 Liquid 2 Electric	2.	
SS-24	1 to 10	Design load of snow-melting system	QSNOW	Btu/hr			5000.	This is added to peak heating when sizing boiler. If N/A, use 0.
SS-25	1 to 10	Total snow-melting slab area	SAREA	sq. ft.			1000.	
SS-26	1 to 10	Type of floor covering	KFLCV			1 Bare concrete 2 Tile 3 Carpeting	1.	These items used only for floor panel heating systems
SS-27	1 to 10	Floor insulation conductance	CINSL	Btu/hr-sq ft-°F			0.2	
SS-28	1 to 10	Floor insulation thickness	DINSL	ft			1.	
SS-29	1 to 10	Number of fan systems in building	KMAX				20.	
SS-30	1 to 10	Number of cases to be run	NCASE				5.	
SS-31	1 to 10	Is one of cases a conventional building?	KHCST			1 Yes 2 No	1.	
SS-32	1 to 10	Peak cooling hour No.	IHRMC		1 to 8784		114.	Obtain these quantities from the printed output of the Load Calculation Sub-program.
	11 to 20	Peak cooling hour outside air temperature	TOAC	°F			102.	
	21 to 30	Peak cooling hour outside air humidity ratio	WOAC	lb/lb			0.00923	
	31 to 40	Peak cooling hour barometric pressure	PATMC	inches of mercury			29.921	
	41 to 50	Peak cooling hour building sensible load	QSBCM	Btu/hr			153000.	
	51 to 60	Peak cooling hour building latent load	QLBCM	Btu/hr			14000.	
	61 to 70	Peak cooling hour building plenum heat from lights	QLITC	Btu/hr			0.0	

TABLE 22 (CONT'D) SYSTEMS SIMULATION SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
SS-33	1 to 10	Peak heating hour No.	IHRMH		1 to 8784		16.	Obtain these quantities from the print output of the Load Calculation Sub-program.
	11 to 20	Peak heating hour outside air temperature	TOAH	°F			-10.	
	21 to 30	Peak heating hour outside air humidity ratio	WOAH	lb/lb			0.00125	
	31 to 40	Peak heating hour barometric pressure	PATMH	inches of mercury			29.421	
	41 to 50	Peak heating hour building sensible load	QSBHM	Btu/hr			-120000.	Must be negative to indicate heating load.
SS-34	1 to 10	Type of thermal distribution system	KFAN(K)			1 Single zone 2 Multi-zone 3 Dual duct 4 Single zone/Reheat 5 Unit ventilator 6 Unit heater 7 Floor panel heating	2. For multi-zone fan system	See note below.
	11 to 20	Number of zones on system	JMAX(K)				4.	
	21 to 30	System set point temperature	TSP(K)	°F			75.	
	31 to 40	System total pressure	FPRES(K)	in. water			4.	Any value is allowable.
	41 to 50	Location of floor heating panels	FLOC(K)			1 Slab on grade 2 Intermediate slab	1.	These only applicable to Type 7 system. For all other systems, leave these items blank.
	51 to 60	Floor area available for heating panels	PAREA(K)	sq. ft.			100.	
	61 to 70	Exposed perimeter of floor	PERIM(K)	ft.			30.	

NOTE: ONE OF CARD 34 IS REQUIRED FOR EACH FAN SYSTEM IN THE BUILDING.
ALL OF THESE CARDS ARE PLACED TOGETHER IN THE DECK.

SS-35	1 to 10	Zone auxiliary exhaust air quantities	CFM(K, J)	cfm			20.	See note below.

NOTE: ONE OF CARD 35 WILL BE REQUIRED FOR EACH FAN ZONE IN BUILDING.
THE SEQUENCE WILL BE FAN 1-ZONE 1, FAN 1-ZONE 2, ...FAN 2-ZONE 1, FAN 2-ZONE 2, ... etc.

TABLE 22 (CONT'D) SYSTEMS SIMULATION SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
SS-36	1 to 10	System combination number	ISYS				1.	For identification purposes
	11 to 20	Type of building	KBLDG			1 Conventional or on-site 2 Heat conservation	1.	This indicates how zone air flows are to be sized.
	21 to 30	Type of chiller	M1			1 Reciprocating 2 Hermetic centrifugal 3 Open centrifugal 4 Steam absorption 5 Centrifugal/Steam Turbine	2.	
	31 to 40	Source of chiller energy	M2			1 Gas 2 Oil 3 Steam 4 Electric	4.	
	41 to 50	Source of heating energy	M3			1 Gas 2 Oil 3 Steam 4 Electric	1.	
	51 to 60	Source of reheat coil energy	KREHT			0 None 1 Gas/hot water or steam 2 Oil/hot water or steam 3 Steam/hot water or steam 4 Electric/resistance, hot water or steam	0.	Only for single zone reheat system
	61 to 70	Type of auxiliary chiller	M6			0 None 1 Reciprocating 2 Hermetic centrifugal 3 Open centrifugal	0.	For heat conservation buildings only
SS-37	1 to 10	Source of supplemental heat	M7			0 None 1 Gas 2 Oil 3 Electric 4 Well water 5 City water	0.	For heat conservation buildings only
	11 to 20	Number of on-site generation engine/generator sets	M4				0.	If left 0, program will calculate this quantity
	21 to 30	Type of on-site generation engine/generator sets	M5			0 None 1 Diesel 2 Gas	0.	

NOTE: 1. AS MANY SETS OF CARDS 36 AND 37 ARE REQUIRED AS THERE ARE BUILDING SYSTEMS COMBINATIONS TO BE RUN.
2. PLACE HEAT CONSERVATION SYSTEMS LAST IN THE DECK.

SS-38	WBAN Summary of Day Deck 345	SNOW(K)	This card deck can be obtained from the National Weather Record Center, Ashville, N. C. The deck would consist of 365 or 366 cards and is placed in the Systems Simulation Sub-program data deck after card SS-37. If no snow-melting system is to be used, the snow data need not be placed in deck.

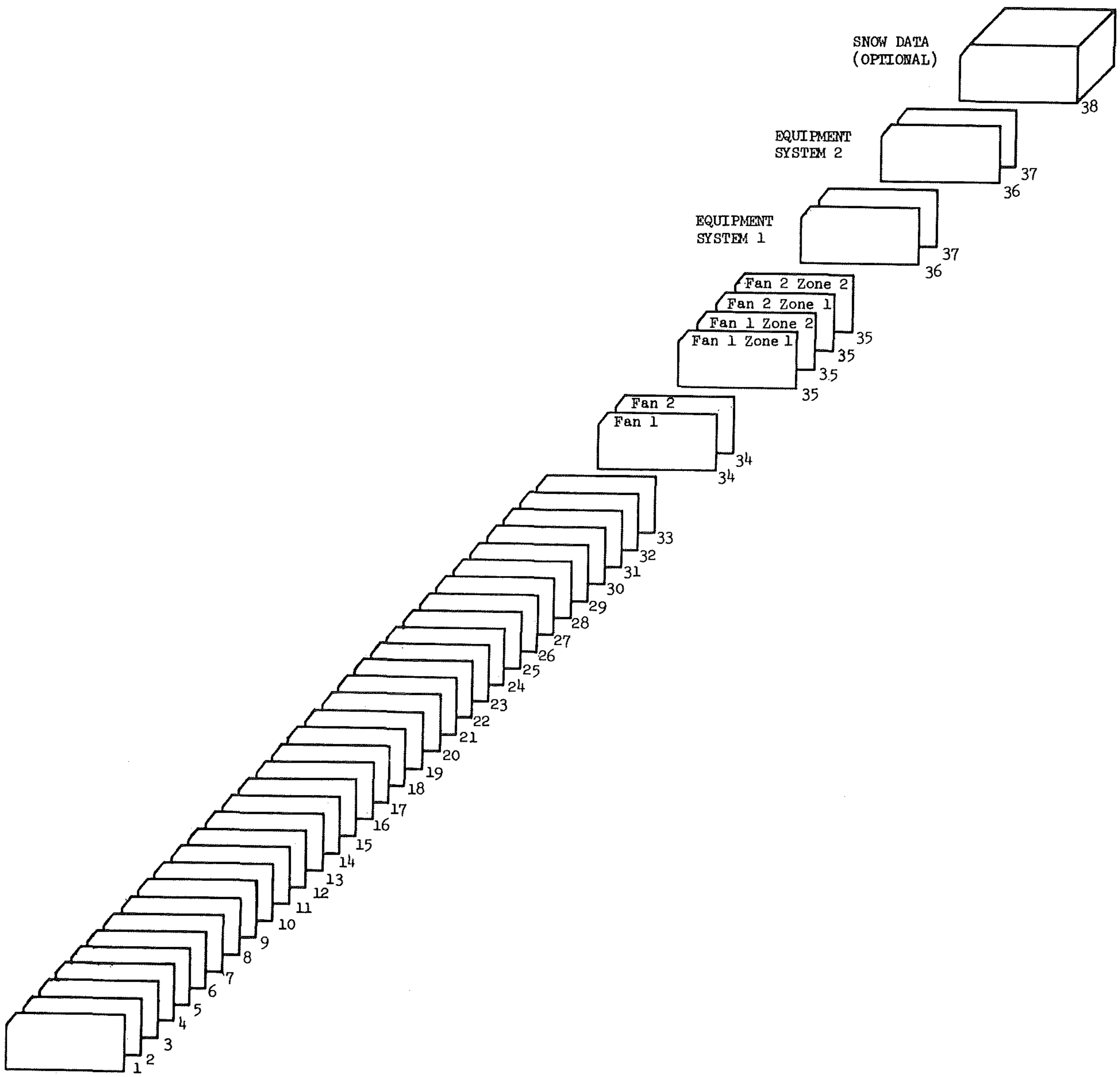


Figure 66 MAKEUP OF A TYPICAL INPUT DECK FOR SYSTEMS SIMULATION SUB-PROGRAM

U. S. P. O. D. CODING FORM NO. 3 FOR
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET
PITTSBURGH, PA. POST OFFICE	60311	R. HENNINGER	4/10	1 - OF - 2

