SOME MICRO-CLIMATIC EFFECTS ON THE SITING AND ORIENTATION OF BUILDINGS IN A NORTHERN ENVIRONMENT

A Thesis

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Master of Architecture

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by

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This study summerizes work begun as an undergraduate in computer applications of climate information for architectural projects. Through the interest of several individuals, this has been expanded, explored, modified, and developed into a study topic.

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Sincere appreciation is expressed to the numerous people involved in this study. Specifically, the writer would like to thank Professor Ben Harnish for his supervision, criticism, and guidance throughout the evolution of the topic. The writer would also like to thank Professors Al Rattray and Jim Wells, Carl Nelson Jr.; Harold Jackson, and Barbara Dakin for their encouragement and efforts in seeing this study to its conclusion.

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ABSTRACT

This study illustrates a method of architectural site planning using a digital computer. It attempts to determine the optimum placement and orientation of a building or a group of buildings on a chosen site. It uses as input variables from the following areas:

a) Topography

b) Surface Features

c) Climate

The final output identifies the locations best suited for the placement of buildings based upon solar, wind, and precipitation factors. The individual buildings or groups of buildings may then be oriented in such a manner as to best satisfy their performance requirements.

INTENT OF THE THESIS

The intent of this thesis is to develop and illustrate a method for locating and orienting buildings. It uses as a vehicle a land area taken from a Boreal Environment.

In general, problems associated with the siting of buildings have relied on hard physical data such as topography, soils, vegetation, etc. This thesis attempts to introduce some of the dynamic influences (or sub-systems) affecting the site and a dwelling unit which has been selected as a standard control building.

The effects of these factors will be identified by the application of linear models, using existing data bases (mapped site data) and readily available climatic information.

A final site selection will be made using the general modelling technique as described in the Introduction.

INTRODUCTION

This study is concerned with site selection and subsequent orientation of a building on that site. The specific study uses some salient environmental factors to control the siting and the orientation of detached dwelling units in Northern Boreal Regions. The study is developed as a method by which physical, environmental, and; although not shown; economical, and ecological factors can be included in the site selection process.

The natural environment is a complex integrated system that dynamically responds to the influences exerted upon it. Under normal circumstances, slight changes to the system are assimilated and a state of equilibrium is maintained. Major interventions, natural or man-made, can have dramatic effects upon the system's mechanisms and extent of response. In the extreme condition, the state of equilibrium can be totally disrupted, reducing the system to a lesser level of organization.

All intervention does not necessarily have a devestating impact on the natural environment.

Intervention in the form of development (eg. housing) may (and in most cases probably will) have some effect upon the natural site systems. Likewise, the natural site system and any resultant changes effect that development.

Coping with this relationship between the natural and man-made organization, is partially the responsibility of designers. Information utilized in this situation is usually derived from other disciplines. The success of a design will be determined by the quality of the information and the decision-making capabilities applied to and by the designer. The successful design will, among other criteria, anticipate the response of a site's systems to proposed development. Development should be structured by the designer to minimize or mitigate impairment while capitalizing on the inherent site attributes.

The designer is the responsible individual in planning and determining the arrangement of the components in the man-made environment. As our knowledge of the environment's natural systems increases, society places very demanding sets of requirements on the designer.

The designer's understanding of the natural environment, its inter-relationships with man's social and physical organization, and its inter-relationships within itself, requires the assimilation, analysis, and adjudication of vast amounts of information. This information must be prepared, structured, transcribed, and presented in a form which can be capable of predicting the effects of intervention on the natural environment. The utilization of this information requires a method which structures and facilitates the handling of that information.

The evolution of the method is part of the design process. This process uses a model as a vehicle. The usefulness of the model is measured by how well it embodies and reflects the relationships of the elements comprising the environment. It also depends on the extent to which it facilitates the designer's understanding of the 'real world' system being simulated. Also important is the responsiveness of the model to changes when it is manipulated for design study purposes.

The specific technique used in this study, reflects the information constraints posed by our understanding of site systems. Specific site sub-systems (eg. solar radiation) are reasonably well studied and documented, thereby lending themselves to a linear modelling technique. (A linear modelling technique is a step by step process of solving a simulated environmental problem in sequential additive steps, wherein the results of one step effects the results of the following steps). Conversely, the relationships of the sub-systems, and the holistic properties of the system itself, are not as well described or understood. This requires a model (See page) whose structure is capable of dealing with general statements of decision, as well as a satisfactory means of inter-relating seperate site sub-systems.

In this study, the digital computer was chosen as the medium through which the data, models, and design operations could best be studied. This medium facilitates:

1) the storage, retrieval, and manipulation of large volumes of information at a high rate of speed

2) the ability to maintain specific procedures and the consistent application of decision rules not normally available to the designer

3) the ease of transcribing, in suitable visual and descriptive ways, information for the designer

4) ease by which considerations can be changed and the problem re-worked (feedback)

Although an electronic computer can handle vast amounts of information, there is a finite limit to any given machine. The size and speed of the computer employed in an analysis poses some constraints on the amount of data that can be practically utilized. It is necessary to establish a standard format for the collection, coding, and analysis of site data. To satisfy these requirements, the site is divided into a series of smaller areas called 'cells'. This is done by superimposing a regular grid over the site which describes the chosen proportions and sizes of the cells. A square grid is normally used.

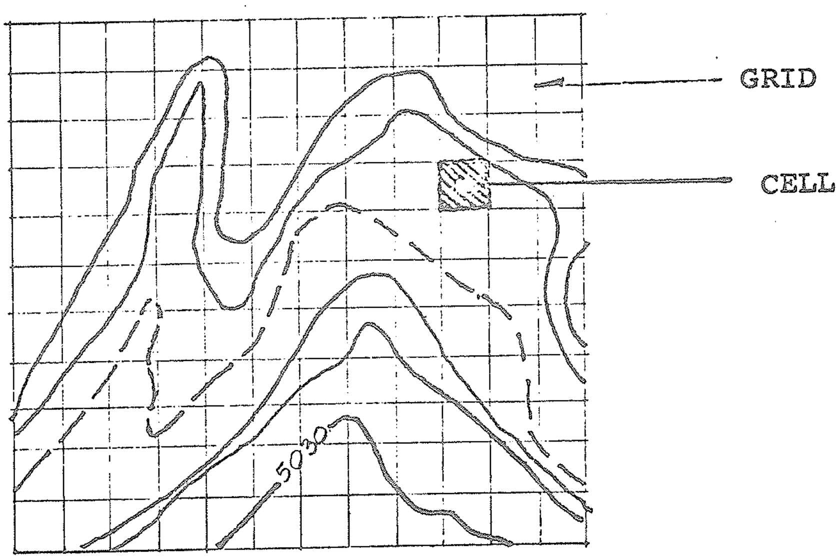


figure 1

The size of the cells and grid are established by taking into account such factors as:

1) the type of analysis to be done

2) the accuracy required in the coded data (coarseness or fineness) to attain the required accuracy in the analysis

3) the sources of the data for each of the variables to be coded (maps, aerial photographs, etc.)

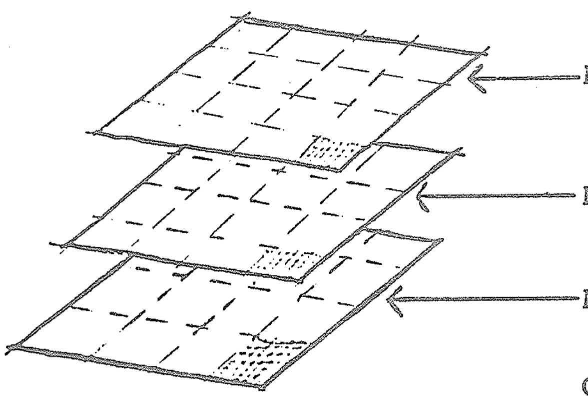
4) the type of variables to be coded

5) the availability of digitizing equipment, whether machine, or man-made

Once the cell and grid size are determined, criteria for the evaluation of the variables (eg. solar radiation) occurring within each cell are established. These criteria are then used to determine the coded values for each cell, for each variable. Each variable is coded as a map, with numeric representations for the conditions occurring within each cell. The coded maps then become the data bank for the analysis.

The initial step in the analysis usually consists of the formulation of a number of predictive models (or simulations of the 'real world') proposing a situation or event occurring on the site (eg. placing a dwelling unit). The coded variables that work in combination and define the proposed event are isolated. Each cell on the map is evaluated according to the model. A resultant map is generated from an evaluation which ranks each cell on the map according to the model formulation of data variable input.

The methods for handling linear modelling techniques are well defined. The means by which the general methodology of modelling is accomplished can be described simply as a series of map overlays. Each overlay represents one element in the total system.



Map 1 (variable 1) x wt 1 = N_1

Map 2 (variable 2) x wt 2 = N_2

Map N (variable 3) x wt 3 = N_3

CELL EVALUATION .... = $\overline{\sum N}$

figure 2

Of major significance is the development (derivation) of a suitable model weighting structure.

The weights applied to the various elements within the system can be readily changed in response to changes in policy, user preference, or outside expertise. The weights are therefore negotiable. The ease by which the model weights can be changed facilitates the rapid evaluation of differing value judgements or other changes.

VARIABLES CONSIDERED

The variables considered in this study are divided into two classifications: external influences and the site physical features. The variables considered in the first category (the external influences) are:

1) solar radiation
2) wind
3) precipitation

Those considered in the second category are:

1) topographic elevations
2) topographic slope
3) topographic slope-orientation
4) surface feature type
5) surface feature height
6) surface feature density

The variables are discussed in detail in Part 'A' of the thesis.

PART 'A'

CHAPTER II

SOLAR RADIATION

2.1 INTRODUCTION

The sun is one of the most frequently considered environmental parameters in building design or site selection problems. It is usually considered in the following ways:

1) as a source of heat and/or

2) as a source of light

Of the two aspects cited, the first is likely to receive the most attention by designers working in extreme environments.

As the sun is the only external source of heat in a Northern Environment, it is only logical that the Solar Heat Gains on buildings and building sites receive attention by the designer.

To determine the Solar Heat Gain on a surface, it is necessary to know the following:

1) the sun's position

2) the atmospheric conditions through which the sun's radiation must pass

3) the objects, natural or man-made, that absorb or reflect radiation on the site, or block radiation from reaching the site.

This section will deal with each of these factors in turn.

2.2 THE POSITION OF THE SUN

The position of the sun relative to any geographic location on earth can be determined if given:

1) the Latitude
2) the Longitude
3) the Time
4) the Date

Using the variables listed above, two angles can be found that will describe the sun's position relative to a particular point on earth. They are:

1) ALTITUDE — The vertical angle of the sun above the horizon

2) AZIMUTH — The horizontal angle of the sun measured from a fixed point. (eg. North or South depending upon the convention chosen) See figure 1.

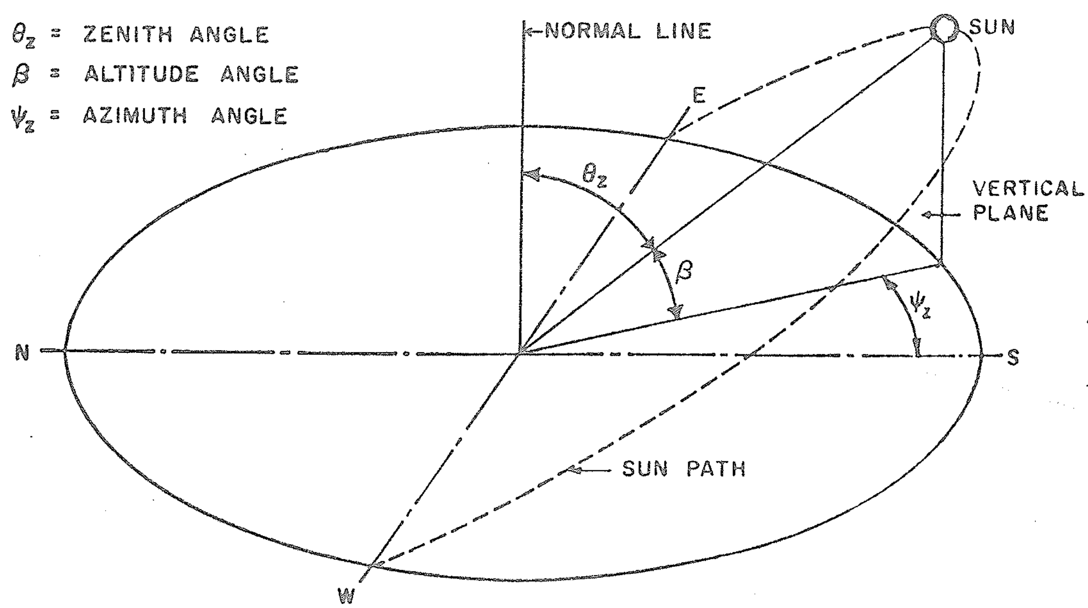


figure 1

For the purposes of this study, the convention chosen for measuring the solar azimuth was one of standard mapping convention. This means that the azimuth angles are measured from the North through a 360° clockwise arc. While this is not one of the standard conventions used for measuring Azimuth angles, it does clarify the exact position for the user conversant with standard mapping conventions. See Appendix 'A'.

2.3 SOLAR RADIATION

> " Radiant energy emitted from the sun is transmitted at a fairly uniform rate through space in the form of diverging rays traveling at the speed of light. Small bodies situated at great distances from the sun however, intercept such a small part of the sun's energy that the rays may be considered as parallel beams." (1)

These beams passing through space, have, when reaching the outer limits of the earth's atmosphere, a level of energy that can be assumed constant.

> " At the outer boundary of the earth's atmosphere, the flux of solar radiation which is received on a surface normal to the sun's rays is very nearly constant. This flux, at the mean distance between the sun and the earth, is known as the solar constant I_o." (2)

The value of the solar constant has been estimated by a number of scientists, and the values fall into a range of approximately 375-445 BTU/hour/ square foot. See Appendix 'A'.

> " Fortunately, the earth's surface is shielded from the full brunt of the sun's heat by an insulating blanket extending about 7 miles above sea level." (3)

The solar radiation actually reaching the earth's surface is only a small component of the solar constant I_o. Much of the radiation is absorbed by the earth's atmosphere, reflected back into space or scattered throughout the atmosphere.

> " About 43 per cent of the incoming solar radiation reaches the surface, either directly (27 per cent) or as a diffuse sky radiation (16 per cent). About 42 per cent is lost into space, mainly by direct reflection from clouds and the surface and about 15 per cent is absorbed by the atmosphere." (4)

In general, the greater the depth of the atmosphere the rays of the sun pass through, the greater the energy losses. See figure 2

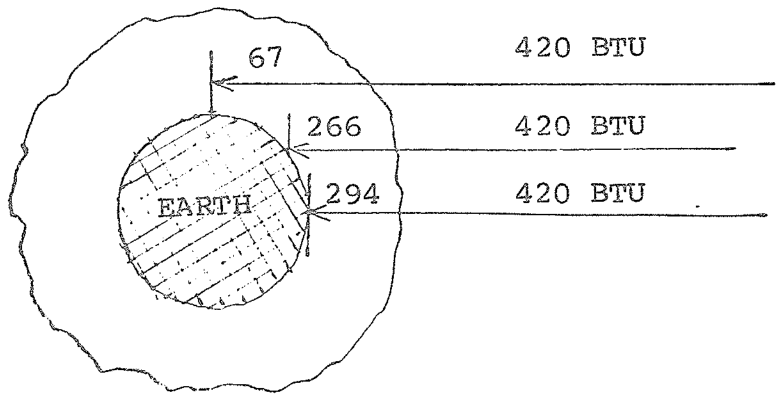


figure 2

This accounts for the reduction in the solar irradiation during periods when the sun's altitude is low. The lower the altitude, the more oblique the sun's rays are to the surface. The sun's rays must then pass through a greater depth of atmosphere.

The actual amount of radiation falling on the earth's surface can be predicted with reasonable accuracy, once the position of the sun in respect to a particular surface and the atmospheric variables can be determined. See Appendix 'A'

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1) OWENS - CORNING; The Economics of Sensible Heat Control, Owens-Corning Fibreglas Corporation, February, 1963, page 10.

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3) OWENS - CORNING; The Economics of Sensible Heat Control, Owens-Corning Fibreglas Corporation, February, 1963, page 10.

4) SUTTON, E.; Micro Meteorology, McGraw Hill, New York, 1953, page 160

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1) DEGELMAN, L. O.; The Development of a Mathematical Model for Predicting Solar Heat Gains Through Building Walls and Roofs; Better Building Report No. 6, The Pennsylvania State University Institute for Building Research, June, 1966, page 7.

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CHAPTER III

CLIMATIC INFLUENCES

3.1 INTRODUCTION

Of all the determinants on the design of buildings and building siting, the climatic influences are likely the most unpredictable. Where the Solar Radiation can be determined with a high degree of accuracy, most other climatic factors cannot.

It is not the purpose of this study to develop a climatic model capable of predicting what the climate on any given site will be, but rather to make some predictions about the effects the site and structures placed upon it will have on the site's climate. In short, it is attempting to establish what micro-climate is likely to exist on the site.

The number of climatic variables are of necessity limited to those having the greatest influence in a Northern Environment. The climatic variables to be considered are wind and precipitation.

3.2 THE EFFECTS OF THE SITE SURFACE FEATURES ON THE WIND VELOCITY

Of prime importance to the study of the windflow through a given area is a knowledge of the surface features in the area, their widths, heights, densities, and positions.

As the area under consideration is one of large forest expanses, the type of surface features that will be considered are large treed plantations. The method of coding the existing surface features data (cells, generalized for an area) tends to limit the type of features that can be utilized in an analysis.

To gain some understanding in the field of wind passage through wooded areas requires an exploration into a general field of study called 'shelter'.

> " Theoretically the term shelter comprises any reduction in the velocity of flow behind an object situated in an air current ..." (1)

Of the various types of shelter, the following are considered in this study:

" (f) SHELTER BELT: plantation of trees and/or shrubs of great length in proportion to its width, and of a width a few times its height.

(g) WOOD OR PLANTATION: wooded zone of great length and width in proportion to its height.

(h) LANDSCAPE: area covering many kilometers and well provided with sheltering objects."

(2)

In general, using the first case, the effect of 'shelter belts' can be defined as:

" The extent to which a shelter belt is able to reduce windspeed, its effect in depth depends upon wind direction, and the height, breadth, and the nature of the belt. In all cases, the protective effect is a function of distance from the shelter belt. It is substantially greater downwind than upwind. All investigations have shown fortunately, that the effect in depth is proportional to the height 'h' of the shelter belt, to a very close approximation, and also proportional to the wind speed 'v'. Distance 'x' in front of the shelter belt (-) or behind it (+) are therefore expressed in units of 'h', that is, the quantity used is $\pm x/h$ = multiples of height of the belt. Wind speeds are expressed as a percentage of the windspeed in the open."

(3)

See figure 1

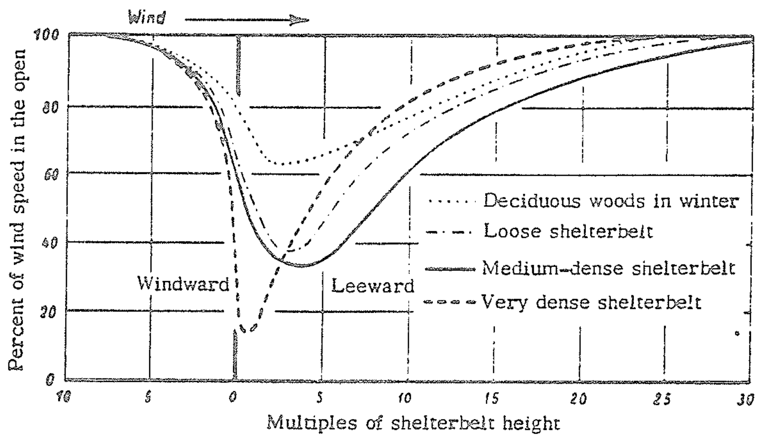


Fig. 265. The effect of a shelterbelt as a function of its penetrability. (After W. Nägeli)

figure 1

3.3 WIND DIRECTION

The complexities of approximating the resultant direction of wind passing over or around obstructions are beyond the scope of this study. For the purposes of this study, the wind is considered to act linearally - ie. the wind striking an object passes directly over it without any horizontal changes in direction.

This is done for a number of reasons: the first being the complexities of the development of a model and program, and the second being a general lack of information on the deflections of wind around objects.

3.4 SNOW DRIFTING

> Usually, "snow drifting occurs when, at a temperature below 0^{o} C, snow falls with a heavy wind."
>
> (4)

As the study area is in a Northern Environment the first of the stated conditions exists for a large part of the year. The second condition, that of heavy wind, is not as easily determined as the temperature, due to the interference of a specific site's surface features as discussed in Section 3.2

> " ... the influences of wind screens on the sand and snow moved by the wind - in other words, the formation of drifts - becomes clear when the properties of the wind fields of these screens is fully considered. The moving particles which draw near a screen will settle down as soon as they reach a zone which the velocity of the wind is sufficiently reduced. Which zone this is depends both on the velocity of the wind and the properties of the sheltering object. In a very strong wind perhaps, this zone will be only the wind minimum on the screen... As a rule, however, accumulations of sand and snow are found on both the wind side and the lee of the screens...
>
> "Several writers have, in fact, observed that drifts caused by dense screens are narrower and higher than those caused by screens with a lower density. According to Bates and Stoecheler (1941), two drifts will develop behind a very dense screen;

one will be just behind the screen and one will be a little further to the leeward. This is caused by the whirl behind the screen which has a horizontal axis to the screen. Where the whirl strikes the ground, that is, at its centre, the snow layer is relatively thin. Yet the drifts develop on both sides of the whirl.

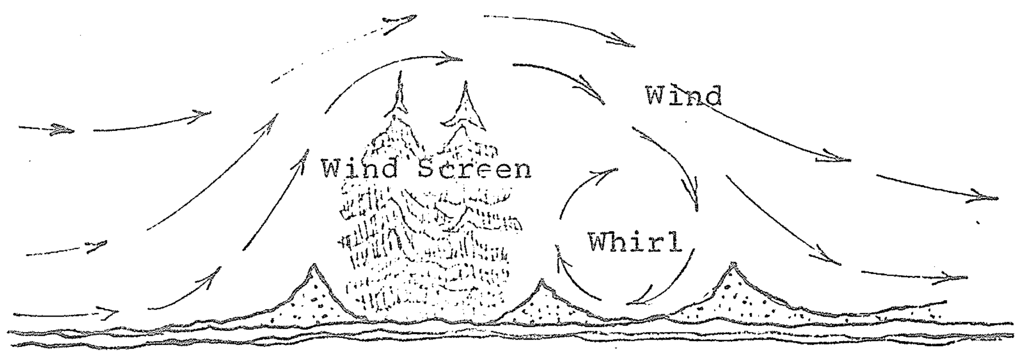


figure 2

"windscreens with an open stem story, a high wind velocity will occur during a high wind. The snow is then blown underneath the trees and lies rather evenly on the adjacent fields."

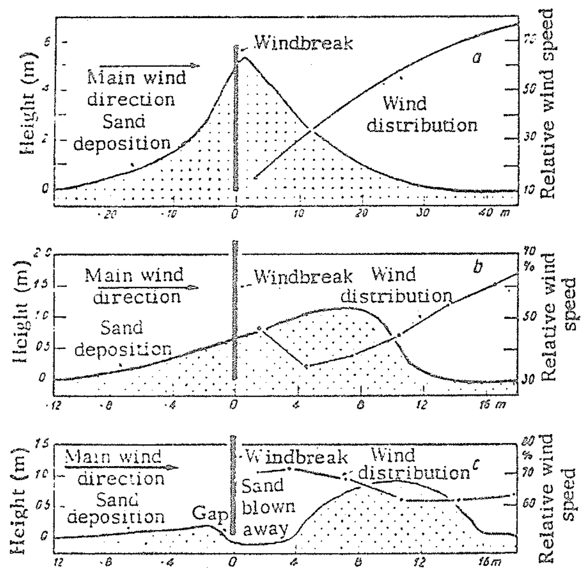
(5)

Geiger points out the similarities between drifting snow and sand:

"Similiar processes can be observed at work in drifting sand where it is possible to follow the effects for a considerably longer time than with snow."

(6)

In general, the more rapid the decrease in wind velocity, the greater will be the accumulation of snow, in the form of drifts. See figure 3.



Sand accumulation at windbreaks of different density. (After H. Kaiser)

figure 3

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4) F.A.O. UNITED NATIONS; Forest Influences, United Nations Press, 1954, page 193.

5) IBID

6) GEIGER, R.; The Climate Near the Ground, Harvard University Press, 1965, page 508.

FIGURES

1) GEIGER, R.; The Climate Near the Ground, Harvard University Press, 1965, page 499.

2) DAKIN, R.A.; Some Micro-Climatic Effects on the Siting and Orientation of Buildings in a Northern Environment, University of Manitoba, 1972.

3) GEIGER, R.; The Climate Near the Ground, Harvard University Press, 1965, page 508.

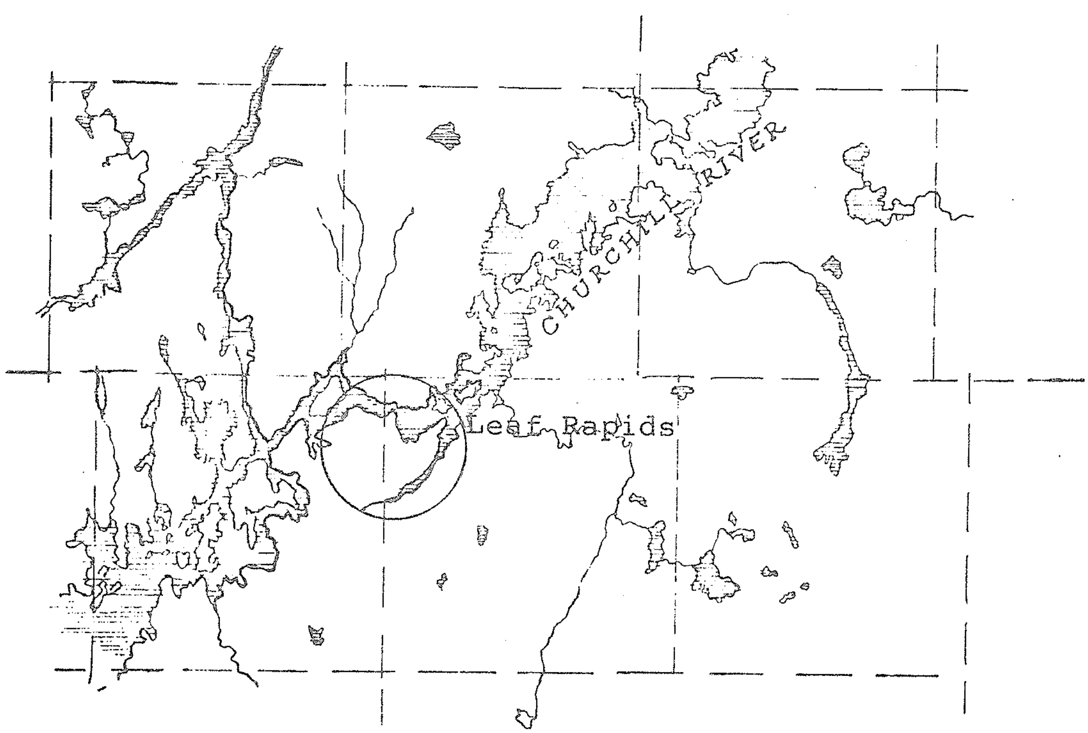
CHAPTER IV

SITE VARIABLES

4.1 THE SITE

The area chosen as the vehicle for this study is located in Northern Manitoba. The area is one of predominantly coniferous vegetation, muskeg, rock outcrops, and irregular topography.

The specific site chosen from within the area, is located at approximately 56° 31' North Latitude and 100° West Longitude. It includes a small portion of the townsite of Leaf Rapids, Manitoba.



The cell size chosen measures 100'-0" x 100'-0". This cell size was chosen for the coding of all site data for the following reasons:

1) the type and scale of available information on the variables to be coded was not accurate below this scale

2) an increase in the scale would increase the coarseness of the data

3) the 100'-0" x 100'-0" cell seemed a best compromise in terms of describing the standard residential lot

For the purposes of this study, a small test site was chosen measuring 2000'-0" x 2000'-0". Using the cells of 100'-0" x 100'-0", the site is divided into a grid of 20 rows and 20 columns, or 400 cells in total.

4.2 TOPOGRAPHY

In general, topographic maps provide three types of information:

1) Elevations

2) Slopes (derived)

3) Slope-orientations (derived)

The most accurate and readily obtainable information is the elevation. As the slope and slope-orientations are derived from the difference in elevations, it was decided to eliminate these two factors from any manual coding operations. One of the intents of using the computer was to save time while handling large amounts of data. Therefore, a program was written to accept as input, the elevations of cells, and generate as output, the cell centre elevations, slopes, and slope-orientations for each cell.

See Appendix 'B' for the method of coding and program; Maps 1, 2, 3 for the output.

4.3 SITE SURFACE FEATURES

The Site Surface Features (primarily vegetation) play an important part in the micro-climate of a site. They have a significant influence on the amount of solar radiation received by the site, as well as the velocity of the wind passing through the site. The important aspects of the Site Surface Features can be divided into three classifications:

1) the nature of the object: the characteristics of its surface (eg. deciduous vegetation loses 60% of its density during the winter)

2) the height of the object above the landform

3) the density of the object

See Appendix 'C' for the method of coding the Site Surface Feature variables, Maps 4, 5, 6 for the output.

PART 'B'

CHAPTER V

SITE ANALYSES

5.1 SITE SOLAR ANALYSIS

Using topographic information as described in Chapter IV, specifically:

1) topographic slopes
2) topographic slope-orientations

and the data on the Site Surface Features as described in Chapter IV, Section 4.3 , specifically:

1) surface feature type
2) surface feature height
3) surface feature density

a program was written to determine the amount of solar radiation falling on each cell on the chosen site. Each cell on the site is assumed to be cleared of all vegetation.

The Solar Radiation values were calculated for the 21st day of each month, using a one hour time interval beginning at solar midnight. The constants used in the program are those outlined in Appendix 'A'.

The direct and diffuse radiation to each cell on clear days only, was considered in the analysis. The effects of the atmosphere, in terms of local weather conditions, such as the amount of cloud cover, was not taken into account.

The reflected radiation from adjacent cells was not included in the calculations as Wilson (1) claims that even in situations where high reflectance is apparent (ie. snow @ 70%), the reflectance on moderate slopes is so small that it can, for all practical purposes, be ignored. Garnier (2) tends to support this idea. He concludes that the reflected radiation from surrounding areas is normally less than 3% of the shortwave radiation falling on a surface. (Again, each cell on the site is assumed to be cleared of all vegetation.)

A number of different analyses of the radiation falling on the site were done. The hourly values for each day's radiation were totalled. These daily totals were then used as the data bank for each month.

The mapped output for each analysis gives the total possible radiation in BTU's/ft^2/day for each cell. The darkest cells on each mapped output represent the highest daily totals; the lighest cells represent the lowest.

The analyses were done as follows:

ANALYSIS ONE

This analysis was made by taking into account the slope and slope-orientation of each cell on the site. No attempt was made to include the effects of solar shading from the Surface Features found on the adjacent cells. The output represents the amount of radiation available at each cell's surface.

ANALYSIS TWO

This analysis was made by taking into account the slope, slope-orientation, as well as the effects of solar shading from the Surface Features on adjacent cells. The output represents the amount of radiation available at each cell's surface. See Maps 7 - 18

ANALYSIS THREE

The values generated in 'Analysis Two' were re-scaled and mapped. The original values in 'Analysis Two' were mapped in a '1-9' value range, where the maximum and minimum values were the highest cell and the lowest cell value for each month. This analysis took the lowest value and the highest value for the year and mapped each month's values according the the annual value range.

ANALYSIS FOUR

This analysis consisted of calculating the total daily radiation falling on a vertical surface. The surface was oriented perpendicular to the Solar Azimuth. The effects of Solar Shading from the Surface Features on adjacent cells was taken into account.

See Maps 19 - 30 for the output on a monthly basis.

ANALYSIS FIVE

The results of 'Analysis Four' were remapped as were those in 'Analysis Three'. See Maps 31 - 42

5.2 SITE WIND ANALYSIS

As explained in Chapter III, Section 3.1, no attempt was made to determine the velocity of the wind on the site. But, rather, using the Site Surface Features data as described in Chapter IV, Section 4.3, specifically:

1) the surface feature type
2) the surface feature height
3) the surface feature density

a model was developed to determine the effects of the Site's Surface Features upon the passage of wind across the site.

The output from the model gives each cell on the site a value that indicates the percentage wind reduction afforded by the cells upwind. See Appendix 'E'.

Initially, a series of eight analyses were done varying the wind direction across the site. The wind directions used were: North, North-East, East, South-East, South, South-West, West, and North-West. See figure 1.

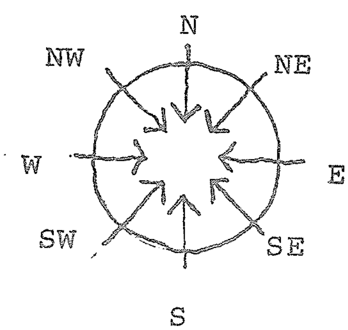


figure 1

Three of the analyses, specifically the West, North-West, and North appear in Maps 43, 44 and 45. The darkest cells in each mapped output represent the highest amount of shelter; the lightest represent the least.

5.3 SITE PRECIPITATION ANALYSIS

For the purposes of this study, the model for the precipitation analysis is a duplication of the wind analysis.

As described in Chapter III, Section 3.4, the drifting probabilities are greatest in areas of highest shelter on the wind analysis maps.

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1) DAKIN, R.A.; Some Micro-climatic Effects on the Siting and Orientation of Buildings in a Northern Environment, University of Manitoba, October, 1972.

PART 'C'

CHAPTER VI

BUILDING SITE SELECTION ANALYSIS

6.1 INTRODUCTION

The previous analyses on Solar Radiation, Wind, and Precipitation, do not in their generated form, give the designer much assistance in determining the best cells for the placement of a building.

This section deals with the method of combining a number of the previous analyses to generate a final mapped output that indicates the best cells on the site for the placement of a single building.

Generally, the prime climatic and building performance concern in a Northern Environment is the period of the year when the outside temperature falls below 32° F. This portion of the analysis restricts itself to this period. Specifically, the months of October to April inclusive are considered.

The specific variables considered in this analysis are:

1) Solar Radiation

2) Wind

3) Precipitation

4) Surface Feature Type

6.2 SOLAR RADIATION INPUT

The Solar Radiation values for the vertical surface (see Chapter V, Section 5.1; Analysis 4) were used. The radiation values for the period October to April inclusive were summed and a composite Radiation map was formed.

6.3 WIND INPUT

It is important to note that similiar winds occurring on a site do not necessarily have the same magnitude of severity. In order to compensate for the variations in severity, a composite shelter map was produced.

Based on the climatic data found in Appendix 'F', the following were used to weight the importance of shelter for each wind direction:

1) the mean monthly temperature

2) the direction of the prevailing wind

3) the average velocity of the prevailing wind

As the concern of the study was months of October to April, the number of prevailing wind directions was reduced to three. The wind directions considered were North, North-West, and West.

The weights used were as follows based on velocity, temperature, and frequency of occurance:

North	1
North-West	3
West	2

The values on each shelter map were multiplied by the map's weighting factor. The three maps were then summed to form a composite map. See Map 46.

6.4 PRECIPITATION INPUT

As little information on the amount and frequency of snowfall was available, the composite shelter map was used. See Map 46.

6.5 SITE INPUT

The Surface Feature Type map was used as the input for this portion of the model. Surface Feature heights and densities had already been utilized in the Solar Radiation and Wind Analyses.

6.6 MODELLING TECHNIQUE

Each of the previously selected maps, with the exception of the Surface Feature Type, was rescaled. The rescaling consisted of dividing the maximum to minimum range of cell values on each map into nine equal groups. Each map's cells were then converted into the appropriate '1-9' value range.

Each particular combination of variables was then evaluated in terms of its desirability in respect to the type of analysis being performed. A range of qualitative evaluation was established as follows:

3	desirable	best
2	less desirable	medium
1	undesirable	poor

Each map was then evaluated according to the previously mentioned value scale, for example:

	VALUE									
	0	1	2	3	4	5	6	7	8	9
MAP 1		3								
MAP n		1								

Numerical values in any given map indicate the severity of the condition mapped. Therefore, within the analysis, the occurance of a '1' on MAP '1' may be rated as best or desirable, while a '1' on MAP 'n' may be rated as being poor or undesirable.

In order to establish the importance of the various variables within the system being analyzed, each map was weighted. For example:

	VALUE										
	0	1	2	3	4	5	6	7	8	9	WEIGHT
MAP 1		3									0.5
MAP n		1									0.2

The occurance of a '1' on MAP '1' is given a value of (3 x 0.5) 1.5 . The occurance of a '1' on MAP 'n' is given a value of (1 x 0.2) 0.2 . This process is repeated for every cell on every map and a composite map is formed. Each cell on the composite consists of the sum of the weighted values of the corresponding cells on the maps used in the model. These composite map cell values are rescaled to a '1-9' range and printed. The darkest printed cells represent those that satisfy the model the most. The lightest represent those that satisfy the model the least.

6.7 BUILDING SITE SELECTION MODEL

The initial building site selection model was formulated as follows as an example to illustrate that weights are selected without rigorous consideration. In a 'real' situation, these weights should be a product of discussion and adjudication by experts in modelling and/or the phenomena being weighted.

See the table overleaf.

MAP	VALUE 0	1	2	3	4	5	6	7	8	9	WEIGHT
SOLAR RADIATION	0	1	1	1	2	2	2	3	3	3	0.4
WIND	0	1	1	1	2	2	2	3	3	3	0.3
PRECIPITATION	0	3	3	3	2	2	2	1	1	1	0.2
SURFACE TYPE	0	0	3	2	2	0	0	0	0	0	0.1

See Map 47 for the output from the first Site Selection Model.

Subsequent analyses on the chosen residential building indicated a gross error in the weighting of the Solar Radiation and Wind components of Model #1. The model weights were then changed as follows:

MAP	VALUE 0	1	2	3	4	5	6	7	8	9	WEIGHT
SOLAR RADIATION	0	1	1	1	2	2	2	3	3	3	0.2
WIND	0	1	1	1	2	2	2	3	3	3	0.5
PRECIPITATION	0	3	3	3	2	2	2	1	1	1	0.2
SURFACE TYPE	0	0	3	2	2	0	0	0	0	0	0.1

See Map 48 for the output from this analysis.

CHAPTER VII

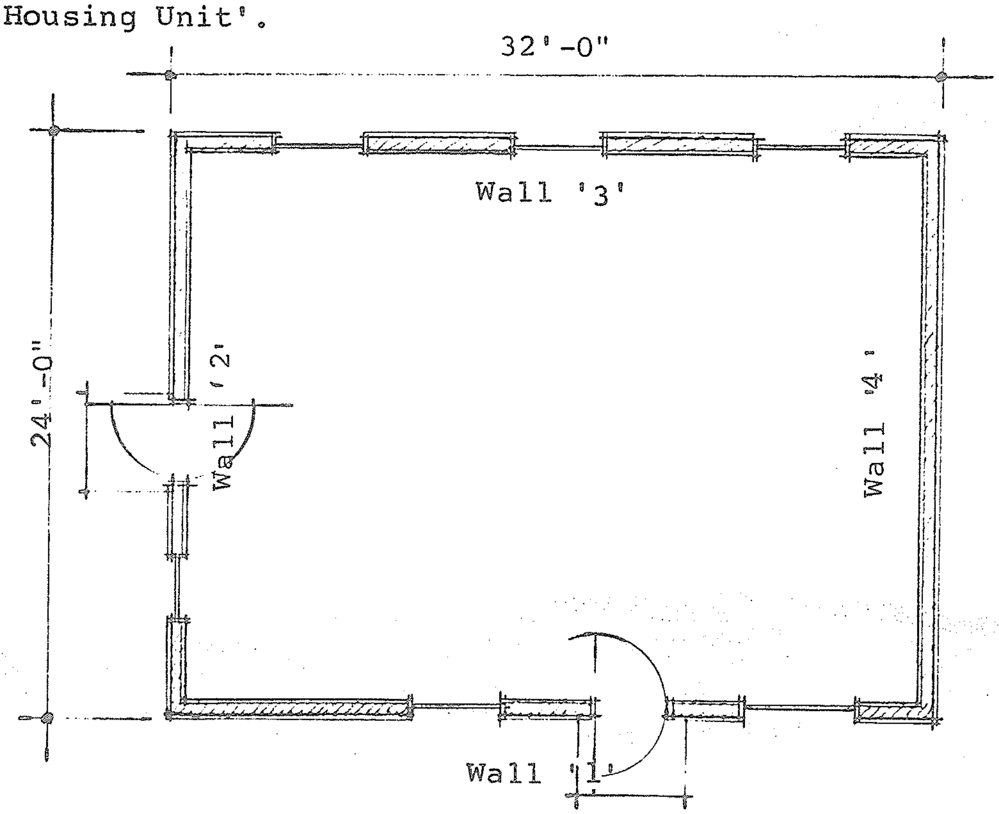
BUILDING ANALYSIS

7.1 INTRODUCTION

This section of the study is established to determine the best orientation of a building on a given cell. The cell upon which the building is placed being chosen from the previous site selction model.

