JPL PUBLICATION 78-76

JPL Energy Consumption Program (ECP) Documentation

A Computer Model Simulating Heating, Cooling and Energy Loads in Buildings

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ABSTRACT

This engineering manual provides a complete companion documentation about the structure of the main program and subroutines, the preparation of input data, the interpretation of output results, access and use of the program, and the detailed description of all the analytic, logical expressions and flow charts used in computations and program structure. A numerical example is provided and solved completely to show the sequence of computations followed. The program is carefully structured to reduce both user's time and costs without sacrificing accuracy. The user would expect a cost of CPU time of approximately $5.00 per building zone excluding printing costs. The accuracy, on the other hand, measured by deviation of simulated consumption from watt-hour meter readings, has been found by many simulation tests not to exceed ±10% margin, a margin which is considered very reasonable for engineering purposes.

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SECTION I
INTRODUCTION

1.1 Background

It is commonly conceived that buildings can be designed for minimum energy consumption if their thermal insulation is increased, window air leakage is reduced, lighting levels are decreased, shading devices are properly installed, heating and cooling equipment are adequately designed, maintained and their capacity fully utilized. These energy saving ideas and many others should be coupled before implementation with the cost of add-on equipment and materials, operation and maintenance cost, constraints of building codes, life styles, aesthetic attractiveness, etc.

The common design methodology used in sizing heating and cooling systems based upon the single-value quasi-steady state peak summer hour or peak winter hour usually results in oversizing of equipment and consequently overheating or overcooling of the space to be controlled. Over-designed systems, while they are occupying more space, always operate at lower efficiency and in turn require more energy to function compared to properly designed ones. The single-valued design methods are, therefore, ruled out in any study or design of energy systems.

The only effective way to study and design heating or cooling-systems and minimize their energy consumption, is to simulate the building thermal performance as accurately as possible. With the advent of high speed digital computers, the above simulation requirement can be done on an hourly basis for a full year and with summation over many zones or buildings. In the last ten years, several of these simulation programs have been developed which vary in cost, availability to the user, program structure, and assumptions used in computations as indicated in references (1) and (2). Most of these programs, whether they are public or proprietary, are applicable to new system design or to add-on or retrofit systems. The user may access the programs by : (1) purchasing public source codes, (2) input data only through time sharing when dealing with proprietary source codes or (3) input data only to the developer when dealing with complete proprietary codes. The disadvantages to the user in types (2) and (3) above are the lack of awareness about assumptions and limitations made by the developer and the inability of the user to improve or modify the codes. Proprietary programs are commonly written by architect-engineering consultants, heating, ventilation and air conditioning (HVAC) equipment manufacturers or utility companies. The cost to the user is usually included in their service.

The need for a building simulation tool was essential to support the Deep Space Network (DSN) Energy Conservation project. The latter has been initiated to save energy and associated cost at government installations, and specifically at the Deep Space Communication Complex, at Goldstone, California. Twenty-three buildings out of fifty were identified, by a first phase study, as major energy consumption buildings and were further put under investigation for a second building modification study. Both studies were performed by architect-engineering firms in cooperation with the DSN engineering section at JPL, resulting in many energy saving recommendations. Furthermore, several suggestions and proposals regarding building modifications have been presented by operations technicians and engineers motivated by the personnel Energy Conservation, Awareness and Recognition program (ECARP). It has, therefore, become essential for economic and technical reasons to develop a tool for accurate assessment and evaluation of all building modifications.

To accomplish the task of finding the building simulation tool, a survey was made among fourteen available codes for heating and cooling load calculations. The major codes among them are (1) ECUBE 75 which was developed by the American Gas Association, (2) NBSLD, the National Bureau of Standards Load Calculation Program, (3) NECAP, the comprehensive and expensive NASA's Energy Cost Analysis program, (4) TRACE, the Trane Air Conditioning and Economics Program and (5) USPS, the United States Postal Services Program developed by the General American Transportation Corporation.

Unfortunately, none of these programs was found: (1) suitable to simulate the unique features of two-level electronic control rooms located at the Goldstone Communication Complex, (2) low in running cost to yield an inexpensive evaluation of the tens of possible energy saving recommendations, and (3) simple enough for the average user with minimum input data about system parameters. Toward these objectives, an in-house Energy Consumption Program (ECP) was developed both to satisfy the Deep Space Network needs and to be also applicable to residential and institutional buildings.

1.2 Purpose of Documentation

The purpose of this engineering manual is to provide a complete companion documentation about the structure of main program and subroutines, the preparation of input data, the interpretation of output forms, the access and use of the program, and the detailed description of all the analytic expressions and flow charts used in computations. The program is considered non-proprietary and is carefully structured to reduce both user's time and cost without sacrificing accuracy.

1.3 Overview of Program Structure

The calculation of energy requirements for heating or cooling in any enclosure involves three major successive steps. First, the calculation of the heat loss or heat gain to the enclosure which is heated or cooled is computed. Second, the heating or cooling loads imposed on the heating or cooling coils inside the fan-coil units (or air handlers) are determined. Third, the energy input to all of the primary components constituting the air conditioning system such as compressors, heat pumps, boilers, engines, etc., is calculated. Each of these calculation steps may be carried out with various degrees of complexity and sophistication if more refinement or accuracy is required.

Fig. 1-1 illustrates, for example, the possible sources of heat gain or loss to or from a simple zone as needed in the first step of calculation. These sources include (a) solar heat gain through windows and glass areas, (b) heat transmission

1 SOLAR HEAT GAIN THROUGH WINDOWS, GLASS AREAS

2 SOLAR HEAT GAIN THROUGH WALLS, ROOF

3 TRANSMISSION HEAT GAIN/LOSS DUE TO HOT/COLD OUTSIDE AIR THROUGH WALLS/ROOF

4 TRANSMISSION HEAT LOSS/GAIN DUE TO COLD/HOT OUTSIDE AIR THROUGH WINDOWS, GLASS AREAS

5 HEAT GAIN/LOSS DUE TO VARIOUS TYPES OF NEIGHBOURING ZONES AT DIFFERENT TEMP.

6 LIGHTS HEAT GAIN FLOURESCENT AND INCANDESCENT

7 PEOPLE HEAT GAIN

8 ELECTRONICS EQUIP. HEAT GAIN

9 MECHANICAL EQUIP. HEAT GAIN

10 INFILTRATION/EXFILTRATION LOSS OR GAIN, CRACKS, DOORS WINDOWS. . .

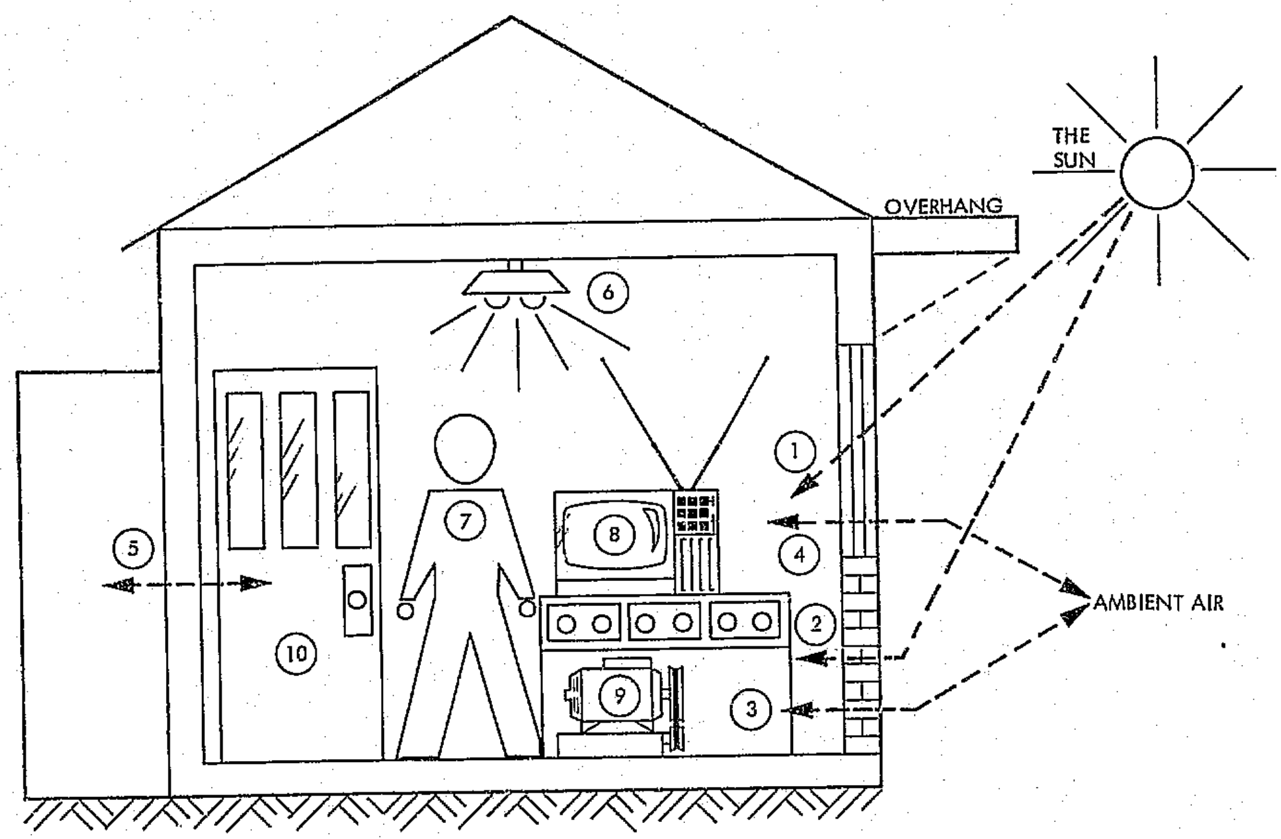


Figure 1-1. Simple-zone heat gain/loss

through walls and roofs due to solar and ambient air effects, (c) internal heat gain from lights, people, electronic and mechanical equipment, (d) infiltration or exfiltration from cracks, and natural draft, and (e) effect of neighboring nodes at different temperature compared to the zone under study. In Figure 1-2, the location of the fan-coil unit (air handler) with respect to the zone is illustrated. The expressions of "supply air" to the zone, "return air" from the zone, "outside air" and "mixed air" will be repeated throughout the text and the reader should be familiar with their positions in the common air conditioning loop in Fig. 1-2. The fresh outside air charge to the loop and the recycling of some of the warm return air from the zone(s) is a common practice to both satisfy the ventilation needs and to save heating or cooling energy needed at the air handler coils. Fig. 1-3 shows how the air conditioning loop can be different when a two-level zone versus a simple zone is conditioned. Two-level zones are quite common in industrial or utility plants where large number of automatic control and monitor equipment or racks are grouped in one room. The equipment cooling is made via a large cold duct (air plenum) that exhausts in the room through the racks. For personnel comfort in this type of zones, another stream of "comfort air" is fed into the room, through ceiling or floor level outlets, to mix with air discharged from electronic racks.

The second step of program calculations, the heating or cooling loads at the air handler coils, are computed to match the zone needs. The third step of calculations then follows and requires the definition of HVAC components such as the boilers (whether gas-fired or electric type) for heating and the electric driven vapor-compressor refrigeration units for cooling. Other supporting components such as motors, pumps, fans, engines, etc., need to be also included.

The dual duct system, shown in Fig. 1-4 for example, is one of many fan-coil arrangements that will be explained in detail later. This is only presented at this stage to acquaint the program user with the type and location of components included in the building energy analysis. In the dual duct multizone system, the mixed air leaving the fan section is divided into two main air streams; one of them is cooled down to the cooling set point temperature (commonly at 55-60^{o}F) and the other one is heated up to the heating set point temperature (commonly at 80-90^{o}F). Each zone according to its internal heat gain or loss asks the air handler for a specific "supply air" temperature to meet the comfort conditions inside it. The mixing box, located prior to each zone air supply section, extracts the appropriate amounts of air from each of the hot and cold ducts and mixes them together to yield the air mixture temperature requested by the zone. The function of controlling the mixing process is usually made by motorized dampers that are actuated by signals from temperature sensors. The cooling coil, heating coil, boiler, and the vapor compression refrigeration unit are included in Fig. 1-4 to show their relative position in the cycle.

1.4 Program Methodology

The following paragraphs explain the methodology used to express each major heading in the program. More input data description can be found in Section III.