Line	DATA FIELD (columns 1–70)	IDENTIFICATION FIELD (columns 71–80)	Line
1	60.	RHH SS1-1	1
2	45.	RHH SS2-2	2
3	75.	RHH SS3-3	3
4	115.	RHH SS4-4	4
5	140000.	RHH SS5-5	5
6	140000.	RHH SS6-6	6
7	55.	RHH SS7-7	7
8	60.	RHH SS8-8	8
9	60.	RHH SS9-9	9
10	10.	RHH S10-10	10
11	200.	RHH S11-11	11
12	150.	RHH S12-12	12
13	350.	RHH S13-13	13
14	80.	RHH S14-14	14
15	3600.	RHH S15-15	15
16	100.	RHH S16-16	16
17	100.	RHH S17-17	17
18	100.	RHH S18-18	18
19	100.	RHH S19-19	19
20	1000.	RHH S20-20	20
21	2.	RHH S21-21	21
22	20.	RHH S22-22	22
23	0.	RHH S23-23	23
24	0.	RHH S24-24	24
25	0.	RHH S25-25	25
26	1.	RHH S26-26	26
27	0.2	RHH S27-27	27
28	1.	RHH S28-28	28
29	2.	RHH S29-29	29
30	1.	RHH S30-30	30

Figure 67 TYPICAL INPUT FORM FOR SYSTEMS SIMULATION SUB-PROGRAM

U. S. P. O. D. CODING FORM NO. 3 FOR
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET
DITTSBURGH, PA. POST OFFICE	60311	R. HENNINGER	4/10	2 - OF - 2

DATA FIELD / IDENTIFICATION FIELD

Row	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80 (Identification Field)
1	1.							RHH S31-31
2	114.	95.	.00923	29.921	153000.	5000.	0.	RHH S32-32
3	16.	-10.	.00030	29.921	-120000.			RHH S33-33
4	2.	2.	75.	2.				RHH S34-34
5	4.	2.	75.	2.				RHH S34-35
6	0.							RHH S35-36
7	0.							RHH S35-37
8	0.							RHH S35-38
9	0.							RHH S35-39
10	1.	1.	1.	4.	1.	4.	0.	RHH S36-40
11	0.	0.	0.					RHH S37-41
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
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28								
29								
30								

Figure 68 TYPICAL INPUT FORM FOR SYSTEMS SIMULATION SUB-PROGRAM (CONT'D)

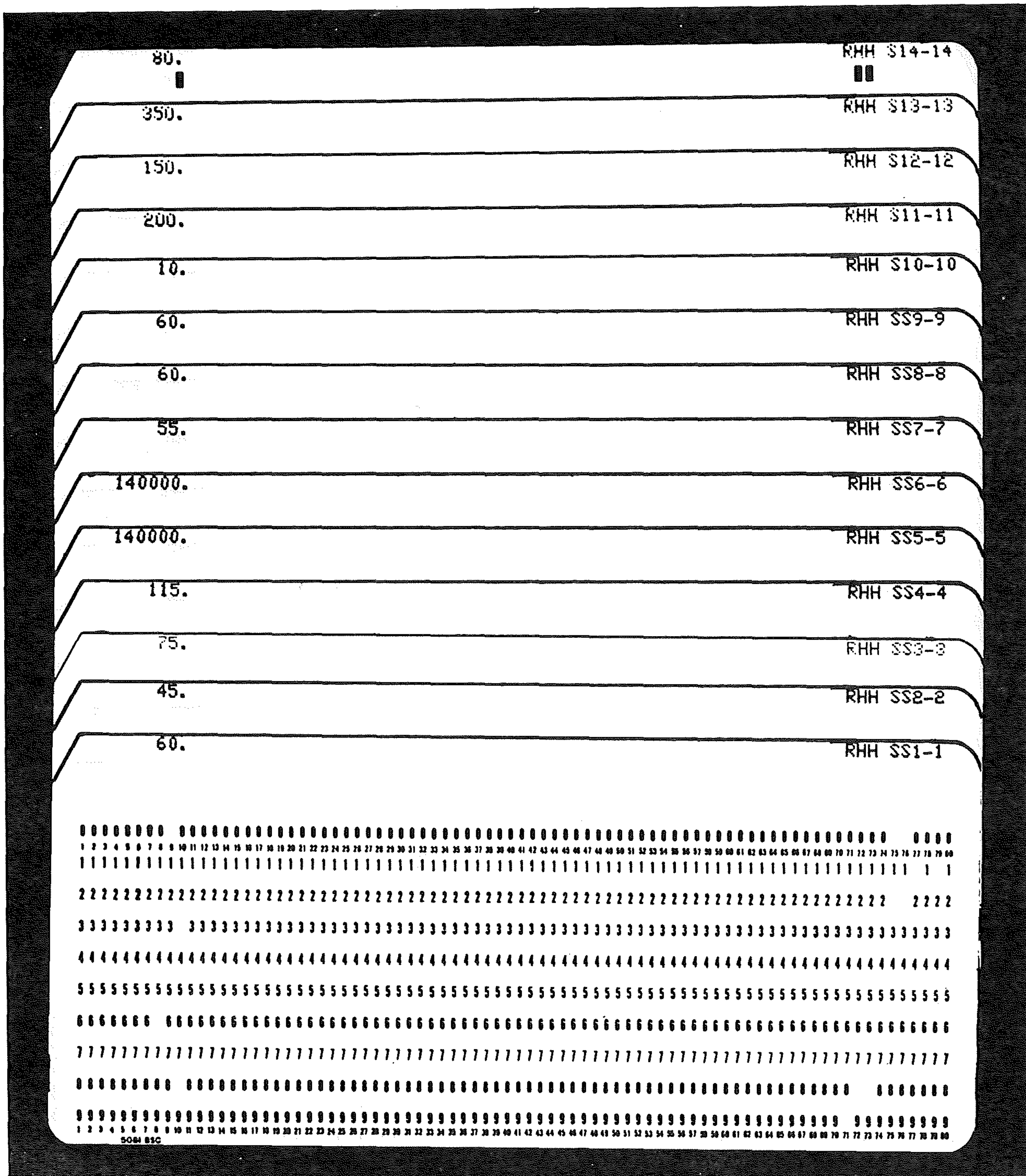

Figure 69 TYPICAL INPUT CARD DECK FOR SYSTEMS SIMULATION SUB-PROGRAM

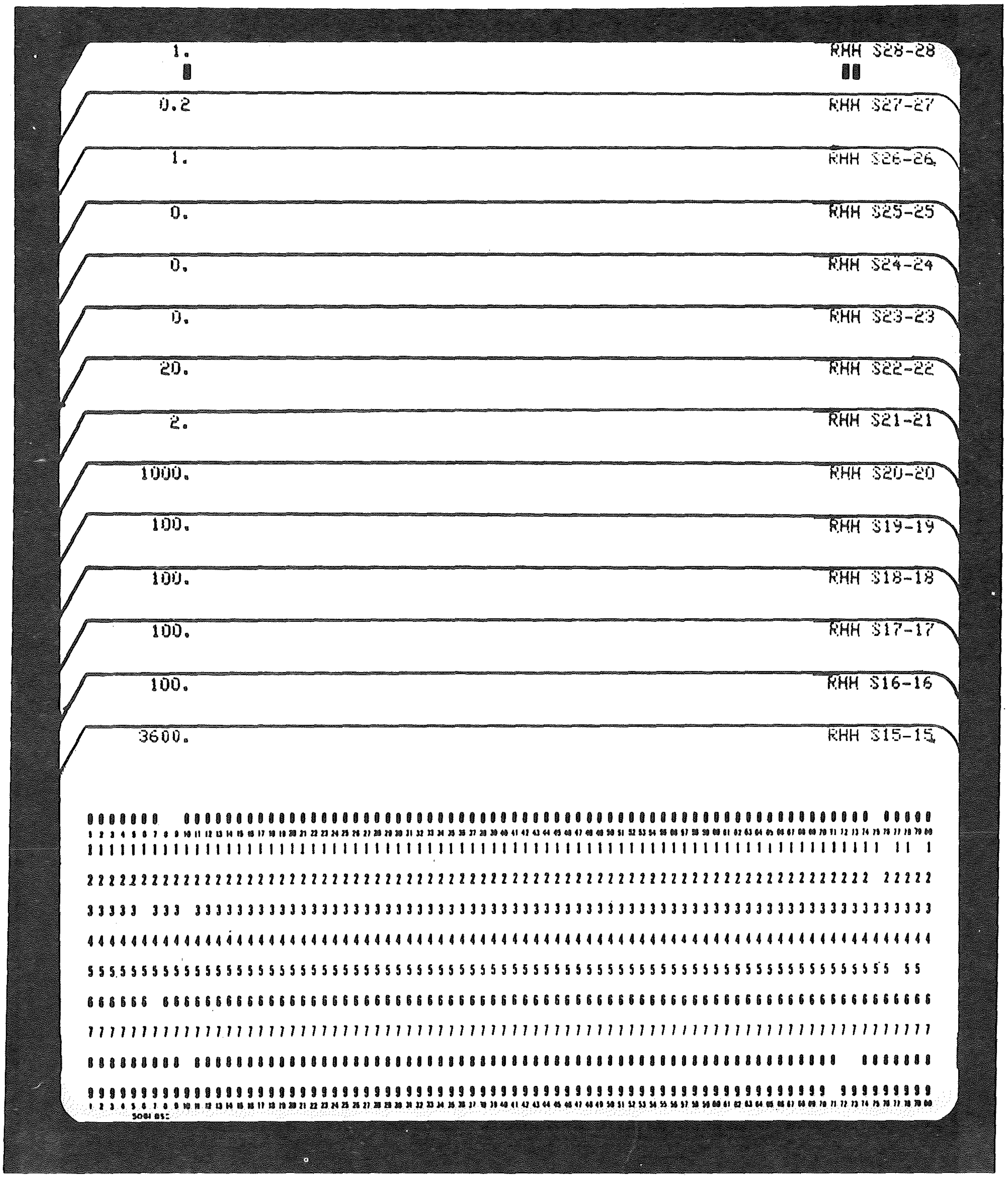

Figure 70 TYPICAL INPUT CARD DECK FOR SYSTEMS SIMULATION SUB-PROGRAM (CONT'D)