7.2 THE BUILDING

The standard chosen for the building analysis was the Manitoba Government 'Three Bedroom Remote Housing Unit'.



7.3 BUILDING VARIABLES

The variables used to describe each surface on the building were:

1) the orientation of the surface
2) the slope of the surface
3) the area of the surface
4) the co-efficient of heat transfer of the surface (U)
5) the absorptivity of the surface for direct and diffuse radiation
6) the unit of surface conductance (F_{co})

See Appendix 'G'.

7.4 CLIMATIC VARIABLES

The Climatic Variables used in the analysis were those listed in Appendix 'F'.

The mean monthly temperature and average wind-speed for the month's prevailing winds were used.

7.5 BUILDING ANALYSIS

The geographic location of the building was the chosen site.

The previously described building was given an initial orientation as follows:

WALL '1' ... 180°

WALL '2' ... 270°

WALL '3' ... 360°

WALL '4' ... 90°

The following heat loss/gain components were then calculated for the building at one hour intervals for the given orientation:

1) transmission heat loss/gain for each surface (walls, glass, floor, roof)

2) solar heat gain on each surface (walls, roof)

3) the instantaneous heat gain due to Solar Radiation through the glass

4) the infiltration heat loss/gain for the total building

The building was then rotated through a 22.5° clockwise arc. The heat loss/gain calculations were done for the new orientation. This was repeated until the building had been rotated through 360° in 22.5° increments.

See Tables 1 - 16 (pages 106 - 121) for the Net Heat Gain/Loss calculations for the building, for the month of January.

See Tables 17 - 20 (pages 122 - 125) for the most and least BTU's lost with respect to the orientation of a given building per month from January through to December. Table 20 (page 125) illustrates the most and least BTU's lost annually.

PART 'D'

CONCLUSIONS

There are a number of points that can be made based upon the previous analyses.

It is generally accepted that in Northern Hemisphere, Solar Radiation is the most intense on those surfaces with South facing slopes. However, on the study site, the steepest southerly slopes tend to receive less radiation due to the density and the height of vegetation found there. It is, therefore, a fallacy to assume that South facing slopes always receive the greatest amount of Solar Radiation. See Maps 7 to 18.

Vegetation interference has a marked effect on the amount of radiation falling on a vertical surface during the winter. However, during the summer, the vegetation interference does not significantly change the amount of radiation falling on a vertical surface. See the following table.

MONTH	MINIMUM	MAXIMUM	DIFFERENCE	% DIFFERENCE
December	47	710	663	93%
January	73	1090	1017	92%
June	2401	2826	425	15%
July	2381	2718	337	13%

It would appear that vegetation interference is significant during the coldest period of the year.

Wind, in conjunction with low temperatures, is the most severe parameter of the variables studied. Wind alone accounts for approximately 20% of the possible heat loss in the chosen building.

Solar Radiation, on the other hand, is of small consequence in the comparison with the wind. During the coldest months of the year (October to April), solar heat gains account for an average 8% reduction in the total possible heat loss. For example:

December - estimated possible heat loss =

(1.00 AM loss x 24 hours)

	=	905453 BTU
Total loss	=	880835 BTU
Difference	=	24618 BTU

The 24618 BTU is from Solar Radiation input. Solar accounts for 2.72% decrease in Total Possible Heat Loss. See Table 1.

Wind on the other hand accounted for approximately 21% of the building heat loss. As infiltration rates are a function of the wind velocity, an increase in the wind velocity would increase the infiltration and, therefore, the heat losses.

The best orientation for the chosen building was in most cases South. This orientation takes into account the Solar Heat Gains. In order to compensate for the Wind (infiltration) a more detailed knowledge of the exact flows around buildings is necessary. More work is required in this area.

Based upon the previous analyses, the following conclusions can be drawn:

SOLAR MAPS:

1) All things being equal, in the Northern Hemisphere, Solar Radiation on the surface of cells is greatest on the south-facing slopes. However, on the study site, the steepest slopes tend to have less radiation due to the density and height of the vegetation on them. Therefore, it is a fallacy to assume that south facing slopes always receive the greatest amount of Solar Radiation.

2) Vegetation interference has a marked effect on the amount of radiation falling on a vertical surface during the winter.

December	...	93% reduction
January	...	92% reduction
February	...	50% reduction

3) During the summer periods, vegetation does not significantly change the amount of radiation falling on a vertical surface.

June	...	15% reduction
July	...	13% reduction

WIND:

1) Shelter vegetation should be no lower than the height of the structure to maximize the effects of shelter due to upwind vegetation.

2) Upwind shelter should be as dense as possible to minimize the effects of snow drifting and accumulation of snow.

BUILDING:

1) The most severe parameter of the variables studied is the wind in conjunction with low temperatures. Wind alone accounts for approximately 20% of the possible heat loss in the building chosen. The 20% figure does not reflect the fact that air changes are increased when wind is present.

2) Solar heat gain on the building chosen

(although beneficial) is of small consequence in comparison with the wind. During the coldest months of the year, (October to April), solar heat gains account for an average 8% reduction of the total possible heat loss.

3) Building should be oriented so that the wall with the minimum number of openings is windward.

4) The best orientation for the chosen building is the front facing South. Due to the fluctuations of the severe winds from West to North, little can be gained by placing the West wall into the North-West wind.

MAPS

All maps found on the following pages have been processed through the program 'GRID' * to give symbolic output to the values.

The line printer used for the output has a horizontal spacing of 10 characters, and a vertical spacing of 6 characters to the inch. In order to eliminate distortions in the visual representation of the cells and the site, each cell is represented by 3 vertical and 5 horizontal print positions. For example:

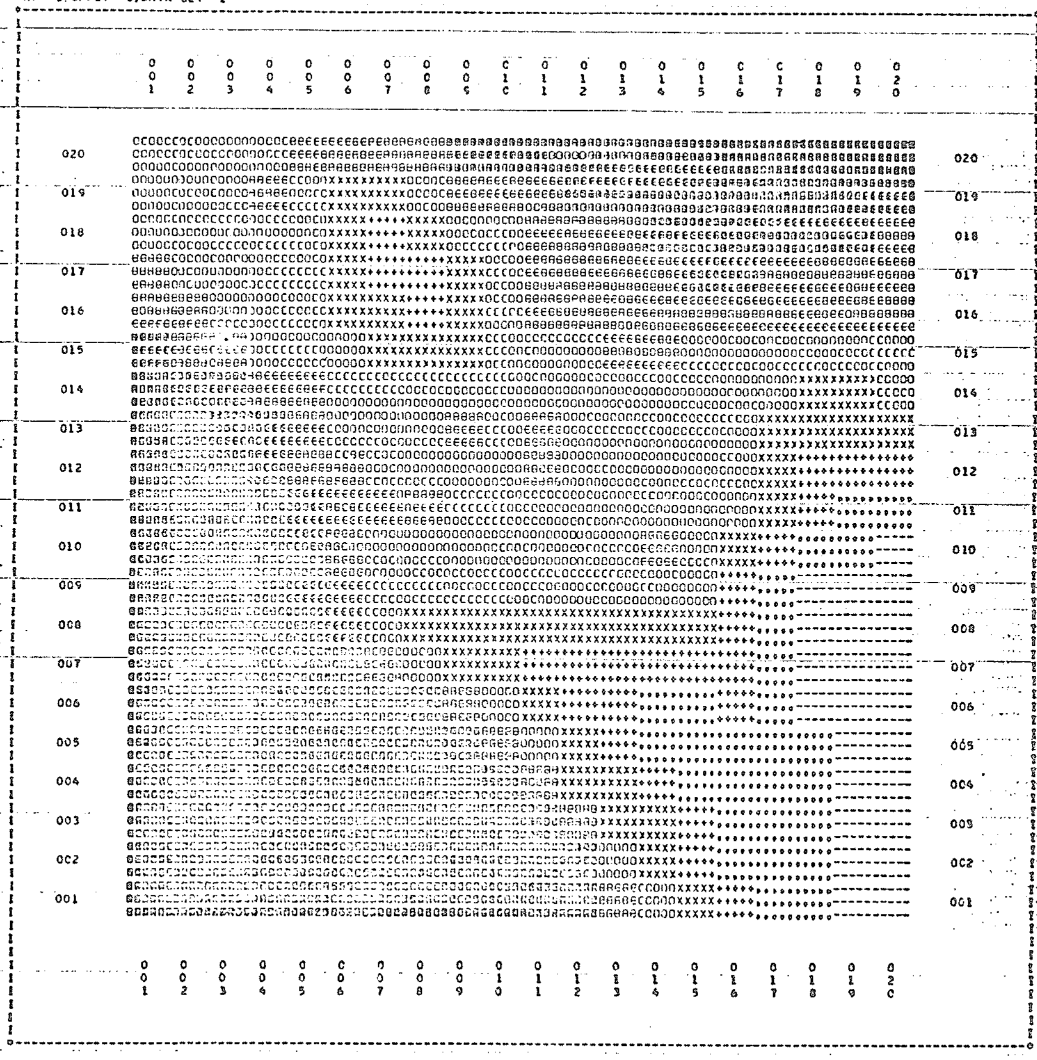
```
@@@@@
@@@@@
@@@@@
```

NORTH is found to the top of each map.

* DEPARTMENT OF LANDSCAPE ARCHITECTURE
Faculty of Architecture
University of Manitoba

MAP #1

MAP 1, SHEET 1, DATA SET 1



ELEVATIONS OF GRID CELLS

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 13.00 AND 107.00 MEAN = 61.23 ST. DEV. = 89.71

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	13.00	22.40	31.80	41.20	50.60	60.00	69.40	78.80	88.20	97.60
MAXIMUM	22.40	31.80	41.20	50.60	60.00	69.40	78.80	88.20	97.60	107.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

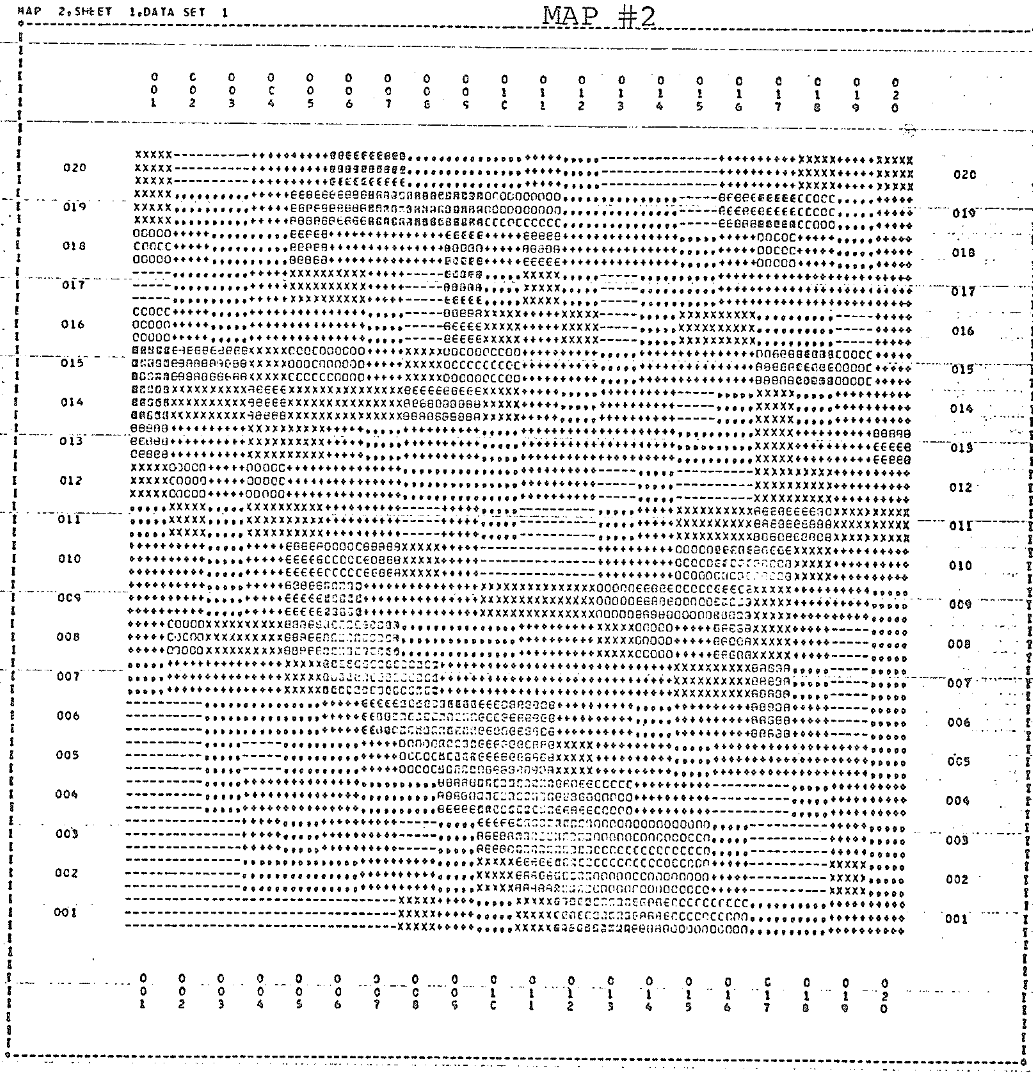
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	23	27	28	39	99	57	37	28	28	40

MAP 2, SHEET 1, DATA SET 1

MAP #2



SLOPES OF GRID CELLS

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 14.00 MEAN = 4.09 ST. DEV. = 6.39

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.0	1.40	2.80	4.20	5.60	7.00	8.40	9.80	11.20	12.60
MAXIMUM	1.40	2.80	4.20	5.60	7.00	8.40	9.80	11.20	12.60	14.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

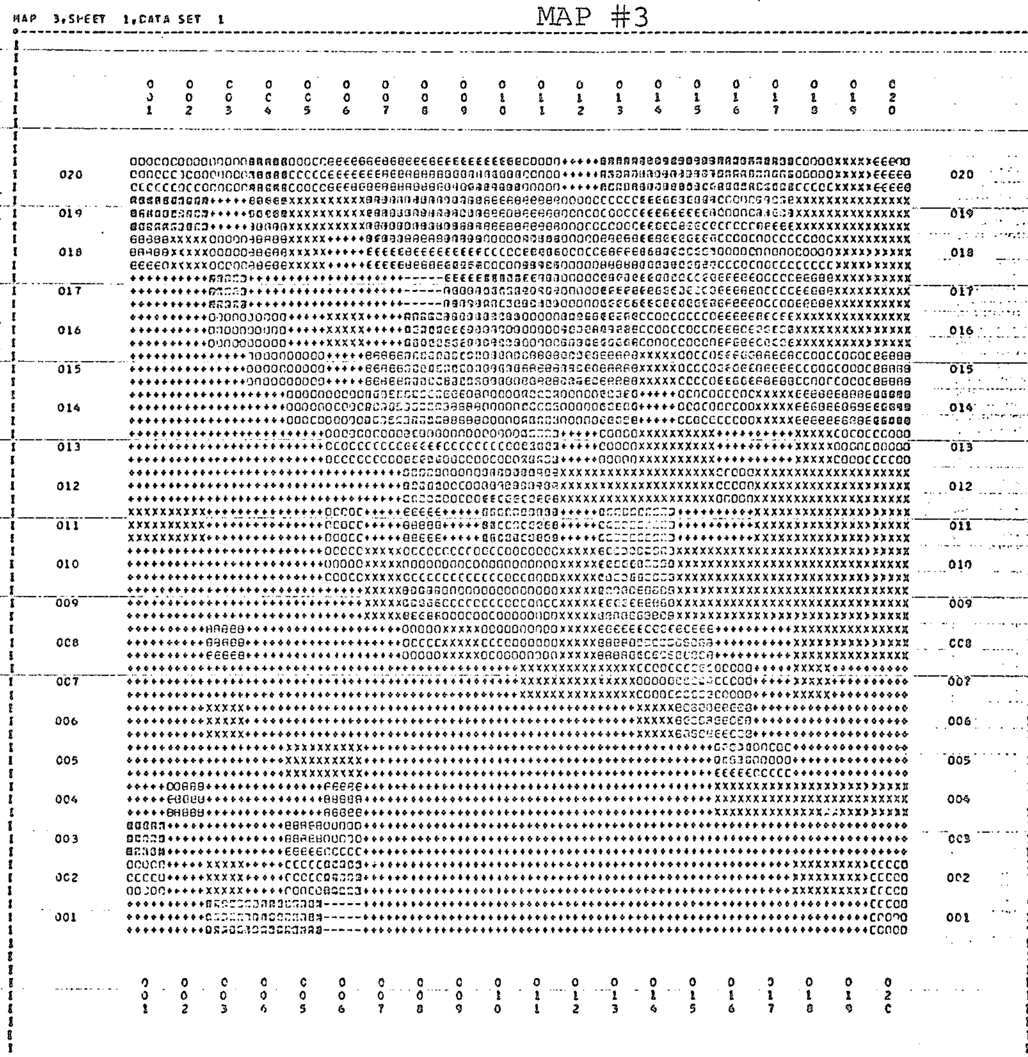
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	[illegible]	+++++++++	XXXXXXXXX	OOOOOOOOO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FREQUENCY	52	77	127	51	29	34	11	13	4	2

MAP 3,SHEET 1,DATA SET 1

MAP #3



ORIENTATION OF GRID CELL SLOPES

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 8 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 360.00 MEAN = 142.59 ST. DEV. = 215.21

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

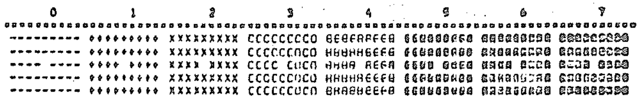
MINIMUM	0.0	45.00	90.00	135.00	180.00	225.00	270.00	315.00
MAXIMUM	45.00	90.00	135.00	180.00	225.00	270.00	315.00	360.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50

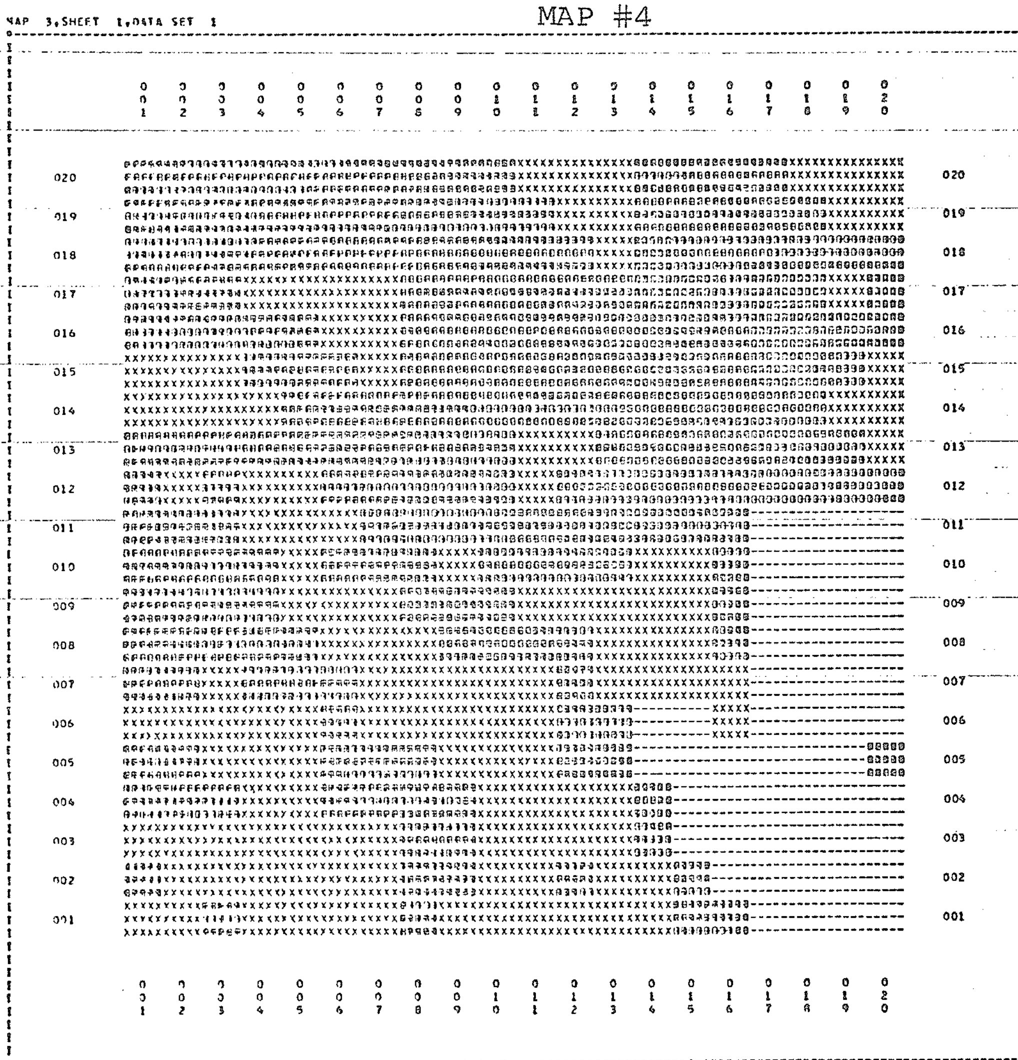
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7
SYMBOLS								
FREQUENCY	2	167	72	42	31	42	12	12



MAP 3, SHEET 1, DATA SET 1

MAP #4



SURFACE FEATURE TYPE

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

1 = MUSKEG
2 = LANDFORM
3 = CONIFEROUS VEGETATION
4 = DECIDUOUS VEGETATION

DATA MAPPED IN 4 LEVELS BETWEEN EXTREME VALUES OF 1.00 AND 4.00 MEAN = 2.45 ST. DEV. = 0.99

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	1.00	1.75	2.50	3.25
MAXIMUM	1.75	2.50	3.25	4.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

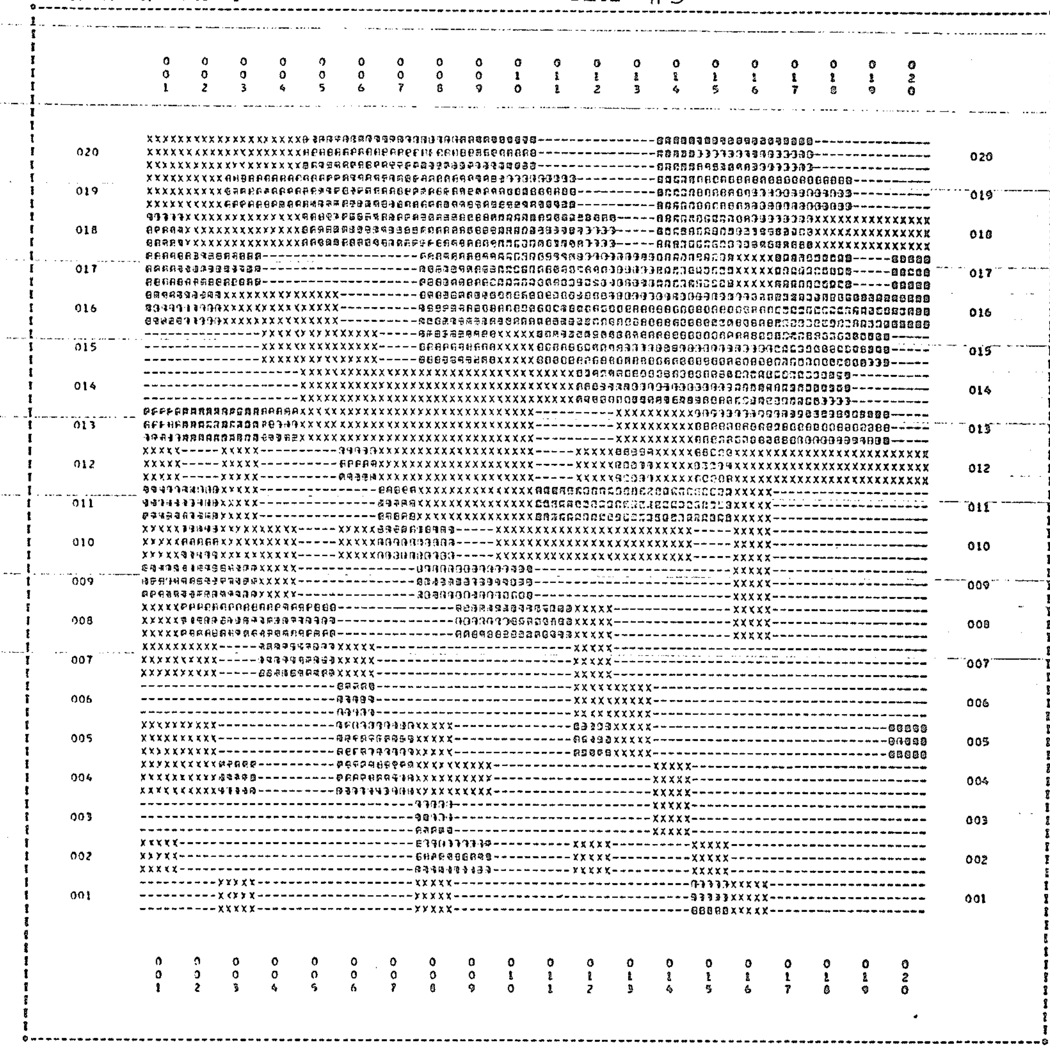
25.00	25.00	25.00	25.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

```
LEVELS          1          2          3          4
          ****************************************
          --------- XXXXXXXXX 000000000 888888888
          --------- XXXXXXXXX 000000000 888888888
SYMBOLS   ---- ---- XXXX XXXX 0000 0000 8888 8888
          --------- XXXXXXXXX 000000000 888888888
          --------- XXXXXXXXX 000000000 888888888
          ****************************************
FREQUENCY    93        120        219        11
```

MAP 1, SHEET 1, DATA SET 1

MAP #5



SURFACE FEATURE HEIGHT

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

0 = NO SIGNIFICANT HEIGHT ABOVE LANDFORM
1 = 0 TO 10 FEET HIGH
2 = 10 TO 20 FEET HIGH
3 = 20 TO 30 FEET HIGH

DATA MAPPED IN 4 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 3.00 MEAN = 0.96 ST. DEV. = 1.67

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.0	0.75	1.50	2.25
MAXIMUM	0.75	1.50	2.25	3.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

25.00	25.00	25.00	25.00

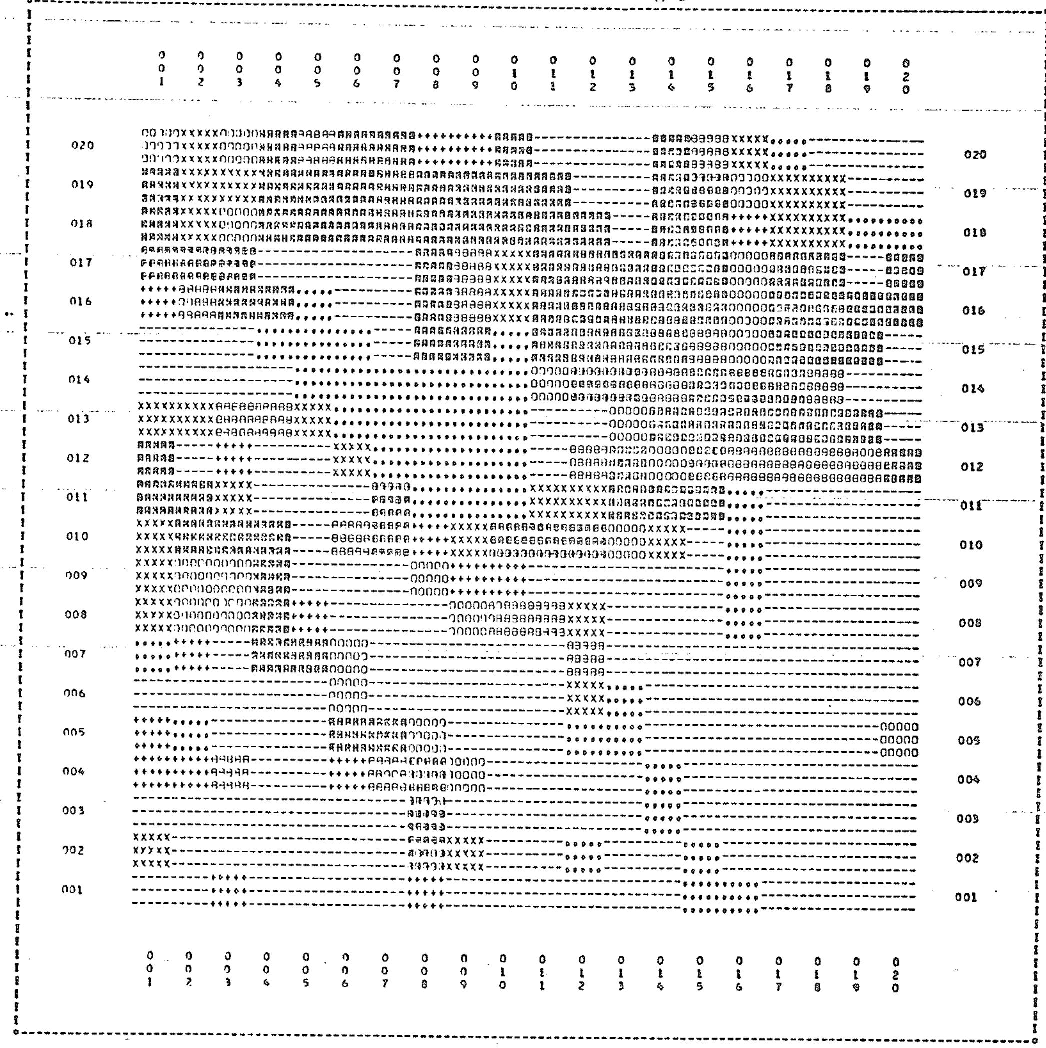
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3
SYMBOLS	---------	XXXXXXXXX	[illegible]	@@@@@@@@@
FREQUENCY	176	90	109	25

2409

MAP 2,SHEET 1,DATA SET 1

MAP #6



2410

SURFACE FEATURE DENSITY

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

0 = NO SIGNIFICANT DENSITY ABOVE LANDFORM
1 = 0 TO 10 PERCENT
2 = 10 TO 20 PERCENT
3 = 20 TO 30 PERCENT
4 = 30 TO 40 PERCENT
5 = 40 TO 50 PERCENT
6 = 50 TO 60 PERCENT
7 = 60 TO 70 PERCENT
8 = 70 TO 80 PERCENT
9 = 80 TO 90 PERCENT

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 9.00 MEAN = 2.69 ST. DEV. = 4.02

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.0	0.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10
MAXIMUM	0.90	1.80	2.70	3.60	4.50	5.40	6.30	7.20	8.10	9.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

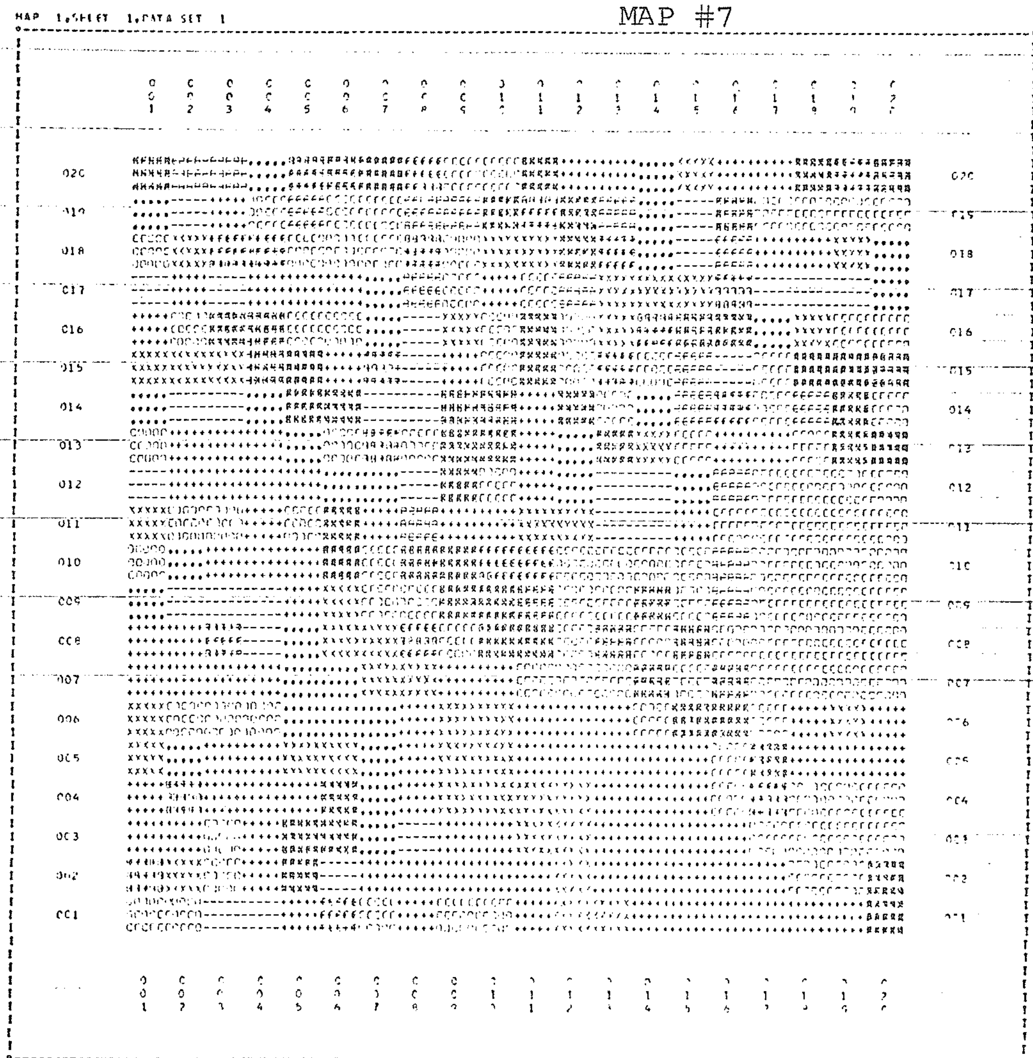
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	999999999	ΘΘΘΘΘΘΘΘΘ	HHHHHHHHH	ΘΘΘΘΘΘΘΘΘ
FREQUENCY	175	41	16	27	72	21	17	42	17	22

MAP 1,SELECT 1,DATA SET 1

MAP #7



SOLAR RADIATION - JANUARY 21

A. DAVIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 62.37 AND [illegible] MEAN = [illegible] ST. DEV. = [illegible]

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	62.37	94.03	125.69	157.36	189.02	220.68	252.34	284.00	315.66	347.32
MAXIMUM	94.03	125.69	157.36	189.02	220.68	252.34	284.00	315.66	347.32	[illegible]

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

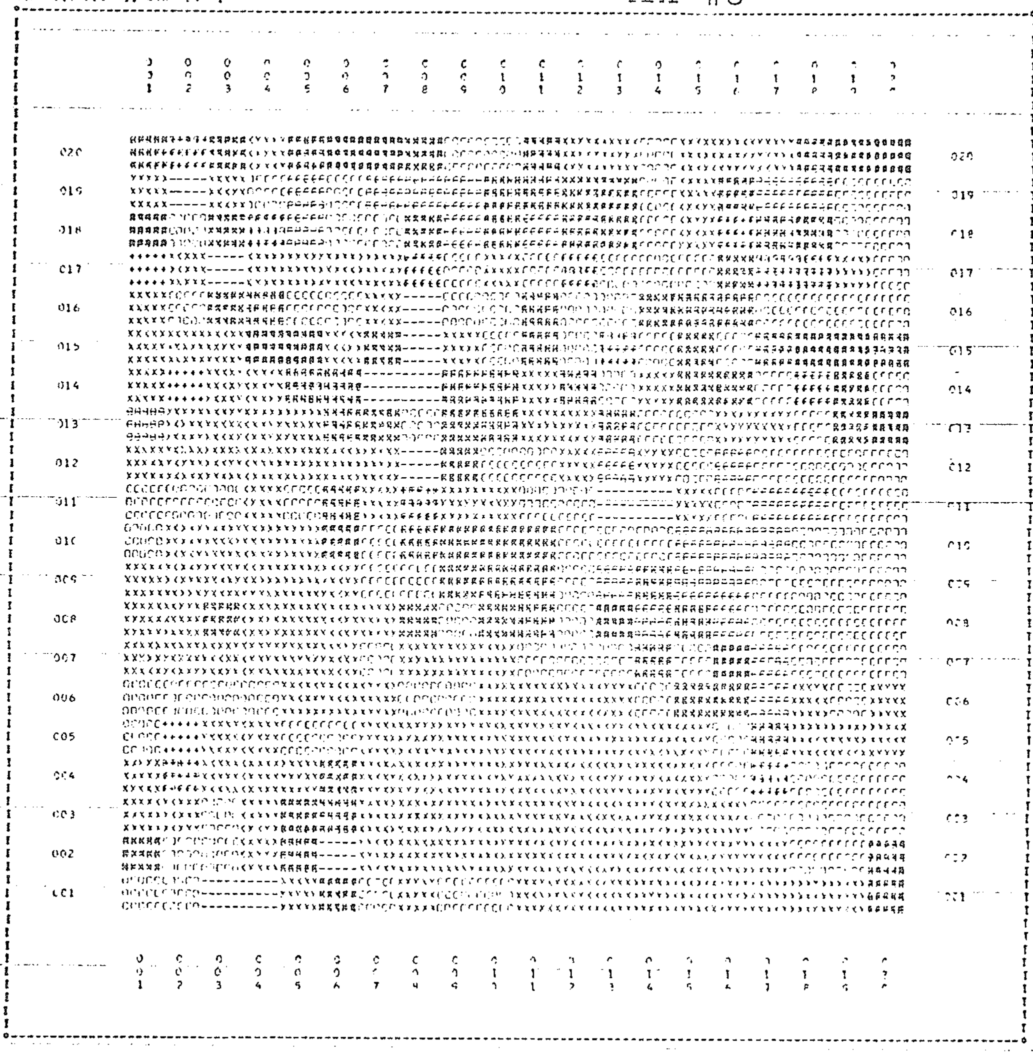
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXX	CCCCCCCC	#####@@@	++++++++	XXXXXXXX	XXXXXXXX	88888888
FREQUENCY	29	31	98	42	106	16	[illegible]	[illegible]	[illegible]	[illegible]

MAP 2,SHEET 1,DATA SET 1

MAP #8



SOLAR RADIATION - FEBRUARY 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 113.72 AND 875.19 MEAN = 4[illegible]7.5[illegible] ST. DEV. = 1[illegible]8.56

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	113.72	189.87	266.01	342.16	418.31	494.45	570.60	646.75	722.90	799.04
MAXIMUM	189.87	266.01	342.16	418.31	494.45	570.60	646.75	722.90	799.04	875.19

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

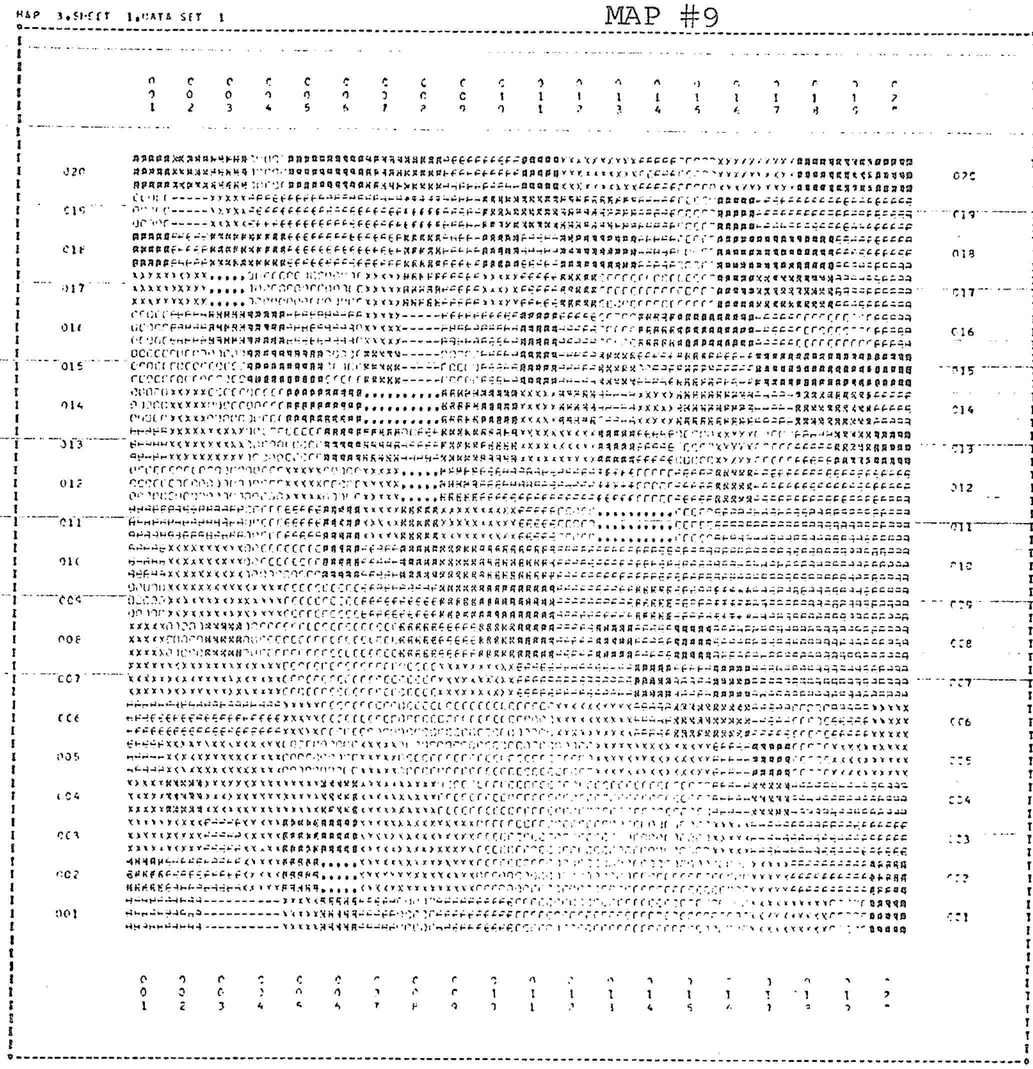
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
	---------	....	+++++++++	XXXXXXXXX	CCCCCCCCC	HHHHHHHHH	[illegible]	[illegible]	[illegible]	[illegible]
	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHFFFFF	[illegible]	[illegible]	[illegible]	[illegible]
SYMBOLS	---- ----	....	++++ ++++	XXXX XXXX	OOOO OOOO	HHHH HHHH	[illegible]	[illegible]	[illegible]	[illegible]
	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	[illegible]	[illegible]	[illegible]	[illegible]
	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHFFFFF	[illegible]	[illegible]	[illegible]	[illegible]
FREQUENCY	12	0	3	146	117	24	12	14	11	12