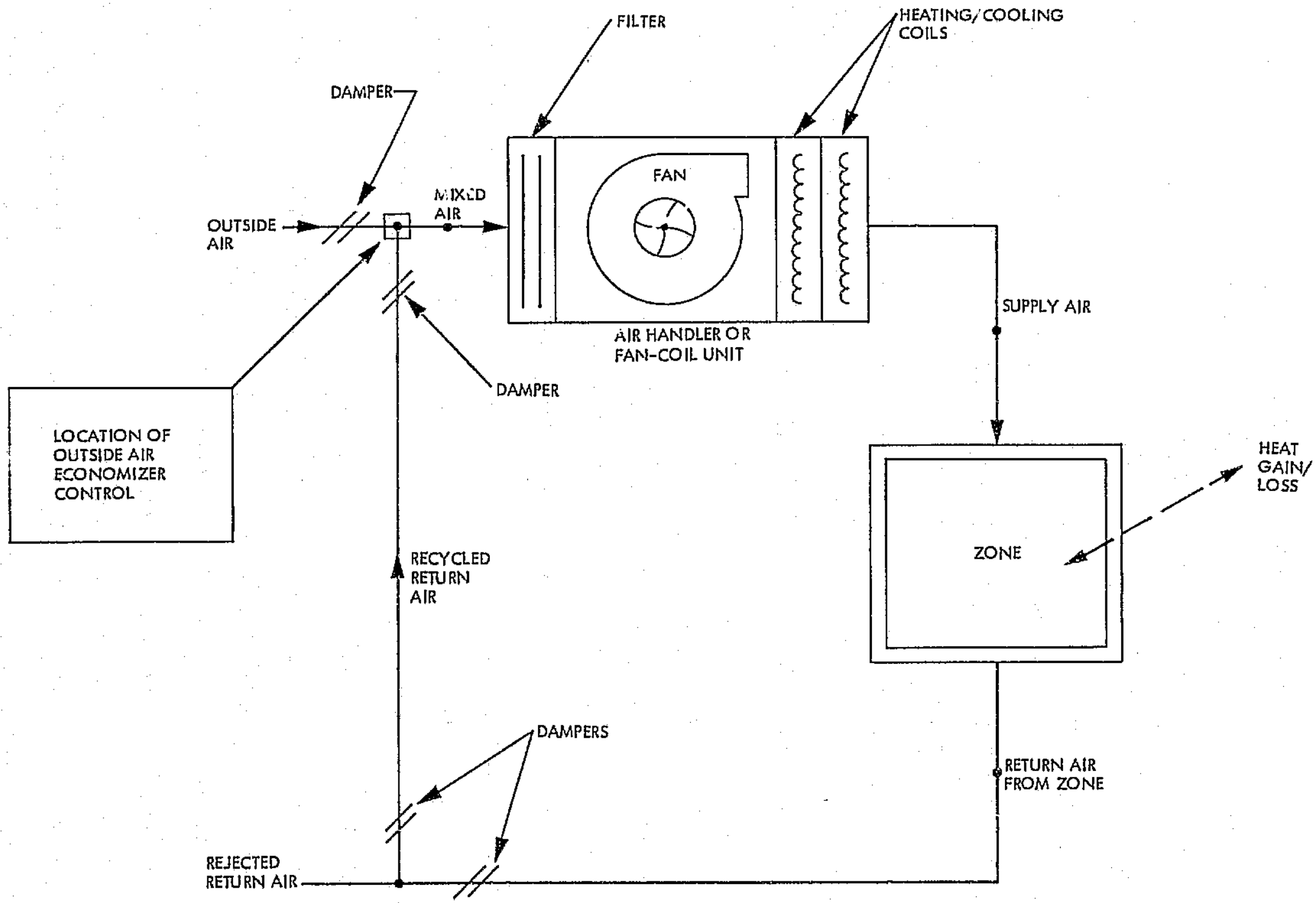


Figure 1-2. General schematic of an air conditioning system

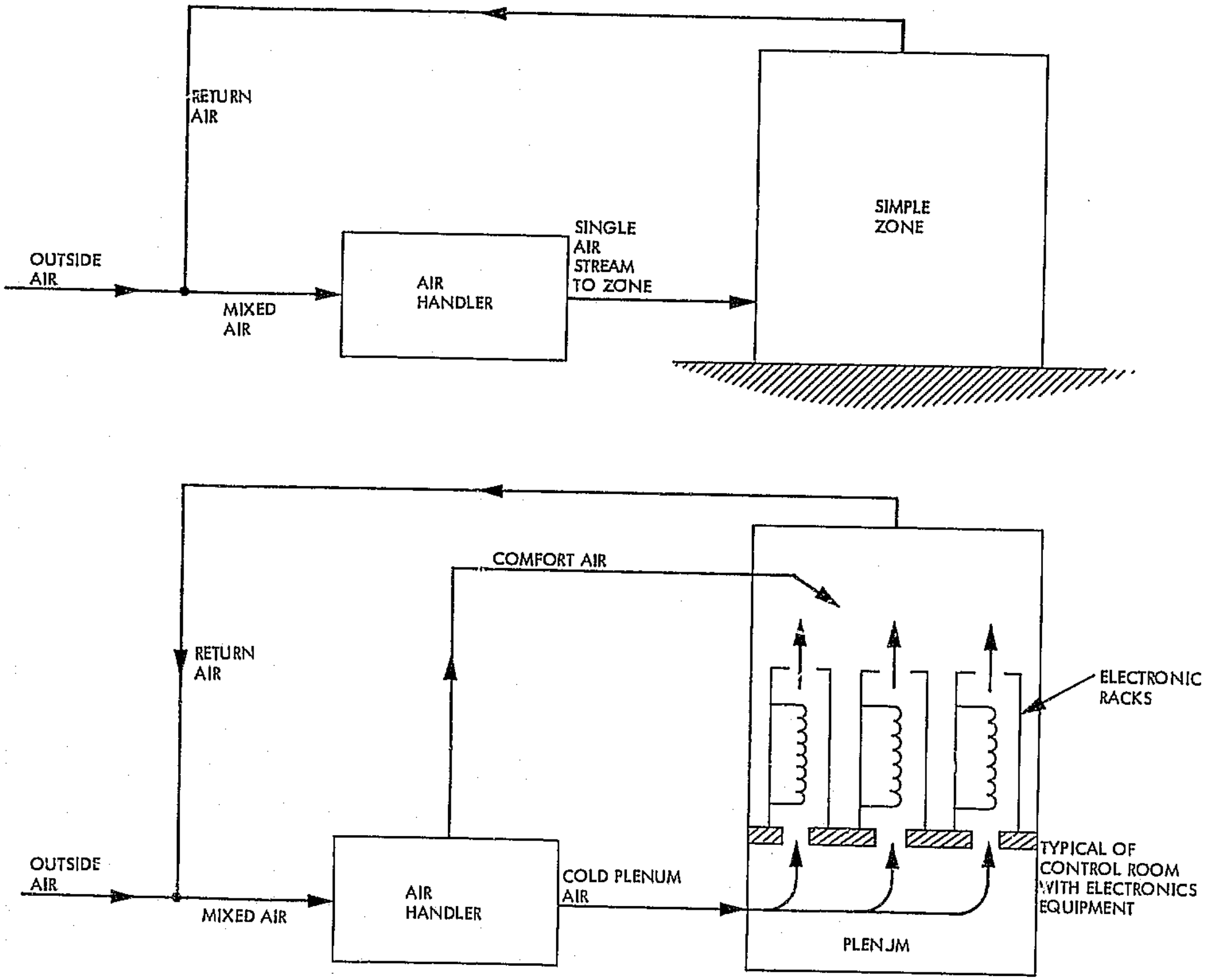


Figure 1-3. Schematic of a simple zone (top) and a two-level zone (bottom)

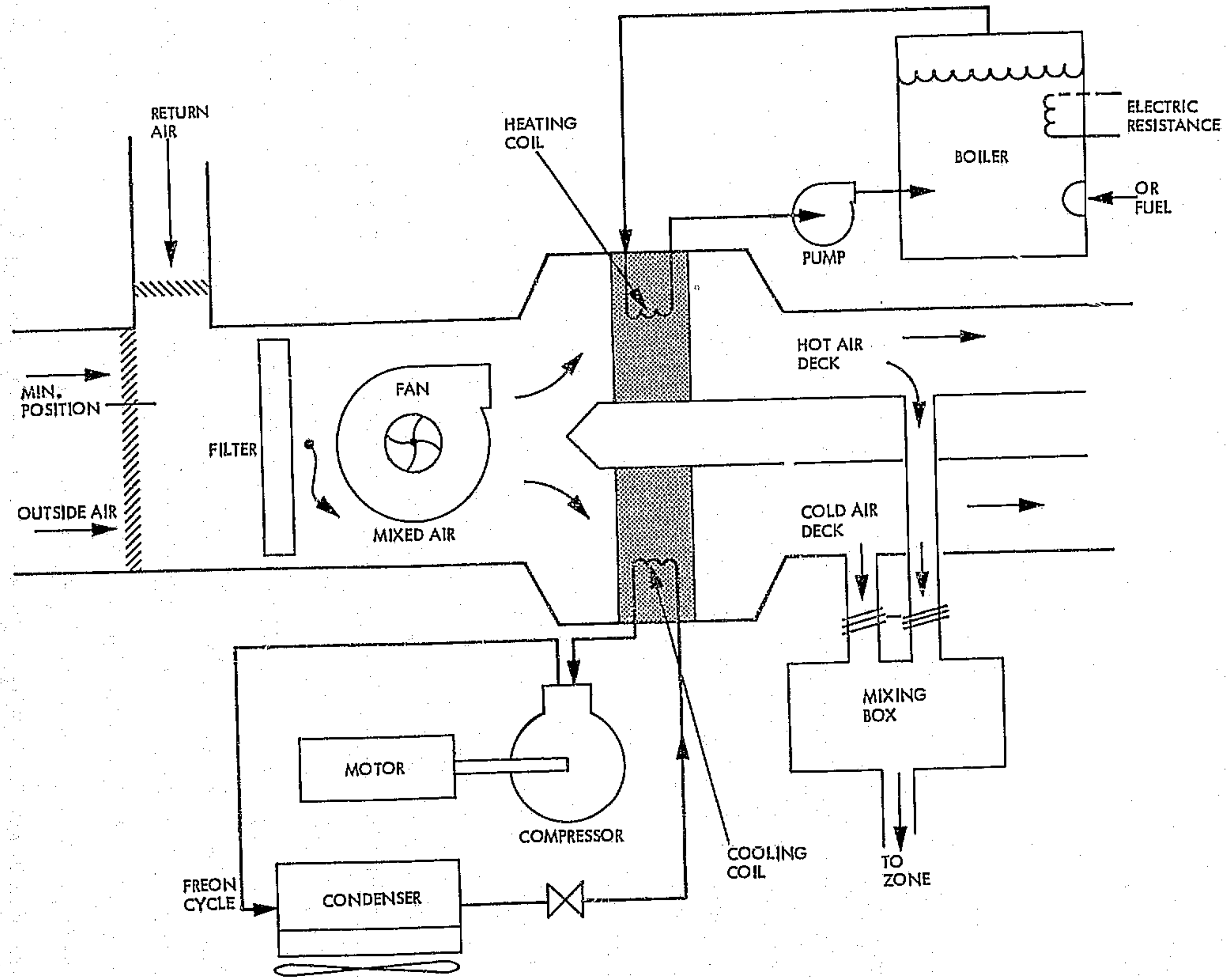


Figure 1-4. Example of primary air conditioning equipment components in a dual duct multizone system

1.4.1. Weather Data

Only outside air dry bulb temperature, cloud cover factors and wind speed are needed. Since the program is handling only sensible loads with no consideration to latent loads, the outside air wet bulb temperature or relative humidity is not needed in the weather data.

1.4.2. Transmission Loads Through Walls and Roofs

The methods that have been developed in the past, such as degree-days or bin methods, for proportioning the design load to provide hourly loads, were found unacceptable with their gross approximations. On the other hand, sophisticated and time consuming methods such as using the transfer functions or response factors are expensive and cannot be justified on the basis of the random changes of many other parameters in the system. This means that it is illogical to increase the accuracy of only one of the many sources of heating or cooling loads (i.e., the heat transmission through walls/roofs) while the other sources are subject to random changes with very large errors.

The methodology used in ECP is the sol-air temperature method or Total Equivalent Temperature Difference method (TETD) as described in references (3) and (4) and is written in (TRANS) subroutine section VII. It is a comprehensive yet easy to apply method. In the TETD method, the effects of outside air temperature and solar radiation intensity are combined into a single quantity. Walls and roofs are assumed homogeneous with constant material properties that are determined in advance by the special sub-program (UVPHI), presented in appendix C. The steady state and transient heat transfer coefficients together with the phase hours needed to run the heat transmission calculations in (TRANS) subroutine are expressed analytically in (UVPHI) subprogram.

1.4.3. Solar Heat Gain

Local solar radiation values have been calculated in (SOLAR) subroutine, as explained in Section VI, using the well-known ASHRAE model described in Reference (3). Cloud cover factors are used to modify the hourly radiation values from (SOLAR) subroutine to yield the local and site-specific values. This procedure was found to be effective in reducing solar radiation and cloud data required for manipulation, since only the monthly integration of direct normal solar irradiation is required for the computation of monthly cloud cover factors. The latter can be measured by an integrating type radiation pyrometer. Heat gain through glass doors or windows will then follow in computation given the glass transmissivity.

1.4.4. Infiltration/Exfiltration Load

The "air change method" is used to calculate the infiltration/exfiltration heat load in this program instead of the common "crack method". In this method,the effect of repetitive opening or closing of doors, windows and leakage of outside air to or from the zone by natural draft is averaged by assuming a fixed outside air change rate of 1.2 changes/hr. The computation of heat loss or gain from or to the zone then follows assuming quasi-steady state conditions.

1.4.5. Internal Heat Load Profile

Since latent loads due to humidity gain or loss to the zone are often less than 10% of the total heat load, only sensible heat loads are considered in the program. With this approximation in mind, the computer memory storage and humidity related calculations were simplified. The cancellation of psychrometric chart manipulations and the reduction of weather deck data are examples of simple handling of data. It is worth mentioning in this respect that the assumption of negligible latent loads, although it appears as a gross approximation, is not seriously affecting the accuracy of computations for a full year simulation period. This is due to the fact that the other sources of internal heat loads usually encompass parameters of random nature and given by the user based on his "best estimate".

The internal heat load in a zone is composed of heat gain from people, light (incandescent or fluorescent), electronic and mechanical equipment, and other miscellaneous sources such as process steam, kitchen equipment, etc. Each of these loads are calculated on an hourly basis for two day-types representing repetitive events for the whole year. The first day-type represents all working weekdays (approximately 251 days) and the second day-type augments all weekends and holidays (approximately 114 days to include 10 official holidays). The number of persons occupying the zone, the wattage rating of electrical, mechanical equipment and light bulbs are listed every hour for the two day-types. Since the data collected under this internal load calculation section are considered approximate estimates with varying degrees of uncertainty, it was decided in the early stages of ECP development that the (TETD) method, previously described under subsection 1.4.2, and the assumption of zero latent loads are in fact adequate to meet the program goals of simplicity and low running cost. Furthermore, the transient effects of convection-radiation segments of all internal heat loads from light, people and equipment were neglected. The internal loads are assumed totally convective and their hourly values were computed by quasi-steady state equations.

1.4.6. Architectural Data

The physical and architectural characteristics of the building and its zones play a significant role in the sensible heat load. The required data include building orientation, latitude, elevation above sea level, wall areas, glass areas, space volume, physical dimensions, exterior walls solar absorptivity and the cross section description of layers constituting walls and roofs. The data are grouped by zone; the maximum number of zones per building is not allowed to exceed eight in the program. If there are more than eight zones, grouping of several zones into macrozones having the same fan-coil feed arrangement may be done.

1.4.7 Shading Factors

The shading factors are used to attenuate the incident solar radiation and the heat transmission to exterior walls. Shading due to overhangs, side projections or adjacent buildings is handled in ECP as a fixed fraction between zero and one given by the user based on yearly average observation. This approximate method is used in lieu of the detailed analytical methods used to compute hourly shaded areas at varying sun angles.

1.4.8 Loads Due to Neighbouring Areas

The effect of a neighbouring zone having a temperature different from that of the zone under study has been taken into consideration in load calculations. Ground floors were assumed perfectly insulated with no heat exchange to or from the varying temperature ground. Temperatures of neighbouring zones are specified by the program user as input data as will be explained later.

1.4.9 Fan-Coil Types and Arrangement

There are nine types of fan-coil arrangements that have been incorporated into the program for the second step of calculations. These are sketched in Fig. 1-5 and will be explained in detail in Section VIII. Nine subroutines (KEQ1) through (KEQ9) are presented corresponding to each fan-coil arrangement. The maximum number of fan-coil units for each building is ten. To support the calculation of the heating and cooling loads of the fan-coil units, the ratio of outside air to total circulating air, and the set point temperatures of both hot and cold supply ducts are required as input. Moreover, for two-level rooms the maximum allowable plenum air temperature and the ratio of comfort air discharge to total circulating air discharge are required from the user. The program also includes outside air economizer cycles and their various air flow and temperature control mechanisms. The outside air economizer cycles considered are explained in the main program Section V in detail.

1.4.10 Time Clocks

The inclusion of time clocks, to control the operation (on or off) of fan-coil units only, has been presented as an energy saving suggestion. The energy saved by a time clock control is optimum for buildings that operate on the common 8:00 AM to 5:00 PM schedule. The time clock on/off control in the program is not made applicable to lighting, electronic or mechanical equipment since these latter changes will appear directly under the internal load schedule data.

1.4.11 Primary Equipment Performance

The user will identify under this heading: (1) type of heating or reheating

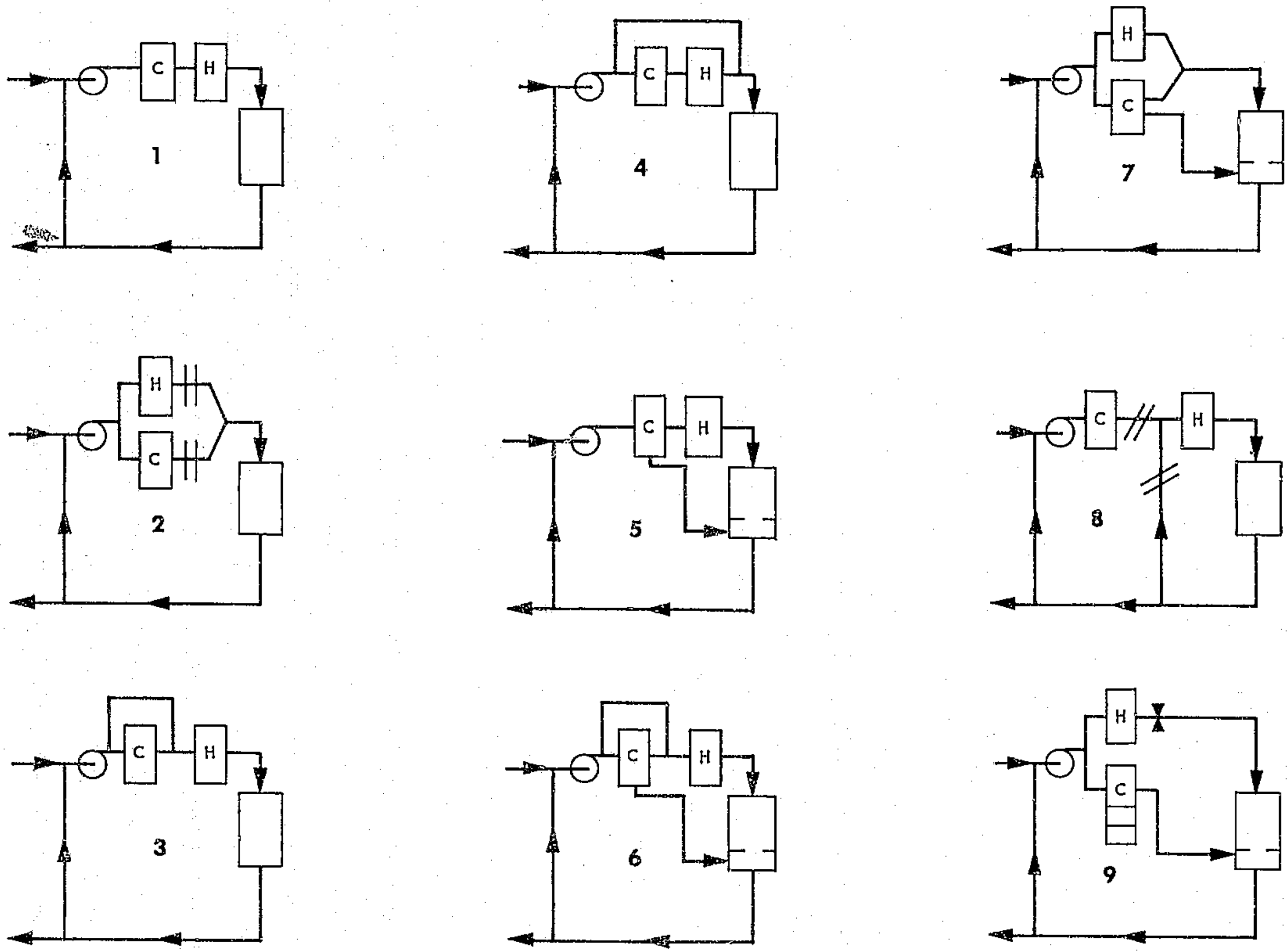


Figure 1-5. Fan coil arrangements handled by ECP

systems (electric, gas-fired or heat pump), (2) the arrangement of fan-coil units with respect to the electric driven compressor/chiller (vapor compression refrigeration units) and (3) compressor stages and size. The maximum number of compressors allowed in the program is ten per building. Each compressor was assumed to be made of two stages with the second stage giving the full refrigeration tons when on. The coefficient of performance of heat pumps and vapor compression refrigerators was assumed a fraction ($\sim$50%) of the ideal Carnot's cycle working between the refrigerant's evaporator and condenser temperatures. Partial-load performance was assumed unchanged from 100% full load until 40% of the full load. Beyond the 40% full load point, the external energy consumed was assumed constant. Further details are given in the coefficient of performance (COP) subroutine in Section IX. Electric heaters (or boilers) were assumed having a constant 80% efficiency at all loads. No absorption chillers, steam turbines or engines were considered in the primary equipment performance at this stage but the program is simply structured to allow for future expansions or inclusions if needed.