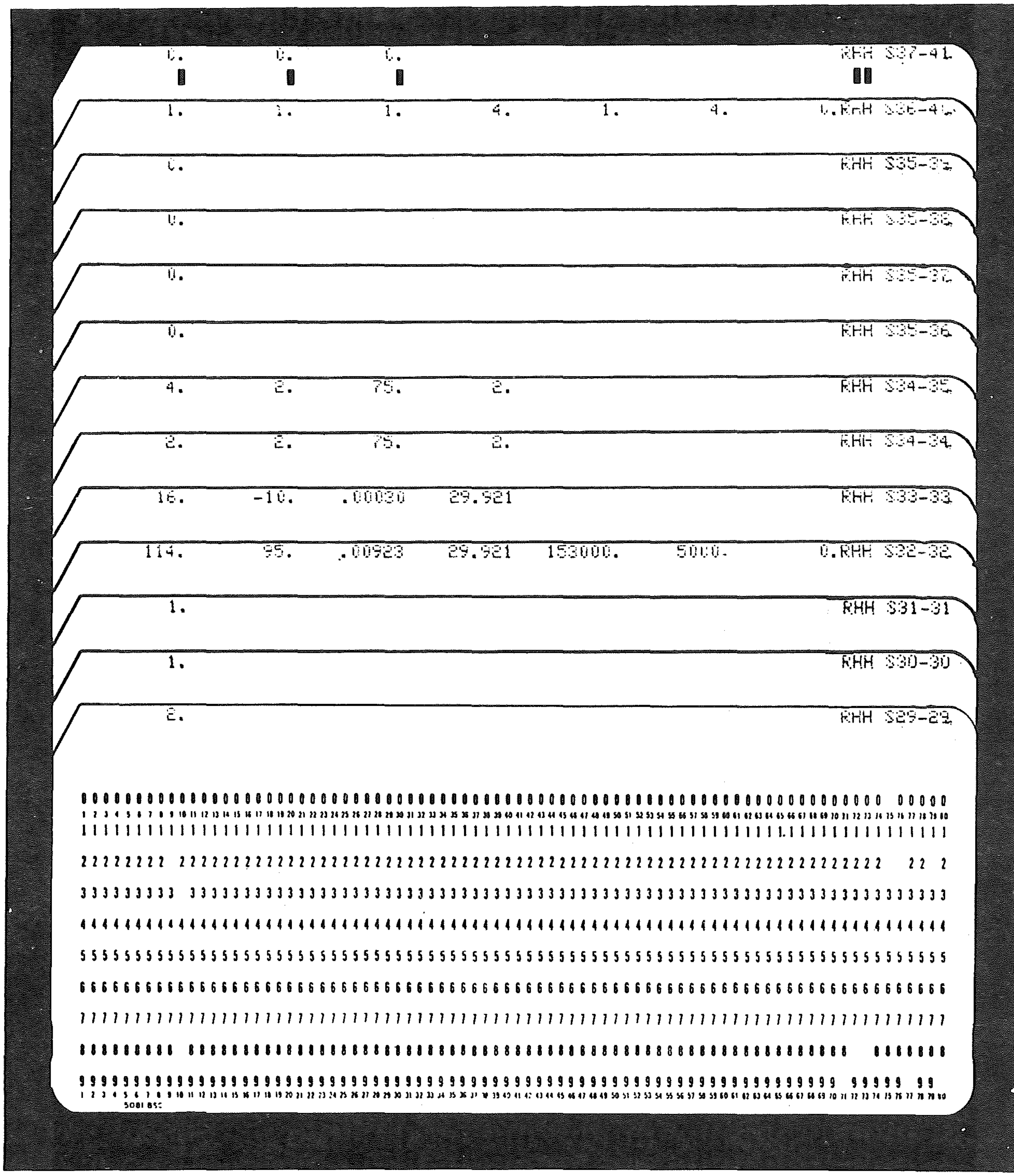

Figure 71 TYPICAL INPUT CARD DECK FOR SYSTEMS SIMULATION SUB-PROGRAM (CONT'D)

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*                      ANALYSIS OF ENERGY UTILIZATION IN                    *
*                                                                           *
*                                                                           *
*                        U. S. POST OFFICE AND V.M.F.                       *
*                                                                           *
*                                                                           *
*                                 FACILITY                                  *
*                                                                           *
*                                                                           *
*                              PITTSBURGH, PA.                              *
*                                                                           *
*                                                                           *
*  ENGINEER     -  R. HENNINGER                                             *
*  PROJECT NO   -  60311                                                    *
*  DATE         -  APR. 10, 1969                                            *
*                                                                           *
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Figure 72 OUTPUT 1 OF SYSTEMS SIMULATION SUB-PROGRAM

U. S. POST OFFICE AND V.M.F. PITTSBURGH, PA. APR. 10, 1969 60311
SYSTEM SIMULATION AND ENERGY ANALYSIS

SUMMARY OF FAN SYSTEM CHARACTERISTICS

FAN SYSTEM	TYPE	FAN BHP	NO. OF ZONES	SET POINT	TOTAL CFM	MIN. O.A. CFM	EXH. CFM	PERCENT VENT. AIR
1	MZS	1.0	2	75.0	2556	256	0	10.0
2	SZRH	.9	2	75.0	2315	231	0	10.0

Figure 73 OUTPUT 2 OF SYSTEMS SIMULATION SUB-PROGRAM

U. S. POST OFFICE AND V.M.F. PITTSBURGH, PA. APR. 10, 1969 60311
SYSTEM SIMULATION AND ENERGY ANALYSIS

SUMMARY OF ZONE AIR FLOWS

FAN SYSTEM	ZONE	SUPPLY CFM	EXHAUST CFM
1	1	1308	0
1	2	1248	0
2	1	1188	0
2	2	1127	0

Figure 74 OUTPUT 3 OF SYSTEMS SIMULATION SUB-PROGRAM

U. S. POST OFFICE AND V.M.F.   PITTSBURGH, PA.   APR. 10, 1969   60311
SYSTEM SIMULATION AND ENERGY ANALYSIS

SUMMARY OF EQUIPMENT SIZES

TYPE OF CHILLER	=	OPEN CENTRIFUGAL
NO. OF CHILLERS	=	2
SIZE OF CHILLERS	=	8.2 TONS

TYPE OF BOILER	=	GAS
NO. OF BOILERS	=	1
SIZE OF BOILERS	=	58.8 MBTU

TOTAL HEATING CAPACITY	=	58.8 MBTU
TOTAL COOLING CAPACITY	=	16.4 TONS
PEAK SENSIBLE COOLING	=	196 MBTU
PEAK LATENT COOLING	=	* MBTU

NO TERMINAL REHEAT USED

COOLING TOWER FAN REQUIREMENT   4918 CFM   1.0 IN. S.P.   1.0 BHP

BOILER AUXILIARY HORSEPOWER REQUIREMENT (FAN,BLOWER,PUMP)   .1 BHP

TOTAL FAN PLANT HORSEPOWER FOR BUILDING   1.9 BHP

SUMMARY OF PUMP SIZES

LOCATION	TOTAL GPM	TOTAL HEAD (FT)	TOTAL BHP
CHILLED WATER	39	40.0	.8
CONDENSER WATER	49	40.0	1.0
HEATING WATER	6	40.0	.1

Figure 75 OUTPUT 4 OF SYSTEMS SIMULATION SUB-PROGRAM

POST OFFICE DEPARTMENT EQUIPMENT AND ENERGY CONSUMPTION ANALYSIS	I FACILITY/ADDRESS I U. S. POST OFFICE AND V.M.F. IPITTSBURGH, PA.			I DATE/PROJECT I NOV. 25, 1968 I 60311	I ENGINEER/SYSTEM IDENTIFICATION IR. HENNINGER I SYSTEM NO. 1	
	ENERGY CONSUMPTION					
	JAN.	FEB.	MARCH	APRIL	MAY	JUNE
MONTHLY BTU/1000						
HEAT (MHB)						
MIN. DEMAND	22.	19.	12.	0.	0.	0.
MAX. DEMAND	175.	162.	137.	65.	21.	3.
CONSUMPTION	5214.	4560.	3758.	1891.	573.	52.
COOL (MCB)						
MIN. DEMAND	0.	0.	0.	0.	218.	267.
MAX. DEMAND	0.	0.	0.	250.	520.	597.
CONSUMPTION	0.	0.	0.	7245.	12669.	14316.
ELECTRICITY						
LIGHTS AND MOTORS						
INTERNAL						
DEMAND(KW)	5400.	5400.	5400.	5400.	5400.	5400.
CONS.(KWH)	3526770.	3526770.	3526770.	3526770.	3526770.	3526770.
EXTERNAL						
DEMAND(KW)	1820.	1820.	1820.	1820.	1820.	1820.
CONS.(KWH)	175350.	175350.	175350.	175350.	175350.	175350.
HEAT						
DEMAND(KW)	112.	112.	112.	0.	0.	0.
CONS.(KWH)	78400.	76160.	72800.	0.	0.	0.
COOL						
DEMAND(KW)	0.	0.	0.	1802.	1802.	2195.
CONS.(KWH)	0.	0.	0.	630021.	1101500.	1244888.
TOTAL						
DEMAND(KW)	7332.	7332.	7332.	9022.	9022.	9415.
CONS.(KWH)	3780520.	3778280.	3774920.	4332142.	4803621.	4947009.
GAS						
HEAT						
DEMAND(THERMS)	1719300.	1525000.	993270.	219800.	105071.	13140.
CONS.(THERMS)	8022201.	7016001.	5782001.	2864500.	881800.	81200.
COOL						
DEMAND(THERMS)	0.	0.	0.	0.	0.	0.
CONS.(THERMS)	0.	0.	0.	0.	0.	0.
GENERATION						
DEMAND(THERMS)	0.	0.	0.	0.	0.	0.
CONS.(THERMS)	0.	0.	0.	0.	0.	0.
TOTAL						
DEMAND(THERMS)	1719300.	1525000.	993270.	219800.	105071.	13140.
CONS.(THERMS)	8022201.	7016001.	5782001.	2864500.	881800.	81200.