MAP 3,SHEET 1,DATA SET 1

MAP #9



SOLAR RADIATION - MARCH 21

A. PAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 192.17 AND 1424.25 MEAN = 871.94 ST. DEV. = 1251.46

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	192.17	306.38	430.58	554.79	679.00	803.21	927.42	1051.63	1175.84	1300.05
MAXIMUM	306.38	430.58	554.79	679.00	803.21	927.42	1051.63	1175.84	1300.05	1424.25

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

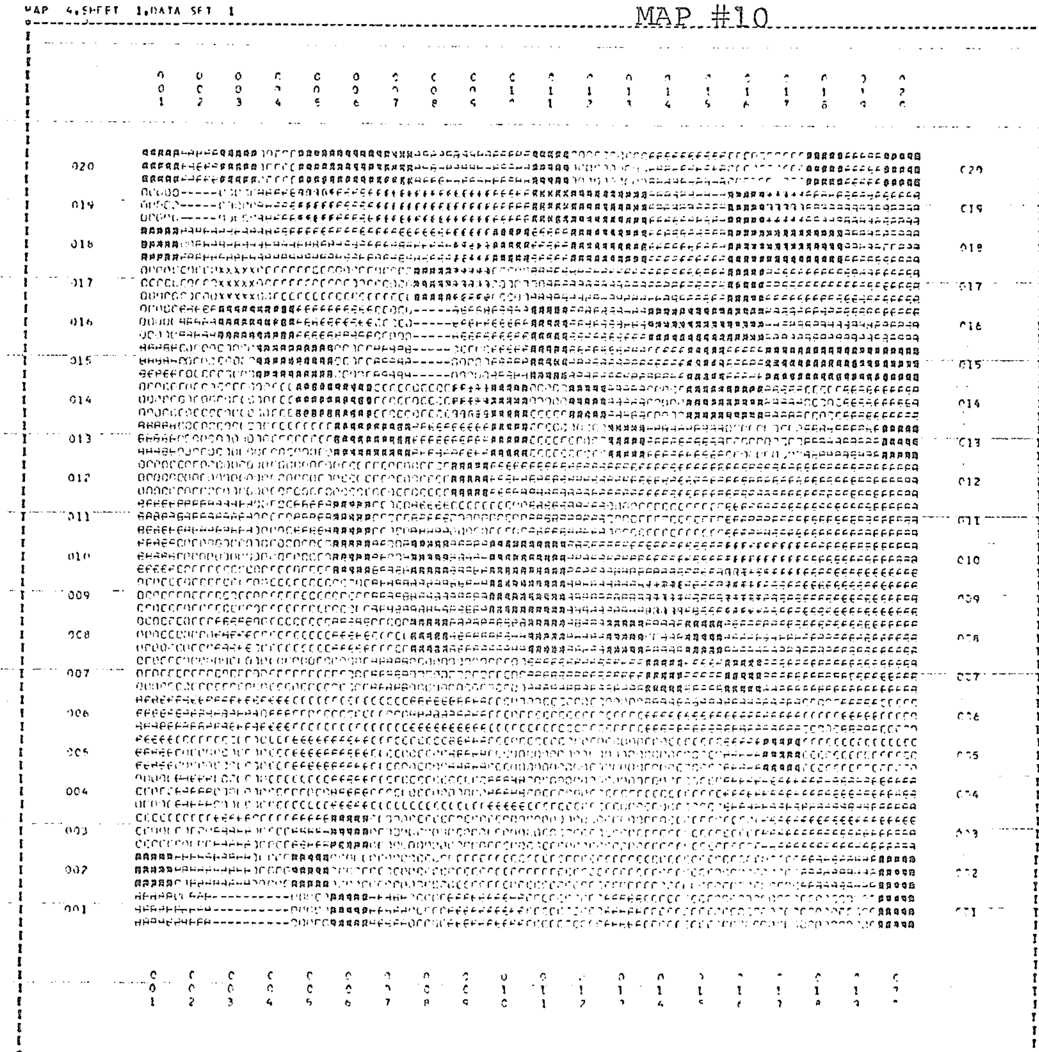
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	#########	ÆÆÆÆÆÆÆÆÆ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	5	7	0	65	51	126	9	25	21	45

MAP 4,SHEET 1,DATA SET 1

MAP #10



SOLAR RADIATION - APRIL 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 313.89 AND 1985.23 MEAN = 1249.17 ST. DEV. = 1421.76

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	313.89	481.02	648.16	815.29	982.42	1149.56	1316.69	1483.83	1650.96	1818.09
MAXIMUM	481.02	648.16	815.29	982.42	1149.56	1316.69	1483.83	1650.96	1818.09	1985.23

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

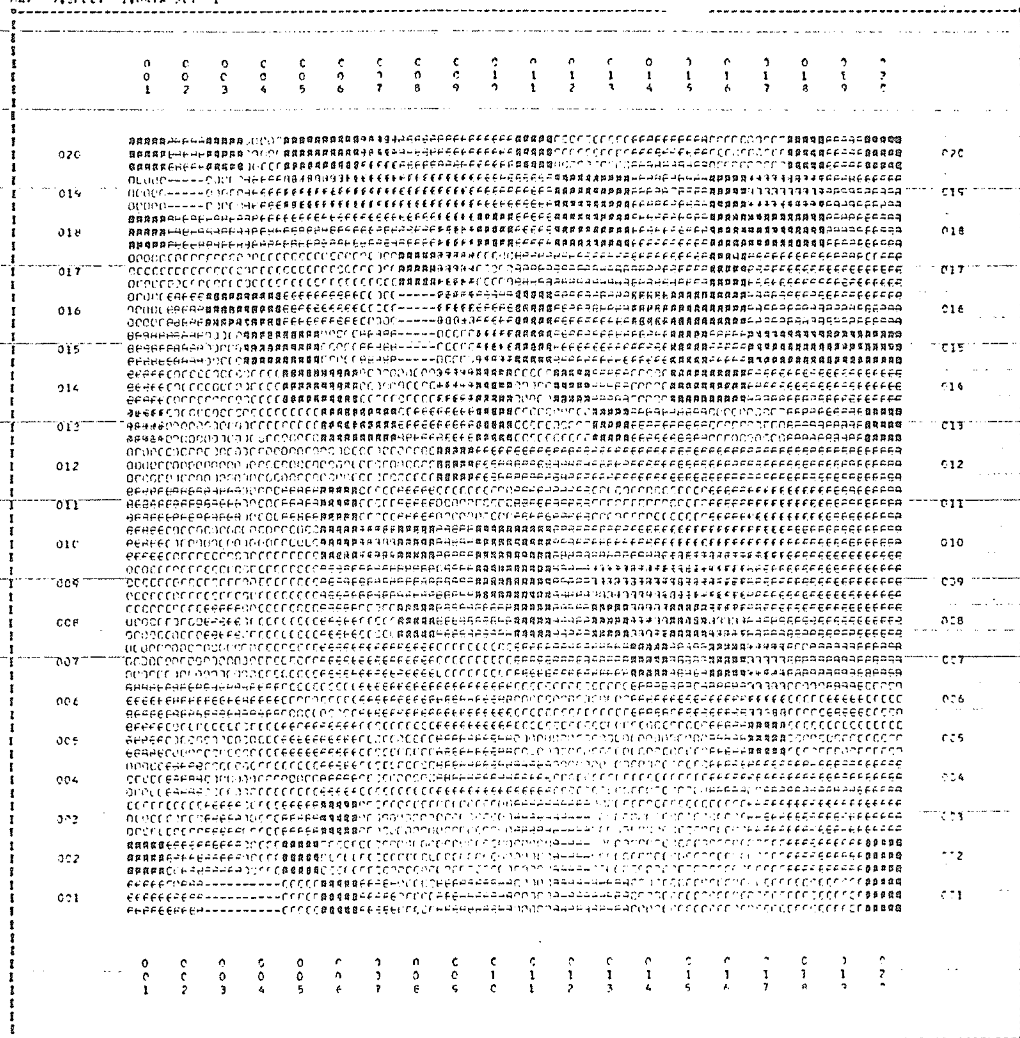
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FREQUENCY	5	0	0	1	147	168	12	2	0	65

MAP #11

MAP 5,SUBSET 1,DATA SET 1



SOLAR RADIATION - MAY 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 470.57 AND 2364.53 MEAN = 1890.38 ST. DEV. = 2255.79

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	470.57	659.97	849.36	1038.76	1228.15	1417.55	1606.94	1796.34	1985.73	2175.13
MAXIMUM	659.97	849.36	1038.76	1228.15	1417.55	1606.54	1796.34	1985.73	2175.13	2364.53

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

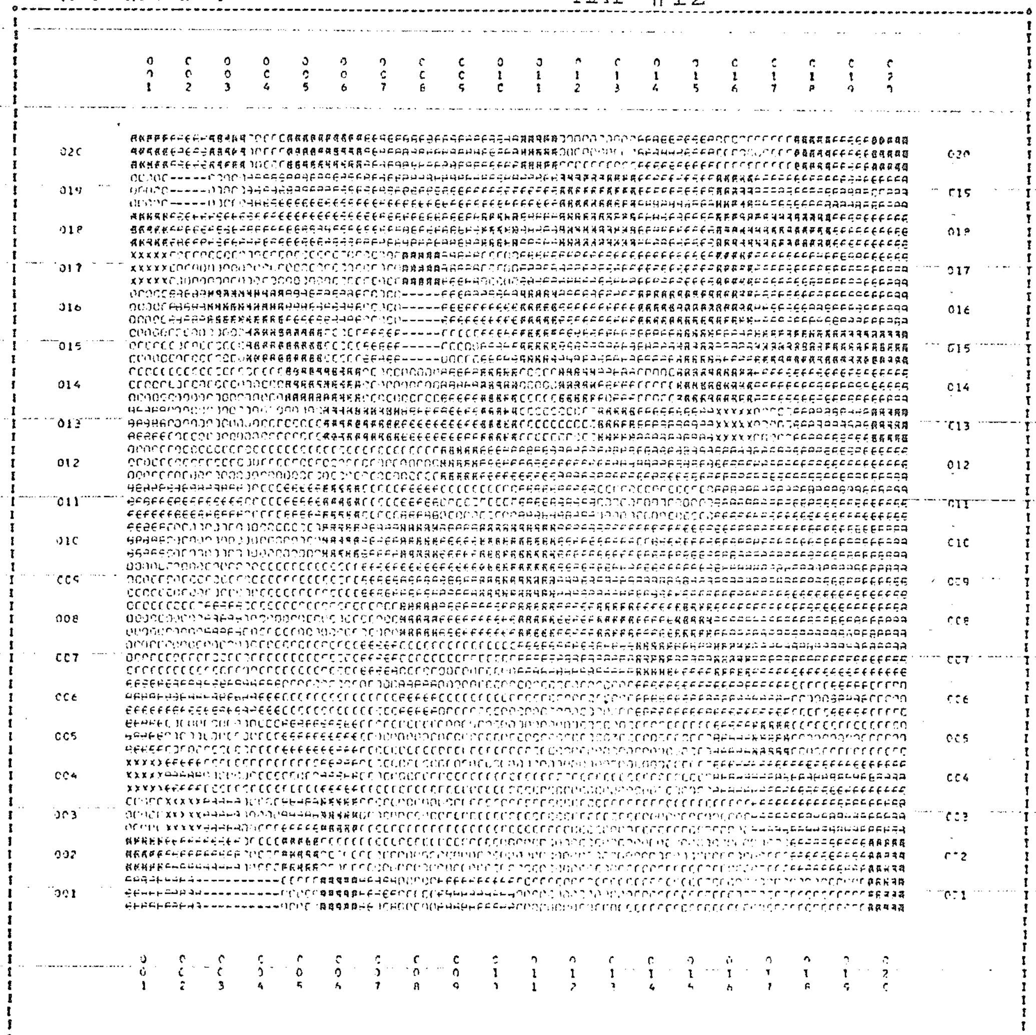
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	'''''''''	+++++++++	XXXXXXXXX	CCCCCCCCC	EEEEEEEEE	@@@@@@@@@	RRRRRRRRR	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	5	0	0	0	131	179	28	0	1	64

MAP 6, SHEET 1, DATA SET 1

MAP #12



SOLAR RADIATION - JUNE 21

A. DAVIS, M. [illegible], 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 655.26 AND 2557.66 MEAN = 1611.30 ST. DEV. = 2294.15

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	655.26	845.50	1035.74	1225.98	1416.22	1606.46	1796.70	1986.94	2177.18	2367.42
MAXIMUM	845.50	1035.74	1225.98	1416.22	1606.46	1796.70	1986.94	2177.18	2367.42	2557.66

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

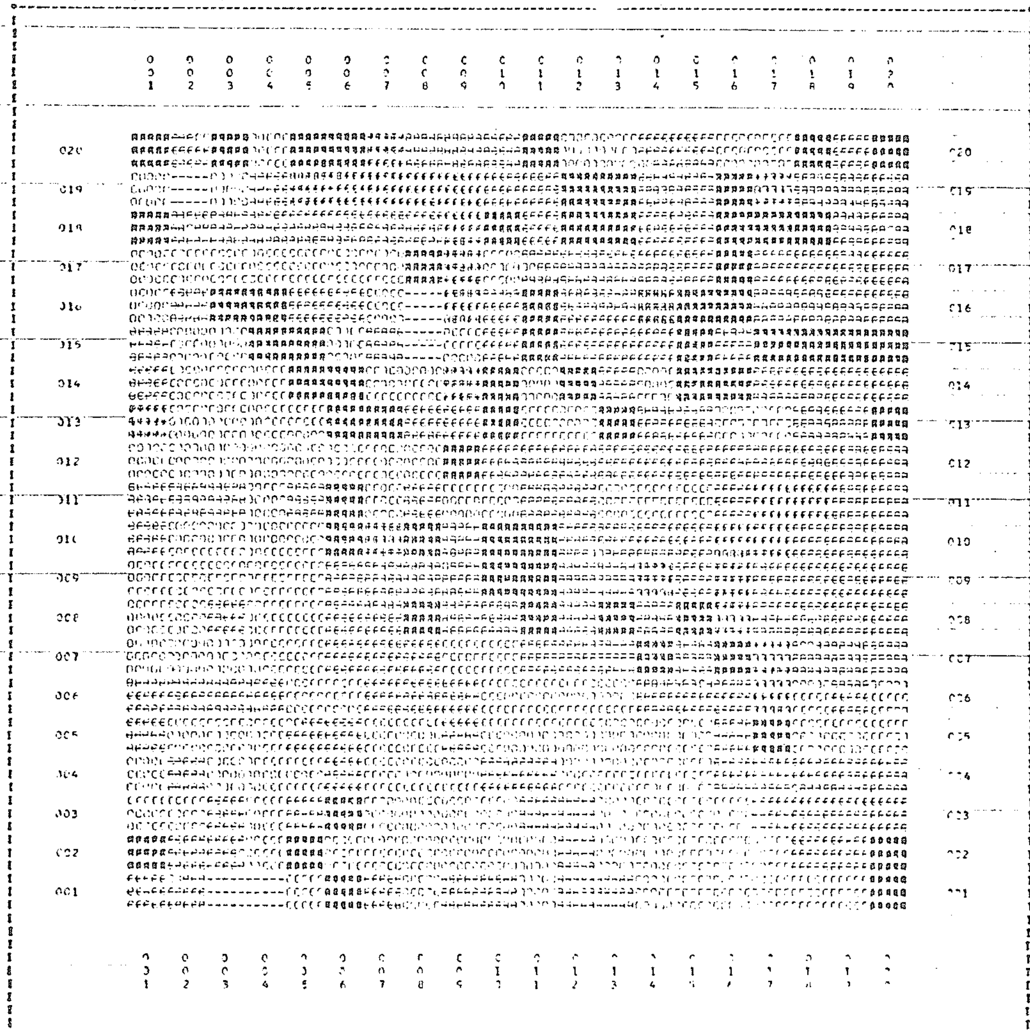
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	5	3	0	4	149	117	0	0	[illegible]	2

MAP 7, SHEET 1, DATA SET 1

MAP #13



SOLAR RADIATION - JULY 21

A. DAVID, 4. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 507.50 AND 2364.83 MEAN = 1593.85 ST. DEV. = 2277.59

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	507.50	693.23	878.96	1064.70	1250.43	1436.16	1621.90	1807.63	1993.36	2179.10
MAXIMUM	693.23	878.96	1064.70	1250.43	1436.16	1621.90	1807.63	1993.36	2179.10	2364.83

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

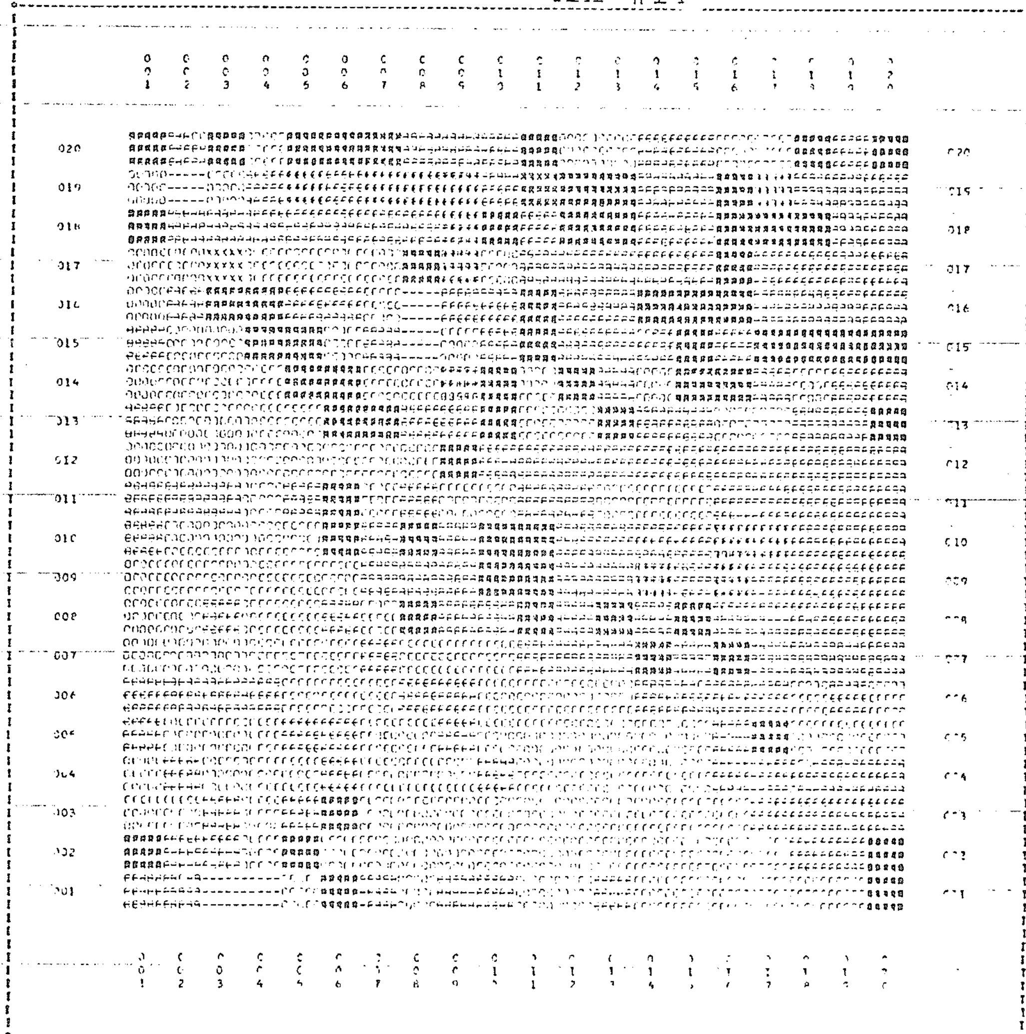
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS										
FREQUENCY	5	0	0	0	136	172	22	0	1	66

MAP 2, SHEET 1, DATA SET 1

MAP #14



SOLAR RADIATION - AUGUST 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 367.55 AND 1964.95 MEAN = 1233.3[illegible] ST. DEV. = [illegible]

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	367.55	527.29	687.03	846.77	1006.51	1166.25	1325.99	1485.73	1645.47	1805.21
MAXIMUM	527.29	687.03	846.77	1006.51	1166.25	1325.99	1485.73	1645.47	1805.21	1964.95

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

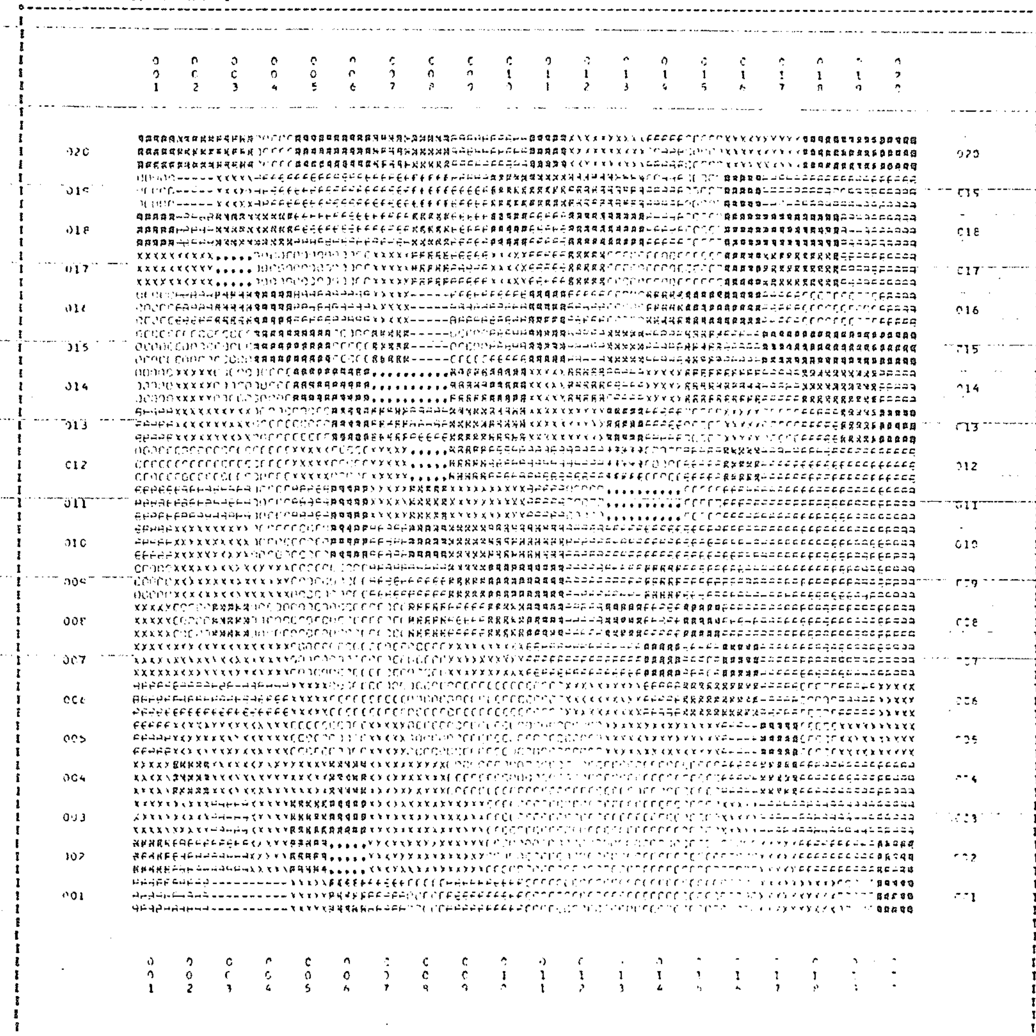
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	-	'	+	X	O	Ø	$\oplus$	⊠	⊠	■
FREQUENCY	5	0	0	1	147	164	12	[illegible]	[illegible]	65

MAP #15

MAP 9,SHEET 1,DATA SET 1



SOLAR RADIATION - SEPTEMBER 21

A. DAKIN, M. ARCE, 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 215.96 AND 1365.28 MEAN = 862.61 ST. DEV. = 1276.11

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	215.96	330.69	445.83	560.76	675.69	790.62	905.55	1020.48	1135.41	1250.35
MAXIMUM	330.89	445.83	560.76	675.69	790.62	905.55	1020.48	1135.41	1250.35	1365.28

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

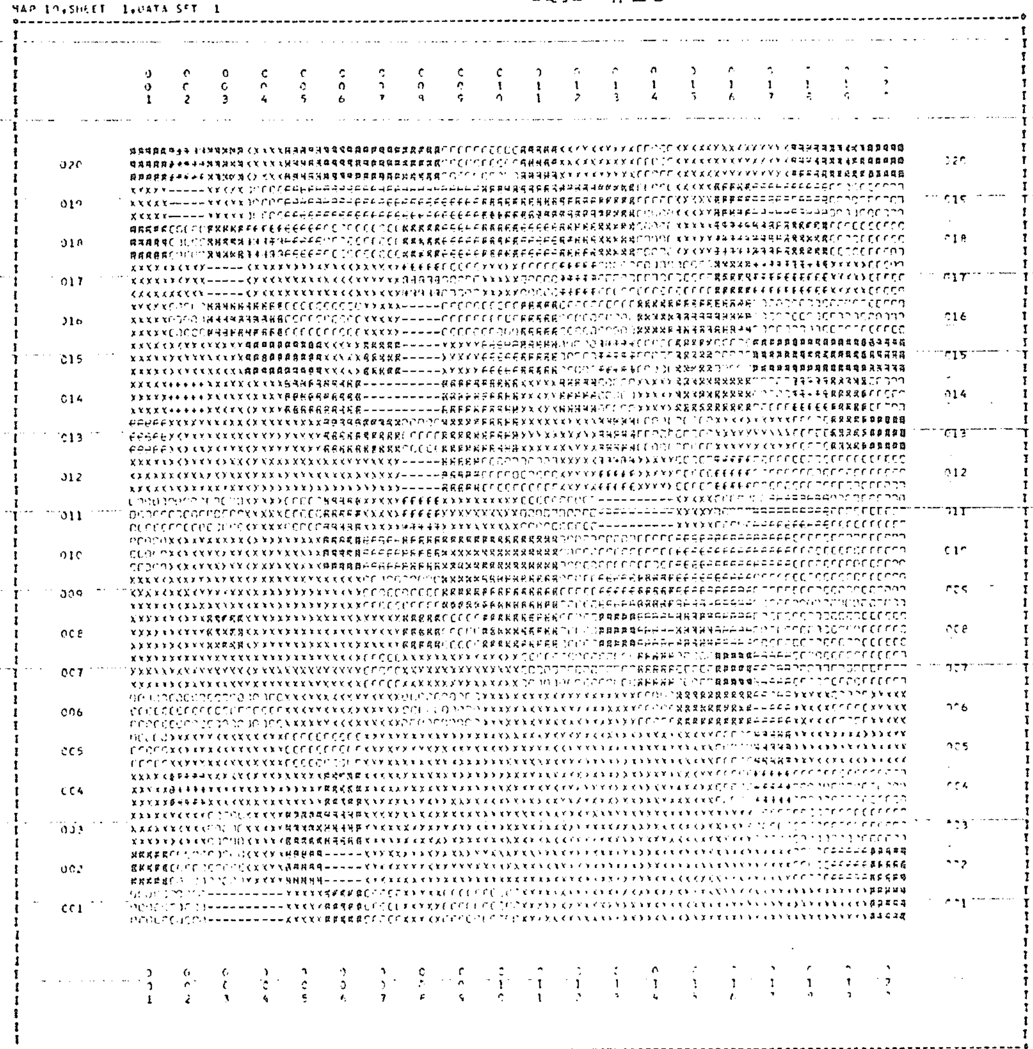
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	,,,,,,,,,	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	5	7	0	65	91	127	2	90	23	45

MAP #16

MAP 10,SHEET 1,DATA SET 1



SOLAR RADIATION - OCTOBER 21

A. JAXIF, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 129.40 AND 851.98 MEAN = 516.23 ST. DEV. = 232.24

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	129.40	201.66	273.92	346.19	418.43	490.69	562.95	635.21	707.47	779.72
MAXIMUM	201.66	273.92	346.18	418.43	490.69	562.95	635.21	707.46	779.72	851.98

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

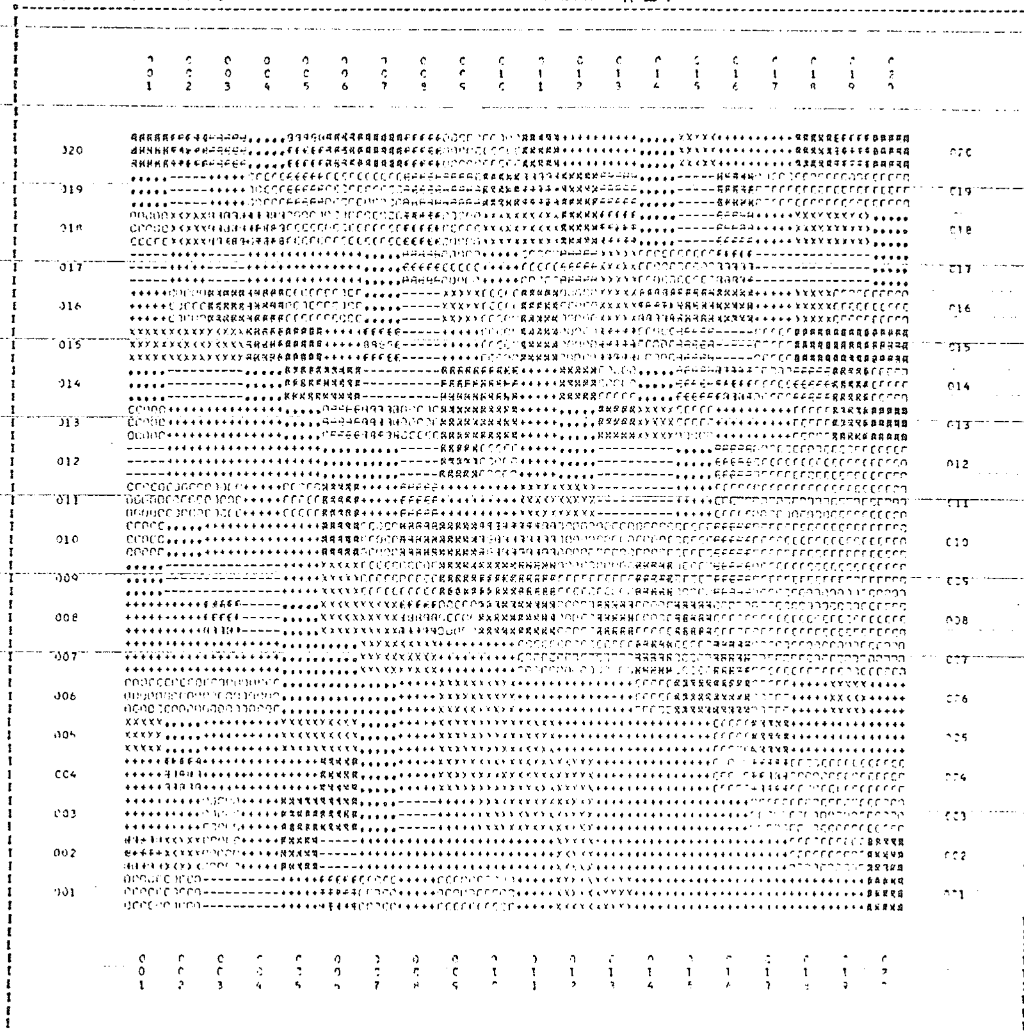
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	·········	+++++++++	XXXXXXXXX	CCCCCCCCC	EEEEEEEEE	#########	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	12	3	1	150	113	26	14	11	13	14

MAP 11,SHEET 1,DATA SET 1

MAP #17



SOLAR RADIATION - NOVEMBER 21

A. PAKIN, H. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 65.77 AND 376.40 MEAN = 191.64 ST. DEV. = 275.64

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	65.77	96.84	127.90	158.96	190.03	221.09	252.15	283.21	314.28	345.34
MAXIMUM	96.84	127.90	158.96	190.03	221.09	252.15	283.21	314.28	345.34	376.40

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

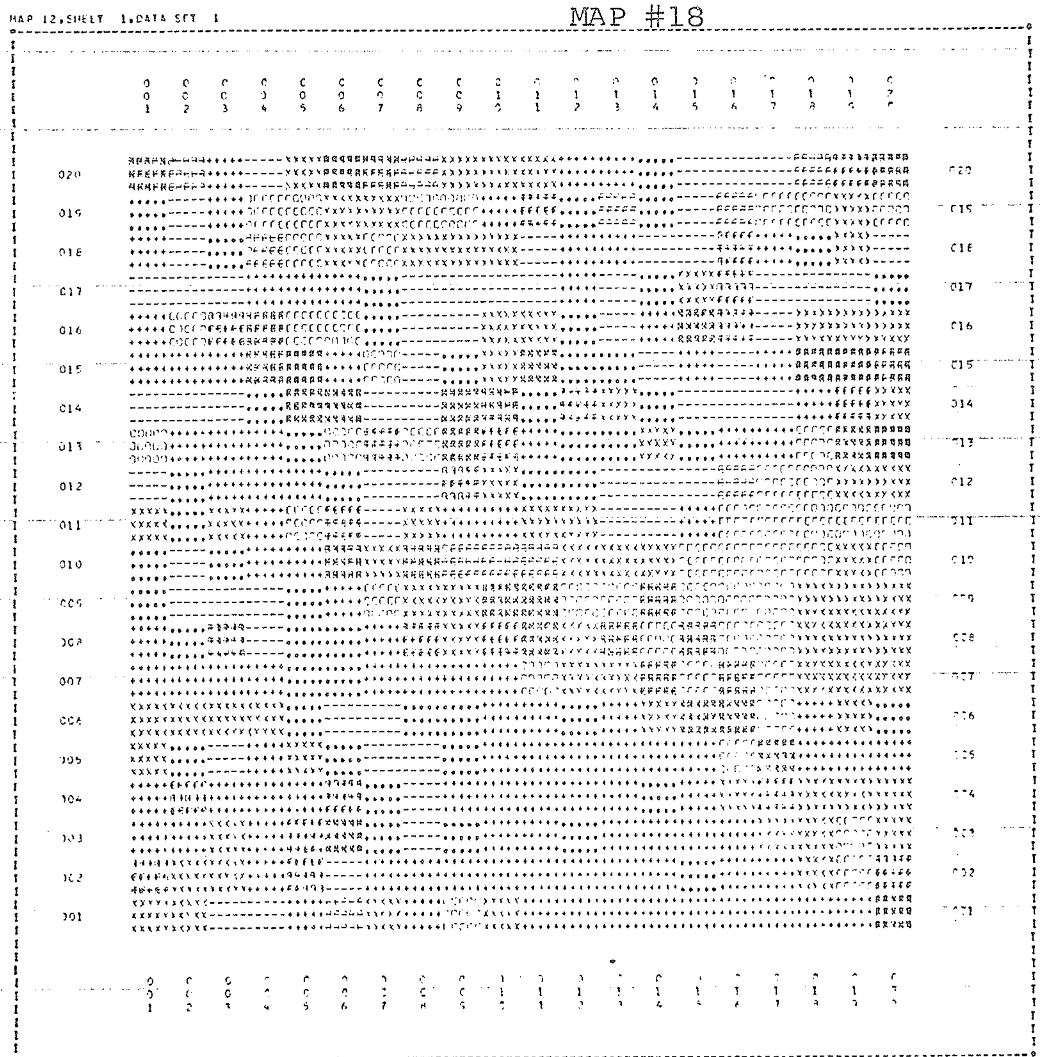
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	#########	$$$$$$$$$	#########	#########	@@@@@@@@@
FREQUENCY	29	39	66	41	109	16	23	13	17	6

MAP 12, SHEET 1, DATA SET 1

MAP #18



SOLAR RADIATION - DECEMBER 21

A. CAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 39.68 AND 220.19 (MEAN = 98.22 ST. DEV. = 144.56

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	39.68	57.73	75.78	93.83	111.88	129.93	147.98	166.03	184.08	202.14
MAXIMUM	57.73	75.78	93.83	111.98	129.93	147.98	166.03	184.08	202.14	220.19

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

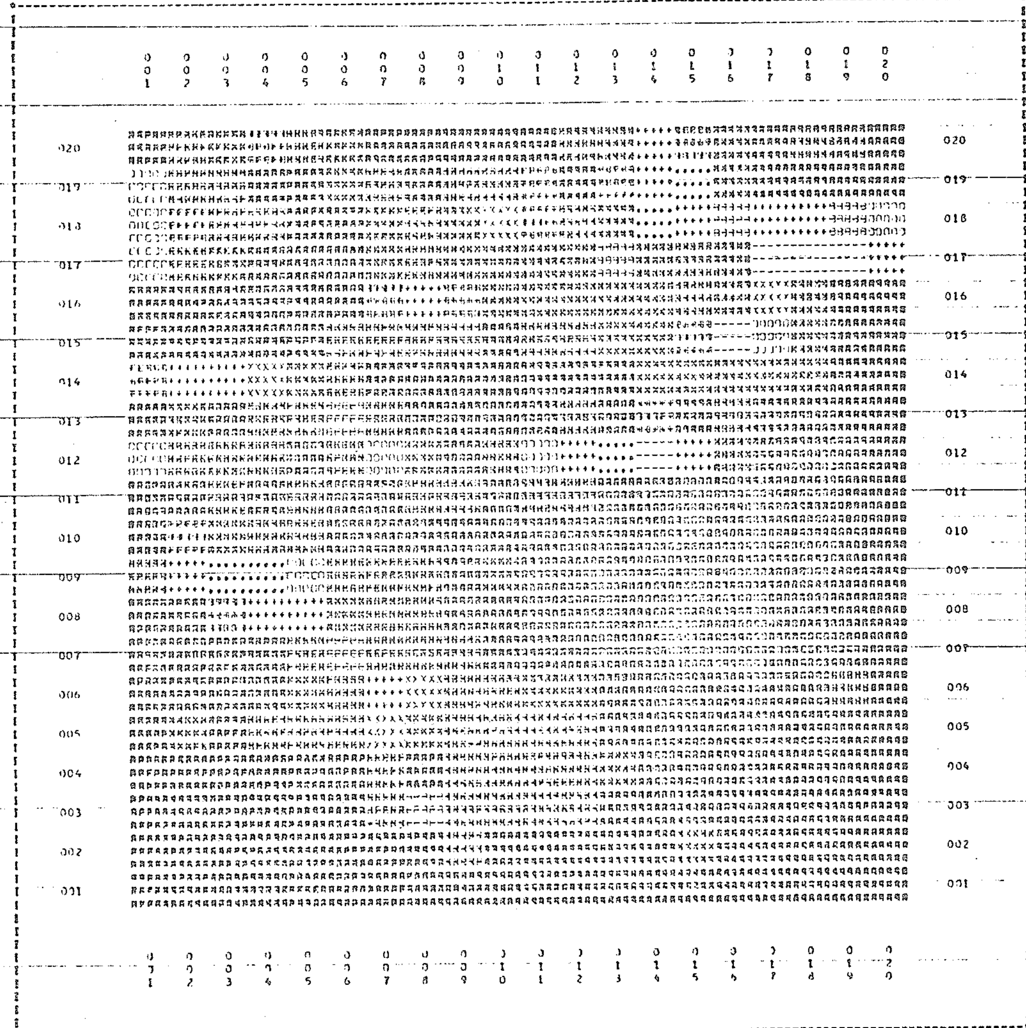
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	⊕⊕⊕⊕⊕⊕⊕⊕⊕	XXXXXXXXX	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	61	43	103	73	47	11	22	15	14	9

MAP 1, SHEET 1, DATA SET 1

MAP #19



SOLAR RADIATION - JANUARY 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 73.67 AND 1090.48 MEAN = 925.63 ST. DEV. = 1327.60

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	73.67	175.35	277.03	378.71	480.39	582.08	683.76	785.44	887.12	988.80
MAXIMUM	175.35	277.03	378.71	480.39	582.08	683.76	785.44	887.12	988.80	1090.48