1.4.12 Energy Consumed in Auxiliary Equipment

An auxiliary equipment is defined in this program as that equipment outside the air conditioned space which is necessary for building operation but does not affect the heating/cooling loads calculations significantly or at all. Auxiliary equipment include air handler fans, condenser fans (if air cooled), condenser pumps (if water cooled), cooling tower pumps and fans, boiler pumps, external lights, etc. The energy consumed by these equipment directly affect the watt-hour meter reading. Their load profile and schedule can be quite complex if not simplified. The auxiliary equipment consumption is modelled in this program by name tag capacities and their total hours of operation. No allowance was made for partial load performance or flow,pressure and discharge variations.

1.4.13 Energy Cost

The unit cost of both thermal and electric forms of energy as purchased from a utility company or generated on site was used to compute monthly and yearly cost of energy. The economic section of the program is therefore made short with results that can fit many well-developed cost-benefit programs using the cash flow analysis.

1.4.14 Other Program Features

In addition to the above component description, many default values are assigned to fill unknown input data. The program is written in FORTRAN V computer language using the EXEC-8 commands and codes of UNIVAC-1108 machines at JPL. The program output results are explained in detail in Section IV. The user would expect a cost of CPU time of approximately $5.00 per building-zone excluding printing cost. In this regard the program is considered inexpensive compared to other complex codes. The accuracy, on the other hand, measured by deviation of simulated consumption from watt-hour meter readings, has been found by actual tests not to exceed ± 10% margin, which is considered very reasonable for engineering purposes.

SECTION II

ACCESS AND USE OF ECP

ECP is accessed on the Univac 1108 System through the use of EXEC-8 control language. The following cards are necessary to execute the program:

A. 1108 Control Cards

A control card is used to control the flow, make necessary file(s) assignment(s) and execute the program.

(1) @ASG,A PROGRAM. FILE.
Assigns the file(s) containing the absolute element, ECPABS and all data elements.

(2) @XQT FILE.ELEMENT
Executes the ECP absolute element.

(3) @ ADD FILE.ELEMENT
Adds the data needed for the run from FILE.ELEMENT

B. Data Deck

The data bank is divided into three decks: a weather deck, an air conditioning equipment deck and a macrozone deck. The three decks are described in detail in Section III of this document.

A typical program deck is illustrated in Fig. 2.1. It is assumed that the user has some knowledge of logging-on and logging-off the 1108 system.

2.1 Use of (NAMELIST)

With the exception of the weather deck, all data are input into ECP using NAMELIST, explained as follows:

NAMELIST is a FORTRAN V input/output option which allows an entire list of data to be input in the program with only one READ statement. The data within a NAMELIST must comply with FORTRAN V NAMELIST rules. These rules are discussed briefly below. A typical NAMELIST deck is illustrated in Fig. 2.2.

The first card in a NAMELIST is a Title Card. This card must have $$ followed by the title of the NAMELIST with no blanks between, i.e., $$TITLE.

Cards following the Title Card are Data Cards. The general form of input data is, for example:

AH(8,3) = 1, NOP (22,5) = 3., HEATER = 1,

The data are punched on a card between columns 2 and 80 in any order. Data items are separated by commas; the final comma of the last data card is optional. FORTRAN V ignores all blanks within a NAMELIST. Numerical values can be input in any form: real, integer or exponential form. All real data must

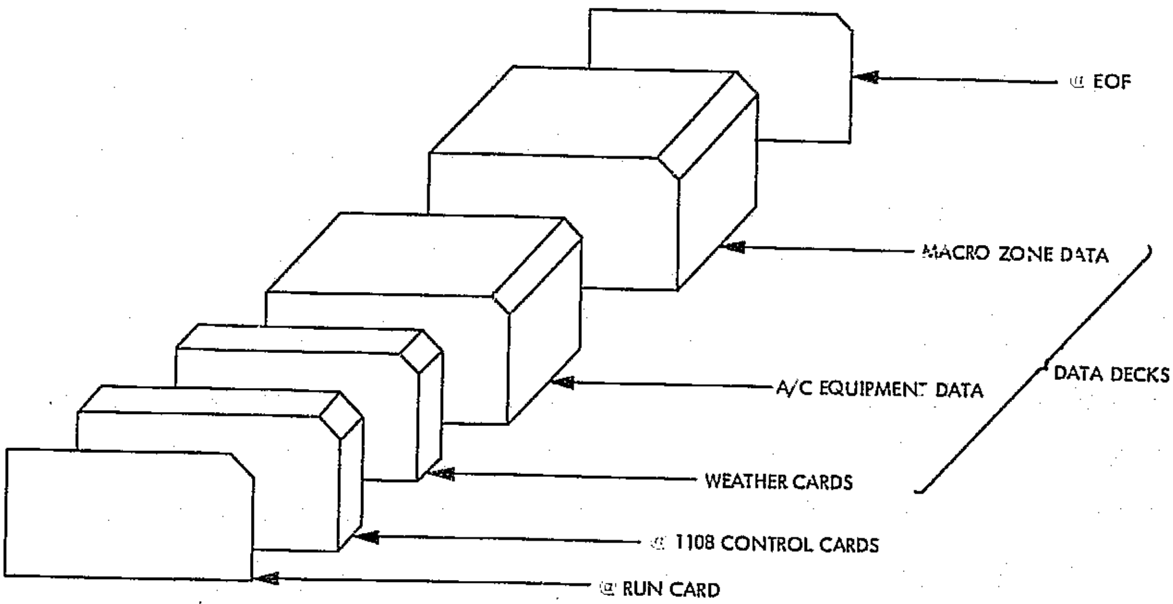


Figure 2-1. Program card deck

contain a decimal point. (A numeric character following the decimal point is not necessary.) Integer values are entered without a decimal point. The detailed description of each data entry includes the form of the data entry which allows the user to decide if a decimal point is needed or not. This is explained in Section III. For the two variables (HEATER) and (AH), for example, having dimensions (10) and (8,10), respectively, the following demonstrate the use of shorthand notation and overwriting in a NAMELIST deck.

EXAMPLES OF SHORTHAND NOTATION

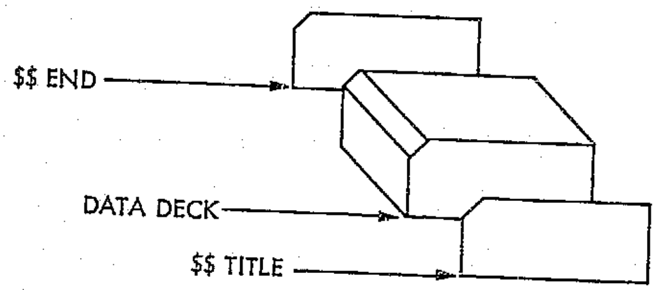
Card Image	Equivalent
HEATER (5) = 1,1,1, or HEATER (5) = 3*1,	HEATER (5) = 1 HEATER (6) = 1 HEATER (7) = 1
AH (7,9) = 1,1,1, or AH (7,9) = 3*1,	AH (7,9) = 1 AH (8,9) = 1 AH (1,10) = 1
HEATER = 1,1,1, or HEATER (1) = 1,1,1,	HEATER (1) = 1 HEATER (2) = 1 HEATER (3) = 1

EXAMPLES OF OVERWRITING

Card Image	Equivalent
AH = 5*1, AH (3) = 2,1,3,	AH (1,1) = 1 AH (2,1) = 1 AH (3,1) = 2 AH (4,1) = 1 AH (5,1) = 3

If any data entries are omitted in a NAMELIST they will be taken as zero unless a default value has been set.

The final card in a (NAMELIST) is the END card. The END card must have a $$ followed by END with no blanks between as shown in Figure 2.2. The data within a (NAMELIST) is further divided into two subgroups: (1) NAMELIST/HANDLR/ data which are related to the fan-coil units (air handler) and the primary air conditioning components and (2) NAMELIST/INPUT1/ data which are related to building architectural data and other zone data. The detailed description of the data in each NAMELIST subgroup is given in the next Section.



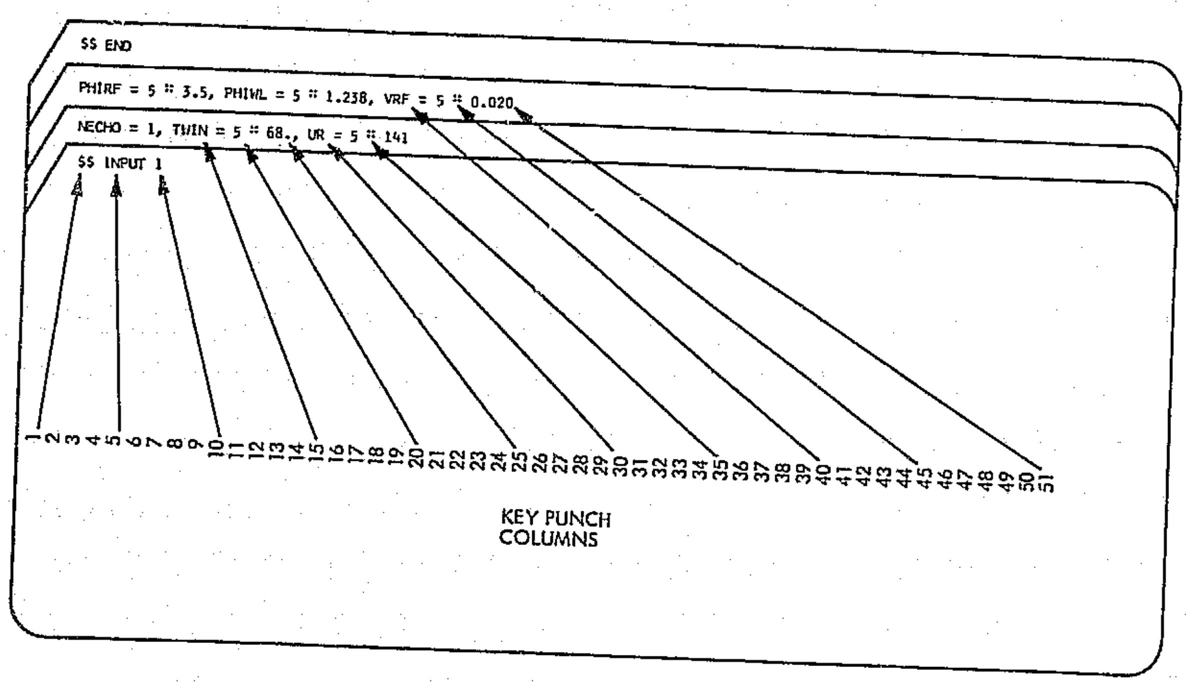


Figure 2-2. Arrangement of cards for typical namelist

SECTION III

INPUT DATA DESCRIPTION

Each of the weather deck, the air conditioning equipment deck and the macro-zone deck will be explained in detail as follows:

3.1 Weather Deck

The weather deck consists of three weather related data items: dry bulb temperatures of outside air, monthly cloud cover factors and hourly wind speed for the location under investigation. The dry bulb temperatures and cloud cover factors are taken as monthly averages and are listed in Table 3.1.

Table 3.1 Weather Deck

No.	Variable	Numeric form	Dimension	Description
1.	CCF	REAL	(12) vector	CCF is the monthly cloud cover factor. One representative value for each month. The cloud cover data card consists of twelve entries each occupying six columns. (12F6.2). CCF(i) indicates the cloud cover factor for the i^{th} month.
2.	TOA	REAL	(12,24) matrix	TOA is the outside air dry bulb temperature in degrees F. Each month is associated with twenty-four values: one value for every hour in a representative day of that month. One data card consists of twenty-four entries, each occupying three columns. (24F3.0) TOA(i,j) indicates the outside air temperature of the i^{th} month at the jth hour of the representative day.
3.	WMPH	REAL	(24) vector	Wind speed in miles per hour is used for computing the convective heat transfer coefficient of exterior walls. Twenty-four values are needed corresponding to twenty-four hours of a day representative of the year. Each of the twenty-four entries occupies three columns on the wind speed data card. (24F3.0) WMPH(j) indicates the wind speed in miles per hour of the j^{th} hour of the representative day of the year.

3.2 Air Conditioning Equipment Deck

All data for the air conditioning equipment deck are input through NAMELIST/ HANDLR/ in a free field format. These data items simulate the fan-coil unit configurations, hot and cold deck set points, outside air economizer cycles, type and size of primary equipment, compressor-air handler arrangement, etc. The total number of variables entered in this deck is 21 as listed in Table 3.2 in alphabetic order. The data entry is started by writing

$$HANDLR

and is ended by writing

$$END

Table 3.2 Air Conditioning Equipment Deck

No.	Variable	Numeric form	Dimension	Description
1	ACCERY	Real	(2,5) matrix	ACCERY is the daily energy consumption in kilowatt-hrs of each auxiliary equipment (fans, pumps, external lights, etc.) that does not contribute to the air conditioning load of the building. Data are entered according to day type and use of auxiliary equipment as defined below. If M is the daytype then ACCERY (M,1) = energy consumption by lights external to the building ACCERY (M,2) = energy consumption by fans in all air handlers in the building ACCERY (M,3) = energy consumption by pumps and fans in all condensers in the building ACCERY (M,4) = energy consumption by all boiler pumps in the building ACCERY (M,5) = energy consumption by any other equipment which does not contribute to the air conditioning load and is not mentioned above
2	AH	Integer	(8,10) matrix	Air handler type. (AH) identifies the mechanism which modulates the temperature of air leaving a specific air handler to match the zone needs as shown in Fig. 1-5. There are nine air handler types 1. Single cold duct with terminal reheat at the zone 2. Dual duct, multizone with mixing boxes, or single duct, multizone with mixing at the air handler

Table 3.2 (continued)

No.	Variable	Numeric Form	Dimension	Description
				3. Single cold duct with bypass and terminal reheat. 4. Heat pump with bypass control, or single duct with alternately operating cooling and heating coils with bypass control. 5. Two-level room with cold plenum air and comfort air modulated by terminal reheat. 6. Two-level room with cold plenum air and comfort air modulated by a mixture of cold air with bypassed mixed air and terminal reheat. 7. Two-level room with cold plenum air and comfort air modulated by mixing cold and hot decks. 8. Single cold deck with fixed, bypassed return air and terminal reheat. 9. Two-level room with constant volume cold plenum air and variable volume comfort air at fixed hot deck temperature. AH(i,j) indicates the jth air handler type that feeds the ith zone.
3	ALFA	Real	(10) vector	ALFA(i) is the ratio of fresh outside air discharge to total circulating air discharge of the ith air handler.
4	BLDG	String	-----	BLDG is the name of the building under study with maximum of six alphanumeric characters (e.g. BLDG = "G-86").
5	CLIMIT	Integer	1	CLIMIT is the number of compressors in the building. CLIMIT cannot exceed 10.
6	COPRES	Integer	(10,10) matrix	COPRES indicates the compressor-air handler feed arrangement. Each compressor can feed a maximum of ten air handlers. All air handlers fed by the same compressor will be listed as follows: COPRES(M,N) = N implies the Nth air handler fed by Mth compressor is air handler No. N.
7	DKWHE	Real	1	DKWHE is the cost per kilowatt-hr electric in dollars; default value is $.03.
8	DKWHT	Real	1	DKWHT is the cost per kilowatt-hr thermal in dollars; default value is $.012.