Figure 76 OUTPUT 5, PAGE 1 OF SYSTEMS SIMULATION SUB-PROGRAM

POST OFFICE DEPARTMENT	I FACILITY/ADDRESS	I DATE/PROJECT	I ENGINEER/SYSTEM IDENTIFICATION
EQUIPMENT AND ENERGY	I U. S. POST OFFICE AND V.M.F.	I NOV. 25, 1968	IR. HENNINGER
CONSUMPTION ANALYSIS	IPITTSBURGH, PA.	I 60311	I SYSTEM NO. 1

	ENERGY CONSUMPTION						
	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
MONTHLY BTU/1000							
HEAT (MHB)							
MIN. DEMAND	0.	0.	0.	3.	20.	25.	
MAX. DEMAND	0.	0.	10.	61.	128.	170.	
CONSUMPTION	0.	0.	295.	1499.	3262.	5074.	26178.
COOL (MCB)							
MIN. DEMAND	266.	269.	271.	209.	23.	0.	
MAX. DEMAND	595.	605.	590.	499.	113.	0.	
CONSUMPTION	14563.	15317.	14950.	10159.	2566.	0.	91785.
ELECTRICITY							
LIGHTS AND MOTORS							
INTERNAL							
DEMAND(KW)	5400.	5400.	5400.	5400.	5400.	5400.	
CONS.(KWH)	3526770.	3526770.	3526770.	3526770.	3526770.	3526770.	42321232.
EXTERNAL							
DEMAND(KW)	1820.	1820.	1820.	1820.	1820.	1820.	
CONS.(KWH)	175350.	175350.	175350.	175350.	175350.	175350.	2104200.
HEAT							
DEMAND(KW)	0.	0.	0.	0.	0.	112.	
CONS.(KWH)	0.	0.	0.	0.	0.	80640.	308000.
COOL							
DEMAND(KW)	2195.	2195.	2195.	1802.	590.	0.	
CONS.(KWH)	1266417.	1331922.	1300043.	883435.	223152.	0.	7981379.
TOTAL							
DEMAND(KW)	9415.	9415.	9415.	9022.	7810.	7332.	
CONS.(KWH)	4968538.	5034043.	5002164.	4585556.	3925272.	3782760.	52714816.
GAS							
HEAT							
DEMAND(THERMS)	0.	0.	50410.	119492.	880810.	1398140.	
CONS.(THERMS)	0.	0.	454600.	2307000.	5019001.	7806501.	40234808.
COOL							
DEMAND(THERMS)	0.	0.	0.	0.	0.	0.	
CONS.(THERMS)	0.	0.	0.	0.	0.	0.	0.
GENERATION							
DEMAND(THERMS)	0.	0.	0.	0.	0.	0.	
CONS.(THERMS)	0.	0.	0.	0.	0.	0.	0.
TOTAL							
DEMAND(THERMS)	0.	0.	50410.	119492.	880810.	1398140.	
CONS.(THERMS)	0.	0.	454600.	2307000.	5019001.	7806501.	40234808.

Figure 77 OUTPUT 5, PAGE 2 OF SYSTEMS SIMULATION SUB-PROGRAM

POST OFFICE DEPARTMENT EQUIPMENT AND ENERGY CONSUMPTION ANALYSIS	I FACILITY/ADDRESS	I DATE/PROJECT	I ENGINEER/SYSTEM IDENTIFICATION
	I U. S. POST OFFICE AND V.M.F.	I NOV. 25, 1968	IR. HENNINGER
	IPITTSBURGH, PA.	I 60311	I SYSTEM NO. 1

	ENERGY CONSUMPTION					
	JAN.	FEB.	MARCH	APRIL	MAY	JUNE
STEAM						
HEAT						
DEMAND(K LBS)	0.	0.	0.	0.	0.	0.
CONS.(K LBS)	0.	0.	0.	0.	0.	0.
COOL						
DEMAND(K LBS)	0.	0.	0.	0.	0.	0.
CONS.(K LBS)	0.	0.	0.	0.	0.	0.
TOTAL						
DEMAND(K LBS)	0.	0.	0.	0.	0.	0.
CONS.(K LBS)	0.	0.	0.	0.	0.	0.
OIL						
HEAT						
CONS.(K GALS)	0.	0.	0.	0.	0.	0.
COOL						
CONS.(K GALS)	0.	0.	0.	0.	0.	0.
TOTAL						
CONS.(K GALS)	0.	0.	0.	0.	0.	0.
DIESEL FUEL						
GENERATION						
CONS.(K GALS)	0.	0.	0.	0.	0.	0.
CITY WATER						
DEMAND (K GALS)	0.	0.	0.	0.	0.	0.
CONS. (K GALS)	0.	0.	0.	0.	0.	0.

Figure 78 OUTPUT 5, PAGE 3 OF SYSTEMS SIMULATION SUB-PROGRAM

POST OFFICE DEPARTMENT EQUIPMENT AND ENERGY CONSUMPTION ANALYSIS	I FACILITY/ADDRESS	I DATE/PROJECT	I ENGINEER/SYSTEM IDENTIFICATION
	I U. S. POST OFFICE AND V.M.F.	I NOV. 25, 1968	IR. HENNINGER
	IPITTSBURGH, PA.	I 60311	I SYSTEM NO. 1

ENERGY CONSUMPTION	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
STEAM							
HEAT							
DEMAND(K LBS)	0.	0.	0.	0.	0.	0.	
CONS.(K LBS)	0.	0.	0.	0.	0.	0.	0.
COOL							
DEMAND(K LBS)	0.	0.	0.	0.	0.	0.	
CONS.(K LBS)	0.	0.	0.	0.	0.	0.	0.
TOTAL							
DEMAND(K LBS)	0.	0.	0.	0.	0.	0.	
CONS.(K LBS)	0.	0.	0.	0.	0.	0.	0.
OIL							
HEAT							
CONS.(K GALS)	0.	0.	0.	0.	0.	0.	0.
COOL							
CONS.(K GALS)	0.	0.	0.	0.	0.	0.	0.
TOTAL							
CONS.(K GALS)	0.	0.	0.	0.	0.	0.	0.
DIESEL FUEL							
GENERATION							
CONS.(K GALS)	0.	0.	0.	0.	0.	0.	0.
CITY WATER							
DEMAND (K GALS)	0.	0.	0.	0.	0.	0.	
CONS. (K GALS)	0.	0.	0.	0.	0.	0.	0.

Figure 79 OUTPUT 5, PAGE 4 OF SYSTEMS SIMULATION SUB-PROGRAM

SECTION 7

ECONOMICS ANALYSIS SUB-PROGRAM

The Economics Analysis Sub-program determines the annual total owning and operating costs of each building equipment combination considered in the Systems Simulation Sub-program and enables the POD engineer to determine which building equipment combination is the most economical for the building in question. This program takes into consideration energy cost, installed equipment cost, salvage value of equipment at the end of the building life, maintenance costs, periodic overhaul costs, and floor space cost. The annual owning and operating cost is computed based upon the discounted cash flow technique. Figure 80 outlines the workings of the Economics Analysis Sub-program.

7.1 Input Forms

The input information required for the Economics Analysis Sub-program has to be gathered by the engineer from various sources. The energy costs must be calculated external to this program, using the monthly energy consumption summary output of the System Simulation Sub-program and the utility rate schedules for the city in which the building is to be located. The installed cost of equipment must be estimated by the engineer. The annual maintenance costs and labor rates can be obtained from the proper Post Office Department Bureau, as can the floor space cost and estimated building life. The estimation of equipment life is very important and has a decided effect on the final economic outcome. The equipment life affects the cost analysis in the following manner. If, for example, the machine life expectancy is 20 years and the building life expectancy is 40 years, two machines will be required during the building's life span and would have no salvage value at that time. If, however, the building life is 40 years and the machine life is 15 years, three machines would be required during the life of the building. Furthermore, at the end of the building life, the machine will have a resale value, since it will have some useful years of life left. The engineer can decide whether or not to account for this credit.

In short, the Economics Analysis Sub-program accounts for all relevant costs and computes them for the life span of the building. Care must be exercised when using this program so that the equipment costs are coincident with the equipment component capacity output list of the Systems Simulation Sub-program.