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

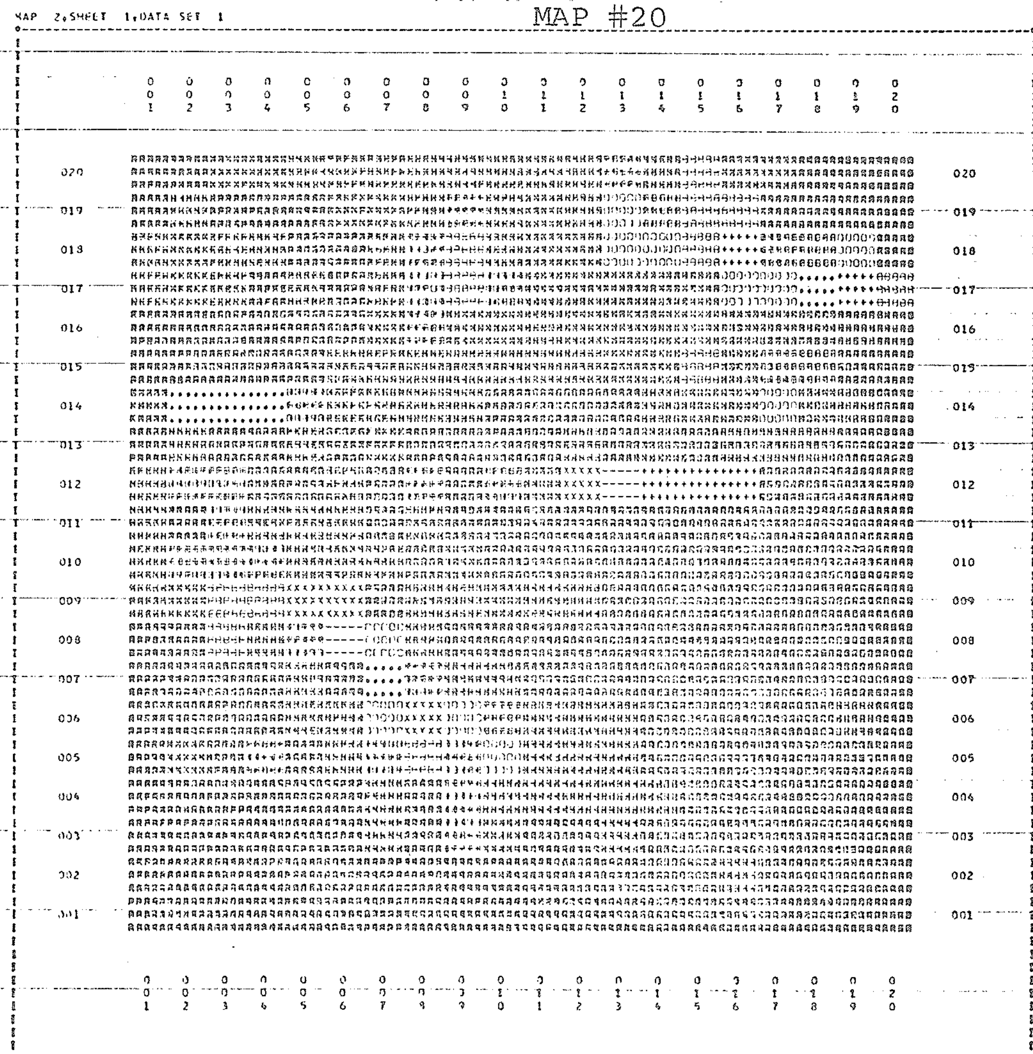
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	·········	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	*********	ЯЯЯЯЯЯЯЯЯ	ЯЯЯЯЯЯЯЯЯ	ЯЯЯЯЯЯЯЯЯ
FREQUENCY	5	5	15	5	9	6	11	45	76	221

MAP 2,SHEET 1,DATA SET 1

MAP #20



1608

SOLAR RADIATION - FEBRUARY 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 1144.42 AND 1862.49 MEAN = 1755.58 ST. DEV. = 2486.69

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	1144.42	1216.23	1288.03	1359.84	1431.64	1503.45	1575.25	1647.06	1718.86	1790.67
MAXIMUM	1216.23	1288.03	1359.84	1431.64	1503.45	1575.25	1647.06	1718.86	1790.67	1862.48

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

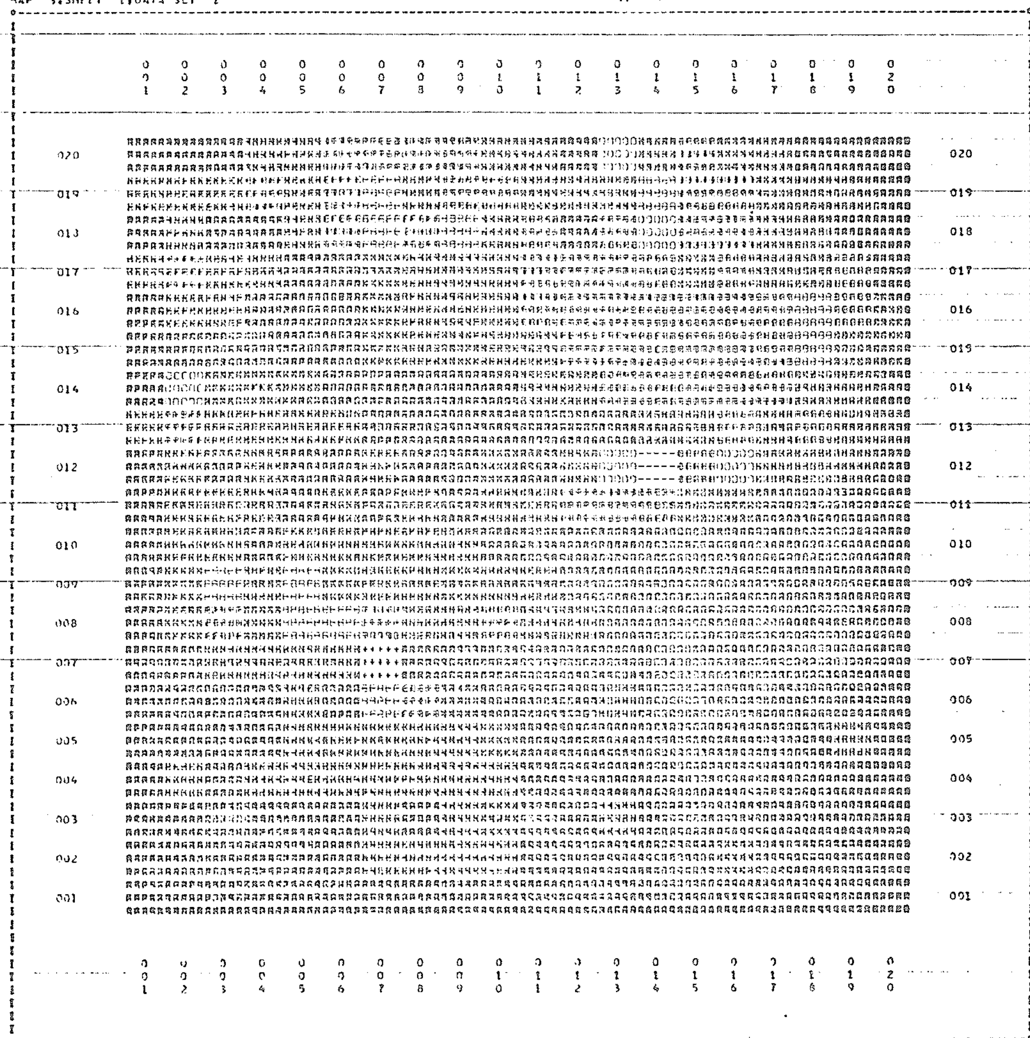
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	@@@@@@@@@	########	########	########
FREQUENCY	2	5	5	4	11	12	28	41	86	208

MAP #21

MAP 3,SHEET 1,DATA SET 1



SOLAR RADIATION - MARCH 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 1811.03 AND 2403.46 MEAN = 2324.11 ST. DEV. = 3288.03

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	1811.03	1870.28	1929.52	1988.76	2048.00	2107.25	2166.49	2225.73	2284.97	2344.21
MAXIMUM	1870.28	1929.52	1988.76	2048.00	2107.25	2166.49	2225.73	2284.97	2344.21	2403.46

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

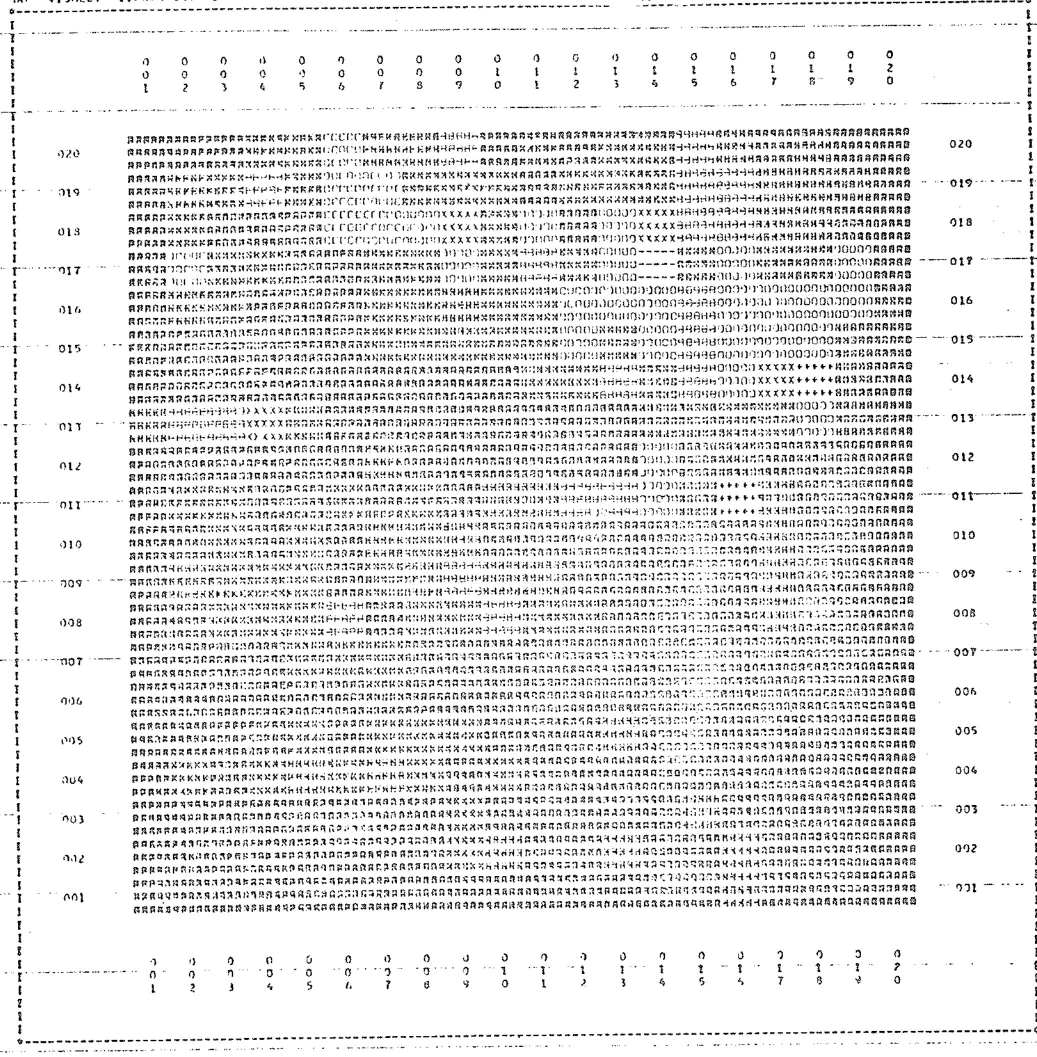
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	·········	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	◆◆◆◆◆◆◆◆◆	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	1	0	1	0	5	11	54	25	108	195

MAP 4,SHEET 1,DATA SET 1

MAP #22



1611

SOLAR RADIATION - APRIL 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 2244.52 AND 2651.96 MEAN = 2593.56 ST. DEV. = 3663.69

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	2244.52	2235.26	2325.00	2366.75	2407.49	2448.24	2488.99	2529.73	2570.47	2611.22
MAXIMUM	2285.26	2326.00	2366.75	2407.49	2448.24	2488.99	2529.73	2570.47	2611.22	2651.96

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

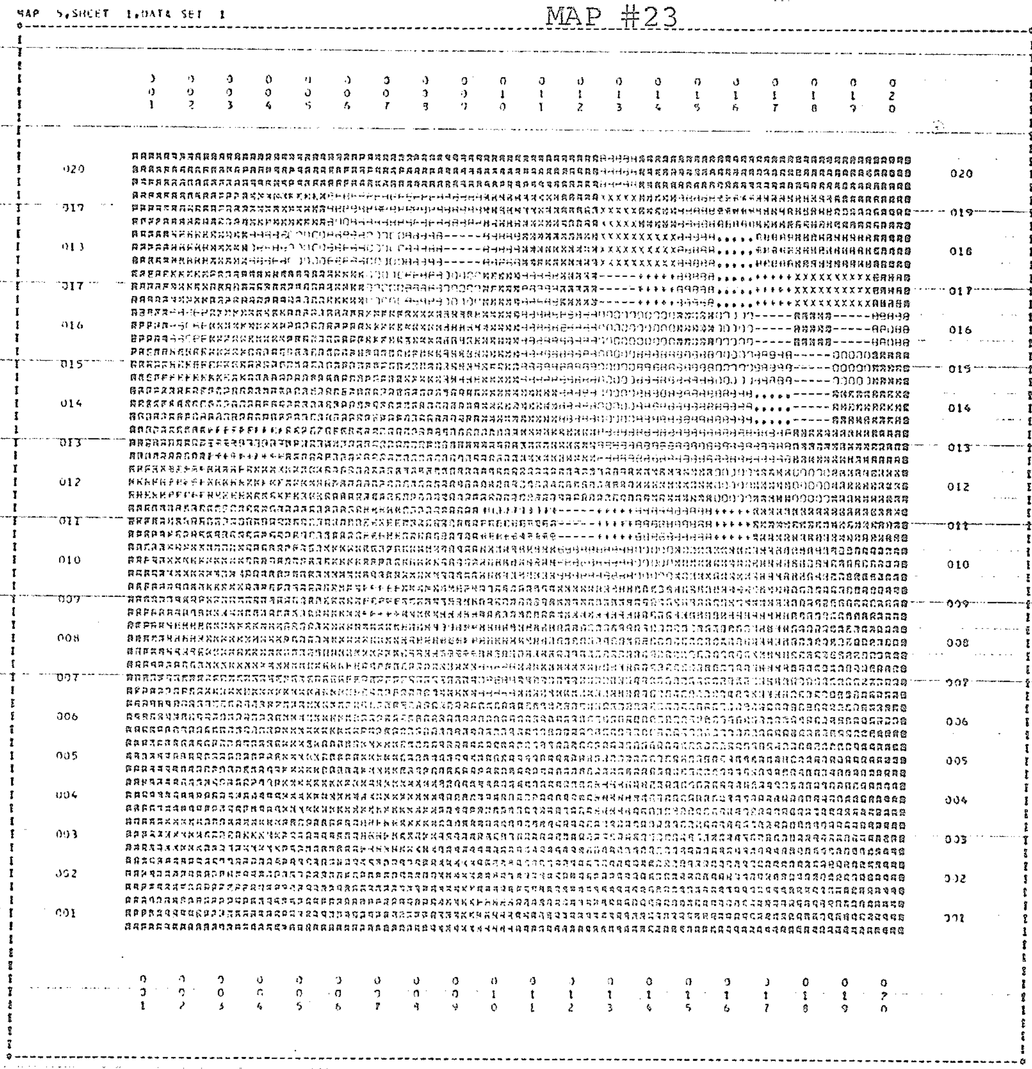
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	•••••••••	+++++++++	XXXXXXXXX	OOOOOOOOO	#########	•••••••••	#########	#########	#########
FREQUENCY	1	0	2	4	29	19	0	85	36	226

MAP 5, SHEET 1, DATA SET 1

MAP #23



SOLAR RADIATION - MAY 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 2450.63 AND 2794.52 MEAN = 2737.32 ST. DEV. = 3372.65

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	2450.63	2485.02	2519.41	2553.80	2588.19	2622.57	2656.96	2691.35	2725.74	2760.13
MAXIMUM	2485.02	2519.41	2553.80	2588.19	2622.57	2656.96	2691.35	2725.74	2760.13	2794.52

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

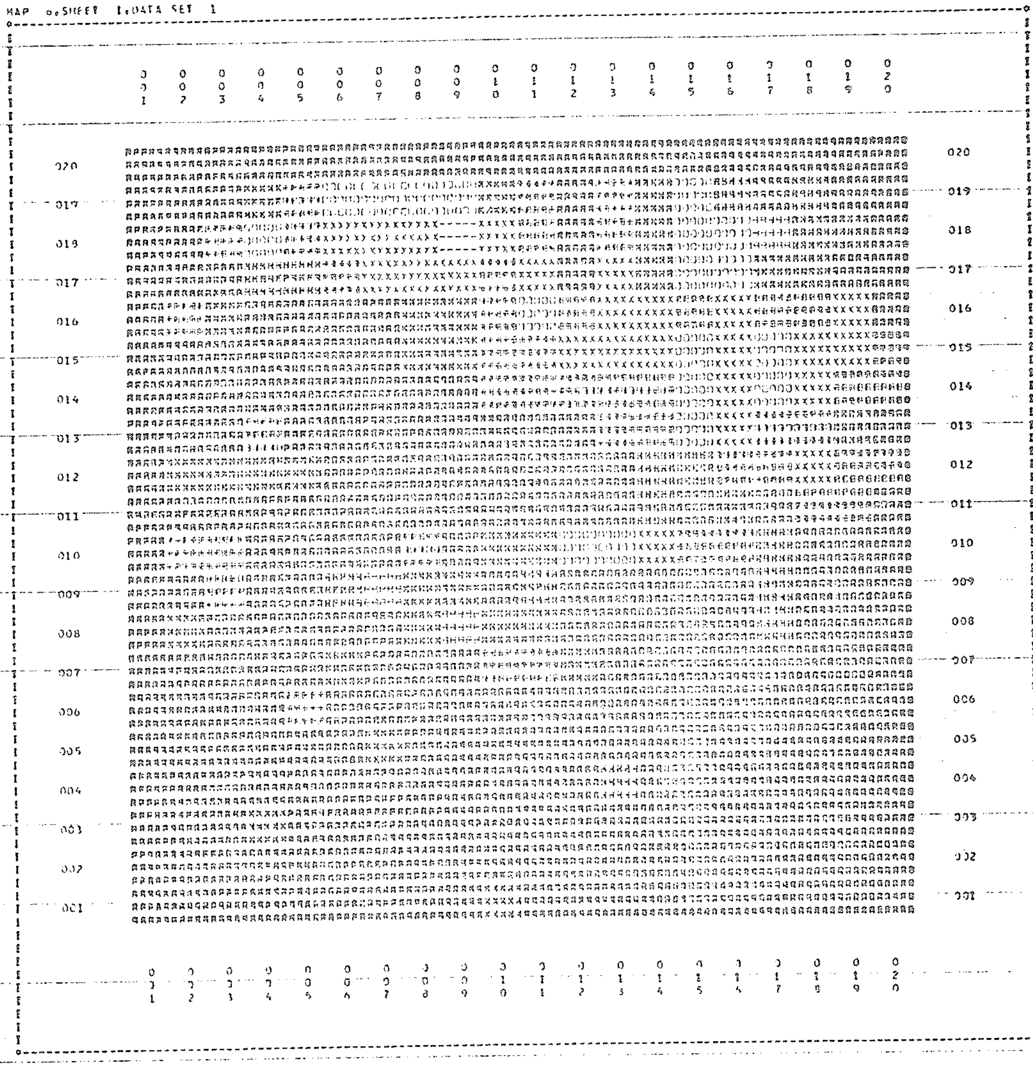
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	•••••••••	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	[illegible]	[illegible]	[illegible]	@@@@@@@@@
FREQUENCY	7	3	4	5	14	17	9	74	33	214

MAP #24

MAP 0, SHEET 1, DATA SET 1



1614

SOLAR RADIATION - JUNE 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 2401.03 AND 2826.61 MEAN = 2763.71 ST. DEV. = 3909.44

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	2401.03	2443.59	2486.15	2528.70	2571.26	2613.82	2656.38	2698.94	2741.49	2784.05
MAXIMUM	2443.59	2486.15	2528.70	2571.26	2613.82	2656.38	2698.94	2741.49	2784.05	2826.61

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

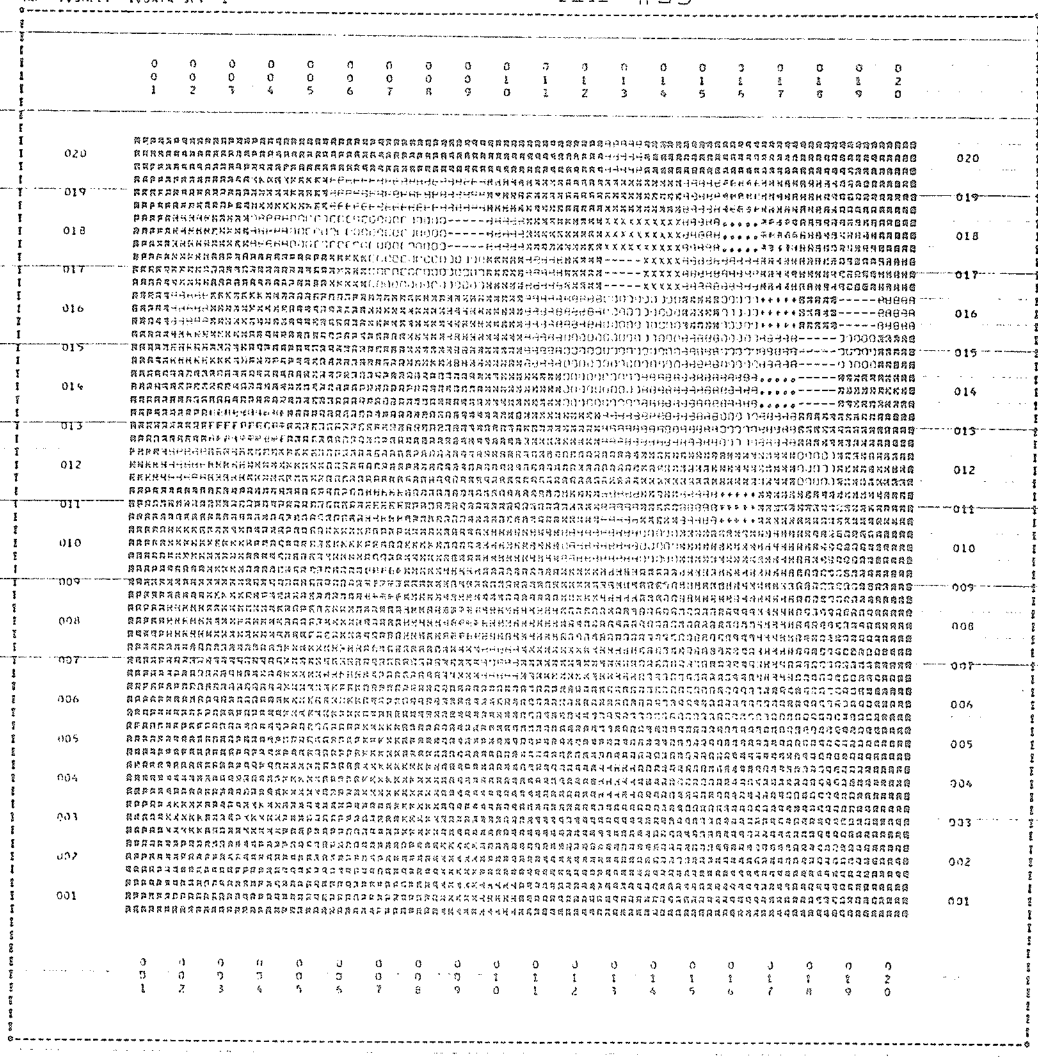
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	·········	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	⊕⊕⊕⊕⊕⊕⊕⊕⊕	▇▇▇▇▇▇▇▇▇	▇▇▇▇▇▇▇▇▇	▇▇▇▇▇▇▇▇▇
FREQUENCY	1	0	0	26	18	8	45	33	13	263

MAP 7, SHEET 1, DATA SET 1

MAP #25



SOLAR RADIATION - JULY 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 2381.75 AND 2714.06 MEAN = 2667.24 ST. DEV. = 3772.70

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	2381.75	2415.37	2449.01	2482.64	2516.27	2549.90	2583.57	2617.15	2650.78	2684.42
MAXIMUM	2415.34	2449.01	2482.64	2516.27	2549.90	2583.57	2617.15	2650.78	2684.41	2719.06

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

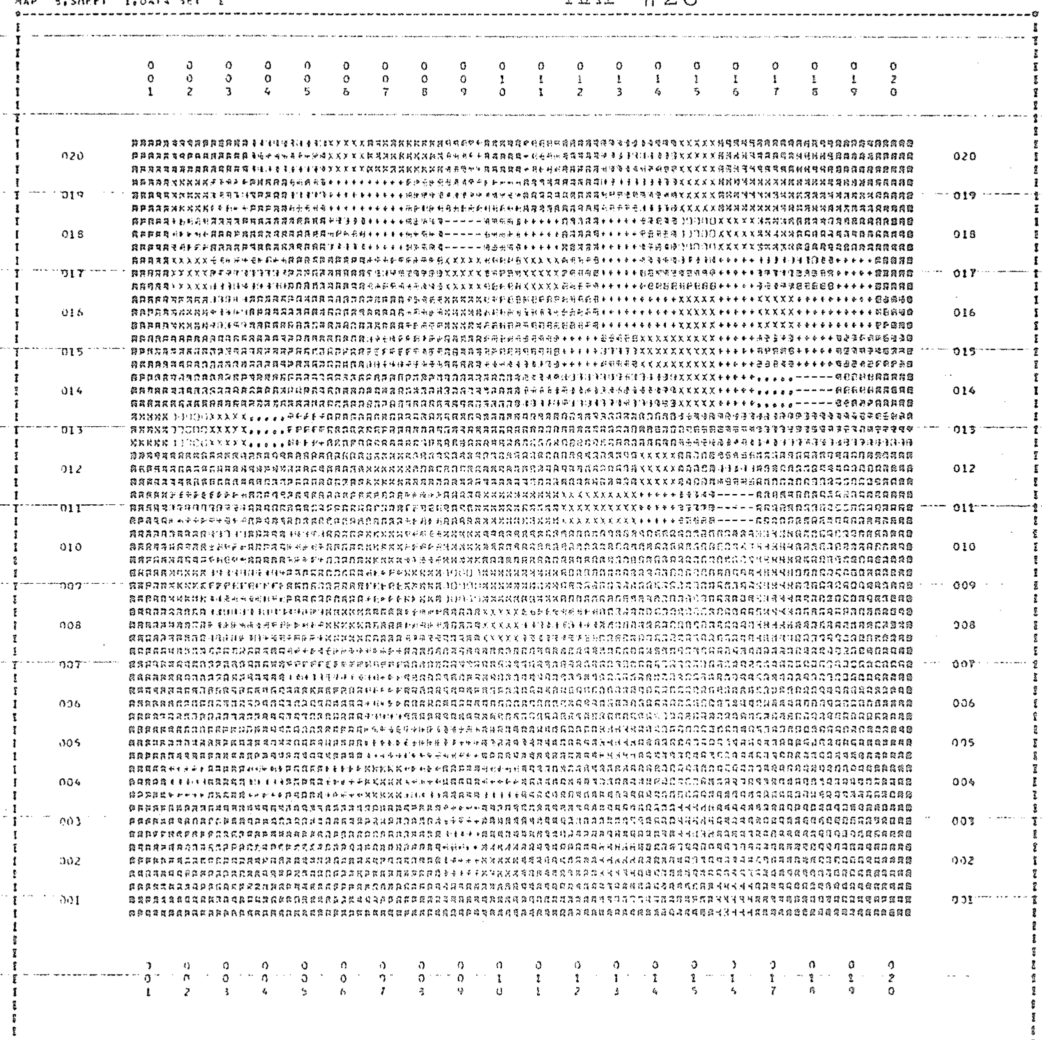
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	--------	....	++++++++	XXXXXXXX	OOOOOOOO	########	$$$$$$$$	XXXXXXXX	&&&&&&&&	@@@@@@@@
FREQUENCY	5	2	7	1	20	12	6	72	36	226

1616

MAP 3,SHEET 1,DATA SET 1

MAP #26



1617

SOLAR RADIATION - AUGUST 21

S. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 2236.60 AND 2514.88 MEAN = 2466.55 ST. DEV. = 3640.87

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	2236.60	2264.42	2292.25	2320.08	2347.91	2375.74	2403.57	2431.40	2459.22	2487.05
MAXIMUM	2264.42	2292.25	2320.08	2347.91	2375.74	2403.57	2431.40	2459.22	2487.05	2514.88

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

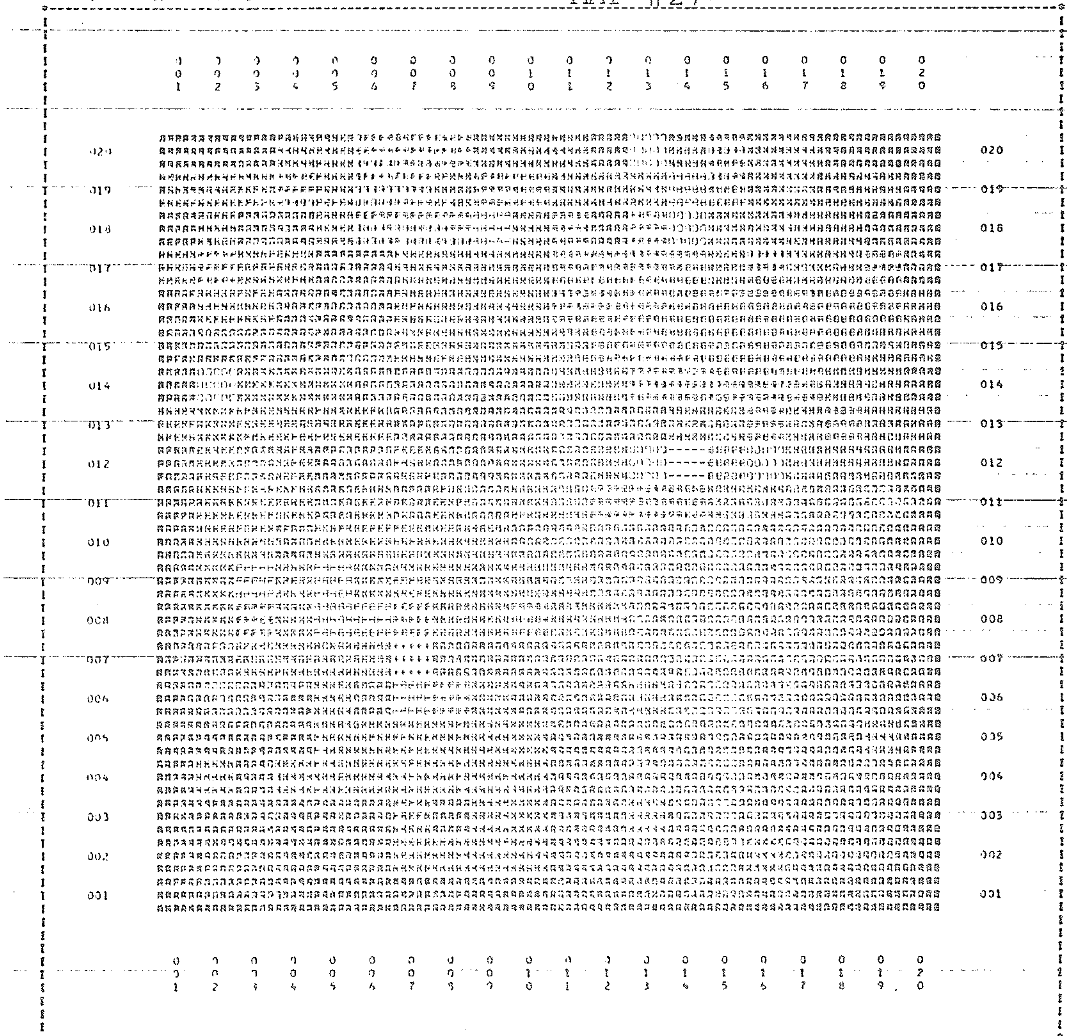
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	3	2	18	17	3	0	85	23	9	240

MAP 2, SHEET 1, DATA SET 1

MAP #27



SOLAR RADIATION - SEPTEMBER 21

A. OSKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 1700.78 AND 2220.49 MEAN = 2153.20 ST. DEV. = 3046.09

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	1700.78	1752.75	1804.72	1856.70	1908.67	1960.64	2012.61	2064.58	2116.55	2168.52
MAXIMUM	1752.75	1804.72	1856.70	1908.67	1960.64	2012.61	2064.58	2116.55	2168.52	2220.49

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

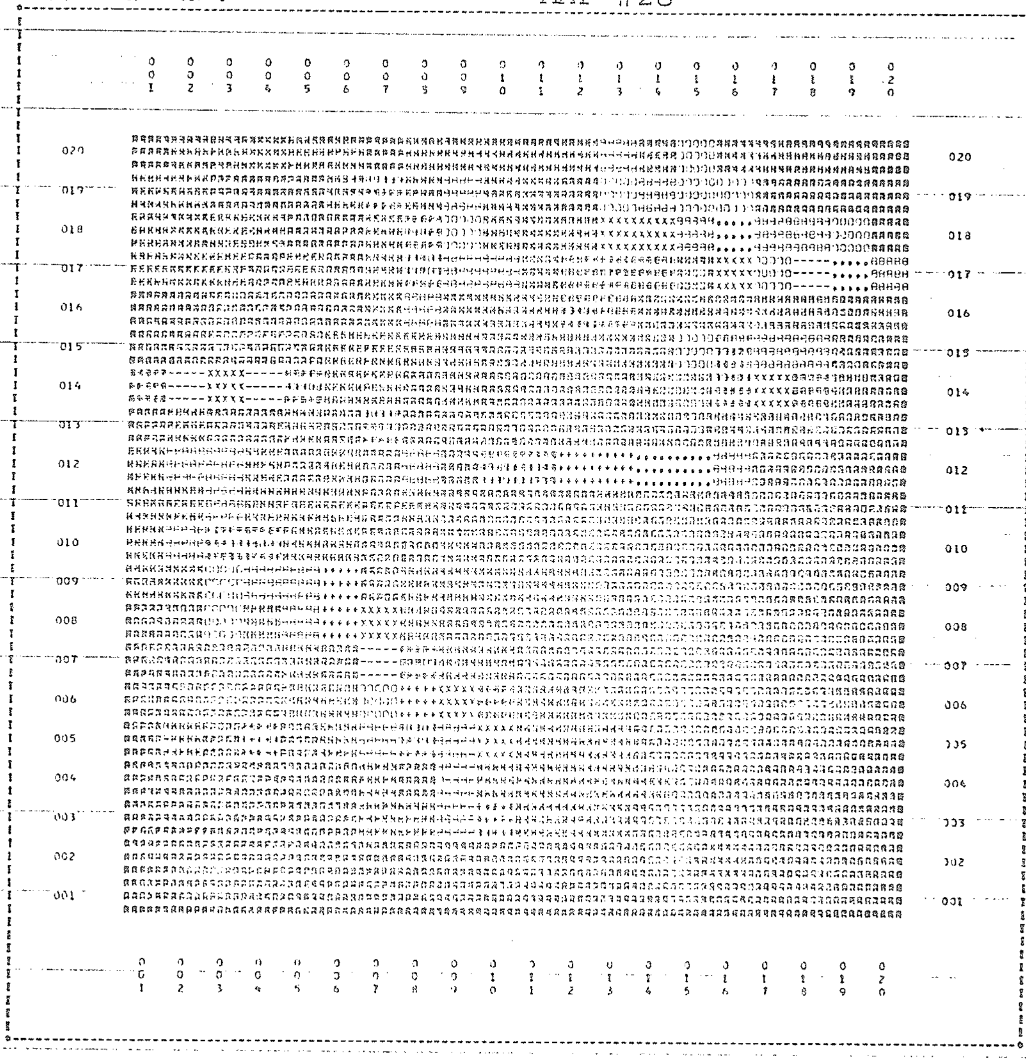
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	·········	+++++++++	XXXXXXXXX	OOOOOOOOO	#########	#########	XXXXXXXXX	#########	@@@@@@@@@
FREQUENCY	1	0	1	0	5	7	53	21	117	195

MAP 10, SHEET 1, DATA SET 1

MAP #28



SOLAR RADIATION - OCTOBER 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 1168.47 AND 1750.26 MEAN = 1659.97 ST. DEV. = 2350.71

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	1168.47	1226.65	1284.82	1343.00	1401.18	1459.35	1517.53	1575.71	1633.88	1692.06
MAXIMUM	1226.65	1284.82	1343.00	1401.18	1459.35	1517.53	1575.71	1633.88	1692.06	1750.26

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

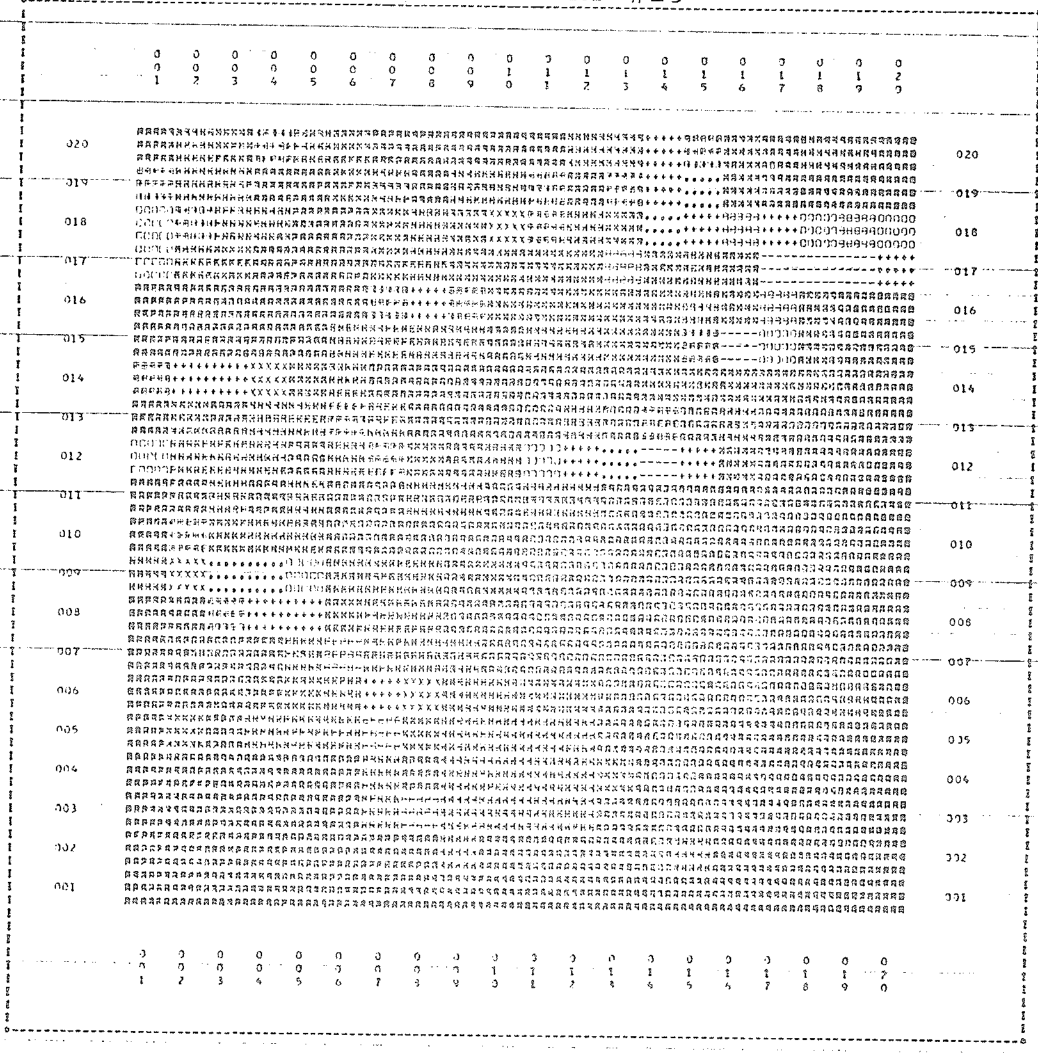
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	--------	oooooooo	++++++++	XXXXXXXX	OOOOOOOO	HHHHHHHH	@@@@@@@@	RRRRRRRR	HHHHHHHH	@@@@@@@@
FREQUENCY	6	6	5	8	11	25	23	22	95	203

MAP 11, SHEET 1, DATA SET 1

MAP #29



SOLAR RADIATION - NOVEMBER 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 74.11 AND 1060.63 MEAN = 931.67 ST. DEV. = 1295.07

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	74.11	172.77	271.42	370.07	468.72	567.37	666.02	764.68	863.33	961.98
MAXIMUM	172.77	271.42	370.07	468.72	567.37	666.02	764.68	863.33	961.98	1060.63