Table 3.2 (continued)

No.	Variable	Numeric Form	Dimension	Description
9	ECON	Integer	(10) vector	ECON indicates the type of outside air economizer cycle used for each air handler. ECON(i) is the type of outside air economizer cycle, if any, controlling the ith air handler. ECON is defined as follows: 0. No outside air economizer cycle 1. Honeywell economizer 2. Barber-Coleman DIGI-DAP Control The explanation of the different economizer logic in each is presented in the main program Section V.
10	HEATER	Integer	(10) vector	HEATER indicates the type of heater used in each air handler as follows: 0 - electric heater 1 - gas-fired boiler 2 - heat pump HEATER(M) = 1 indicates that the heater in the Mth air handler is gas-fired.
11	HFBRA	Real	(8) vector	HFBRA is the ratio of the comfort air discharge to the total air discharge for air handler type 5, 6, 7 and 9. Also HFBRA is the ratio of bypassed return air to the total air discharge for air handler type 8. HFBRA(i) means the air flow ratio for the ith special zone.
12	ICNTRL	Integer	(8,10) matrix	ICNTRL is an index that differentiates between air handlers feeding two-level zones and single level zones. The index ICNTRL can be 0, 1 or 2 according to the following: 0 - Single level zone fed by one or more air handlers supplying each the same temperature to the zone. 0 - Two-level zone fed by two air streams (plenum and comfort air) both from a single air handler 1 - Two-level zone with the air handler(s) feeding its plenum air only 2 - Two-level zone with the air handler feeding the comfort air only. If ICNTRL equals 0 then the air handler type (AH) can be from 1 to 9. If ICNTRL equals 1 or 2 then (AH) can only be 1, 2, 3, 4 or 8. ICNTRL(i,j) presents the index for the jth air handler that feeds the ith zone.

Table 3.2 (continued)

No.	Variable	Numeric Form	Dimension	Description
13	KLIMIT	Integer	1	KLIMIT is the number of air handlers in the building. KLIMIT cannot exceed 10.
14	MAXMO	Real	1	MAXMO is the number of months requested by the user for analysis. Default value is 12. MAXMO = 8 means that the calculations will be executed for the first 8 months of the year starting with January.
15	MLT	Real	1	MLT is the mass-specific heat multiplier for the elevation of the site under investigation. At sea level MLT is 1.08; default value is 0.97 for Goldstone, California. For elevations different from sea level, MLT equals 1.08x(local pressure/sea level pressure).
16	REHEAT	Integer	(8) vector	REHEAT indicates the type of heating used for the terminal reheat coils at the zone. REHEAT only applies to those air handler types which have reheat coils, i.e., for AH = 1, 3, 5, 6, or 8. REHEAT is defined as follows: 0 - electric heater 1 - gas-fired boiler 2 - heat pump REHEAT(M) = 2 indicates that air reheat system at the Mth zone is done by a heat pump.
17	SETPTS	Real	(2,10) matrix	SETPTS is the temperature set point of the cooling/heating coil for each air handler in deg. F. SETPTS is defined as follows: SETPTS(1,M) is the cooling set point of the Mth air handler. SETPTS(2,M) is the heating set point of the Mth air handler.
18	SIZE	Real	(3,10) matrix	SIZE gives the air conditioning equipment capacity. SIZE allows for a two stage compressor and a heat pump and is defined as follows: SIZE(1,M) = size of first stage compressor in tons of refrigeration for the Mth compressor. SIZE(2,M) = size of second stage compressor in tons of refrigeration for the Mth compressor SIZE(3,M) = size of heat pump in BTU per hour for the Mth compressor when it is in heating mode.

Table 3.2 (continued)

No.	Variable	Numeric Form	Dimension	Description
19	TMCLK	Integer	(48,10)	TMCLK represents the ON-OFF schedule of a time clock which controls the air conditioning equipment. Forty-eight values per air handler represent twenty-four values for each daytype. 0 - Time clock is off, implies equipment is on. 1 - Time clock is on, implies equipment is off. TMCLK(I,K) = 1 implies that the time clock associated with the Kth air handler is on during the Ith hour.
20	ZCFM	Real	(8,10) matrix	ZCFM is the zone air discharge which is fed by a particular air handler in cubic feet per minute (cfm). Zones that are fed by the same fan-coil configuration can be grouped as one macrozone. One macrozone may be fed by several air handlers or one air handler may feed several macrozones. ZCFM of a macrozone is the sum of air discharge (cfm) of each zone within the macrozone. ZCFM(K,M) refers to the air discharge (cfm) of the Mth air handler which feeds the Kth macrozone.
21	ZLIMIT	Integer	1	ZLIMIT is the number of zones or macrozones in the building. ZLIMIT cannot exceed 8. If ZLIMIT exceeds 8, zones may be grouped into macrozones having the same air handler type.

3.3 Macrozone Deck

All data for the macrozone deck are input through NAMELIST/INPUT1/ and in a free field format. These data items give the geographic location of the building, the physical dimensions of each macrozone and other related thermal and structural properties of walls bordering each macrozone. Table 3.3 lists the twenty-six variables defined in this deck in alphabetic order.

Table 3.3 Macrozone Deck

No.	Variable	Numeric form	Dimension	Description
1	ABSORT	Real	1	Solar absorbtivity of exterior walls and roofs. Default value is 0.62.
2	ADJ	Integer	(9,8) matrix	ADJ determines the nature and conditions of adjacent neighboring macrozones and their thermal environment. Orientation is given a number from 1 to 9 representing S,SW, W, NW, SE, E, NE, N and roof, respectively. ADJ can be either 0,1,2, or 3 as follows: ADJ(5,M) = 0 indicates that no wall exists or there is a thin partition separating the southeast side of the M^{th} macrozone from surroundings. ADJ(5,M) = 1 indicates that the southeast wall of the M^{th} macrozone is adjacent to a room that is maintained at a constant temperature all year around. ADJ(5,M) = 2 indicates that the southeast wall of the M^{th} macrozone is adjacent to an unconditioned zone typical to mechanical rooms housing boilers, air conditioners, pumps, etc. The unconditioned zone is exposed to fluctuating outside air temperature. ADJ(5,M) = 3 indicates that the southeast wall of the M^{th} macrozone is an exterior wall exposed to ambient air temperature fluctuations in addition to direct solar radiation.
3	AGLAS	Real	(9,8)	AGLAS is the total area in square feet of all glass windows and doors in each wall (according to its orientation) surrounding the macrozone. Wall orientation is given a number from 1 to 9 representing S,SW,W,NW,SE,E,NE,N and roof, respectively. AGLAS(4,M) = area of glass windows in the northwest wall of the M^{th} macrozone.

Table 3.3 Macrozone Deck (cont'd)

No.	Variable	Numeric form	Dimension	Description
4	AWAL	Real	(9,8) matrix	AWAL is the net area (in square feet) of each wall excluding glass areas, surrounding a macrozone according to its orientation. Wall orientation is given a number from 1 to 9 representing S,SW,W, NW,SE,E,NE,N and roof, respectively. For example, AWAL(2,M) = area of southwest wall of M^{th} macrozone.
5	BOLEFF	Real	1	Boiler combustion efficiency. Default value is 0.8.
6	GRREFL	Real	1	Ground reflectivity to solar radiation. Default value is 0.2.
7	KEQUPE	Real	(24,16) matrix	Schedule of major electrical equipment load and miscellaneous electrical loads within the zone. KEQUPE should be given in kilowatts. Twenty-four values for each daytype for each zone are needed. Electrical loads that do not affect the air conditioning load are excluded.
8	KEQUPM	Real	(24,16) matrix	Schedule of major mechanical equipment load and miscellaneous mechanical loads within the zone. KEQUPM should be given in kilowatts and should exclude all loads which do not affect air conditioning. Twenty-four values for each daytype for each zone are needed.
9	KFLGHT	Real	(24,16) matrix	Schedule of fluorescent light loads for each zone on an hourly basis. The total electric kilowatts consumed by fluorescent lights (excluding external lights) should be entered. Twenty-four values for each daytype for each zone are needed.
10	KILGHT	Real	(24,16) matrix	Schedule of incandescent light loads for each zone on an hourly basis. The total electric kilowatts consumed by incandescent lights in each zone (excluding external lights) should be entered. Twenty-four values for each daytype for each zone are needed.
11	LAT	Real	1	Latitude of the location under investigation. LAT is given in radians. Default value is 0.611 (35 deg).
12	NECHO	Integer	1	NECHO is a flag used to control the subroutine ECHO. ECHO will reprint out all the input data in neat tabulated forms if NECHO equals 1. If NECHO equals zero, input data will not be printed. See Section IV for more details. Default value is 0.

Table 3.3 Macrozone Deck (cont'd)

No.	Variable	Numeric form	Dimension	Description
13	NOP	Real	(24,16) matrix	Number of people occupying each macrozone. An estimation of the number of people occupying each zone on an hourly basis for a typical day is requested from the user. Two daytypes for each of the allowable 8 zones are included. Twenty-four values are needed for each daytype.
14	PHIRF	Real	(8) vector	PHIRF(M) is the phase angle or thermal lag for the roof of the M^{th} macrozone. PHIRF is given in radians. Default value is 1.30. See UVPHI subprogram, Appendix C, for PHIRF calculation.
15	PHIWL	Real	(8) vector	PHIWL(M) is the phase angle or thermal lag for the exterior walls of the M^{th} macrozone. PHIWL is given in radians. Default value is 1.10. See UVPHI subprogram, Appendix C, for PHIWL calculations.
16	TAU	Real	1	Glass transmissivity. Default value is 0.88.
17	TNEXT	Real	(8,8) matrix	TNEXT is the temperature of a neighboring room adjacent to a given macrozone wall that is maintained at a constant temperature. TNEXT is only applicable when ADJ = 1. Wall orientation is given a number from 1 to 8 representing S,SW,W,NW,SE,E, NE and N. TNEXT (6,M) = 65 means that the east wall of the M^{th} zone is next to a zone maintained at 65°F all year round.
18	TPAM	Real	1	TPAM is the maximum allowable temperature of plenum air in deg F. Only applicable for two-level zones. Default value is 62°F.
19	TSUM	Real	(8) vector	TSUM(M) is the summer design temperature of the M^{th} macrozone in degrees Fahrenheit. Default value is 75°F.
20	TWIN	Real	(8) vector	TWIN(M) is the winter design temperature for the M^{th} macrozone. Default value is 75°F.
21	UGLASS	Real	1	Glass overall heat transfer coefficient in BTU/hr-ft^2 - deg F. Default value is 1.13.
22	UR	Real	(8) vector	UR(M) is the steady state overall heat transfer coefficient of the roof for the M^{th} macrozone. UR is given in BTU/hr-ft^2- deg F. Default value is 0.1. See UVPHI subprogram, Appendix C, for UR calculation.
23	UW	Real	(8) vector	UW(M) is the steady state overall heat transfer coefficient of exterior walls for the M^{th} macrozone. UW is given in BTU/hr-ft^2 - deg F. Default value is 0.21. See UVPHI subprogram, Appendix C, for UW calculation.

Table 3.3 (continued)

No.	Variable	Numeric Form	Dimension	Description
24	VOL	Real	(8) vector	VOL(M) is the volume of the Mth macrozone in cubic feet. Default value is 5000 cubic feet. The zone boundary used to calculate VOL is the occupied volume not including attics.
25	VRF	Real	(8) vector	VRF(M) is the amplitude of transient heat transfer coefficient for the roof of the Mth macrozone. VRF is given in BTU/hr-ft^2-deg F. Default value is 0.05. See UVPHI subprogram, Appendix C, for VRF calculation.
26	VWL	Real	(8) vector	VWL(M) is the amplitude of transient heat transfer coefficient for exterior walls of the Mth macrozone. VWL is given in BTU/hr-ft^2-deg F. Default value is 0.05. See UVPHI subprogram, Appendix C, for VWL calculation.

From Table 3.3 the six variables number 14, 15, 22, 23, 25 and 26 are extracted from preceding execution of the UVPHI subprogram described in Appendix C. These six variables require for their evaluation the type, density, specific heat, thermal conductivity, thickness and number of layers used to construct exterior walls and roofs of each zone.

Also, in Table 3.3, the five data arrays number 7, 8, 9, 10 and 13 provide the information needed for the internal load calculation. The values and time schedules entered are usually estimated with various degrees of uncertainty. For each zone (or macrozone) the five arrays are given for two daytypes representing the whole year profile: Daytype (1) which is a typical weekday and Daytype (2) which augments the profile during weekends and holidays. Each zone is associated with two columns of each array. The (2M-1) column represents daytype (1) schedule and the (2M) column represents daytype (2) schedule of the Mth zone.

3.4 Sample Preparation of Input Data and a Case Study

To simplify the process of gathering input data, a set of blank forms are provided in Appendix B. The set of tables, table B-1 to table B-41, should be filled in on site by cognizant personnel. Each table is provided with a brief explanation free from the abbreviations and expressions commonly used by computer programmers. The intent is for it to be understandable to users of different backgrounds with minimum familiarity with computer terminology. A second set of tables, given in Section 3.4.2 as an example, represents a translated draft of the first set to be used by the machine operator. An execution of the subprogram (UVPHI), as explained in Appendix C, is still required before a full run of (ECP) can be made.

The following case study illustrates the use of data tables presented in Appendix B and lists the assumptions and guidelines used in performing a complete energy analysis for a given building.

3.4.1 Description of Building Zones

The selected building under investigation is the Operations Support Building (building G-86) which is located at the Mars Deep Space Station. The latter is one station in the Deep Space Communication Complex located at Goldstone, California.

Building G-86 is a two story building whose floor plan is illustrated in Figures 3.1 and 3.2. The type of occupancy in each room is presented in Table 3.4. In the first floor shown in Fig. 3.1, Room (101) acts as a large cold air duct (or plenum) providing the air upward to the second floor control room number 201. Similarly, Room 102 acts as a cold air plenum providing the air upward to the second floor communication room number 213.

The building is originally composed of seven air conditioning zones as shown in Table 3.4 and Fig. 3.3.

The first zone is the cold plenum (rooms 101 and 102) which receives a total of 40,000 cfm of cold air from only two air handlers; 23,000 cfm from air handler 1 and 17,000 cfm from air handler 2. Both air handlers 1 and 2 are multizone type with twin hot and cold ducts. A third air handler is located in room 107 which acts as a standby only to air handler 1 in case of failure. The second zone is the electronic communication room located on the second floor which receives 4000 cfm of "comfort air" from air handler 2 in addition to the part of upward plenum air that is coming through the electronic racks located in the communication room only.The third zone is the electronic control room located also on the second floor which receives another 4000 cfm of "comfort air" from air handler 2 in addition to the part of upward plenum air that is coming through the electronic racks located in the control room only. The comfort air temperature is maintained by proper air mixing in hot and cold decks. The fourth zone supplies 2350 cfm conditioned air to the second floor rooms number 202,206,207,208 and 209. The fifth zone supplies 125 cfm conditioned air to the second floor rooms number 203,204 and 205. The sixth zone supplies 400 cfm conditioned air to the second floor rooms number 210, 211 and 212. The fourth, fifth and sixth zones are fed by a main air duct from air handler 2 through proper mixing of air in hot and cold decks. The seventh zone is supplying equipment room 105 in the first floor with 400 cfm from the main "comfort air" duct that supplies zones 2 and 3. This is in addition to direct infiltration of plenum air in zone 1 to zone 7. For building modelling, zones 1, 2, 3 and 7 are grouped into one large macrozone given the name macrozone 1. The comfort air for macrozone 1 is accordingly fed by air handler 2 by a lumped quantity of 8400 cfm. Also, zones 4, 5 and 6 are summed together and modelled as macrozone 2, which is fed by air handler 2 by 2875 cfm of conditioned air. The single line schematic of the building two macrozones is shown in Fig. 3.3(b). The data collected to support the calculations are described next.

