THE DEVELOPMENT AND UTILIZATION OF AN AVERAGE ILLUMINANCE CALCULATING SOFTWARE PROGRAM

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PREFACE

This study focuses on the development and utilization of an average illuminance calculating software program. The software will be applicable to most general lighting systems. The primary objectives are: 1) to develop a software model utilizing the zonal cavity and lumen method concepts associated with quantitative lighting design, 2) to establish a permanent luminaire data base which will contain luminaire descriptions, CU values, maximum spacing to mounting height ratios, luminaire distributions, and maintenance categories for each included luminaire, 3) to establish a luminaire output report which will enable the user to analyze various luminaire/lamp combinations in an efficient and effective manner.

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CHAPTER I

INTRODUCTION

Prior to the Mid-1970's lighting design calculations were primarily performed manually and on hand calculators. The advent and mass marketing of the small personal computer, however, has resulted in cheaper computer power and more versatility in all design challenges including those involved in lighting design (Napoli, 1984a, p. 18).

At present the technology exists to design lighting software systems linking illumination values for a space, the number and placement of luminaires, and financial accounting data. A total interior design facilities management and lighting system. However, it is felt that the market does not exist to economically justify the software's development (Napoli, 1984b, p. 25). Hence, marketability and not technology appears to fuel the computerization of lighting design techniques. Computerization, however, has rendered archaic the old "put a 2 x 4 troffer every 6 foot and things will be just fine" solution.

Basically, the harder the design question the more it costs to find the answer. Most hand lighting decisions, such as machinery's effect on light levels in a room, are answered on the fly assuming the room is empty.

The advent of the IBM PC (utilized in the development of the lighting software included within this report) has increased the market scope of lighting software and, therefore, computer interest among lighting professionals and developers is on the increase because of the broader potential for exposure and sales (Napoli, 1984b, p. 23).

Computer programs, in addition to calculating illuminances, may have the capability of determining surface luminances, visual comfort probabilities (V.C.P.), and equivalent sphere illumination (E.S.I.). The programs may also be applicable to daylighting, as well as to electric sources. Several comprehensive computer programs have been developed for calculating extensive printouts on illumination levels for a matrix of points. These programs are applicable to non-uniform room surface reflectances as may be caused by windows, doors, or other wall inserts. These programs are under constant expansion and development to be more versatile and to handle more complicated systems (Napoli, 1984b, p. 25).

Evaluation has to be performed by lighting designers to determine which scheme meets the design objectives and satisfies the project considerations, e.g., lumen method, point calculations, E.S.I., V.C.P., and luminance. The lighting design scheme to be utilized depends on or is a function of the size and complexity of the lighting system, degree of computational ability available, time, funding and need. Because of the broadness associated with the consideration of all lighting systems, this report will concentrate on the uniform general lighting system.

The design of a lighting system is concerned with both the quality and quantity of the light provided. Quality deals with the quality of the visual environment, e.g., color, direct/indirect glare, brightness and shadows produced. These factors are influenced by the type of luminaires utilized as well as the entire optical system. Due to the broadness of scope associated with this phase of the lighting design process, it is only considered briefly within the report.

Specifically, the major concentration of this report is the development of a general lighting system software model which will enable the user to calculate average illuminance for most general lighting systems. The software utilizes the zonal cavity and lumen method approach to quantitative lighting design. Proper utilization of the software herein contained will allow the lighting designer to more intelligently answer the following questions.

How many luminaires are required to maintain a required illumination level? What combination of wall, floor, and ceiling colors will provide maximum system efficiency? What lamping system will provide the lowest annual operating cost while providing the required minimum lighting level? What room shape and sizing, and luminaire mounting height will provide the lowest annual operating cost? What lamping system should be implemented in order to meet recommended wattage per square foot limits? What ceiling type should be utilized to minimize lamp operating costs?

With the manual approach (non-computerized) to general lighting design, the task of varying wall colors, mounting heights, replacement intervals, luminaire types, lamp lumens, and spacing criterion in order to compare alternative systems is quite tedious. Numerous data points must be manually interpolated/extrapolated for each system alternative. Arduous, methodical calculations must be performed rendering the manual approach to general lighting design extremely time consuming. The advent of the small personal computer, however, has antiquated non-computerized methodical calculations. The computer has allowed data sets to be placed in files, and methodical, technical calculations to be software encoded.

Discussion of the lumen method utilizing the zonal cavity concept and its application to general lighting systems will follow in the text, as well as discussion of the software developed to aid in the average illuminance design of uniform general lighting systems. The software serves as a potential economic instrument permitting opportunities for energy and cost savings in the field of general industrial lighting.

CHAPTER II

BACKGROUND

Lighting System Quality

The lumen method approach to general lighting system design does not consider the quality of the light produced, only the quantity. The cumulative effect of even slightly glaring conditions or overly bright conditions can result in loss of visual efficiency and fatigue. Therefore, it is of necessity for the lighting designer to apply considerable thought to the luminaire type to be selected for implementation and to further consider the placement of the luminaire within the operating environment upon selection. Frier (1980) felt that considerable emphasis should be placed on the following prior to luminaire selection: ambient dirt conditions, ambient temperature, noise criterion, mounting height, beam spread, shielding angle and reflector shape. Luminaire dirt depreciation is directly related to the luminaire maintenance category of the lamp being considered. Cleaning to maintain light outputs for some luminaire types could be cost prohibitive or not cost effective. It should also be mentioned that in some hazardous operating environments where explosion from electrostatic discharge is possible, explosion proof luminaires should be utilized. Ambient temperature will effect the lumen output of some lamps as well as lamp life.

Some luminaires are designed for installment at low mounting heights, that is below 7.6 meters (25 feet) while other luminaires are intended for use primarily above 7 meters. Available beam spreads of luminaires being considered should also be researched as beam spread can drastically effect light distribution and uniform light levels. Shielding angles will effect the direct and indirect glare produced by a lamping system and hence, operator comfort. Reflector shapes are important in that they redirect the luminaire intensity of the light source. Other aspects of the lamping system which may need to be considered prior to "quantity" determination (lumen method utilizing the zonal cavity approach) are the color of the illuminated light, brightness, and veiling reflections. It may be found, especially in office areas, that veiling reflectance is critically important. If this be the case, then equivalent sphere illumination (E.S.I.), a concept that relates the visibility of the task to the illumination level needs to be considered.

General Lighting

Prior to expounding on the methodology entailed in the lumen method and its application to general lighting design, we should discuss what is meant by a general lighting system.

General lighting is intended to provide relatively uniform illumination throughout a specified area for closely grouped tasks and for surrounding (ambient) lighting on isolated tasks. Examples of general lighting utilization would be warehouse lighting, manufacturing area lighting, and ambient office lighting. Uniform general lighting is the distribution of light such that the maximum and minimum illumination at any point is not more than 1/6 above or below the average level (I.E.S., 1979). Following the recommended spacing to mounting height criterion associated with a select luminaire type will in general provide uniform lighting while avoiding variance in light distribution.

The lumen method applies most soundly to the average illuminance design of uniform general lighting systems. General lighting is the simplest and often the most effective layout. It is usually a regular array of luminaires designed to achieve an overall level of illumination. Usually with a general lighting system, sufficient light is provided to allow specific visual tasks to be carried out anywhere within the room.

CHAPTER III

AVERAGE ILLUMINANCE CALCULATIONS

Overview

The lumen method is used in calculating the illuminance of all points on the work plane in an interior. It is based on the definition of average illuminance as luminous flux per unit area. It should be noted that this method assumes a relative uniform spacing of luminaires within the interior, surfaces of known diffuse reflectance, and an empty room with no interference from partitions or furniture. The lumen method is a proven procedure for determining the number of luminaires necessary to achieve an average lighting level or for predicting the general level from an existing specific lighting system (Pierpoint, 1979, p. 31).

To properly utilize the method, the lighting designer must initially collect accurate room dimension data, luminaire and lamp data, wall, ceiling, and floor reflectivity data, and operating environment data. The purpose of the collected or researched data as well as the calculations involved in the lumen method will be discussed in length in the sections which follow.

All of the principles, concepts, and calculations which are contained in the sections which follow were utilized in the development of the software enclosed within this report (Appendix C). Discussion of the software will be provided in the subsequent chapter.

Coefficient of Utilization Determination

Zonal Cavity Method

The coefficient of utilization (CU) is the ratio of the lumens which fall on the work surface (usually a plane about 0.9 meters, or 3 feet above the floor) to the lumens generated by the lamp. The CU charts in photometric data are based on a luminaire spacing of approximately 0.7 times the mounting height. This is a realistic spacing to use for high bay lighting, but it is often too close for systems installed at heights between 3 and 6 meters (10 and 20 feet). Any error in CU tables resulting from the use of a constant spacing to mounting height (S/MH) ratio is not significant (Frier, 1980, p. 92).

The CU value is a critical input into the lumen method's calculations. Manufacturers of luminaires provide CU tables such as the one shown in Table I for each of the luminaires manufactured. The CU value for a given luminaire type is dependent on the room cavity ratio of the room being considered, effective ceiling and wall reflectances, and the floor reflectance. In most cases interpolation or extrapolation of the tables is necessary in order to obtain system accuracy. Poor accuracy in this area will only be duplicated in later calculations.

The horizontal row entitled "PCC" shown at the very top of Table I is an abbreviation for the effective ceiling reflectance. The intervals within this row are quite large and, therefore, interpolation/extrapolation is often required. The numerical values shown in the row are percent values associated with the expected reflectance of the ceiling.

TABLE I

COEFFICIENTS OF UTILIZATION

pcc→	80			70			50			30			10			0		pcc→
pw→	50	30	10	50	30	10	50	30	10	50	30	10	50	30	10	0	WDRC	pw→
RCR ↓	Coefficients of Utilization for 20 Per Cent Effective Floor Cavity Reflectance (pfc = 20)																	RCR ↓
0	.52	.52	.52	.51	.51	.51	.48	.48	.48	.46	.46	.46	.45	.45	.45	.44	—	0
1	.49	.48	.48	.48	.48	.47	.47	.46	.46	.45	.45	.44	.44	.43	.43	.42	.036	1
2	.47	.46	.45	.46	.45	.44	.45	.44	.43	.44	.43	.42	.43	.42	.42	.41	.034	2
3	.45	.44	.43	.45	.43	.42	.44	.42	.42	.43	.42	.41	.42	.41	.40	.40	.033	3
4	.43	.42	.41	.43	.41	.40	.42	.41	.40	.41	.40	.39	.41	.40	.39	.38	.032	4
5	.42	.40	.39	.41	.40	.38	.41	.39	.38	.40	.39	.38	.39	.38	.38	.37	.033	5
6	.40	.39	.37	.40	.38	.37	.39	.38	.37	.39	.38	.37	.38	.37	.36	.36	.032	6
7	.39	.37	.36	.39	.37	.36	.38	.37	.35	.38	.36	.35	.37	.36	.35	.35	.032	7
8	.37	.36	.34	.37	.35	.34	.37	.35	.34	.36	.35	.34	.36	.35	.34	.33	.032	8
9	.36	.34	.33	.36	.34	.33	.35	.34	.33	.35	.34	.33	.35	.33	.33	.32	.032	9
10	.35	.33	.32	.35	.33	.32	.34	.33	.32	.34	.33	.32	.34	.32	.31	.31	.032	10

It should be noted that reflectance values should never exceed 100%. Row number 2 is entitled "PW" which is an abbreviation for the percent wall reflectance.

The vertical column of the table is entitled "RCR" which stands for the room cavity ratio. A room cavity ratio (RCR) of 10 is the limit of coefficient of utilization (CU) tables used in the zonal cavity method of lighting design. Some areas or rooms have RCR values exceeding 10; this is characteristic of long, narrow, deep areas where the mounting height is much greater than the width of the area. In such situations it is desirable to use calculation methods that are similar to those used for outdoor lighting in that only the direct component contribution of the luminaires is considered (Frier, 1980, p. 158).

In selecting a CU value for a given luminaire the designer should enter the table along the columns/rows correspondent with the determined reflectances and RCR value. Interpolation/extrapolation is frequently required to obtain an accurate CU value. Since CU tables are generally established for a 20 percent floor reflectance, adjustments must be made to take into account floor reflectances significantly less/greater than 20 percent.

The software developed and presented in Appendix C of this report uses the interpolation/extrapolation process associated with the CU tables since a CU table for the luminaire being considered by the designer will be in the luminaire data base. Adjustments are made to the CU value to take into account the effect of floor reflectivities significantly larger or smaller than 20 percent. The interpolation/extrapolation methodology is internally software encoded.

Room Cavities

The term "zonal cavity" was presented in the previous section. The term refers to the method utilized by designers in calculating the CU value. With the zonal cavity method, which is incorporated in the included lighting design software, the designer divides the room into zones. The ceiling cavity is the space between the ceiling and the bottom of the luminaire. The room cavity is the space between the bottom of the luminaire and the work plane, and the floor cavity is the space between the work plane and the floor. If the work space is broken up by partitions, beams, furniture, or other light impeding obstructions, the designer may want to break the room into smaller sections for design purposes since the lumen method assumes the room is empty.

Cavity Ratios

Cavity ratios for the floor, room and ceiling cavities (zones) may be determined by utilizing select equations which incorporate the dimensions of the room being considered for illumination (I.E.S., 1981). Figure I indicates illustratively the three zones and also presents the heights that will be required for the subsequent cavity ratio equations.

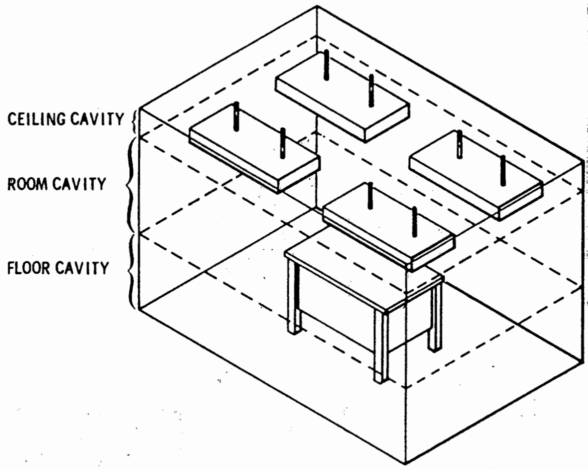


Figure 1. The Three Room Cavities

The room cavity ratio (RCR) is a necessary value for the determination of the CU value as was related in the initial paragraphs of this chapter. Each of the cavity ratios may be determined through the utilization of specific equations which incorporate various room dimensions. The following equation is useful in the determination of the room cavity ratio (RCR) for rectangular cavities.

$$RCR = 5\ hrc\ (r.l. + r.w.)/(r.l. \times r.w.) \qquad (3\text{-}1)$$

where

RCR = room cavity ratio

HRC = room cavity height

R.L. = room length

R.W. = room width

The ceiling cavity ratio (CCR) is a necessary value if the effective ceiling cavity reflectance is to be determined. Tables exist in most all lighting handbooks for determining the effective ceiling reflectance if the ceiling cavity ratio, wall reflectance, and ceiling reflectance are known. The equation for determining the ceiling cavity ratio is shown below.

$$CCR = rcr \times hcc/hrc \qquad (3\text{-}2)$$

where

CCR = ceiling cavity ratio

RCR = room cavity ratio

HCC = ceiling cavity height

HRC = room cavity height

The floor cavity ratio is also necessary if the effective floor cavity reflectance is to be determined utilizing the tabular method mentioned in the previous paragraph. The floor cavity ratio (FCR) may be determined through the utilization of the equation which follows.

$$FCR = rcr \times hfc/hrc \qquad (3\text{-}3)$$

where

FCR = floor cavity ratio

RCR = room cavity ratio

HRC = room cavity height

HFC = floor cavity height

The above formulations are useful if the room is rectangular. However, if the room is not of rectangular type, other equations are necessary. If the area to be illuminated is irregularly shaped, the RCR can be found with this formula.

$$RCR = 2.5 \times hrc \times perimeter/area\ of\ work\ plane \qquad (3\text{-}4)$$

The CCR and FCR can be determined utilizing equations 3-2 and 3-3, respectively.

If the area to be illuminated is circular, then the following formula may be utilized.

$$RCR = 5\ hcc/room\ radius \quad (3\text{-}5)$$

As with the irregularly shaped room, the CCR and FCR for the circular room may be determined through utilization of equations 3-2 and 3-3.

Thus far we have considered only horizontal ceiling types or assumed that the ceiling type was horizontal. If, however, the ceiling is nonhorizontal, the tabular approach to determine effective ceiling reflectivity need not be utilized. The following formula will suffice (I.E.S., 1981).

$$PCC = pao/as - pas + pao \quad (3\text{-}6)$$

where

Ao = area of ceiling opening

As = area of ceiling surface

p = reflectance of ceiling surface

It should be mentioned that if the luminaires are flush with the ceiling or recessed, the CCR will be zero since the ceiling cavity height is zero. Likewise, if the work plane is at floor level, the FCR will be zero. If this case exists, the effective ceiling and floor cavity reflectances are equivalent to the initial ceiling and floor reflectances. The concept of effective ceiling and floor reflectances will be discussed in more detail in a later section of this chapter.

To this point in time, however, we should realize that they may be determined from tables found in most all lighting handbooks and that they are used in determination of the CU value for a luminaire mounted in a specific room type.

Reflectance

The higher the reflectivity of the walls, ceiling and floor the greater the coefficient of utilization will be for the luminaire type being considered. A review of Table I will indicate clearly that higher ceiling and wall reflectivities will indeed result in a larger CU value; therefore, in general, the higher the reflectances, the higher the utilization of light.

Reflection values should approximate expected initial reflectivities if the maintained illumination level is to be determined. If the initial illumination level is to be calculated, the initial expected reflectivities should also be utilized. If large pieces of furniture, windows, or other light absorbing or reflecting obstructions exist or will exist within the area being considered, it becomes necessary to obtain a weighted average reflectivity. The weighted average reflectivity will provide more accuracy to the reflectivities obtained. If reflectivities are unknown or cannot be estimated or measured, a 30 percent wall, 30 percent ceiling, and 20 percent floor reflectance can be used (Frier, 1980, p. 105).

The lighting software contained within this report eases the problem of identifying exact numerical values to attach to particular surfaces by presenting to the user a color table. The color table contains a list of 24 colors which correlate to numerical reflectivity values. It should be mentioned that the color chosen should approximate what would actually be seen by an observer under the lamp types being considered for implementation.

Much research has been directed to surface texture. Texture of the surface does offset reflectivity, but this will not be considered within this report since it is an area of study in itself. The user of the software contained herein may account for textures by avoiding the color table and directly entering the reflectivity values.

Effective Reflectance

Before the coefficient of utilization can be selected, the combination of ceiling and wall reflectance as well as floor and wall reflectance must be converted to effective ceiling or floor reflectance. The effective reflectance of the ceiling and floor cavities takes into account the effect of interreflection of light among the various room surfaces. Again, charts or tables can be found for this conversion. But, if the reflectances are assumed to be perfectly diffuse and the flux is assumed to enter the cavity in a perfectly diffuse way, it is possible to calculate the effective cavity reflectance utilizing flux transfer theory. DiLauru (1978, p. 5) states that the zonal cavity method of calculating illuminance is derived from flux transfer theory which bases its derivation on the above assumptions. Therefore, by utilizing the zonal cavity method of calculating illuminances, we commit ourselves to the underlying assumptions and principles associated with flux theory. Hence, with these assumptions in mind, we can utilize the following equation derived from flux transfer theory (I.E.S., 1981).

$$PEFF = (AB/AW)\ PW(1 - F)^2 \times (1 + PBF)^2 / \quad (3\text{-}7)$$

$$1 - [1 - AB/AW(1 - F)]PW - AB/AW(1 - F)^2 PWPB$$

where

AB, AW = Areas of the cavity base (ceiling or floor), and walls.

PB, PW = Reflectance of cavity base (ceiling or floor), and walls.

F = Radiative exchange factor between the cavity opening and the cavity base (flux)

where

$$F = 2/\pi\ x\ y\ (Ln\ [(1 + x^2)(1 + y^2)/1 + x^2 + y^2]^{1/2}$$
$$+ y(1 + x^2)^{1/2}\tan^{-1}[y/(1 + x^2)^{1/2}]$$
$$+ x(1 + y^2)^{1/2}\tan^{-1}[x/(1 + y^2)^{1/2}]$$
$$- y\tan^{-1}(y) - x\tan^{-1}(x)$$

where

x = Cavity Length/Cavity Depth

y = Cavity Width/Cavity Depth

* NOTE: Arc tangents are expressed in radians.

Equation 3-7 may be utilized in the calculation of the effective ceiling cavity reflectance and floor cavity reflectance, bearing the previous assumptions in mind. Calculation of the effective ceiling cavity reflectance will require the designer to enter various ceiling dimensions and reflectivity values into the equation. Calculation of the effective floor cavity reflectance will require entry of floor data.

Thus far in Chapter III we have reflected on wall, floor, and ceiling reflectivities. We have discussed the utilization of transfer flux theory in calculating effective ceiling and floor reflectances. Equations have been presented to allow us to calculate the RCK, CCR, and FCR for rectangular, square, circular and irregularly shaped rooms with horizontal or nonhorizontal ceilings. The use of this data in calculating the coefficient of utilization (CU) has been presented.

Report focus will now center on those factors which contribute over a period of time to a decline or degradation of the light output of a given lamping system.

Light Loss Factors

Once the basic facts about the task, the area to be illuminated, and the chosen luminaire are collected, light loss factors (LLF) can be researched. Light loss factors are those factors which contribute over a period of time (relamping period) to a decline of the light output of a given lamping system. The light loss factor is usually considered to be the lamp lumen depreciation (LLD) times the luminaire dirt depreciation factor (LDD) times the room surface dirt depreciation factor (RSDD) times the lamp burn-out factor (LBO). Equation 3-8 is the formula representing the LLF and is the equation used in the lighting software to be presented in a subsequent chapter.

$$LLF = LLD \times LDD \times RSDD \times LBO \qquad (3\text{-}8)$$

where

LLF = light loss factor

LLD = lamp lumen depreciation factor

LDD = lamp dirt depreciation

RSDD = room surface dirt depreciation

LBO = lamp burn-out factor

Some of the factors associated with loss of light from an optical system over time are not as correctable through standard maintenance procedures as are others. The factors which are more difficult to correct once luminaire installation has occurred are the luminaire ambient temperature, luminaire surface depreciation, voltage to the luminaire, and ballast factor. These factors are not considered within the software developed within this report due to the difficulty of predicting and/or modeling their effect on lumen output. Each of the factors deserve additional research; but due to the broadness of scope associated with each and the limitations of scope of this report, they will not be considered in the software.

However, there are several factors which can be modeled and software encoded with reasonable accuracy. These factors, which contribute to a significant loss of light over an extended period of time and which can be maintained through lamp maintenance programs, are the lamp dirt depreciation factor (LDD), room surface depreciation factor (RSDD), and lamp burn-out factor (LBO). Each of these light reducing factors are represented in the developed software provided within this report; and, therefore, each deserves further delineation.

Lamp Dirt Depreciation Factor (LDD)

The lamp dirt depreciation factor (LDD) is associated with the accumulation of dirt on the luminaire. Dirt accumulation is primarily due to the type of enclosures associated with the luminaire being considered for installation, the dirtiness of the ambient environment, and the time elapsed since the last cleaning. The type of enclosures utilized determines which of the six maintenance categories the luminaire falls into. Maintenance categories for select luminaire/lamp combinations can be obtained from manufacturers data or from generic-type photometric data provided in the I.E.S. Handbook. In most cases, the maintenance category is positioned adjacent to the coefficients of utilization (CU) within the photometric data. The maintenance category is usually expressed as a Roman numeral of value I. through VI. with I. representing no top or bottom enclosures.

The I.E.S. Handbook and most other lighting design books recognize five degrees of dirt conditions, e.g., very clean, clean, medium, dirty, and very dirty. The dirtier the ambient environment the faster the rate of lamp dirt depreciation with time.

The I.E.S. Handbook also provides six categories of curves (one set of curves for each maintenance type) from which the LDD factor may be obtained given that the elapsed time (months) since the previous cleaning and the degree of dirtiness is known. However, this approach to LDD determination is not easily computerized since each set of curves (five curves for each maintenance category) must be modeled in non-linear equation form. An alternative approach is to utilize the curve-fitted formula (I.E.S., 1981):

$$LDD = e^{-A(t^{B})} \qquad (3\text{-}9)$$

where

LDD represents the lamp lumen depreciation factor.

A is a dirt depreciation constant.

B is a constant dependent on the maintenance category.

t is the elapsed time since the previous cleaning in months.

Both A and B may be obtained through reference of the Luminaire Dirt Depreciation Constant Table which is shown in Table II.

TABLE II

LUMINAIRE DIRT DEPRECIATION CONSTANTS

Luminaire Maintenance Category	B	A				
		Very Clean	Clean	Medium	Dirty	Very Dirty
I	.69	.038	.071	.111	.162	.301
II	.62	.033	.069	.102	.147	.188
III	.70	.079	.106	.143	.184	.236
IV	.72	.070	.131	.216	.314	.452
V	.53	.078	.128	.190	.249	.321
VI	.88	.076	.145	.218	.284	.396

Source: I.E.S. Handbook, 1981

As can be denoted through observation of Table II and equation 3-9, the longer the time duration since the last cleaning, and the dirtier the environment the larger the value of LDD, e.g., the closer to 1.0.

Room Surface Dirt Depreciation Factor (RSDD)

The room surface dirt depreciation factor (RSDD) is a quantitative light loss factor represented the proportion of light lost because of accumulation of dirt on room surfaces. The dirt accumulation reduces the amount of light reflected from all surfaces and, therefore, causes a reduction in illumination at the work plane level. As a note it should be remembered that utilization of the RSDD factor in our calculations requires us to use the initial expected reflectances of the surfaces in determining both the initial and maintained illumination levels since reduction in surface reflection is taken into account by the RSDD factor.

To determine the RSDD factor we need as inputs the luminaire distribution type, percent expected dirt depreciation, and the room cavity ratio (RCR).

There are five standard luminaire distribution types which are described briefly as follows (ANSI/IES, 1979, p. 13):

- Direct - Units which emit practically all (90 to 100 percent) of their light downward.
- Semi-Direct - Units which direct from 60 to 90 percent of their light downward.
- Direct-Indirect - Units in which the downward and upward components are approximately the same: 40 to 60 percent of the total luminaire output.
- Semi-Indirect - Units which emit most of their light (60 to 90 percent) upward.
- Indirect - Units emitting from 90 to 100 percent of their light upward.

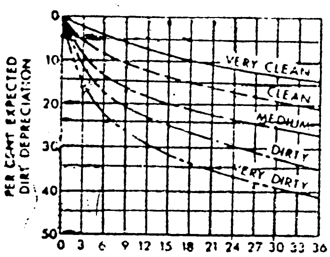
With each of these luminaire types, it is imperative that the surfaces to which most of the light is directed be of high reflectance value in order to increase the utilization of light (coefficient of utilization). It is also imperative that the luminaire type considered for installation provide the qualitative results desired.

The second input necessary in the determination of the RSDD is the percent expected dirt depreciation. The percent expected dirt depreciation may be obtained from expected dirt depreciation curves. The curves are provided in the I.E.S. Handbook and are shown in Table III below.

The software formulated for the basis of this report piece-wise interpolates the percent expected dirt depreciation provided the room surface cleaning interval and environmental dirt condition are known. Upon obtaining the luminaire type, percent expected dirt depreciation, and the room cavity ratio (RCR), the RSDD factor may be determined from the Room Surface Dirt Depreciation Factor Table (I.E.S., 1981) which is also shown in Table III.

TABLE III

ROOM SURFACE DIRT DEPRECIATION FACTORS



	Luminaire Distribution Type																			
	Direct				Semi-Direct				Direct-Indirect				Semi-Indirect				Indirect			
Per Cent Expected Dirt Depreciation	10	20	30	40	10	20	30	40	10	20	30	40	10	20	30	40	10	20	30	40
Room Cavity Ratio																				
1	.98	.96	.94	.92	.97	.92	.89	.84	.94	.87	.80	.76	.94	.87	.80	.73	.90	.80	.70	.60
2	.98	.96	.94	.92	.96	.92	.88	.83	.94	.87	.80	.75	.94	.87	.79	.72	.90	.80	.69	.59
3	.98	.95	.93	.90	.96	.91	.87	.82	.94	.86	.79	.74	.94	.86	.78	.71	.90	.79	.68	.58
4	.97	.95	.92	.90	.95	.90	.85	.80	.94	.86	.79	.73	.94	.86	.78	.70	.89	.78	.67	.56
5	.97	.94	.91	.89	.94	.90	.84	.79	.93	.86	.78	.72	.93	.86	.77	.69	.89	.78	.66	.55
6	.97	.94	.91	.88	.94	.89	.83	.78	.93	.85	.78	.71	.93	.85	.76	.68	.89	.77	.66	.54
7	.97	.94	.90	.87	.93	.88	.82	.77	.93	.84	.77	.70	.93	.84	.76	.68	.89	.76	.65	.53
8	.96	.93	.89	.86	.93	.87	.81	.75	.93	.84	.76	.69	.93	.84	.76	.68	.88	.76	.64	.52
9	.96	.92	.88	.85	.93	.87	.80	.74	.93	.84	.76	.68	.93	.84	.75	.67	.88	.75	.63	.51
10	.96	.92	.87	.83	.93	.86	.79	.72	.93	.84	.75	.67	.92	.83	.75	.67	.88	.75	.62	.50

Source: I.E.S. Handbook, 1981

The structure of the RSDD Factor Table lends itself to software encoding. More will be presented on both the LDD and RSDD factors and their method of determination in the software development chapters of this report.

Lamp Burn-Out Factor

Another light loss factor controllable through a good lamp maintenance program is the lamp burn-out factor (LBO). The LBO factor is defined as the ratio of lamps remaining lighted to the total number of lamps. The LBO is dependent on the type of lamps used and the lamping program in place. The value of LBO to be utilized in the lumen method calculation is dependent on the time frame for which the maintained illumination level is to be calculated. If the minimum maintained illumination level is to be determined then the designer would utilize a LBO factor representing the maximum number of burn-outs allowed by the maintenance relamping program.

Lamp Lumen Depreciation Factor

One factor that has not been mentioned but contributes significantly to light loss is the lamp lumen depreciation factor (LLD). The LLD figure is the percentage of initial rated lamp lumens which are still being emitted at the time of relamping. In order for this figure to be accurate, the expected time of relamping should be known, so that the corresponding figure may be obtained from the photometric data provided by they lamp manufacturer. It is not significantly correctable after installation; therefore, it should be analyzed prior to average illuminance calculations and installation. The designer should consider lamps that have a lower lamp lumen depreciation over rated life even though the lamps may have a higher initial investment since the investment can generally be recovered by lower energy and maintenance costs.