Thirty cards per equipment combination make up the input deck for the Economics Analysis Sub-program. The information contained on each card is outlined in Table 23. The program is capable of handling any number of 30-card sets at one time. All that has to be done is to stack one set behind the other. If, for example, 5 equipment combinations are to be run, 150 cards will make up the input deck. The last card in the total deck should always be a blank card. This indicates to the computer that there are no more sets of data to be read and the program is exited from the computer with the output information. See Figures 81 to 84 for an example of a completed input form and card deck.

7.2 Output Forms

Figure 85 indicates the form of the output received from the Economics Analysis Sub-program, one for every building equipment combination that is run.

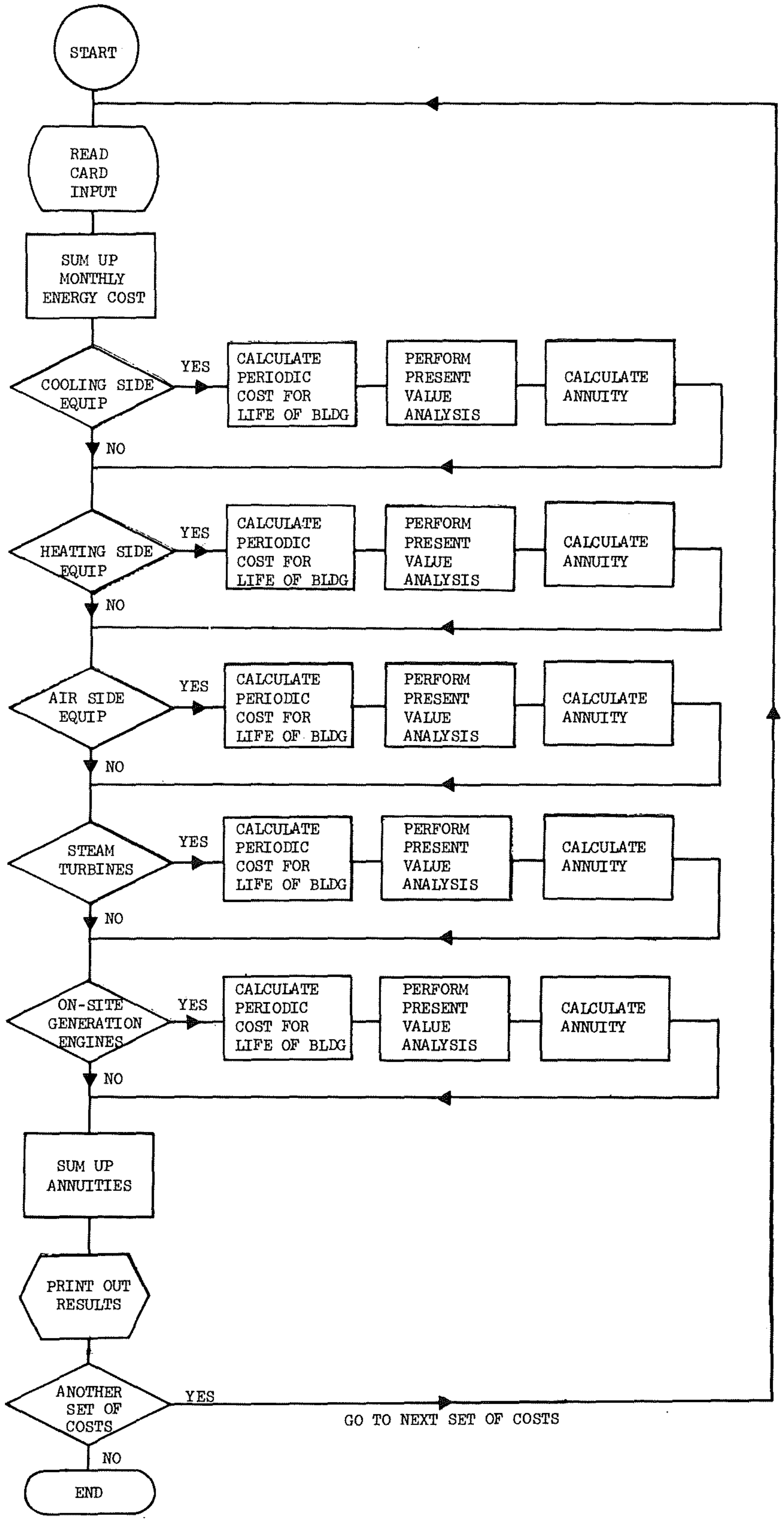

Figure 80 LOGIC FLOW CHART OF ECONOMICS ANALYSIS SUB-PROGRAM

TABLE 23 ECONOMICS ANALYSIS SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
EA-1	1 to 35	Facility name	FAC				U.S. Post Office	
EA-2	1 to 35	Facility location	CITY				Chicago, Illinois	
EA-3	1 to 15	Project number	PROJ				60311	
EA-4	1 to 15	Date	DATE				10/10/69	
EA-5	1 to 35	Name of engineer	ENGR				R. Henninger	
EA-6	1 to 10	Type of building	SYSTM			1 Conventional 2 Heat conservation 3 On-site generation	2.	
EA-7	1 to 10	Building life	BLGLF	Years			40.	
EA-8	1 to 10	Annual interest rate	RINT	%			7.	
	11 to 20	Estimated annual labor wage increase	RINL	%			4.	
	21 to 30	Estimated annual maintenance material cost increase	RINM	%			5.	
	31 to 40	Estimated annual increase of floor space cost	RINF	%			4.	
EA-9	1 to 10	Energy cost for January	ENGY(1, J)	$			1000.	See note below READING ORDER EA-10.
	11 to 20	Energy cost for February	ENGY(2, J)	$			1000.	
	21 to 30	Energy cost for March	ENGY(3, J)	$			1000.	
	31 to 40	Energy cost for April	ENGY(4, J)	$			1000.	
	41 to 50	Energy cost for May	ENGY(5, J)	$			1000.	
	51 to 60	Energy cost for June	ENGY(6, J)	$			1000.	

TABLE 23 (CONT'D) ECONOMICS ANALYSIS SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
EA-10	1 to 10	Energy cost for July	ENGY(7, J)	$			1000.	See note below.
	11 to 20	Energy cost for August	ENGY(8, J)	$			1000.	
	21 to 30	Energy cost for September	ENGY(9, J)	$			1000.	
	31 to 40	Energy cost for October	ENGY(10, J)	$			1000.	
	41 to 50	Energy cost for November	ENGY(11, J)	$			1000.	
	51 to 60	Energy cost for December	ENGY(12, J)	$			1000.	

NOTE: Six sets of Cards 9 and 10 are required. Each set, in the order indicated below, describes the input data for the following energies:

Cards 9 and 10, Fuel oil
11 and 12, Gas
13 and 14, Electricity
15 and 16, Purchase steam
17 and 18, City water
19 and 20, Diesel fuel

If certain of the above energies are not used in a building, leave the card blank. There must be 6 sets of cards in the input deck, one set for each of the above.

TABLE 23 (CONT'D). ECONOMICS ANALYSIS SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
EA-21	1 to 10	Installed cost of equipment	COST(I)	$			10000.	See note below READING ORDER EA-22.
	11 to 20	Expected life of equipment	LIFE(I)	years			15.	
	21 to 30	Is resale value to be considered?	SV(I)			0 = No; 1 = Yes	1.	Based on straight-line depreciation
	31 to 40	Major overhaul period	OHPD(I)	years			10.	
EA-22	1 to 10	Estimated annual maintenance labor cost	AML(I)	$			1000.	See note below.
	11 to 20	Estimated annual maintenance material cost	AMM(I)	$			500.	
	21 to 30	Estimated major overhaul labor cost	OHL(I)	$			5000.	
	31 to 40	Estimated major overhaul material cost	OHM(I)	$			4000.	
	41 to 50	Estimated cost of floor space required by equipment	FLR(I)	$			100.	

NOTE: Five sets of Cards 21 and 22 are required. Each set, in the order indicated below, describes the input data for the following equipment:

Cards 21 and 22, Cooling Side Equipment
23 and 24, Heating Side Equipment
25 and 26, Air Side Equipment
27 and 28, Steam Turbines
29 and 30, On-site Engine-Generator Sets

If certain of the above components are not used in a building, then leave the card blank.

U. S. P. O. D. CODING FORM NO. 3 FOR
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET
U. S. POST OFFICE AND V. M. F.	60921	R. HENNINGER	10/10	1 – OF – 1

Line	DATA FIELD 1–10	11–20	21–30	31–40	41–50	51–60	61–70	IDENTIFICATION FIELD 71–80	Line
1	U. S. POST OFFICE AND V.M.F.							RHH EA-1	1
2	CHICAGO, ILLINOIS							RHH EA-2	2
3	60921							RHH EA-3	3
4	10-10-1969							RHH EA-4	4
5	R. HENNINGER							RHH EA-5	5
6	2.							RHH EA-6	6
7	40.							RHH EA-7	7
8	7.	4.	5.	4.				RHH EA-8	8
9	0.	0.	0.	0.	0.	0.		RHH EA-9	9
10	0.	0.	0.	0.	0.	0.		RHH EA-10	10
11	4000.	4000.	3000.	2000.	1000.	500.		RHH EA-11	11
12	500.	500.	500.	2000.	3000.	4000.		RHH EA-12	12
13	15000.	15000.	40000.	40000.	40000.	75000.		RHH EA-13	13
14	90000.	100000.	85000.	60000.	10000.	5000.		RHH EA-14	14
15	0.	0.	0.	0.	0.	0.		RHH EA-15	15
16	0.	0.	0.	0.	0.	0.		RHH EA-16	16
17	0.	0.	0.	0.	0.	0.		RHH EA-17	17
18	0.	0.	0.	0.	0.	0.		RHH EA-18	18
19	0.	0.	0.	0.	0.	0.		RHH EA-19	19
20	0.	0.	0.	0.	0.	0.		RHH EA-20	20
21	200000.	25.	1.	7.				RHH EA-21	21
22	3000.	300.	250.	150.	1400.			RHH EA-22	22
23	100000.	35.	1.	0.				RHH EA-23	23
24	1000.	100.	0.	0.	1200.			RHH EA-24	24
25	200000.	25.	1.	10.				RHH EA-25	25
26	3000.	300.	0.	0.	1400.			RHH EA-26	26
27	0.	0.	0.	0.				RHH EA-27	27
28	0.	0.	0.	0.	0.			RHH EA-28	28
29	0.	0.	0.	0.				RHH EA-29	29
30	0.	0.	0.	0.	0.			RHH EA-30	30