3.4.2 Collection of Input Data

The following data points are gathered to support the modelling process. The data are listed in tables 3.5.1 through 3.5.25 and are explained as follows:

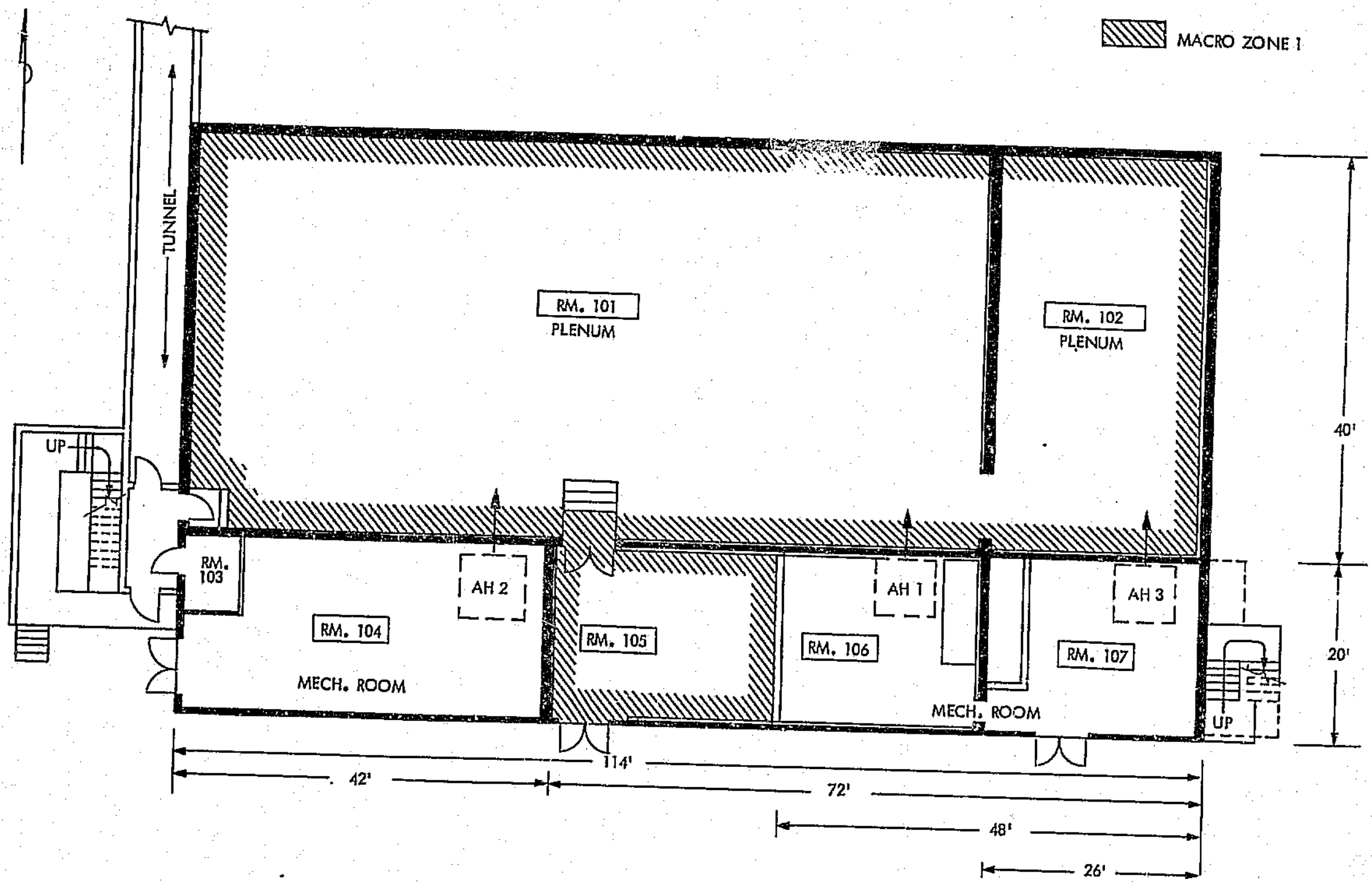


Figure 3-1. First floor plan view of operations support bldg [G-86] mars station

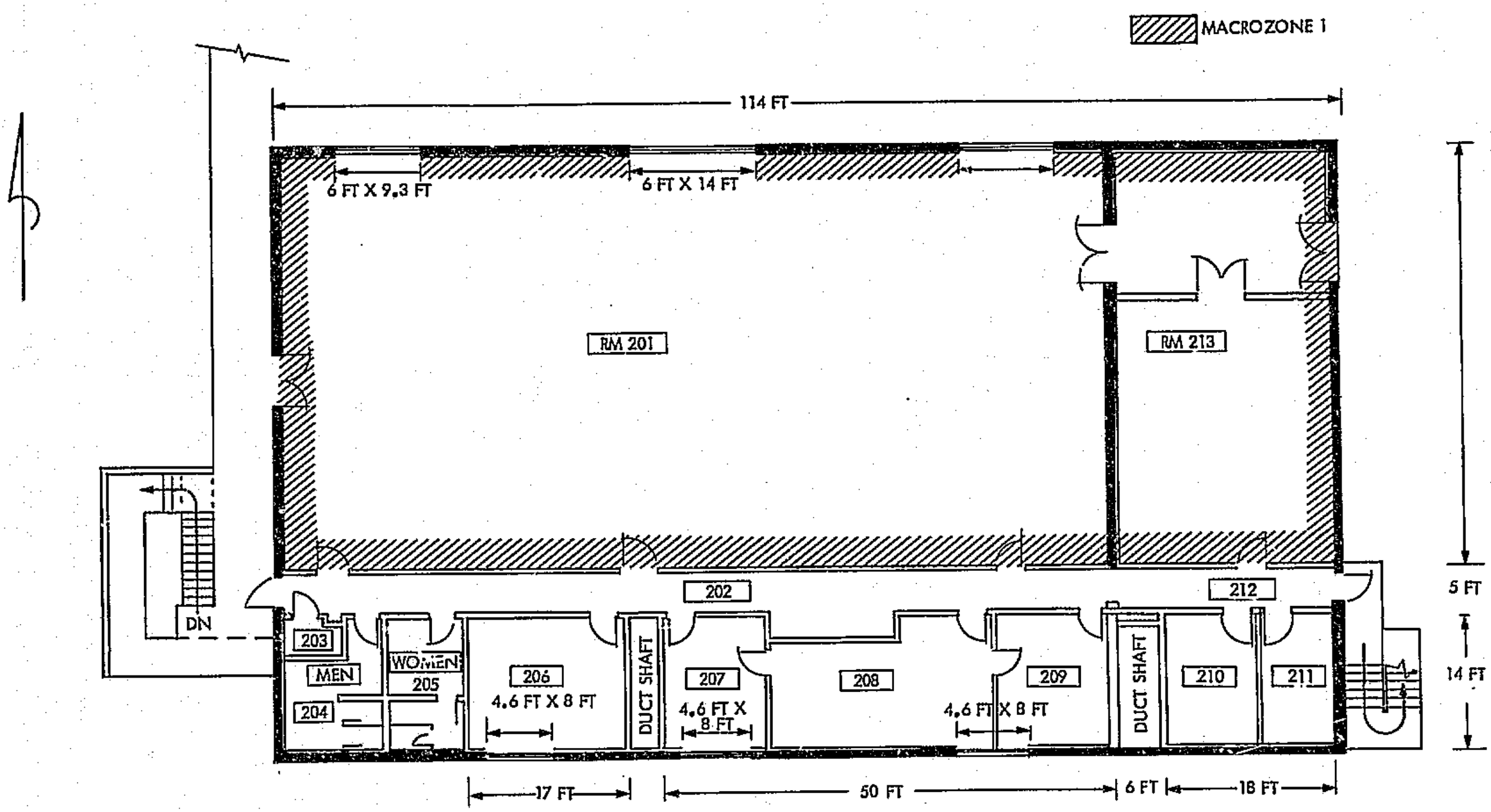
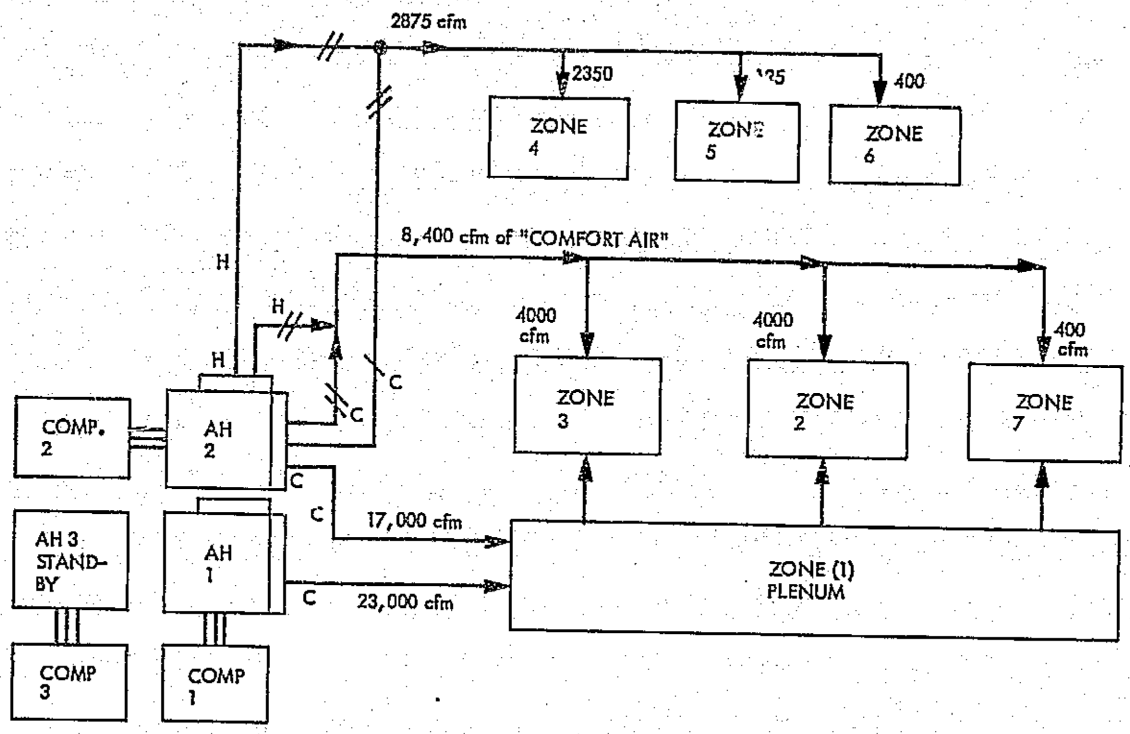
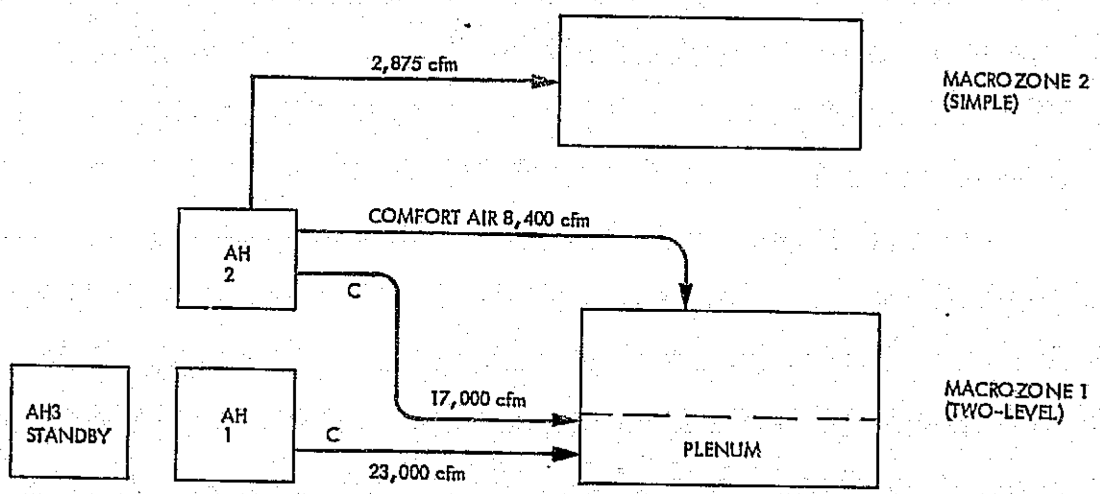


Figure 3-2. Second floor plan view of operations support bldg [G-86] mars station



a) SINGLE LINE SCHEMATIC SHOWING THE 7 AIR CONDITIONING ZONES PRIOR TO PROGRAM SIMULATION



b) SINGLE LINE SCHEMATIC SHOWING THE TWO AIR CONDITIONING MACROZONES

Figure 3-3. Building-86 air conditioning zones and macrozones

Table 3.4 Type of Room Activity in Building G-86

Floor	Room Number	Nature of Activity	Air Conditioning Zone
1	101	Electronic control room plenum	1
1	102	Electronic communication room plenum	1
1	103	Tunnel entrance	---
1	104	Mechanical room housing air handler No. 2	---
1	105	Maser room	7
1	106	Mechanical room housing air handler No. 1	---
1	107	Mechanical room housing air handler No. 3 (stand by).	---
2	201	Electronic control room	3
2	202	Hallway	4
2	203	Janitor Room	5
2	204	Rest room	5
2	205	Rest room	5
2	206	Offices area	4
2	207	Offices area	4
2	208	Rest area with snack machines	4
2	209	Offices area	4
2	210	Offices area	6
2	211	Offices area	6
2	212	Hallway	6
2	213	Electronic communication room	2

3.4.2.1 Weather

Weather data for calendar years 1970 through 1973 were made available for the study from nearby sites. Data for a "typical" year were developed from the dry bulb temperatures previously measured at ECHO station site and the cloud cover data were taken from the China Lake site. Both sites are within a radius of 20 miles from the MARS site. A "typical day" in each month was formed by averaging over the days of the month. Dry bulb temperature data were listed in Table 3.5.1. Raw wind data for the location were available but were not statistically processed. The location is known to be non-windy and have an average wind speed of 10 mi/hr all year around. Cloud cover factors were given in Table 3.5.2 by the ratio of integrated monthly solar radiation (at China Lake site) to that calculated theoretically by ASHRAE (ref. 3).

In Table 3.5.3, the wind velocity (WMPH) was assumed 10 mph for each hour.

3.4.2.2 Air Handler Type

In Table 3.5.4, the first macrozone is fed by the first air handler with cold plenum air and the AH type is 1. Also, the first macrozone is fed by the second air handler with both plenum and comfort air the type that is described under AH = 7. The second macrozone is fed by the second air handler by the method described under AH = 2.

3.4.2.3 Set Points

By actual field measurements, the first air handler is set at 60^{O}F and 95^{O}F for cold and hot decks, respectively. The second air handler is set at 55^{O}F and 95^{O}F for cold and hot decks, respectively. Data are entered in Table 3.5.5.

3.4.2.4 Zone Air Handler Characteristics

Since there is no terminal reheat at any macrozone, the variable REHEAT is set equal to zero in Table 3.5.6. The air flow ratio for special zones (HFBRA) is only applicable to the first macrozone and is equal to 8,400/25400 = 0.33. The type of heating used in both air handlers is electric. No outside air economizer cycle is used in both air handlers. The percentages of outside air to total circulating air are measured as 0.05 and 0.17 for air handlers 1 and 2, respectively, and are entered in Table 3.5.7. The air discharge to each macrozone from each air handler is abstracted from Fig. 3.3 and entered in Table 3.5.8. The index for two-level zones (ICNTRL) is given in Table 3.5.9 for the first macrozone and the first air handler only. Since there is no time clock used to control the operation of both air handlers Table 3.5.10 is left blank or filled with zeros.

3.4.2.5 Compressor-Air Handler Arrangement

From field observations, the first compressor which is feeding the first air handler is composed of two multistage units; each produces 56 tons of refrigeration at full load. Although one of them is actually used as a standby, both tonnage are entered in Table 3.5.11. The second compressor, feeding the second air handler, is composed of three multistage units each having 28 tons of refrigeration at full load. The second compressor produces 84 tons total at full load and is modelled as a two-stage compressor with 42 tons each. Tables 3.5.12 and 3.5.13 are completed following the above information. Since the local elevation is 3000 ft. above sea level with an atmospheric pressure of 26.82 in Hg, the multiplier (MLT) in Table 3.5.13 is found to be 1.08 X 26.82/29.92 or 0.97.

3.4.2.6 Accessories Load

The data used in Table 3.5.14 are entirely estimated and taken from name plate information. The 4 KW_e external lights to the building are assumed to be on for 12 hrs/day. The sum of the two air handlers fan power is 6 KW_e is assumed continuously on for 24 hrs. The same is done with the 10 KW_e condenser fans and the 7 KW_e electric boiler circulating pumps. No differentiation is made in auxiliary equipment consumption for daytype (1) and daytype (2).

3.4.2.7 Architectural Data

Wall areas, glass areas, orientation, adjacent neighbour condition and its temperature, and the fraction of unshaded portions are entered in Tables 3.5.15 through 3.5.19. Data are collected from field measurements and as built drawings. Structural details of walls and roofs are found from architectural drawings to support the UVPHI subprogram. The values of UR, UW, VRF, VWL, PHIRF, and PHIWL listed in Table 3.5.20, are taken from the G-86 example in Appendix C.

3.4.2.8 Time Schedule of People, Light and Equipment

For each macrozone, Tables 3.5.21 through 3.5.25 include the time schedule of number of occupying persons, wattage of fluorescent and incandescent light bulbs, wattage of electrical and mechanical equipment. Data for daytype (1) and daytype (2) are also entered. The data were abstracted from tracking station maintenance files, communication with building personnel relative to operating practice, field survey and actual measurements. No consideration was given to predicted future changes and only present conditions are used in computations.