Lumen Method

Prior to calculating the average illuminance (utilizing the lumen method) the designer should consider the quality of illumination provided by the tentative choice of luminaire and lamp type. The initial lumen output of the lamp type to be utilized should also be considered. The wattage or lumen output of the lamp will determine the luminaire spacing and, consequently, the ratio of spacing to mounting height (S/MH). Manufacturers photometric data and most photometric data in general provide the S/MH ratio for the luminaire being considered. A "rule of thumb" formula that may be used to determine the approximate initial lumen output and, consequently, the lamp size is provided to the designer in equation 3-10 (Frier, 1980, p. 122).

$$\text{Approximate initial lumen output per lamp} = \text{Adjustment factor} \times \text{Maintained illumination level} \times MH^2 \quad (3\text{-}10)$$

where

- The adjustment factor is the reciprocal of the proportion of light (decimal value less than 1.0) expected to reach the work plane.
- The maintained illumination level is the minimum illumination desired at the work plane level (footcandles).
- The mounting height (MH) is the expected mounting height (feet) of the luminaire above the work plane.

Equation 3-10 will give the designer direction with regard to the approximate lamp size that will be required to attain the maintained illumination level without requiring extensive trial and error calculations.

Once the tentative luminaire type, lamp type, lamp size, CU value, and light loss factors have been identified, the designer may apply the lumen method calculations. The lumen method will allow the lighting designer to determine the number of lamps required to provide a maintained illumination level (footcandles). The direct and reflected component of light are calculated for the particular room dimensions and reflectance and type of luminaire used, as was mentioned in our previous discussion of the coefficient of utilization . The calculations are simplified by the use of tabular data and the basic formula presented below.

$$\text{Total Number of Luminaires} = \frac{(\text{Room Area}) \times (\text{Maintained Illumination Level})}{(\text{No. Lamps/Luminaire}) \times (\text{No. Lumens/Lamp}) \times CU \times LLF} \quad (3\text{-}11)$$

Equation 3-11 can be modified such that maintained illumination level is determined as is presented in the following formula.

$$\text{Maintained Illumination Level} = \frac{(\text{No. of Luminaires}) \times (\text{Lamps/Lumin.}) \times (\text{Lumens/Lamp}) \times CU \times LLF}{(\text{Room Area})} \quad (3\text{-}12)$$

It should be noted that the initial illumination level may be determined by dividing the maintained illumination by the LLF.

These equations represent the primary equations utilized in the lumen method. Most other quantitative aspects of average illumination associated with the general lighting system may be determined through manipulation of the two equations presented above. However, uniform lighting levels will not be attained if the recommended spacing to mounting height ratio is violated as is discussed in the following paragraphs.

Luminaire Spacing

Luminaire spacing is determined by the light distribution from the luminaire, the level of illumination required, the height of the building, and other practical considerations, e.g., the layout of the roof structure members to which the luminaire can be attached. Manufacturers of lighting luminaires specify for any given luminaire a maximum spacing to mounting height ratio (S/MH) which takes into consideration the beam spread and light distribution and the spacing required to provide illumination on the horizontal plane such that the minimum value is not less than 0.7 of the maximum (Hewitt, 1975, p. 123). Frier (1980) indicates that the S/MH ratio is frequently utilized with the assumption that the quality of the lighting system remains constant regardless of the luminaire spacing, so long as the S/MH ratio is not exceeded. Frier states that this is not always the case, especially when luminaires are used which have a highly polished reflector, such as is the case in the metal working industry, and if visibility is influenced by both the reflected brightness and the average illumination level. To clear up this ambiguity the Design Practice Committee of the Illuminating Engineering Society (I.E.S.) redefined the concept and established a new criterion called the luminaire space criterion (SC), which designers will want to utilize when considering lighting system quality, especially when using spherical reflectors. However, for most general lighting systems the S/MH ratio will suffice and may in fact provide higher quality illumination, especially if the S/MH ratio is less than the SC rating (Frier, 1980, p. 46).

How does the maximum spacing to mounting height ratio work? Manufacturers, as was previously mentioned, provide photometric data containing the S/MH ratio. The designer determines the S/MH ratio for the luminaire he is considering and he also determines the mounting height. If the system he has designed exceeds the recommended ratio, the designed lighting system could provide a nonuniform light distribution. Frier (1980) also points out that the luminaire brightness will get brighter as S/MH is increased because the lamp image (the reflection the worker sees when viewing the luminaire) is lower on the reflector when viewed from any given viewing angle.

Hopefully, the S/MH ratio is now more understandable. To aid the lighting designer the software presented in Appendix C will provide the maximum spacing to mounting height ratio for the luminaire being considered and the maximum allowed spacing of the luminaires. This will allow the user to determine if the layout he has in mind for the required number of luminaires is in violation of the maximum spacing, e.g., exceeds the maximum spacing. More will be mentioned on this subject in later chapters.

Example Calculations Utilizing the Lumen Method

There are a multitude of quantitative calculations which may be performed utilizing the lumen method. The designer may determine how increasing room size will effect operating costs, how changing room colors may effect illumination levels, how increases/decreases in luminaire mounting height will effect illumination levels. The method may be utilized to determine the number of luminaires required to provide a maintained illumination level, the lamp size required in existing luminaires to satisfy a maintained illumination level, etc. It is obvious that even more calculations could be performed by interrelating the above lamping design concepts. To provide the user with an idea of how the calculations are performed manually and how the method is software encoded, example calculations will be provided.

To aid in the simplification of the following examples, we will assume the coefficient of utilization (CU) and light loss factors (LLF) have already been determined. This should not imply that the CU and LLF are insignificant for they are not. An understanding of how the CU is determined by the software program through the utilization of the zonal cavity technique may be attained by referencing Chapter II. An understanding of how the light loss factors are determined may be obtained by referencing portions of this chapter.

As has been mentioned earlier, the lumen method is primarily a method of calculating the expected level of illumination on a horizontal plane from a particular lamp-luminaire combination, although many other quantities may be calculated. The following example will illustrate some of the concepts which may be quantitatively determined through the utilization of the lumen method.

Scenario: The desired maintained illumination level to be obtained with a general lamping system is 70 footcandles. The area of the room is 10,000 ft^2. The value of the coefficient of utilization is .50, the LLD is .60, the LDD is .42. The ratio of lamps burning to the total (LBO) is .97 and the RMSD is .60. The type of luminaire to be utilized in illuminating the area is the two lamp (4 ft.) florescent strip unit. The wattage associated with each of the lamps is 34 watts and the design lumens per lamp is 3,500.

(1) Determine the number of required luminaires to illuminate the environment.

(2) Given that the S/MH ratio is .7 and the mounting height is 15 feet, does square spacing[1] of the luminaires satisfy the S/MH ratio?

(3) Determine the wattage per square foot.

(4) If the lamp lumen depreciation is increased to .80 and the LDD and RMSD factors are raised to .70 and .80, respectively, determine the decrease in the number of lamps required.

Analysis Question #1: To determine the solution to Question 1 we must initially calculate the light loss factor (LLF). This may be determined by utilizing equation 3-8 below.

LLF = LLD x LDD x LBO x RSDD

By inserting the numerical values into equation 3-8 we obtain the following:

LLF = .80 x .42 x .97 x .60 = 0.19

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[1]Although layout is not considered within the report, this question will allow the designer to have a better understanding of how the S/MH ratio is used. Square spacing is determined from utilization of the following formula: Spacing between luminaires = (Area of Room/ Number of Luminaires)$^{1/2}$

To find the number of luminaires for this application, we may use the following formula (equation 3-11):

$$\text{Total Number of Luminaires} = \frac{\text{(Room Area) x (Maintained Illumination Level)}}{\text{(No. Lamps/Luminaire) x (No. Lumens/Lamp) x CU x LLF}}$$

$$\text{Total Number of Luminaires} = \frac{(10{,}000 \text{ ft}^2) \times (70 \text{ f.c.})}{(2) \times (3{,}500) \times (.50) \times (0.19)}$$

1,052.6 (or) 1,053 luminaires

Analysis Question #2: To determine the solution to this question we must first determine the distance between luminaires utilizing the square spacing formula. A comparison must then be made between the actual spacing and the design spacing. The maximum spacing allowed to provide uniform illumination is the actual mounting height multiplied by the S/MH ratio.

$$\text{Square Spacing} = (\text{Area of Room/Number of Luminaires})^{1/2} \quad (3\text{-}13)$$

$$\text{Square Spacing} = (10{,}000 \text{ ft}^2/1{,}053)^{1/2} = 3.08 \text{ ft.}$$

The maximum spacing allowed may be determined by equation 3-14.

$$\text{Maximum Spacing} = (\text{Actual Mounting Ht.}) \times (\text{S/MH Ratio}) \quad (3\text{-}14)$$

$$\text{Maximum Spacing} = (15 \text{ ft.}) \times (.7) = 10.5 \text{ ft.}$$

Therefore, since 3.08 ft. is less than 10.5 ft. we may assume that uniform illumination will be provided by the lamping system.

Analysis Question #3: To determine the wattage per square foot we must divide the total lamp wattage by the square footage of the room. This is, obviously, ((34 watts x 1,053)/10,000) equal to 3.6 watts per square foot which may be compared to recommended power limits established by the Illuminating Engineering Society (I.E.S., 1981).

Analysis Question #4: Recalculation of the LLF is required and then through utilization of equation 3-8 we may determine the solution.

$$LLF = LLD \times LDD \times LBO \times RSDD$$

$$= .80 \times .70 \times .97 \times .80 = .43$$

Total Number of Luminaires =

$$\frac{(10{,}000\ ft^2) \times (70\ f.c.)}{(2) \times (3{,}500) \times (.50) \times (.43)} = 465 \text{ luminaires}$$

The reduction in the number of luminaires required through improvement of the LLF by 56 percent is 588. A dramatic reduction which could be obtained by selecting a lamp type having a higher LLD over the rated life of the lamp and by improving the cleaning of luminaires and room surfaces.

Chapter Summary

This chapter has presented many concepts necessary in the determination of the average illuminance of a general lamping system. While inclusive with respect to many of the concepts, it lacks in full coverage of all the aspects of general lighting design. The quality of illumination is very important in most operating environments and limited coverage of this area was provided. Likewise, spacing criterion was not fully covered. These aspects may be researched further by referencing the bibliography contained at the conclusion of this report.

Critical to the understanding of the software presented herein is a basic understanding of the zonal cavity technique and the lumen method. Qualitative descriptions have been provided within this report to aid the user in becoming familiar with these concepts. Quantitative examples have been presented to aid the user in understanding how the lumen method may be utilized.

Chapter IV will familiarize the user with the software development of the general lighting design program.

CHAPTER IV

SYSTEM DEVELOPMENT

The concepts developed and presented in the previous chapters will enable the reader to have a basic understanding of how to design a uniform general lighting system and how the lighting software performs the required calculations. Two of the major concepts presented previously were the zonal cavity technique utilizing flux transfer theory and the lumen method both of which are useful in determining general lighting system illuminances and both of which are utilized in the general lighting software which is the focus of this report. This chapter will present the operational methodology of the software (written in basic) developed to aid the user in calculating general lighting system illuminances. The software was developed on the IBM PC 3270.

The software program "Light Design" is menu driven thereby streamlining the accomplishment of the desired objectives. The software consists of an optional help session, a master program (Standard Program Operation - Option #1) and two subprogram modules (Coefficient of Utilization (CU) Data Append - Option #2) and (Luminaire Description File Append - Option #3). Each of which contains a menu driven screen. The standard program operation module utilizes four data files (LUMDSC, FILENM$, LUMDDC, ROOMSD). LUMDSC is utilized in the storage of luminaire numbers and luminaire descriptions, which are user input. FILENM$ is a sequential data file utilized in the storage (user input) of the CU values, maximum spacing to mounting height ratio, maintenance category and light distribution type. LUMDDC is a sequential permanent data file utilized in the storage of the luminaire dirt depreciation constants. ROOMSD is also a permanent sequential data file, which is utilized in the storage of room surface dirt depreciation factors. The Standard Program Operation module temporarily stores data during the program operation in a series of eleven separate arrays. The CU Data Append Subprogram primarily utilizes one data file (FILENM$) which stores luminaire data (CU values, S/MH, maintenance category and light distribution type). The Luminaire Description File Append Subprogram utilizes the data file LUMDSC which allows luminaire descriptions to be permanently stored.

The help session which has yet to be expounded on provides the user with the information required to accomplish the program objectives the user has in mind in an efficient and effective manner.

The master program (Standard Program Operation) and the two subprograms (CU Data Append and Luminaire Description File Append) will now be discussed in more detail.

Standard Program Operation Subprogram

The master program, Standard Program Operation (Option #1), allows the user to accomplish the following objectives:

1) Transfer control to subprogram modules, e.g., Luminaire Descr. Append and Luminaire Coeff. of Utilization Append, to allow the addition/modification of luminaire/lamp descriptions, luminaire/lamp data, CU values, S/MH ratio, light distribution and maintenance category.

2) Input the lamp burn-out factor (LBO), lamp lumen depreciation factor (LLD), ceiling, wall, and floor reflectivities and/or colors, lamp operating details, and operating environment details.

3) Select luminaire/lamp type from luminaire description screen.

4) Utilize the zonal cavity approach and the lumen method to calculate the room surface dirt depreciation factor (RSDD), lamp dirt depreciation factor (LDD), room cavity ratio (RCR) for circular, irregular and rectangular rooms, effective cavity reflectances for the ceiling and floor, coefficient of utilization, light loss factor, initial and maintained illumination level, power per square foot, maximum suggested spacing for uniform light levels, total material and installation cost, annual operating cost, annual lamp replacement cost, and total operation cost.

5) Print a Luminaire Output Report to the printer or to the screen.

6) Exit program operation.

The Standard Program Operation Module (Option #1 in the master menu screen) is the controlling program in the software structure. This module must be entered into initially if the programmer desires to enter luminaire data coefficients of utilization and various other luminaire data, since the variable luminaire data file name is determined through the concantenation of the string constant "LUMEN" with the number of the luminaire selected from the luminaire menu screen. For example, if the user selected luminaire number one from the luminaire description screen and then transferred control to the

Coefficient of Utilization Append Module to add luminaire data, the software would allow the user to proceed in adding or modifying data. The software would store the data in the file "LUMEN1". However, if the user had not entered the luminaire number, then program control would transfer the user back to the master menu screen. This safety feature prevents the user from entering all of the luminaire data only to find that it was stored in the file "LUMEN0"[1] which corresponds to none of the luminaire numbers in the description screen.

If the user desires to enter a luminaire type not existing in the luminaire data base, control must be transferred to the Luminaire Description File Append Module where the luminaire description may be added. Control would then be transferred to the Standard Program Operation Module where the luminaire number would be entered. The user would then proceed to the CU Append Module where entry of luminaire data would be allowed.

The master program performs numerous calculations, most of which were detailed in Chapter III. Transfer flux theory (equation 3-7) is utilized to determine effective cavity reflectances. The zonal cavity method is utilized to calculate the appropriate CU value. A three variable interpolation/extrapolation program within the master program allow the CU values to be determined with high accuracy. The room surface dirt depreciation constants in the data file ROOMSD allow the user to determine the room surface dirt depreciation factor (RSDD) if the expected dirt depreciation (determined internally through

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[1]LUMEN0 would result since the luminaire number was not entered. The default for blanks is the numeral zero.

interpolation), luminaire distribution type, and room cavity ratio are known. The luminaire dirt depreciation constants in the data file LUMDDC allow the designer to determine the LDD factor given that the luminaire maintenance category (file entry) and degree of dirtiness are known.

An environmental dirtiness selection screen is provided to the user in the Standard Program Operation Module. This screen allows the user to better understand the entry of the dirt condition, as examples are provided.

A Color Table selection screen is also provided within this module to aid the user in determining the reflectivities of the ceiling, wall, and floor. Twenty-four colors are provided in the Color Table. The user may select a different color for the walls, ceiling, and floor or he may enter the reflectivities directly.

The end result of input of luminaire/lamp data and various screen entries and software calculations is the Luminaire Output Report which may be used by the designer to evaluate the quantity of light provided by the lamping system as well as a multitude of other quantitative aspects associated with the selected lamp/luminaire combination. More emphasis will be placed on the Luminaire Output Report and analysis of the report in Chapter VI - Software Application and Analysis of Output.

The Coefficient of Utilization Append Module (Option #2)

The CU Append Module may be utilized provided the user has entered the luminaire number. The subprogram allows addition of luminaire data and modification of luminaire data. The luminaire data that may be entered are the CU values, maximum spacing to mounting height ratio, maintenance category, and light distribution type. Luminaire data associated with each of the luminaires incorporated into the luminaire data base is stored in separate sequential luminaire data files. Luminaire data associated with luminaire number one would be stored in the sequential file "LUMEN1" while data associated with luminaire number two would be stored in the file "LUMEN2". The variable string "FILENM$" allows the process to be accomplished. The subprogram module utilizes the major array CU(row,column) to allow temporary storage of CU values prior to or after transfer from the luminaire data file. The array allows the process of modification/addition of CU values to be performed. The CU array subscript "row" is dimensioned to 11 and the subscript "column" is dimensioned to 15. Therefore, 165 CU values must be entered by the user for each luminaire being considered. A positive note, however, is that once entered the data forms a permanent luminaire data file which will aid in subsequent analyses, unless, of course, the data becomes extremely outdated due to technological advances in the area of luminaire development which, consequently, could effect the utilization values. The modification option of the program, however, would allow any of the data associated with a select luminaire to be changed, therefore, eliminating some of the effect of technological advancement.

In summary, the CU Append Module allows the user to write luminaire input data to an individual sequential file by means of a temporary storage array (CU(row,column)). The data forms a permanent data base thereby increasing the volume of luminaires that may be considered. Modification of the data (an option in the CU Append menu screen) will allow a complete revision of all of the CU data if such action is found to be necessary.

Luminaire Description Append Subprogram

The Luminaire Description Append Subprogram's objective is to allow the user to add or modify luminaire descriptions. The subprogram stores luminaire data in the sequential data file "LUMDSC". The array utilized in temporary storage of the descriptions and which allows output to the file and input from the file is LUMDESC$(J) which is dimensioned to 100. An internal check within the software coding will not allow the user to exceed a string length of 80 characters. If the length of the description exceeds 80 characters, the user will be asked to reenter the description.

CHAPTER V

LOADING AND RUNNING THE "LIGHT DESIGN" SOFTWARE

This chapter will present the necessary information to enable the user of the software to operate the software in a reasonably comfortable manner. Step by step instructions are presented to the user to allow operation methodology to be better understood.

Loading the "Light Design" Software

The following is a list of instructions for loading and unloading the lighting design software.

Step 1 If the power is off on the system, turn it on. Be sure that there are no diskettes in the disk drive. Turn on the printer.

Step 2 Locate the "DOS" diskette and insert it into the A disk drive. Be sure the label on the disk is on the top and the arrow is pointing toward the computer.

Step 3 Flip on the disk drive switch, monitor switch, and printer. The computer will prompt you to supply the date in the form HH:MM:SS (HH (hours)) varies from 1 to 24). The computer will subsequently prompt you with a >.

Enter the word Basica to load basic language into program memory. Note: When entering in all input, make sure that capital letters are typed and that the return key is depressed after each input.

Step 4 Remove the "DOS" diskette. Locate the diskette labeled "Light Design" and insert it into the A disk drive. Be sure the label on the disk is on the top and the arrow is pointing toward the computer.

Step 5 Type in the following command: LOAD "LIGHT DESIGN" and hit the enter key. The software will be loaded and the computer will begin prompting the user for data.

Step 6 When you are finished using the software, remove the diskette from the disk drive and return it to the protective diskette cover. Be sure to never remove the diskette while the red light on the disk drive is lit.

Warning*** While using the software do not depress the break or clear keys on the keyboard. ***If you hit the break key, type CONTINUE to resume.

How to Obtain a Luminaire Output Report

This option (option number one in the master menu screen) is utilized when the user desires to analyze a given luminaire/lamp combination and obtain a luminaire output report for the combination. Following are the steps which will enable the user to obtain the report. *System Warning - All input should be entered in capital type to avoid system errors. After entry the user should depress the enter key.

Step 1 Enter option number one from the master menu screen.

Step 2a Enter the luminaire number from the Luminaire Description Screen. If the desired luminaire does not exist in the screen then proceed to Step 2b. Otherwise proceed to Step 3.

Step 2b Return to the master menu screen and select option number three to allow entry of the luminaire description. After the luminaire description has been entered, option number two should be selected from the master menu screen to allow the user to enter luminaire data, e.g., CU values, S/MH, maintenance category, light distribution type. After entry of the luminaire data, the user should process through Steps 1, 2a, and 3 through 6.

Step 3 Enter requested luminaire/lamp data, operating data, implementation costs, and room dimensions.

Step 4 Enter the wall, ceiling, and floor colors from the Color Table or enter the reflectance values directly (less than 1.0).

Step 5 Enter environmental dirt conditions from the dirt condition selection screen.

Step 6 Enter number one if the luminaire output report is to be printed to the screen. Enter number two if it is to be printed to the printer.

How to Add a Luminaire Description

This feature is used when the user desires to add luminaire descriptions to the list of descriptions already established. It should be noted that the user should not enter a description unless he/she is prepared to enter luminaire data (Luminaire Data Append Sub-program), otherwise, system errors would result in attempting to analyze the luminaire/lamp type since data would not exist.

Step 1 Enter option number three from the master menu selection screen.

Step 2 Select option number one from the Luminaire Description Append menu screen (add option)

Step 3 Input the number of descriptions to be added.

Step 4 Enter a luminaire description less than or equal to 80 characters.

Step 5 Review the addition(s) if necessary.

Step 6 Change addition(s) if required.

Step 7 Return to master menu screen and select new option.

How to Modify a Luminaire Description

This feature will allow the user to modify previously entered luminaire descriptions.

Step 1 Enter menu number one (Standard Program Operation).

Step 2 Review the luminaire descriptions, particularly review the luminaire description to be changed.

Step 3 Return to the master menu screen. Enter menu number three from the master menu screen.

Step 4 Select option number two from the Luminaire Description Append menu screen (modify option).

Step 5 Upon prompt enter the number of the luminaire description to be modified.

Step 6 Reenter the luminaire description.

Step 7 Review the modification if necessary.

Step 8 Change modification if required.

Step 9 Return to the master menu selection screen and select a new option.

How to Add Luminaire Data

This feature allows the user to add luminaire data, e.g., coefficient of utilization values, maximum spacing to mounting height ratio, maintenance category, luminaire distribution type, and lamp length.

*** Warning *** The user may not enter luminaire data prior to the entry of the associated luminaire description. To add a luminaire description follow steps one through six of "How to Add a Luminaire Description."

Step 1 Enter option number one (Standard Program Option).

Step 2 Select the luminaire number associated with the data to be entered upon system prompt.

Step 3 Upon prompt return to the master menu screen.

Step 4 Enter menu number two (CU Data Append Subprogram).

Step 5 Select option number one from the CU Data Append menu screen.

Step 6 Enter luminaire data upon prompt.

Step 7 Review the entered data if necessary. Return to the master menu and enter new option.

Warning*** Program methodology will not allow luminaire data to be entered if luminaire data for the selected luminaire number was previously entered.

How to Modify Luminaire Data

Step 1 Enter option number one (Standard Program Option)

Step 2 Select the luminaire number associated with the data to be entered upon system prompt.

Step 3 Upon prompt return to the master menu screen.

Step 4 Enter menu number two (CU Data Append Subprogram).

Step 5 Select option number two from the CU Data Append menu screen (modify option).

Step 6 Modify luminaire data upon prompt.

Step 7 Review the entered data if necessary. Return to the master menu and enter new option.

CHAPTER VI

SOFTWARE APPLICATION AND OUTPUT ANALYSIS

Software Application

Vital to the proper operation of any software program is an understanding of how the software appears on the screen, how the data should be input, and how to manipulate the software to achieve the desired objectives. To aid the user in obtaining the necessary tools to operate the lighting software efficiently and effectively, three example applications are provided within this section.

Example number one demonstrates the manipulation of the software to analyze a luminaire/lamp combination and to obtain a luminaire output report (e.g., Standard Program Operation).

Example number two demonstrates the utilization of the CU Append Subprogram to view and modify existing luminaire data.

Example number three presents the methodology required to enable the user to modify existing luminaire descriptions.

The "How To" of Standard Program Operation

Selection of option number one from the master menu screen will allow the user to enter the Standard Program Operation module as is shown in the following printout.

```
****************************************
*AN INTERACTIVE LIGHTING DESIGN PROGRAM*
*                                      *
*                 BY                   *
*                                      *
*             RICK WHITNEY             *
*                                      *
*      MASTER'S  (1985)  REPORT        *
****************************************
                    FOREWORD
THIS PROGRAM WILL AID THE DESIGNER IN SELECTING A COST EFFICIENT
LUMINAIRE/LAMP COMBINATION SYSTEM THAT WILL PROVIDE AN AVERAGE
MAINTAINED ILLUMINATION LEVEL CORRESPONDENT WITH THE LIGHTING LEVEL
REQUIREMENTS OF THE AREA TO BE ILLUMINATED.THE PROGRAM WILL AID THE
USER TO ANALYZE EXISTING  GENERAL LIGHTING SYSTEMS OR AID THE USER
IN DESIGNING NEW SYSTEMS

        TO CONTINUE FORWARD IN EVALUATION-HIT ANY KEY

                A DESIGN LIGHTING MENU SCREEN

      ***************************************
      *-#1-STANDARD PROGRAM OPERATION       *
      *                                     *
      *-#2-LUMINAIRE COEFFICIENTS OF UTILIZ *
      *----ATION APPEND                     *
      *                                     *
      *-#3-LUMINAIRE DESCRIPTION FILE APPEND*
      *                                     *
      *-#4-EXIT                             *
      ***************************************

   PLEASE INPUT NUMBER OF SELECTION :I.E.,#1-4

   ? 1
```

Selection of option number one will provide the user with an opportunity to peruse the luminaire descriptions existing in the luminaire description data base. After perusal the user will be asked to enter the luminaire number corresponding to the luminaire type he/ she wishes to analyze.

LUMINAIRE MENU SCREEN

LUM #	LUMINAIRE DESCRIPTION
# 1	"HIGH BAY" NARROW DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HI D LAMP
# 2	"HIGH BAY" INTERMEDIATE DISTRIBUTION VENTILATED REFLECTOR WITH CL EAR HID LAMP
# 3	"HIGH BAY" WIDE DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HID LAMP
# 4	"HIGH BAY" WIDE DISTRIBUTION VENTILATED REFLECTOR WITH PHOSPHOR C OATED HID LAMP
# 5	WIDESPREAD, RECESSED, SMALL OPEN BOTTOM REFLECTOR WITH LOW WATTAGE DIFFUSE HID LAMP
# 6	2 LAMP PRISMATIC WRAPAROUND. MAY BE UTILIZED WITH 2 OR 4 FLUORESCE NT LAMPS
# 7	"HIGH BAY" INTERMEDIATE DISTRIBUTION VENTILATED REFLECTOR WITH PH OSPHOR COATED HID LAMP
# 8	FLUOR. UNIT W/FLAT PRISMATIC LENS UTILIZED W/ A MAXIMUM OF 4 LAMPS

Selection of the luminaire type and continuation in the Standard Program module will require the user to enter lamp/operating area data. The necessary entries are shown in the following printout.

```
PLEASE ENTER THE LAMP'S LIFE IN HOURS-#ONLY? 24000
PLEASE ENTER THE LAMP OPERATING HRS. PER YEAR-NUMBER ONLY PLEASE
? 2800
PLEASE ENTER THE LAMP LUMEN DEPRECIATION FACTOR(LLD)
AT 70% OF THE USEFUL LIFE OF THE BULB - DECIMAL FORM PLEASE-
IE.,.80,.70 ETC.
? .80
PLEASE ENTER THE DECIMAL VALUE OF THE NUMBER OF BULBS EXPECTED
TO BE BURNING AT REPLACEMENT TIME(70% OF USEFUL LIFE.EG.,.97, .85,ETC.
? .99
ENTER THE INITIAL LUMENS PER LAMP-NUMBER ONLY PLEASE
? 140000
ENTER THE # OF LAMPS PER LUMINAIRE-NUMBER ONLY PLEASE
? 1
ENTER THE WATTAGE PER LAMP-# ONLY PLEASE
? 1000
ENTER THE BALLAST WATTAGE/LUMINAIRE-NUMBER ONLY PLEASE-IF ZERO INPUT 0
? 50
IS THE DESIGN BEING CONSIDERED A NEW DESIGN-Y/N
? Y
ENTER THE DESIRED MAINTAINED ILLUMINATION LEVEL IN FOOTCANDLES
(NUMBER ONLY)-EG.,70,60,50 ETC.
? 70
ENTER THE DOLLAR COST PER LUMINAIRE - NUMBER ONLY PLEASE-NUMBER ONLY
? 63.00
ENTER THE INSTALLATION COST PER LUMINAIRE-NUMBER ONLY
? 50.00
ENTER THE ENERGY COST-$/KWH-NUMBER ONLY PLEASE
? .04
ENTER THE COST PER LAMP IN DOLLARS-NUMBER ONLY
? 22.00
ENTER THE LABOR COST PER LAMP INSTALLATION IN DOLLARSNUMBER ONLY PLEASE
? 10
```

In entering all data the user should make sure that all alphabetic entries are made in capital letter format and that the enter key is depressed following the entry of data.