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

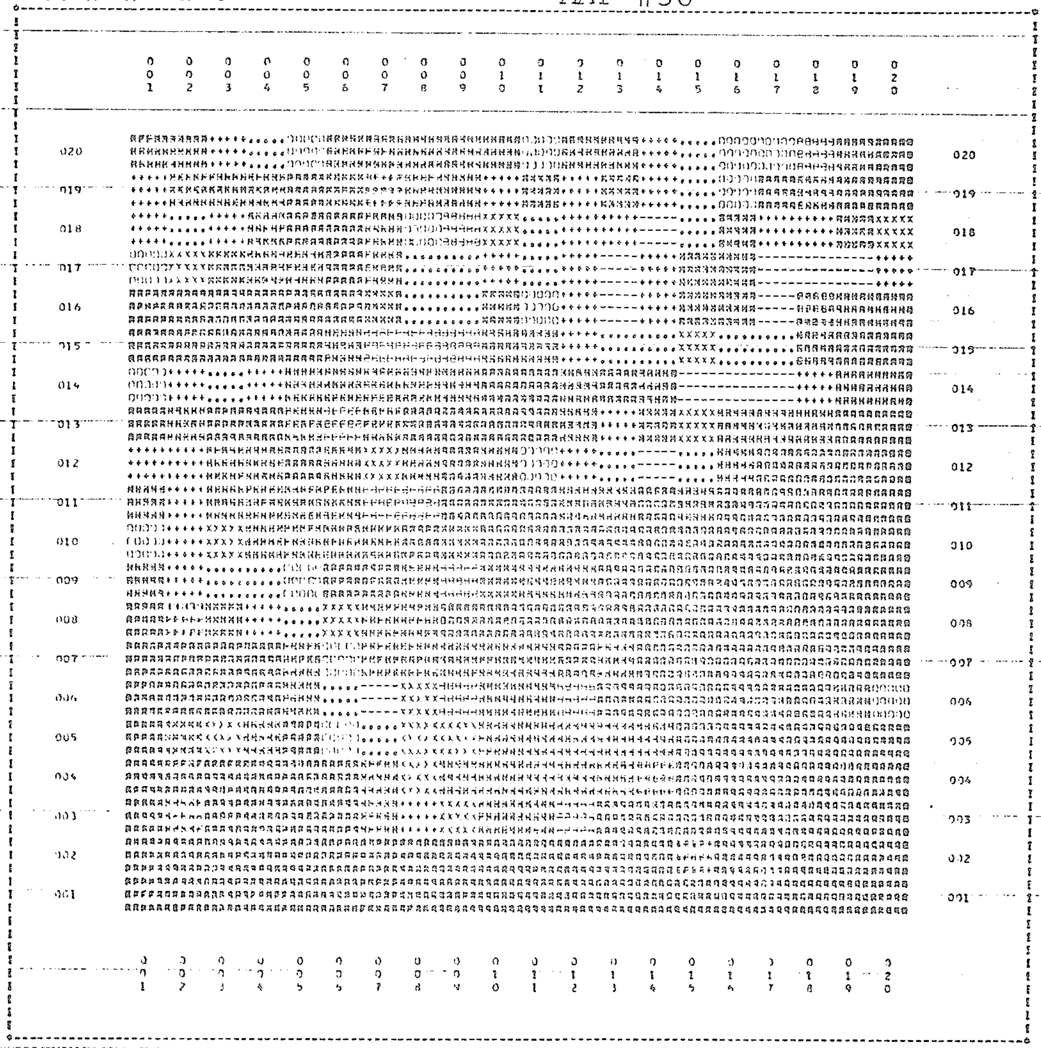
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	··········	++++++++	XXXXXXXX	OOOOOOOO	HHHHHHHH	ØØØØØØØØ	ØØØØØØØØ	ØØØØØØØØ	ØØØØØØØØ	ØØØØØØØØ
FREQUENCY	5	5	13	6	8	7	16	44	77	221

MAP 12, SHEET 1, DATA SET 1

MAP #30



SOLAR RADIATION - DECEMBER 21

A. JAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.56 AND 710.93 MEAN = 547.82 ST. DEV. = 601.02

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.55	113.89	180.23	246.57	312.90	379.24	445.58	511.92	578.25	644.59
MAXIMUM	113.89	180.23	246.57	312.90	379.24	445.58	511.92	578.25	644.59	710.93

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

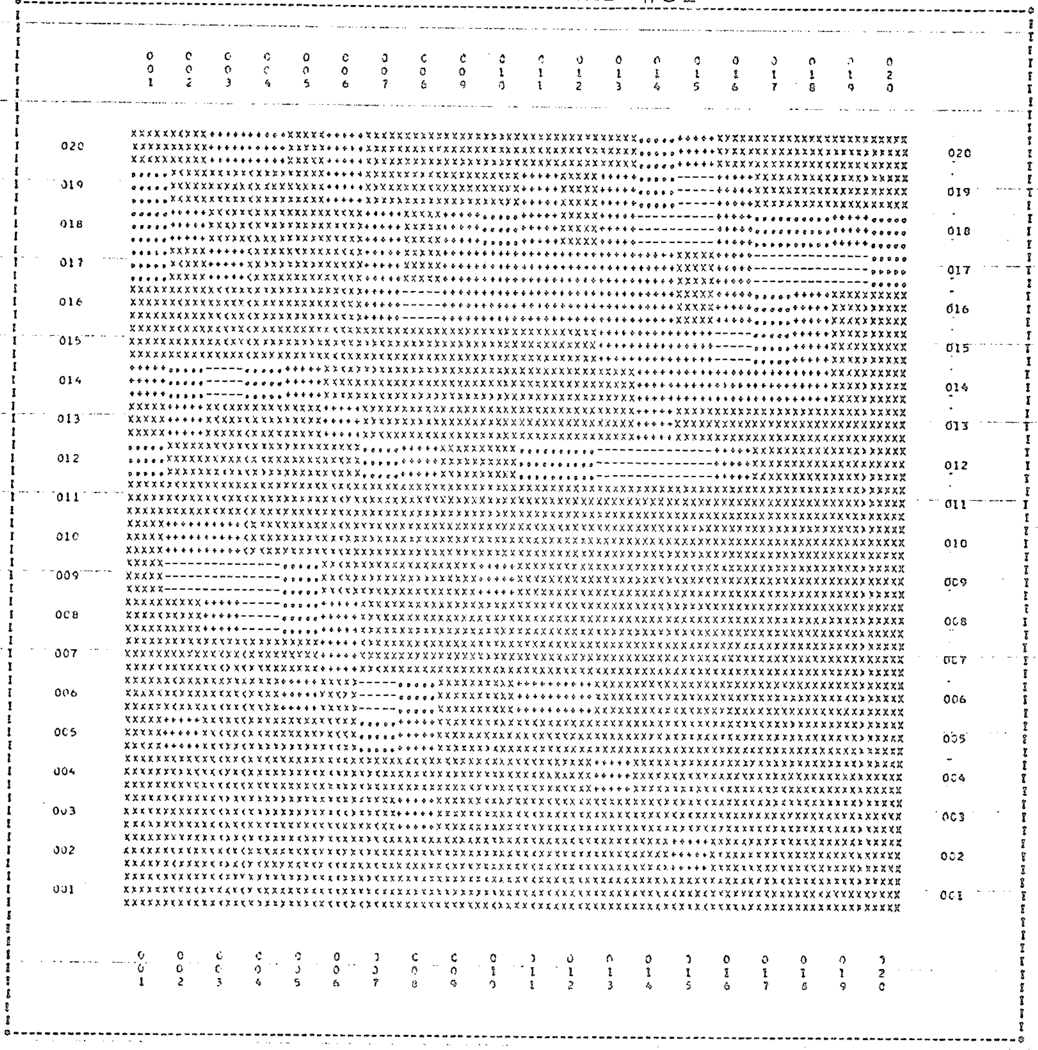
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	·········	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	ØØØØØØØØØ	ЖЖЖЖЖЖЖЖЖ	ЖЖЖЖЖЖЖЖЖ	ØØØØØØØØØ
FREQUENCY	12	23	31	14	15	12	5	17	94	177

MAP 1,SHEET 1,DATA SET 1

MAP #31



1810

SOLAR RADIATION - JANUARY 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 925.60 ST. DEV. = 1327.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

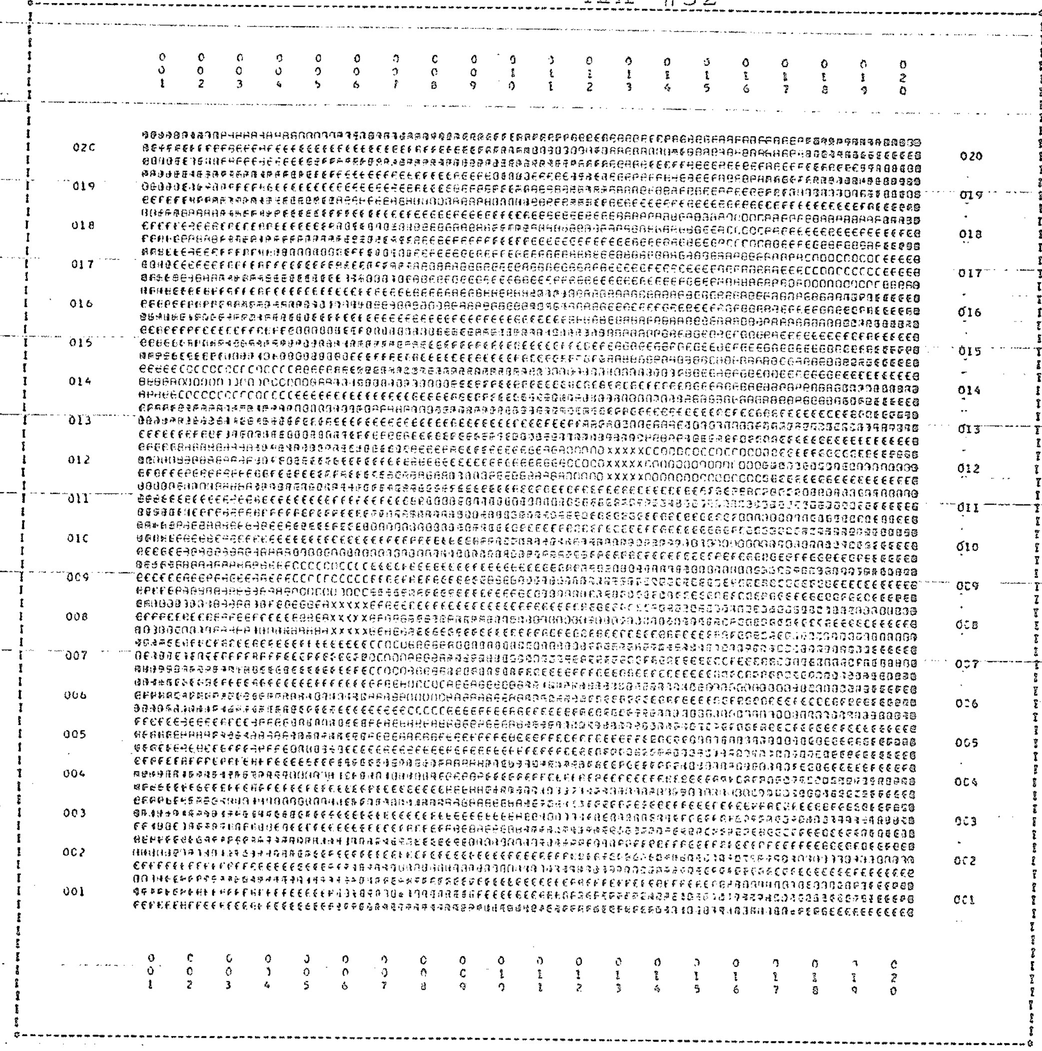
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		---------	....	+++++++++	XXXXXXXX	OOOOOOOO	HHHHHHHH	[illegible]	[illegible]	[illegible]	[illegible]	
FREQUENCY	0	17	22	63	298	0	0	0	0	0	0	0

MAP 2.SHEET 1.DATA SET 1

MAP #32



SOLAR RADIATION - FEBRUARY 21

A. BAKIN. M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 1755.58 ST. DEV. = 2486.69

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

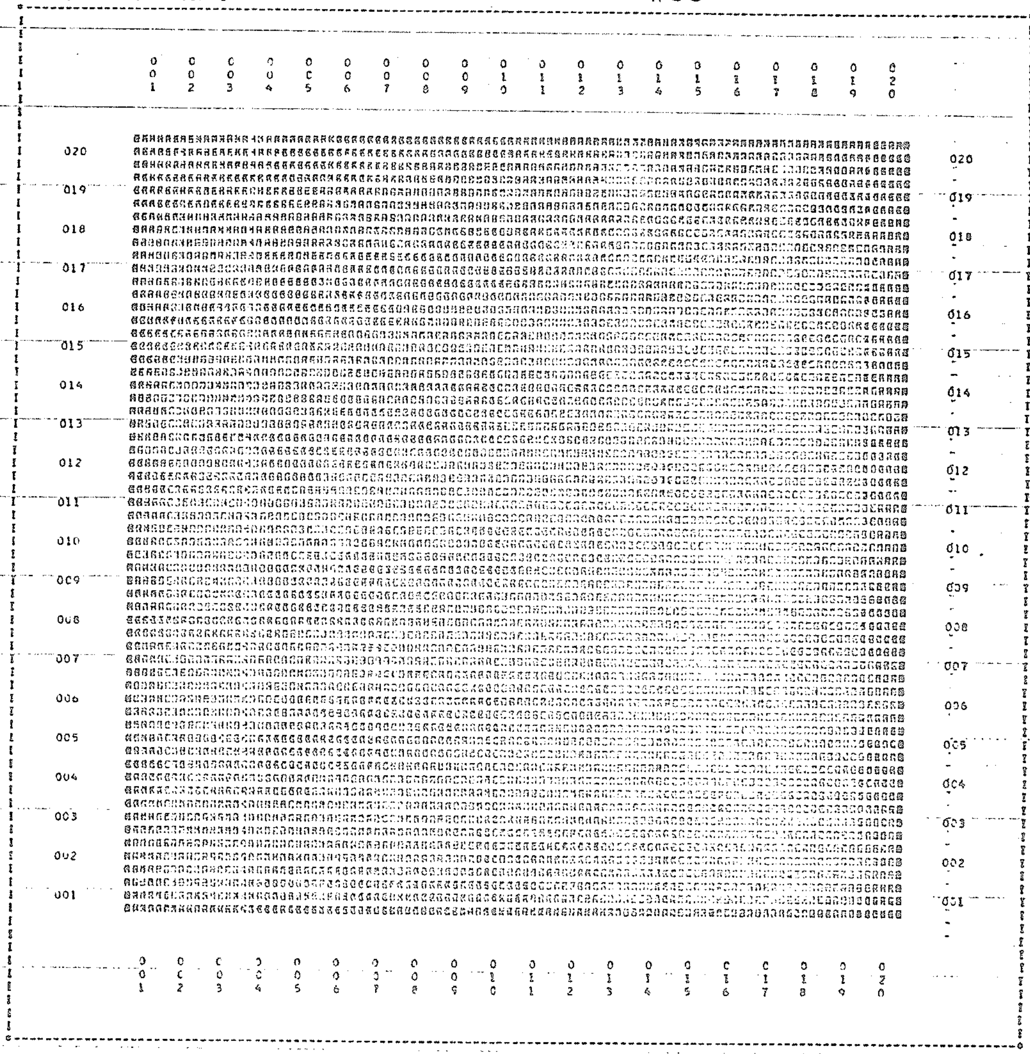
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		---------	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	888888888	ØØØØØØØØØ	███████		
FREQUENCY	0	0	0	0	2	14	91	293	0	0	0	0

1812

MAP 3,SHEET 1,DATA SET 1

MAP #33



1813

SOLAR RADIATION - MARCH 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2324.11 ST. DEV. = 3288.09

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

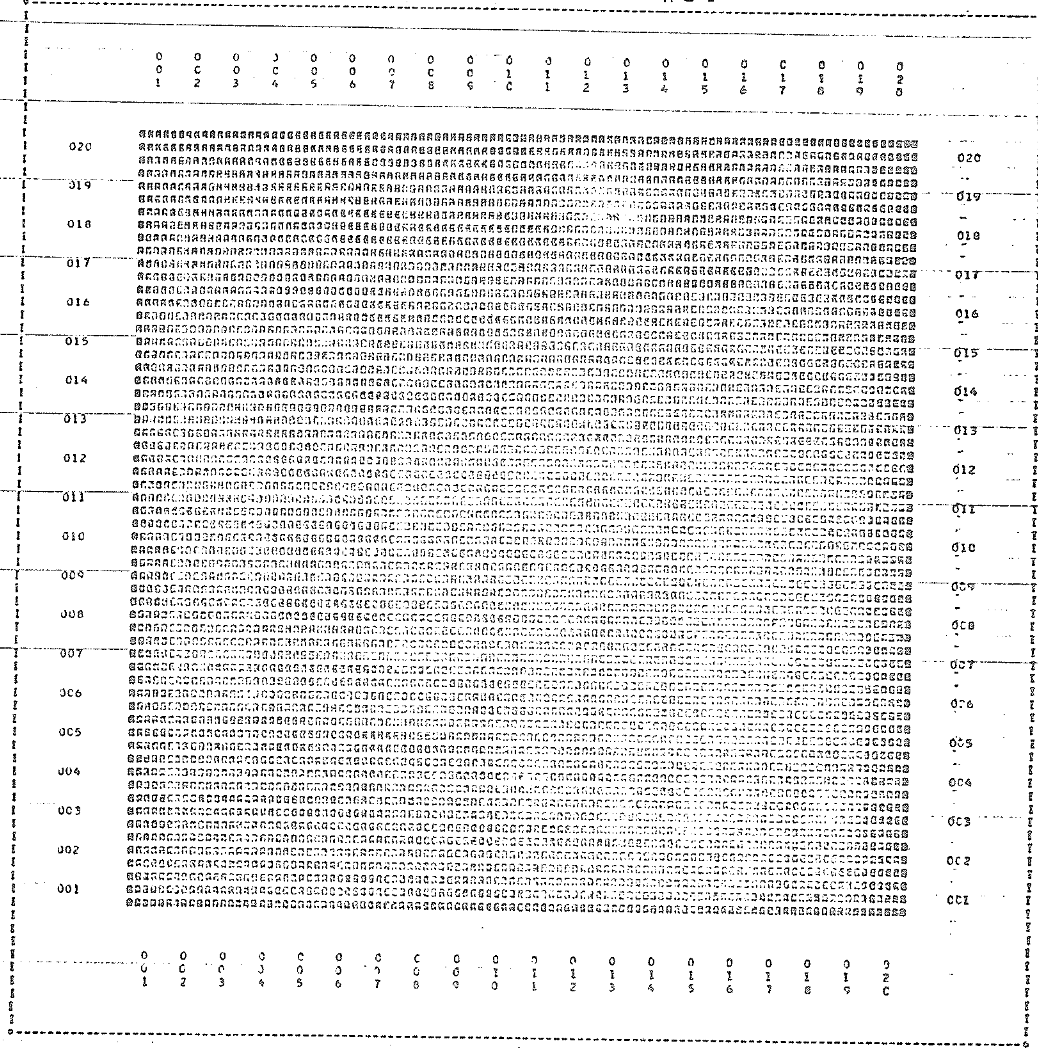
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		--------	....	++++++++	XXXXXXXX	OOOOOOOO	AAAAAAAA	[illegible]	[illegible]	[illegible]	[illegible]	
FREQUENCY	0	0	0	0	0	0	0	2	89	319	0	0

MAP 4, SHEET 1, DATA SET 1

MAP #34



SOLAR RADIATION - APRIL 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2593.56 ST. DEV. = 3668.69

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

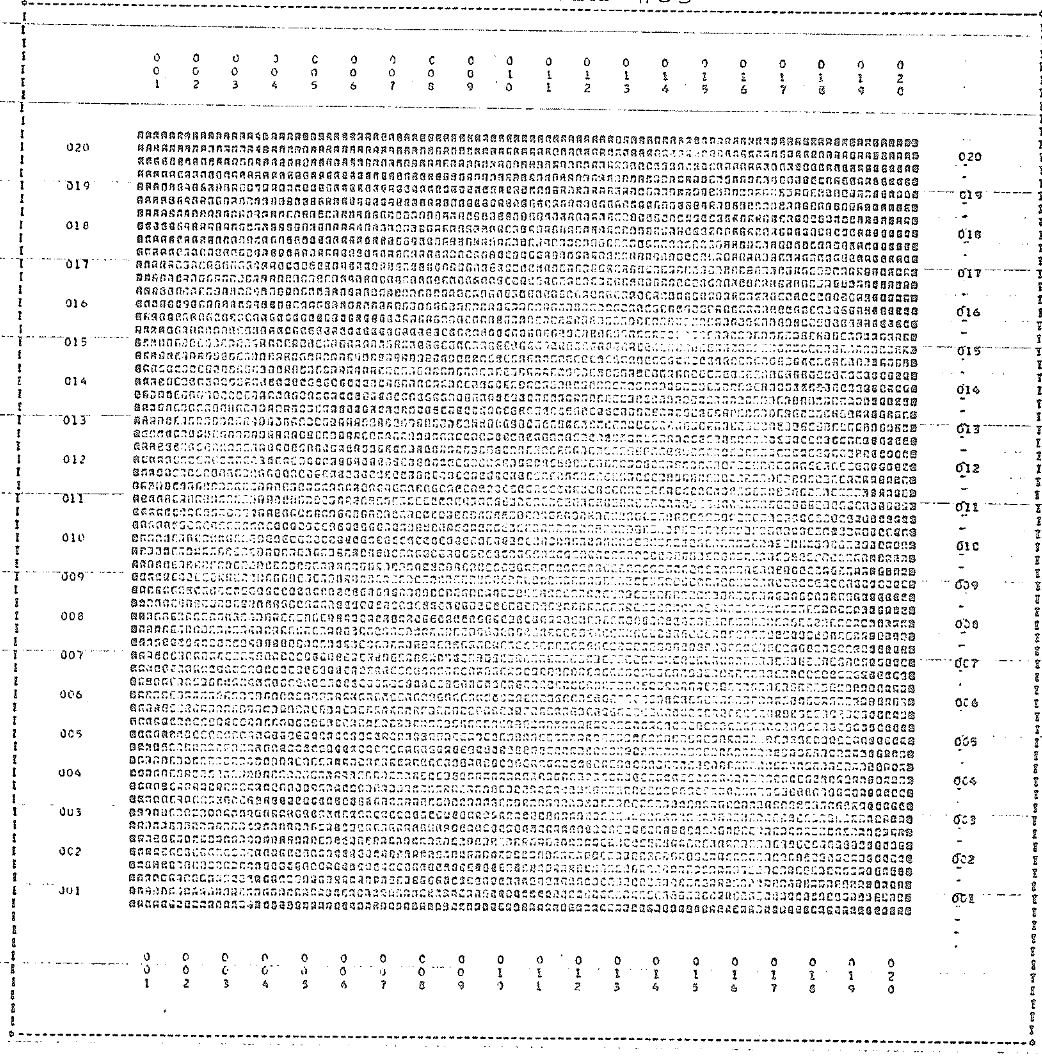
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
1815 SYMBOLS		---------	········	++++++++	XXXXXXXX	OOOOOOOO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
FREQUENCY	0	0	0	0	0	0	0	0	1	102	291	0

MAP 5,SHEET 1,DATA SET 1

MAP #35



1816

SOLAR RADIATION - DAY 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2737.82 ST. DEV. = 3872.65

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

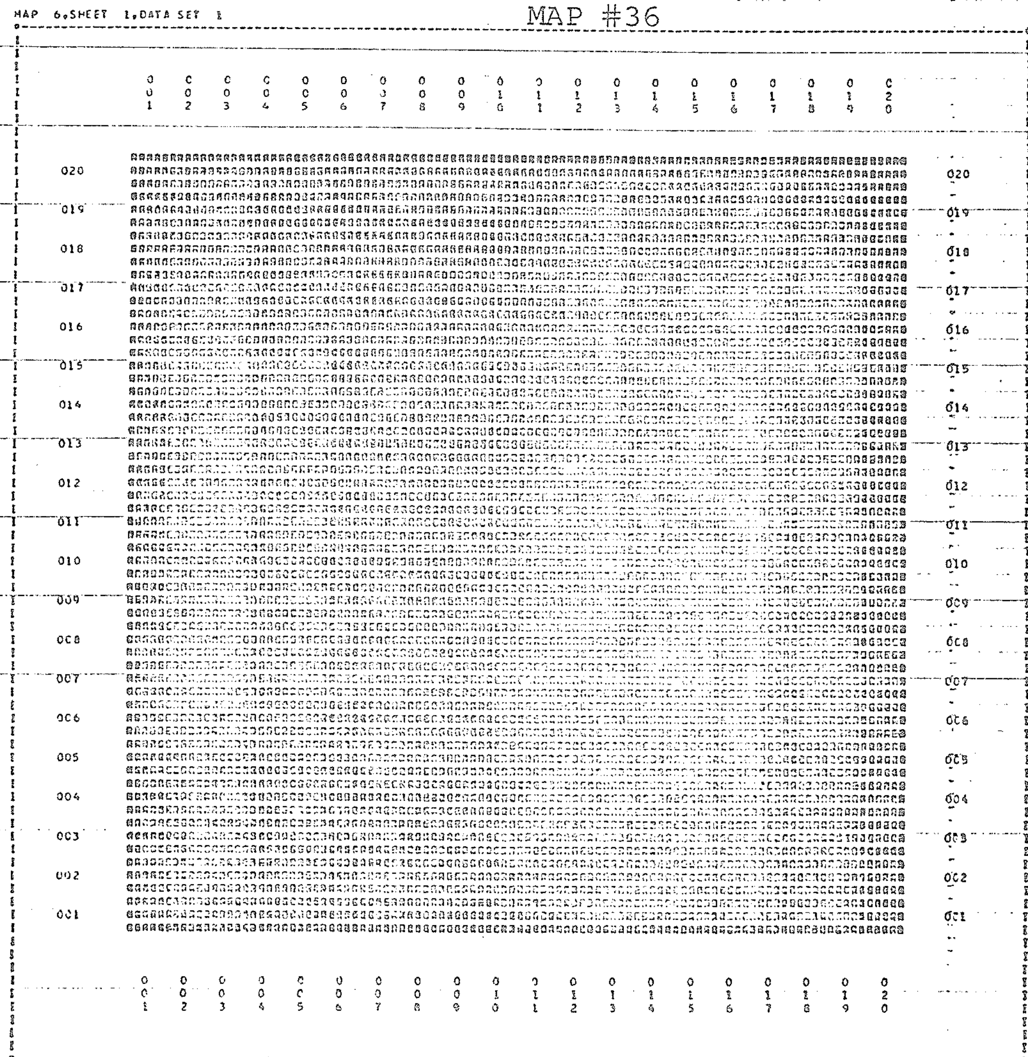
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		--------	....	++++++++	XXXXXXXX	OOOOOOOO	AAAAAAAA	########	MMMMMMMM	########	@@@@@@@@	
FREQUENCY	0	0	0	0	0	0	0	0	0	12	388	0

MAP 6,SHEET 1,DATA SET 1

MAP #36



SOLAR RADIATION - JUNE 21

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2763.71 ST. DEV. = 3909.44

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

	1	2	3	4	5	6	7	8	9	10
MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

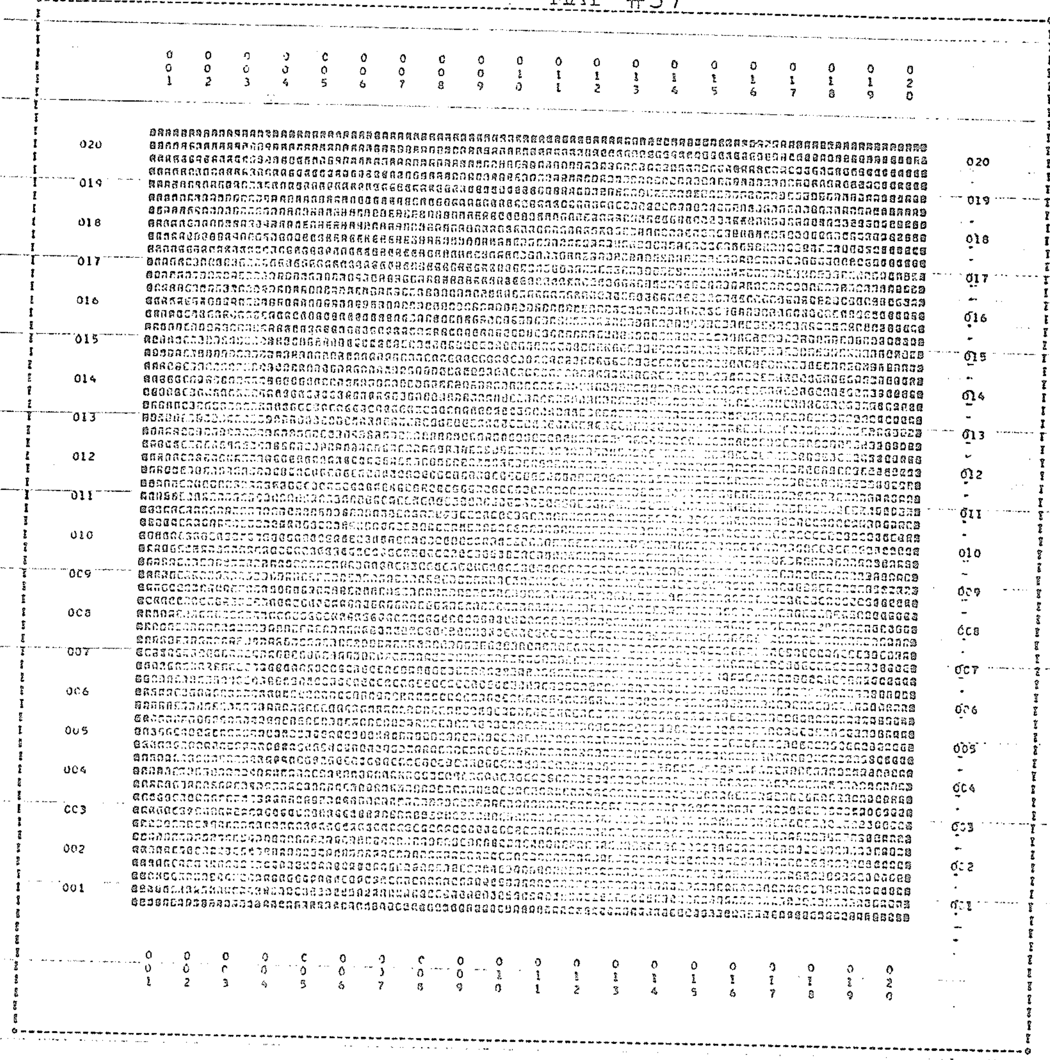
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		---------	....	+++++++++	XXXXXXXX	OOOOOOOO	AAAAAAAA	@@@@@@@@	@@@@@@@@	@@@@@@@@	@@@@@@@@	
FREQUENCY	0	)	C	C	0	0	0	0	0	5	399	0

MAP 7,SHEET 1,DATA SET 1

MAP #37



1819

SOLAR RADIATION - JULY 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2667.24 ST. DEV. = 3772.70

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

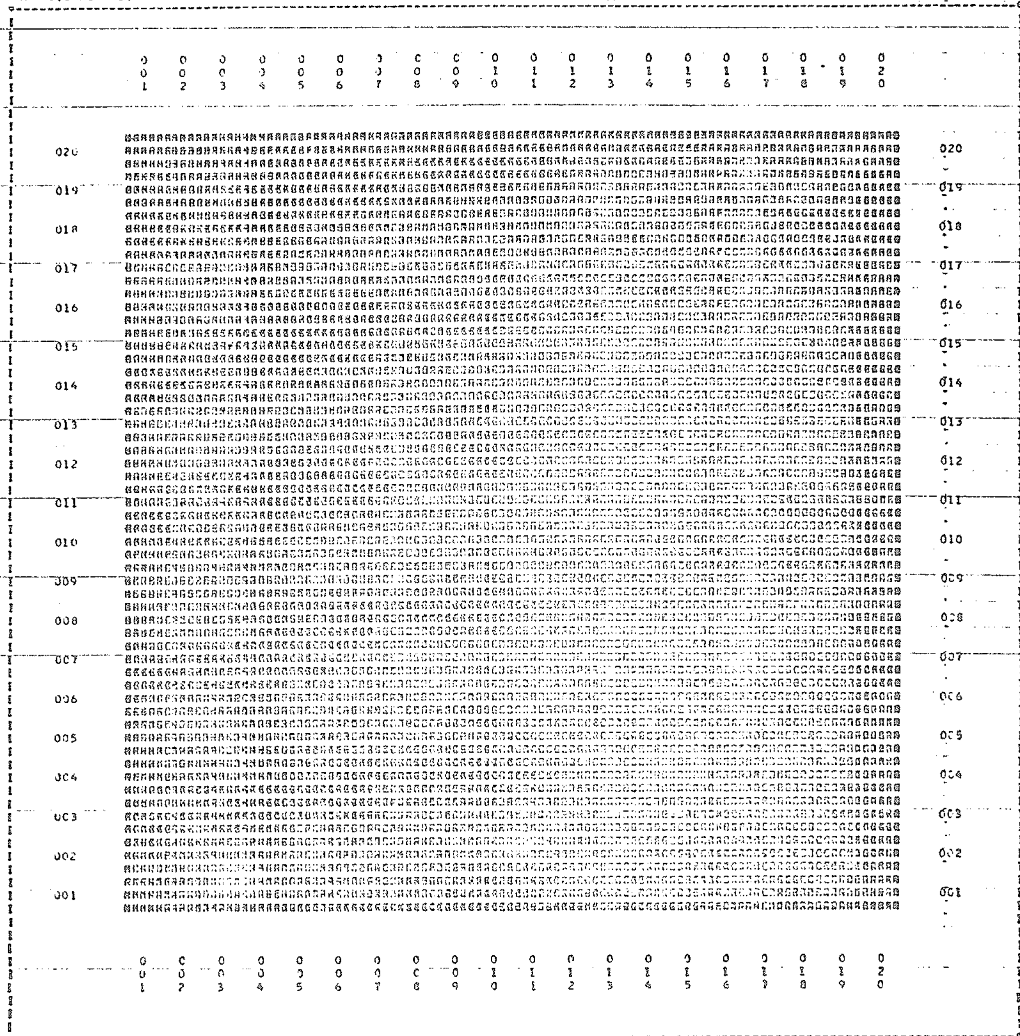
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		--------	********	++++++++	XXXXXXXX	OOOOOOOO	HHHHHHHH	████████	████████	████████	████████	
FREQUENCY	0	7	0	0	0	0	0	0	0	32	360	0

MAP 9,SHEET 1,DATA SET 1

MAP #38



SOLAR RADIATION - AUGUST 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2466.59 ST. DEV. = 3486.87

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

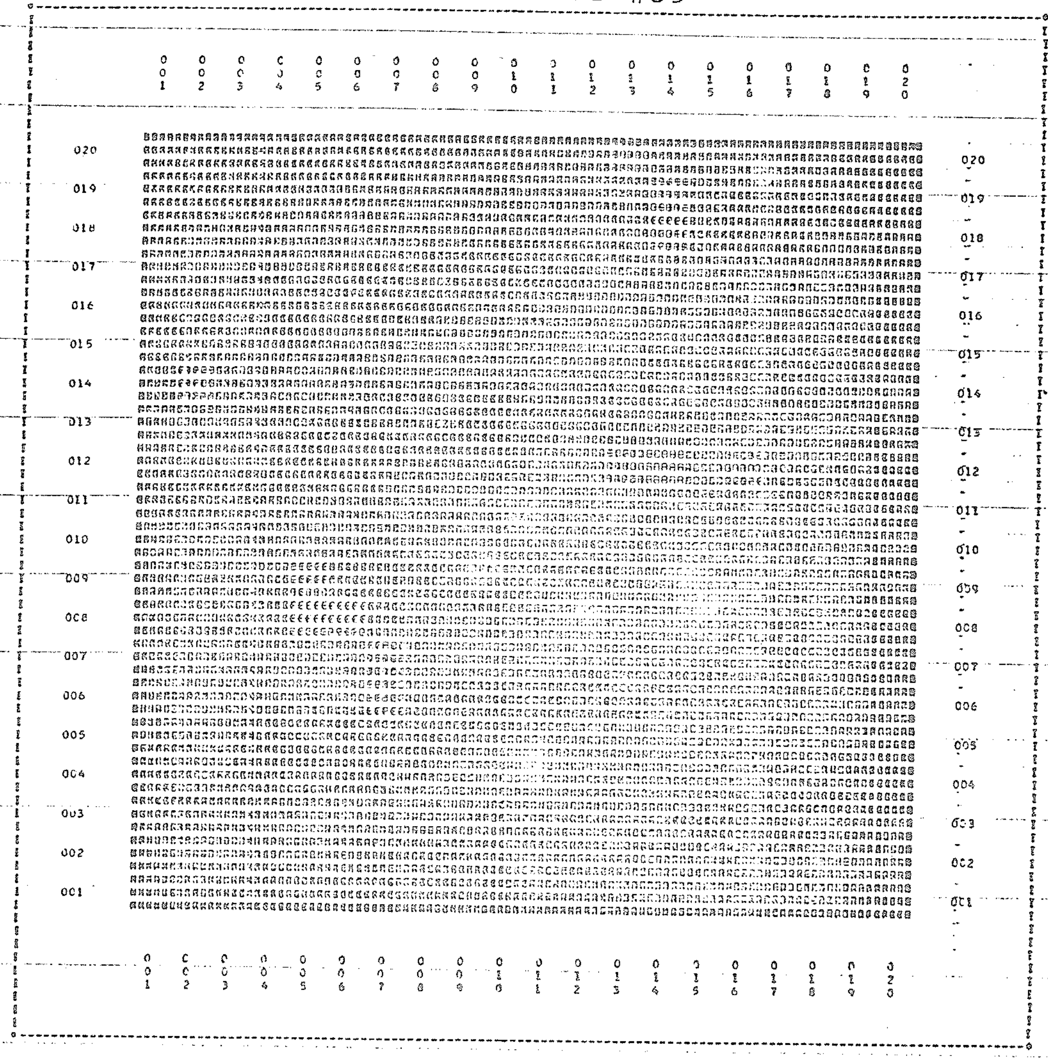
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		---------	·········	·········	XXXXXXXXX	OOOOOOOOO	ΘΘΘΘΘΘΘΘΘ	ΘΘΘΘΘΘΘΘΘ	ΘΘΘΘΘΘΘΘΘ	ΘΘΘΘΘΘΘΘΘ	ΘΘΘΘΘΘΘΘΘ	
FREQUENCY	0	0	0	0	0	0	0	0	4	396	0	0

MAP 9.SHEET 1.DATA SET 1

MAP #39



1822

SOLAR RADIATION - SEPTEMBER 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 2153.20 ST. DEV. = 3046.00

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

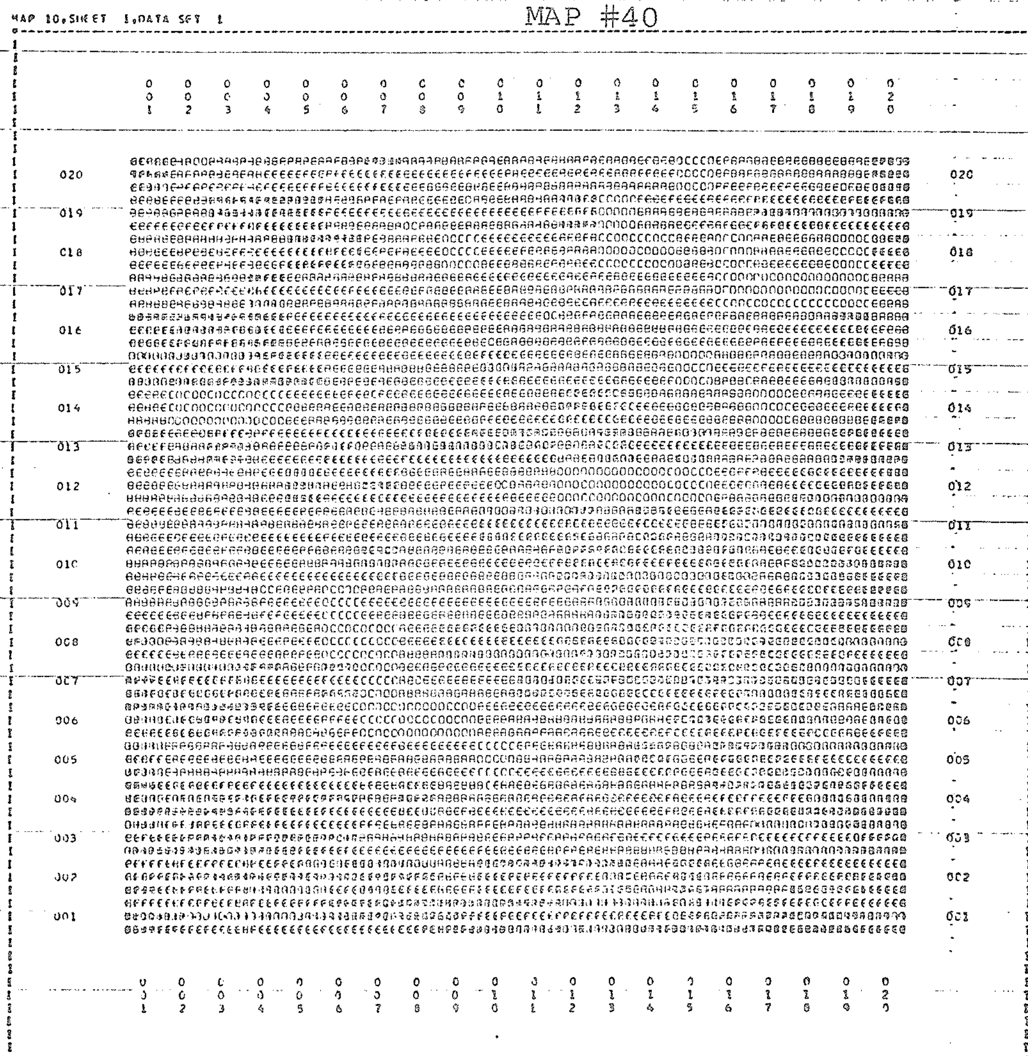
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		--------	oooooooo	++++++++	XXXXXXXX	OOOOOOOO	HHHHHHHH	@@@@@@@@	@@@@@@@@	@@@@@@@@	@@@@@@@@	
FREQUENCY	0	0	0	0	0	0	1	11	388	0	0	0