Figure 81 TYPICAL INPUT FORM FOR ECONOMICS ANALYSIS SUB-PROGRAM

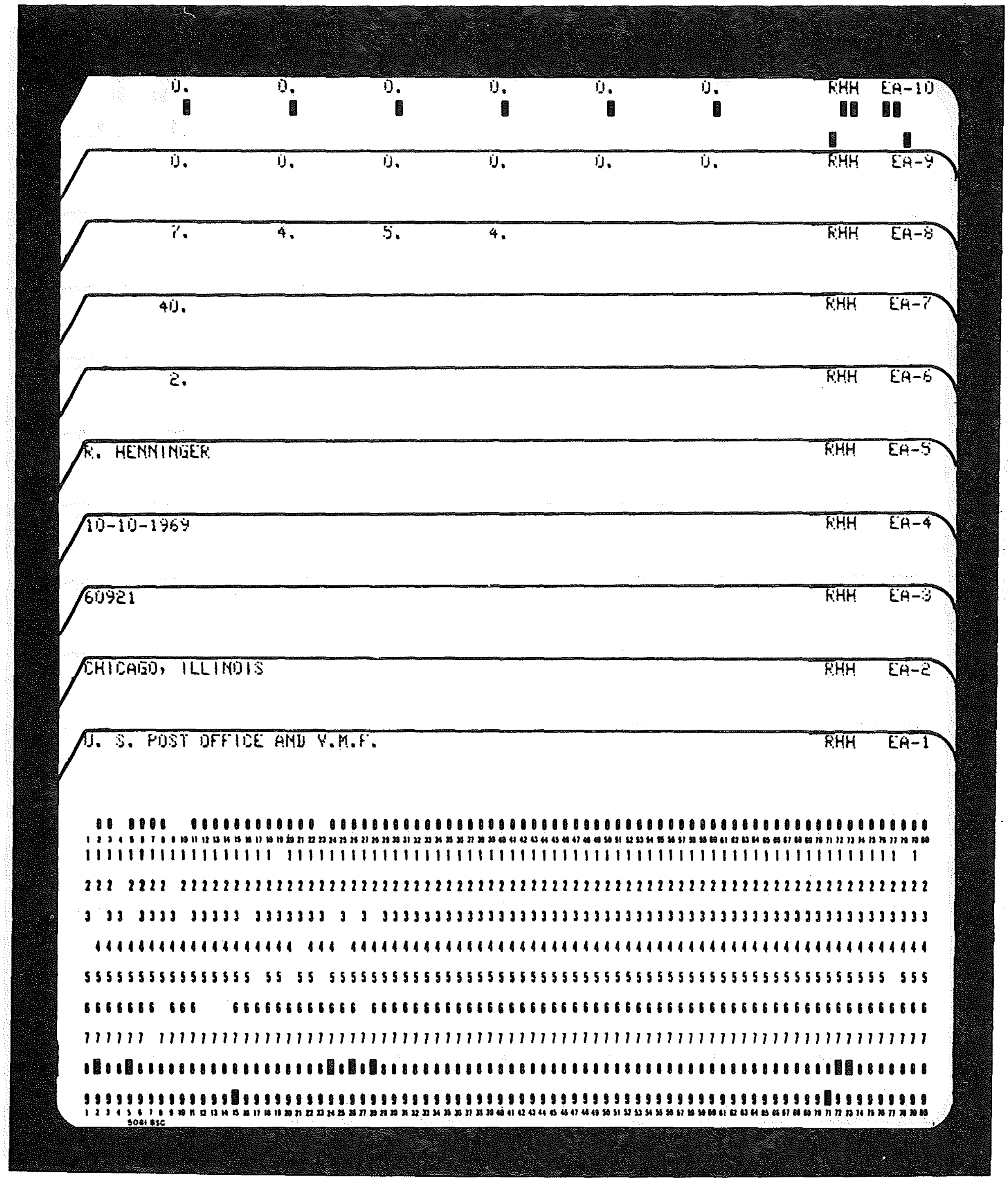

Figure 82 TYPICAL INPUT DECK FOR ECONOMICS ANALYSIS SUB-PROGRAM

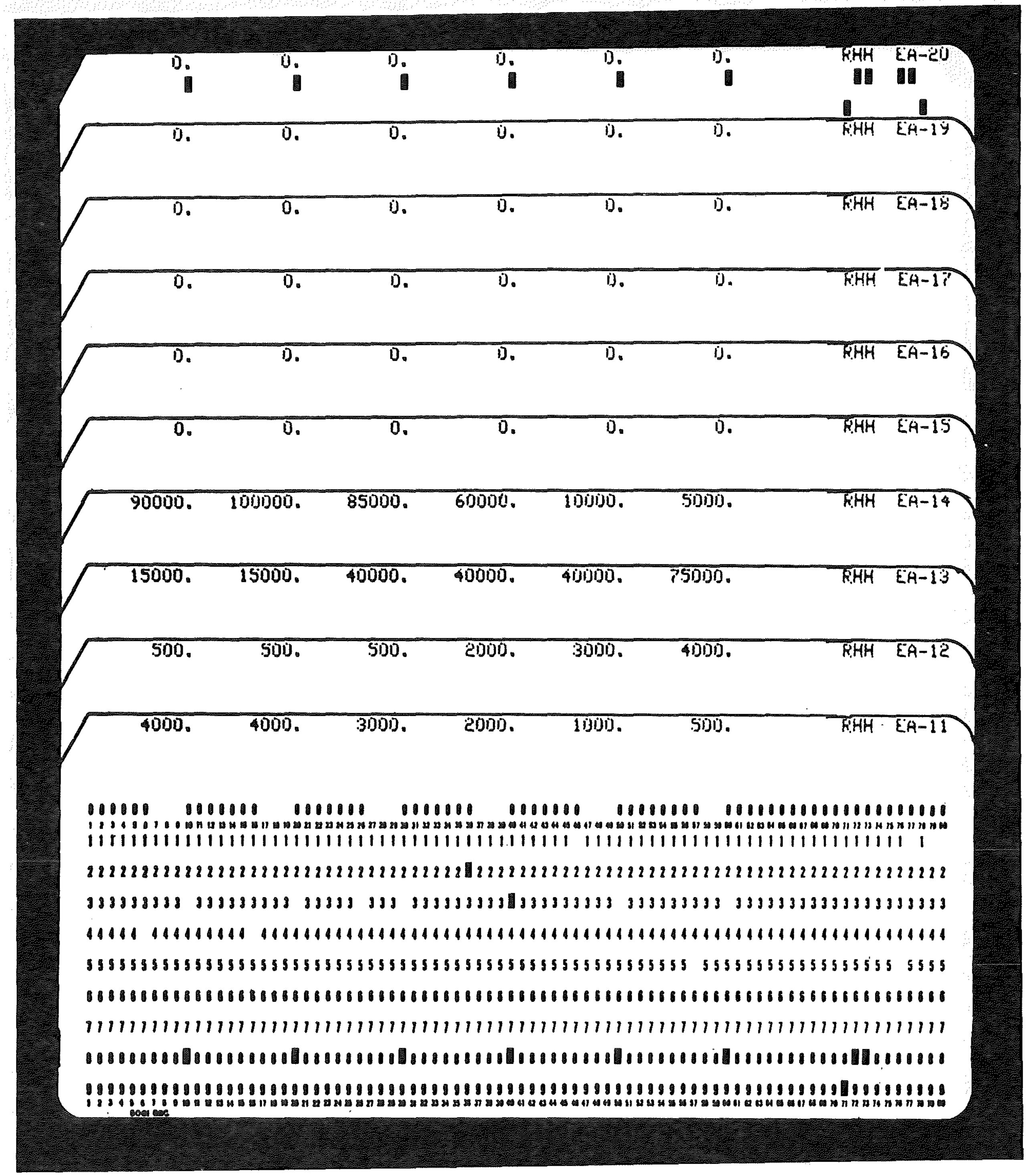

Figure 83 TYPICAL INPUT DECK FOR ECONOMICS ANALYSIS SUB-PROGRAM (CONT'D)