Following the detail entry section, the user will be presented with the room shape selection screen from which the room shape should be selected. Selection of option number two from the screen will require the user to enter the following room dimension data. Selection of options one or three will require entry of similar data.

```
THE FOLLOWING PROGRAMMING SECTION WILL DETERMINE THE
          ROOM CAVITY RATIO FOR THE AREA UNDER CONSIDERATION

                    ******************************
                    *A ROOM SHAPE SELECTION SCREEN*
                    *                            *
                    *                            *
                    *     #1--CIRCULAR ROOM      *
                    *                            *
                    *     #2--RECTANGULAR ROOM   *
                    *                            *
                    *     #3--IRREGULAR ROOM     *
                    ******************************

PLEASE INPUT THE # CORRESPONDING TO THE DESCRIPTION BEST
DESRIBING THE SHAPE OF THE ROOM
? 2
ENTER THE ROOMLENGTH IN FEET-NUMBER ONLY
? 200
ENTER THE ROOMWIDTH IN FEET-NUMBER ONLY
? 200
ENTER THE FIXTURE MOUTING HEIGHT ABOVE THE WORKPLANEIN FEET-NUMBER ONLY
? 20
```

The next software input section enables the software program to determine the floor, wall and ceiling reflectances and subsequently the effective floor and wall reflectances. The user is provided with two options: (1) the user may enter the room reflectivities directly or (2) the user may observe the Colored Surfaces Selection Guide and select the representative colors for the floor, wall, and ceiling. These provisions are illustrated for the user in the following.

```
        DO YOU WISH TO ENTER THE REFLECTANCE VALUES FOR THE FLOOR
        WALL AND CEILING DIRECTLY(OR) DO YOU WISH TO OBSERVE THE
        COLORED SURFACES TABLE-TYPE 1 FOR DIRECT ENTRY AND 2 FOR
        TABLE OBSERVATION
? 2
               COLORED SURFACES SELECTION GUIDE

                         COLOR# COLOR DESCRIPTION

                           1    WHITE PAPER
                           2    LIGHT GRAY
                           3    MEDIUM GRAY
                           4    DARK GRAY
                           5    IVORY WHITE
                           6    BUFF STONE
                           7    TAN
                           8    COCOANUT BROWN
                           9    SATIN GREEN
                           10   BRIGHT SAGE AND IVORY TAN
                           11   BRIGHT SAGE
                           12   FOREST GREEN
                           13   OLIVE GREEN
                           14   PALE AZURE AND WHITE

REVIEW SCREEN FOR ENTRY OF WALL,CEILING AND FLOOR COLORS.WHEN YOU DESIRE TO CONTINUE TYPE 1
? 1
DO YOU WISH TO ENTER THE WALL AND CEILING COLORS NOW OR DO YOU
WISH TO OBSERVE THE REMAINING COLORS-TYPE 1 FOR ENTRY AND 2 FOR
COLOR OBSERVATION
? 1
INPUT THE NUMBER ASSOCIATED WITH THE COLOR OF THE WALLS--1
PLEASE INPUT THE NUMBER ASSOCIATED WITH THE CEILING COLOR-1
PLEASE ENTER THE NUMBER ASSOCIATED WITH THE FLOOR COLOR-17
IS THE CEILINGTYPE (1) HORIZONTAL (2)NONHORIZONTAL? 1
ARE THE LUMINAIRES SURFACE MOUNTED/RECESSED?-IF SURFACE
MOUNTED/RECESSED TYPE 1 IF NOT TYPE 0
? 1
IS THE WORKPLANE TO BE CONSIDERED FOR ILLUMINATION PURPOSES AT FLOOR LEVEL?---Y/N
? N
ENTER THE AREA OF THE FLOOR CAVITY BASE(FLOOR SURFACE AREA)40000
PLEASE ENTER THE FLOOR CAVITY WALL AREA(SURFACE AREA OF THE WALLS WITHIN THE FLOOR CAVITY)2400
PLEASE ENTER THE FLOOR CAVITY LENGTH(LENGTH IN FEET ASSOCIATED WITH THE FLOOR CAVITY)200
PLEASE ENTER THE FLOOR CAVITY WIDTH(WIDTH IN FEET ASSOCIATED WITH THE FLOOR CAVITY)200
PLEASE ENTER THE DISTANCE FROM THE FLOOR TO THE WORKPLANE LEVEL,E.G.,)=0.0
? 3
```

------ If the user selects the color entry option, he/she should enter representative colors as they would appear under the lamp source being investigated. It should be mentioned that selection of the color entry does not take into consideration the texture of the room surfaces. However, the user may take surface texture into consideration by entering the initial room reflectivities directly.

The questions following the color/reflectance entry section allow the software program to determine the effective ceiling and floor reflectances. If the luminaires are surface mounted or recessed, the effective ceiling reflectance is equivalent to the initial ceiling reflectance. If the work plane is at floor level, the effective floor reflectivity is equivalent to the initial floor reflectance, otherwise floor cavity data must be entered and an effective floor cavity reflectance determined.

Following the entry of the surface reflectances, the user will be entering operating environment dirt conditions, room surface cleaning intervals, and lamp/luminaire cleaning intervals as is shown below.

FIVE DEGREES OF DIRT CONDITIONS

	(1) VERY CLEAN	(2) CLEAN	(3) MEDIUM	(4) DIRTY	(5) VERY DIRTY
GENERATED DIRT	NONE	VERY LITTLE	NOTICEABLE/ NOT HEAVY	ACCUMULATES RAPIDLY	CONSTANT ACCUMULATION
AMBIENT DIRT	NONE(OR NONE ENTERS	SOME-ALMOST NONE ENTERS	SOME ENTERS AREA	LARGE AMNT ENTERS AREA	ALMOST NONE EXCLUDED
REMOVAL OR FILTRATION	EXCELLENT	BETTER THAN AVERAGE	POORER THAN AVERAGE	ONLY FANS OR BLOWERS IF ANY	NONE
ADHESION	NONE	SLIGHT	VISIBLE AFTER SOME MONTHS	HIGH-DUE TO OIL, HUMID-ITY, OR STAT IC	HIGH

```
PLEASE PONDER THE CHARACTERISTICS OF THE VARIOUS ENVIRON-
MENTS; AND PREPARE TO ENTER THE FITTING DIRT CONDITION -TYPE 1 TO CONTINUE
? 1
```

DIRT CONDITION EXAMPLES

VERY CLEAN	CLEAN	MEDIUM	DIRTY	VERY DIRTY
HIGH GRADE OFFICES NOT NEAR PROD-UCTION; LABS CLEAN ROOMS	OFFICES IN OLDER BUILD-INGS OR - NEAR PROD-UCTION, ASS-EMBLY, INSP-ECTION	MILL OFFICE PAPER PROC-ESSING; LIGHT MACH-INING	HEAT TREAT-ING;HIGH SPEED PRINT ING; RUBBER PROCESSING	SIMILAR TO DIRTY BUT LUMINAIRES WITHIN - IMMEDIATE AREA OF- DIRT SOURCE

```
PLEASE OBSERVE THE DIRT CONDITION EXAMPLES.  WHEN YOU DESIRE;TO CONTINUE TYPE 1
? 1
PLEASE ENTER THE # CORRESPONDING TO THE EXISTING ENVIRONMENT;
DIRT CONDITION; (I.E., (1) VERY CLEAN, (2) CLEAN, (3) MEDIUM,
(4) DIRTY, (5) VERY DIRTY)
? 5
PLEASE ENTER THE LUMINAIRE CLEANING INTERVAL IN DECIMAL YEARS
NUMBER ONLY (E.G., 36 MONTHS = 3.0, 13 WEEKS = .25 YEARS)
? .25
PLEASE ENTER THE ROOM WALL, FLOOR AND CEILING CLEANING INTERVAL
IN MONTHS (= 36 MONTHS ONE # PLEASE
? 1
```

The dirt condition descriptions and dirt condition examples were taken from the I.E.S. Handbook. The descriptions and examples provide uniformity to the selection of the dirt conditions.

At this point, all Standard Program screens have been perused and all necessary data has been entered. The screen printout (Luminaire Output Report) below displays the results of our input efforts.

```
ARE ENERGY EFFICIENT LAMPS UTILIZED.TYPE 1 FOR YES AND 2 FOR NO
? 2
       ***LUMINAIRE  OUTPUT  REPORT***
LUMINAIRE DESCRIPTION:
"HIGH BAY" NARROW DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HID LAMP

                REQUIRED DATA
-------------------------------------------------
                * INITIAL LUMENS/LAMP............. 140000
                * INITIAL LUMENS/LUMINAIRE........ 140000
                * LAMPLIFE........................ 24000
                * AVERAGE WATTS/LAMP.............. 1000
                * WATTS /LUMINAIRE................ 1050
                * U.P.D. (POWER LIMIT-WATTS/SQ.FT). 1.072782
                * COEFFICIENT OF UTILIZATION.......0.74
                * MAINTENANCE CATEGORY............ 3
                * LUMINAIRE LIGHT DISTRIBUTION.... 1
                * LIGHT LOSS FACTOR(LLF)...........0.66
                * LAMP LUMEN DEPRECIATION FACTOR...0.80
                * LAMP BURNOUT FACTOR..............0.99
                * LAMP DIRT DEPRECIATION FACTOR....0.84
                * ROOM SURFACE DIRT DEPREC.FACTOR..0.99
                * ROOM CAVITY RATIO(RCR)...........2.00
                * MAX.SPC/MNTING HT.RATIO..........0.70
                * EXISTING SPACING(=0 IF NEW......
                  DESIGN CONSIDERED............... 0
                * SUGGESTED MAX SPACING FOR UNIFORM
                  LIGHTING LEVELS................. 14
                * MAINT.ILLUM.LEVEL(FC)........... 70
                * INITIAL ILLUMINATION LEVEL..(FC) 105.8112
                * LUMINAIRES REQUIRED FOR UNIFORM.
                  MAINTAINED FOOTCANDLES.......... 10.21697
                * AREA OF ROOM (SQ.FT.)........... 10000
                * OPERATING HOURS PER YEAR........ 2800
                * LAMP REPLACEMENTS PER YEAR...... 1.19198

MATERIAL  AND  INSTALLATION  COST

                * LUMINAIRE COST..................          $643.67
                * LAMP COST.......................          $224.77
                * LUMINAIRE INSTALLATION CHARGE...          $510.85
                * LAMP INSTALLATION CHARGE........          $102.17

                * TOTAL MATERIAL AND INSTALLATION.
                  COST............................        $1,481.46


ANNUAL  OPERATING  COST

                * ANNUAL ENERGY COST..............        $1,201.52
                * LAMP REPLACEMENT COST/YEAR......           $11.92
                *TOTAL ANNUAL OPERATING COST......        $1,213.44
```

Analysis of the output may now be performed. Analysis will be provided in the analysis section of this chapter. Report focus will now concentrate on example number two -- the utilization of the CU Append Subprogram to view and/or modify existing luminaire data.

The "How To" of the CU Append Module

The example which follows demonstrates the utilization of the CU Append Subprogram module to view and/or modify existing luminaire data. The user should first enter the luminaire number from the luminaire description screen (Standard Program Operation) and return to the master menu screen. The user should select option number two from the master menu screen to transfer program control to the Luminaire Data Menu Screen.

```
                A DESIGN LIGHTING MENU SCREEN

        ****************************************
        *-#1-STANDARD PROGRAM OPERATION        *
        *                                      *
        *-#2-LUMINAIRE COEFFICIENTS OF UTILIZ  *
        *----ATION APPEND                      *
        *                                      *
        *-#3-LUMINAIRE DESCRIPTION FILE APPEND*
        *                                      *
        *-#4-EXIT                              *
        ****************************************


    PLEASE INPUT NUMBER OF SELECTION :I.E.,#1-4

    ? 2
```

Upon entry into the CU Append Program module the lighting designer will be required to acknowledge a system warning. The purpose of the warning is to remind the user that the luminaire number should be entered prior to the utilization of the CU Append Program module. If the luminaire number was not previously entered, the methodology of the software will return the user to the master menu screen.

Selection of option number two from the Luminaire Data Menu Screen will allow the user to modify existing luminaire data. Existing luminaire data is displayed on the screen for the perusal of the user. The user may modify the data or leave it as is. These points are demonstrated in the following.

```
          ***ACKNOWLEDGE THE SYSTEM WARNING BY PRESSING ANY KEY***

ENTRY STATUS/HAVE YOU ENTERED THE LUMINAIRE DESCRIPTION-TYPE 1 FOR YES AND 2 FOR NO
? 1
                    ****************************
                    *LUMINAIRE DATA MENU SCREEN*
                    *                          *
                    *-#1-ADD LUMINAIRE DATA    *
                    *                          *
                    *-#2-MODIFY EXISTING DATA  *
                    *                          *
                    *-#3-EXIT SUBPROGRAM       *
                    ****************************
PLEASE INPUT THE NUMBER ASSOCIATED WITH YOUR SELECTION:E.G.,1-3
? 2
       MAX.SP.          MAINT.CAT.         LUM.DIST.         LAMPLENGTH

       --------         --------           ---------         --------
         .7                3                  1                   0
DO YOU WISH TO CHANGE A DATA ENTRY-Y/N
? N
                              COEFFICIENTS OF UTILIZATION
                              --------------------------


              PCC/   80    /   70    /   50    /   30    /   10    / 0 /
              PW /50 30 10/50 30 10/50 30 10/50 30 10/50 30 10/     /
              RCR
                1
                 .93.93.93.90.90.90.86.86.82.82.82.78.78.78.87
                2
                 .85.83.85.83.82.81.81.80.79.78.77.76.75.75.74
                3
                 .81.79.76.80.77.75.77.75.73.75.73.72.72.71.70
                4
                 .77.73.71.76.72.70.73.71.69.71.69.67.70.68.66
                5
                 .73.69.66.72.68.65.70.67.64.68.66.64.67.65.63
                6
                 .69.65.62.68.64.61.66.63.61.65.62.60.64.60.59
                7
                 .65.61.58.64.61.58.63.60.57.62.59.57.61.58.56
                8
                 .62.57.54.61.57.54.60.56.54.59.56.53.58.55.53
                9
                 .58.54.51.58.54.51.57.53.51.56.53.51.55.52.50
               10
                 .55.51.48.55.51.48.54.50.48.53.50.48.53.50.48
               11
                 .53.49.46.52.48.46.52.48.46.51.48.45.50.47.45
```

In this example a CU value was selected for change. The CU value to be changed was CU(1,1) which has a numerical value of .93. To change a CU value the user must enter the row and column number of the existing value to be modified. The new CU value should also be entered.

```
DO YOU WISH TO CHANGE A CU VALUE-Y/N
? Y
ENTER THE ROW NUMBER OF THE CU VALUE TO BE CHANGED1
ENTER THE COLUMN # OF THE CU VALUE TO BE CHANGED1
ENTER THE NEW CU VALUE.05
```

The new CU value is read into a temporary storage array and output to the luminaire data file. Review of the luminaire data after modification reveals the following.

```
                COEFFICIENTS OF UTILIZATION
                ---------------------------

PCC/   80   /   70   /   50   /   30   /   10   / 0 /
PW /50 30 10/50 30 10/50 30 10/50 30 10/50 30 10/   /
RCR
  1
   .05.93.93.90.90.90.86.86.82.82.82.78.78.78.87
  2
   .85.83.85.83.82.81.81.80.79.78.77.76.75.75.74
  3
   .81.79.76.80.77.75.77.75.73.75.73.72.72.71.70
  4
   .77.73.71.76.72.70.73.71.69.71.69.67.70.68.66
  5
   .73.69.66.72.68.65.70.67.64.68.66.64.67.65.63
  6
   .69.65.62.68.64.61.66.63.61.65.62.60.64.60.59
  7
   .65.61.58.64.61.58.63.60.57.62.59.57.61.58.56
  8
   .62.57.54.61.57.54.60.56.54.59.56.53.58.55.53
  9
   .58.54.51.58.54.51.57.53.51.56.53.51.55.52.50
  10
   .55.51.48.55.51.48.54.50.48.53.50.48.53.50.48
  11
   .53.49.46.52.48.46.52.48.46.51.48.45.50.47.45
```

As can be quickly observed, the CU(1,1) value has been modified from .93 to .05.

The add option operates similarly, therefore, it will not be expounded on.

The exit option will return the user to the master menu screen.

The "How To" of the Luminaire Description File Append Subprogram

This example will demonstrate the utilization of the Luminaire Description Append Subprogram in modifying existing luminaire descriptions.

The user should select option number three from the master menu screen to transfer software control to the Luminaire Description Append Menu Screen which is shown in the following printout.

```
                A DESIGN LIGHTING MENU SCREEN

          ***************************************
          *-#1-STANDARD PROGRAM OPERATION       *
          *                                     *
          *-#2-LUMINAIRE COEFFICIENTS OF UTILIZ *
          *----ATION APPEND                     *
          *                                     *
          *-#3-LUMINAIRE DESCRIPTION FILE APPEND*
          *                                     *
          *-#4-EXIT                             *
          ***************************************


     PLEASE INPUT NUMBER OF SELECTION ;I.E.,#1-4

     ? 3

        ******************************************
        *LUMINAIRE DESCRIPTION APPEND MENU SCREEN *
        *                                         *
        *--#1-ADD/VIEW LUMINAIRE DESCRIPTIONS     *
        *                                         *
        *--#2-MODIFY EXISTING LUMINAIRE DESCRIP-  *
        *     TIONS                               *
        *--#3-EXIT LUMINAIRE DESCRIPTION SUBPROG- *
        *     RAM                                 *
        ******************************************
PLEASE INPUT THE NUMBER OF YOUR SELECTION,E.G.,#1-3
? 2
```

Entry from the Luminaire Description Append Menu Screen is required at this point. To modify existing luminaire descriptions the user will select option number two.

After perusal of the luminaire descriptions (shown in the following printout), the lighting designer may decide to modify an existing luminaire description.

```
PLEASE ACKNOWLEDGE THE CORRECTNESS OF THE PRESENT OR PREVIOUS DATA ENTRIES

                         LUMINAIRE MENU SCREEN
                         ---------------------

LUM #                    LUMINAIRE DESCRIPTION

# 1    "HIGH BAY" NARROW DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HI
       D LAMP
# 2    "HIGH BAY" INTERMEDIATE DISTRIBUTION VENTILATED REFLECTOR WITH CL
       EAR HID LAMP
# 3    "HIGH BAY" WIDE DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HID
       LAMP
# 4    "HIGH BAY" WIDE DISTRIBUTION VENTILATED REFLECTOR WITH PHOSPHOR C
       OATED HID LAMP
# 5    WIDESPREAD,RECESSED,SMALL OPEN BOTTOM REFLECTOR WITH LOW WATTAGE
       DIFFUSE HID LAMP
# 6    2 LAMP PRISMATIC WRAPAROUND.MAY BE UTILIZED WITH 2 OR 4 FLUORESCE
       NT LAMPS
# 7    "HIGH BAY" INTERMEDIATE DISTRIBUTION VENTILATED REFLECTOR WITH PH
       OSPHOR COATED HID LAMP
# 8    FLUOR.UNIT W/FLAT PRISMATIC LENS UTILIZED W/ A MAXIMUM OF 4 LAMPS
       .
REVIEW THE SCREEN FOR POSSIBLE INPUT ERROR TYPE 1 TO CONTINUE
? 1
# 9    FLUORESCENT UNIT WITH FLAT PRISMATIC LENS.MAY USE 2,3, OR 4 LAMPS

# 10   GOOD
```

If this be the case, the number of the description to be changed must be entered. For the purposes of this example, luminaire description #10 will be modified. A new description less than 80 characters must be entered to replace the old description. The existing description in this example is simply "Good". The new description to replace the old description is "This was changed". The results of the modification are shown in the screen printout which follows.

```
DO YOU WISH TO CHANGE A LUMINAIRE DESCRIPTION:Y-N
? Y
ENTER THE #OF THE DESCRIPTION TO BE CHANGED-10
PLEASE ENTER A SHORT USEFUL DESCRIPTION LESS THAN 2 LINES--THIS WAS CHANGED
DO YOU WISH TO CHANGE ANOTHER DESCRIPTION-Y/N
? N
DO YOU DESIRE TO SEE THE CHANGES-Y/N
? Y
                              LUMINAIRE MENU SCREEN
                              ---------------------

LUM #                         LUMINAIRE DESCRIPTION

# 1     "HIGH BAY" NARROW DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HI
        D LAMP
# 2     "HIGH BAY" INTERMEDIATE DISTRIBUTION VENTILATED REFLECTOR WITH CL
        EAR HID LAMP
# 3     "HIGH BAY" WIDE DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HID
        LAMP
# 4     "HIGH BAY" WIDE DISTRIBUTION VENTILATED REFLECTOR WITH PHOSPHOR C
        OATED HID LAMP
# 5     WIDESPREAD, RECESSED, SMALL OPEN BOTTOM REFLECTOR WITH LOW WATTAGE
        DIFFUSE HID LAMP
# 6     2 LAMP PRISMATIC WRAPAROUND. MAY BE UTILIZED WITH 2 OR 4 FLUORESCE
        NT LAMPS
# 7     "HIGH BAY" INTERMEDIATE DISTRIBUTION VENTILATED REFLECTOR WITH PH
        OSPHOR COATED HID LAMP
# 8     FLUOR. UNIT W/FLAT PRISMATIC LENS UTILIZED W/ A MAXIMUM OF 4 LAMPS

REVIEW THE SCREEN FOR POSSIBLE INPUT ERROR TYPE 1 TO CONTINUE
? 1
# 9     FLUORESCENT UNIT WITH FLAT PRISMATIC LENS. MAY USE 2, 3, OR 4 LAMPS

# 10    THIS WAS CHANGED
```

This section of Chapter VI has presented pragmatic applications of the "Light Design" software. The section should have aided the user in understanding how the software appears on the screen, how the data should be input, and how to manipulate the software to achieve the desired objectives.

The next section of this chapter will aid the user in analyzing the luminaire output report data.

Luminaire Output Analysis

The purpose of this section is to provide to the user a basic understanding of how the data supplied on the Luminaire Output Report may be utilized to aid in the selection of a cost efficient luminaire/ lamp combination.

To aid in the analysis of the data, two separate luminaire output reports will be referenced. The reports were generated for the same luminaire and lamp types utilizing varying parameters, e.g., room cleaning and luminaire cleaning intervals, room colors, and room dimensions (room length and width). The Luminaire Output Reports are shown in the following printouts.

LUMINAIRE OUTPUT REPORT - SCENARIO #1

```
ARE ENERGY EFFICIENT LAMPS UTILIZED.TYPE 1 FOR YES AND 2 FOR NO
? 2
        ***LUMINAIRE OUTPUT REPORT***
LUMINAIRE DESCRIPTION:
"HIGH BAY" NARROW DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HID LAMP

              REQUIRED DATA
------------------------------------------------
              * INITIAL LUMENS/LAMP............. 140000
              * INITIAL LUMENS/LUMINAIRE........ 140000
              * LAMPLIFE........................ 24000
              * AVERAGE WATTS/LAMP.............. 1000
              * WATTS /LUMINAIRE................ 1050
              * U.P.D.(POWER LIMIT-WATTS/SQ.FT). 1.072782
              * COEFFICIENT OF UTILIZATION.......0.74
              * MAINTENANCE CATEGORY............ 3
              * LUMINAIRE LIGHT DISTRIBUTION.... 1
              * LIGHT LOSS FACTOR(LLF)...........0.66
              * LAMP LUMEN DEPRECIATION FACTOR...0.80
              * LAMP BURNOUT FACTOR..............0.99
              * LAMP DIRT DEPRECIATION FACTOR....0.84
              * ROOM SURFACE DIRT DEPREC.FACTOR..0.99
              * ROOM CAVITY RATIO(RCR)...........2.00
              * MAX.SPC/MNTING HT.RATIO..........0.70
              * EXISTING SPACING(=0 IF NEW......
                DESIGN CONSIDERED............... 0
              * SUGGESTED MAX SPACING FOR UNIFORM
                LIGHTING LEVELS................. 14
              * MAINT.ILLUM.LEVEL(FC)........... 70
              * INITIAL ILLUMINATION LEVEL..(FC) 105.8112
              * LUMINAIRES REQUIRED FOR UNIFORM.
                MAINTAINED FOOTCANDLES.......... 10.21697
              * AREA OF ROOM (SQ.FT.)........... 10000
              * OPERATING HOURS PER YEAR........ 2800
              * LAMP REPLACEMENTS PER YEAR...... 1.19198

MATERIAL AND INSTALLATION COST

              * LUMINAIRE COST..................          $643.67
              * LAMP COST.......................          $224.77
              * LUMINAIRE INSTALLATION CHARGE...          $510.85
              * LAMP INSTALLATION CHARGE........          $102.17

              * TOTAL MATERIAL AND INSTALLATION.
                COST............................        $1,481.46

ANNUAL OPERATING COST

              * ANNUAL ENERGY COST..............        $1,201.52
              * LAMP REPLACEMENT COST/YEAR......           $11.92
              *TOTAL ANNUAL OPERATING COST......        $1,213.44
DESIRE TO ANALYZE ANOTHER LAMPING SYSTEM OR CONTINUE,E.G.,TRANSFER
CONTROL TO   THE MASTER MENU SCREEN:Y/N
```

Scenario number one was obtained from entry of the data presented in the "How To" of Standard Program Operation section of this chapter.

The second luminaire report to be analyzed is shown in the printout which follows.

LUMINAIRE OUTPUT REPORT - SCENARIO #2

```
          ***LUMINAIRE  OUTPUT  REPORT***
LUMINAIRE DESCRIPTION:
"HIGH BAY" NARROW DISTRIBUTION VENTILATED REFLECTOR WITH CLEAR HID LAMP

               REQUIRED DATA
--------------------------------------------------
               * INITIAL LUMENS/LAMP............. 140000
               * INITIAL LUMENS/LUMINAIRE........ 140000
               * LAMPLIFE........................ 24000
               * AVERAGE WATTS/LAMP.............. 1000
               * WATTS /LUMINAIRE................ 1050
               * U.P.D.(POWER LIMIT-WATTS/SQ.FT). .8261788
               * COEFFICIENT OF UTILIZATION.......0.88
               * MAINTENANCE CATEGORY............ 3
               * LUMINAIRE LIGHT DISTRIBUTION.... 1
               * LIGHT LOSS FACTOR(LLF)...........0.72
               * LAMP LUMEN DEPRECIATION FACTOR...0.80
               * LAMP BURNOUT FACTOR..............0.99
               * LAMP DIRT DEPRECIATION FACTOR....0.91
               * ROOM SURFACE DIRT DEPREC.FACTOR..1.00
               * ROOM CAVITY RATIO(RCR)...........1.00
               * MAX.SPC/MNTING HT.RATIO..........0.70
               * EXISTING SPACING(=0 IF NEW......
                 DESIGN CONSIDERED............... 0
               * SUGGESTED MAX SPACING FOR UNIFORM
                 LIGHTING LEVELS................. 14
               * MAINT.ILLUM.LEVEL(FC)........... 70
               * INITIAL ILLUMINATION LEVEL..(FC) 96.65742
               * LUMINAIRES REQUIRED FOR UNIFORM.
                 MAINTAINED FOOTCANDLES.......... 31.47348
               * AREA OF ROOM (SQ.FT.)........... 40000
               * OPERATING HOURS PER YEAR........ 2800
               * LAMP REPLACEMENTS PER YEAR...... 3.671906
MATERIAL  AND  INSTALLATION  COST

               * LUMINAIRE COST..................          $1,982.83
               * LAMP COST.......................            $692.42
               * LUMINAIRE INSTALLATION CHARGE...          $1,573.67
               * LAMP INSTALLATION CHARGE........            $314.73

               * TOTAL MATERIAL AND INSTALLATION.
                 COST............................          $4,563.65

ANNUAL  OPERATING  COST

               * ANNUAL ENERGY COST..............          $3,701.28
               * LAMP REPLACEMENT COST/YEAR......             $36.72
               *TOTAL ANNUAL OPERATING COST......          $3,738.00
DESIRE TO ANALYZE ANOTHER LAMPING SYSTEM OR CONTINUE,E.G.,TRANSFER CONTROL TO
THE MASTER MENU SCREEN:Y/N  ? N
                     Ok
```

As was previously mentioned, the same luminaire/lamp types were considered in both analyses. Table IV defines the data inputs associated with the individual output reports which were not the same; all other data inputs besides those delineated in Table IV were identical.

TABLE IV

DATA INPUTS

DATA DESCR.	OUTPUT REPORT #1	OUTPUT REPORT #2
Dirt Environment	Very Clean	Very Dirty
Lum. Cleaning Interval	3 Years	.25 Years
Room Cleaning Interval	12 Mos.	1 Mo.
Room Width	100 Feet	200 Feet
Room Length	100 Feet	200 Feet
Wall Color	Olive Green (.14)	White Paper (.81)
Floor Color	Ivory Tan (.58)	Shell Pink (57)
Ceiling Color	Bright Sage (.43)	White Paper (.81)

Similar data inputs were associated with both software runs. A mounting height of 20 feet was utilized, a rectangular room type and horizontal ceiling type were assumed. The work plane was estimated to be three feet from floor level and the luminaires were surface mounted in both cases. The high bay narrow distribution ventilated reflector with clear HID lamp (1,000 watts - 140,000 lumens) was used in both calculations.

Not all of the data provided within the luminaire output report deserve delineation. It will be left up to the user to understand the basic data inputs, since a basic understanding of lighting design is assumed. Among the data deserving qualitative focus are the lamp dirt depreciation factor, room surface dirt depreciation factor, CU value, reflectance values, room sizes, mounting height, lamp lumen depreciation, and the economics associated with the installation and operation of the lamping system.

Lamp Dirt Depreciation

By cleaning fixtures and lamps more frequently, even though the operating environment is extremely dirty, we can maintain a high LDD factor. This is evidenced in the output reports. Scenario number one assumed a very clean operating environment and a luminaire cleaning interval of three years. The associated LLD was .84. Output report number two assumed a very dirty operating environment and a luminaire cleaning interval of .25 years. The associated LLD was .91.

The higher LDD value was associated with the dirtier environment. The reason for this lies in the frequent cleaning of the luminaires.

The same concepts apply to the room surface dirt deprecation.

In summary, LDD and RSDD may be maintained at high levels if frequent cleaning of the luminaries and room surfaces is performed. This, however, is not without cost since increased maintenance will be required.

Coefficient of Utilization

The coefficient of utilization is primarily based on the room dimensions and room surface reflectances. Data input for scenario number one resulted in a CU value of .74 while data input associated with scenario number two resulted in a CU value of .88.

Why does this difference exist? Clean surfaces and surface colors of higher reflectance provide more illumination at the work plane level with the same lumen output. The larger the room and the lighter the color of the room surfaces the lower the rate of light absorption.

In our example applications these concepts are pointed out. Output report number one utilized a room width and length of 100 feet; number two a room width and length of 200 feet. Scenario number two utilized wall and ceiling colors significantly higher than those used in scenario number one.

The room dimensions associated with the second report resulted in a RCR value of 1.0 as compared to an RCR of 2.0 for number one.

The combination of room dimensions and higher room reflectivities resulted in a 15 percent increase in the luminaire CU value.

Lighting Economics

The objective of a routine lighting maintenance program is to maintain a desired light level for the minimum operating and maintenance cost. This objective may be achieved by computing the B/C ratio. The B/C ratio could be represented by the ratio of maintained illumination to the uniform annual cost per unit area. A similar analysis approach could be utilized in analyzing the material and installation costs. It should, however, be mentioned that the time duration associated with the elapsed time between the obtainment of the initial illumination level and the maintained illumination level is most likely not a single year. The lamp replacement time, which more often than not corresponds to the minimum maintained illumination level, should be determined prior to luminaire analysis.