MAP 10, SHEET 1, DATA SET 1

MAP #40



SOLAR RADIATION - OCTOBER 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 67.00 AND 2827.00 MEAN = 1659.97 ST. DEV. = 2330.71

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	67.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

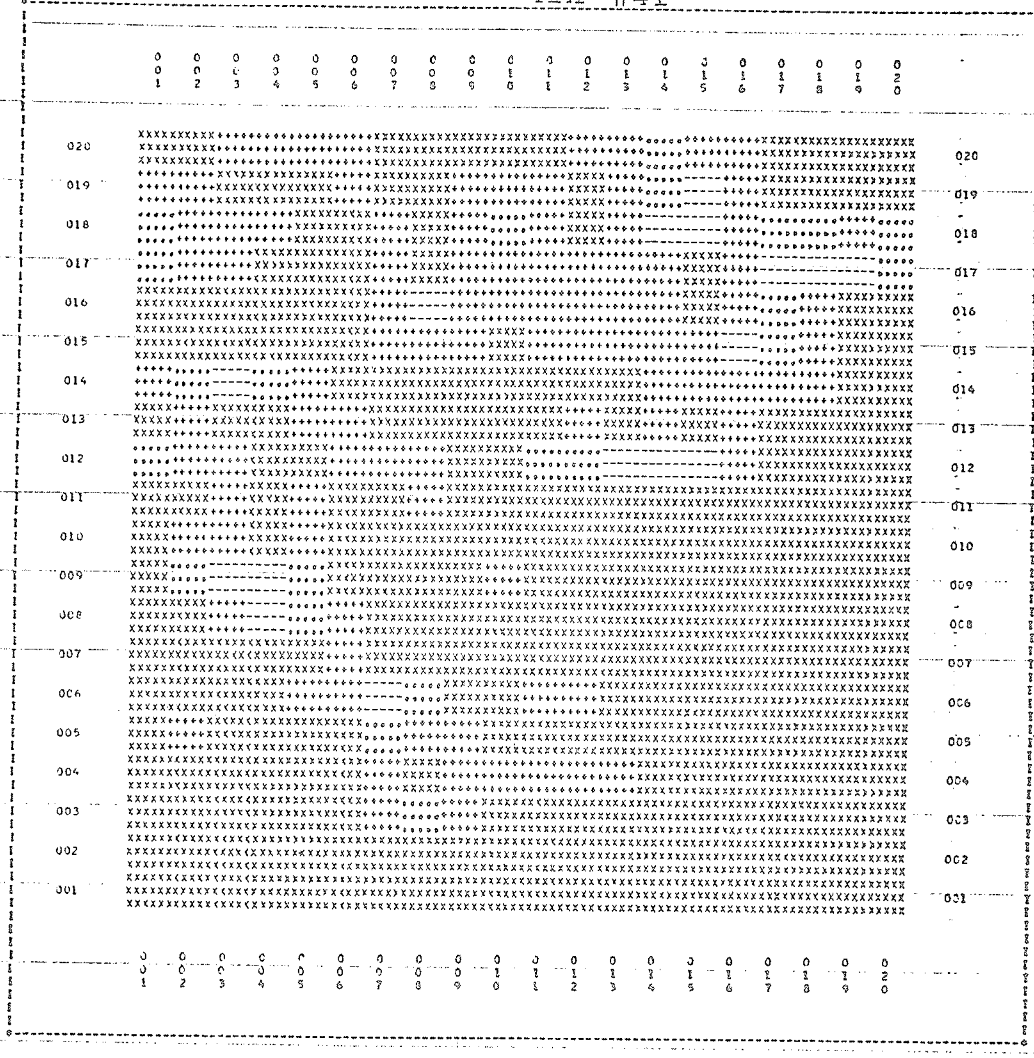
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		---------	ooooooooo	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	▓▓▓▓▓▓▓▓▓	▓▓▓▓▓▓▓▓▓	▓▓▓▓▓▓▓▓▓	▓▓▓▓▓▓▓▓▓	
FREQUENCY	0	0	0	0	0	24	198	174	0	0	0	0

1824

MAP 11,SHEET 1,DATA SET 1

MAP #41



1825

SOLAR RADIATION - NOVEMBER 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 903.67 ST. DEV. = 1295.07

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.30	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

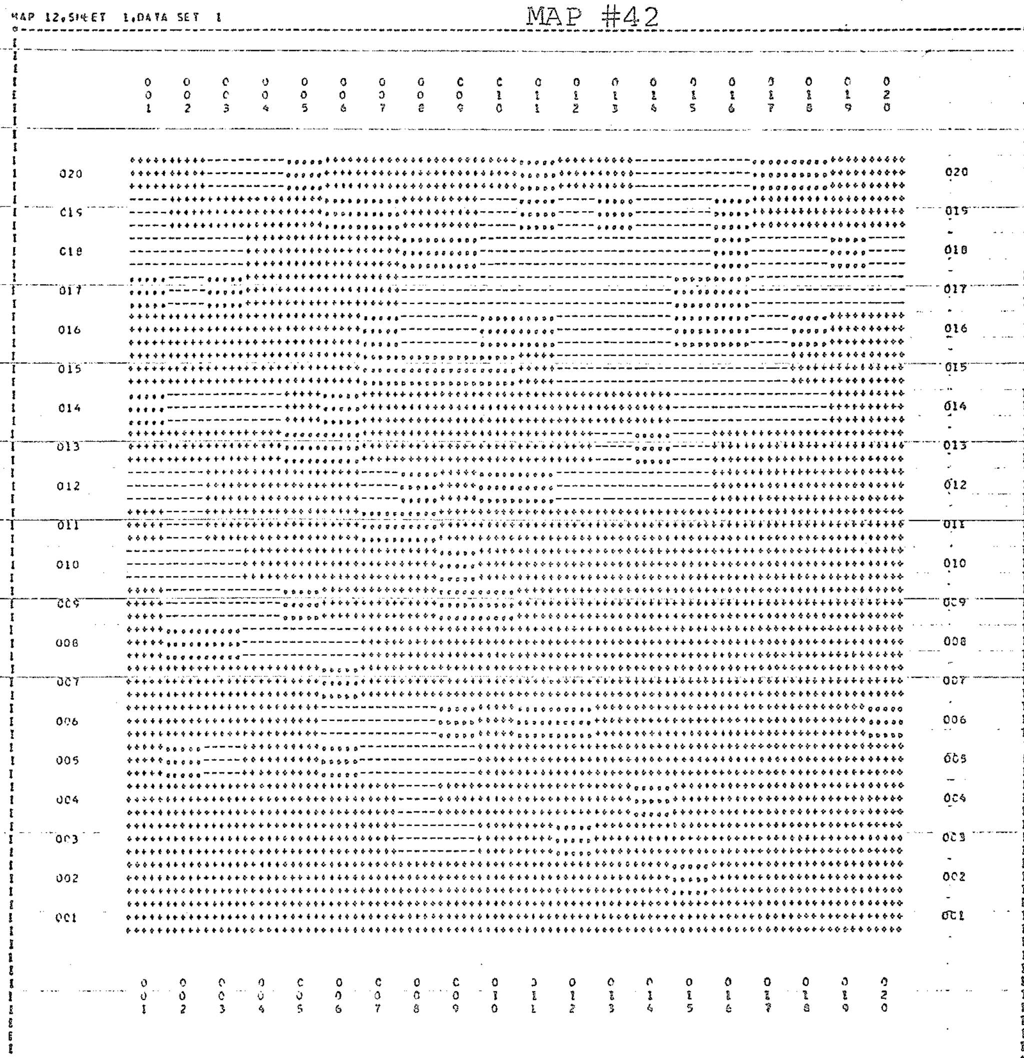
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	LOW VALUES 0	1	2	3	4	5	6	7	8	9	10	HIGH VALUES 11
SYMBOLS		---------	....	+++++++++	XXXXXXXXX	CCCCCCCCC	AAAAAAAAA					
FREQUENCY	0	16	22	97	265	0	0	0	0	0	0	0

MAP 12, SHEET 1, DATA SET 1

MAP #42



SOLAR RADIATION - DECEMBER 21

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 47.00 AND 2827.00 MEAN = 567.82 ST. DEV. = 801.02

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	47.00	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00
MAXIMUM	325.00	603.00	881.00	1159.00	1437.00	1715.00	1993.00	2271.00	2549.00	2827.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

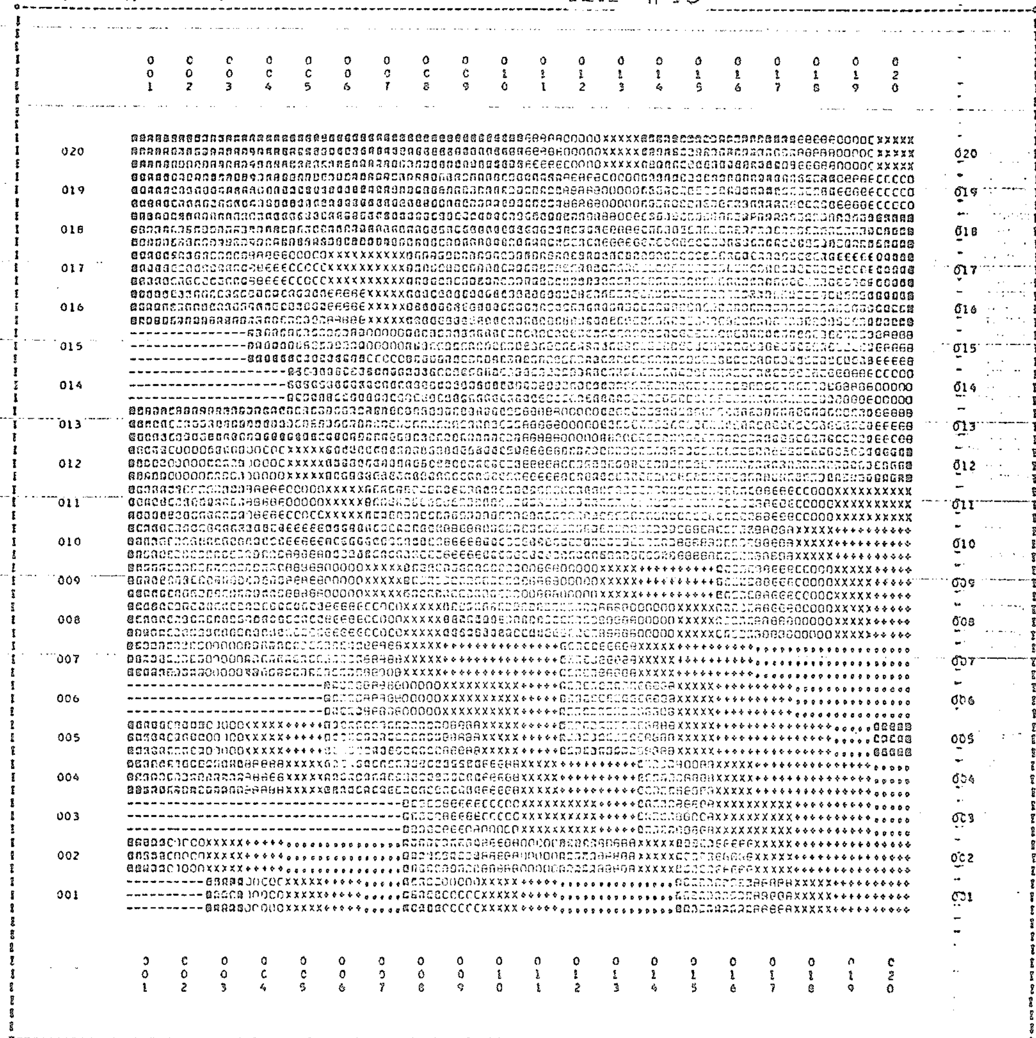
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0 (LOW VALUES)	1	2	3	4	5	6	7	8	9	10	11 (HIGH VALUES)
SYMBOLS		---------	•••••••••	+++++++++	XXXXXXXXX	OOOOOOOOO	AAAAAAAAA	[illegible]	[illegible]	[illegible]	[illegible]	
FREQUENCY	0	82	53	263	0	0	0	0	0	0	0	0

1827

MAP 1,SHEET 1,DATA SET 1

MAP #43



SHELTER - WIND DIRECTION - 270 DEGREES

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 1.00 MEAN = 0.70 ST. DEV. = 1.09

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
MAXIMUM	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

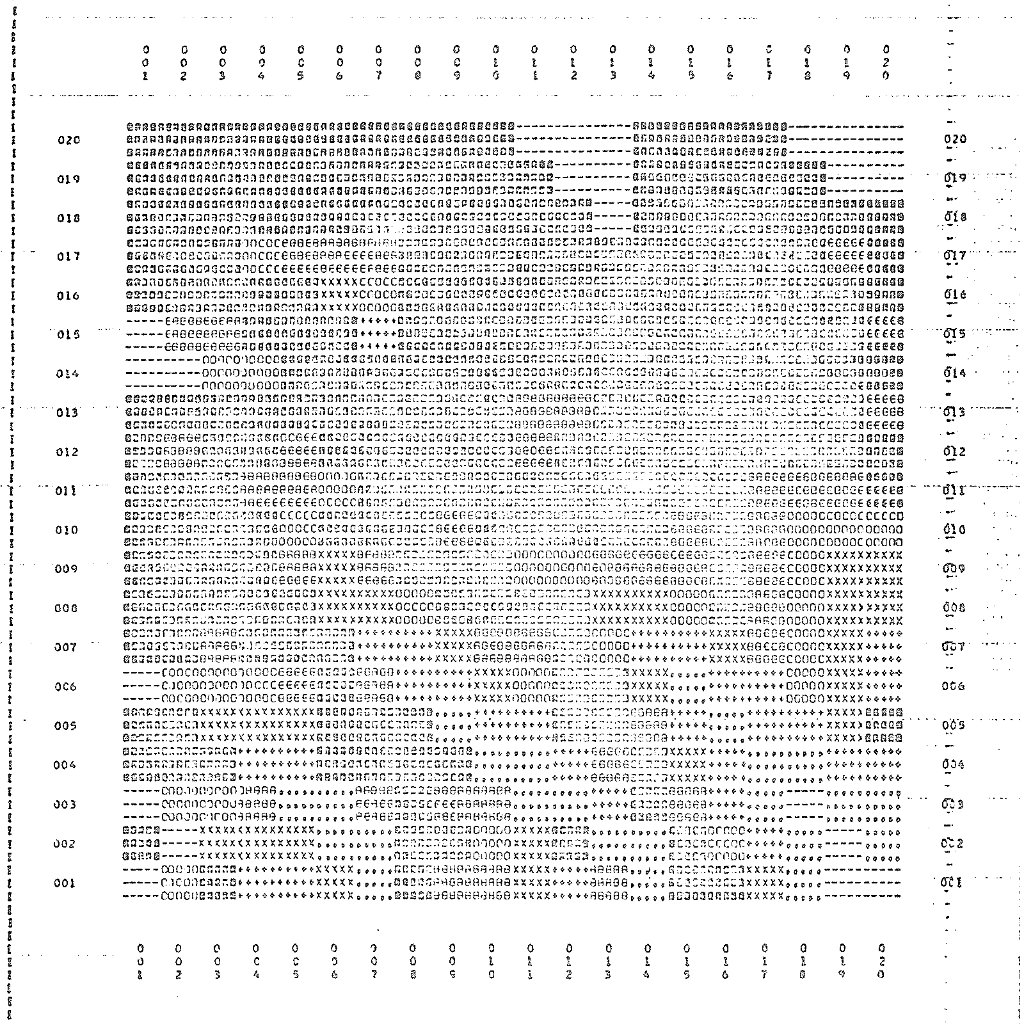
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	AAAAAAAAA	[illegible]	[illegible]	[illegible]	[illegible]
FREQUENCY	21	17	35	37	26	39	1	0	0	224

MAP 2,SHEET 1,DATA SET 1

MAP #44



SHELTER - WIND DIRECTION - 315 DEGREES

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 1.00 MEAN = 0.71 ST. DEV. = 1.06

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
MAXIMUM	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

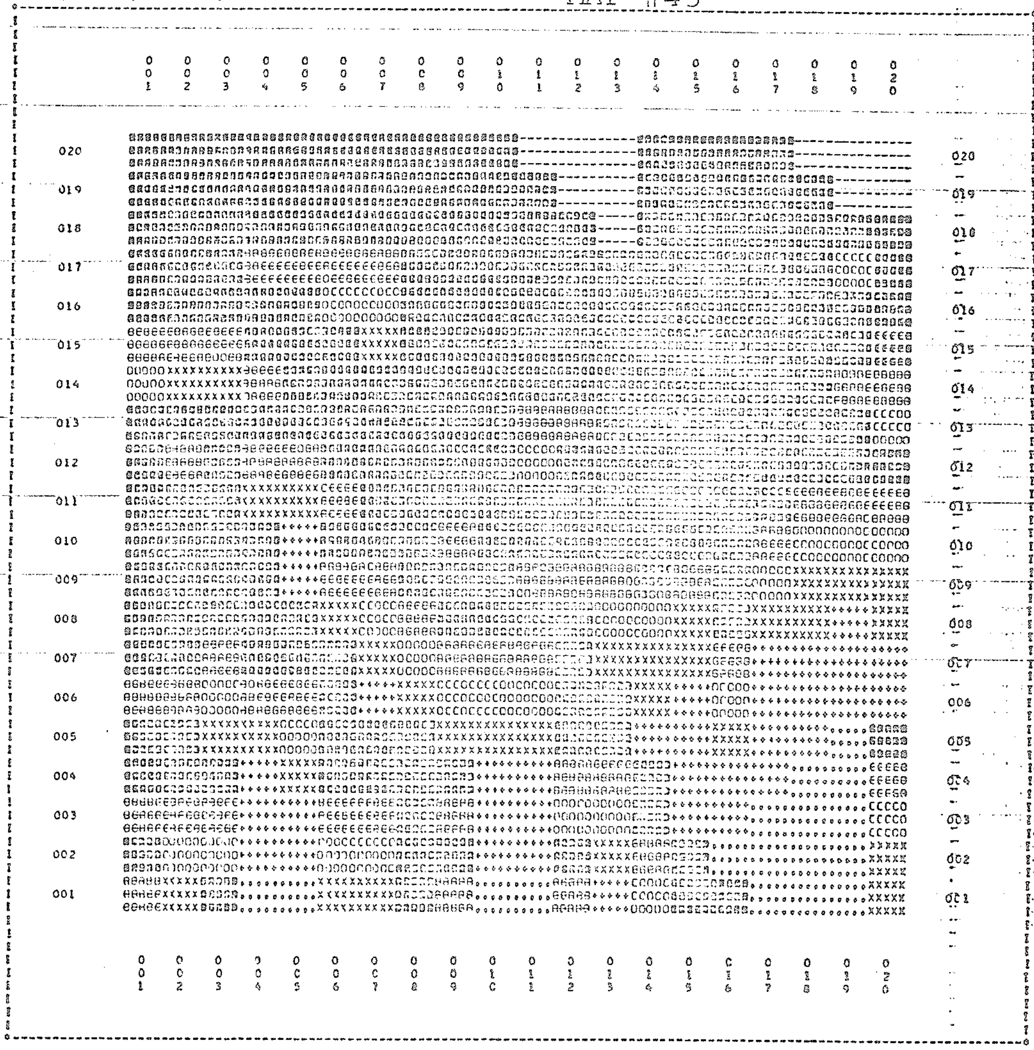
FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
FREQUENCY	22	23	28	28	27	43	4	1	0	226

1233

MAP 3,SHEET 1,DATA SET 1

MAP #45



SHELTER - WIND DIRECTION - 360 DEGREES

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 0.0 AND 1.00 MEAN = 0.72 ST. DEV. = 1.07

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
MAXIMUM	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

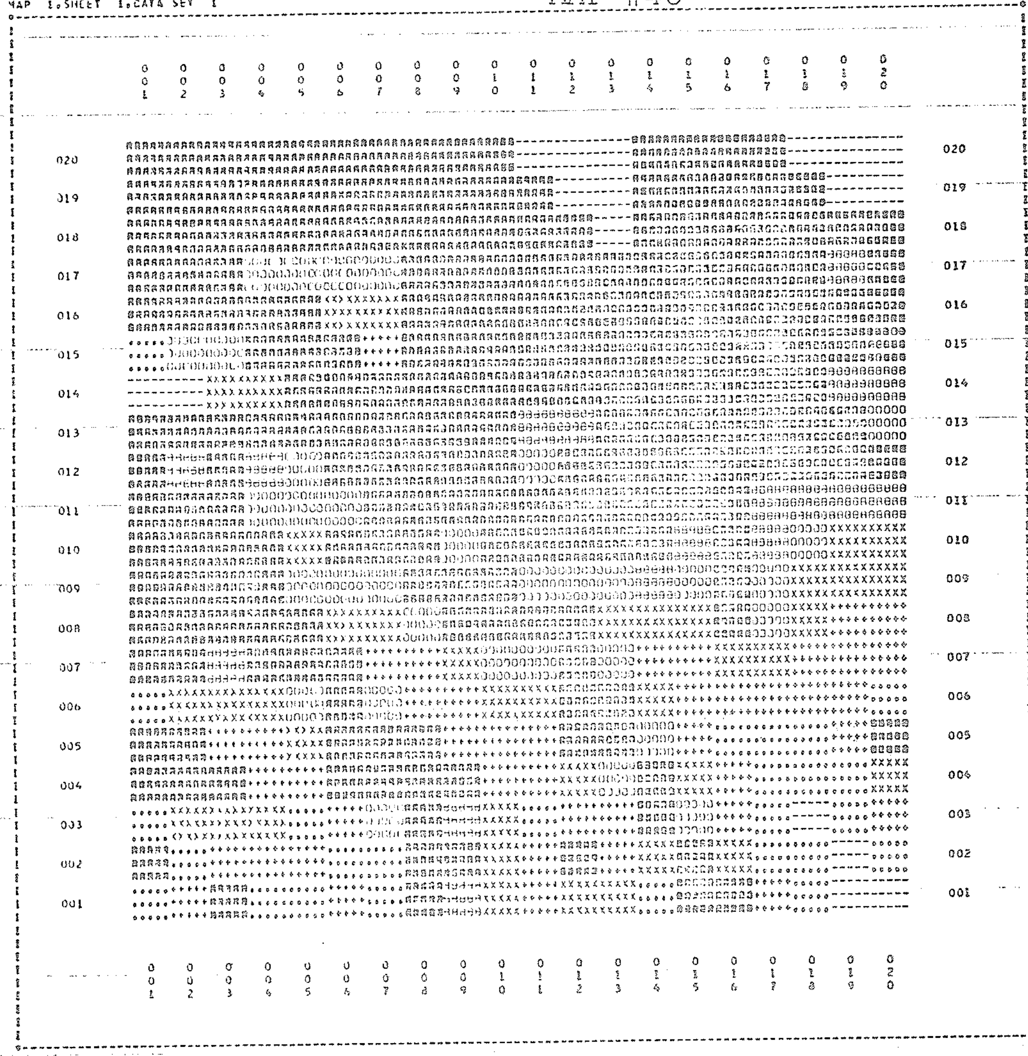
LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	'''''''''	+++++++++	XXXXXXXXX	OOOOOOOOO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FREQUENCY	11	17	34	32	28	90	4	0	0	226

4234

4235

MAP 1.SHEET 1.DATA SET 1

MAP #46



COMPOSITE SHELTER

A. OAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

DATA MAPPED IN 10 LEVELS BETWEEN EXTREME VALUES OF 0.32 AND 6.00 MEAN = 4.26 ST. DEV. = 6.36

ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

MINIMUM	0.32	0.89	1.46	2.02	2.59	3.16	3.73	4.30	4.86	5.43
MAXIMUM	0.89	1.46	2.02	2.59	3.16	3.73	4.30	4.86	5.43	6.00

PERCENTAGE OF TOTAL ABSOLUTE VALUE RANGE APPLYING TO EACH LEVEL

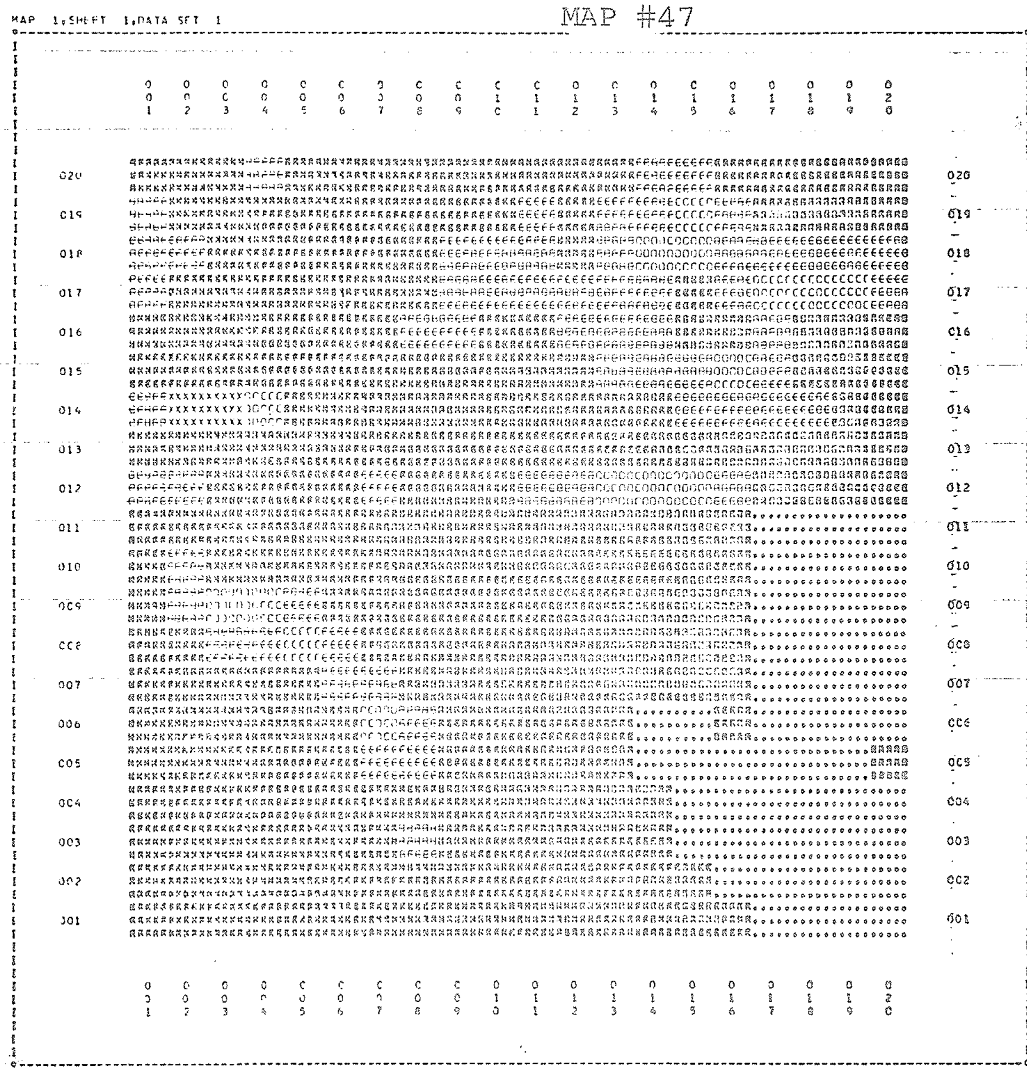
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00

FREQUENCY DISTRIBUTION OF DATA POINT VALUES IN EACH LEVEL

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	HHHHHHHHH	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ	ØØØØØØØØØ
FREQUENCY	17	26	45	39	33	17	1	0	0	224

MAP 1, SHEET 1, DATA SET 1

MAP #47



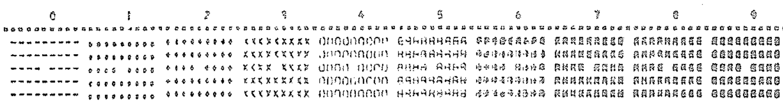
SITE SELECTION -- MODEL ONE

A. DAKIN, M. ARFE, 1972

UNIVERSITY OF MANITOBA

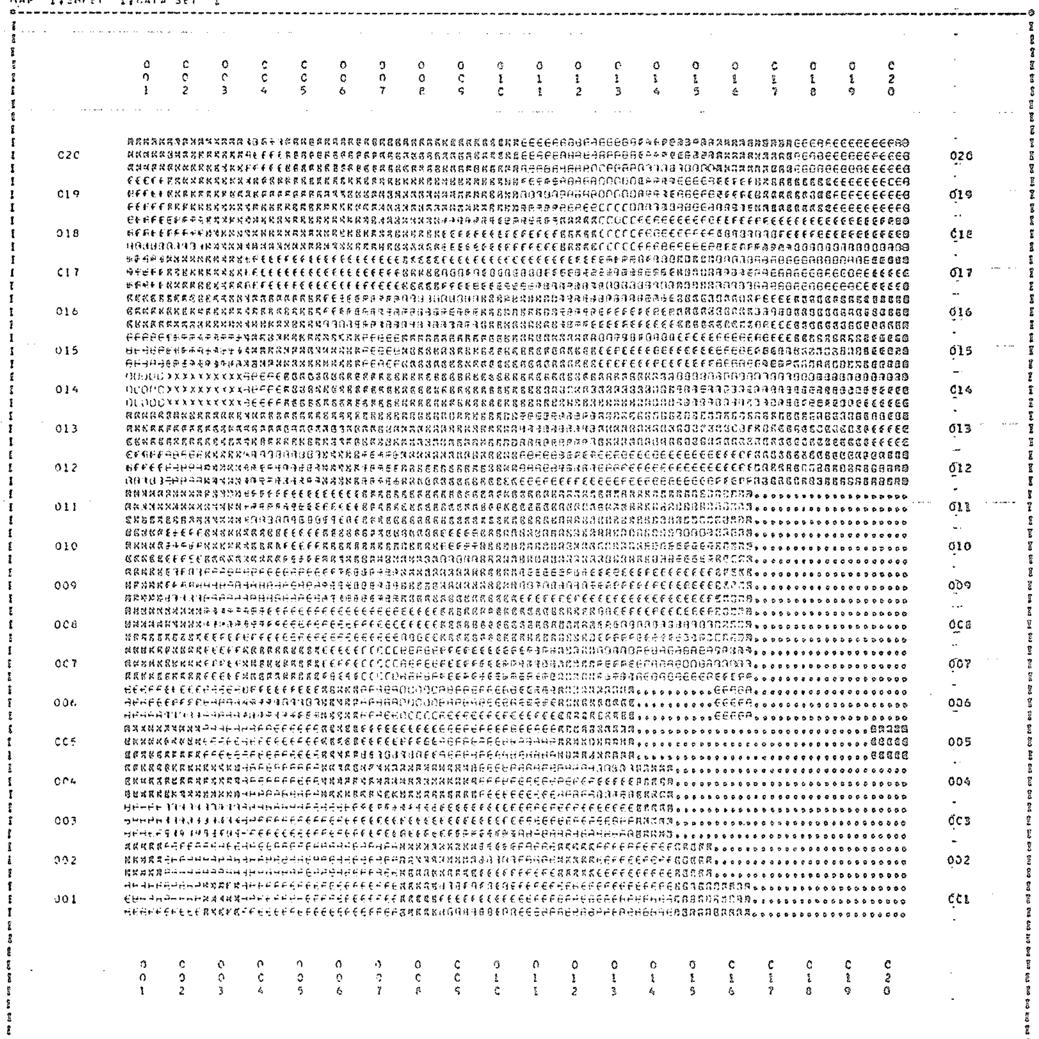
0= NULL CELL
1= POOR CELLS FOR DEVELOPMENT
2= POOR CELLS FOR DEVELOPMENT
3= POOR CELLS FOR DEVELOPMENT
4= MEDIUM CELLS FOR DEVELOPMENT
5= MEDIUM CELLS FOR DEVELOPMENT
6= MEDIUM CELLS FOR DEVELOPMENT
7= GOOD CELLS FOR DEVELOPMENT
8= GOOD CELLS FOR DEVELOPMENT
9= GOOD CELLS FOR DEVELOPMENT

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS										
FREQUENCY	0	53	0	2	15	61	0	268	1	0



MAP #48

MAP 1,SHEET 1,DATA SET 1



SITE SELECTION -- MOTEL INC

A. DAKIN, M. ARCH. 1972

UNIVERSITY OF MANITOBA

0= NULL CELL
1= POOR CELLS FOR DEVELOPMENT
2= POOR CELLS FOR DEVELOPMENT
3= POOR CELLS FOR DEVELOPMENT
4= MEDIUM CELLS FOR DEVELOPMENT
5= MEDIUM CELLS FOR DEVELOPMENT
6= MEDIUM CELLS FOR DEVELOPMENT
7= GOOD CELLS FOR DEVELOPMENT
8= GOOD CELLS FOR DEVELOPMENT
9= GOOD CELLS FOR DEVELOPMENT

LEVELS	0	1	2	3	4	5	6	7	8	9
SYMBOLS	---------	....	+++++++++	XXXXXXXXX	OOOOOOOOO	AAAAAAAAA	[illegible]	[illegible]	[illegible]	[illegible]
FREQUENCY	0	53	0	2	5	76	104	159	1	0

TABLES

INTRODUCTION TO INTERPRETING THE TABLES

Due to the nature of the print-out and the resulting reduction, the columns for the following tables are not labeled.

Tables 1 - 16 should be read from left to right, beginning with the first column as: Time (hour), Wall '1', Wall '2', Wall '3', Wall '4', Roof, Floor, Infiltration, and Net Hourly Total. This series of Tables represent the Net Heat Loss/ Gains; and should be read in conjunction with Chapter VII, Section 7.5. (increment rotation)

Tables 17 - 20 show the BTU's lost per day, per month, using the same rotation of the building. The BTU's shown with an 'M' represent the most loss, while the 'L' represents the least.

The following tables are the result of investigations for the Building Analysis.

TABLE #1

VALUES FOR DEC. 21 ST.

POLAR DECLINATION = -23.4500 DEGREES

WALL SURFACE ONE @180.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3666.	1869.	3048.	1582.	7505.	12128.	7883.	37632.
10	845.	1852.	3007.	1494.	7172.	12128.	7883.	34383.
11	-1044.	1843.	2985.	1498.	6832.	12128.	7883.	32125.
12	-1680.	1840.	2979.	1575.	6709.	12128.	7883.	31436.
13	-1044.	1625.	2985.	1576.	6832.	12128.	7883.	31985.
14	845.	1573.	3007.	1579.	7172.	12128.	7883.	34133.
15	3666.	1863.	3048.	1584.	7505.	12128.	7883.	37677.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.

TOTAL HEAT LOSS/GAIN 880335.

MAX= 905453. SOLAR= 2.72 INFIL= 20.90

TABLE #2

1930

WALL SURFACE ONE @202.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3684.	1869.	3048.	1581.	7505.	12128.	7883.	37699.
10	1694.	1852.	3007.	1440.	7172.	12128.	7883.	35177.
11	-106.	1843.	2985.	1403.	6832.	12128.	7883.	32969.
12	-1287.	1840.	2979.	1461.	6709.	12128.	7883.	31714.
13	-1208.	1843.	2985.	1547.	6832.	12128.	7883.	32011.
14	488.	1821.	3007.	1579.	7172.	12128.	7883.	34079.
15	3656.	1867.	3048.	1584.	7505.	12128.	7883.	37671.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								882678.

MAX= 905453. SOLAR= 2.52 INFIL= 20.90

TABLE #3

WALL SURFACE ONE @225.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3703.	1869.	3048.	1581.	7505.	12128.	7883.	37718.
10	2951.	1852.	3007.	1407.	7172.	12128.	7883.	36401.
11	1498.	1843.	2985.	1335.	6832.	12128.	7883.	34505.
12	-53.	1840.	2979.	1364.	6709.	12128.	7883.	32851.
13	-643.	1843.	2985.	1445.	6832.	12128.	7883.	32473.
14	601.	1852.	3007.	1526.	7172.	12128.	7883.	34171.
15	3654.	1869.	3048.	1583.	7505.	12128.	7883.	37671.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								887148.

MAX= 905453. SOLAR= 2.02 INFIL= 20.90

TABLE #4

WALL SURFACE ONE 3247.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1869.	3042.	1581.	7505.	12128.	7883.	37713.
10	3622.	1852.	2945.	1400.	7172.	12128.	7883.	37003.
11	3397.	1843.	2985.	1303.	6832.	12128.	7883.	36372.
12	1886.	1840.	2979.	1299.	6709.	12128.	7883.	34725.
13	663.	1843.	2985.	1363.	6832.	12128.	7883.	33598.
14	1222.	1852.	3007.	1465.	7172.	12128.	7383.	34730.
15	3659.	1869.	3048.	1582.	7505.	12128.	7383.	37675.
16	3706.	1869.	3049.	1584.	7508.	12128.	7383.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								893274.

MAX= 905453. SOLAR= 1.35 INFIL= 20.90

TABLE #5

WALL SURFACE ONE @270.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7383.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7383.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1869.	3032.	1581.	7505.	12128.	7883.	37704.
10	3622.	1852.	2343.	1420.	7172.	12128.	7883.	36422.
11	3578.	1843.	2483.	1313.	6832.	12128.	7883.	36060.
12	3565.	1840.	2979.	1276.	6709.	12128.	7883.	36382.
13	2590.	1843.	2985.	1313.	6832.	12128.	7883.	35575.
14	2279.	1852.	3007.	1420.	7172.	12128.	7883.	35742.
15	3673.	1869.	3048.	1581.	7505.	12128.	7883.	37688.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								896930.

MAX= 905453. SOLAR= 0.94 INFIL= 20.90

TABLE #6

WALL SURFACE ONE @292.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1869.	3026.	1582.	7505.	12128.	7883.	37699.
10	3622.	1852.	1832.	1465.	7172.	12128.	7683.	35955.
11	3578.	1843.	1555.	1363.	6832.	12128.	7883.	35181.
12	3565.	1840.	2141.	1299.	6709.	12128.	7883.	35567.
13	3578.	1843.	2881.	1303.	6832.	12128.	7883.	36448.
14	3516.	1852.	3007.	1400.	7172.	12128.	7883.	36959.
15	3693.	1869.	3048.	1581.	7505.	12128.	7883.	37707.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7383.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								896874.

MAX= 905453. SOLAR= 0.95 INFIL= 20.90

TABLE #7

WALL SURFACE ONE @315.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1869.	3023.	1583.	7505.	12128.	7883.	37697.
10	3622.	1852.	1531.	1526.	7172.	12128.	7383.	35715.
11	3578.	1843.	921.	1445.	6832.	12128.	7883.	34630.
12	3565.	1340.	1206.	1364.	6709.	12128.	7883.	34696.
13	3578.	1843.	1958.	1335.	6832.	12128.	7883.	35557.
14	3622.	1852.	2666.	1407.	7172.	12128.	7883.	36731.
15	3705.	1869.	3047.	1581.	7505.	12128.	7883.	37719.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.

TOTAL HEAT LOSS/GAIN

894103.

MAX= 905453. SOLAR= 1.25 INFIL= 20.90

TABLE #8

WALL SURFACE ONE @337.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1867.	3024.	1584.	7505.	12128.	7883.	37696.
10	3622.	1821.	1475.	1579.	7172.	12128.	7883.	35681.
11	3578.	1843.	646.	1547.	6832.	12128.	7883.	34457.
12	3565.	1840.	607.	1461.	6709.	12128.	7883.	34194.
13	3578.	1843.	1182.	1403.	6832.	12128.	7883.	34849.
14	3622.	1852.	2061.	1440.	7172.	12128.	7883.	36159.
15	3705.	1869.	3038.	1581.	7505.	12128.	7883.	37709.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								892103.

MAX= 905453. SOLAR= 1.47 INFIL= 20.90

TABLE #9

WALL SURFACE ONE @ 0.0 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1863.	3029.	1584.	7505.	12128.	7883.	37697.
10	3622.	1573.	1650.	1579.	7172.	12128.	7883.	35608.
11	3578.	1625.	726.	1576.	6832.	12128.	7883.	34348.
12	3565.	1840.	415.	1575.	6709.	12128.	7883.	34117.
13	3578.	1843.	726.	1498.	6832.	12128.	7883.	34438.
14	3622.	1852.	1650.	1494.	7172.	12128.	7883.	35802.
15	3705.	1869.	3029.	1582.	7505.	12128.	7883.	37702.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								891119.