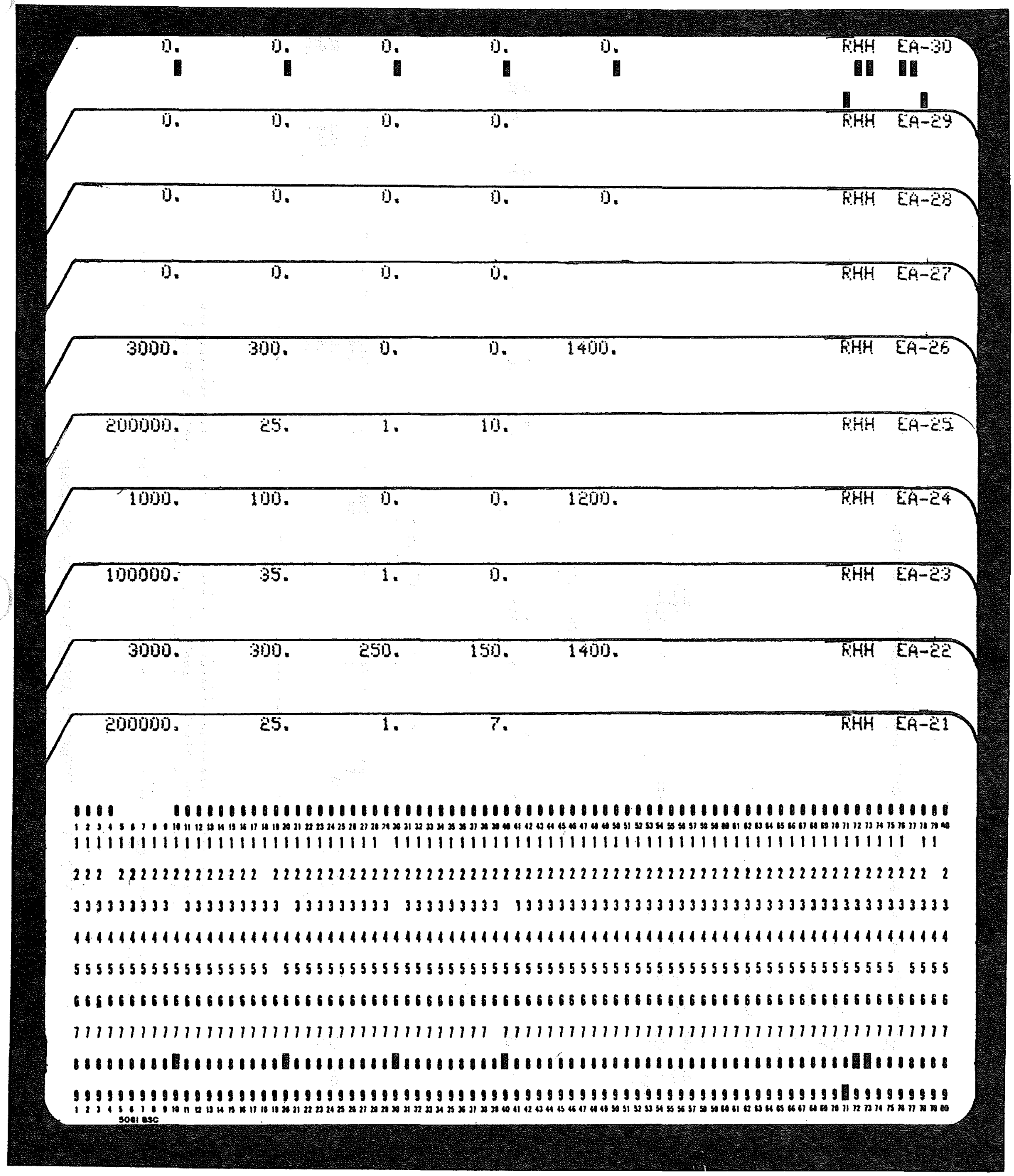

Figure 84 TYPICAL INPUT DECK FOR ECONOMICS ANALYSIS SUB-PROGRAM (CONT'D)

ECONOMIC ANALYSIS FOR AIR CONDITIONING EQUIPMENT SELECTION
****

U. S. POST OFFICE
CHICAGO, ILLINOIS
10-10-1969
R. HENNINGER
60921

CONVENTIONAL AIR CONDITIONING SYSTEM
****

*****INPUT ASSUMPTIONS*****

BUILDING LIFE	40.00 YEARS
ANNUAL INTEREST RATE	7.00 PERCENT
ESTIMATED LABOR WAGE ANNUAL INCREASE	4.00 PERCENT
ESTIMATED MATERIAL COST ANNUAL INCREASE	5.00 PERCENT
ESTIMATED FLOOR SPACE COST ANNUAL INCREASE	4.00 PERCENT

ENERGY COST
****

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
GAS COST	4000	4000	3000	2000	1000	500	500	500	500	2000	3000	4000	25000
ELECTRICITY COST	15000	15000	40000	40000	40000	75000	90000	100000	85000	60000	10000	5000	575000

*** ANNUAL ENERGY COST ****************************** 600000

MACHINE AND EQUIPMENT COST
****

	INITIAL COST	ANTICIPATED LIFE	SALVAGE CONSID.	MAJOR OVERHAUL PERIOD	MAJOR OVERHAUL LABOR	MAJOR OVERHAUL MATERIAL	ANNUAL MAINTENANCE LABOR	ANNUAL MAINTENANCE MATERIAL	FLOOR SPACE COST	ANNUITY
COOLING SIDE EQUIP.	200000	25	NO	7	250	150	3000	300	1400	32853
HEATING SIDE EQUIP.	100000	35	NO				1000	100	1200	15471
AIR SIDE EQUIP.	200000	25	NO	10	0	0	3000	300	1400	32761

TOTAL MACHINE AND EQUIPMENT ANNUITY******************** 81086

****
*TOTAL OWNING AND OPERATING ANNUITY 681086 DOLLARS *
****

NOTE -- ANNUITY IS CONSTRUED TO MEAN THE UNIFORM ANNUAL COST, CONSIDERING ALL THE LISTED COSTS, TO THE OWNER DURING THE LIFE TIME OF THE BUILDING.

Figure 85 OUTPUT OF ECONOMICS ANALYSIS SUB-PROGRAM

SECTION 8

PACKAGED SYSTEMS SIMULATION SUB-PROGRAM

Small one- or two-story Post Office buildings usually do not contain the type of fan systems or heating and cooling plants discussed in Section 6. Instead, packaged unitary heating/cooling systems are usually installed within or atop the building. The Packaged Systems Simulation Sub-program was written therefore, to simulate the operation of the following four types of packaged unitary equipment:

(1) Electric air conditioning (DX coil) with gas heat

(2) Electric air conditioning (DX coil) with oil heat

(3) Reversible cycle heat pump with electric resistance heating

(4) Gas air conditioning with gas heat.

The procedures for analyzing a small Post Office building which contains packaged system(s) are as follows:

(1) Break the building up into spaces so that each space will be served by a single packaged system.

(2) Use the Load Calculation Sub-program to compute the hourly loads for each space within the building.

(3) Since each packaged system serves only one space, there will probably be no need to use the Thermal Loads Plot Sub-program or Load Editing Sub-program. The engineer could, however, run the Thermal Loads Plot Sub-program to establish the load profile of a space or the entire building, if he deemed it necessary.

(4) Prepare the necessary card input and run the Packaged Systems Simulation Sub-program using the output tape of the Load Calculation Sub-program as the input load tape.

A logic flow chart of the calculations performed within the Packaged Systems Simulation Sub-program is shown in Figure 86.

8.1 Input Forms

Table 24 outlines the information that is to be contained on the input cards required for the Packaged Systems Simulation Sub-program. Figure 87 illustrates a typical completed input form and the accompanying punched cards are shown in Figure 88.

8.2 Output Forms

The output forms of this sub-program are similar to the Systems Simulation Sub-program outputs. Output 1 is a title page (see Figure 72). Output 2 summarizes the packaged systems characteristics and is illustrated in Figure 89. Output 3 is the same as the monthly energy consumption summary shown in Figures 76 to 79.