Calculation of the B/C ratio (maintained footcandles/annual operating cost/ft^2) for scenario number one results in a value of 583. The B/C ratio for scenario two is 777. Therefore, if analysis were totally based on the annual operating cost per square foot in comparison with the maintained footcandles, we would select scenario number two.

Additional Discussion

It should be noted by referring to the output reports that scenario number two required 32 luminaires (one lamp per luminaire) to illuminate a 40,000 square foot area while scenario number one required 11 luminaires to illuminate a 10,000 square foot area. This indicates that larger areas with higher reflectance surfaces result in more efficient utilization of light.

What about luminaire spacing? If we assume square spacing, e.g., $(\text{room area/number luminaires})^{1/2}$, then both scenarios result in spacings exceeding 30 feet which is twice as large as the suggested maximum spacing (14 feet, e.g., S/MH x MH). Therefore, uniform light distributions would possibly not be obtained for either scenario utilizing the narrow distribution reflector with large lumen output HID lamp.

It is possible that a wide distribution reflector or a lower lumen output lamp be considered to aid in the maintenance of uniform light distributions.

If maximum spacing were not violated by both scenarios, scenario number two would be selected over scenario number one provided that both room designs were pragmatic and cleaning costs were not prohibitive.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This report has presented the development of a general lighting system software model which will enable the user to calculate average illuminance for most general lighting systems. The software utilizes the zonal cavity and lumen method approach to quantitative lighting design, where the proper utilization of the lumen method assumes a relative uniform spacing of luminaires within the interior, surfaces of known diffuse reflectance and an empty room with no interference from partitions or furniture. Proper utilization of the software and analysis of the calculated lighting data will allow the lighting designer to more intelligently analyze general lighting system alternatives.

General conclusions drawn from this research effort are:

(1) Average illuminance calculating routines may be software encoded in basic and run on the IBM PC.

(2) The time associated with the performance of average illuminance calculations may be significantly reduced through the utilization of a microcomputer.

(3) Flux transfer theory equations may be accurately modeled in basic language.

(4) Three variable interpolation/extrapolation routines may be accurately encoded in basic language.

(5) Average illuminance calculations are quite complex due to the large number of contributing factors that are involved, e.g., room dimensions, room reflectances, luminaire/lamp types, luminaire/lamp data, and environmental factors.

Several areas are recommended for further research and development. Further research in these areas will improve the operation of the software model and the accuracy and pragmatism of the model.

Areas deserving future research and development are as follows:

(1) Diskette Load and Unload Routine - An interactive diskette load and unload routine should be established to allow the addition of new luminaire data on a new diskette once the present diskette is full.

(2) Modification of Select Parameters - Add a temporary data storage file to enable the user to modify one or several data inputs from a previous run without necessarily modifying all previous data inputs.

(3) Spacing Criterion Parameter - The addition of the spacing criterion parameter to the luminaire data base will allow a more in-depth analysis of luminaire spacing.

(4) Expansion of Lighting Software Analysis - The addition of subprograms to enable the consideration of partitioned rooms, brightness levels, luminance, and daylighting.

(5) Flux Transfer Theory - Consider the utilization of flux transfer theory to calculate CU values. This modification will reduce user input time and diskette storage space.

(6) Advanced Economics - The addition of lifecycle costing techniques including consideration of group replacement/ singular replacement, maintenance costs, room cleaning costs, and luminaire cleaning costs.

(7) Demand Billing - The addition of a demand input to fit localized utility billing.

(8) Surface Textures - Future research into the effects of surface texture on surface reflections would improve model accuracy.

(9) Field Test - Illumination calculations assume ideal conditions such as uniform diffusing reflective surfaces and empty rooms, which are rarely found in practice. There is, therefore, possibly an element of uncertainty in the calculations. Field testing of the calculated illuminances will identify the error of uncertainty to be accounted for in future analyses.

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APPENDIXES

APPENDIX A

DESCRIPTION OF FILES, ARRAYS, AND VARIABLES

Files	File Description
LUMDSC	Sequential file utilized in the storage of luminaire descriptions.
FILENM$	Sequential file utilized in the storage of luminaire data, e.g., S/MH ratio, maintenance category, luminaire distribution, lamp length, and CU values. Each luminaire has a separate data file.
LUMDDC	Sequential file utilized in the storage of the luminaire dirt depreciation constants. Input data needed to access the file is the luminaire maintenance category and the degree of dirtiness.
ROOMSD	Sequential file utilized in the storage of the room surface dirt depreciation factors. Required data necessary in accessing the file is the luminaire distribution type and the room cavity ratio.

Major Arrays	Array Description
LUMDESC$(J)	Array utilized in the temporary storage of luminaire descriptions. The array is dimensioned to 100. String length may not exceed 80 characters.
CU!(Row,Col.)	Array utilized in the temporary storage of CU values. Maximum row dimension is 11, and the maximum column dimension is 15.
COLR!(I)	Array utilized in the storage of reflection factors associated with the colors presented in the program screen entitled "Colored Surfaces Selection Guide". The array is dimensioned to 24 values.

Y(I)	An array which stores the tabular column indexes associated with the luminaire data files. There are 11 tabular row indexes associated with each data file.
K(I)	An array which stores five ceiling reflectivity table indexes.
K(I)	An array which stores three wall reflectivity table indexes.
CST!(I,J)	An array which temporarily stores the luminaire dirt depreciation constants read from the data file LUMDDC.
RSD!(I,J)	An array which temporarily stores the room surface dirt factors read from the data file ROOMSD.
LEN (LUMDESC$)	An array containing the length of the string LUMDESC$ (luminaire description). Maximum string length is 80 characters.
LUMDESC$(L)	An array which temporarily stores the luminaire descriptions read from the data file LUMDSC.

Variable Name	Variable Description
MD	Selection variable for the master menu screen. MD may represent 1, 2, 3, or 4.
J	Array counter, e.g., LUMDESC$ array.
K	Array counter variable used in presenting the luminaire descriptions on the screen.
LUMNO$	String variable representing the luminaire number to be considered by the user.
DES$	String variable containing user's answer to yes or no type questions.

MAIN$	String variable represented by "LUMEN". Utilized in the determination of which coefficient of utilization file to write to or read from or to create, (e.g., FILENM$ (variable file name) = MAIN$ + STRG(LUMNO$) - i.e., LUMEN1, LUMEN2, etc.)
MAXSP	Variable representing the maximum spacing to mounting height ratio. The variable is allocated to one field of the data file FILENM$.
MAINTCAT	Represents the maintenance category (Numbers 1-5) associated with the luminaire type, allocated to one field of the data file FILENM$.
LUMDIST	Represents the luminaire distribution type. The luminaire distribution may be direct, semi-direct, direct-indirect, semi-indirect, or indirect. The value assigned to LUMDIST is an integer value between 1 and 5.
LAMPLENGTH	Integer value representing the length of the lamp in feet. Value must be greater than or equal to 0 and less than 8.
ROW	Subscript for CU array, e.g.,CU(row,column).
COLUMN	Subscript for coefficient of utilization array, e.g., CU(row,column).
LAMPLIFE	Expected lamp life in hours: (User input).
OPERHRS	Lamp operating hours per year: (User input).
LLD!	Decimal value representing the lamp lumen depreciation factor, i.e., .70, .60, etc.: (User input).
LBO!	Value representing the lamp burn-out factor (decimal value of the number of bulbs expected to be burning at replacement time): (User input).

LAMPLUM	Integer value representing the initial lumens per lamp at installation time: (User input).
LAMP	Integer value representing the number of lamps per luminaire: (User input).
LAMPWATT	Value representing the wattage per lamp: (User input).
CUCORRECT$	String variable containing user's answer to yes or no type questions.
MAINTILLUM	Integer value representing the desired maintained illumination level in footcandles, i.e., 70, 60, 50, etc.: (User input).
LUMCOST!	The dollar cost per luminaire: (User input).
LUMINSTALL!	The installation cost per luminaire: (User input).
LUMEXIST	The number of existing luminaires (Retrofit System): (User input).
EXISTSP!	The maximum existing spacing of the luminaires.
ENERGYCOST!	$/KWH: (User input).
LAMPCOST!	The individual lamp cost: (User input).
LAMPLAB!	The labor cost per lamp installation: (User input).
ROOMSHAPE	The decision variable for the room shape selection screen.
ROOMWIDTH	The width of the room (ft): (User input).
ROOMLENGTH	The length of the room (ft): (User input).
MOUNTHT!	The fixture mounting height (ft) above the work plane: (User input).
ROOMRADIUS!	The radius (ft) of a circular room: (User input).
AREAPER!	The perimeter (ft) of an irregularly shaped room: (User input).

ROOMAREA	The area of the room (ft^2): (User input).
RCR!	The room cavity ratio for the room type being considered.
REFLECTWALL!	The decimal reflectivity value of the walls.
REFLECT CEILING!	The decimal reflectivity value of the ceiling.
CEILINGTYPE	Variable depicting the ceiling type, e.g., (1) horizontal, (2) nonhorizontal: (User input).
SURFACEMT	Variable depicting the method of luminaire mounting. (1) surface mounted or recessed, (2) not surface mounted or recessed: (User input).
BASEAREA	Ceiling or floor area (ft^2): (User input).
WALLAREA!	Ceiling cavity wall area (ft^2): (User input).
CEILINGL!	Ceiling cavity length (ft): (User input).
CEILINGW!	Ceiling cavity width (ft): (User input).
CAVITYD!	Ceiling or floor cavity depth in feet: (User input).
PCEFF!	The effective ceiling cavity reflectance.
A1	Area of the ceiling opening in sq. ft. (nonhorizontal ceilings): (User input).
A2	Area of ceiling surface (nonhorizontal ceiling - ft^2): (User input).

APPENDIX B

CALCULATIONS

Room Cavity Ratio (Rectangular Room)

$$= 5 \times (\text{Mounting Ht. Above the Work Plane}) \times \frac{(\text{Room Length} + \text{Room Width})}{(\text{Room Length}) \times (\text{Room Width})}$$

Room Cavity Ratio (Circular Room)

$$= (5 \times \text{Mounting Ht. Above the Work Plane})/(\text{Room Radius})$$

Room Cavity Ratio (Irregular Room)

$$= (2.5 \times \text{Area Perimeter})/(\text{Room Area})$$

Effective Cavity Reflectance - PCC (Rectangular Cavity)

$$= AB/AW\ PW(1 - F)^2 \times (1 + PBF)^2/1 - [1 - AB/AW(1 - F)]PW - AB/AW(1 - F)^2 PWPB$$

where

AB, AW = Area of the Cavity Base and Walls, respectively

PW, PB = Reflectance of Cavity Base and Walls, respectively

F = Radiative exchange factor between the cavity opening and the cavity base;

where

$$F = 2/\pi xy\ [Ln[(1 + x^2)(1 + y^2)/1 + x^2 + y^2]^{1/2} + y(1 + x^2)^{1/2} \tan^{-1}[y/(1 + x^2)^{1/2}] + (1 + y^2)^{1/2} \tan^{-1}[x/(1 + y^2)^{1/2}] - y\tan^{-1}(y) - x\tan^{-1}(x)]$$

where

$$x = \frac{\text{Cavity Length}}{\text{Cavity Depth}} \qquad y = \frac{\text{Cavity Width}}{\text{Cavity Depth}}$$

and the arc tangents are expressed in radians.

Effective Cavity Reflectance - PCC (Nonhorizontal Ceilings)

= pAo/As - pAs + pAO

where

Ao = Area of Ceiling Opening

As = Area of Ceiling Surface

p = Reflectance of Ceiling Surface

Luminaire Dirt Depreciation Factor (LDD)

= $e^{-A(t^B)}$

where

A and B are luminaire dirt depreciation constants and t is the luminaire cleaning interval in decimal years.

Room Surface Dirt Depreciation (RMSD)

Calculations utilized in determination of the room surface dirt depreciation factor are similar in concept to those used in extrapolation/interpolation of the CU value (see CU calculation)

Light Loss Factor (LLF)

= (Room Surface Dirt Depreciation Factor) x (Lamp Lumen Deprecation Factor) x (Lamp Burn-Out Factor) x (Luminaire Dirt Depreciation Factor)

Maintained Illumination Level (MAINTILLUM)

= (Number Luminaires x Number Lamps/Luminaire x Number Lumens/Lamp x CU x LLF)/Area of Room

Initial Illumination Level (INITILLUM)

= Maintained Illumination Level/LLF

Maximum Suggested Spacing for Uniform Lighting Levels (MAXSPACING)

= (Mounting Height of Luminaires Above the Work Plane) x (Maximum Spacing to Mounting Height Ratio)

Watts/Luminaire (LUMWATTS)

= (Watts/Lamp x Number Lamps/Luminaire) + Ballast Wattage

Total Number of Lamps (LAMPTOTAL)

= (Number Luminaires) x (Number Lamps/Luminaire)

Number Lumens/Luminaire (LUMUM)

= Number Lumens/Lamp x Number Lamps/Luminaire

Total Lamp Cost (TOTLAMPCOST)

= (Total Number of Lamps) x (Lamp Cost)

Total Lamp Installation Cost (LAMPLABCOST)

= (Total Number of Lamps Installed) x (Installation Cost/Lamp)

Total Luminaire Cost (TOTLUMCOST)

= (Number Luminaires Installed) x (Cost/Luminaire)

Total Luminaire Installation Cost (LUMLABCOST)

= (Total Number of Luminaires Installed) x (Installation Cost/Luminaire)

Total Material and Installation Cost (TOTALCOST)

= Total Lamp Cost + Total Luminaire Cost + Total Lamp Installation Cost + Total Luminaire Installation Cost

Annual Operating Cost

= (Energy Cost) x (Lamp Operating Hours/Year) x (Watts/Luminaire) x (Number Luminaires)/1000

Annual Lamp Replacement Cost

= (Lamp Life/Lamp Operating Hours/Year) x (Total Number of Lamps x Installation Cost/Lamp)

Total Operating Cost

= Annual Operating Cost + Annual Lamp Replacement Cost

Interpolation/Extrapolation Case Descriptions

The following is a presentation of the numerous cases that are considered by the software program in interpolating/extrapolating the CU values from the coefficient of utilization table.

Case Numbers	Case Descriptions
(1, 2)	Ceiling Reflectance = Table Value (e.g., 80, 70, 50, 30, 10). Wall Reflectance = Table Value (e.g., 50, 30, 10). RCR = 0, 1, 2, 3,...,10 or RCR < > 0, 1, 2, 3,...,10
(3, 4)	Ceiling reflectance = Table Value (e.g., 80, 70, 50, 30, 10). Wall Reflectance < > Table Value but between Table Values, e.g., between 50, 30, and 10. RCR = 0, 1, 2, 3,...,10 or RCR < > 0, 1, 2, 3,...,10.
(5, 6)	Ceiling Reflectance = Table Value, Wall Reflectance < > Table Value and outside Table Values, e.g., 50 and 10.
(7, 8)	Ceiling Reflectance < > Table Value, Wall Reflectance = Table Value, e.g., 50, 30, 10. RCR = 0, 1, 2, 3,...,10 or RCR < > 0, 1, 2, 3,...,10.
(9, 10)	Ceiling Reflectance < > Table Value, Wall Reflectance < > Table Value but between Table Values, e.g., between 50, 30, and 10. RCR = 0, 1, 2, 3,...,10 or RCR < > 0, 1, 2, 3,...,10.

(11, 12) Ceiling Reflectance < > Table Value, Wall Reflectance < > Table Value and outside Table Values, e.g., outside 50 and 10. RCR = 0, 1, 2, 3,...,10 or RCR < > 0, 1, 2, 3,...,10.

To aid the user in understanding how the interpolation/extrapolation program operates (utilizes three-way double interpolations in worst case scenario, e.g., ceiling and wall reflectance not equal to tabular value, row value not equal to tabular value), the following example calculations are presented.

Basic Calculation - Case #3 (Integer RCR Value)

XDIFF! (Difference between the RCR value and the lower datum point[1] (integer value $\leq$ 10) bounding the RCR value) = RCR (Room Cavity Ratio) - X(I)

XSTO1 Lower row value bounding the RCR value in the CU table.

XSTO2 Higher row value bounding the RCR value in the CU table.

STO1 Lower (column-wise) bounding datum point for the calculated wall reflectance value.

STO2 Higher (column-wise) bounding datum point for the calculated wall reflectance value.

PCW Wall reflectance value.

---

[1]Datum refers to the tabular row and column heading in the CU table, e.g., RCR integer values, ceiling reflectivity heading values, and wall reflectivity table heading values.

YDIFF! A fraction representing the difference between the calculated wall reflectance value and the higher (column-wise) bounding datum point divided by the difference between the bounding datum points.

CU1! CU(XSTO1, STO1); Represents the higher (number-wise) CU value associated with the lower row value bounding the RCR value and the lower (column-wise) bounding datum point.

CU2! CU(XSTO1, STO2); Represents the lower (number-wise) CU value associated with the lower row value bounding the RCR value and the upper (column-wise) bounding datum point.

CUH! CU value for the lower row value bounding the RCR value.

CU = CUH! if XSTO2 (higher row value) = 0.

= CU1! - YDIFF x (CU1! - CU2!)

Case #4 (Non-integer RCR Value ≤ 10)

Note: Variables/equations presented in Case #3 apply. Also, XSTO2 is not equal to zero[1].

CUH = CU1! - YDIFF x (CU1! - CU2!): (Reference previous discussion)

CUL = CU1! - YDIFF! x (CU1! - CU2!)

---

[1]XSTO2 was equal to zero in Case #3 since the RCR was an integer value. XSTO1 in Case #3 represented the row value associated with the integer RCR. However, in Case #4 the RCR value is not an integer but falls between integer RCR values.

where

CU1 and CU2 represent the CU values associated with the higher row value bounding the RCR value in the CU table. CU2 represents the CU value associate with the higher row value bounding the RCR value.

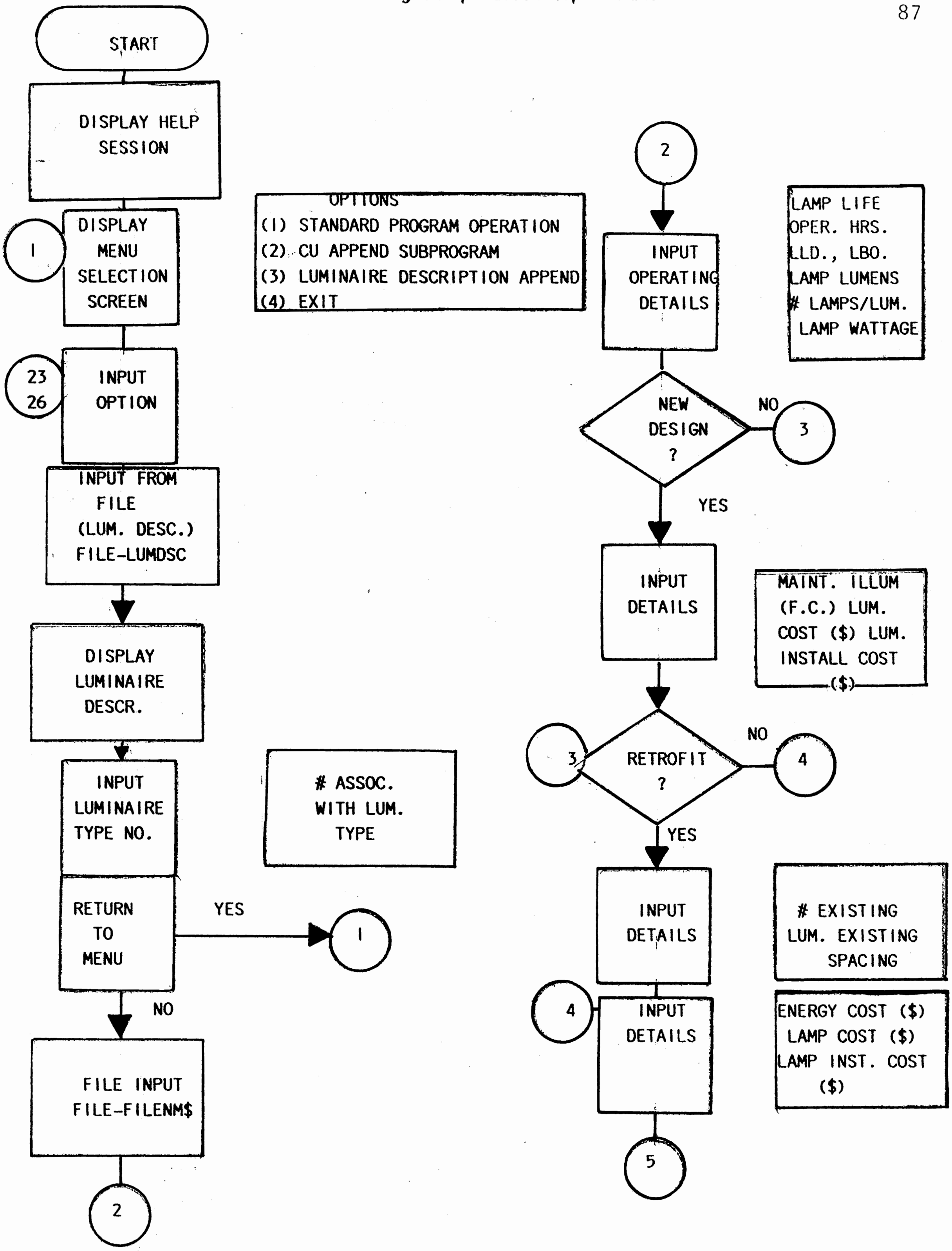
CU = A double interpolated value associated with the luminaire and room characteristics being considered.

= CUH! - XDIFF! x (CUH! - CUL!)

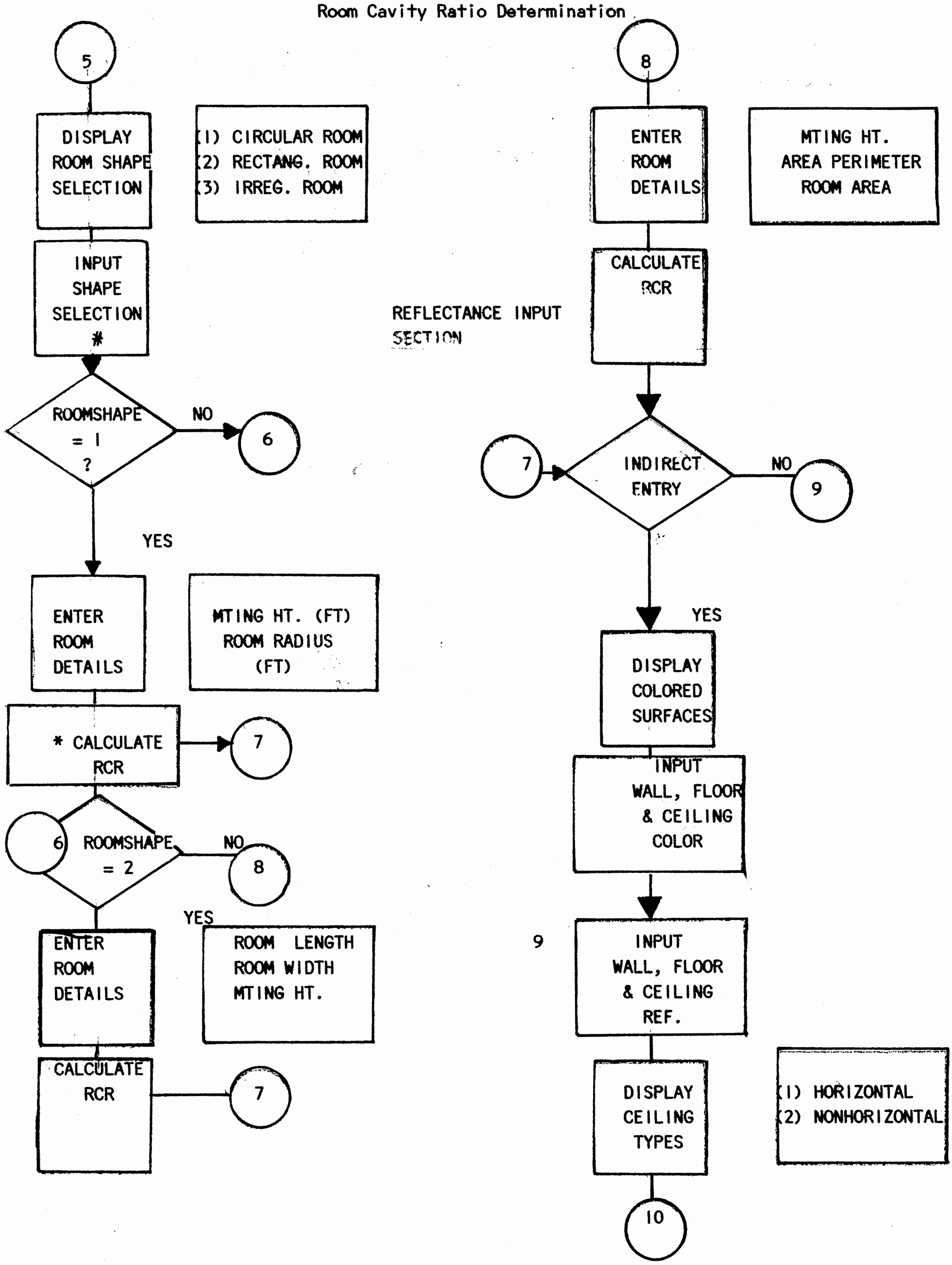
APPENDIX C

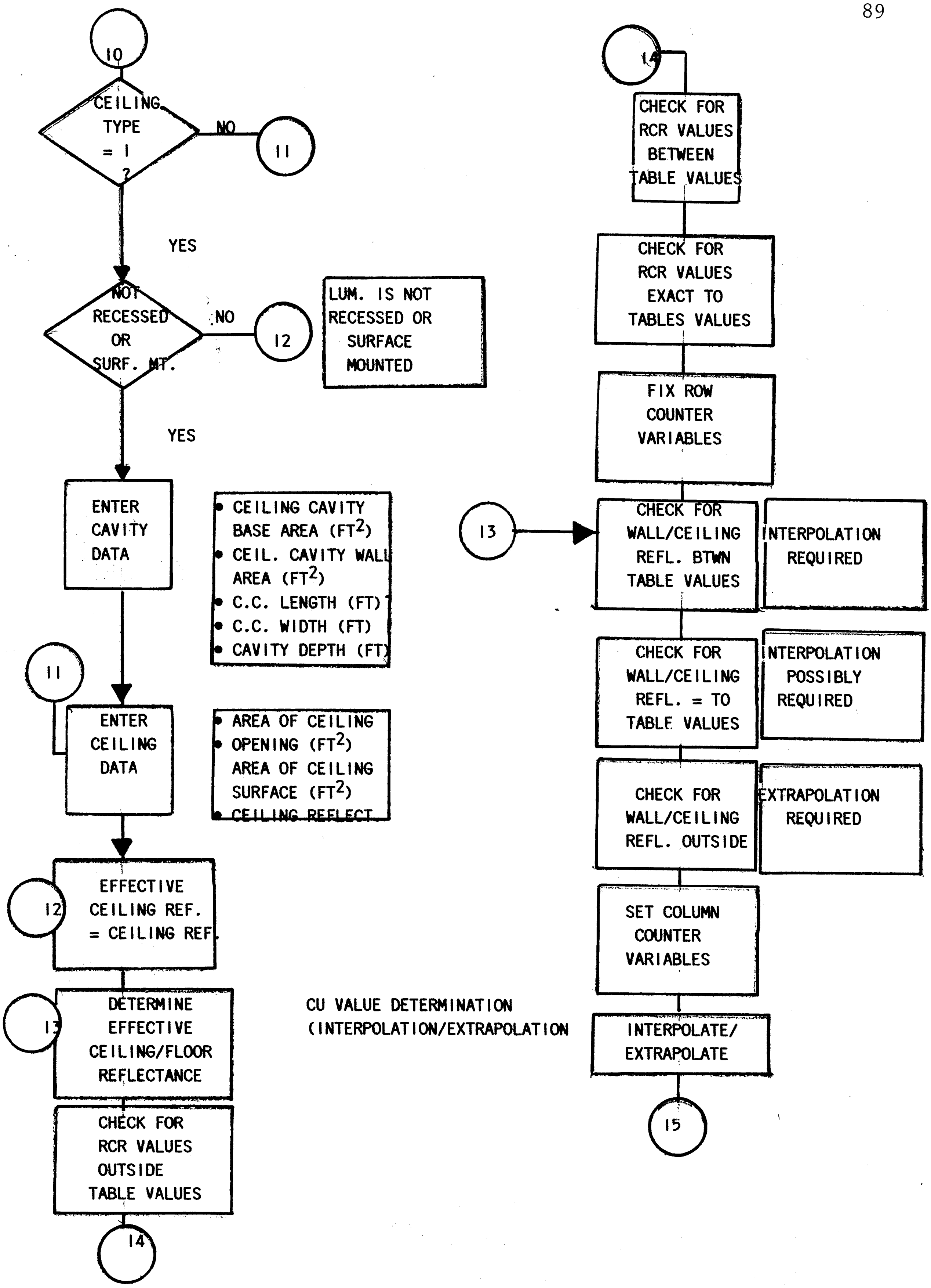
PROGRAM FLOWCHART AND PROGRAM LISTING

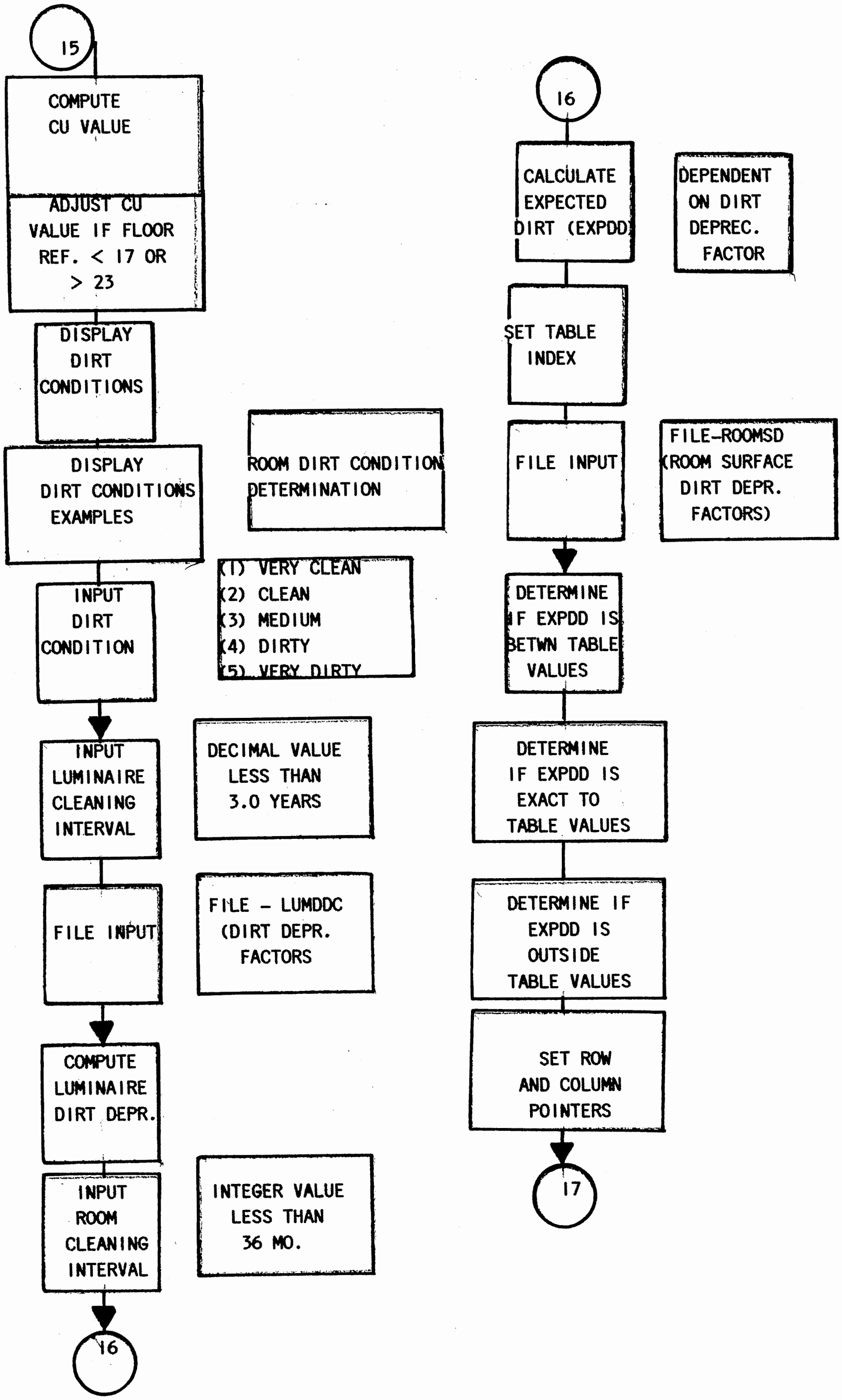
Standard Program Operation (Option #1)