MAX= 905453. SOLAR= 1.58 INFIL= 20.90

TABLE #10

WALL SURFACE ONE @ 22.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1860.	3038.	1584.	7505.	12128.	7883.	37703.
10	3622.	1364.	2061.	1579.	7172.	12128.	7883.	35810.
11	3578.	1247.	1182.	1576.	6832.	12128.	7883.	34426.
12	3565.	1485.	607.	1575.	6709.	12128.	7883.	33953.
13	3578.	1792.	646.	1576.	6832.	12128.	7883.	34434.
14	3622.	1852.	1475.	1561.	7172.	12128.	7883.	35694.
15	3705.	1869.	3024.	1583.	7505.	12128.	7883.	37698.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.

TOTAL HEAT LOSS/GAIN 891075.

MAX= 905453. SOLAR= 1.59 INFIL= 20.90

TABLE #11

WALL SURFACE ONE @ 45.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3705.	1859.	3047.	1584.	7505.	12128.	7883.	37711.
10	3622.	1240.	2666.	1579.	7172.	12128.	7883.	36291.
11	3578.	987.	1958.	1576.	6832.	12128.	7883.	34942.
12	3565.	1103.	1206.	1575.	6709.	12128.	7883.	34170.
13	3578.	1412.	921.	1576.	6832.	12128.	7883.	34330.
14	3622.	1705.	1531.	1579.	7172.	12128.	7883.	35620.
15	3705.	1869.	3023.	1584.	7505.	12128.	7883.	37697.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								892118.

MAX= 905453. SOLAR= 1.47 INFIL= 20.90

TABLE #12

WALL SURFACE ONE @ 67.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3693.	1859.	3048.	1584.	7505.	12128.	7883.	37700.
10	3516.	1217.	3007.	1579.	7172.	12128.	7883.	36502.
11	3578.	873.	2881.	1576.	6832.	12128.	7883.	35750.
12	3565.	857.	2141.	1575.	6709.	12128.	7883.	34960.
13	3578.	1094.	1555.	1576.	6832.	12128.	7883.	34645.
14	3622.	1458.	1832.	1579.	7172.	12128.	7883.	35675.
15	3705.	1865.	3026.	1584.	7505.	12128.	7883.	37696.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								894137.

MAX= 905453. SOLAR= 1.24 INFIL= 20.90

TABLE #13

WALL SURFACE ONE @ 90.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3673.	1861.	3048.	1584.	7505.	12128.	7883.	37682.
10	2279.	1289.	3007.	1579.	7172.	12128.	7883.	35338.
11	2590.	907.	2985.	1576.	6832.	12128.	7883.	34901.
12	3565.	777.	2979.	1575.	6709.	12128.	7883.	35618.
13	3578.	907.	2483.	1576.	6832.	12128.	7883.	35386.
14	3622.	1289.	2343.	1579.	7172.	12128.	7883.	36017.
15	3705.	1861.	3032.	1584.	7505.	12128.	7883.	37699.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								893999.

MAX= 905453. SOLAR= 1.27 INFIL= 20.90

TABLE #14

WALL SURFACE ONE 3112.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3659.	1865.	3048.	1584.	7505.	12128.	7883.	37672.
10	1222.	1458.	3007.	1579.	7172.	12128.	7883.	34450.
11	663.	1094.	2985.	1576.	6832.	12128.	7883.	33162.
12	1886.	857.	2979.	1575.	6709.	12128.	7883.	34018.
13	3397.	873.	2985.	1576.	6832.	12128.	7883.	35674.
14	3622.	1217.	2945.	1579.	7172.	12128.	7883.	36546.
15	3705.	1859.	3042.	1584.	7505.	12128.	7883.	37706.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								890587.

MAX= 905453. SOLAR= 1.64 INFIL= 20.90

TABLE #15

WALL SURFACE ONE @135.00 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3654.	1869.	3048.	1584.	7505.	12128.	7883.	37671.
10	601.	1705.	3007.	1579.	7172.	12128.	7883.	34075.
11	-643.	1412.	2985.	1576.	6832.	12128.	7883.	32173.
12	-53.	1103.	2979.	1575.	6709.	12128.	7883.	32325.
13	1498.	987.	2985.	1576.	6832.	12128.	7883.	33890.
14	2951.	1240.	3007.	1579.	7172.	12128.	7883.	35960.
15	3703.	1859.	3048.	1584.	7505.	12128.	7883.	37711.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								835163.

MAX= 905453. SOLAR= 2.24 INFIL= 20.90

TABLE #16

WALL SURFACE ONE @157.50 DEGREES

1	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
2	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
3	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
4	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
5	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
6	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
7	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
8	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
9	3656.	1869.	3048.	1583.	7505.	12128.	7883.	37673.
10	488.	1852.	3007.	1561.	7172.	12128.	7883.	34093.
11	-1208.	1792.	2985.	1576.	6832.	12128.	7883.	31948.
12	-1287.	1485.	2979.	1575.	6709.	12128.	7883.	31472.
13	-106.	1247.	2985.	1576.	6832.	12128.	7883.	32546.
14	1694.	1364.	3007.	1579.	7172.	12128.	7883.	34828.
15	3684.	1860.	3048.	1584.	7505.	12128.	7883.	37692.
16	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
17	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
18	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
19	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
20	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
21	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
22	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
23	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
24	3706.	1869.	3049.	1584.	7508.	12128.	7883.	37727.
TOTAL HEAT LOSS/GAIN								881650.

MAX= 905453. SOLAR= 2.63 INFIL= 20.90

HEAT LOSS TABLES

TABLE #17

The following tables show the orientation in degrees for the total building, wall '1' as shown; the numbers under the months shown are the BTU's lost per day.

WALL '1'	JANUARY	FEBRUARY	MARCH	APRIL
180	1002560 L	855115 L	715316 L	463342
202.5	1005560	860218	719121	461431
225	1012307	869107	722733	455769
247.5	1019713	874501	722685	451412
270	1024085	878858	725625	452592
292.5	1025294 M	883561	732059	458110
315	1022466	884573 M	739070	468226
337.5	1019344	880412	739249 M	475576
0 - 360	1017635	877299	736833	477794 M
22.5	1017752	877832	736581	473666
45	1019566	880161	734414	464680
67.5	1021364	877800	726314	454070
90	1019787	872532	719481	448456
112.5	1015783	868740	716940	447372 L
135	1009407	864694	718077	452223
157.5	1003969	857639	716453	459524

TABLE #18

WALL '1'	SEPTEMBER	OCTOBER	NOVEMBER
180	234001 L	380052 L	675892 L
202	237631	384814	678807
225	241204	393127	685349
247.5	241292	398147	692494
270	244057	402221	696713
292.5	249937	406610	697910 M
315	256256 M	407560 M	695195
337.5	256188	403665	692165
0	91768 M	400761	690503
22.5	253728	401255	690620
45	251966	403443	692385
67.5	244640	401233	694101
90	238378	396316	692548
112.5	235995	392769	688685
135	236914	389009	682539
157.5	235171	382404	677262

TABLE #19

WALL '1'	MAY	JUNE	JULY	AUGUST
180	250880	108697	32310	78543
202	245452	102453	26915	76604
225	234085	89925	15769	71027
247.5	227450	82369	9283	66888
270	226852	80940	8629	67930
292.5	231287	84849	12837	73043
315	241515	94844	22673	82521
337.5	253450	107635	34327	89590
0	258568 M	113321 M	39372 M	91768 M
22.5	252357	106927	33314	87837
45	239400	93444	20708	74249
67.5	228998	83365	10716	69333
90	224645 L	79607	6601 L	64145
112.5	225162	80885 L	7163	63178 L
135	231970	88525	13805	67756
157.5	244359	101746	25903	74852

TABLE #20

WALL '1'	DECEMBER	ANNUAL
180	880835 L	5677540
202.5	882678	5681682
225	887148	5677543
247.5	893274	5679504
270	896930 M	5705425
292.5	896874	5752367
315	894103	5808999
337.5	892103	5843695
0	891119	5848853 M
22.5	891075	5822938
45	892118	5771528
67.5	894187	5706115
90	893999	5656488
112.5	890587	5633251 L
135	885163	5640074
157.5	881650	5660926

APPENDICES

APPENDIX 'A'

ALTITUDE:

The solar ALTITUDE can be calculated from the following equation:

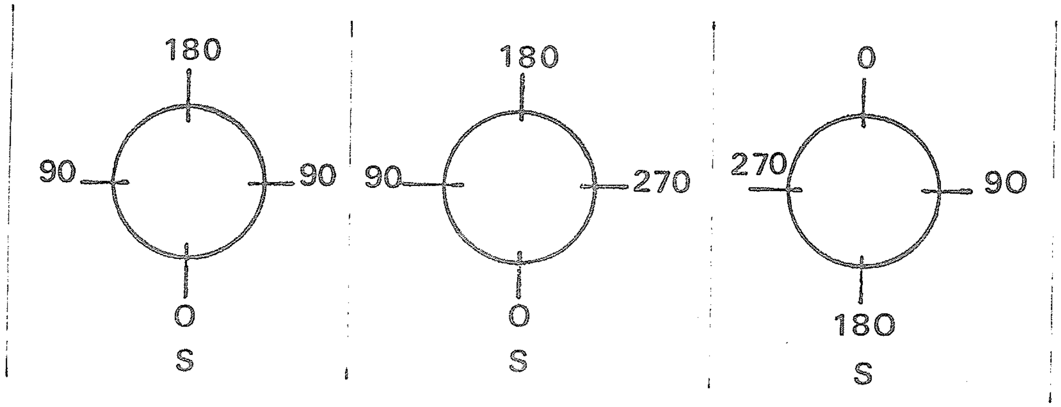
$$\text{Sin(ALT)} = \text{Cos(L) Cos(D) Cos(H)} + \text{Sin(L) Sin(D)} \quad (1)$$

where:

ALT = ALTITUDE
D = Polar Declination
L = Latitude
H = Hour Angle

The sources consulted agree with the basic equation, but, disagree on the derivation of the 'H' factor. TIME SAVER STANDARDS, page 80, describe 'H' as being the number of hours before or after 12:00 noon times 15^{o} , where noon is equal to 0^{o}. ASHRAE also uses this convention. The ECONOMICS OF SENSIBLE HEAT CONTROL describes 'H' as the number of hours times 15^{o} measured westward from 12:00 noon, where noon is equal to 0^{o}.

The method chosen for this study is one described in BETTER BUILDING REPORT #6, page 7, where all time angles are measured from solar midnight through a full 360^{o}. See figure A-1 below.



TIME SAVER STANDARDS

ECONOMICS OF SENSIBLE HEAT CONTROL

DEGELMAN

figure A-1

The general equation for the calculation of the Solar ALTITUDE now becomes:

$$\text{Sin(ALT)} = \text{Sin(D) Sin(L)} - \text{Cos(D) Cos(L) Cos}(\pi T/12) \quad (2)$$

The major change in this equation from the other cited sources is that, the term ($\pi T/12$) has replaced the 'H' factor. This is a result of using the 360^{o} measurement of the time angle.

<u>AZIMUTH</u>:

The general form of the equation for calculating the solar AZIMUTH is as follows:

$$\mathrm{Sin(AZ)} = \frac{\mathrm{Cos(D)\ Sin(H)}}{\mathrm{Cos(ALT)}} \qquad (3)$$

The sources cited agree with this form of the equation, with the exception of BETTER BUILDING REPORT #6. The equation now becomes:

$$\mathrm{Cos(AZ)} = \frac{\mathrm{Sin(L)\ Cos(D)\ Cos(\ T/12) + Cos(L)\ Cos(D)}}{\mathrm{Cos(ALT)}} \qquad (4)$$

SUNRISE AND SUNSET:

As sunrise and sunset occur when solar ALTITUDE is equal to 0°, the equation for the sunrise and sunset times is:

$$\mathrm{Cos(T)} = -\mathrm{Tan(L)\ Tan(D)} \qquad (5)$$

The equation for the Solar AZIMUTH at sunrise and sunset is:

$$\mathrm{Cos(AZ)} = \mathrm{Sin(D)\ \ 1/Cos(L)} \qquad (6)$$

DIRECT SOLAR RADIATION:

The equation for determining the direct component of solar radiation has the following general form:

$$I_{DN} = I_o \, e^{-a/\mathrm{Cos}(\theta_Z)} \qquad (7)$$

where:

I_{DN} = the radiation falling on a surface perpendicular to the sun's rays

I_o = apparent solar constant

a = atmospheric extinction co-efficient

θ_z = zenith angle

> " I_o is a nearly constant value known as the 'apparent solar constant'. This term is created by a mathematical concept by extrapolating the atmospheric attenuation to zero. In reality, I_o has a value about 85% of the true solar constant."
>
> (8)

The apparent solar constant (I_o) has various forms of measurement, some of which include:

1.98 langleys/minute (9)

2.00 ($\pm$2%) calories/centimeter^2/minute (10)

442 BTU/hour/foot^2 (11)

375 BTU/hour/foot^2 (12)

The term 'a' in the equation is denoted as the atmospheric extinction co-efficient. The larger the value of 'a', the less the solar radiation intensity will be that reaches the earth. (13)

The equation and variables chosen for the study are the ones outlined in NRC 9528 by Stephenson.

This equation for the direct beam radiation now becomes:

$$I_{DN} = \frac{A}{e(B/\sin(ALT))} \qquad (14)$$

DIFFUSE SOLAR RADIATION

The radiation from a cloudless sky falling on a horizontal surface can be approximated by:

$$I_{dH} = C \cdot I_{DN} \qquad (15)$$

where:

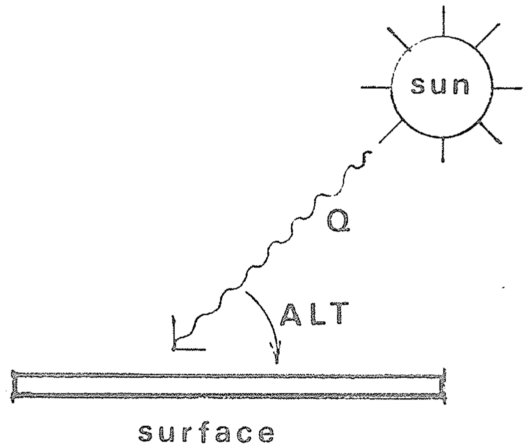
C varies with season and dust content of the air (See Table I)

The equations used for calculating the radiation on surfaces are to be found in this section. The variables used in the equations are as follows:

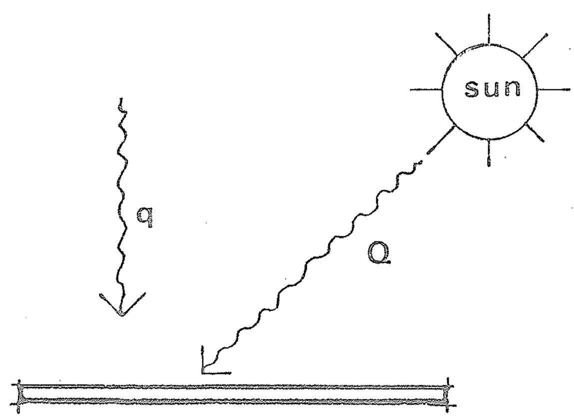
Q	=	direct beam radiation
q	=	sky diffuse radiation
I_{DN}	=	direct normal radiation
I_{DH}	=	direct radiation on horizontal surfaces
s	=	slope surface
h	=	horizontal surface
v	=	vertical surface

SOLAR RADIATION ON SURFACES

1) Horizontal:



$$Q_h = I_{DN} \times (\text{Sin (ALT)}) \qquad (16)$$



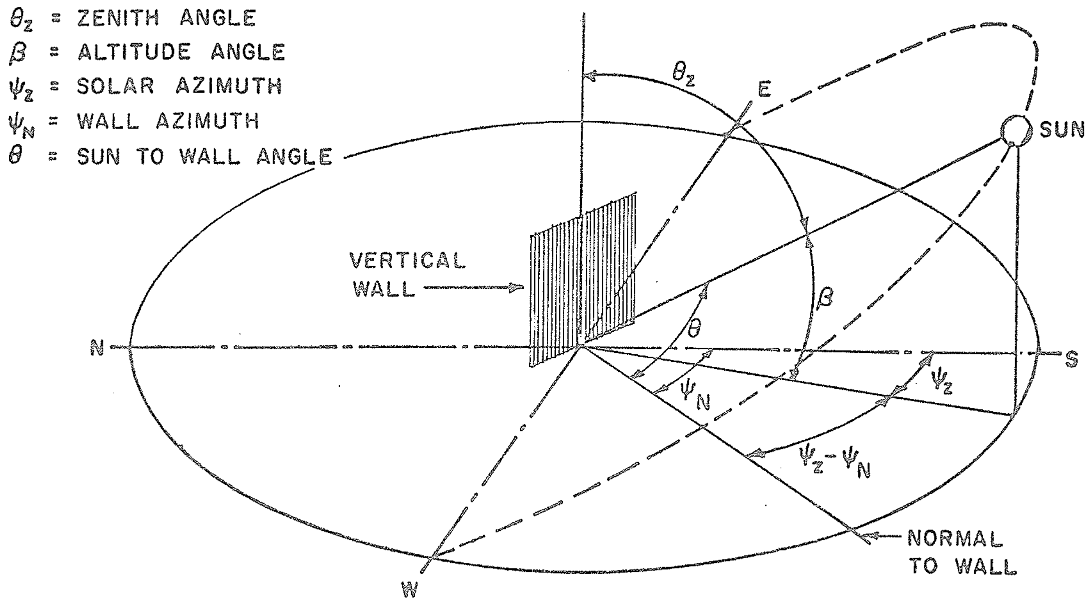
$$qh = I_{DN} \times (C + \text{Sin(ALT)}) \qquad (17)$$

Where: C is a dimension less constant

Total Radiation on a Horizontal Surface

$$I_h = Q_h + qh \qquad (18)$$

2) Sloped:



Angles Between Sun and a Vertical Wall

figure 1

WAZ = Wall Azimuth (Azimuth of normal to surface)

AZ = Solar Azimuth

= $|WAZ - AZ|$

IF $\gamma > 90^{\circ}$, the surface is in Shade

K = Angle of the Surface from Horizontal

INCIDENT ANGLE:

$$\text{Cos}\ \theta = \text{Cos(ALT)}\ \text{Cos}(\gamma)\ \text{Sin(K)} + \text{Sin(AL)}\ \text{Cos(K)} \qquad (19)$$

$$Q_s = I_{DN} \times \text{Cos}\ \theta \qquad (20)$$

IF Surface Horizontal (0^o)

$$Q_h = I_{DN} \times \text{Sin(ALT)} \qquad (21)$$

IF Surface Vertical (90^o)

$$Q_v = I_{DN} \times \text{Cos(ALT)} \times \text{Cos}(\gamma) \qquad (22)$$

DIFFUSE RADIATION ON SLOPE:

F_{sg} = Factor from surface to ground

F_{sg} = $(1-\text{Cos(K)}) / 2$

F_{ss} = Factor from surface to sky

F_{ss} = $1 - F_{sg}$

qs = $C \times I_{DN} \times F_{ss}$

(23)

TABLE I

Data for Calculation of Solar Radiation Intensity

Date	δ Degrees	A $\frac{BTU}{hr\ ft^2}$	B Air Mass^{-1}	C Dimensionless
Jan 21	-20.0	390	0.142	0.058
Feb 21	-10.8	385	0.144	0.060
Mar 21	0.0	376	0.156	0.071
Apr 21	11.6	360	0.180	0.097
May 21	20.0	350	0.196	0.121
June 21	23.45	345	0.205	0.134
July 21	20.6	344	0.207	0.136
Aug 21	12.3	351	0.201	0.122
Sept 21	0.0	365	0.177	0.092
Oct 21	-10.5	378	0.160	0.073
Nov 21	-19.8	387	0.149	0.063
Dec 21	-23.45	391	0.142	0.057

STEPHENSON, D.G.; Tables of Solar Altitude, Azimuth, Intensity and Heat Gain Factors for Latitudes from 43 to 55 Degrees North, National Research Council, Ottawa, April, 1967, page 10.

REFERENCES

1) ASHRAE; Handbook of Fundamentals, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1967, page 475.

2) DEGELMAN, L.O.; The Development of a Mathematical Model for Predicting the Solar Heat Gains Through Building Walls and Roofs, Better Building Report No. 6, The Pennsylvania State University, Institute for Building Research, June, 1966, page 9.

3) ASHRAE; Handbook of Fundamentals, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, 1967, page 475.

4) DEGELMAN, L.O.; The Development of a Mathematical Model for Predicting the Solar Heat Gains Through Building Walls and Roofs, Better Building Report No. 6, The Pennsylvania State University, Institute for Building Research, June, 1966, page 10.

5) ______, Time Saver Standards; A Handbook of Architectural Design, McGraw Hill Book Company, New York, 1966, page 80.

6) IBID; page 80.

7) DEGELMAN, L.O.; The Development of a Mathematical Model for Predicting the Solar Heat Gains Through Building Walls and Roofs, Better Building Report No. 6, The Pennsylvania S ate University, Institute for Building Research, June, 1966, page 14.

8) IBID; page 14

9) WILSON, R.G.; Topographic Influences on a Forest Microclimate, McGill University, Department of Geography, September, 1970, page 3.

10) GEIGER, R; The Climate Near the Ground, Harvard University Press, 1965, page 6.

11) DEGELMAN, L.O.; The Development of a Mathematical Model for Predicting the Solar Heat Gains Through Building Walls and Roofs, Better Building Report No. 6, The Pennsylvania State University, Institute for Building Research, June, 1966, page 17.

12) IBID, page 17.

13) IBID, page 14.

14) STEPHENSON, D.G.; Tables of Solar Altitude, Azimuth, Intensity and Heat Gain Factors for Latitudes from 43 to 55 Degrees North, National Research Council, Ottawa, April, 1967, page 2.

15) IBID; page 5

16) ASHRAE; Handbook of Fundamentals, American Society of Heating, Refrigeration, and Air-Conditioning, 1967, page 476.

17) IBID; page 476

18) WILSON, R.G.; <u>Topographic Influences on a Forest Microclimate</u>, McGill University, Department of Geography, Septemebr, 1970, page 3.

19) ASHRAE; <u>Handbook of Fundamentals, American Society of Heating, Refrigeration, and Air-Conditioning Engineers</u>, 1967, page 475.

20) IBID; page 475

21) IBID; page 476

22) IBID; page 476

23) IBID; page 476

FIGURES

1) DEGELMAN, L.O.; <u>The Development of a Mathematical Model for Predicting the Solar Heat Gains Through Building Walls and Roofs</u>, Better Building Report No. 6, Pennsylvania State University, Institute for Building Research, June, 1966, page 22.

APPENDIX 'B'

TOPOGRAPHIC CODING:

The available data on the site topography was in the form of a 1" = 400'-0" scale topographic map, having 5'-0" interpolated contours.

Elevations of cells can be approximated by setting the elevation of the cell equal to the elevation found at the centre of the cell. However, there are some complications in interpreting the slopes and slope-orientations using the cell centre elevation. It is difficult to conceive of slopes and slope-orientations when the cell for which they are to be found, also contains the elevation from which they are to be derived. Therefore, corner elevations are used to determine cell slopes and slope-orientations.

To code the corner elevations, a grid of the established cell size , but containing one more row and column is superimposed on the existing grid on the topographic map. This larger grid is shifted one half cell horizontally and vertically so that the intersections of the grid lines on the topographic map are in effect the centre points of this new, larger, superimposed grid. This large grid, then, provides the corner elevations for the chosen map grid. See figure 1.

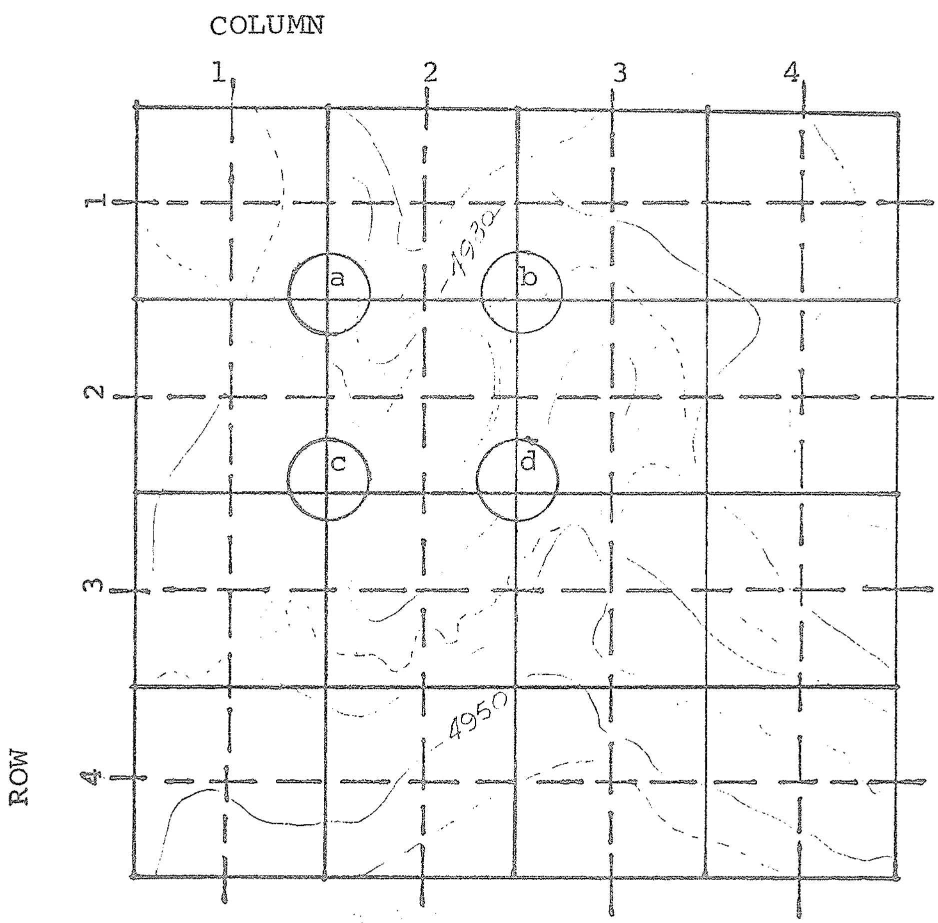


figure 1

As indicated in the above figure, the solid lines represent the chosen grid for coding the site data; the dotted line, the shifted grid used to record the corner point elevations. It can be seen that if the elevations at the points indicated 'a', 'b', 'c', 'd', are plotted on the dotted grid, they are in effect the corner points of the cell found at the intersection of the second column and second row of the mapping grid.

When the corner points are defined in this manner, it becomes a simple matter to determine the slope and slope-orientations for each cell.

```
$JOB    WATFIV
        REAL SLP(20,20),ORI(20,20),ELEV(20,20),P(3,3)
        INTEGER MTOPO(21,21)
        INTEGER UNITA/5/,UNITB/6/,UNITC/3/
        R=.0174532
C****   READ FORMATS
100     FORMAT(2I3)
150     FORMAT(F15.6)
200     FORMAT(3X,21I3)
C****   WRITE FORMATS
300     FORMAT(' ',21I4)
400     FORMAT(' ',20F5.0)
500     FORMAT(20F4.0)
600     FORMAT('1',' ')
        READ(5,100) M,N
        READ(5,150) SCALE
        WRITE(6,600)
        DO 10 I=1,M
        READ(UNITA,200) (MTOPO(I,J),J=1,N)
        WRITE(UNITB,300) (MTOPO(I,J),J=1,N)
10      CONTINUE
        M1=M-1
        N1=N-1
        CALL STUP(M,N,M1,N1,R,SCALE,P,MTOPO,SLP,ORI,ELEV)
        WRITE(6,600)
        DO 15 I=1,M1
        WRITE(UNITB,400) (ELEV(I,J),J=1,N1)
        WRITE(UNITC,500) (ELEV(I,J),J=1,N1)
15      CONTINUE
        WRITE(6,600)
        DO20 I=1,M1
        WRITE(UNITB,400) (SLP(I,J),J=1,N1)
        WRITE(UNITC,500) (SLP(I,J),J=1,N1)
20      CONTINUE
        WRITE(6,600)
        DO 30 I=1,M1
        WRITE(UNITB,400) (ORI(I,J),J=1,N1)
        WRITE(UNITC,500) (ORI(I,J),J=1,N1)
30      CONTINUE
        WRITE(6,600)
        STOP
        END
        SUBROUTINE PLN(R,P,SLP,ORI)
C****   THIS ROUTINE TAKES THREE(3) POINTS IN SPACE
C       AND DEVELOPS THE EQUATION OF THE PLANE
C       DESCRIBED BY THESE POINTS.
        REAL P(3,3)
        RKK=1.
        RX1=((P(2,2)-P(1,2))*(P(3,3)-P(1,3)))
        RX2=((P(2,3)-P(1,3))*(P(3,2)-P(1,2)))
        RY1=((P(2,3)-P(1,3))*(P(3,1)-P(1,1)))
        RY2=((P(2,1)-P(1,1))*(P(3,3)-P(1,3)))
        RZ1=((P(2,1)-P(1,1))*(P(3,2)-P(1,2)))
        RZ2=((P(2,2)-P(1,2))*(P(3,1)-P(1,1)))
```

```
      IF(RX2.GT.RX1) RKK=-1.
      RX=RKK*(RX1-RX2)
      RY=RKK*(RY1-RY2)
      RZ=RKK*(RZ1-RZ2)
      CON=(RX*P(1,1))+(RY*P(1,2))+(RZ*P(1,3))
      RT=((RX**2)+(RY**2)+(RZ**2))**.5
      IF(CON.LT.0.)GOTO10
      GOTO20
 10   RT=-1*RT
 20   A=RX/RT
      B=RY/RT
      C=RZ/RT
      D=CON/RT
      ANGL1=ARCOS(A)*57.295779
      ANGL2=ARCOS(B)*57.295779
      ANGL3=ARCOS(C)*57.295779
      SLP=ANGL3
      IF(RX.GT.0..AND.RY.EQ.0..AND.A.GT.0.)GOTO80
      IF(RX.GT.0..AND.RY.EQ.0..AND.A.LT.0.)GOTO90
      IF(RX.EQ.0..AND.RY.GT.0..AND.B.GT.0.)GOTO100
      IF(RX.EQ.0..AND.RY.LT.0..AND.B.LT.0.)GOTO110
      X=COS(ANGL1*R)*D
      Y=COS(ANGL2*R)*D
      H=COS((SLP)*R)*D
      IF(H.GT..000001)GOTO15
      XH=0.00
      GOTO25
 15   XH=ARSIN(X/H)*57.295779
 25   IF(X.GT.0..AND.Y.LT.0.)GOTO30
      IF(X.GT.0..AND.Y.GT.0.)GOTO40
      IF(X.LT.0..AND.Y.GT.0.)GOTO50
      IF(X.LT.0..AND.Y.LT.0.)GOTO60
 30   ORI=90.-XH
      GOTO120
 40   ORI=90.+XH
      GOTO120
 50   ORI=270.+XH
      GOTO120
 60   ORI=270-XH
      GOTO120
 80   ORI=90.
      GOTO120
 90   ORI=270.
      GOTO120
 100  ORI=180.
      GOTO120
 110  ORI=360.
      GOTO120
 120  RETURN
      END
      SUBROUTINE STUP(M,N,M1,N1,R,S,P,MM,S1,OR,EL)
C**** THIS ROUTINE COMPUTES THE AVERAGE SLOPE AND
C     SLOPE ORIENTATION OF EACH CELLS NORMAL.
C     REQUIRES THREE ELEVATIONS AND DISTANCES FROM AXIS.
```

```
      INTEGER MM(M,N)
      REAL P(3,3),S1(M1,N1),CR(M1,N1),EL(M1,N1)
      DO 10 I=1,M1
      DO 20 J=1,N1
      SS=0.
      OO=0.0
      K1=MM(I,J)
      K2=MM(I,J+1)
      K3=MM(I+1,J)
      K4=MM(I+1,J+1)
      EL(I,J)=(K1+K2+K3+K4)/4.
C**   CHECK FOR HORIZONTAL......FOUR PTS EQUAL
      IF(((K1.EQ.K2).AND.(K1.EQ.K3)).AND.(K1.EQ.K4))GOTO30
C*** CHECKS REQUIRED****
C**** CHECK FOR RIDGE CONDITION
      IF(K3.EQ.K2)GOTO40
      GOTO100
40    IF(K3.EQ.K1)GOTO50
      IF(K3.EQ.K4)GOTO60
C**** CHECK FOR OPPOSING RIDGE CONDITION
100   IF(K1.EQ.K4)GOTO120
      GOTO130
120   IF(K1.EQ.K3)GOTO70
      IF(K1.EQ.K2)GOTO80
130   CALL QUAD1(R,S,P,MM,M,N,I,J,SLP,ORI)
      SS=SS+SLP
      OO=OO+ORI
      CALL QUAD2(R,S,P,MM,M,N,I,J,SLP,ORI)
      SS=SS+SLP
      OO=OO+ORI
      CALL QUAD3(R,S,P,MM,M,N,I,J,SLP,ORI)
      SS=SS+SLP
      OO=OO+ORI
      CALL QUAD4(R,S,P,MM,M,N,I,J,SLP,ORI)
      SS=SS+SLP
      OO=OO+ORI
      S1(I,J)=SS/4.
      OR(I,J)=OO/4.
      GOTO20
50    CALL QUAD2(R,S,P,MM,M,N,I,J,SLP,ORI)
      GOTO90
60    CALL QUAD1(R,S,P,MM,M,N,I,J,SLP,ORI)
      GOTO90
70    CALL QUAD4(R,S,P,MM,M,N,I,J,SLP,ORI)
      GOTO90
80    CALL QUAD3(R,S,P,MM,M,N,I,J,SLP,ORI)
90    S1(I,J)=SLP
      OR(I,J)=ORI
      GOTO20
30    S1(I,J)=0.0
      OR(I,J)=0.0
20    CONTINUE
10    CONTINUE
      RETURN
```

```
      END
      SUBROUTINE QUAD1(R,S,P,MM,M,N,I,J,SLP,ORI)
      REAL P(3,3)
      INTEGER MM(M,N)
      P(1,1)=0.
      P(1,2)=0.
      P(1,3)=FLOAT(MM(I,J))
      P(2,1)=S
      P(2,2)=0.
      P(2,3)=FLOAT(MM(I,J+1))
      P(3,1)=0.
      P(3,2)=S
      P(3,3)=FLOAT(MM(I+1,J))
      CALL PLN(R,P,SLP,ORI)
      RETURN
      END
      SUBROUTINE QUAD2(R,S,P,MM,M,N,I,J,SLP,ORI)
      REAL P(3,3)
      INTEGER MM(M,N)
      P(1,1)=0.
      P(1,2)=S
      P(1,3)=FLOAT(MM(I+1,J))
      P(2,1)=S
      P(2,2)=0.
      P(2,3)=FLOAT(MM(I,J+1))
      P(3,1)=S
      P(3,2)=S
      P(3,3)=FLOAT(MM(I+1,J+1))
      CALL PLN(R,P,SLP,ORI)
      RETURN
      END
      SUBROUTINE QUAD3(R,S,P,MM,M,N,I,J,SLP,ORI)
      REAL P(3,3)
      INTEGER MM(M,N)
      P(1,1)=0.
      P(1,2)=0.
      P(1,3)=FLOAT(MM(I,J))
      P(2,1)=S
      P(2,2)=S
      P(2,3)=FLOAT(MM(I+1,J+1))
      P(3,1)=0.
      P(3,2)=S
      P(3,3)=FLOAT(MM(I+1,J))
      CALL PLN(R,P,SLP,ORI)
      RETURN
      END
      SUBROUTINE QUAD4(R,S,P,MM,M,N,I,J,SLP,ORI)
      REAL P(3,3)
      INTEGER MM(M,N)
      P(1,1)=0.
      P(1,2)=0.
      P(1,3)=FLOAT(MM(I,J))
      P(2,1)=S
      P(2,2)=0.
```

```
      P(2,3)=FLOAT(MM(I,J+1))
      P(3,1)=S
      P(3,2)=S
      P(3,3)=FLOAT(MM(I+1,J+1))
      CALL PLN(R,P,SLP,CRI)
      RETURN
      END
$ENTRY
```

APPENDIX 'C'

SURFACE FEATURE CODING:

The available data on the Site Surface Features was in the form of aerial photographs. It was necessary to use photo-interpretation in order to classify the variables.

Due to the irregularities of the heights, densities, and types of Surface Features found on the site, it was necessary to develop criteria for the interpretation and coding of each cell, for each classification. The criteria were as follows:

1) The Surface Feature Type that was prevelant over the largest portion of the cell was coded for the whole cell.

2) The Surface Feature Height was coded as the average height of the features found within the cell.

3) The Surface Feature Density (specifically vegetation) was coded as a composite per-

centage density of the number of stems per cell and the summer crown cover.

The codes used to record these variables are as follows:

SURFACE FEATURE TYPE

CODE	
0	water
1	muskeg, bog
2	landform, no significant vegetation
3	coniferous vegetation
4	deciduous vegetation

SURFACE FEATURE HEIGHT

CODE	
0	no significant height above landform
1	0 to 10 feet high
2	10 to 20 feet high
3	20 to 30 feet high
4	30 to 40 feet high

SURFACE FEATURE DENSITY

CODE	
0	no significant density above landform
1	10 %
2	20 %
3	30 %
4	40 %
5	50 %
6	60 %
7	70 %
8	80 %
9	90 %
10	solid object

The coded variables of Surface Feature Type, Height and Density are found in Maps 4,5,6.

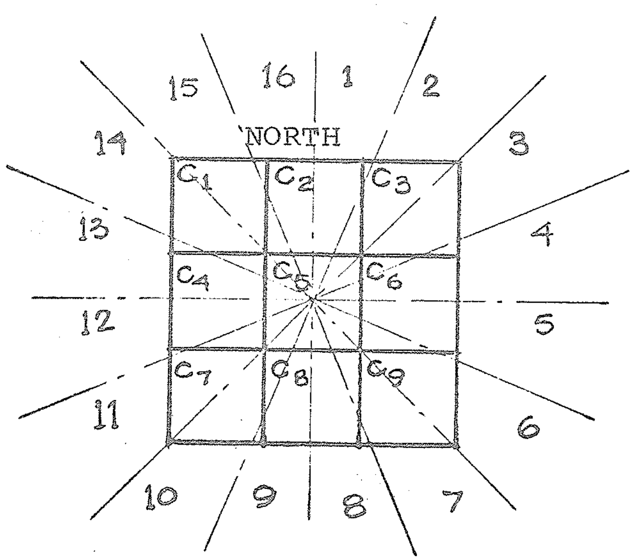
APPENDIX 'D'

SOLAR SHADING:

The effects of objects interferring with the passage of Solar Radiation to a cell were determined as follows:

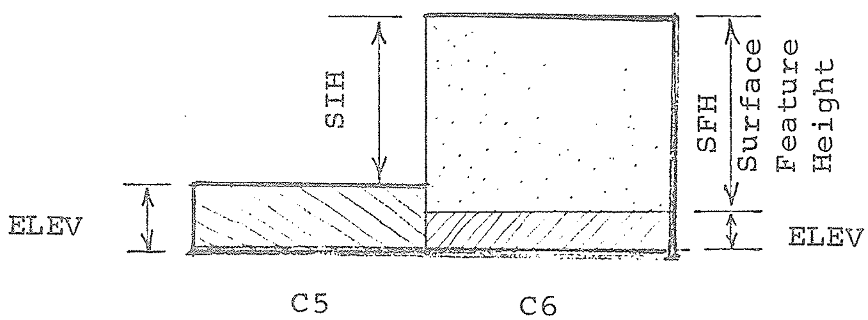
1) Only cells immediately adjacent to the cell under consideration were checked for possible interference.

2) To determine the cell to be checked, for possible interference, the Solar Azimuths were divided into sixteen (16) sectors of 22.5° increments measured clockwise from North as follows:



For example, if the Solar Azimuth falls between 67.5° and 112.5° (Sectors 4 and 5), Cell 'C6' was checked for possible interference.

3) The vertical relationship of the cells was then determined.



SIH = Surface Interference Height

ELEV = Elevation

SFH = Surface Feature Height

SIH = (ELEV (C6) + SFH (C6)) - ELEV (C5)

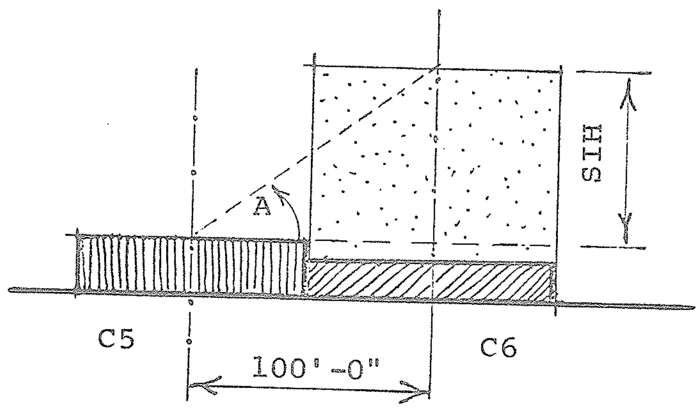
if ... SIH $\leq$ 0, no interference occurred

if ... SIH $>$ 0, interference was checked

Interference was checked as follows:

1) The horizontal distance between cell centres was fixed at 100'-0" for all conditions.