Table 3.5 Set of Tables For G-86 Input Data

Table 3.5.1 TOA (F3.0)

MONTH	HOUR																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	40	40	40	39	39	39	38	38	40	44	47	50	51	53	53	52	50	47	43	41	41	40	40	40
2	46	45	45	45	45	44	44	45	47	52	56	59	62	63	63	63	62	59	55	52	50	49	48	47
3	47	46	46	45	45	45	46	49	52	56	59	60	63	64	64	64	63	61	58	55	53	51	50	49
4	51	50	49	48	48	48	48	52	55	59	62	64	66	68	68	69	68	67	65	61	58	55	53	52
5	61	59	58	57	56	56	55	57	61	65	68	72	75	77	79	80	80	80	78	76	73	69	66	63
6	7[illegible]	70	68	67	66	65	65	69	73	77	81	85	87	90	91	92	93	92	91	88	84	80	76	74
7	79	77	76	75	74	73	72	74	78	82	87	90	93	95	97	98	98	98	97	94	91	87	84	81
8	80	78	77	76	75	74	73	73	76	81	86	89	91	93	95	95	95	95	94	91	88	85	83	81
9	71	69	68	67	67	66	65	66	70	74	78	82	85	86	87	88	87	86	84	81	77	75	73	71
10	59	58	57	57	56	55	55	57	60	63	66	69	72	73	74	73	73	70	67	65	62	61	59	59
11	46	46	46	45	46	45	45	45	48	54	56	58	60	61	61	61	59	55	52	50	49	49	48	47
12	39	38	37	37	37	37	36	38	40	44	46	48	49	49	49	48	46	43	41	40	39	39	38	38

Table 3.5.2 CCF (F 6.2)

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
CCF	0.88	0.92	0.95	0.94	0.96	0.98	0.88	0.94	0.98	0.98	0.97	0.92

Table 3.5.3 WMPH (F3.0)

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
WMPH	←										10													→

3.5.4 AH TABLE

ZONE / KNUM	1	2	3	4	5	6	7	8
1	1	0						
2	7	2						
3								
4								
5								
6								
7								
8								
9								
10								

3.5.5 SETPTS TABLE

KNUM	COLD	HOT
1	60	95
2	55	95
3		
4		
5		
6		
7		
8		
9		
10		

3.5.6 REHEAT & HFBRA TABLE

ZONE	1	2	3	4	5	6	7	8
REHEAT	0	0						
HFBRA	0.33	0						

3.5.7 HEATER, ALFA & ECON TABLE

KNUM	1	2	3	4	5	6	7	8	9	10
HEATER	0	0								
ALFA	.05	.17								
ECON	0	0								

3.5.8 ZCFM TABLE

KNUM \ ZONE	1	2	3	4	5	6	7	8
1	23,000							
2	25,400	2875.						
3								
4								
5								
6								
7								
8								
9								
10								

3.5.9 ICNTRL TABLE

KNUM \ ZONE	1	2	3	4	5	6	7	8
1	1	0						
2	0	0						
3								
4								
5								
6								
7								
8								
9								
10								

3.5.10 TMCLK TABLE

KNUM	DAYTYPE \ HOUR	24 HOUR SCHEDULE
1	1	24 x 0
	2	
2	1	
	2	
3	1	
	2	
4	1	
	2	
5	1	
	2	
6	1	
	2	
7	1	
	2	
8	1	
	2	
9	1	
	2	
10	1	
	2	

3.5.11 SIZE TABLE

CNUM \ SIZE	FIRST STAGE (TONS)	SECOND STAGE (TONS)	HEAT PUMP (BTU/HR)
1	56	56	
2	42	42	
3			
4			
5			
6			
7			
8			
9			
10			

3.5.12 COPRES TABLE

COMPRESSOR	NO. SEQUENCE OF AIR HANDLERS FED BY COMPRESSOR
1	1 , , , ,
2	2 , , , ,
3	

3.5.13 MISCELLANEOUS

VARIABLE	INPUT	DEFAULT
BLDG	G-86	
KLIMIT	2	
ZLIMIT	2	
CLIMIT	2	
MLT		0.97
DKWHE		0.03
DKWHT		0.012
MAXMO		12

3.5.14 ACCERY TABLE

ACCESSORIES (KWH)	DAYTYPE 1	DAYTYPE 2
EXT. LIGHT	48.	48.
AH FAN	144.	144.
COND. FAN	240.	240.
BOILER PUMP	168.	168.
OTHER		

3.5.15 AWAL TABLE

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1	284.	0	800.	0	0	800.	1380.	1514.	4560.
2	1035.	0	200.	0	0	196.	0	1770.	2290.
3									
4									
5									
6									
7									
8									

3.5.16 AGLAS TABLE

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1	4.	0	0	0	0	0	0	196.	0
2	110.	0	0	0	0	4.	0	0	0
3									
4									
5									
6									
7									
8									

3.5.17 ADJ TABLE

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1	3	0	3	0	0	3	2	3	3
2	3	0	3	0	0	3	0	2	3
3									
4									
5									
6									
7									
8									

3.5.18 SHADE TABLE

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1									
2									
3									
4									
5									
6									
7									
8									

3.5.19 TNEXT TABLE

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)
1								
2								
3								
4								
5								
6								
7								
8								

3.5.20 OTHER ZONE DATA

ZONE		1	2	3	4	5	6	7	8	D.V.
VOL	FT^3	96960.	22900.	0	0	0	0	0	0	5500
TSUM	^oF	78.	78.	0	0	0	0	0	0	75
TWIN	^oF	68.	68.	0	0	0	0	0	0	75
UR		.0657	.0657	0	0	0	0	0	0	0.1
UW		.0755	.0755	0	0	0	0	0	0	0.1
PHIRF	RAD.	1.704	1.704	0	0	0	0	0	0	1.3
PHIWL	RAD.	2.962	2.962	0	0	0	0	0	0	1.1
VRF		.0378	.0378	0	0	0	0	0	0	0.05
VWL		.0181	.0181	0	0	0	0	0	0	0.05
ABSORT										0.62
LAT	RAD									0.611
TPAM	^oF									62
NECHO		1								0

3.5.21 NOP TABLE

ZONE	DAY	24 HOUR SCHEDULE
1	1	24 * 7.0
	2	24 * 7.0
2	1	6 * 0, 10 * 4, 8 * 0
	2	24 * 0
3	1	24 * 0
	2	24 * 0
4	1	24 * 0
	2	24 * 0
5	1	24 * 0
	2	24 * 0
6	1	24 * 0
	2	24 * 0
7	1	24 * 0
	2	24 * 0
8	1	24 * 0
	2	24 * 0

3.5.22 KFLGHT TABLE

ZONE	DAYTYPE	24 HOUR - SCHEDULE
1	1	6 * 13.0, 4 * 16.5, 6 * 20.5, 2 * 17., 6 * 13.
	2	6 * 13.0; 4 * 16.5, 6 * 20.5, 2 * 17, 6 * 13.
2	1	6 * 3.0, 10 * 6.9, 8 * 3.0
	2	24 * 3.0
3	1	24 * 0.0
	2	24 * 0.0
4	1	24 * 0.0
	2	24 * 0.0
5	1	24 * 0.0
	2	24 * 0.0
6	1	24 * 0.0
	2	24 * 0.0
7	1	24 * 0.0
	2	24 * 0.0
8	1	24 * 0.0
	2	24 * 0.0

3.5.23 KILGHT TABLE

ZONE	DAYTYPE	24 HOUR - SCHEDULE
1	1	24 * 0
	2	24 * 0
2	1	6 *0, 10 * 0.1, 8 * 0
	2	24 * 0
3	1	24 * 0
	2	24 * 0
4	1	24 * 0
	2	24 * 0
5	1	24 * 0
	2	24 * 0
6	1	24 * 0
	2	24 * 0
7	1	24 * 0
	2	24 * 0
8	1	24 * 0
	2	24 * 0

3.5.24 KEQUPE TABLE

ZONE	DAYTYPE	24 HOUR - SCHEDULE
1	1	24 * 99.4
	2	24 * 99.4
2	1	6 * 3.0, 10*3.3, 8 * 3.0
	2	24 * 3.0
3	1	24 * 0
	2	24 * 0
4	1	24 * 0
	2	24 * 0
5	1	24 * 0
	2	24 * 0
6	1	24 * 0
	2	24 * 0
7	1	24 * 0
	2	24 * 0
8	1	24 * 0
	2	24 * 0

3.5.25 KEQUPM TABLE

ZONE	DAYTYPE	24 HOUR - SCHEDULE
1	1	24 * 0
	2	24 * 0
2	1	24 * 0
	2	24 * 0
3	1	24 * 0
	2	24 * 0
4	1	24 * 0
	2	24 * 0
5	1	24 * 0
	2	24 * 0
6	1	24 * 0
	2	24 * 0
7	1	24 * 0
	2	24 * 0
8	1	24 * 0
	2	24 * 0

SECTION IV

DESCRIPTION OF OUTPUT FORMS

The program results are given in tabular form and are divided into seven groups:

1) Tables of echoed input data
2) Tables of hourly, daily and monthly load calculation of each zone
3) Tables of hourly, daily and monthly cooling and heating loads of each air handler
4) Tables of hourly, daily, and monthly cooling load of each vapor-compression compressor
5) Tables of hourly, daily and monthly profile of watt-hour meter
6) Tables of new design conditions
7) Tables of monthly and yearly itemization of energy consumption and cost

Each group of tables is described next.

4.1 Tables of Echoed Input Data

Upon assigning the variable NECHO (see number 12, Table 3.3) the value "one," the program will call the subroutine ECHO to echo all the input data in a readable tabular form. Fig. 4.1 illustrates the output form for the example building (G-86) given in Sec. 3.4. The input data presented in Fig. 4-1 should match the data in Section 3.4.2 and are sectioned for convenience to the reader.

4.2 Tables of Zone Loads

The output form presented in Fig. 4-2 pertains to the same example, Building G-86, presented in Section 3.4. Only the result of the month of January is given as an example; i.e., Fig. 4-2 presents 1/12 of the zone loads output. The columns from left to right are explained as follows:

Column 1 (MO)	gives the month (varies from Jan to Dec)
Column 2 (ZONE)	gives the zone or macrozone number (varies from 1 to 8)
Column 3 (DAY-TYPE)	gives the daytype number (1 or 2)
Column 4 (HR)	gives the hour of the day (varies from 1 to 24)
Column 5 (INFILTN)	gives the infiltration heat gain or loss to the zone in Btu/hr
Column 6 (GLASS)	gives the direct solar heat gain and heat transmission from the outside air through glass areas of the zone, in Btu/hr
Column 7 (TRANSMTN)	gives the combined solar and ambient heat transmitted through solid walls and roofs of the zone, in Btu/hr
Column 8 (LIGHT)	gives the heat gain to the zone by incandescent and fluorescent lights, in Btu/hr
Column 9 (PEOPLE)	gives the sensible heat gain to the zone due to people, in Btu/hr
Column 10 (EQUIPMENT)	gives the heat gain to the zone by mechanical and electrical equipment in Btu/hr
Column 11 (NET HEAT)	gives the algebraic sum of columns 5 through 10, in Btu/hr
Column 12 (SUPPLIED AIR TEMP)	gives the supply air temperature to the zone, in deg F
Column 13 (RESULTANT RM TEMP)	gives the zone inside temperature in deg F. This should match the design conditions with proper air handling.

Column 14 (COOLING)	This gives the cooling coil load in tons of refrigeration that is required to satisfy the zone needs.
Column 15 (HEATER) Column 16 (BOILER) Column 17 (PUMP)	This gives the heating coil load in Btu/hr, which is required to satisfy the zone needs. Column (15) is used for electric heating, column (16) for gas-fired boilers and column (17) for heat pumps. Only one of the three columns will give the heating load values.

4.3 Tables of Air-handler Loads

The hourly, daily or monthly cooling and heating loads on the air handler coils are presented in Fig. 4.3, for the example building G-86. Table 4.3 presents only results for the month of January i.e., 1/12 of the yearly total air-handler load tables.

The columns of Fig. 4.3 from left to right are explained as follows:

Column 1 (AIR-HANDLER)	gives the air-handler number (varies from 1 to 8 maximum)
Column 2 (MO)	gives the month (varies from Jan to Dec)
Column 3 (DAY-TYPE)	gives the day-type number (1 or 2)
Column 4 (HR)	gives the hour of the day (varies from 1 to 24)
Column 5 (TEMP OF MIXED AIR)	gives the temperature, in deg F, of the air mixture at the fan-coil entrance. This is a mixture of outside air and return air
Column 6 (COOLING) TONS	gives the cooling load on the air-handle cooling coil in tons of refrigeration
Column 7 (HEATER) Column 8 (BOILER) Column 9 (PUMP)	gives the heating load on the air handler heating coil in Btu/hr. Column (7) for electric resistance heaters, column (8) for gas-fired boilers and column (9) for a heat pump
Column 10 (MIN TSAZ) Column 11 (MAX TSAZ)	gives the limits of the supply air temperature (in deg F) to all the zones fed by a particular air handler. Column (10) gives the minimum value, and column (11) gives the maximum value.

In addition to the above, the monthly minimum and maximum supply air temperature to the air handler zones are listed for reference.

4.4 Tables of Refrigeration-Compressor Loads

The hourly, daily or monthly cooling loads on the vapor-compression refrigerator compressors are printed in a form identical to Fig. 4.4. Fig. 4.4 lists the output results for the example building G-86, and the results shown present 1/12 of the full year performance. The columns are explained as follows:

Column 1 (COMPRESSOR)	gives the number of compressors (varies from 1 to a maximum of 10)
Column 2 (MONTH)	gives the month of the year (varies from Jan to Dec)
Column 3 (DAY-TYPE)	gives the number of day-type (1 or 2)
Column 4 (HOUR)	gives the hour of the day (varies from 1 to 24)
Column 5 (TONNAGE)	gives the cooling load on compressor, in tons of refrigeration

Next to the above columns, the "DAILY TOTAL" line gives the sum of cooling energy consumed for each day in ton-hrs. The number of hours per day during which the compressor was "off" is also included.

4.5 Watt-hour Profile

The hourly electrical energy consumption of the building under study is summed for all the lights, electronic equipment, mechanical equipment, etc., and presented in the form of Fig. 4.5. Fig. 4.5 presents the results of the example building G-86. The simulated KW_e values given in Fig. 4.5 should not deviate very much (± 10% at the most) from the actual watt-hour meter chart, if available.

4.6 Design Conditions

The design conditions output provide data for the user who is designing new building equipment, or for quantizing the difference between a "present" condition and a "properly designed" one. The design conditions data are divided into three sets.

4.6.1 Zone Design Conditions

These consist of:

a) Minimum one-hour heat gain or loss to or from the zone, in Btu/hr, among the whole year hourly data
b) Maximum one-hour heat gain to or from the zone, in Btu/hr, among the whole year hourly data
c) Design value of cfm for proper design
d) Present value of cfm
e) Maximum cooling load in tons of refrigeration needed to satisfy the zone needs

4.6.2 Air-Handler Conditions

a) Minimum ventilation air, in cfm (MIN CFM)
b) Minimum ratio of outside air to total air circulation (MIN ALFA)
c) Yearly minimum and maximum temperature of supply air to zones fed by a given air handler
d) Yearly maximum cooling load on air handler cooling coils

4.6.3 Compressor Design Conditions

These include:

a) Yearly sum of cooling energy in TON HOURS
b) The yearly maximum cooling load in TONS.

4.7 Monthly Energy Consumption, Itemization and Cost

This output is presented in a tabular form similar to that in Fig 4.7 for the example building G-86. The columns from left to right are explained as follows:

Column 1	gives the month of the year
Column 2	gives the monthly energy consumption due to incandescent and fluorescent lights in the building , in KWH_e
Column 3	gives the monthly energy consumption due to mechanical and electrical equipment in the building in KWH_e
Column 4	gives the monthly energy consumption due to auxiliaries in KWH_e
Column 5	gives the monthly energy consumption by vapor compression refrigeration machines in KWH_e

Column 6	gives the monthly energy consumption by electric resistance heaters in KWH_e, if any
Column 7	gives the monthly energy consumption by heat pump(s) in KWH_e, if any
Column 8	gives the monthly electric energy consumption, in KWH_e. Column 8 is the sum of columns 2,3,4,5,6,and 7.
Column 9	gives the monthly thermal energy consumption by gas-fired boilers used for heating, in KWH_t
Column 10	gives the monthly energy cost in dollars, combining electrical and thermal forms.

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*** ENERGY CONSUMPTION ESTIMATION FOR BUILDING G-86

*** NUMBER OF MACROZONES	=	2
*** NUMBER OF AIRHANDLERS	=	2
*** ABSORPTIVITY OF WALLS AND ROOFS	=	.62
*** LATITUDE ANGLE FOR THE LOCATION	=	35.