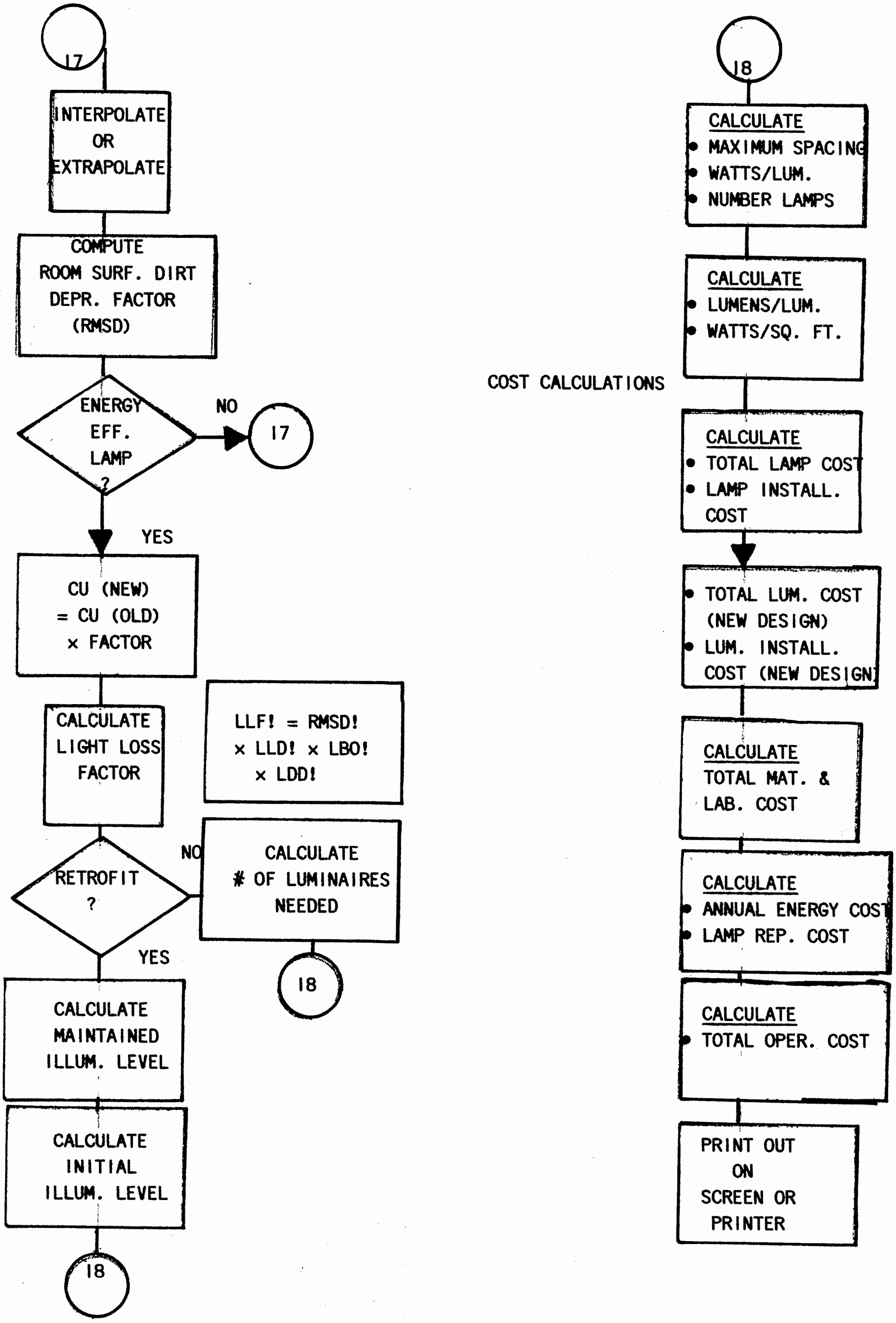


Room Cavity Ratio Determination

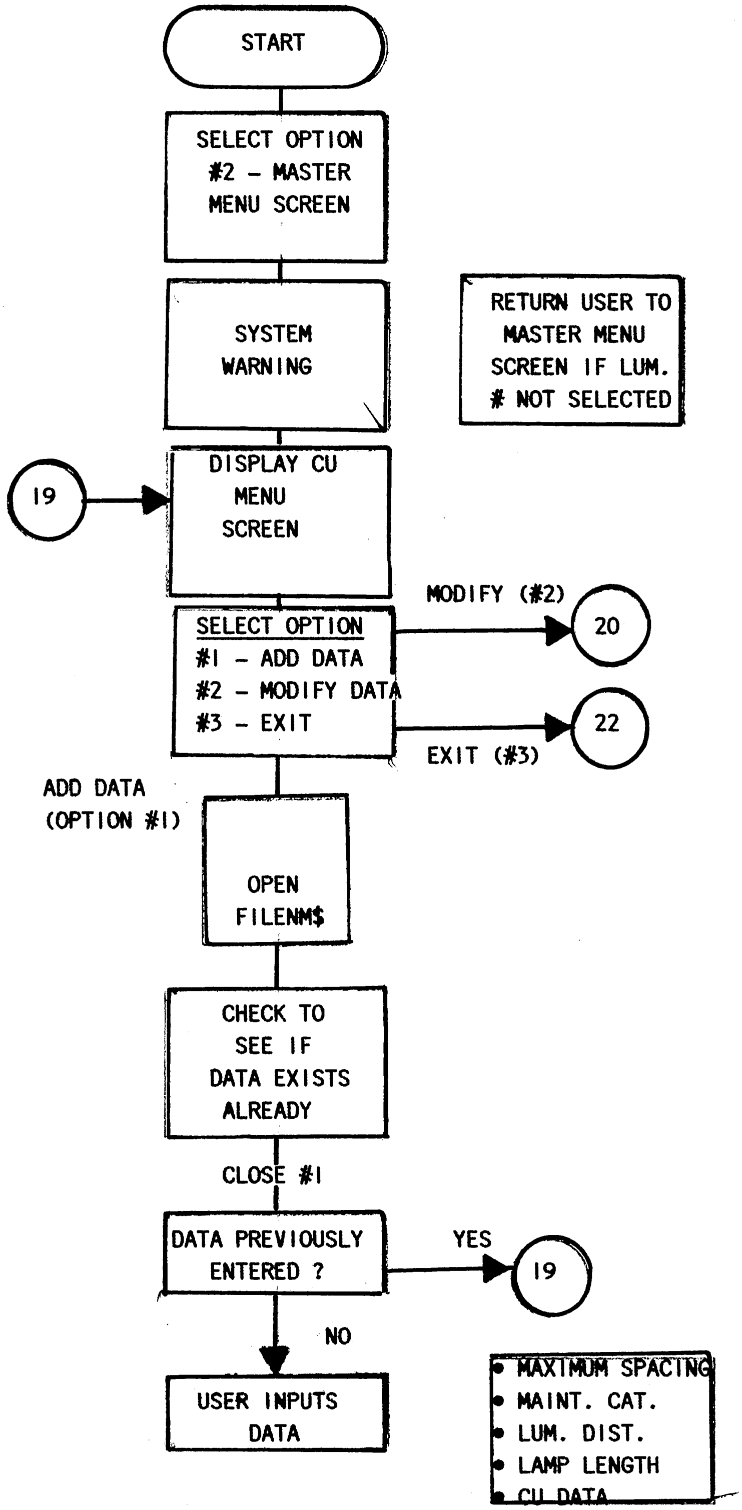



10
CEILING TYPE = 1 ?
NO
11
YES
NOT RECESSED OR SURF. MT.
NO
12
LUM. IS NOT RECESSED OR SURFACE MOUNTED
YES
ENTER CAVITY DATA
• CEILING CAVITY BASE AREA (FT2)
• CEIL. CAVITY WALL AREA (FT2)
• C.C. LENGTH (FT)
• C.C. WIDTH (FT)
• CAVITY DEPTH (FT)
11
ENTER CEILING DATA
• AREA OF CEILING
• OPENING (FT2)
AREA OF CEILING SURFACE (FT2)
• CEILING REFLECT.
12
EFFECTIVE CEILING REF. = CEILING REF.
13
DETERMINE EFFECTIVE CEILING/FLOOR REFLECTANCE
CHECK FOR RCR VALUES OUTSIDE TABLE VALUES
14
CU VALUE DETERMINATION (INTERPOLATION/EXTRAPOLATION
14
CHECK FOR RCR VALUES BETWEEN TABLE VALUES
CHECK FOR RCR VALUES EXACT TO TABLES VALUES
FIX ROW COUNTER VARIABLES
13
CHECK FOR WALL/CEILING REFL. BTWN TABLE VALUES
INTERPOLATION REQUIRED
CHECK FOR WALL/CEILING REFL. = TO TABLE VALUES
INTERPOLATION POSSIBLY REQUIRED
CHECK FOR WALL/CEILING REFL. OUTSIDE
EXTRAPOLATION REQUIRED
SET COLUMN COUNTER VARIABLES
INTERPOLATE/ EXTRAPOLATE
15

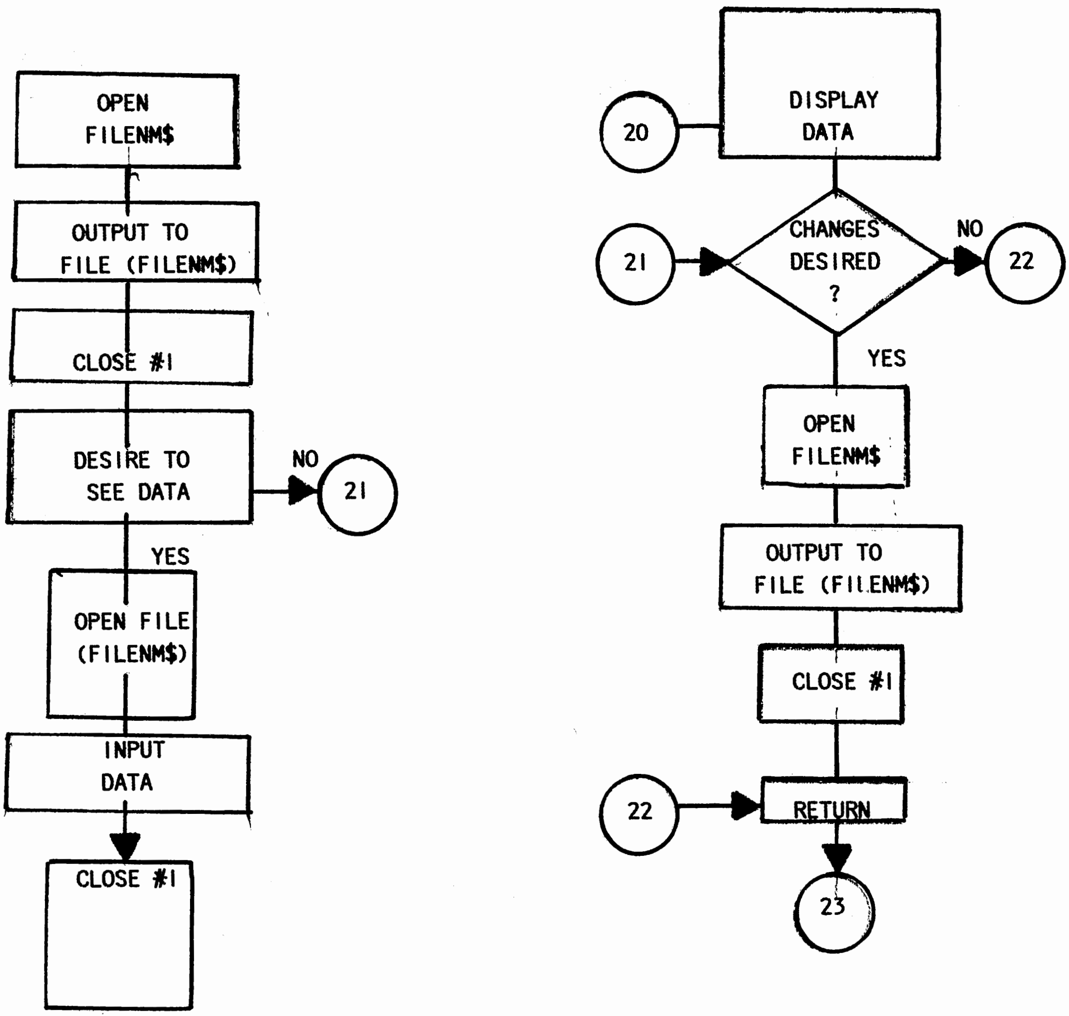

15
COMPUTE CU VALUE
ADJUST CU VALUE IF FLOOR REF. < 17 OR > 23
DISPLAY DIRT CONDITIONS
DISPLAY DIRT CONDITIONS EXAMPLES
ROOM DIRT CONDITION DETERMINATION
INPUT DIRT CONDITION
(1) VERY CLEAN
(2) CLEAN
(3) MEDIUM
(4) DIRTY
(5) VERY DIRTY
INPUT LUMINAIRE CLEANING INTERVAL
DECIMAL VALUE LESS THAN 3.0 YEARS
FILE INPUT
FILE – LUMDDC (DIRT DEPR. FACTORS
COMPUTE LUMINAIRE DIRT DEPR.
INPUT ROOM CLEANING INTERVAL
INTEGER VALUE LESS THAN 36 MO.
16
16
CALCULATE EXPECTED DIRT (EXPDD)
DEPENDENT ON DIRT DEPREC. FACTOR
SET TABLE INDEX
FILE INPUT
FILE-ROOMSD (ROOM SURFACE DIRT DEPR. FACTORS)
DETERMINE IF EXPDD IS BETWN TABLE VALUES
DETERMINE IF EXPDD IS EXACT TO TABLE VALUES
DETERMINE IF EXPDD IS OUTSIDE TABLE VALUES
SET ROW AND COLUMN POINTERS
17


17
INTERPOLATE OR EXTRAPOLATE
COMPUTE ROOM SURF. DIRT DEPR. FACTOR (RMSD)
ENERGY EFF. LAMP ?
NO
17
YES
CU (NEW) = CU (OLD) x FACTOR
CALCULATE LIGHT LOSS FACTOR
LLF! = RMSD! x LLD! x LBO! x LDD!
RETROFIT ?
NO
CALCULATE # OF LUMINAIRES NEEDED
18
YES
CALCULATE MAINTAINED ILLUM. LEVEL
CALCULATE INITIAL ILLUM. LEVEL
18
COST CALCULATIONS
18
CALCULATE
• MAXIMUM SPACING
• WATTS/LUM.
• NUMBER LAMPS
CALCULATE
• LUMENS/LUM.
• WATTS/SQ. FT.
CALCULATE
• TOTAL LAMP COST
• LAMP INSTALL. COST
• TOTAL LUM. COST (NEW DESIGN)
• LUM. INSTALL. COST (NEW DESIGN)
CALCULATE TOTAL MAT. & LAB. COST
CALCULATE
• ANNUAL ENERGY COST
• LAMP REP. COST
CALCULATE
• TOTAL OPER. COST
PRINT OUT ON SCREEN OR PRINTER

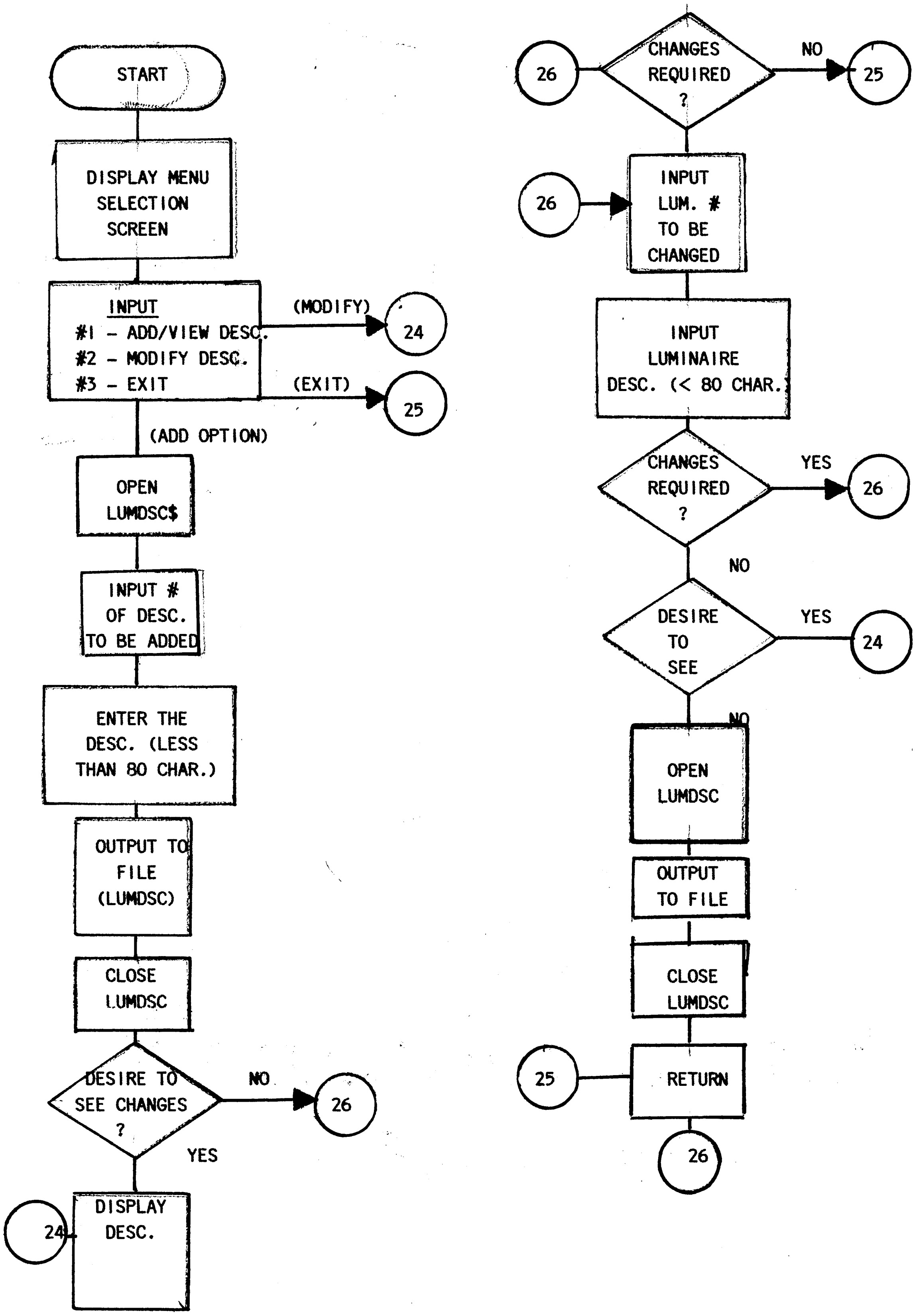
Coefficient of Utilization Append Subprogram (Option #2)



Coefficient of Utilization (Continued)



Luminaire Description Append



```
10        '*****************************************************************
20        '* THIS SOFTWARE SECTION(THE HELP SESSION WILL AID THE USER IN    *
30        '* ACCOMPLISHING THE PROGRAM OBJECTIVES HE/SHE HAS IN MIND IN A   *
40        '* REASONABLY EFFICIENT AND EFFECTIVE MANNER                      *
50        '*****************************************************************
60    CLS:'**********HELP SECTION**********
70    PRINT TAB(26)"*WELCOME TO THE HELP SESSION*"
80    PRINT:PRINT
90    PRINT"@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@@@@@@@@@@"
100   PRINT TAB(26)"PURPOSE:TO PROVIDE THE USER WITH A DESIGNATED PATHWAY FOR TH
E ACCOMPLISHMENT OF THE PROGRAM GOALS OR OBJECTIVES HE/SHE HAS IN MIND IN A REAS
ONABLY EFFICIENT MANNER"
110   PRINT"@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@@@@@@@@@@@@"
120   PRINT"DO YOU DESIRE TO CONTINUE IN THE HELP SESSION OR DO YOU DESIRE TO PR
OCEED TO THE LIGHT DESIGN SOFTWARE"
130   PRINT:PRINT"TYPE 1 AND HIT THE ENTER KEY IF YOU DESIRE TO CONTINUE IN THE
HELP SESSION.TYPE 2 AND HIT THE ENTER KEY IF YOU DESIRE TO PROCEED TO THE LIGHT
DESIGN SOFTWARE"
140   INPUT DIRECT
150   IF DIRECT=1 THEN GOTO 160  ELSE GOTO  470
160   FOR I=1 TO 1000:PAUSE=1+I:NEXT I:CLS
170   PRINT "PROGRAM OBJECTIVE                PATH DESCRIPTION":PRINT
180   PRINT"TO VEIW LUMINAIRE DESCRIPTIONS---SELECT OPTION#1 OR OPTION#3 FROM TH
E MASTER "
190   PRINT TAB(34)"MENU SCREEN.VEIW LUMINAIRE DESCRIPTIONS."
200   PRINT TAB(34)"RETURN TO MASTER MENU SCREEN"
210   PRINT
220   PRINT"TO ADD LUMINAIRE DESCRIPTIONS----SELECT OPTION #3 FROM THE MASTER ME
NU SCREEN."
230   PRINT TAB(34)"RETURN TO MASTER MENU SCREEN:SELECT NEW OPTION":PRINT
240   PRINT"TO MODIFY LUMINAIRE DESCRIPTIONS-SELECT OPTION #3 FROM THE MASTER ME
NU SCREEN"
250   PRINT TAB(34)"MODIFY DESCRIPTION RETURN TO MASTER MENU"
260   PRINT TAB(34)"SCREEN.SELECT NEW OPTION":PRINT
270   PRINT:PRINT:PRINT TAB(15)"*PERUSE THE OPTIONS/PATHWAYS.TO CONTINUE HIT ANY
 KEY*"
280   J$=INKEY$
290   IF J$="" THEN GOTO 280 ELSE GOTO 300
300   CLS:LOCATE 8,1
310   PRINT"TO ADD LUMINAIRE DATA(CU VALUES--SELECT OPTION #1 TO VEIW LUM.DESCRI
PTIONS"
320   PRINT"MAINT.CATEGORY,S/MH RATIO,LIGHT AND TO SELECT LUMINAIRE#.RETURN TO M
ASTER MENU"
330   PRINT"DISTRIBUTION)                     SCREEN.SELECT OPTION #2.***WARNING**
*DO NOT"
340   PRINT"                                  ADD DATA(OPTION#2)UNLESS LUM.# HAS B
EEN SELECTED":PRINT
350   PRINT"TO MODIFY LUMINAIRE DATA--------SELECT OPTION#1.SELECT LUMINAIRE#.SE
LECT "
360   PRINT"                                  OPTION#2.MODIFY DATA.RETURN TO MASTE
R MENU."
370   PRINT"                                  SCREEN.SELECT NEW OPTION":PRINT
380   PRINT"TO PERFORM LUMINAIRE ANALYSIS---SELECT OPTION#1.SELECT LUM.# AND PRO
CEED"
390   PRINT"ON LUM./LAMP COMBINATION"
400   PRINT"AND OBTAIN OUTPUT REPORT"
410   PRINT:PRINT
420   PRINT"REVEIW THE OBJECTIVES TO FIND THE APPROPRIATE PATHWAY.IF YOU DESIRE
TO REVEIW FURTHER TYPE 1 IF NOT TYPE 2"
430   INPUT RESUM
440   IF RESUM <>1 AND RESUM <>2 THEN GOTO 420
450   IF RESUM = 1 THEN GOTO 160
460   IF RESUM = 2 THEN GOTO 470
```

```
470   CHAIN "main1"
480        KEY OFF:'SONATA .B11
490       'BEETHHOVEN'S MOONLIGHT
500       PLAY "MFMNL16T160P1P1 "
510       PLAY "O1P16G+O2C+EG+C+EG+O3C+O2EG+O3C+EO2G+O3C+E"
520       PLAY"O3G+C+EG+O4C+O3EG+O4C+EO3MLG+O4C+EMSG+8G+8MN"
530       PLAY"O1P16G+O2CD+G+CD+G+O3CO2D+G+O3CD+O2G+CD+"
540       PLAY"O3G+CD+G+O4CO3D+G+O4CD+O3MLG+O4CD+MSG+8G+8MN"
550       PLAY"O2C+FG+O3C+O2FG+O3C+FO2G+O3C+FG+C+FG+"
560       PLAY"O4C+O3FG+O4C+FO3G+O4C+FG+MLC+FG+O5MSC+8C+8MN"
570       PLAY"O2P16MLC+F+AO3MSC+MLC+F+AO4MSC+MLC+F+AO5MSC+8C+8MN"
580       PLAY"O2P16MLC+EGO3MSC+MLC+EGO4MSC+MLC+EGO5MSC+8C+8MN"
590      COLOR 1,5:CLS
600      DIM Y(15),K(20),L(3),X(11),CU!(11,15),COLR!(24),LUMDESC$(100),RSD!(10,20
),ADJ!(10,12),Z(12)
610       TESTFLAG=0
620   PRINT"                  ***************************************"
630   PRINT"                  *AN INTERACTIVE LIGHTING DESIGN PROGRAM*"
640   PRINT"                  *                                     * "
650   PRINT"                  *              BY                     *"
660   PRINT"                  *                                     *"
670   PRINT"                  *          RICK WHITNEY               *"
680   PRINT"                  *                                     *"
690   PRINT"                  *      MASTER'S  (1985)  REPORT       *"
700   PRINT"                  ***************************************"
710      FOR I = 1 TO 1000
720              PAUSE=I*12+14
730      NEXT I
740      CLS
750 '      THIS PROGRAM WILL AID THE NOVICE LIGHTING DESIGNER IN SELECTING A
760 '      COST EFFICIENT LUMINAIRE/LAMP SYSTEM THAT WILL PROVIDE AN AVERAGE
770 '      MAINTAINED ILLUMINATION LEVEL CORRESPONDENT WITH THE LIGHTING LEVEL
780 '      REQUIREMENTS OF THE AREA TO BE ILLUMINATED.THE PROGRAM WILL ALLOW
790 '      THE USER TO ANALYZE EXISTING GENERAL LIGHTING SYSTEMS OR AID THE
800 '      USER IN DESIGNING NEW SYSTEMS.
810      PRINT"                             FOREWORD"
820      PRINT"          THIS PROGRAM WILL AID THE DESIGNER IN SELECTING A COST EF
FICIENT"
830      PRINT"          LUMINAIRE/LAMP COMBINATION SYSTEM THAT WILL PROVIDE AN AV
ERAGE "
840      PRINT"          MAINTAINED ILLUMINATION LEVEL CORRESPONDENT WITH THE LIGH
TING LEVEL"
850      PRINT"          REQUIREMENTS OF THE AREA TO BE ILLUMINATED.THE PROGRAM WI
LL AID THE"
860      PRINT"          USER TO ANALYZE EXISTING  GENERAL LIGHTING SYSTEMS OR AID
 THE USER"
870      PRINT"          IN DESIGNING NEW SYSTEMS"
880      PRINT:PRINT
890      PRINT TAB(18)"TO CONTINUE FORWARD IN EVALUATION-HIT ANY KEY"
900      L$=INKEY$
910      IF L$= "" THEN GOTO 900 ELSE GOTO 920
920      PRINT:PRINT:CLS:LOCATE 10,1
930       MD=1:TESTFLAG=0
940       CLS:LOCATE 8,1
950       IF MD<>1 AND MD<>2 AND MD<>3 AND MD<>4 THEN PRINT"PLEASE REENTER SELECT
ION"
960       CLS:PRINT TAB(26) "A DESIGN LIGHTING MENU SCREEN"
970       PRINT:PRINT
980       PRINT TAB(21) "***************************************"
990       PRINT TAB(21) "*-#1-STANDARD PROGRAM OPERATION       *"
1000       PRINT TAB(21) "*                                    *"
1010       PRINT TAB(21) "*-#2-LUMINAIRE COEFFICIENTS OF UTILIZ *"
1020       PRINT TAB(21) "*----ATION APPEND                     *"
1030       PRINT TAB(21) "*                                    *"
1040       PRINT TAB(21) "*-#3-LUMINAIRE DESCRIPTION FILE APPEND*"
1050       PRINT TAB(21) "*                                    *"
1060       PRINT TAB(21) "*-#4-EXIT                             *"
1070       PRINT TAB(21) "***************************************"
1080       PRINT
```