2) The angle 'A' was then calculated, where tan(A) = SIH/100:



3) If angle 'A' was less than the Solar Altitude, no interference occurred.

4) If angle 'A' was greater than the Solar Altitude, interference occurred.

The effect of the interference on the incoming Solar Radiation is dependent upon the density of the interfering object. In the case of vegetation, the following diagram was used to establish the amount of reduction in the Solar Radiation due to the density of the interfering vegetation.

FIGURE 14. – *Net gains and losses of net radiation to the snow in relation to the hemispherical crown coverage of the forest, in Oregon. Curve A: net all-wave gain; Curve B: net long-wave gain from forest only; Curve C: net long-wave loss to sky only; Curve D: net short-wave gain.*

(United States Army Snow Investigations, 1953)

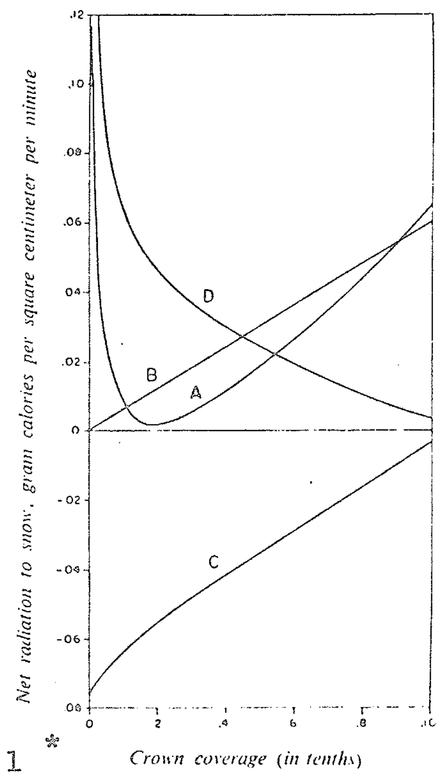


figure 1 *

As the concern of the study is with the short-wave radiation, the 'D' curve on the diagram was interpreted for reduction values based upon the percentage crown cover. The density of the interference is used to select the proper multiplier as indicated

* ______, Forest Influences; Food and Agricultural Organization of the United Nations, Rome, 1962, page 85

from the following table. If interference is occuring on a cell, the hourly value of the Solar Radiation is multiplied by the multiplier.

DENSITY	MULTIPLIER
0	1.0
10	.58
20	.41
30	.35
40	.25
50	.20
60	.16
70	.12
80	.08
90	.04
100	0

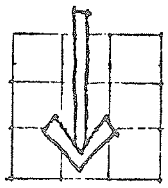
APPENDIX 'E'

WIND MODEL AND PROGRAM:

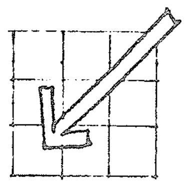
The method of analysis and operation of the program is such that wind passing through the site is assumed to operate in a linear fashion. Wind striking an obstruction is assumed to pass directly over it. No attempt is made to determine the amount of wind being deflected around it.

The general method of handling the various wind directions is by using vertical, horizontal, and diagonal sorts through the 20 x 20 array that describes the site. For the purposes of simplification of the program, and the reduction of the program running time, the wind directions were reduced to a total of eight. The wind directions were in 45^{o} increments, measured from North. It was felt than an increase in the accuracy of the wind direction would not substantially increase the accuracy of the model. This was due to the general nature of the variables being considered and the increased complexities of the sorts.

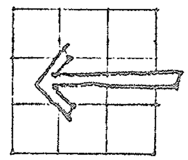
The sorts were done as follows:



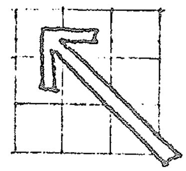
NORTH



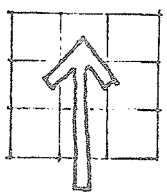
NORTH-EAST



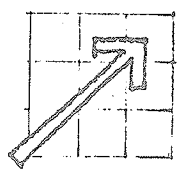
EAST



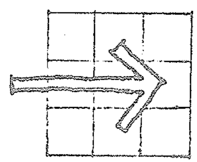
SOUTH-EAST



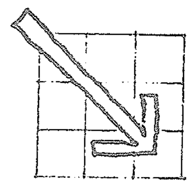
SOUTH



SOUTH-WEST



WEST



NORTH-WEST

The basic factors used to determine the 'shelter effect' of woods, was taken from the diagram below.

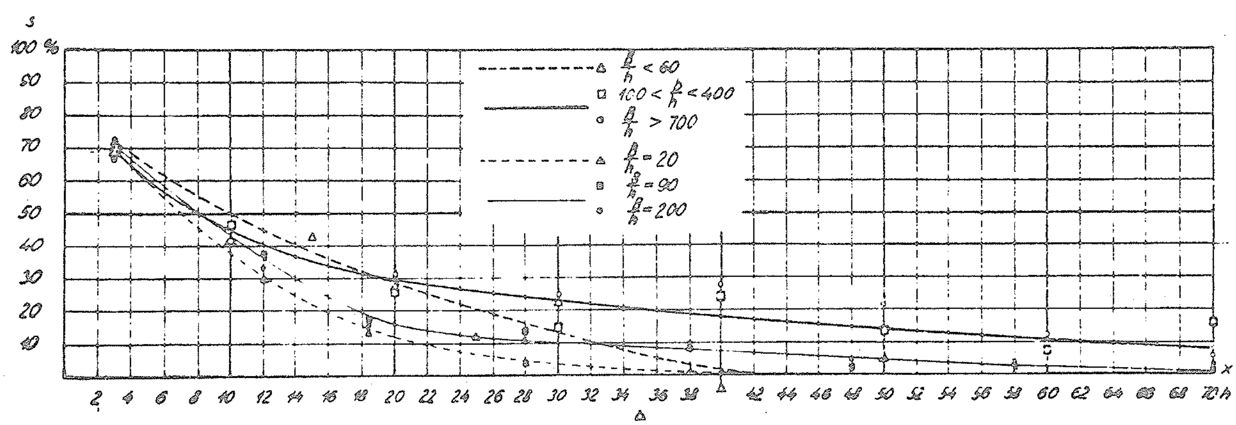


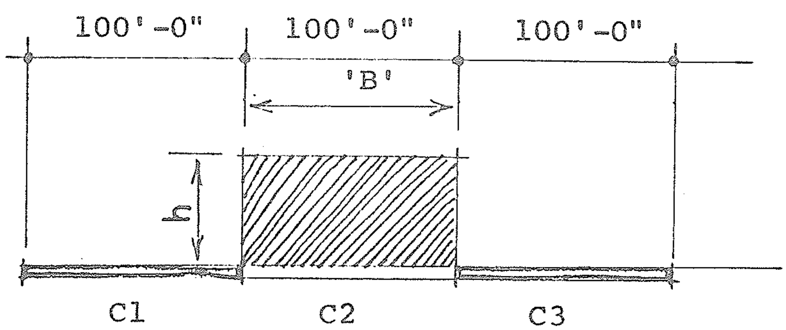
Fig. 218. Shelter effect of woods.
The thin lines show the shelter effects measured in the model tests. The solid lines indicate the shelter behind the wide wood models. The dotted line shows the shelter behind the narrowest model (width ÷ height = 20). The fat lines indicate the mean value of shelter effects measured in nature. The solid line shows the shelter behind wide woods and the dotted line the shelter behind narrow woods (width ÷ heights less than 60).

The mean curve was used, and values were interpolated for each value of 'h'. These values then became the base for the derivation of the shelter effects on all cells.

MODELS

The general models are as follows:

Case I

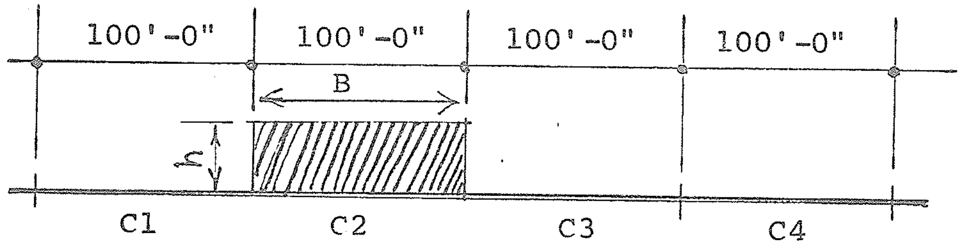


1) The wind passing over the first cell (C1) is not reduced.

2) Wind passing through the second cell 'C2' is assumed to be minimal. In other words, 'C2' has 100% shelter.

3) The shelter effect in the third cell 'C3' is then determined knowing the height and width of the obstruction in 'C2'.

Case II

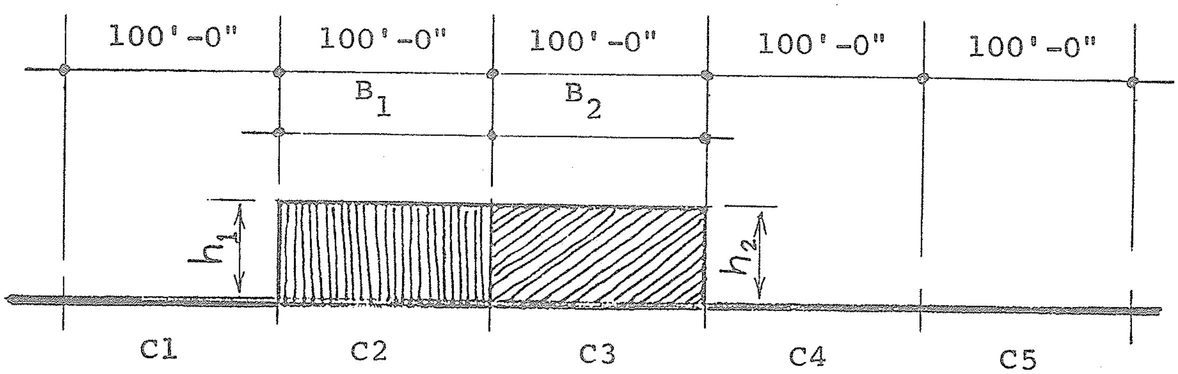


GIVEN: h = 50'-0" B = 100'-0"

Shelter Index for 'C3' = 100/50 = 2

Shelter Index for 'C4' = C3 x 2 = 4

Case III



GIVEN: h = 50'-0" 'B1' = 100'-0"

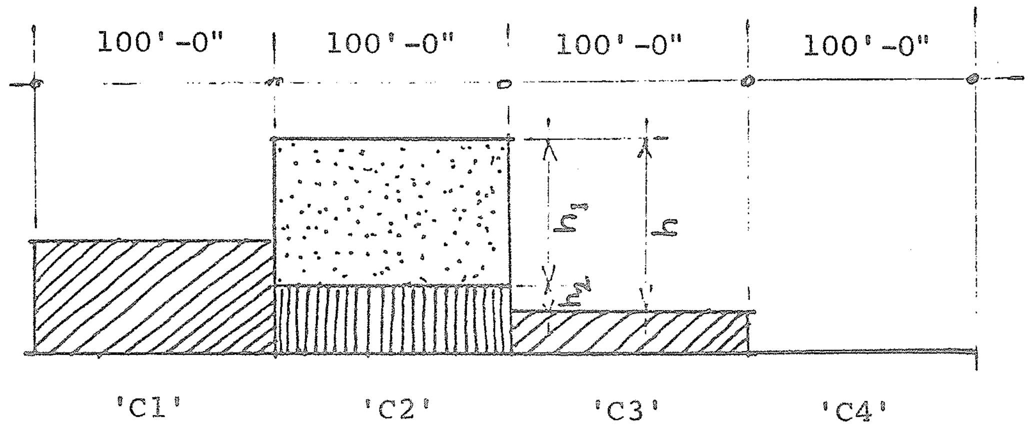
'B2' = 100'-0"

Shelter Index for 'C4' $= \frac{B1 + B2}{h1 + h2} = 2$

Shelter Index for 'C5' = SI for C4 x 2

= 4

The models are programmed to accept topographic elevations, and to combine them with the Surface Feature Heights to give a gross elevation for each cell. For example:



The values used to determine the shelter effect of various heights of Surface Features, are established for very dense (100%) growth. This in fact does not occur in most cases, therefore, a means of correcting these shelter effects for deviations in the density was established.

The effect of density was handled by a series of values as follows:

Effect Figures of Hedgerows (2)

	Coniferous	Deciduous
Very Open	2	1
Open	3	2
Medium	3	3
Close	3	3
Very Close	4	3

The very close category was assumed to have a 90% - 100% density. The categories were then expanded to a 0 - 10 density range to match the coded densities. The values used were as follows:

Coded Density	Coniferous	Deciduous
0	0.0	0.0
1	.25	.25
2	.50	.50
3	.75	.50
4	.75	.75
5	.75	.75
6	.75	.75
7	.75	.75
8	.90	.75
9	1.00	.75
10	1.00	1.00

Shelter effects were then multiplied by the appropriate effect figure to give the final value.

```
// EXEC FORTGCG,SIZE=150K
//GO.FT03F001  DD DSN=DAKIN.#0226.JUNE5.PUFF,UNIT=DISK,
//   SPACE=(TRK,(10,1),RLSE),DISP=(NEW,KEEP),
//   DCB=(RECFM=VBS,LRECL=80,BLKSIZE=7204),VOL=REF=ONE.MONTH
//GO.SYSUDUMP  DD  SYSOUT=A
//GO.SYSIN DD *
$JOB    WATFIV
//FORT.SYSIN DD *
C
      REAL RMAP(20,20),PMAP(20,20),TED(10),TEC(10)
      REAL SH(70)/.70,.70,.70,.65,.57,.55,.52,.50,.47,.45,.42,
     C.40,.39,.37,.36,.35,.33,.32,.31,.30,.29,.27,.26,.26,.25,
     C.25,.24,.24,.22,.22,.22,.21,.21,.21,.20,.20,.19,.19,.18,.18,
     C.18,.17,.17,.16,.16,.15,.15,.15,.14,.14,.14,.13,.13,.12,.12,
     C.12,.12,.12,.11,.11,.11,.10,.10,.09,.09,.09,.08,.08,.08,.08/
      INTEGER H(20,20),D(20,20),T(20,20)
      INTEGER UNITA/5/,UNITB/6/,UNITC/3/,UNITD/4/
100   FORMAT(2I3,F15.6)
      READ(5,100)M,N,SCALE
      KS=1
      CALL ININT(M,N,UNITA,H)
      CALL ININT(M,N,UNITA,D)
      CALL ININT(M,N,UNITA,T)
      CALL OUTINT(M,N,UNITB,H)
      CALL OUTINT(M,N,UNITB,D)
      CALL OUTINT(M,N,UNITB,T)
      CALL INPUTW(TED,TEC,N1,N2)
      CALL WD045(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,RMAP)
      CALL WD090(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,RMAP)
      CALL WD135(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,PMAP)
      CALL WD180(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,RMAP)
      CALL WD225(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,RMAP)
      CALL WD270(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,RMAP)
      CALL WD315(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N1,KS)
      CALL OUTRL(M,N,RMAP)
      CALL WD360(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      CALL OUTRL(M,N,RMAP)
      STOP
      END
      SUBROUTINE WD045(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      K=0
      J=1
      K1=1
      K2=1
10    DO 20 I=K1,K2
      CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
```

```
      K=1
      J=J-1
20    CONTINUE
      IF(K2.EQ.N)GOTO30
      K2=K2+1
      J=K2
      K=0
      GOTO10
30    IF(K1.EQ.N)GOTO40
      K1=K1+1
      J=N
      K=0
      GOTO10
40    RETURN
      END
      SUBROUTINE WD090(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      K=0
      DO 10 I=1,M
      J=N
20    CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      J=J-1
      K=1
      IF(J.GT.0)GOTO20
      K=0
10    CONTINUE
      RETURN
      END
      SUBROUTINE WD135(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      K=0
      K1=1
      K2=1
      K3=0
      I=1
      J=N
10    DO 20II=K1,K2
      CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      K=1
      I=I-1
      J=J-1
20    CONTINUE
      IF(K2.EQ.M)GOTO30
      K2=K2+1
      I=K2
      J=N
      K=0
      GOTO10
30    IF(K2.EQ.M.AND.K1.EQ.M)GOTO40
      K1=K1+1
      K3=K3+1
      I=M
```

```
      J=N-K3
      K=0
      GOTO10
40    RETURN
      END
      SUBROUTINE WD180(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      K=0
      DO 10 J=1,N
      I=M
20    CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      K=1
      I=I-1
      IF(I.GT.0)GOTO20
      K=0
10    CONTINUE
      RETURN
      END
      SUBROUTINE WD225(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
C *** SQUARE MATRIX ONLY **********
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      K=0
      I=N
      K1=M
      K2=N
10    DO 20 J=K2,K1
      CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      K=1
      IF(I.EQ.1)GOTO20
      I=I-1
20    CONTINUE
      IF(K2.EQ.1)GOTO30
      K2=K2-1
      I=M
      K=0
      GOTO10
30    IF((K1.EQ.1).AND.(K2.EQ.1))GOTO40
      K1=K1-1
      I=K1
      K=0
      GOTO10
40    RETURN
      END
      SUBROUTINE WD270(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      DO 10I=1,M
      K=0
      DO 10 J=1,N
      CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      K=1
10    CONTINUE
```

```
      RETURN
      END
      SUBROUTINE WD315(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      KSEAS=1
      K=0
      J=1
      K1=M
      K2=M
      K3=1
10    DO 20 I=K1,K2
      CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      J=J+1
      K=1
20    CONTINUE
      IF(K1.EQ.1)GOTO30
      K1=K1-1
      J=1
      K=0
      GOTO10
30    IF((K1.EQ.1).AND.(K2.EQ.1))GOTO40
      K2=K2-1
      K3=K3+1
      J=K3
      K=0
      GOTO10
40    RETURN
      END
      SUBROUTINE WD360(M,N,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
      KSEAS=1
      K=0
      J=1
20    DO 10 I=1,M
      CALL BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      K=1
10    CONTINUE
      J=J+1
      K=0
      IF(J.LE.N)GOTO20
      RETURN
      END
      SUBROUTINE GRND(M,N,EL,HT,RES)
      REAL EL(M,N),RES(M,N)
      INTEGER HT(M,N)
      DO 10 I=1,M
      DO 10 J=1,N
      RES(I,J)=EL(I,J)+HT(I,J)
10    CONTINUE
      RETURN
      END
      SUBROUTINE INPUTW(TED,TEC,N1,N2)
```

```
      REAL TEC(10),TED(10)
100   FORMAT(10F4.2)
150   FORMAT(I2)
200   FORMAT(' ',10F5.2)
240   FORMAT(' ','CONIFEROUS VEG. EQUALS  ',I2)
250   FORMAT(' ','DECIDUOUS VEG. EQUALS  ',I2)
      READ(5,150) N1
      WRITE(6,240) N1
      READ(5,100) (TEC(I),I=1,10)
      WRITE(6,200) (TEC(I),I=1,10)
      READ(5,150) N2
      WRITE(6,250) N2
      READ(5,100) (TED(I),I=1,10)
      WRITE(6,200) (TED(I),I=1,10)
      RETURN
      END
      SUBROUTINE BLOW(M,N,I,J,K,H,D,T,SH,RMAP,TEC,TED,N1,N2,KS)
      INTEGER H(M,N),D(M,N),T(M,N)
      REAL RMAP(M,N),SH(70),TEC(10),TED(10)
C***  K= CHECK FOR COMPLETE ROW
C***  S=SCALE
C***  ITHC=  TOTAL HEIGHT OF CELLS
C***  TLC= TOTAL LENGTH OF CELLS
C***  ICHK=  CHECK FOR CELLS BEHIND OBSTRUCTION
      S=100.
      IF(K.GT.0)GOTO10
      IF(H(I,J).GT.0)GOTO20
      GOTO30
20    ICHK=1
      TLC=S
      KCHK=0
      ITHC=H(I,J)
      RMAP(I,J)=1.
      CALL BLEW(M,N,I,J,R,D,T,TEC,TED,N1,N1,KS)
      GOTO100
30    RMAP(I,J)=0.
      ICHK=0
      GOTO100
C***  CATCH FOR NEXT CELL HAVING VEGETATION
10    IF(H(I,J).EQ.0)GOTO40
      IF(ICHK.GT.0)GOTO50
      GOTO20
50    TLC=TLC+S
      ITHC=ITHC+H(I,J)
      ICHK=ICHK+1
      RMAP(I,J)=1.
      CALL BLEW(M,N,I,J,R,D,T,TEC,TED,N1,N2,KS)
      KCHK=0
      GOTO100
40    IF(ICHK.EQ.0)GOTO30
      IF(KCHK.GT.0)GOTO60
      TEFF=TLC/(ITHC*10)
      ITEFF=IFIX(TEFF)
```

```
      IF(ITEFF.GT.70)GOTO70
      RMAP(I,J)=SH(ITEFF)*R
      KCHK=2
      GOTO100
70    RMAP(I,J)=0.
      GOTO100
60    TEFF1=KCHK*TEFF
      ITEFF=IFIX(TEFF1)
C***  CHECK FOR SHELTER GREATER THAN 70H
      IF(ITEFF.GT.70)GOTO80
      RMAP(I,J)=SH(ITEFF) *R
      KCHK=KCHK+1
      GOTO100
80    RMAP(I,J)=0.
100   RETURN
      END
      SUBROUTINE BLEW(M,N,I,J,R,D,T,TEC,TED,N1,N2,KS)
      INTEGER D(M,N),T(M,N)
      REAL TEC(10),TED(10)
      IF(T(I,J).EQ.N1)GOTO10
      IF(T(I,J).EQ.N2)GOTO20
      GOTO30
20    IF(KS.EQ.1)GOTO25
      WD=D(I,J)*.4
      IWD=IFIX(WD)
      R=TED(IWD)
      GOTO40
25    R=TED(D(I,J))
      GOTO40
10    R=TEC(D(I,J))
      GOTO40
30    R=1.
40    RETURN
      END
      SUBROUTINE ININT(M,N,KK,MAP)
      INTEGER MAP(M,N)
100   FORMAT(20I1)
      DO 10 I=1,M
      READ(KK,100) (MAP(I,J),J=1,N)
10    CONTINUE
      RETURN
      END
      SUBROUTINE OUTINT(M,N,KK,MAP)
      INTEGER MAP(M,N)
100   FORMAT(' ',44I3)
      DO 10 I=1,M
      WRITE(KK,100)(MAP(I,J),J=1,N)
10    CONTINUE
      RETURN
      END
      SUBROUTINE OUTRL(M,N,RR)
      REAL RR(M,N)
100   FORMAT(' ',20F6.3)
200   FORMAT('1',1H )
```

```
      WRITE(6,200)
      DO 10 I=1,M
      WRITE(6,100) (RR(I,J),J=1,N)
10    CONTINUE
      RETURN
      END
      SUBROUTINE OUTDSK(KK,M,N,RMAP)
      REAL RMAP(M,N)
      DO 10 I=1,M
      WRITE(KK) (RMAP(I,J),J=1,N)
10    CONTINUE
      RETURN
      END
      SUBROUTINE RL(M,N,MM,RR)
      REAL RR(M,N)
      INTEGER MM(M,N)
      DO 10 I=1,M
      DO 10 J=1,N
      RR(I,J)=FLOAT(MM(I,J))
10    CONTINUE
      RETURN
      END
```

APPENDIX 'F'

WIND AND TEMPERATURE DATA:

Due to the sketchiness of the records for the study area, records from the nearest stations were used.

	Mean Temper-ature (1) (Lynn Lake)	Average Wind Velocity (2) (The Pas)	Prevailing Wind Direction (3) (The Pas)
January	-16.4	11	NW
February	-6.3	10	NW
March	4.1	9	N
April	24.7	10	W
May	42.0	11	SE
June	53.6	11	SE
July	60.2	10	W
August	56.8	10	W
September	44.4	11	W
October	33.4	11	W
November	10.8	14	NW
December	-5.2	11	NW

REFERENCES

1) *Temperature and Precipitation Tables for the Prairie Provinces*, Canada Department of Transport, Meteorological Branch, Toronto, 1967, page 45

2) *Climatic Normals, Volume 5, Wind,* Canada Department of Transport, Meteorological Branch, Toronto, 1968, page 40

3) IBID, page 40

APPENDIX 'G'

FORMULAE USED:

1) Transmission heat loss/gain through walls and windows

$$H_t = AU\ (t_i - t_o) \quad (1)$$

where:

A = area of surface

U = co-efficient of transmission, air to air BTU/hour/foot^2

t_i = indoor temperature ^oF

t_o = outdoor temperature ^oF

2) Sol-air Temperature

$$t_e = t_o + \frac{a\ I_t}{f_{co}} \quad (2)$$

where:

t_o = outdoor air temperature ^oF

a = aborbtivity of outer surface to direct and diffuse radiation

I_t = total solar radiation BTU/hr/ft^2

f_{co} = unit of surface conductance (radiation and convection combined) BTU/hr/ft^2/ ^oF difference between surface temperature and the ambient air in shade

3) Solar Heat Gain Factor

Transmitted Component:

$$I_D \sum_{J=0}^{5} t_j \ \mathrm{Cos}^J \theta + I_d \ 2 \sum_{J=0}^{5} \frac{t_j}{J+2} \qquad (3)$$

Absorbed Component

$$I_D \sum_{J=0}^{5} a_j \ \mathrm{Cos}^J \theta + I_d \ 2 \sum_{J=0}^{5} \frac{a_j}{J+2} \qquad (4)$$

Solar Heat Gain Factor = Transmitted Component + N_i absorbed Component

where:

I_D = Direct radiation

I_d = Diffuse radiation

t_j = transmission co-efficient for glass

a_j = absorption co-efficient for glass

N_i = heat transfer factor, inward flow fraction

4) Infiltration Heat Loss

$$H_s = BL\ (t_i - t_o) \qquad (5)$$

where:

H_s = $B \times L \times 0.018 \times (t_i - t_o)$

B = air leakage/hr/ft of crack

L = length of window or crack

TRANSMISSION HEAT LOSS:

The values for variables used in the analysis for transmission heat loss were as follows:

T_o = mean daily temperature for month of analysis (See Appendix 'F')

t_i = 70° F

U - floor = 0.21

U - roof = 0.13

U - walls = 0.13

U - windows = 0.63

SOL-AIR TEMPERATURE:

t_o = mean daily temperature for month of analysis (See Appendix 'F')

a = Roof 0.80 (6)
Walls 0.50

f_{co} = 6 $BTU/hr/ft^2/{}^\circ F$

The solar radiation components of the heat load were calculated for the 21st of each month, using the variables and formulae found in Appendix 'A'. The method follows that recommended by ASHRAE.

AIR INFILTRATION:

Air changes method was used as recommended by ASHRAE (7) as the necessary information on pressure differences was not available for the building to utilize the 'crack' method.

As was recommended by ASHRAE:

> " For residences, it is common practice to assume that the total infiltration allowance for the residence is equal to the sum of the infiltration allowances of the individual rooms."
>
> (8)

The infiltration allowance was taken as one air change per hour per room, or one complete building air change per hour.

It was felt, based upon consultation with authorities that one air change per hour for a building of the type described was a reasonable choice, based upon the wind velocity (approximately 10 mph), then number, and type of openings and the type of construction.

The analysis was done using the variables and values previously listed.

```
*     $JOB           SOLAR
      C         H=HOUR ANGLE(HOURS IN DEGREES)
      C         A=SOLAR ALTITUDE
      C         D=POLAR DECLINATION
      C         AZ=AZIMUTH
                REAL THEAT(16)/16*0./
                REAL L(3),DUM(40),LT,LG
                REAL TC(6)/-0.00885,2.71235,-0.62062,-7.07329,9.75995,-3.89922/
                REAL AC(6)/0.01154,0.77674,-3.94657,8.57881,-8.38135,3.01188/
                REAL WORI(10),WOR(10),WSL(10),AW(10),UW(10),AG(10),UG(10),CL(10
               CB(10),AB(10),FC(10)
                REAL  WS(12),WD(12),TO(12),TI(12)
                REAL  STOR(24,6)
                REAL D(12)/-20.,-10.8,0.,11.6,20.,23.45,20.6,12.3,
               C0.,-10.5,-19.8,-23.45/
                REAL ASI(12)/390.,385.,376.,360.,350.,345.,344.,351.,
               C365.,378.,387.,391./
                REAL AEC(12)/.142,.144,.156,.180,.196,.205,.207,.201,
               C.177,.160,.149,.142/
                REAL C(12)/.058,.060,.071,.097,.121,.134,.136,.122,.092,
               C.073,.063,.057/
                INTEGER MONTHA(12)/'JAN.','FEB.','MAR.','APR.','MAY','JUNE',
               C'JULY','AUG.','SEPT','OCT.','NOV.','DEC.'/
                INTEGER TITLE(80),UNITC/3/
                R=.01745329
        120     FORMAT(I2)
        130     FORMAT(I3)
        140     FORMAT(80A1)
        150     FORMAT('1',80A1)
                READ(5,120) NOSAM
                READ(5,130) N
                DO 5 NOT=1,NOSAM
                READ(5,140) TITLE
                WRITE(6,150) TITLE
                READ(5,100) NTYPE
                REF=00.
        100     FORMAT(I2,I2)
        110     FORMAT(I2)
        200     FORMAT('0',18HWALL SURFACE ONE @,F6.2,9H  DEGREES)
        210     FORMAT('0',2H  )
        220     FORMAT('0',I2,2X,6F10.0,2X,F10.0,2X,F10.0)
        230     FORMAT('0',20HTOTAL HEAT LOSS/GAIN,58X,F10.0)
        240     FORMAT(' ',F16.0)
        250     FORMAT(' ',5HMAX= ,F12.0,2X,7HSOLAR= ,F6.2,2X,7HINFIL= ,F6.2)
        500     FORMAT('0','VALUES FOR  ',A4,'  21 ST.')
        600     FORMAT('0','POLAR DECLINATION =',F10.4,'   DEGREES')
        800     FORMAT('1',A1)
                READ(5,100) M1,M2
                IF(M2.EQ.0) M2=M1
                CALL LAT(L,LT)
                CALL LCNG(L,LG,T1)
                WRITE(6,800)
                READ(5,110) NWALL
                CALL WALL(NWALL,WORI,WSL,AW,UW,AB,AG,UG,CL,B,FC)
```

```
      WRITE(6,210)
      CALL CLIMAT(N,WS,WD,TO,TI)
      WRITE(6,800)
      DO 10 MONTH=M1,M2
      WRITE(6,500) MONTHA(MONTH)
      WRITE(6,600) D(MONTH)
      DO 15 II=1,NWALL
      WOR(II)=WORI(II)
15    CONTINUE
      DO 20 IA=1,16
      BTOT=0.
      WRITE(6,200) WOR(1)
      WRITE(6,210)
      DO 30 I=1,24
      TOT=0.
      T=FLOAT(I)
      CALL SALT(R,N,LT,D,MONTH,T,A)
      CALL SAZ(R,N,D,MONTH,A,AZ,T,LT)
      CALL NRAD(R,N,A,AZ,MONTH,ASI,AEC,RDN,T)
      DO 40 K=1,NWALL
      HLIN=0.
      TRAD=0.
      GHL=0.
      WHL=0.
      RAD=0.
      IF(K.NE.NWALL)GOTO32
C****  CALC FLOOR
      CALL TRHL(HL,AW(K),UW(K),TI(MONTH),TO(MONTH))
      WHL=HL
      GOTO55
32    IF(A.GT.0.)GOTO35
      CALL TRHL(HL,AW(K),UW(K),TI(MONTH),TO(MONTH))
      WHL=HL
      CALL TRHL(HL,AG(K),UG(K),TI(MONTH),TO(MONTH))
      GHL=HL
      GOTO55
35    IF(WSL(K).GT.0.1)GOTO37
      RAD=RDN*SIN(A*R)
      GOTO42
37    CALL SLOPES(R,A,AZ,WSL(K),WOR(K),AIN)
      IF(AIN.GT.89.)GOTO42
      RAD=RDN*COS(R*AIN)
42    CALL DIFF(R,N,A,C,MONTH,RDN,WSL(K),RTD,0.)
      TRAD=RAD+RTD
      CALL SOL(TE,TO(MONTH),AB(K),TRAD,FC(K))
      CALL TRHL(HL,AW(K),UW(K),TI(MONTH),TE)
      WHL=HL
      CALL SHGF(SH,AC,TC,AIN,R,RAD,RTD)
      GHL=((-1*SH)+(UG(K)*(TI(MONTH)-TO(MONTH))))*AG(K)
55    STOR(I,K)=HLIN+WHL+GHL
      TOT=TOT+STOR(I,K)
      BTOT=BTOT+STOR(I,K)
*     PRINT,TRAD,HLIN,WHL,GHL
40    CONTINUE
```

```
      CALL INFHL(HL,AW(6),7.5,TI(MONTH),TO(MONTH))
      BHL=HL
      TOT=TOT+ BHL
      BTOT=BTOT+BHL
      WRITE(6,220) I,(STOR(I,K),K=1,NWALL),BHL,TOT
30    CONTINUE
      WRITE(6,230) BTOT
      CALL ROTAT(NWALL,WOR,22.5)
      THEAT(IA)=THEAT(IA)+BTOT
      T1=TOT*24.
      T2=BTOT
      T3=T1-T2
      T4=(T3/T1)*100.
      T5=((BHL*24.)/T1)*100.
      WRITE(6,210)
      WRITE(6,250) T1,T4,T5
      WRITE(6,210)
      WRITE(6,210)
20    CONTINUE
      WRITE(6,210)
      DO 13 KHT=1,16
      WRITE(6,240) THEAT(KHT)
13    CONTINUE
      WRITE(6,800)
10    CONTINUE
5     CONTINUE
      STOP
      END
      SUBROUTINE LAT(L,LT)
C * READS AND COVERTS MIN. AND SEC. TO DECIMALS OF DEGREES
      REAL L(3),LT
100   FORMAT(' ','LATITUDE=',F15.6,' DEGREES')
      CALL LCON(L,LT)
      WRITE(6,100) LT
      RETURN
      END
      SUBROUTINE LONG(L,LG,T1)
      REAL L(3),LG
100   FORMAT(' ','LONGTITUDE=',F15.6,'  DEGREES')
      CALL LCON(L,LG)
      WRITE(6,100) LG
      RETURN
      END
      SUBROUTINE LCON(L,R)
C******READS AND CONVERTS LATITUDE & LONGTITUDE TO DEGREES
      REAL L(3)
100   FORMAT(F4.0,2F3.0)
      READ(5,100) L
      IF(L(2).EQ.0..AND.L(3).EQ.0.)GOTO10
      IF(L(2).EQ.0..AND.L(3).GT.0.)GOTO20
      R=L(1)+(((L(2)*60.)+L(3))/3600.)
      GOTO30
10    R=L(1)
      GOTO30
```

```
20      R=L(1)+(L(3)/3600.)
30      RETURN
        END
        SUBROUTINE SALT(R,N,LT,D,MONTH,T,A)
C ***   COMPUTES THE SOLAR ALTITUDE
        REAL D(N),LT
        B=LT*R
        C=D(MONTH)*R
        PI=3.141593
        A=(SIN(C)*SIN(B))-(COS(B)*COS(C)*COS((PI*T)/12.))
        A=ARSIN(A)*57.29578
        RETURN
        END
        SUBROUTINE SAZ(R,N,D,MONTH,A,AZ,T,LT)
C   COMPUTES THE SOLAR AZIMUTH
        REAL D(N),LT
        B=LT*R
        C=D(MONTH)*R
        PI=3.141593
        IF(T.EQ.12.)GOTO10
        IF(T.EQ.24.)GOTO20
        AZ=((SIN(B)*COS(C)*COS((PI*T)/12.))+(COS(B)*SIN(C)))
        IF(AZ.GT.1.)GOTO15
        AZ=ARCOS(AZ)*57.29578
        IF(T.GT.12.) AZ=360.-AZ
        GOTO30
10      AZ=180.00
        GOTO30
15      AZ=360.
        GOTO30
20      AZ=360.
30      RETURN
        END
        SUBROUTINE NRAD(R,N,A,AZ,MONTH,ASI,AEC,RDN,T)
C****    COMPUTES THE RDN AND RDH ON A SURFACE
C       RDN=DIRECT NORMAL RADIATION
        REAL ASI(N),AEC(N)
        IF(A.LT.0.)GOTO10
        IF(A.LT..0001)GOTO10
        RDN=ASI(MONTH)/EXP(AEC(MONTH)/SIN(R*A))
        GOTO20
10      RDN=0.0
20      RETURN
        END
        SUBROUTINE RHOR(R,A,RDN,RDH)
        IF(A.LT.0.)GOTO10
        RDH=RDN*SIN(R*A)
        GOTO20
10      RDH=0.
20      RETURN
        END
        SUBROUTINE SLOPES(R,A,AZ,SLP,ORI,AIN)
C       AIN= INCIDENT ANGLE
C       SLP= SLOPE OF SURFACE FROM HORIZONTAL
```

```
      C     ORI=ORIENTATION OF SURFACE ( ANGLE FROM NORTH TO NORMAL)
      C     AZIMUTH MUST BE IN RANGE 0 TO 360 DEGREES
            IF(ORI.GE.AZ)GOTO10
            D=AZ-ORI
            GOTO15
      10    D=ORI-AZ
      15    IF(D.LT.270.)GOTO20
            D=360.-D
      20    IF(D.GT.90.)GOTO70
            GOTO80
      70    AIN=90.
            GOTO90
      80    IF(SLP.LT.0.1)GOTO40
            IF(SLP.GT.89.)GOTO50
            AIN=(COS(A*R)*COS(D*R)*SIN(SLP*R))+(SIN(A*R)*COS(SLP*R))
            GOTO60
      40    AIN=SIN(A*R)
            GOTO60
      50    AIN=COS(A*R)*COS(D*R)
      60    AIN=ARCOS(AIN)*57.29578
      90    RETURN
            END
            SUBROUTINE DIFF(R,N,A,C,MONTH,RDN,E,RTD,REF)
      C     COMPUTES THE DIFFUSE RADIATION
      C     FSS=ANGLE FACTOR FROM SURFACE TO SKY
      C     FSG=ANGLE FACTOR FROM GROUND TO SURFACE
      C     RDS=RADIATION(DIFFUSE) FALLING FROM SKY
      C     RTH=RADIATION(TOTAL) HORIZONTAL @ GROUND
      C     RGR=RADIATION --- GROUND REFLECTED
      C     RTD= RADIATION(TOTAL DIFFUSE) FALLING ON SURFACE
      C     REF=GROUND REFLECTANCE (IN % )
      C     E=SLOPE OF SURFACE
            REAL C(N)
            FSG=(1.-COS(E*R))/2.
            FSS=1.-FSG
            RDS=C(MONTH)*RDN*FSS
            RTH=RDN*(C(MONTH)+SIN(A*R))
            RGR=RTH*REF*FSG
            RTD=RDS+RGR
            RETURN
            END
            SUBROUTINE TRHL(HL,A,U,TI,TO)
            HL=A*U*(TI-TO)
            RETURN
            END
            SUBROUTINE INFHL(HL,B,CL,TI,TO)
            HL=B*CL*0.0182*(TI-TO)
            RETURN
            END
            SUBROUTINE ROTAT(N,OR,A)
            REAL OR(N)
            DO 10 I=1,N
            OR(I)=OR(I)+A
            IF(OR(I).LT.360.)GOTO10
```

```
      OR(I)=OR(I)-360.
   10 CONTINUE
      RETURN
      END
      SUBROUTINE WALL(N,OR,SL,AW,UW,AB,AG,UG,CL,B,FC)
      REAL OR(N),SL(N),AW(N),UW(N),AB(N),AG(N),UG(N),CL(N),B(N),FC(N)
  100 FORMAT(10F6.2)
  200 FORMAT(' ',10F12.2)
      DO 10 I=1,N
      READ(5,100) OR(I),SL(I),AW(I),UW(I),AB(I),AG(I),UG(I),CL(I),B(I),
     CFC(I)
      WRITE(6,200) OR(I),SL(I),AW(I),UW(I),AB(I),AG(I),UG(I),CL(I),B(I)
     CFC(I)
   10 CONTINUE
      RETURN
      END
      SUBROUTINE CLIMAT(N,WS,WD,TO,TI)
      REAL WS(N),WD(N),TO(N),TI(N)
  100 FORMAT(4F6.2)
  200 FORMAT(' ',4F12.2)
      DO 10 I=1,N
      READ(5,100) WS(I),WD(I),TO(I),TI(I)
      WRITE(6,200) WS(I),WD(I),TO(I),TI(I)
   10 CONTINUE
      RETURN
      END
      SUBROUTINE SOL(TE,TO,A,R,F)
      TE=TO+((A*R)/F)
      RETURN
      END
      SUBROUTINE SHGF(SH,A,T,AIN,R,RD,RDD)
      REAL A(6),T(6)
      TDA=0.
      TDT=0.
      DO 10 I =1,6
      DT=(RD*(T(I)*(COS(R*AIN)**(I-1))))+(RDD*(2.*(T(I)/(I+1))))
      TDT=TDT+DT
      DA=(RD*(A(I)*(COS(R*AIN)**(I-1))))+(RDD*(2.*(A(I)/(I+1))))
      TDA=TDA+DA
   10 CONTINUE
      SH=TDT+(.267*TDA)
      RETURN
      END
```

REFERENCES

1) ASHRAE; Handbook of Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1967. page 461

2) OWENS - CORNING; The Economics of Sensible Heat Control, Owens-Corning Fibreglas Corporation, February, 1963, page 18

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