** ZONE INPUT DATA **

*** WALL AREA IN SQ. FT.

ORIENTATION ZONE	S	SW	W	NW	SE	E	NE	N	ROOF
1	284.	0.	800.	0.	0.	800.	1380.	1514.	4560.
2	1035.	0.	200.	0.	0.	196.	0.	1770.	2290.

*** WALL ADJACENT CONDITIONS

0 FOR NO WALL OR PARTITIONS
1 FOR AN INTERIOR WALL ADJOINTING A CONSTANT TEMP
2 FOR AN INTERIOR WALL ADJOINTING A UNCONDITIONED ZONE
3 FOR AN EXTERIOR WALL EXPOSED TO AMBIENT

ORIENTATION ZONE	S	SW	W	NW	SE	E	NE	N	ROOF
1	3	0	3	0	0	3	2	3	3
2	3	0	3	0	0	3	0	2	3

*** FRACTION OF UNSHADED AREA OF WALL

ORIENTATION ZONE	S	SW	W	NW	SE	E	NE	N	ROOF
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

*** GLASS AREA IN SQ. FT.

ORIENTATION ZONE	S	SW	W	NW	SE	E	NE	N	ROOF
1	4.	0.	0.	0.	0.	0.	0.	196.	0.
2	110.	0.	0.	0.	0.	4.	0.	0.	0.

Fig. 4.1 Input Data from Echo Subroutine

SCHEDULE

** OCCUPANCY LOAD

ZONE	DAY TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
1	2	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
2	1	.0	.0	.0	.0	.0	.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	.0	.0	.0	.0	.0	.0	.0	.0
2	2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

** FLUORESCENT LIGHT IN KW

ZONE	DAY TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

1	1	13.0	13.0	13.0	13.0	13.0	13.0	16.5	16.5	16.5	16.5	20.5	20.5	20.5	20.5	20.5	20.5	17.0	17.0	13.0	13.0	13.0	13.0	13.0	13.0
1	2	13.0	13.0	13.0	13.0	13.0	13.0	16.5	16.5	16.5	16.5	20.5	20.5	20.5	20.5	20.5	20.5	17.0	17.0	13.0	13.0	13.0	13.0	13.0	13.0
2	1	3.0	3.0	3.0	3.0	3.0	3.0	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
2	2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

** INCANDESCENT LIGHT IN KW

ZONE	DAY TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1	2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	1	.0	.0	.0	.0	.0	.0	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0
2	2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

** ELECTRICAL EQUIPMENT LOAD IN KW

ZONE	DAY TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4
1	2	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4	99.4
2	1	3.0	3.0	3.0	3.0	3.0	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
2	2	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

** MECHANICAL EQUIPMENT LOAD IN KW

ZONE	DAY TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1	2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

MACROZONE	1	2	3	4	5	6	7	8
VOLUME OF ZONE IN CU. FT.	96960.0	22900.0						
SUMMER INSIDE DESIGN CONDITION (DEG F)	78.00	78.00						
WINTER INSIDE DESIGN CONDITION (DEG F)	68.00	68.00						
HEAT TRANSFER COEFF FOR WALLS	.07	.07						
HEAT TRANSFER COEFF FOR ROOFS	.08	.08						

*** AIR HANDLER DATA ***

** AIR HANDLER TYPE

AIRHANDLER NO.	1	2	3	4	5	6	7	8	9	10
ZONE										
1	1	7								
2	0	2								

** AIR HANDLER SCHEDULE WITH TIME CLOCK

Fig. 4.1(Continuation)

DAY

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AH	TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
1	2	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2	1	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2	2	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON

** AIR QUANTITY DISTRIBUTION IN CFM

AIRHANDLER NO.	1	2	3	4	5	6	7	8	9	10
ZONE										
1	23000.0	25400.0								
2	.0	2875.0								

AIRHANDLER NO.	1	2	3	4	5	6	7	8	9	10
COLD DECK SETPOINT	60.00	55.00								
HOT DECK SETPOINT	95.00	95.00								
PERCENT VENT AIR	.05	.17								
OUTSIDE AIR ECONOMIZER	NO	NO								
TYPE OF HEATING IN AH	ELEC	ELEC								

** COMPRESSOR DATA **

** COMPRESSOR/AIRHANDLER DISTRIBUTION

AIR HANDLER NO. CONNECTED TO	1	COMPRESSOR	1	0	0	0	0	0	0	0	0	0
AIR HANDLER NO. CONNECTED TO	2	COMPRESSOR	2	0	0	0	0	0	0	0	0	0

SIZE OF CONDENSERS AND HEAT PUMP

COMPRESSOR NO.	1	2	3	4	5	6	7	8	9	10
FIRST CONDENSER TONNAGE	56.00	-42.00								
2ND CONDENSER TONNAGE	56.00	42.00								
SIZE OF HEAT PUMP(BTU/H)	.0	.0								

****

Fig. 4.1 (Continuation)

```
13592*VIC(1).NAMELIST/G-86-NEW
        $$HANDLR
             AH=1,7*0,7.2,    SETPTS=60.,95.,55.,95.,
             SIZE=56.,56.,0.,42.,42.,0
             HEATER=10*0, KLIMIT=2, ZLIMIT=2, ACCERY=2*48.,2*144.,2*240.,2*168.,
             BLDG='G-86', ALFA=.05,.17,8*0., MAXMO=12,
             ECON=10*0, HFBRA=.33,7*0.,
             ZCFM=23000.,7*0.,25400.,2875.,
             COPRES=1,2,  CLIMIT=2,
             ICNTRL=1,
        $$END
        $$INPUT1     AWAL=284.,0.,800.,0.,0.,800.,1380.,1514.,4560.,
                    AWAL(1,2)=1035.,0.,200.,0.,0.,196.,0.,1770.,2290.,
                    AGLAS=4.,6*0.,196.,0.,110.,4*0.,4.,3*0.,
                    ADJ=3,0,3,0,0,3,2,3,3,3,0,3,0,0,3,0,2,3,
                   VOL=96960.,22900., UR=.0657,.0657,6*0.,
                   UW=.0755,.0755,6*0., PHIRF=2*1.704,6*0.,
                   PHIWL=2*2.962,6*0., VRF=2*.0378,6*0.,
                   VWL=2*.0181,6*0., ABSORT=.62,
                   TSUM=2*78.,6*0., TWIN=2*68.,6*0.,
                   NOP=48*7.,6*0.,10*4.,8*0.,24*0.,
                   KILGHT=48*0.,6*0.,10*0.1,8*0.,24*0.,
                   KFLGHT=6*13.,4*16.5,6*20.5,2*17.,6*13.,
                   KFLGHT(1,2)=6*13.,4*16.5,6*20.5,2*17.,6*13.,
                   KFLGHT(1,3)=6*3.,10*6.9,8*3.,24*3.,
                   KEQUPE=24*99.4,24*99.4,
                   KEQUPE(1,3)=6*3.0,10*3.3,8*3.,24*3.,
                   KEQUPM=96*0.0,
            NECHO=1
        $$END

CPU:.543    CTP:.086    SUPS:17.177

@XQT   VIC.ECPABS-VA

@ADD,P   VIC.ECP2/WEATHER

@ADD,P   VIC.NAMELIST/G-86-NEW
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ORIGINAL PAGE IS
OF POOR QUALITY

Fig. 4.1 (Continuation)

```
13592*VIC(1).ECP2/WEATHER
     1        40 40 40 39 39 39 38 38 40 44 47 50 51 53 53 52 50 47 43 41 41 40 40 40
     2        46 45 45 45 45 44 44 45 47 52 56 59 62 63.63 63 62 59 55 52 50 49 48 47
     3        47 46 46 45 45 45 46 49 52 56 59 60 63 64 64 64 63 61 58 55 53 51 50 49
     4        51 50 49 48 48 48 48 52 55 59 62 64 66 68 68 69 68 67 65 61 58 55 53 52
     5        61 59 58 57 56 56 55 57 61 65 68 72 75 77 79 80 80 80 78 76 73 69 66 63
     6        71 70 68 67 66 65 65 69 73 77 81 85 87 90 91 92 93 92 91 88 84 80 76 74
     7        79 77 76 75 74 73 72 74 78 82 87 90 93 95 97 98 98 98 97 94 91 87 84 81
     8        80 78 77 76 75 74 73 73 76 81 86 89 91 93 95 95 95 95 94 91 88 85 83 81
     9        71 69 68 67 67 66 65 66 70 74 78 82 85 86 87 88 87 86 84 81 77 75 73 71
    10        59 58 57 57 56 55 55 57 60 63 66 69 72 73 74 73 73 70 67 65 62 61 59 59
    11        46 46 46 45 46 45 45 45 48 54 56 58 60 61 61 61 59 55 52 50 49 49 48 47
    12        39 38 37 37 37 37 36 38 40 44 46 48 49 49 49 48 46 43 41 40 39 39 38 38
    13         0.88  0.92  0.95  0.94  0.96  0.98  0.88  0.94  0.98  0.98  0.97  0.92
    14        10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10