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090        PRINT:PRINT:PRINT TAB(15) CHR$(7)"PLEASE INPUT NUMBER OF SELECTION :I.
E.,#1-4"
1100       PRINT
1110 '      PROGRAMMING TO DETERMINE SELECTION
1120       PRINT
1130       PRINT TAB(15):INPUT MD
1140       IF MD<>1 AND MD<>2 AND MD<>3 AND MD<>4 THEN PRINT "# SELECTION IS NOT"
:         "LOGICAL SELECTION ALTERNATIVE-PLEASE TRY AGAIN"
1150       IF MD<>1 AND MD<>2 AND MD<>3 AND MD <>4 THEN GOTO 940
1160       PRINT:PRINT
1170      ON MD GOSUB 1220,9800,11490,1220
1180      PRINT "DESIRE TO ANALYZE ANOTHER LAMPING SYSTEM OR CONTINUE,E.G.,TRANSF
ER CONTROL TO   THE MASTER MENU SCREEN:Y/N"
1190      INPUT REITERATE$
1200      IF REITERATE$ ="N" THEN END ELSE GOTO 620
1210 '     STANDARD PROGRAM OPERATION-LUMINAIRE DESCRIPTION PRESENTATION
1220      N=0
1230 '     OPEN THE LUMINAIRE DESCRIPTION FILE
1240      OPEN "A:LUMDSC" FOR INPUT AS #1
1250 '     SET THE MAXIMUM # OF ROWS IN THE FILE TO 100
1260 '     MAY BE CHANGED IF LARGER # OF ROWS NEEDED.
1270      FOR J= 1 TO 100          'READ THE FILE INTO AN ARRAY
1280              IF EOF(1) THEN 1320
1290              LINE INPUT#1,LUMDESC$
1300              LUMDESC$(J)=LUMDESC$
1310      NEXT J
1320      CLOSE #1:COLOR 8,15:CLS
1330      PRINT:PRINT
1340      '
1350 '     DISPLAY THE LUMINAIRE SCREEN FOR USER SELECTION
1360      PRINT TAB(29) "LUMINAIRE MENU SCREEN"
1370     CLS:N=0
1380      PRINT TAB(29)" *********************"
1390      PRINT "LUM#"TAB(28)"LUMINAIRE DESCRIPTION"
1400      PRINT
1410                          OBSERVE =0
1420      FOR K=1 TO J-1
1430              PRINT "#"K;
1440     PRINT TAB(7) LEFT$(LUMDESC$(K),65)
1450     PRINT TAB(7) MID$(LUMDESC$(K),66,80)
1460              N=N+1
1470              IF N<>8 THEN GOTO 1560
1480              IF N=8 THEN PRINT"REVIEW THE SCREEN FOR POSSIBLE LUMINAIRE SELE
CTION -OBSERVE THE LUMINAIRE # DESIRED.TYPE 1 TO CONTINUE"
1490              IF N=8 THEN INPUT OBSERVE
1500              IF N=8 AND OBSERVE =1 THEN GOTO 1510 ELSE GOTO 1480
1510              IF N=8 THEN PRINT"DO YOU DESIRE TO ENTER THE LUMINAIRE# AT THIS
  TIME OR WOULD YOU PREFER TO SEE  THE  REMAINDER OF THE DESCRIPTIONS"
1520              IF N=8 THEN PRINT"TYPE 1 FOR ENTRY AND 2 FOR FURTHER REVEIW":IN
PUT DES
1530              IF N=8 AND DES =1 THEN GOTO 1570
1540              IF N=8 THEN CLS
1550              IF N=8 THEN N=0
1560      NEXT K
1570 '     SELECTION OF THE LUMINAIRE TYPE
1580     PRINT:PRINT"IF YOU DESIRE TO SEE THE LUMINAIRE DESCRIPTIONS AGAIN HIT AN
Y KEY WITHIN 5 SECONDS  OTHER WISE INPUT THE LUMINAIRE # UPON THE PROMPT."
1590     FOR I= 1 TO 1000
1600     D$=INKEY$
1610             IF D$="" THEN GOTO 1620 ELSE GOTO 1370
1620     NEXT I
1630      PRINT:INPUT LUMNO
1640      IF LUMNO<1 OR LUMNO>J THEN PRINT"YOU HAVE ENTERED AN INFEASIBLE LUM.#.R
ETYPE PLEASE"
```

```
1650     IF LUMNO <1 OR LUMNO >J THEN GOTO 1580
1660 '            STANDARD PROGRAM OPERATION-FILE ENTRY OF LUMINAIRE DETAILS I.E
.    '            MAINTENACE CATEGORY,LUM.DIST.,MAX SP/MH,LAMPLENGTH
1670    TESTFLAG=1
1680    PRINT:PRINT
1690    PRINT"DO YOU DESIRE TO RETURN TO THE MENU SCREEN(TO ENTER LUMINAIRE DATA
 OR TO ENTER A LUMINAIRE DESCRIPTION OR TO EXIT?):Y/N"
1700     INPUT DES$
1710     IF DES$="N" THEN GOTO 1720 ELSE GOTO 960
1720     COLOR 4,7:CLS
1730     LOCATE 1,12
1740     MAIN$="LUMEN"
1750    L=LEN(STR$(LUMNO))
1760    LUMNO$=STR$(LUMNO)
1770    LUMNO$=MID$(LUMNO$,2,L-1)
1780    FILENM$=MAIN$+LUMNO$
1790     OPEN FILENM$ FOR INPUT AS #1
1800     WHILE NOT EOF(1)
1810    INPUT#1,MAXSP,MAINTCAT,LUMDIST,LAMPLENGTH
1820 '            READ IN LUMINAIRE VALUES
1830     FOR ROW=1 TO 11
1840             FOR COLUMN =1 TO 15
1850                     INPUT #1,CU!(ROW,COLUMN)
1860             NEXT COLUMN
1870     NEXT ROW
1880     WEND
1890     CLOSE #1
1900 '     STANDARD PROGRAM OPERATION
1910     PRINT TAB(26)"LAMP OPERATING DETAIL ENTRY"
1920     PRINT TAB(26)"----------------------------"
1930     PRINT:PRINT
1940     INPUT"PLEASE ENTER THE LAMP'S LIFE IN HOURS-#ONLY";LAMPLIFE
1950     PRINT "PLEASE ENTER THE LAMP OPERATING HRS. PER YEAR-NUMBER ONLY PLEASE
"
1960     INPUT OPERHRS
1970     IF OPRHRS <0 THEN PRINT"INVALID ENTRY"
1980     IF OPERHRS <0 THEN GOTO 1950
1990     PRINT "PLEASE ENTER THE LAMP LUMEN DEPRECIATION FACTOR(LLD)"
2000     PRINT "AT 70% OF THE USEFUL LIFE OF THE BULB - DECIMAL FORM PLEASE-"
2010     PRINT"IE...80,.70 ETC.":INPUT LLD!
2020     IF LLD!<0 OR LLD!>1 THEN PRINT"INVALID DATA ENTRY"
2030     IF LLD!<0 OR LLD!>1 THEN GOTO 1990
2040     PRINT "PLEASE ENTER THE DECIMAL VALUE OF THE NUMBER OF BULBS EXPECTED";
            "TO BE BURNING AT REPLACEMENT TIME(70% OF USEFUL LIFE.EG...97, ";
            ".85,ETC.":INPUT LBO!
2050     IF LBO!<0 OR LBO!>1 THEN PRINT"INVALID DATA ENTRY"
2060     IF LBO!<0 OR LBO!>1 THEN GOTO 2040
2070     PRINT "ENTER THE INITIAL LUMENS PER LAMP-NUMBER ONLY PLEASE"
2080     INPUT LAMPLUM
2090     IF LAMPLUM <0 THEN PRINT"INVALID DATA ENTRY"
2100     IF LAMPLUM<0 THEN GOTO 2070
2110     PRINT "ENTER THE # OF LAMPS PER LUMINAIRE-NUMBER ONLY PLEASE"
2120     INPUT LAMP
2130     IF LAMP<1 THEN PRINT "INVALID DATA ENTRY"
2140     IF LAMP<1 THEN GOTO 2110
2150     CLS
2160     PRINT "ENTER THE WATTAGE PER LAMP-# ONLY PLEASE":INPUT LAMPWATT
2170     IF LAMPWATT<0 THEN PRINT"INVALID DATA ENTRY"
2180     IF LAMPWATT<0 THEN GOTO 2160
2190     PRINT "ENTER THE BALLAST WATTAGE/LUMINAIRE-NUMBER ONLY PLEASE-";
            "IF ZERO INPUT 0":INPUT BALLAST
2200     IF BALLAST <0 THEN PRINT"INVALID ENTRY"
2210     PRINT  "IS THE DESIGN BEING CONSIDERED A NEW DESIGN-Y/N"
2220     INPUT CUCORRECT$
2230     IF CUCORRECT$ <>"Y" AND CUCORRECT$ <>"N" THEN PRINT "IMPROPER"
```

```
        "SELECTION ENTRY-TRY AGAIN PLEASE"
2240    IF CUCORRECT$ <> "Y" AND CUCORRECT$ <> "N" THEN GOTO 2210
2250    IF CUCORRECT$="N" THEN DESIGN=2 ELSE DESIGN=1
2260    IF CUCORRECT$ ="N" THEN GOTO 2380
2270    PRINT"ENTER THE DESIRED MAINTAINED ILLUMINATION LEVEL IN FOOTCANDLES":
                    "(NUMBER ONLY)-EG., 70,60,50 ETC."
2280    INPUT MAINTILLUM
2290    IF MAINTILLUM<1 OR MAINTILLUM>100 THEN PRINT"INVALID ENTRY"
2300    IF MAINTILLUM<1 OR MAINTILLUM>100 THEN GOTO 2270
2310    PRINT"ENTER THE DOLLAR COST PER LUMINAIRE - NUMBER ONLY PLEASE":
              "-NUMBER ONLY" :INPUT LUMCOST!
2320    IF LUMCOST!<0 THEN PRINT "INVALID ENTRY"
2330    IF LUMCOST!<0 THEN GOTO 2310
2340    PRINT  "ENTER THE INSTALLATION COST PER LUMINAIRE-NUMBER ONLY"
2350    INPUT LUMINSTALL!
2360    IF LUMINSTALL!<0 THEN PRINT"INVALD DATA ENTRY"
2370    IF LUMINSTALL!<0 THEN GOTO 2340
2380    IF CUCORRECT$="Y" THEN GOTO 2450
2390    PRINT "ENTER THE NUMBER OF EXISTING LUMINAIRESIN THE AREA ":
              "BEING CONSIDERED FOR RETROFIT-NUMBER ONLY ":INPUT LUMEXIST
2400    IF LUMEXIST<0 THEN PRINT"INVALID DATA ENTRY"
2410    IF LUMEXIST<0 THEN GOTO 2390
2420    PRINT "ENTER THE MAXIMUM EXISTING SPACING OF THE LUMINAIRES ":
              "IN FEET-NUMBER ONLY":INPUT EXISTSP!
2430    IF EXISTSP!<0 OR EXISTSP!=0 THEN PRINT"INVALID ENTRY"
2440    IF EXISTSP!<0 OR EXISTSP!=0 THEN GOTO 2420
2450    PRINT "ENTER THE ENERGY COST-$/KWH-NUMBER ONLY PLEASE"
2460    INPUT ENERGYCOST!
2470    IF ENERGYCOST!<0 THEN PRINT"INVALID ENTRY"
2480    IF ENERGYCOST!<0 THEN GOTO 2450
2490    CLS
2500    PRINT  "ENTER THE COST PER LAMP IN DOLLARS-NUMBER ONLY"
2510    INPUT LAMPCOST!
2520    PRINT "ENTER THE LABOR COST PER LAMP INSTALLATION IN DOLLARS":
              "NUMBER ONLY PLEASE" :INPUT LAMPLAB!
2530 '           ROOM CAVITY RATIO DETERMINATION
2540    CLS
2550    LOCATE 1,12
2560    PRINT TAB(14)"THE FOLLOWING PROGRAMMING SECTION WILL DETERMINE THE ":
        TAB(14) "ROOM CAVITY RATIO FOR THE AREA UNDER CONSIDERATION"
2570    PRINT:PRINT
2580   PRINT TAB(26)"********************************"
2590    PRINT TAB(26)"*A ROOM SHAPE SELECTION SCREEN*"
2600   PRINT TAB(26)"*                              *"
2610   PRINT TAB(26)"*                              *"
2620    PRINT TAB(26)"*     #1--CIRCULAR ROOM        *"
2630    PRINT TAB(26)"*                              *"
2640    PRINT TAB(26)"*     #2--RECTANGULAR ROOM     *"
2650    PRINT TAB(26)"*                              *"
2660    PRINT TAB(26)"*     #3--IRREGULAR ROOM       *"
2670    PRINT TAB(26)"********************************"
2680    PRINT TAB(26)"------------------------"
2690    PRINT "PLEASE INPUT THE # CORRESPONDING TO THE DESCRIPTION BEST ":
        "DESRIBING THE SHAPE OF THE ROOM"
2700    INPUT ROOMSHAPE
2710    IF ROOMSHAPE <>1 AND ROOMSHAPE <>2 AND ROOMSHAPE <> 3 THEN :
        PRINT"IMPROPER SELECTION INPUT -PLEASE TRY AGAIN"
2720    IF ROOMSHAPE <> 1 AND ROOMSHAPE <> 2 AND ROOMSHAPE <>3 THEN GOTO 2530
2730    IF ROOMSHAPE =1 THEN GOTO 2860
2740    IF ROOMSHAPE =2 THEN GOTO 2760
2750    IF ROOMSHAPE =3 THEN GOTO 2930
2760    PRINT "ENTER THE ROOMLENGTH IN FEET-NUMBER ONLY"
2770    INPUT ROOMLENGTH!
2780    PRINT "ENTER THE ROOMWIDTH IN FEET-NUMBER ONLY"
2790    INPUT ROOMWIDTH!
2800    PRINT "ENTER THE FIXTURE MOUTING HEIGHT ABOVE THE WORKPLANE":
              "IN FEET-NUMBER ONLY"
2810    INPUT MOUNTHT!
```

```
2820 '              CALCULATIONS TO DETERMINE THE RCR
2830      RCR!=((5*MOUNTHT!)*(ROOMLENGTH!+ROOMWIDTH!))/(ROOMLENGTH!*ROOMWIDTH!)
2840      ROOMAREA!=ROOMLENGTH!*ROOMWIDTH!
2850      GOTO 3030
2860      PRINT "ENTER THE FIXTURE MOUNTING HEIGHT ABOVE THE WORKPLANE";
                "IN FEET-NUMBER ONLY PLEASE"
2870      INPUT MOUNTHT!
2880      PRINT "ENTER THE RADIUS OF THE ROOM IN FEET-NUMBER ONLY"
2890      INPUT ROOMRADIUS!
2900      RCR!=(5*MOUNTHT!)/ROOMRADIUS!
2910      ROOMAREA!=3.14*(ROOMRADIUS!^2)
2920      GOTO 3030
2930      PRINT "ENTER THE FIXTURE MOUNTING HEIGHT ABOVE THE WORKPLANE";
                "IN FEET-NUMBER ONLY"
2940      INPUT MOUNTHT!
2950      PRINT "ENTER THE PERIMETER OF THE AREA"
2960      INPUT AREAPER!
2970      PRINT "ENTER THE WORKPLANE AREA"
2980      INPUT ROOMAREA!
2990      RCR!=(2.5*AREAPER!)/(ROOMAREA!)
3000 '
3010 '              WALL,CEILING AND FLOOR REFLECTANCE VALUE INPUT SECTION
3020 '
3030      CLS
3040      SELECT=0
3050      PRINT TAB(11)"DO YOU WISH TO ENTER THE REFLECTANCE VALUES FOR THE FLOOR
"
3060      PRINT TAB(11)"WALL AND CEILING DIRECTLY(OR) DO YOU WISH TO OBSERVE THE"

3070      PRINT TAB(11)"COLORED SURFACES TABLE-TYPE 1 FOR DIRECT ENTRY AND 2 FOR"

3080      PRINT TAB(11)"TABLE OBSERVATION"
3090      INPUT SELECT
3100      IF SELECT =1 THEN GOTO 3750
3110      COLOR 1,0:CLS
3120      LOCATE 1,12
3130      PRINT TAB(29)"COLORED SURFACES SELECTION GUIDE"
3140      PRINT:PRINT TAB(33)"COLOR# COLOR DESCRIPTION"
3150      PRINT:PRINT TAB(36)"1" TAB(40)"WHITE PAPER"
3160      PRINT TAB(36)"2" TAB(40)"LIGHT GRAY"
3170      PRINT TAB(36)"3" TAB(40)"MEDIUM GRAY"
3180      PRINT TAB(36)"4" TAB(40)"DARK GRAY"
3190      PRINT TAB(36)"5" TAB(40)"IVORY WHITE"
3200      PRINT TAB(36)"6" TAB(40)"BUFF STONE"
3210      PRINT TAB(36)"7" TAB(40)"TAN"
3220      PRINT TAB(36)"8" TAB(40)"COCOANUT BROWN"
3230      PRINT TAB(36)"9" TAB(40)"SATIN GREEN"
3240      PRINT TAB(36)"10" TAB(40)"BRIGHT SAGE AND IVORY TAN"
3250      PRINT TAB(36)"11" TAB(40)"BRIGHT SAGE"
3260      PRINT TAB(36)"12" TAB(40)"FOREST GREEN"
3270      PRINT TAB(36)"13" TAB(40)"OLIVE GREEN"
3280      PRINT TAB(36)"14" TAB(40)"PALE AZURE AND WHITE"
3290      PRINT
3300      PRINT"REVIEW SCREEN FOR ENTRY OF WALL,CEILING AND FLOOR COLORS.WHEN YOU
 DESIRE TO CONTINUE TYPE 1"
3310      INPUT DEC
3320      IF DEC=1 THEN GOTO 3330 ELSE GOTO 3300
3330      PRINT"DO YOU WISH TO ENTER THE WALL AND CEILING COLORS NOW OR DO YOU"
3340      PRINT"WISH TO OBSERVE THE REMAINING COLORS-TYPE 1 FOR ENTRY AND 2 FOR"
3350      PRINT"COLOR OBSERVATION"
3360      INPUT CHOICE
3370      IF CHOICE =1 THEN GOTO 3520
3380      CLS
3390      LOCATE 1,12
```

```
3400    PRINT TAB(29)"COLORED SURFACES SELECTION GUIDE"
3410    PRINT:PRINT TAB(33)"COLOR#  COLOR DESCRIPTION"
3420    PRINT:PRINT TAB(36)"15" TAB(40)"PALE AZURE"
3430    PRINT TAB(36)"16" TAB(40)"SKY BLUE"
3440    PRINT TAB(36)"17" TAB(40)"SHELL PINK"
3450    PRINT TAB(36)"18" TAB(40)"PINK"
3460    PRINT TAB(36)"19" TAB(40)"CARDINAL RED"
3470    PRINT TAB(36)"20" TAB(40)"IVORY TAN"
3480    PRINT TAB(36)"21" TAB(40)"CAEN STONE"
3490    PRINT TAB(36)"22" TAB(40)"PRIM ROSE"
3500    PRINT TAB(36)"23" TAB(40)"SILVER GRAY"
3510    PRINT TAB(36)"24" TAB(40)"PEARL GRAY"
3520    DATA .81,.73,.46,.18,.76,.51,.37,.22,.67,.47
3530    DATA .43,.21,.14,.53,.36,.31,.57,.51,.27,.58
3540    DATA .72,.67,.50,.70
3550    FOR I =1 TO 24
3560            READ COLR!(I)
3570    NEXT I
3580    INPUT"INPUT THE NUMBER ASSOCIATED WITH THE COLOR OF THE WALLS--",WALL
3590    IF WALL <1 OR WALL >24 THEN PRINT"INVALID DATA ENTRY -TRY AGAIN"
3600    IF FIX(WALL)-WALL<>0 THEN PRINT"INVALID DATA ENTRY-TRY AGAIN"
3610    IF WALL<1 OR WALL>24  THEN GOTO 3580
3620    IF FIX(WALL)-WALL<>0  THEN GOTO 3580
3630    REFLECTWALL!=COLR(WALL)
3640    INPUT"PLEASE INPUT THE NUMBER ASSOCIATED WITH THE CEILING COLOR-",CEILIN

3650    IF CEILIN <1 OR CEILIN>24 THEN PRINT"INVALID DATA ENTRY-TRY AGAIN"
3660    IF FIX(CEILIN)-CEILIN<>0 THEN PRINT"INVALID DATA ENTRY-TRY AGAIN"
3670    IF CEILIN<1 OR CEILIN>24 THEN GOTO 3640
3680    IF FIX(CEILIN)-CEILIN<>0 THEN GOTO 3640
3690    REFLECTCEILING!=COLR(CEILIN)
3700   INPUT"PLEASE ENTER THE NUMBER ASSOCIATED WITH THE FLOOR COLOR-",FLOOR
3710   IF FLOOR<1 OR FLOOR>24 THEN PRINT"INVALID DATA ENTRY-TRY AGAIN PLEASE"
3720   IF FLOOR <1 OR FLOOR >24 THEN GOTO 3700
3730   IF FIX(FLOOR)-FLOOR<>0 THEN GOTO 3700
3740   FLOORREF=COLR(FLOOR)
3750    IF SELECT=1 THEN PRINT"PLEASE ENTER IN DECIMAL FORM THE REFLECTIVITY";
        "OF THE WALLS IE.,RELECTIVITY>0.0 AND <1.0" ELSE GOTO 3870
3760    INPUT REFLECTWALL!
3770    IF REFLECTWALL!>1 OR REFLECTWALL!<0 THEN PRINT"INVALID DATA ENTRY";
        "TRY AGAIN PLEASE"
3780    IF REFLECTWALL!>1 OR REFLECTWALL!<0 THEN GOTO 3750
3790    PRINT"PLEASE ENTER IN DECIMAL FORM THE REFLECTIVITY OF THE CEILING";
        "I.E.,>=0.0 AND<=1.0"
3800    INPUT REFLECTCEILING!
3810    IF REFLECTCEILING!>1 OR REFLECTCEILING!<0  THEN PRINT"INVALID DATA ";
        "ENTRY-PLEASE TRY AGAIN"
3820    IF REFLECTCEILING!>1 OR REFLECTCEILING!<0 THEN GOTO 3790
3830   PRINT"PLEASE ENTER IN DECIMAL FORM THE REFLECTIVITY OF THE FLOOR,E.G.,>=0
.0 AND <= 1.0"
3840   INPUT FLOORREF!
3850   IF FLOORREF!>1 OR FLOORREF!<0 THEN PRINT"INVALID DATA ENTRY-PLEASE TRY --
-AGAIN"
3860   IF FLOORREF!>1 OR FLOORREF!<0 THEN GOTO 3830
3870    INPUT"IS THE CEILINGTYPE (1) HORIZONTAL (2)NONHORIZONTAL";CEILINGTYPE
3880    IF CEILINGTYPE<>1 AND CEILINGTYPE<>2 THEN PRINT"INVALID DATA ENTRY";
        "TRY AGAIN PLEASE"
3890    IF CEILINGTYPE<>1 AND CEILINGTYPE<>2 THEN GOTO 3870
3900    IF CEILINGTYPE=2 THEN GOTO 4310
3910    PRINT"ARE THE LUMINAIRES SURFACE MOUNTED OR RECESSED?-IF SURFACE "
3920    PRINT"MOUNTED TYPE 1 IF NOT TYPE 0":INPUT SURFACEMT
3930    IF SURFACEMT<>1 AND SURFACEMT<>0 THEN PRINT"INVALID DATA ENTRY-TRY ";
        "AGAIN PLEASE"
3940    IF SURFACEMT<>1 AND SURFACEMT<>0 THEN GOTO 3910
3950    IF SURFACEMT=1 THEN GOTO 4360
3960    INPUT"ENTER THE AREA OF THE CEILING CAVITY BASE--",BASEAREA!
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3970    IF BASEAREA!=0 OR BASEAREA!<0 THEN PRINT"INVALID DATA ENTRY-PLEASE":
        "TRY AGAIN"
3980    IF BASEAREA!=0 OR BASEAREA!<0 THEN GOTO 3960
3990    INPUT"PLEASE ENTER THE CEILING CAVITY WALL AREA--",WALLAREA!
4000    IF WALLAREA!=0 OR WALLAREA!<0 THEN PRINT"INVALID DATA ENTRY-PLEASE":
        "TRY AGAIN"
4010    IF WALLAREA!=0 OR WALLAREA!<0 THEN GOTO 3990
4020    PRINT"PLEASE ENTER THE CEILING CAVITY LENGTH--"
4030    INPUT CEILINGL!
4040    IF CEILINGL!=0 OR CEILINGL<0 THEN PRINT"INVALID DATA ENTRY PLEASE":
        "TRY AGAIN"
4050    IF CEILINGL!=0 OR CEILINGL!<0 THEN GOTO 4020
4060    PRINT"PLEASE ENTER THE CEILING CAVITY WIDTH IN FEET"
4070    INPUT CEILINGW!
4080    IF CEILINGW!=0 OR CEILINGW!<0 THEN PRINT"INVALID DATA ENTRY PLEASE":
        "TRY AGAIN"
4090    IF CEILINGW!=0 OR CEILINGW!<0 THEN GOTO 4060
4100    PRINT"PLEASE ENTER THE DISTANCE FROM THE CEILING TO THE LUMINAIRES":
        "I.E.,>0.0"
4110    INPUT CAVITYD!
4120    IF CAVITYD!=0 THEN PRINT"INVALID DATA ENTRY-PLEASE TRY AGAIN"
4130    IF CAVITYD!=0 THEN GOTO 4100
4140    X=CEILINGL!/CAVITYD!
4150    Y=CEILINGW!/CAVITYD!
4160    A!=2/(3.14*X*Y)
4170    B!=(1+(X^2)*(1+(Y^2))/(1+(X^2)+(Y^2)))^.5
4180    C!=Y*(1+(X^2))^.5
4190    D!=ATN(Y/(1+(X^2))^.5)
4200    E!=X*(1+(Y^2))^.5
4210    F!=ATN(X/(1+(Y^2))^.5)
4220    G!=(-Y*ATN(Y))-(X*ATN(X))
4230    H!=A!*((2.3*LOG(B!))+(C!*D!)+(E!*F!)+G!)
4240    PCEFF1!=(BASEAREA!/WALLAREA!)*((REFLECTWALL!)*((1-H!)^2))
4250    PCEFF2!=((1+REFLECTCEILING!*H)^2)
4260    PCEFF3!=((1-BASEAREA!/WALLAREA!)*(1-F!)*(REFLECTWALL!))
4270    PCEFF4!=(-(BASEAREA!/WALLAREA!)*((1-H!)^2))*REFLECTWALL!
4280    PCEFF5!=((H!)^2)*REFLECTCEILING!
4290    PCEFF!=((PCEFF1!*PCEFF2!)/(PCEFF3!+PCEFF4!))+PCEFF5!
4300    GOTO 4730
4310    PRINT"PLEASE ENTER THE AREA OF THE CEILING OPENING IN SQ.FT-NUMBERS":
        "ONLY PLEASE"
4320    INPUT A2
4330    IF A2<0 OR A2=0 THEN GOTO 4310
4340    E!=A1*REFLECTCEILING!
4350    PCEFF!=E!/(A2-(A2*REFLECTCEILING!)+(A1*REFLECTCEILING))
4360    PCEFF!=REFLECTCEILING!
4370    '       FLOOR REFLECTANCE DATA ENTRY SECTION
4380    PRINT "IS THE WORKPLANE TO BE CONSIDERED FOR ILLUMINATION PURPOSES AT FLO
OR LEVEL?---Y/N"
4390    INPUT CUCORRECT$
4400    IF CUCORRECT$="Y" THEN GOTO 4730
4410    INPUT "ENTER THE AREA OF THE FLOOR CAVITY BASE(FLOOR SURFACE AREA)",BASEA
REA
4420    IF BASEAREA=0 OR BASEAREA<0 THEN GOTO 4410
4430    INPUT"PLEASE ENTER THE FLOOR CAVITY WALL AREA(SURFACE AREA OF THE WALLS W
ITHIN THE FLOOR CAVITY)",WALLAREA
4440    IF WALLAREA =0 OR WALLAREA<0 THEN PRINT"INVALID DATA ENTRY--WALL AREA MUS
T BE > OR = TO 0.0"
4450    IF WALLAREA =0 OR WALLAREA <0 THEN GOTO 4430
4460    INPUT "PLEASE ENTER THE FLOOR CAVITY LENGTH(LENGTH IN FEET ASSOCIATED WIT
H THE FLOOR CAVITY)",FLOORL
4470    IF FLOORL=0 OR FLOORL<0 THEN PRINT"INVALID DATA ENTRY--TRY AGAIN PLEASE"
4480    IF FLOORL=0 OR FLOORL<0 THEN GOTO 4460
4490    INPUT"PLEASE ENTER THE FLOOR CAVITY WIDTH(WIDTH IN FEET ASSOCIATED WITH T
HE FLOOR CAVITY)",FLOORW
4500    IF FLOORW=0 OR FLOORW<0 THEN PRINT"INVALID DATA ENTRY--PLEASE TRY AGAIN"
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4510    IF FLOORW=0 OR FLOORW<0 THEN GOTO 4490
4520    PRINT"PLEASE ENTER THE DISTANCE FROM THE FLOOR TO THE WORKPLANE LEVEL,E.G
..)=0.0"
4530    INPUT CAVITYD!
4540    IF CAVITYD!=0 OR CAVITYD!<0 THEN PRINT"INVALID DATA ENTRY-MUST BE >= 0.0"