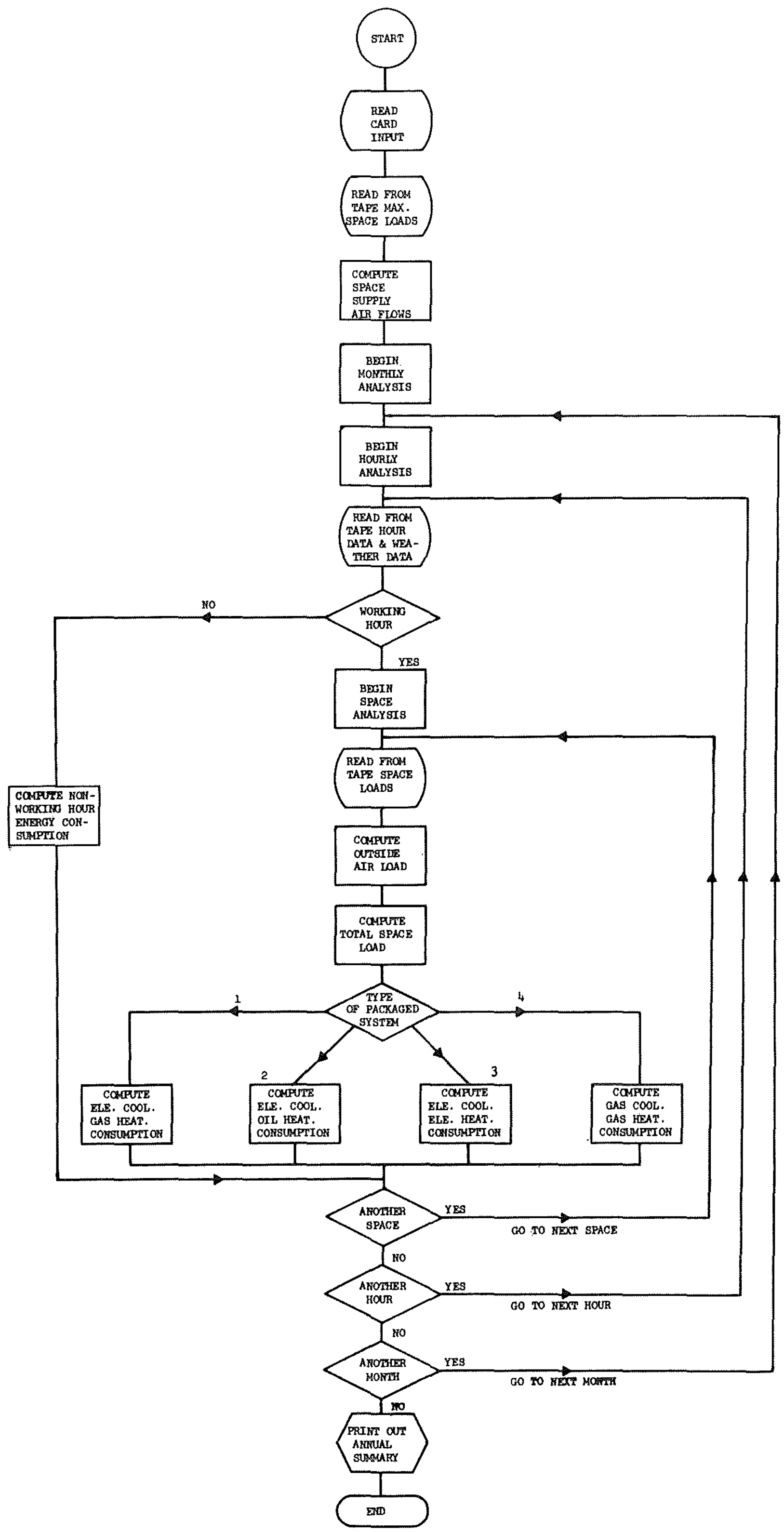

Figure 86 LOGIC FLOW CHART OF PACKAGED SYSTEMS SIMULATION SUB-PROGRAM

TABLE 24 PACKAGED SYSTEMS SIMULATION SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
PS-1	1 to 10	Day at which analysis is to begin	FSDW			1 Sunday 2 Monday 3 Tuesday 4 Wednesday 5 Thursday 6 Friday 7 Saturday	1.	
PS-2	1 to 10	Sunday start-up time of air cond.system	SUDST	hour		1 to 24 with 1 = 1 A.M., etc.	8.	
	11 to 20	Number of Sunday operating hours of air conditioning system	SUDWH	hours			10.	
	21 to 30	Saturday start-up time of air cond. system	SADST	hour		1 to 24 with 1 = 1 A.M., etc.	8.	
	31 to 40	Number of Saturday operating hours of air conditioning system	SADWH	hours			10.	
	41 to 50	Weekday start-up time of air cond. system	WKDST	hour		1 to 24 with 1 = 1 A.M., etc.	8.	
	51 to 60	Number of weekday operating hours of air conditioning system	WKDWH	hours			10.	
PS-3	1 to 10	Christmas start-up time of air cond. system	CHRST	hour		1 to 24 with 1 = 1 A.M., etc.	8.	Christmas schedule operation is from November 15 through December 31.
	11 to 20	Number of Christmas operating hours of air conditioning system	CHRWH	hours			10.	
PS-4	1 to 10	Power of building's external lights during working hours	UKWBX	KW			100.	Assumed ON only when sun not shining.
	11 to 20	Power of building's internal lights during working hours	UKWBI	KW			1000.	
	21 to 30	Power of building's external lights during non-working hours	UKWNX	KW			10.	Assumed ON only when sun not shining.
	31 to 40	Power of building's internal lights during non-working hours	UKWNI	KW			1000.	
PS-5	1 to 10	Heating value of heating oil	HVHO	Btu/gal			150000.	
PS-6	1 to 10	Total number of spaces in building	JMAX				5.	

TABLE 24 (CONT'd) PACKAGED SYSTEMS SIMULATION SUB-PROGRAM CARD INPUT INFORMATION

READING ORDER	COLUMNS	INPUT VARIABLE DESCRIPTION	PROGRAM SYMBOL	UNITS	LIMIT VALUES	CODE	EXAMPLE	COMMENTS
PS-7	1 to 10	Type of packaged system used on Space 1	JM(J)			1 Electric cooling Gas heating	1.	
	11 to 20	" " " 2	"			2 Electric cooling Oil heating	2.	
	21 to 30	" " " 3	"			3 Heat Pump- Electric cooling Electric heating	3.	
	31 to 40	" " " 4	"				4.	
	41 to 50	" " " 5	"			4 Gas Absorption- Gas cooling Gas heating		
	51 to 60	" " " 6	"					
	61 to 70	" " " 7	"					

NOTE: If there are more than 7 packaged systems (or 7 spaces) within a building, use as many of Card 6 as are required to input all the spaces.

U. S. P. O. D. CODING FORM NO. 3 FOR
COMPUTER PROGRAM FOR ANALYSIS OF ENERGY UTILIZATION IN POSTAL FACILITIES

FACILITY IDENTIFICATION	PROJECT NUMBER	ENGINEER	DATE	SHEET
U. S. POST OFFICE AND V. M. F.	60311	R. HENNINGER	4/10	1 – OF – 1

DATA FIELD / **IDENTIFICATION FIELD**

Line	1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80 (Identification Field)
1	7.							RHH PS1-1
2	8.	10.	8.	10.	8.	10.		RHH PS2-2
3	8.	10.						RHH PS3-3
4	100.	1000.	10.	1000.				RHH PS4-4
5	150000.							RHH PS5-5
6	11.							RHH PS6-6
7	1.	1.	1.	1.	1.	2.	2.	RHH PS7-7
8	3.	3.	4.	4.				RHH PS7-8

Figure 87 TYPICAL INPUT FORM FOR PACKAGED SYSTEMS SIMULATION SUB-PROGRAM

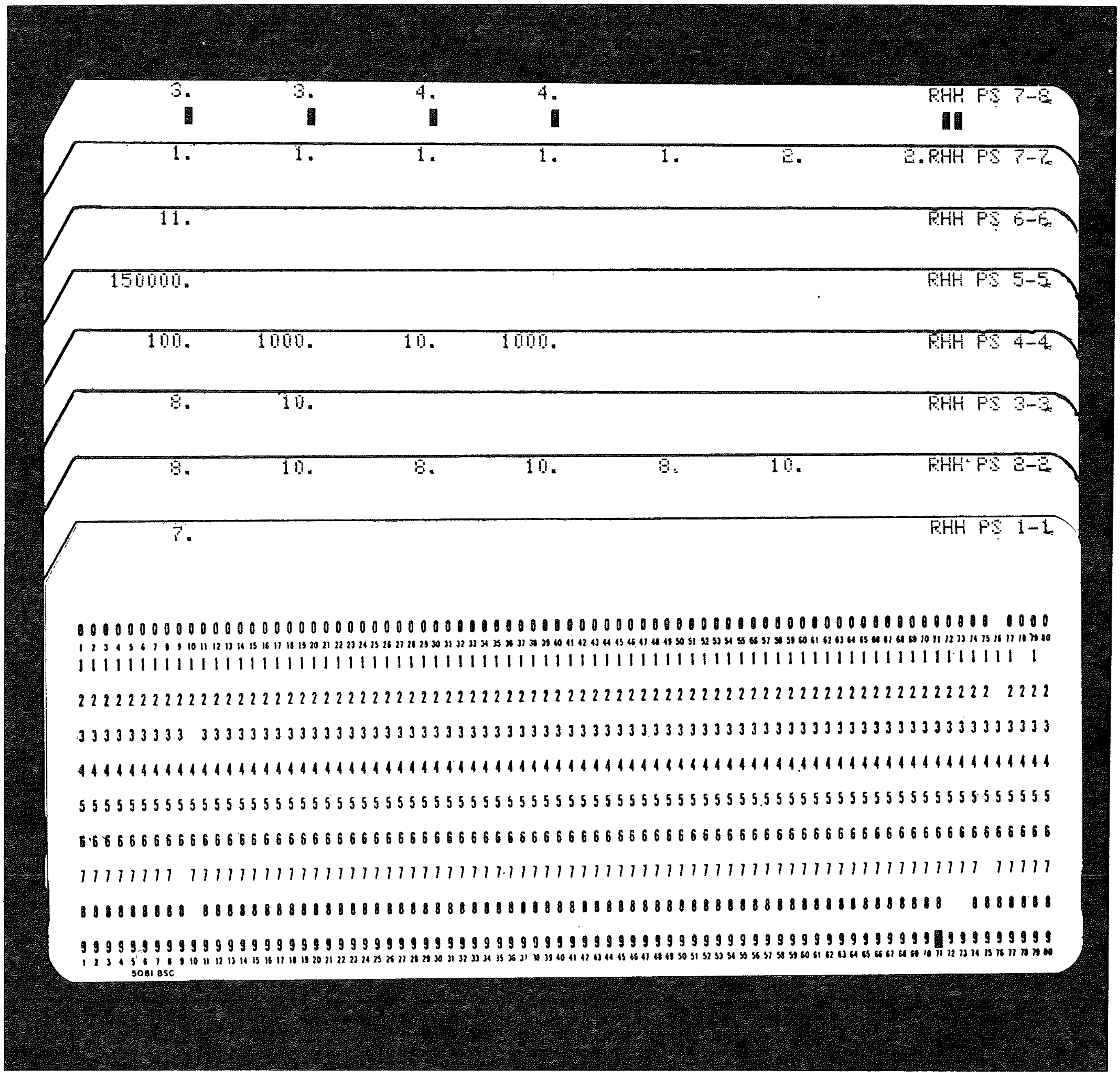

Figure 88 TYPICAL INPUT CARD DECK FOR PACKAGED SYSTEMS SIMULATION SUB-PROGRAM

U. S. POST OFFICE AND V.M.F.   PITTSBURGH, PA.   APR. 10, 1969 60311

SUMMARY OF PACKAGED SYSTEMS CHARACTERISTICS

PKGD SYSTEM	TYPE	TOTAL CFM	PEAK COOLING (TONS)	PEAK HEATING (MBTU)
1	1	1083	2.0	-18.8
2	2	1033	3.5	-13.8
3	3	983	1.8	-19.0
4	4	933	1.7	-19.1

Figure 89 OUTPUT 2 OF PACKAGED SYSTEMS SIMULATION SUB-PROGRAM