4550    IF CAVITYD!=0 OR CAVITYD!<0 THEN GOTO 4520
4560    X=FLOORL/CAVITYD!
4570    Y=FLOORW!/CAVITYD!
4580    A!=2/(3.14*X*Y)
4590    B!=(1+(X^2)*(1+(Y^2))/(1+(X^2)+(Y^2)))^.5
4600    C!=Y*(1+(X^2))^.5
4610    D!=ATN(Y/(1+(X^2))^.5)
4620    E!=X*(1+(Y^2))^.5
4630    F!=ATN(X/(1+(Y^2))^.5)
4640    G!=(-Y*ATN(Y))-(X*ATN(X))
4650    H!=A!*((2.3*LOG(B!))+(C!*D!)+(E!*F!)+G!)
4660    FLOORREF1=(BASEAREA!/WALLAREA)*((REFLECTWALL!)*((1-H!)^2))
4670    FLOORREF2=((1+FLOORREF!*H)^2)
4680    FLOORREF3=((1-BASEAREA!/WALLAREA!)*(1-F!)*(REFLECTWALL!))
4690    FLOORREF4=(-(BASEAREA!/WALLAREA!)*((1-H!)^2))*REFLECTWALL!
4700    FLOORREF5=((H!)^2)*FLOORREF!
4710    FLOORREF!=((FLOORREF1*FLOORREF2)/(FLOORREF3+FLOORREF4))+FLOORREF5
4720     LPRINT"FLOORREF=",FLOORREF
4730    IF FLOORREF!>=.17 AND FLOORREF!<=.23 THEN GOTO 5040
4740    '        FLOOR REFLECTANCE ADJUSTMENT FACTOR SECTION
4750     OPEN"FLOORADJ" FOR INPUT AS#1
4760             FOR ROW = 1 TO 10
4770                     FOR COLUMN= 1 TO 12
4780                             INPUT #1,ADJ!(ROW,COLUMN)
4790                     NEXT COLUMN
4800             NEXT ROW
4810     RCRNEW!=CINT(RCR!)
4820     IF RCRNEW>10 THEN RCRNEW=10
4830     IF RCRNEW<1 THEN RCRNEW=1
4840     Z(1)=8050:Z(2)=8030:Z(3)=8010:Z(4)=7050:Z(5)=7030:Z(6)=7010:Z(7)=5050
4850     Z(8)=5030:Z(9)=5010:Z(10)=1050:Z(11)=1030:Z(12)=1010
4860    IF PCEFF!>.8 OR  PCEFF!=.8 THEN PCEF!=.8
4870    IF PCEFF!>.75 AND PCEFF!<.8 THEN PCEF!=.8
4880    IF PCEFF!>.6 AND PCEFF!<=.75 THEN PCEF!=.7
4890    IF PCEFF!>.3 AND PCEFF!<=.6 THEN PCEF!=.5
4900    IF PCEFF!>.1 AND PCEFF!<=.3 THEN PCEF!=.1
4910    IF PCEFF!<=.1 THEN PCEF!=.1
4920    IF REFLECTWALL>=.5 THEN REFLECT=.5
4930    IF REFLECTWALL>=.4 AND REFLECTWALL<.5 THEN REFLECTWALL=.5
4940    IF REFLECTWALL>=.3  AND REFLECTWALL<.4 THEN REFLECT=.3
4950    IF REFLECTWALL>=.1 AND REFLECTWALL<.3 THEN REFLECT=.1
4960    PCEFNEW=PCEF!*10000
4970    YVALUE=PCEFNEW+(REFLECT*100)
4980     FOR I=1 TO 12
4990             IF YVALUE=Z(I) THEN GOTO 5010
5000     NEXT I
5010    FACTOR =ADJ!(RCRNEW,I)
5020     CLOSE#1
5030 '
5040 '           INITIALIZE ROW COUNTER ARRAY TO RESPECTIVE VALUES
5050     FOR I=1 TO 11
5060             X(I)=I-1
5070 '           CHECK FOR RCR VALUES OUTSIDE THE TABLE
5080     NEXT I
5090     IF RCR!<0 THEN RCR!=0       'IF ROOM CAVITY RATIO<0 SET=0
5100     IF RCR!>10 THEN RCR =10     'IF ROOM CAVITY RATIO>10 SET =10
5110 '           CHECK FOR RCR VALUES EXACT TO THOSE IN THE TABLE
5120     FOR I=1 TO 11
5130             IF RCR!=X(I) THEN GOTO 5210
5140     NEXT I
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5150 '          CHECK FOR RCR VALUE BETWEEN TABULAR VALUES
5160    FOR I=1 TO 10
5170            IF RCR!)X(I) AND RCR!(X(I+1) THEN GOTO 5250
5180    NEXT I
5190 '          SET ROW VALUE FOR THOSE MATCHING EXACT RCR VALUE
5200 '          SUCH THAT THE CU ROW VALUE MAY BE DETERMINED
5210    XSTO1=RCR!+1
5220    XSTO2=0
5230    GOTO 5280
5240 '          SET ROW VALUES FOR THOSE RCR VALUES ENCOMPASSING THE CALCULATED
"1550'          RCR VALUE
5250    XSTO1=X(I)+1
5260    XSTO2=X(I+1)+1
5270    XDIFF!=RCR!-X(I)
5280 '          SET TABLE INDEX FOR THE WALL AND CEILING REFLECTIVITY VALUES
5290    DATA 8050,8030,8010,7050,7030,7010,5050,5030,5010,3050,3030,3010,1050
5300    DATA 1030,1010
5310 '          READ THE TABLE INDEX
5320 '
5330    IF COLR!(1)=0 THEN GOTO 5340 ELSE GOTO 5370
5340    FOR I =1 TO 24
5350            READ COLR!(I)
5360    NEXT I
5370    FOR I=1 TO 15
5380            READ Y(I)
5390    NEXT I
5400 '          INDEX THE REFLECTIVITY VALUES TO THE TABULAR VALUES
5410    PCEFF! = FIX (100 * PCEFF!)
5420    IF PCEFF!)=80 THEN PCEFF!=79
5430    IF PCEFF!(=10 THEN PCEFF!=11
5440    REFLECTWALL! = FIX (100 * REFLECTWALL!)
5450    PCW = (PCEFF! * 100) + REFLECTWALL!
5460 '          BRANCH TO DETERMINE EXTRAPULATED CU VALE IF THE REFLECTANCE
1640 '          OF THE WALL IS LESS THAN 10 OR GREATER THAN 50
5470    IF REFLECTWALL!)=10 AND REFLECTWALL!(=50 THEN REFLECTWALL!=REFLECTWALL!+
1
5480    IF REFLECTWALL! (10 THEN GOTO 5690
5490    IF REFLECTWALL! ) 50 THEN GOTO 6130
5500    FLAG1 = 0
5510    FLAG2 = 0
5520 '          CEILING REFLECTIVITY TABLE INDEX
5530    K(1)=80:K(2)=70:K(3)=50:K(4)=30:K(5)=10
5540 '          WALL REFLECTIVITY TABLE INDEX
5550    L(1)=50:L(2)=30:L(3)=10
5560 '          TEST TO DETERMINE IF CEILING REFLECTIVITIES FALL BETWEEN TABLE
5570 '          VALUE AND IF WALL REFLECTIVITIES FALL BETWEEN TABLE VALUES
5580    FOR J = 1 TO 4
5590            IF PCEFF! (K(J) AND PCEFF! ) K (J + 1) THEN FLAG1=1
5600    NEXT J
5610    FOR I = 1 TO 2
5620            IF REFLECTWALL! ( L(I) AND REFLECTWALL! ) L(I+1) THEN FLAG2=1
5630    NEXT I
5640 '          DETERMINE WHICH PROGRAMMING STEPS TO BRANCH TO DEPENDING ON
5650 '          THE STATUS OF FLAG1 AND FLAG2
5660    IF FLAG1=1 AND FLAG2=1 THEN GOTO 6450
5670    IF FLAG1 () 1 AND FLAG2=1 THEN GOTO 6870
5680    IF FLAG1 () 1 AND FLAG2 () 1 THEN GOTO 7040
5690 '          RCR SET AND NOT SET CASE FOR ALL REFLECTANCE (10
5700 '          SET TABLE INDEX VALUES TO ALLOW EXTRAPOLATION
5710    FOR J = 1 TO 14
5720 '          ESTABLISH COLUMN STORAGE VALUES TO ALLOW EXTRAPOLATION
5730   IF REFLECTWALL!(10 AND PCW(Y(J) AND PCW)Y(J+1) THEN YSTO1=J:YSTO2=YSTO1+3

5740    NEXT J
5750 '          ESTABLISH SECOND COLUMN VALUE TO ALLOW "COMMON" DIFFERENCE
5760 '          TO BE CALCULATED
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5770    YSTO11 = YSTO1-1:YSTO22 = YSTO2-1
5780       '        DETERMINE DIFFERENCE BETWEN C4 SET VALUES SUCH THAT EXACT
1865       '        CU VALUE MAY BE EXTRAPOLATED
5790       '        DETERMINE DIFFERENCE BETWEN C4 SET VALUES SUCH THAT EXACT C
           '        CU VALUE MAY BE EXTRAPOLATED
5800    CUYSTO1DIFF! = CU(XSTO1,YSTO11) - CU(XSTO1,YSTO1)
5810    CUYSTO2DIFF! = CU(XSTO1,YSTO22) - CU(XSTO1,YSTO2)
5820     CUYSTO1NEW! = CU!(XSTO1,YSTO1) - ((10-REFLECTWALL!)/20) * CUYSTO1DIFF!
5830    CUYSTO2NEW! = CU(XSTO1,YSTO2) - ((10-REFLECTWALL!)/20) * CUYSTO2DIFF!
5840  '        OBTAIN THE CEILING REFLECTIVITY FOR THE HIGHER (NUMBER-WISE)
5850  '        COLUMN USED IN THE EXTRAPOLATION
5860    A! = Y(YSTO1)/100
5870  '        OBTAIN THE CEILING REFLECTANCE FOR THE LOWER COLUMN
5880    B! = Y(YSTO2)/100
5890    A1! = FIX(A!)
5900    B1! = FIX(B!)
5910  '        SET THE EXTRAPOLATED VALUE FOR THE RCR (ROW) SET CASE
5920    CU1! = CUYSTO2NEW! +(((PCEFF!-B1!)/(A1!-B1!))*(CUYSTO1NEW!-CUYSTO2NEW!))

5930    IF XSTO2 = 0 THEN CU! = CU1!  'IF ROW VALUE SET THEN SET CU1!=CU
5940    IF XSTO2=0 THEN GOTO 7180
5950  '        DETERMINE THE CU VALUE FOR THE NEXT LARGER ROW - ALLOWS
5960  '        INTERPOLATION BETWEEN ROW VALUES
5970    FOR J = 1 TO 14
5980   IF REFLECTWALL!<10 AND PCW<Y(J) AND PCW>Y(J+1) THEN YSTO1=J:YSTO2=YSTO1+3

5990    NEXT J
6000    IF REFLECTWALL! <10 THEN YSTO11 = YSTO1-1 AND YSTO22 = YSTO2-1
6010    CUYSTO1DIFF! = CU(XSTO2,YSTO11) - CU(XSTO2, YSTO1)
6020    CUYSTO2DIFF! = CU(XSTO2,YSTO22) - CU(XSTO2,YSTO2)
6030    CUYSTO1NEW! = CU(XSTO2,YSTO1) - ((10-REFLECTWALL!)/20) * CUYSTO1DIFF!
6040    CUYSTO2NEW! = CU(XSTO2,YSTO2) - ((10-REFLECTWALL!)/20) * CUYSTO2DIFF!
6050    A! = Y (YSTO1)/100
6060    B! = Y(YSTO2)/100
6070    A1! = FIX (A!)
6080    B1! = FIX (B!)
6090    CU2! = CUYSTO2NEW! + ((PCEFF!-B1!)/(A1!-B1!))* (CUYSTO1NEW!-CUYSTO2NEW!)

6100 '  INTERPOLATE THE CU VALUES FOR THE EXACT CU VALUE
6110    CU! = CU1! - (XDIFF! * (CU1! - CU2!))
6120    GOTO 7180
6130  '  RCR SET AND NOT SET CASE FOR ALL REFLECTANCE > 50
6140            FOR J = 1 TO 14
6150    IF  PCW <Y(J) AND PCW >Y(J+1) THEN YSTO1 = J+1
6160    IF PCW<Y(J) AND PCW> Y(J+1) THEN YSTO2=(J+1)-3
6170    NEXT J
6180    YSTO11 = YSTO1+1 :YSTO22 = YSTO2+1
6190    CUYSTO1DIFF! = CU(XSTO1,YSTO1) - CU(XSTO1,YSTO11)
6200    CUYSTO2DIFF! = CU(XSTO1,YSTO2) - CU(XSTO1,YSTO22)
6210    CUYSTO1NEW! = CU(XSTO1,YSTO1) + ((REFLECTWALL!-50)/20)*CUYSTO1DIFF!
6220    CUYSTO2NEW! = CU(XSTO1,YSTO2) + ((REFLECTWALL!-50)/20)*CUYSTO2DIFF!
6230    A! = Y(YSTO1)/100
6240    B! = Y(YSTO2)/100
6250    A1! = FIX(A!)
6260    B1! = FIX(B!)
6270    CU1! = CUYSTO1NEW!+((PCEFF! - A1!)/(B1!-A1!))*(CUYSTO2NEW!-CUYSTO1NEW!)
6280    IF XSTO2 = 0 THEN CU! = CU1!
6290    IF XSTO2 = 0 THEN GOTO 7180
6300  '        DETERMINE CU VALUE FOR THE NEXT LARGER ROW
6310    CUYSTO1DIFF! = CU(XSTO2,YSTO1) - CU(XSTO2,YSTO11)
6320    CUYSTO2DIFF! = CU(XSTO2,YSTO2) - CU(XSTO2,YSTO22)
6330    CUYSTO1NEW! = CU(XSTO2,YSTO1) + ((REFLECTWALL!-50)/20)*CUYSTO1DIFF!
6340    CUYSTO2NEW! = CU(XSTO2,YSTO2) + ((REFLECTWALL!-50)/20)*CUYSTO2DIFF!
6350    A! = Y(YSTO1)/100
6360    B! = Y(YSTO2)/100
6370    A1! = FIX(A!)
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6380    B1! = FIX(B!)
6390    CU2! = CUYSTO1NEW! + ((PCEFF-A1!)/(B1!-A1!))*(CUYSTO2NEW!-CUYSTO1NEW!)
6400    CU! = CU1! - (XDIFF! * (CU1! - CU2!))
6410    GOTO 7180
6420  '         RCR (ROW VALUE) SET CASE (EXACT) FOR CEILING REFLECTANCES
6430  '         BETWEEN TABULAR VALUES AND WALL REFLECTANCES BETWEEN TABULAR
6440  '         VALUES
6450  '         RCR (ROW SET) CASE
6460    RESTORE
6470    FOR J = 1 TO 4
6480            IF PCEFF!<K(J) AND PCEFF!>K(J+1) THEN YSTO1=K(J):YSTO2 = K(J+1)
6490    PCWT1 = (YSTO1 * 100) + REFLECTWALL!
6500    NEXT J
6510    PCWT2 = (YSTO2 * 100) + REFLECTWALL!
6520    FOR J = 1 TO 14
6530            IF PCWT1<Y(J) AND PCWT1> Y(J+1) THEN YSTO11 = J:YSTO22 = J+1
6540    NEXT J
6550    TOP=PCWT1-Y(YSTO22)
6560    BOTTOM=Y(YSTO11)-Y(YSTO22)
6570    YDIFF! = TOP/BOTTOM
6580    CU1! = CU(XSTO1,YSTO11)
6590    CU2! = CU(XSTO1,YSTO22)
6600    CUHI! = CU1! - (YDIFF!*(CU1! - CU2!))
6610    IF XSTO2 >0 THEN GOTO 6760
6620  '         DETERMINE THE CU VALUE FOR THE LOWER CEILING REFERENCE VALUE
6630    FOR J = 1 TO 14
6640          IF PCWT2<Y(J) AND PCWT2>Y(J+1) THEN YSTO11 = J :YSTO22=J+1
6650  '
6660    NEXT J
6670    YDIFF! = (PCWT2-Y(YSTO22))/(Y(YSTO11)-Y(YSTO22))
6680    CU1! = CU(XSTO1, YSTO11)
6690    CU2! = CU(XSTO1,YSTO22)
6700    CULO! = CU1! - (YDIFF! * (CU1! - CU2!))
6710    CUF! = CULO! + ((PCEFF! - YSTO2)/(YSTO1 - YSTO2)) * (CUHI!-CULO!)
6720    IF XSTO2 = 0 THEN CU! = CUF!
6730            IF XSTO2 = 0 THEN GOTO 7180
6740    IF XSTO2 >0 THEN GOTO 6810
6750  '          ROW VALUE NOT SET CASE (I.E., BETWEEN ROW VALUES)
6760    CU11! = CU (XSTO2,YSTO11)
6770    CU22! = CU(XSTO2,YSTO22)
6780    CUHII! = CU11! - (YDIFF! * (CU11! - CU22!))
6790  '         DETERMINE THE CU VALUE FOR THE LOWER CEILING REFLECTANCE VALUE
6800    IF XSTO2>0 THEN GOTO 6620
6810    CU1! = CU(XSTO2,YSTO11)
6820    CU2! = CU(XSTO2,YSTO22)
6830    CULO! = CU1! - (YDIFF! * (CU1! - CU2!))
6840    CUG!=CULO! + ((PCEFF! - YSTO2)/(YSTO1-YSTO2))*(CUHII! - CULO!)
6850    CU! = CUF! - (XDIFF! * (CUF! - CUG!))
6860    GOTO 7180
6870  '         CEILING REFLECT.  EXACT TO A TABULAR VALUE AND WALL REFLECT.
6880  '         BETWEEN TABLUAR VALUES
6890  '         DETERMINE CU VALUE
6900    FOR I = 1 TO 14
6910            IF PCW (Y(I) AND PCW )Y(I+1) THEN STO1=I:STO2=I+1
6920    NEXT I
6930    YDIFF! = (PCW - Y(STO2)) / (Y(STO1)-YSTO2))
6940    CU1! = CU (XSTO1, STO1)
6950    CU2! = CU (XSTO1, STO2)
6960    CUH! = CU1! - YDIFF! * (CU1! - CU2!)
6970            IF XSTO2 = 0 THEN CU! = CUH!
6980            IF XSTO2 = 0 THEN GOTO  7180
6990    CU1! = CU(XSTO2, STO1)
7000    CU2! = CU (XSTO2, STO2)
7010    CUL! = CU1! - YDIFF! * (CU1! - CU2!)
7020    CU! = CUH! - XDIFF! * (CUH! - CUL!)
7030    GOTO 7180
```

```
7040 '          PROGRAMMING TO DETERMINE CU VALUE FOR CEILING REFLECTANCE=
7050 '          TO TABULAR VALUE AND WALL REFLECTANCE = TABULAR VALUE
7060   FOR I = 1 TO 15
7070          IF PCW = Y(I) THEN STO1 = I
7080   NEXT I
7090   CUH! = CU(XSTO1, STO1)
7100          IF XSTO2 = 0 THEN CU! = CUH!
7110          IF XSTO2 = 0 THEN GOTO 7180
7120   CUL! = CU (XSTO2, STO1)
7130   CU! = CUH! - XDIFF! * (CUH! - CUL!)
7140  'FLOOR REFLECTIVITY ADJUSTMENT
7150  IF FLOORREF!<=17 THEN CU!=CU!/FACTOR
7160  IF FLOORREF!>=23 THEN CU!=CU!*FACTOR
7170  LPRINT"FACTOR="FACTOR
7180   CLS
7190   LOCATE 12,1
7200 '          TABLE DISPLAYING THE USER THE 5 DEGREES OF DIRT CONDITIONS
7210   PRINT TAB(31) "FIVE DEGREES OF DIRT CONDITIONS"
7220   PRINT
7230   PRINT TAB(19)"(1)"TAB(33)"(2)"TAB(45)"(3)"TAB(59)"(4)"TAB(70)"(5)"
7240   PRINT
7250   PRINT TAB(16)"VERY CLEAN" TAB(32)"CLEAN"TAB(44)"MEDIUM"TAB(58)"DIRTY";
       TAB(68)"VERY DIRTY"
7260   PRINT
7270   PRINT TAB(3)"GENERATED"TAB(16)"NONE"TAB(29)"VERY LITTLE"TAB(42);
       "NOTICEABLE/"TAB(55)"ACCUMULATES"TAB(68)"CONSTANT"
7280   PRINT TAB(3)"DIRT"TAB(42)"NOT HEAVY"TAB(55)"RAPIDLY"TAB(68);
       "ACCUMULATION"
7290   PRINT
7300   PRINT TAB(3)"AMBIENT"TAB(16)"NONE(OR"TAB(29)"SOME-ALMOST" TAB(42);
       "SOME ENTERS"TAB(55)"LARGE AMNT"TAB(68)"ALMOST NONE"
7310   PRINT TAB(3)"DIRT" TAB(16)"NONE ENTERS"TAB(29)"NONE ENTERS";
       TAB(42)"AREA"TAB(55)"ENTERS AREA"TAB(68)"EXCLUDED"
7320   PRINT
7330   PRINT TAB(3)"REMOVAL OR" TAB(16)"EXCELLENT"TAB(29)"BETTER THAN";
       TAB(42)"POORER THAN"TAB(55)"ONLY FANS"TAB(68)"NONE"
7340   PRINT TAB(3)"FILTRATION"TAB(29)"AVERAGE"TAB(42)"AVERAGE"TAB(55);
       "OR BLOWERS"
7350   PRINT TAB(55)"IF ANY"
7360   PRINT
7370   PRINT TAB(3)"ADHESION"TAB(16)"NONE"TAB(29)"SLIGHT"TAB(42)"VISIBLE";
       TAB(55)"HIGH-DUE TO"TAB(68)"HIGH"
7380   PRINT TAB(42)"AFTER SOME"TAB(55)"OIL, HUMID-"
7390   PRINT TAB(42)"MONTHS"TAB(55)"ITY, OR STAT"
7400   PRINT TAB(55)"IC"
7410   PRINT
7420         PRINT "PLEASE PONDER THE CHARACTERISTICS OF THE VARIOUS ENVIRON-";
             "MENTS; AND PREPARE TO ENTER THE FITTING DIRT CONDITION -TYPE 1 ";
             "TO CONTINUE"
7430         INPUT ENV:IF ENV=1 THEN GOTO 7440 ELSE GOTO 7420
7440   CLS:LOCATE 12,1
7450   PRINT TAB(28)"DIRT CONDITION EXAMPLES"
7460   PRINT
7470   PRINT   TAB(5)"VERY CLEAN "TAB(21)"   CLEAN   "TAB(37)"   MEDIUM   ";
       TAB(53)"   DIRTY   "TAB(69)"VERY DIRTY"
7480   PRINT: PRINT
7490   PRINT TAB(5) "HIGH GRADE "TAB(21)"OFFICES IN "TAB(37)"MILL OFFICE";
       TAB(53)"HEAT TREAT-"TAB(69)"SIMILAR TO"
7500   PRINT TAB(5)"OFFICES NOT"TAB(21)"OLDER BUILD"TAB(37)"PAPER PROC-";
       TAB(53)"ING;HIGH   "TAB(69)"DIRTY BUT"
7510   PRINT TAB(5)"NEAR PROD- "TAB(21)"-INGS OR   -"TAB(37)"ESSING;"
       TAB(53)"SPEED PRINT"TAB(69)"LUMINAIRES"
7520   PRINT TAB(5)"UCTION; LABS"TAB(21)"NEAR PROD- "TAB(37)"LIGHT MACH-";
        TAB(53)"ING; RUBBER"TAB(69)"WITHIN -"
7530   PRINT TAB(5)"CLEAN ROOMS"TAB(21)"UCTION, ASS-"TAB(37)"INING"TAB(53);
       "PROCESSING"TAB(69)"IMMEDIATE"
```

```
7540     PRINT TAB(21)"EMBLY, INSP-"TAB(69)"AREA OF-"
7550     PRINT TAB(21)"ECTION"TAB(69)"DIRT SOURCE"
7560     PRINT "PLEASE OBSERVE THE DIRT CONDITION EXAMPLES.  WHEN YOU DESIRE:"
         "TO CONTINUE TYPE 1 "
7570     INPUT DEC:IF DEC =1 THEN GOTO 7590 ELSE GOTO 7560
7580     STOP
7590     PRINT "PLEASE ENTER THE # CORRESPONDING TO THE EXISTING ENVIRONMENT:"
         "DIRT CONDITION: (I.E., (1) VERY CLEAN, (2) CLEAN, (3) MEDIUM,":
         "(4) DIRTY, (5) VERY DIRTY)"
7600     INPUT DIRTCOND
7610     IF DIRTCOND <> 1 AND DIRTCOND <> 2 AND DIRTCOND <> 3 AND DIRTCOND<> 4
         AND DIRTCOND <> 5 THEN PRINT "ILLEGAL DATA ENTRY PLEASE TRY AGAIN"
7620     IF DIRTCOND <> 1 AND DIRTCOND<> 2 AND DIRTCOND <> 3 AND DIRTCOND<> 4
         AND DIRTCOND<> 5 THEN GOTO 7590
7630     PRINT "PLEASE ENTER THE LUMINAIRE CLEANING INTERVAL IN DECIMAL YEARS":
         "NUMBER ONLY (E.G., 36 MONTHS = 3.0, 13 WEEKS = .25 YEARS) "
7640     INPUT LUMCLEAN
7650     OPEN"A:LUMDDC" FOR INPUT AS #1
7660     FOR I=1 TO 6
7670             FOR J=1 TO 6
7680                     INPUT #1,CST!(I,J)
7690             NEXT J
7700     NEXT I
7710     A! = CST!(MAINTCAT,DIRTCOND)
7720     B! = CST!(MAINTCAT,6)
7730     C! = -A! * (LUMCLEAN ^ B!)
7740     LDD! = 2.72 ^ C!
7750     IF LDD!>1 THEN LDD=1
7760     CLOSE#1
7770     PRINT "PLEASE ENTER THE ROOM WALL, FLOOR AND CEILING CLEANING INTERVAL":
         "IN MONTHS (= 36 MONTHS ONE # PLEASE"
7780    INPUT ROOMCLEAN
7790     IF ROOMCLEAN <0 OR ROOMCLEAN > 36 THEN GOTO 7770
7800     IF ROOMCLEAN - FIX(ROOMCLEAN) <> 0 THEN GOTO 7770
7810             IF DIRTCOND = 1 THEN GOTO 7900
7820             IF DIRTCOND = 2 THEN GOTO 7920
7830             IF DIRTCOND = 3 THEN GOTO 7960
7840             IF DIRTCOND = 4 THEN GOTO 8000
7850             IF DIRTCOND = 5 THEN GOTO 8050
7860   '         THE FOLLOWING MATHEMATICAL EQUATIONS BREAK THE CURVES
7870   '         ASSOCIATED WITH THE EXPECTED DIRT DEPRECIATION INTO LINEAR
7880   '         SECTIONS APPROXIMATING THE DEPRECIATION AT ANY ROOMCLEANING
7890   '         INTERVAL FOR ANY DIRT CONDITION.
7900     EXPDD! = (.39 * ROOMCLEAN)
7910     GOTO 8090
7920     IF ROOMCLEAN <=9 THEN EXPDD! = 1.2 * ROOMCLEAN
7930      IF ROOMCLEAN >9 AND ROOMCLEAN <=21 THEN EXPDD! =11 + .42 *(ROOMCLEAN -
          9)
7940             IF ROOMCLEAN >21 AND ROOMCLEAN <=36 THEN EXPDD! = 16 + .33
                 * (ROOMCLEAN -21)
7950     GOTO 8090
7960     IF ROOMCLEAN <=3 THEN EXPDD! = 3 * ROOMCLEAN
7970     IF ROOMCLEAN >3 AND ROOMCLEAN <=9 THEN EXPDD! = 9 + .78 * (ROOMCLEAN
         - 3)
7980             IF ROOMCLEAN >9 AND ROOMCLEAN <=36 THEN EXPDD!=16 +.41*(ROOMCLEA
N-9)
7990     GOTO 8090
8000             IF ROOMCLEAN <=3 THEN EXPDD! = 3.7 * ROOMCLEAN
8010             IF ROOMCLEAN >3 AND ROOMCLEAN<=6 THEN EXPDD! = 11 + 2*(ROOMCLEAN
 - 3)
8020             IF ROOMCLEAN >6 AND ROOMCLEAN <=12 THEN EXPDD! = 17 + 1.2 * (ROO
MCLEAN - 6)
8030             IF ROOMCLEAN >12 AND ROOMCLEAN <=36 THEN EXPDD! = 24 + .5*(ROOMC
LEAN - 12)
8040     GOTO 8090
8050             IF ROOMCLEAN <=3 THEN EXPDDD! = 5 * ROOMCLEAN
```

```
8060            IF ROOMCLEAN >3 AND ROOMCLEAN <=6 THEN EXPDDD! = 15 + 2.3
                * (ROOMCLEAN - 3)
8070            IF ROOMCLEAN >6 AND ROOMCLEAN <=9 THEN EXPDD! = 22 + 1.67
                * (ROOMCLEAN - 6)
8080            IF ROOMCLEAN >9 AND ROOMCLEAN <=36 THEN EXPDD! = 27 + .52
                * (ROOMCLEAN - 9)
8090    TABLE = (LUMDIST * 100) + EXPDD!
8100    K(1)=110:K(2)=120:K(3)=130:K(4)=140:K(5)=210:K(6)=220:K(7)=230:K(8)=240
8110    K(9)=310:K(10)=320:K(11)=330:K(12)=340:K(13)=410:K(14)=420:K(15)=430
8120    K(16)=440:K(17)=510:K(18)=520:K(19)=530:K(20)=540
8130    DATA 420,430,440,510,520,530,540
8140    LPRINT"RCR="RCR,"XSTO1="XSTO1,"XSTO2="XSTO2
8150    IF RCR!<=1 THEN XSTO1=1:XSTO2=0
8160    IF RCR!>1 AND RCR!<=10 THEN XSTO1=XSTO1-1:XSTO2=XSTO2-1
8170    IF XSTO2<0 THEN XSTO2=0
8180    IF RCR!>10 THEN XSTO1=XSTO1-1:XSTO2=0
8190    LPRINT"XSTO1="XSTO1,"XSTO2="XSTO2
8200    STO1 = 0 : STO2 = 0: STO3 = 0
8210    OPEN "A:ROOMSD" FOR INPUT AS #1
8220    FOR I =1 TO 10
8230            FOR J= 1 TO 20
8240                    INPUT #1,RSD!(I,J)
8250            NEXT J
8260    NEXT I
8270    CLOSE#1
8280  '         DETERMINE IF THE EXPECTED DIRT DEPRECIATION IS BETWEEN THE
8290  '         TABULAR VALUES
8300    RESTORE
8310    FOR I = 1 TO 19
8320            IF K(I)<TABLE AND K(I+1)>TABLE THEN STO1 = I:STO2 = I +1
8330    NEXT I
8340    LPRINT"STO1="STO1"STO2="STO2
8350    IF STO1<>0 AND STO2 <>0 THEN GOTO 8460
8360  '          DETERMINE IF THE EXPECTED DIRT DEPRECIATION IS EQUIVALENT
8370  '         TO A TABULAR VALUE
8380    FOR I = 1 TO 20
8390            IF K(I) = TABLE THEN STO3 = I
8400    NEXT I
8410            IF STO3 >0 THEN GOTO 8590
8420            IF EXPDD! <10 THEN GOTO 8650
8430            IF EXPDD! >40 THEN GOTO 8820
8440  '         CALCULATIONS TO DETERMINE THE ROOM SURFACE DIRT DEPRECIATION
8450  '         FOR EXPECTED DIRT DEPRECIATION BETWEEN TABULAR VALUES
8460    RSDHI! = RSD!(XSTO1,STO1)
8470    RSDLO! = RSD!(XSTO1, STO2)
8480    RSD1! = RSDHI! -(TABLE - K(STO1))/10* (RSDHI! - RSDLO!)
8490            IF XSTO2 = 0 THEN RMSD! = RSD1!
8500            IF XSTO2 = 0 THEN GOTO 9000
8510    RSDHI! = RSD!(XSTO2,STO1)
8520    RSDLO! = RSD!(XSTO2,STO2)
8530    RSD2! = RSDH1! - (TABLE - K(STO1))/10 * (RSDH1! - RSDLO!)
8540    IF RMSD!>1! THEN RMSD!=.99
8550    LPRINT"3101--RMSD="RMSD!
8560    GOTO 9000
8570  '         CALCULATIONS TO DETERMINE THE ROOM SURFACE DIRT DEPRECIATION
8580  '         FOR EXPECTED DIRT DEPRECIATION EXACT TO TABULAR VALUES
8590    RSDH! = RSD! (XSTO1, STO3)
8600            IF XSTO2 = 0 THEN RMSD! = RSDH!
8610            IF XSTO2 = 0 THEN GOTO 9000
8620    RSDLO!=RSD!(XSTO2,STO3)
8630     RMSD!=RSDHI!-(XDIFF!)*(RSDHI!-RSDLO!)
8640    GOTO 9000
8650            'CALCULATIONS TO EXTRAPOLATE THE ROOM SURACE DEP. FACTORS
8660    IF LUMDIST =1 THEN STO1=1:STO2=2
8670    IF LUMDIST=2 THEN STO1=5 :STO2=6
8680    IF LUMDIST=3 THEN STO1=9:STO2=10
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8690     IF LUMDIST=4 THEN STO1=13:STO2=14
8700     IF LUMDIST=5 THEN STO1=17:STO2=18
8710     RSDHI!=RSD!(XSTO1,STO1)
8720     RSDLO!=RSD!(XSTO1,STO2)
8730     YDIFF!=RSDHI!-RSDLO!
8740     RSD1!=RSDHI!+((10-EXPDD!)*(YDIFF!/10))
8750     IF XSTO2=0 THEN RMSD!=RSD1!
8760     IF XSTO2=0 THEN GOTO 9000
8770     RSDHI!=RSD!(XSTO2,STO1)
8780     RSDLO!=RSD!(XSTO2,STO2)
8790      RSD2!=RSDHI!+((10-EXPDD!)*(YDIFF!/10))
8800      RMSD!=RSD1!-(XDIFF!)*(RSD1!-RSD2!)
8810      GOTO 9040
8820      '        CALCULATIONS TO EXTRAPOLATE THE ROOM SURFACE DIRT DEPRECIATION
8830      '        FACTOR FOR EXPECTED DIRT FACTORS >40
8840      IF LUMDIST =1 THEN STO1=3:STO2=4
8850      IF LUMDIST=2 THEN STO1=7:STO2=8
8860      IF LUMDIST=3 THEN STO1=11:STO2=12
8870      IF LUMDIST=4 THEN STO1=15:STO2=16
8880      IF LUMDIST=5 THEN STO1=19:STO2=20
8890      RSDHI!=RSD!(XSTO1,STO1)
8900      RSDLO!=RSD!(XSTO1,STO2)
8910      YDIFF!=RSDHI!-RSDLO!
8920      RSD1!=RSDHI!-((EXPDD!-40)*(YDIFF!/10))
8930      IF XSTO2=0 THEN RMSD!=RSD1!
8940      IF XSTO2=0 THEN GOTO 9040
8950      RSDHI!=RSD!(XSTO2,STO1)
8960      RSDLO!=RSD!(XSTO2,STO2)
8970      YDIFF!=RSDHI!-RSDLO!
8980      RSD2!=RSDHI!-((EXPDD!-40)*(YDIFF!/10))
8990      RMSD!=RSD1!-(XDIFF!)*(RSD1!-RSD2!)
9000      '        CALCULATIONS TO TAKE INTO ACCOUNT THE UTILIZATION OF ENERGY
9010      '        EFFICIENT LAMPS
9020     PRINT"ARE ENERGY EFFICIENT LAMPS UTILIZED.TYPE 1 FOR YES AND 2 FOR NO"
9030     INPUT ENERGYEFF
9040      IF ENERGYEFF=1 THEN GOTO 9050 ELSE GOTO 9070
9050      IF LAMP>=2 AND LAMP<4 THEN CU!=CU!*1.03
9060      IF LAMP>=4 THEN CU!=CU!*1.07
9070      LLF!=RMSD!*LLD!*LBO!*LDD!
9080      IF DESIGN=2 THEN GOTO 9090 ELSE GOTO 9120
9090      MAINTILLUM!=(LUMEXIST*LAMP*LAMPLUM*CU!*LLF!)/ROOMAREA!
9100      INITILLUM!=MAINTILLUM!/LLF!
9110      GOTO 9140
9120      LUMEXIST=(MAINTILLUM!*ROOMAREA!)/(LAMP*LAMPLUM*CU!*LLF!)
9130      INITILLUM!=MAINTILLUM!/LLF!
9140      MAXSPACING=MOUNTHT!*MAXSP
9150      LUMWATTS=(LAMPWATT*LAMP)+BALLAST
9160      LAMPTOTAL=LUMEXIST*LAMP
9170      LUMLUM=LAMP*LAMPLUM
9180      TOTLAMPCOST=LAMPTOTAL*LAMPCOST
9190      LAMPLABCOST!=LAMPTOTAL*LAMPLAB!
9200      LUMLABCOST!=LUMINSTALL!*LUMEXIST
9210      IF DESIGN=1 THEN TOTLUMCOST=(LUMEXIST*LUMCOST!)
9220             'CALCULATE THE TOTAL MATERIAL AND INSTALLATION COSTS
9230     TOTALCOST=TOTLAMPCOST+TOTLUMCOST+LAMPLABCOST+LUMLABCOST
9240     '       CALCULATE THE ANNUAL OPERATING COST
9250     ANNUALCOST=(ENERGYCOST*OPERHRS)*((LUMWATTS*LUMEXIST))/1000
9260     LAMPREP=(OPERHRS/LAMPLIFE)*LAMPTOTAL
9270     LAMPREPCOST=(LAMPREP)*LAMPLAB!
9280     TOTOPERCOST=ANNUALCOST+LAMPREPCOST
9290     UPL=(LUMWATTS)*LUMEXIST/ROOMAREA
9300     LPRINT CHR$(14) TAB(5)"***LUMINAIRE OUTPUT REPORT***"
9310     LPRINT "LUMINAIRE DESCRIPTION:"LUMDESC$(LUMNO)
9320     LPRINT
9330     LPRINT TAB(15) "REQUIRED DATA"
9340     LPRINT"----------------------------------------------"
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9350    LPRINT TAB(15) "* INITIAL LUMENS/LAMP............."LAMPLUM
9360    LPRINT TAB(15) "* INITIAL LUMENS/LUMINAIRE........"LUMLUM
9370    LPRINT TAB(15) "* LAMPLIFE........................"LAMPLIFE
9380    LPRINT TAB(15) "* AVERAGE WATTS/LAMP.............."LAMPWATT
9390    LPRINT TAB(15) "* WATTS /LUMINAIRE................"LUMWATTS
9400    LPRINT TAB(15) "* U.P.D.(POWER LIMIT-WATTS/SQ.FT)."UPL
9410    LPRINT TAB(15)"* COEFFICIENT OF UTILIZATION......." ;USING"#.##";CU
9420    LPRINT TAB(15) "* MAINTENANCE CATEGORY............"MAINTCAT
9430    LPRINT TAB(15)"* LUMINAIRE LIGHT DISTRIBUTION...."LUMDIST
9440    LPRINT TAB(15)"* LIGHT LOSS FACTOR(LLF)..........";USING"#.##";LLF
9450    LPRINT TAB(15)"* LAMP LUMEN DEPRECIATION FACTOR...";USING"#.##";LLD!
9460    LPRINT TAB(15)"* LAMP BURNOUT FACTOR..............";USING"#.##";LBO!
9470    LPRINT TAB(15)"* LAMP DIRT DEPRECIATION FACTOR....";USING"#.##";LDD!
9480    LPRINT TAB(15)"* ROOM SURFACE DIRT DEPREC.FACTOR..";USING"#.##";RMSD!
9490    LPRINT TAB(15)"* ROOM CAVITY RATIO(RCR)...........";USING"#.##";RCR!
9500    LPRINT TAB(15)"* MAX.SPC/MNTING HT.RATIO..........";USING"#.##";MAXSP
9510    LPRINT TAB(15) "* EXISTING SPACING(=0 IF NEW......"
9520    LPRINT TAB(15) "  DESIGN CONSIDERED..............."EXISTSP
9530    LPRINT TAB(15) "* SUGGESTED MAX SPACING FOR UNIFORM"
9540    LPRINT TAB(15) "  LIGHTING LEVELS................."MAXSPACING
9550    LPRINT TAB(15)"* MAINT.ILLUM.LEVEL(FC)............"MAINTILLUM
9560    LPRINT TAB(15)"* INITIAL ILLUMINATION LEVEL..(FC)"INITILLUM
9570    LPRINT TAB(15)"* LUMINAIRES REQUIRED FOR UNIFORM."
9580    LPRINT TAB(15)"  MAINTAINED FOOTCANDLES..........."LUMEXIST
9590    LPRINT TAB(15)"* AREA OF ROOM (SQ.FT.)............"ROOMAREA
9600    LPRINT TAB(15)"* OPERATING HOURS PER YEAR........"OPERHRS
9610    LPRINT TAB(15)"* LAMP REPLACEMENTS PER YEAR......"LAMPREP
9620    LPRINT
9630    LPRINT CHR$(14) "MATERIAL AND INSTALLATION COST"
9640    LPRINT
9650    LPRINT TAB(15)"* LUMINAIRE COST...................";USING"$$#############,
.##";TOTLUMCOST
9660    LPRINT TAB(15)"* LAMP COST........................";USING"$$#############,
.##";TOTLAMPCOST
9670    LPRINT TAB(15)"* LUMINAIRE INSTALLATION CHARGE...";USING"$$#############,
.##";LUMLABCOST
9680    LPRINT TAB(15)"* LAMP INSTALLATION CHARGE........";USING"$$#############,
.##";LAMPLABCOST
9690    LPRINT
9700    LPRINT TAB(15)"* TOTAL MATERIAL AND INSTALLATION."
9710    LPRINT TAB(15)"  COST.............................";USING"$$#############,
.##";TOTALCOST
9720    LPRINT
9730    LPRINT
9740    LPRINT CHR$(14)"ANNUAL OPERATING COST"
9750    LPRINT
9760    LPRINT TAB(15)"* ANNUAL ENERGY COST...............";USING"$$#############,
.##";ANNUALCOST
9770    LPRINT TAB(15)"* LAMP REPLACEMENT COST/YEAR......";USING"$$#############,
.##";LAMPREPCOST
9780    LPRINT TAB(15)"*TOTAL ANNUAL OPERATING COST......";USING"$$#############,
.##";TOTOPERCOST
9790    RETURN
9800    CLS:        'CU APPEND SUBPROGRAM
9810            'PROGRAMMING FOR SYSTEM WARNING
9820    K$=INKEY$
9830   IF K$="" THEN GOTO  9840 ELSE GOTO  17753
9840            FOR J=1 TO 5
9850                    LOCATE 1,30
9860                    PRINT"***SYSTEM WARNING   "
9870                            FOR X =1 TO 50
9880                            NEXT X
9890                    LOCATE 1,30
9900                    PRINT"   SYSTEM WARNING***"
9910                            FOR X= 1 TO 50
9920                            NEXT X
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9930          NEXT J
9940    PRINT:PRINT:PRINT
9950    PRINT TAB(10)"***ACKNOWLEDGE THE SYSTEM WARNING BY PRESSING ANY KEY***"
9960    K$=INKEY$
9970    IF K$="" THEN GOTO 9960
9980     PRINT:PRINT
9990     PRINT "ENTRY STATUS/HAVE YOU ENTERED THE LUMINAIRE DESCRIPTION-TYPE 1 FO
R YES AND 2 FOR NO":INPUT DES
10000     IF DES <> 1 AND DES <> 2 THEN PRINT"INVALID ENTRY"
10010     IF DES <>1 AND DES <>2 THEN GOTO 9990
10020     IF DES=1 AND TESTFLAG=0 THEN PRINT"INCORRECT ANSWER -YOU MUST FIRST ENT
ER THE LUMINAIRE DESCRIPTION # PRIOR TO UTILIZING THIS SUBPROGRAM.YOU WILL NOW B
E RETURNING TO THE MAIN MENU"
10030     IF DES=1 AND TESTFLAG=0 THEN GOTO 11480
10040     IF DES =2 THEN GOTO 11480
10050    PRINT TAB(19)"*****************************"
10060     MAIN$="LUMEN"
10070     L=LEN(STR$(LUMNO))
10080    LUMNO$=STR$(LUMNO)
10090    LUMNO$=MID$(LUMNO$,2,L-1)
10100     FILENM$= MAIN$ + LUMNO$
10110    PRINT TAB(19)"*LUMINAIRE DATA MENU SCREEN*"
10120    PRINT TAB(19)"*                           *"
10130    PRINT TAB(19)"*-#1-ADD LUMINAIRE DATA     *"
10140    PRINT TAB(19)"*                           *"
10150    PRINT TAB(19)"*-#2-MODIFY EXISTING DATA   *"
10160    PRINT TAB(19)"*                           *"
10170    PRINT TAB(19)"*-#3-EXIT SUBPROGRAM        *"
10180    PRINT TAB(19)"*****************************"
10190    PRINT"PLEASE INPUT THE NUMBER ASSOCIATED WITH YOUR SELECTION;E.G.,1-3"
10200    INPUT LUMSEL
10210    IF LUMSEL<>1 AND LUMSEL<>2 AND LUMSEL<>3 THEN GOTO 10190
10220    IF LUMSEL=1 THEN GOTO 10250
10230    IF LUMSEL=2 THEN GOTO 10690
10240    IF LUMSEL=3 THEN GOTO 11480
10250    OPEN FILENM$ FOR INPUT AS #1
10260     IF EOF(1) THEN GOTO 10350
10270    INPUT #1,MAXSP,MAINTCAT,LUMDIST,LAMPLENGTH
10280    WHILE NOT EOF(1)
10290            FOR ROW =1 TO 11
10300                    FOR COLUMN= 1 TO 15
10310                            INPUT #1,CU!(ROW,COLUMN)
10320                    NEXT COLUMN
10330            NEXT ROW
10340    WEND
10350    CLOSE #1
10360    IF MAINTCAT <> 0 AND MAXSP <> 0 AND CU!(1,1) <> 0 AND CU!(11,15) <> 0 TH
EN GOTO 10370 ELSE GOTO 10430
10370    PRINT TAB(32)"****WARNING****"
10380    PRINT:PRINT"DATA HAS ALREADY BEEN ENTERED FOR LUMINAIRE #"LUMNO" -IF YOU
 DESIRE TO CHANGE DATA FOR THIS LUMINAIRE YOU WILL NEED TO SELECT OPTION #2 FROM
 THE LUMINAIRE DATA MENU SCREEN"
10390    FOR I= 1 TO 700
10400            I=I+1
10410    NEXT I
10420    GOTO 10110
10430     OPEN FILENM$  FOR OUTPUT AS #1
10440     INPUT"ENTER THE MAXSPACING TO MOUNTING HEIGHT RATIO-",MAXSP
10450     IF MAXSP<=0 THEN PRINT "RATIO MUST BE GREATER THAN 1-TRY AGAIN"
10460     IF MAXSP <= 0 THEN GOTO 10440
10470     INPUT"ENTER THE MAINTENANCE CATEGORY-",MAINTCAT
10480     IF MAINTCAT <1 OR MAINTCAT>5 THEN GOTO 10470
10490     INPUT "ENTER THE LUMINAIRE DISTRIBUTION TYPE-",LUMDIST
10500     IF LUMDIST <=0 OR  LUMDIST >5 THEN PRINT"LUM.DIST MUST BE AN INTEGER";
          ">= 1 AND <=5"
10510     IF LUMDIST <= 0 OR LUMDIST >5 THEN GOTO 10490
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10520    INPUT"ENTER THE LAMP LENGTH IN FEET ONLY-",LAMPLENGTH
10530    IF LAMPLENGTH >8 OR LAMPLENGTH <0 THEN PRINT"CANNOT ENTER A LAMP";
         "LENGTH >8 OR < 0 FEET -PLEASE TRY AGAIN"
10540    IF LAMPLENGTH >8 OR LAMPLENGTH <0 THEN GOTO 10520
10550    PRINT #1,MAXSP,MAINTCAT,LUMDIST,LAMPLENGTH
10560            FOR ROW =1 TO 11
10570                    FOR COLUMN =1 TO 15
10580                            PRINT "ROW=",ROW "COL="COLUMN
10590                            INPUT"ENTER THE CU VALUE--",CU!(ROW,COLUMN)
10600                            PRINT#1,CU!(ROW,COLUMN);
10610                    NEXT COLUMN
10620            NEXT ROW
10630    CLOSE #1
10640    CLS
10650    LOCATE 1,12
10660    PRINT"DO YOU WISH TO ACKNOWLEDGE THE CORRECTNESS OF THE MAXSP/MH";
         "RATIO,MAINTCAT,LUMDIST ,AND LAMPLENGTH INPUT ENTRIES-Y/N"
10670    INPUT ANSW$
10680    IF ANSW$="N" THEN GOTO 11140
10690    OPEN FILENM$ FOR INPUT AS #1
10700     IF EOF(1) THEN GOTO 10790
10710    INPUT#1,MAXSP,MAINTCAT,LUMDIST,LAMPLENGTH
10720   WHILE NOT EOF(1)
10730           FOR ROW =1 TO 11
10740           FOR COLUMN= 1 TO 15
10750           INPUT#1,CU!(ROW,COLUMN)
10760           NEXT COLUMN
10770           NEXT ROW
10780   WEND
10790     CLOSE#1
10800     IF MAINTCAT =0 AND MAXSP=0 AND CU(1,1)=0 AND CU(11,15)=0 THEN PRINT"DA
TA HAS NOT BEEN ENTERED FOR THIS LUMINAIRE.RETURN TO THE CU MENU SCREEN AND ENTE
R THE DATA":
10810     IF MAINTCAT=0 AND MAXSP=0 AND CU(1,1)=0 AND CU(11,15)=0 THEN GOTO 1011
0
10820    PRINT TAB(8)"MAX.SP." TAB(23)"MAINT.CAT."TAB(41)"LUM.DIST."TAB(58);
         "LAMPLENGTH"
10830    PRINT
10840    PRINT TAB(8) "---------"TAB(23)"---------"TAB(41)"----------"TAB(58)"--";
         "------"
10850    PRINT TAB(10) MAXSP TAB(27) MAINTCAT TAB(41) LUMDIST TAB(63) LAMPLENGTH

10860    PRINT "DO YOU WISH TO CHANGE A DATA ENTRY-Y/N":INPUT CUCORRECT$
10870    IF CUCORRECT$="N" THEN GOTO 11140
10880    PRINT "DO YOU WISH TO CHANGE THE MAXIMUM SPACING TO MOUNTING HEIGHT";
         "RATIO-Y/N"
10890    INPUT CUCORRECT$
10900    IF CUCORRECT$="N" THEN GOTO 10940
10910    INPUT "ENTER THE CORRECT MAX.SP. /MOUNT HEIGHT RATIO",MAXSP
10920    IF MAXSP<=0 THEN PRINT "RATIO MUST BE >THAN 1-TRY AGAIN PLEASE"
10930    IF MAXSP<=0 THEN GOTO 10910
10940    PRINT"DO YOU WISH TO CHANGE THE MAINT.CATEGORY-Y/N"
10950    INPUT CUCORRECT$
10960    IF CUCORRECT$="N" THEN GOTO 11000
10970    INPUT "ENTER THE MAINTENANCE CATEGORY",MAINTCAT
10980    IF MAINTCAT<1 OR MAINTCAT>5 THEN PRINT"MAINTENANCE CATEGORY MUST BE";
         AN INTEGER BETWEEN 1 AND 5"
10990    IF MAINTCAT<1 OR MAINTCAT>5 THEN GOTO 10970
11000    PRINT "DO YOU WISH TO CHANGE THE LUMINAIRE DISTRIBUTION-Y/N"
11010    INPUT CUCORRECT$
11020    IF CUCORRECT$="N" THEN GOTO 11060
11030    INPUT"ENTER THE LUMINAIRE DISTRIBUTION TYPE",LUMDIST
11040    IF LUMDIST <=0 OR LUMDIST >5 THEN PRINT"LUMDIST MUST BE AN INTEGER";
         ">=1 AND <= 5"
11050    IF LUMDIST <= 0 OR LUMDIST>5 THEN GOTO 11030
11060    PRINT"DO YOU WISH TO CHANGE THE LUMINAIRE LENGTH-Y/N"
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11070    INPUT CUCORRECT$
11080    IF CUCORRECT$="N" THEN GOTO 11110
11090    INPUT "ENTER THE LAMPLENGTH IN FEET -# ONLY",LAMPLENGTH
11100    IF LAMPLENGTH>8 OR LAMPLENGTH<0 THEN PRINT"YOU MAY NOT ENTER A";
         "LAMPLENGTH>8 OR <0.PLEASE TRY AGAIN"
11110    IF LAMPLENGTH >8 OR LAMPLENGTH <0 THEN GOTO 11090
11120    CLS
11130    LOCATE 5,12
11140    PRINT TAB(26) "COEFFICIENTS OF UTILIZATION"
11150    PRINT TAB(26) "---------------------------"
11160    PRINT:PRINT
11170    PRINT TAB(15)"PCC/   80   /   70   /   50   /   30   /   10   / 0 /
11180    PRINT TAB(15)"PW /50 30 10/50 30 10/50 30 10/50 30 10/50 30 10/    /"
11190    PRINT TAB(15)"RCR"
11200    FOR ROW =1 TO 11
11210             PRINT TAB(16)ROW;
11220             PRINT TAB(18);
11230             FOR COLUMN =1 TO 15
11240                     PRINT USING".##";CU(ROW,COLUMN);
11250             NEXT COLUMN
11260    NEXT ROW
11270    PRINT:PRINT
11280    PRINT"DO YOU WISH TO CHANGE A CU VALUE-Y/N"
11290    INPUT CUCORRECT$
11300    IF CUCORRECT$="N" THEN GOTO 11470
11310    INPUT"ENTER THE ROW NUMBER OF THE CU VALUE TO BE CHANGED",R
11320    IF R<1 OR R >11 THEN PRINT"ROW VALUE SELECTED MUST BE BETWEEN 1";
         "AND 11"
11330    IF R<1 OR R>11 THEN GOTO 11310
11340    INPUT"ENTER THE COLUMN # OF THE CU VALUE TO BE CHANGED",C
11350    IF C<1 OR C>15 THEN PRINT"ROW VALUE SELECTED MUST BE BETWEEN 1 AND15"
11360    IF C<1 OR C>15 THEN GOTO 11340
11370    INPUT "ENTER THE NEW CU VALUE",NEWCU
11380    OPEN FILENM$ FOR OUTPUT AS #1
11390    PRINT#1,MAXSP,MAINTCAT,LUMDIST,LAMPLENGTH
11400             FOR ROW=1 TO 11
11410                     FOR COLUMN=1 TO 15
11420                             IF ROW=R AND COLUMN=C THEN CU!(ROW,COLUMN)=NEWCU
11430                               PRINT#1,CU(ROW,COLUMN);
11440             NEXT COLUMN
11450    NEXT ROW
11460   GOTO 11280
11470    CLOSE#1
11480    RETURN
11490    '        SUBPROGRAM LUMINAIRE DESCRIPTION APPEND
11500    COLOR 9,0:CLS
11510   PRINT TAB(19)"*******************************************"
11520   PRINT TAB(19)"*LUMINAIRE DESCRIPTION APPEND MENU SCREEN *"
11530   PRINT TAB(19)"*                                         *"
11540   PRINT TAB(19)"*--#1-ADD/VIEW LUMINAIRE DESCRIPTIONS     *"
11550   PRINT TAB(19)"*                                         *"
11560   PRINT TAB(19)"*--#2-MODIFY EXISTING LUMINAIRE DESCRIP-  *"
11570   PRINT TAB(19)"*      TIONS                              *"
11580   PRINT TAB(19)"*--#3-EXIT LUMINAIRE DESCRIPTION SUBPROG- *"
11590   PRINT TAB(19)"*      RAM                                *"
11600   PRINT TAB(19)"******************************************"
11610   PRINT"PLEASE INPUT THE NUMBER OF YOUR SELECTION,E.G.,#1-3"
11620   INPUT DESCSEL
11630   IF DESCSEL<>1 AND DESCSEL<>2 AND DESCSEL<>3 THEN PRINT"INVALID DATA ENTR
Y"
11640   IF DESCSEL<>1 AND DESCSEL<>2 AND DESCSEL<>3 THEN GOTO 11610
11650   IF DESCSEL =1 THEN GOTO 11690
11660   IF DESCSEL =2 THEN GOTO 11840
11670   IF DESCSEL =3 THEN GOTO 12330
11680 '    SUBROUTINE LUMINAIRE APPEND
11690    OPEN "A:LUMDSC" FOR APPEND AS #1
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11700     PRINT"ENTER THE NUMBER OF DESCRIPTIONS TO BE ADDED-(TYPE 0 IF YOU DO";
               "NOT WANT TO ADD ANY)-----":INPUT NUMBER
11710     PRINT
11720     PRINT "YOU WISH TO ADD " NUMBER "DESRIPTIONS/CORRECT - Y/N"
11730     INPUT DEC$:IF DEC$() "Y" AND DEC$ () "N" THEN GOTO 11720
11740     IF DEC$ ="N" THEN GOTO 11700
11750     IF NUMBER=0 THEN GOTO 11830
11760     PRINT "UPON PROMPT PLEASE ENTER A SHORT USEFUL DESCRIPTION (LESS THAN O
REQUAL TO 80 CHAR.) OF THE LUMINAIRE TO BE ADDED."
11770     FOR K=1 TO NUMBER
11780             LINE INPUT"PLEASE ENTER A DESCRIPTION----",LUMDESC$
11790     IF LEN(LUMDESC$) )80 THEN PRINT"DATA ENTRY TOO LONG-PLEASE TRY AGAIN"
11800     IF LEN(LUMDESC$) )80 THEN GOTO 11780
11810             PRINT #1,LUMDESC$
11820     NEXT J
11830     CLOSE #1
11840     PRINT"PLEASE ACKNOWLEDGE THE CORRECTNESS OF THE PRESENT OR ";
      "PREVIOUS DATA ENTRIES"
11850     OPEN "A:LUMDSC" FOR INPUT  AS #1
11860     FOR J=1 TO 100
11870     IF EOF(1) THEN 11910
11880             LINE INPUT #1,LUMDESC$
11890             LUMDESC$(J)=LUMDESC$
11900     NEXT
11910     CLS
11920     CLOSE #1
11930     PRINT:PRINT
11940     PRINT TAB(29) "LUMINAIRE MENU SCREEN"
11950     PRINT TAB(29) "---------------------"
11960     PRINT:PRINT
11970     PRINT  "LUM #" TAB(29) "LUMINAIRE DESCRIPTION"
11980     PRINT
11990     N=0
12000     FOR K=1 TO J-1
12010             PRINT "#"K;
12020             PRINT TAB(7) LEFT$(LUMDESC$(K),65)
12030             PRINT TAB(7) MID$(LUMDESC$(K),66,80)
12040             N=N+1
12050             IF N=8 THEN PRINT"REVIEW THE SCREEN FOR POSSIBLE INPUT ERROR ";
                  "TYPE 1 TO CONTINUE"
12060             IF N=8 THEN INPUT DES ELSE GOTO 12070
12070             IF DES=1 AND N=8 THEN GOTO 12080
12080             IF N=8 THEN CLS
12090     IF N=8 THEN N=0
12100     NEXT K
12110     GOTO 12120
12120     PRINT"DO YOU WISH TO CHANGE A LUMINAIRE DESCRIPTION:Y-N"
12130     INPUT CUCORRECT$
12140     IF CUCORRECT$="N" THEN GOTO 12270
12150     INPUT"ENTER THE #OF THE DESCRIPTION TO BE CHANGED-",LUMCHG
12160     IF LUMCHG (1 OR LUMCHG ) J-1 THEN PRINT"INVALID ENTRY"
12170     IF LUMCHG (1 OR LUMCHG ) J-1 THEN GOTO 12150
12180     LINE INPUT"PLEASE ENTER A SHORT USEFUL DESCRIPTION LESS THAN 2 LINES--"
,LUMDESC$(LUMCHG)
12190     IF LEN(LUMDESC$(LUMCHG)) )80 THEN PRINT"DATA ENTRY TOO LONG-PLEASE TRY"
;         "AGAIN"
12200     IF LEN(LUMDESC$(LUMCHG)))80 THEN GOTO 12180
12210     PRINT"DO YOU WISH TO CHANGE ANOTHER DESCRIPTION-Y/N"
12220     INPUT CUCORRECT$
12230     IF CUCORRECT$="Y" THEN GOTO 12150
12240     PRINT"DO YOU DESIRE TO SEE THE CHANGES-Y/N"
12250     INPUT CHG$
12260     IF CHG$="Y" THEN GOTO 11940
12270     OPEN "A:LUMDSC" FOR OUTPUT AS #1
12280     FOR L=1 TO J
12290             PRINT #1,LUMDESC$(L)
12300     NEXT L
12310     GOTO 12320
12320     CLOSE #1
12330     RETURN
```