@PRT,S   VIC.NAMELIST/G-86-NEW
```

Fig. 4.1 (Continuation)

ECP PROGRAM

DATE 062378 PAGE

MO	ZONE	DAY-TYPE	HR	INFILTN (BTU)	GLASS (BTU)	TRANSMITN (BTU)	LIGHT (BTU)	POEPLE (BTU)	EQUIPMENT (BTU)	NET HEAT (BTU)	SUPPLIED AIR TEMP	RESULTANT RM TEMP	COOLING (TONS)	HEATER (BTU)	BOILER (BTU)	PUMP (BTU)
JAN	1	1	1	-52669.	-6328.	-9349.	55458.	2030.	339252.	328394.	61.0	68.0	26.26	135282.	0.	0.
JAN	1	1	2	-52669.	-6328.	-10160.	55458.	2030.	339252.	327583.	61.0	68.0	26.25	135925.	0.	0.
JAN	1	1	3	-52669.	-6328.	-10988.	55458.	2030.	339252.	326755.	61.0	68.0	26.24	136583.	0.	0.
JAN	1	1	4	-54550.	-6554.	-11778.	55458.	2030.	339252.	323859.	61.1	68.0	25.61	139626.	0.	0.
JAN	1	1	5	-54550.	-6554.	-12474.	55458.	2030.	339252.	323163.	61.1	68.0	25.79	140182.	0.	0.
JAN	1	1	6	-54550.	-6554.	-13030.	55458.	2030.	339252.	322607.	61.1	68.0	25.78	140625.	0.	0.
JAN	1	1	7	-56431.	-6780.	-13407.	70389.	2030.	339252.	335053.	60.9	68.0	25.61	131386.	0.	0.
JAN	1	1	8	-56431.	-4929.	-13581.	70389.	2030.	339252.	336731.	60.8	68.0	25.64	130039.	0.	0.
JAN	1	1	9	-52669.	-2998.	-13539.	70389.	2030.	339252.	342466.	60.7	68.0	26.51	124109.	0.	0.
JAN	1	1	10	-45145.	-1101.	-13284.	70389.	2030.	339252.	352142.	60.5	68.0	28.23	113933.	0.	0.
JAN	1	1	11	-39502.	172.	-12833.	87453.	2030.	339252.	376572.	60.0	68.0	29.88	93393.	0.	0.
JAN	1	1	12	-33858.	1049.	-12218.	87453.	2030.	339252.	383708.	59.8	68.0	31.23	86472.	0.	0.
JAN	1	1	13	-31977.	1076.	-11479.	87453.	2030.	339252.	386354.	59.8	68.0	31.68	84006.	0.	0.
JAN	1	1	14	-28215.	933.	-10668.	87453.	2030.	339252.	390784.	59.7	68.0	32.58	79778.	0.	0.
JAN	1	1	15	-28215.	-60.	-9840.	87453.	2030.	339252.	390620.	59.7	68.0	32.58	79899.	0.	0.
JAN	1	1	16	-30096.	-1765.	-9051.	87453.	2030.	339252.	387823.	59.7	68.0	32.12	82436.	0.	0.
JAN	1	1	17	-33858.	-4068.	-8355.	72522.	2030.	339252.	367523.	60.2	68.0	30.89	98635.	0.	0.
JAN	1	1	18	-39502.	-4746.	-7799.	72522.	2030.	339252.	361758.	60.3	68.0	29.59	104715.	0.	0.
JAN	1	1	19	-47026.	-5650.	-7421.	55458.	2030.	339252.	336643.	60.8	68.0	27.56	126665.	0.	0.
JAN	1	1	20	-50788.	-6102.	-7248.	55458.	2030.	339252.	332603.	60.9	68.0	26.72	131234.	0.	0.
JAN	1	1	21	-50788.	-6102.	-7290.	55458.	2030.	339252.	332561.	60.9	68.0	26.72	131267.	0.	0.
JAN	1	1	22	-52669.	-6328.	-7545.	55458.	2030.	339252.	330199.	61.0	68.0	26.29	133849.	0.	0.
JAN	1	1	23	-52669.	-6328.	-7996.	55458.	2030.	339252.	329748.	61.0	68.0	26.29	134207.	0.	0.
JAN	1	1	24	-52669.	-6328.	-8611.	55458.	2030.	339252.	329133.	61.0	68.0	26.28	134695.	0.	0.
JAN	1	2	1	-52669.	-6328.	-9349.	55458.	2030.	339252.	328394.	61.0	68.0	26.26	135282.	0.	0.
JAN	1	2	2	-52669.	-6328.	-10160.	55458.	2030.	339252.	327583.	61.0	68.0	26.25	135925.	0.	0.
JAN	1	2	3	-52669.	-6328.	-10988.	55458.	2030.	339252.	326755.	61.0	68.0	26.24	136583.	0.	0.
JAN	1	2	4	-54550.	-6554.	-11778.	55458.	2030.	339252.	323859.	61.1	68.0	25.81	139626.	0.	0.
JAN	1	2	5	-54550.	-6554.	-12474.	55458.	2030.	339252.	323163.	61.1	68.0	25.79	140182.	0.	0.
JAN	1	2	6	-54550.	-6554.	-13030.	55458.	2030.	339252.	322607.	61.1	68.0	25.78	140625.	0.	0.
JAN	1	2	7	-56431.	-6780.	-13407.	70389.	2030.	339252.	335053.	60.9	68.0	25.61	131386.	0.	0.
JAN	1	2	8	-56431.	-4929.	-13581.	70389.	2030.	339252.	336731.	60.8	68.0	25.64	130039.	0.	0.
JAN	1	2	9	-52669.	-2998.	-13539.	70389.	2030.	339252.	342466.	60.7	68.0	26.51	124109.	0.	0.
JAN	1	2	10	-45145.	-1101.	-13284.	70389.	2030.	339252.	352142.	60.5	68.0	28.23	113933.	0.	0.
JAN	1	2	11	-39502.	172.	-12833.	87453.	2030.	339252.	376572.	60.0	68.0	29.88	93393.	0.	0.
JAN	1	2	12	-33858.	1049.	-12218.	87453.	2030.	339252.	383708.	59.8	68.0	31.23	86472.	0.	0.
JAN	1	2	13	-31977.	1076.	-11479.	87453.	2030.	339252.	386354.	59.8	68.0	31.68	84006.	0.	0.
JAN	1	2	14	-28215.	933.	-10668.	87453.	2030.	339252.	390784.	59.7	68.0	32.58	79778.	0.	0.
JAN	1	2	15	-28215.	-60.	-9840.	87453.	2030.	339252.	390620.	59.7	68.0	32.58	79899.	0.	0.
JAN	1	2	16	-30096.	-1765.	-9051.	87453.	2030.	339252.	387823.	59.7	68.0	32.12	82436.	0.	0.
JAN	1	2	17	-33858.	-4068.	-8355.	72522.	2030.	339252.	367523.	60.2	68.0	30.89	98635.	0.	0.
JAN	1	2	18	-39502.	-4746.	-7799.	72522.	2030.	339252.	361758.	60.3	68.0	29.59	104715.	0.	0.
JAN	1	2	19	-47026.	-5650.	-7421.	55458.	2030.	339252.	336643.	60.8	68.0	27.56	126665.	0.	0.
JAN	1	2	20	-50788.	-6102.	-7248.	55458.	2030.	339252.	332603.	60.9	68.0	26.72	131234.	0.	0.
JAN	1	2	21	-50788.	-6102.	-7290.	55458.	2030.	339252.	332561.	60.9	68.0	26.72	131267.	0.	0.
JAN	1	2	22	-52669.	-6328.	-7545.	55458.	2030.	339252.	330199.	61.0	68.0	26.29	133849.	0.	0.
JAN	1	2	23	-52669.	-6328.	-7996.	55458.	2030.	339252.	329748.	61.0	68.0	26.29	134207.	0.	0.
JAN	1	2	24	-52669.	-6328.	-8611.	55458.	2030.	339252.	329133.	61.0	68.0	26.28	134695.	0.	0.

Fig. 4.2 Hourly, Daily, and Monthly Zone Load Calculations

MO	ZONE	DAY-TYPE	HR	INFILTN (BTU)	GLASS (BTU)	TRANSMITN (BTU)	LIGHT (BTU)	POEPLE (BTU)	EQUIPMENT (BTU)	NET HEAT (BTU)	SUPPLIED AIR TEMP	RESULTANT RM TEMP	COOLING (TONS)	HEATER (BTU)	BOILER (BTU)	PUMP (BTU)
JAN	2	1	1	-12439.	-3607.	-3277.	12798.	0.	10239.	3714.	66.7	68.0	1.36	25837.	0.	0.
JAN	2	1	2	-12439.	-3607.	-3718.	12798.	0.	10239.	3272.	66.8	68.0	1.35	26187.	0.	0.
JAN	2	1	3	-12439.	-3607.	-4179.	12798.	0.	10239.	2812.	67.0	68.0	1.34	26553.	0.	0.
JAN	2	1	4	-12884.	-3736.	-4626.	12798.	0.	10239.	1791.	67.4	68.0	1.30	27510.	0.	0.
JAN	2	1	5	-12884.	-3736.	-5030.	12798.	0.	10239.	1387.	67.5	68.0	1.29	27832.	0.	0.
JAN	2	1	6	-12884.	-3736.	-5364.	12798.	0.	10239.	1054.	67.6	68.0	1.28	28098.	0.	0.
JAN	2	1	7	-13328.	-3865.	-5604.	29777.	1160.	11263.	19403.	61.0	68.0	1.56	13522.	0.	0.
JAN	2	1	8	-13328.	6193.	-5734.	29777.	1160.	11263.	29331.	57.5	68.0	1.72	5555.	0.	0.
JAN	2	1	9	-12439.	13218.	-5745.	29777.	1160.	11263.	37233.	54.6	68.4	1.91	0.	0.	0.
JAN	2	1	10	-10662.	17838.	-5637.	29777.	1160.	11263.	43738.	52.3	70.7	2.07	0.	0.	0.
JAN	2	1	11	-9329.	20497.	-5417.	29777.	1160.	11263.	47950.	50.8	72.2	2.19	0.	0.	0.
JAN	2	1	12	-7997.	21475.	-5099.	29777.	1160.	11263.	50578.	49.9	73.1	2.31	0.	0.	0.
JAN	2	1	13	-7552.	21012.	-4706.	29777.	1160.	11263.	50953.	49.7	73.3	2.35	0.	0.	0.
JAN	2	1	14	-6664.	18997.	-4265.	29777.	1160.	11263.	50268.	50.0	73.0	2.43	0.	0.	0.
JAN	2	1	15	-6664.	14893.	-3805.	29777.	1160.	11263.	46624.	51.3	71.7	2.43	0.	0.	0.
JAN	2	1	16	-7108.	7997.	-3357.	29777.	1160.	11263.	39731.	53.8	69.2	2.39	0.	0.	0.
JAN	2	1	17	-7997.	-2319.	-2953.	12798.	0.	10239.	9769.	64.5	68.0	1.76	19903.	0.	0.
JAN	2	1	18	-9329.	-2705.	-2619.	12798.	0.	10239.	8383.	65.0	68.0	1.64	21300.	0.	0.
JAN	2	1	19	-11106.	-3220.	-2379.	12798.	0.	10239.	6331.	65.7	68.0	1.49	23377.	0.	0.
JAN	2	1	[illegible]	-11995.	-3478.	-2249.	12798.	0.	10239.	5315.	66.1	68.0	1.41	24434.	0.	0.
JAN	2	1	21	-11995.	-3478.	-2238.	12798.	0.	10239.	5326.	66.1	68.0	1.4[illegible]	24425.	0.	0.
JAN	2	1	22	-12439.	-3607.	-2346.	12798.	0.	10239.	4645.	66.3	68.0	1.3[illegible]	25098.	0.	0.
JAN	2	1	23	-12439.	-3607.	-2566.	12798.	0.	10239.	4424.	66.4	68.0	1.37	25273.	0.	0.
JAN	2	1	24	-12439.	-3607.	-2884.	12798.	0.	10239.	4107.	66.5	68.0	1.36	25525.	0.	0.
JAN	2	2	1	-12439.	-3607.	-3277.	12798.	0.	10239.	3714.	66.7	68.0	1.36	25837.	0.	0.
JAN	2	2	2	-12439.	-3607.	-3718.	12798.	0.	10239.	3272.	66.8	68.0	1.35	26187.	0.	0.
JAN	2	2	3	-12439.	-3607.	-4179.	12798.	0.	10239.	2812.	67.0	68.0	1.34	26553.	0.	0.
JAN	2	2	4	-12884.	-3736.	-4626.	12798.	0.	10239.	1791.	67.4	68.0	1.30	27510.	0.	0.
JAN	2	2	5	-12884.	-3736.	-5030.	12798.	0.	10239.	1387.	67.5	68.0	1.29	27832.	0.	0.
JAN	2	2	6	-12884.	-3736.	-5364.	12798.	0.	10239.	1054.	67.6	68.0	1.28	28098.	0.	0.
JAN	2	2	7	-13328.	-3865.	-5604.	12798.	0.	10239.	241.	67.9	68.0	1.24	28900.	0.	0.
JAN	2	2	8	-13328.	6193.	-5734.	12798.	0.	10239.	10169.	64.4	68.0	1.41	20933.	0.	0.
JAN	2	2	9	-12439.	13218.	-5745.	12798.	0.	10239.	10071.	61.5	68.0	1.60	14437.	0.	0.
JAN	2	2	10	-10662.	17838.	-5637.	12798.	0.	10239.	24575.	59.2	68.0	1.86	9074.	0.	0.
JAN	2	2	11	-9329.	20497.	-5417.	12798.	0.	10239.	28787.	57.7	68.0	2.04	5706.	0.	0.
JAN	2	2	12	-7997.	21475.	-5099.	12798.	0.	10239.	31416.	56.7	68.0	2.21	3636.	0.	0.
JAN	2	2	13	-7552.	21012.	-4706.	12798.	0.	10239.	31790.	56.6	68.0	2.26	3335.	0.	0.
JAN	2	2	14	-6664.	18997.	-4265.	12798.	0.	10239.	31105.	56.8	68.0	2.32	3803.	0.	0.
JAN	2	2	15	-6664.	14893.	-3805.	12798.	0.	10239.	27462.	58.2	68.0	2.24	6495.	0.	0.
JAN	2	2	16	-7108.	7997.	-3357.	12798.	0.	10239.	20569.	60.6	68.0	2.05	11654.	0.	0.
JAN	2	2	17	-7997.	-2319.	-2953.	12798.	0.	10239.	9769.	64.5	68.0	1.76	19903.	0.	0.
JAN	2	2	18	-9329.	-2705.	-2619.	12798.	0.	10239.	8383.	65.0	68.0	1.64	21300.	0.	0.
JAN	2	2	19	-11106.	-3220.	-2379.	12798.	0.	10239.	6331.	65.7	68.0	1.49	23377.	0.	0.
JAN	2	2	20	-11995.	-3478.	-2249.	12798.	0.	10239.	5315.	66.1	68.0	1.[illegible]	24434.	0.	0.
JAN	2	2	21	-11995.	-3478.	-2238.	12798.	0.	10239.	5326.	66.1	68.0	[illegible].41	24425.	0.	0.
JAN	2	2	22	-12439.	-3607.	-2346.	12798.	0.	10239.	4645.	66.3	68.0	1.37	25098.	0.	0.
JAN	2	2	23	-12439.	-3607.	-2566.	12798.	0.	10239.	4424.	66.4	68.0	1.37	25273.	0.	0.
JAN	2	2	24	-12439.	-3607.	-2884.	12798.	0.	10239.	4107.	66.5	68.0	1.36	25525.	0.	0.

Fig. 4.2 (Continuation)

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AIR-HANDLER	MO	DAY-TYPE	HR	TEMP OF MIXED AIR	COOLING (TONS)	HEATER (BTU)	BOILER (BTU)	PUMP (BTU)	MIN TSAZ (DEG F)	MAX TSAZ (DEG F)
1	JAN	1	1	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	1	2	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	1	3	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	1	4	66.5	12.18	0.	0.	0.	60.00	60.00
1	JAN	1	5	66.5	12.18	0.	0.	0.	60.00	60.00
1	JAN	1	6	66.5	12.18	0.	0.	0.	60.00	60.00
1	JAN	1	7	66.5	12.08	0.	0.	0.	60.00	60.00
1	JAN	1	8	66.5	12.08	0.	0.	0.	60.00	60.00
1	JAN	1	9	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	1	10	66.8	12.64	0.	0.	0.	60.00	60.00
1	JAN	1	11	66.9	12.92	0.	0.	0.	60.00	60.00
1	JAN	1	12	67.1	13.20	0.	0.	0.	60.00	60.00
1	JAN	1	13	67.1	13.29	0.	0.	0.	60.00	60.00
1	JAN	1	14	67.2	13.48	0.	0.	0.	60.00	60.00
1	JAN	1	15	67.2	13.48	0.	0.	0.	60.00	60.00
1	JAN	1	16	67.2	13.39	0.	0.	0.	60.00	60.00
1	JAN	1	17	67.1	13.20	0.	0.	0.	60.00	60.00
1	JAN	1	18	66.9	12.92	0.	0.	0.	60.00	60.00
1	JAN	1	19	66.7	12.55	0.	0.	0.	60.00	60.00
1	JAN	1	20	66.6	12.36	0.	0.	0.	60.00	60.00
1	JAN	1	21	66.6	12.36	0.	0.	0.	60.00	60.00
1	JAN	1	22	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	1	23	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	1	24	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	1	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	2	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	3	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	4	66.5	12.18	0.	0.	0.	60.00	60.00
1	JAN	2	5	66.5	12.18	0.	0.	0.	60.00	60.00
1	JAN	2	6	66.5	12.18	0.	0.	0.	60.00	60.00
1	JAN	2	7	66.5	12.08	0.	0.	0.	60.00	60.00
1	JAN	2	8	66.5	12.08	0.	0.	0.	60.00	60.00
1	JAN	2	9	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	10	66.8	12.64	0.	0.	0.	60.00	60.00
1	JAN	2	11	66.9	12.92	0.	0.	0.	60.00	60.00
1	JAN	2	12	67.1	13.20	0.	0.	0.	60.00	60.00
1	JAN	2	13	67.1	13.29	0.	0.	0.	60.00	60.00
1	JAN	2	14	67.2	13.48	0.	0.	0.	60.00	60.00
1	JAN	2	15	67.2	13.48	0.	0.	0.	60.00	60.00
1	JAN	2	16	67.2	13.39	0.	0.	0.	60.00	60.00
1	JAN	2	17	67.1	13.20	0.	0.	0.	60.00	60.00
1	JAN	2	18	66.9	12.92	0.	0.	0.	60.00	60.00
1	JAN	2	19	66.7	12.55	0.	0.	0.	60.00	60.00
1	JAN	2	20	66.6	12.36	0.	0.	0.	60.00	60.00
1	JAN	2	21	66.6	12.36	0.	0.	0.	60.00	60.00
1	JAN	2	22	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	23	66.6	12.27	0.	0.	0.	60.00	60.00
1	JAN	2	24	66.6	12.27	0.	0.	0.	60.00	60.00

* MONTHLY MIN SUPPLY AIR TEMP = 60.0
* MONTHLY MAX SUPPLY AIR TEMP = 60.0

Fig. 4.3 Hourly, Daily, and Monthly Air-Handler Loads

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AIR- HANDLER	MO	DAY- TYPE	HR	TEMP OF MIXED AIR	COOLING (TONS)	HEATER (BTU)	BOILER (BTU)	PUMP (BTU)	MIN TSAZ (DEG F)	MAX TSAZ (DEG F)
2	JAN	1	1	63.2	15.35	161118.	0.	0.	61.92	66.67
2	JAN	1	2	63.2	15.33	162113.	0.	0.	61.95	66.83
2	JAN	1	3	63.2	15.31	163136.	0.	0.	61.98	66.99
2	JAN	1	4	63.1	14.92	167135.	0.	0.	62.10	67.36
2	JAN	1	5	63.1	14.91	168014.	0.	0.	62.13	67.50
2	JAN	1	6	63.1	14.89	168724.	0.	0.	62.15	67.62
2	JAN	1	7	62.9	15.08	144908.	0.	0.	61.04	61.65
2	JAN	1	8	62.9	15.28	135595.	0.	0.	57.48	61.58
2	JAN	1	9	63.2	16.15	124109.	0.	0.	54.65	61.34
2	JAN	1	10	63.9	17.66	113933.	0.	0.	52.32	60.95
2	JAN	1	11	64.4	19.15	93393.	0.	0.	50.81	59.96
2	JAN	1	12	64.9	20.34	86472.	0.	0.	49.86	59.67
2	JAN	1	13	65.1	20.74	84006.	0.	0.	49.73	59.56
2	JAN	1	14	65.4	21.53	79778.	0.	0.	49.97	59.38
2	JAN	1	15	65.4	21.53	79899.	0.	0.	51.28	59.39
2	JAN	1	16	65.3	21.12	82436.	0.	0.	53.75	59.50
2	JAN	1	17	64.9	19.45	118539.	0.	0.	60.33	64.50
2	JAN	1	18	64.4	18.31	126015.	0.	0.	60.56	64.99
2	JAN	1	19	63.8	16.50	150042.	0.	0.	61.58	65.73
2	JAN	1	20	63.4	15.77	155668.	0.	0.	61.74	66.09
2	JAN	1	21	63.4	15.77	155692.	0.	0.	61.75	66.09
2	JAN	1	22	63.2	15.40	158946.	0.	0.	61.84	66.33
2	JAN	1	23	63.2	15.39	159479.	0.	0.	61.86	66.41
2	JAN	1	24	63.2	15.37	160220.	0.	0.	61.89	66.53
2	JAN	2	1	63.2	15.35	161118.	0.	0.	61.92	66.67
2	JAN	2	2	63.2	15.33	162113.	0.	0.	61.95	66.83
2	JAN	2	3	63.2	15.31	163136.	0.	0.	61.98	66.99
2	JAN	2	4	63.1	14.92	167135.	0.	0.	62.10	67.36
2	JAN	2	5	63.1	14.91	168014.	0.	0.	62.13	67.50
2	JAN	2	6	63.1	14.89	168724.	0.	0.	62.15	67.62
2	JAN	2	7	62.9	14.77	160286.	0.	0.	61.65	67.91
2	JAN	2	8	62.9	14.96	150973.	0.	0.	61.58	64.35
2	JAN	2	9	63.2	15.84	138546.	0.	0.	61.34	61.52
2	JAN	2	10	63.9	17.45	123007.	0.	0.	59.19	60.95
2	JAN	2	11	64.4	19.01	99099.	0.	0.	57.68	59.96
2	JAN	2	12	64.9	20.24	90108.	0.	0.	56.73	59.67
2	JAN	2	13	65.1	20.65	87341.	0.	0.	56.60	59.56
2	JAN	2	14	65.4	21.42	83581.	0.	0.	56.85	59.38
2	JAN	2	15	65.4	21.34	86394.	0.	0.	58.15	59.39
2	JAN	2	16	65.3	20.78	94090.	0.	0.	59.50	60.62
2	JAN	2	17	64.9	19.45	118539.	0.	0.	60.33	64.50
2	JAN	2	18	64.4	18.31	126015.	0.	0.	60.56	64.99
2	JAN	2	19	63.8	16.50	150042.	0.	0.	61.58	65.73
2	JAN	2	20	63.4	15.77	155668.	0.	0.	61.74	66.09
2	JAN	2	21	63.4	15.77	155692.	0.	0.	61.75	66.09
2	JAN	2	22	63.2	15.40	158946.	0.	0.	61.84	66.33
2	JAN	2	23	63.2	15.39	159479.	0.	0.	61.86	66.41
2	JAN	2	24	63.2	15.37	160220.	0.	0.	61.89	66.53

* MONTHLY MIN SUPPLY AIR TEMP = 49.7
* MONTHLY MAX SUPPLY AIR TEMP = 67.9

Fig. 4.3 (Continuation)

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COM-PRESSOR	MONTH	DAY-TYPE	HOUR	TONAGE
1	JAN	1	1	12.27
1	JAN	1	2	12.27
1	JAN	1	3	12.27
1	JAN	1	4	12.18
1	JAN	1	5	12.18
1	JAN	1	6	12.18
1	JAN	1	7	12.08
1	JAN	1	8	12.08
1	JAN	1	9	12.27
1	JAN	1	10	12.64
1	JAN	1	11	12.92
1	JAN	1	12	13.20
1	JAN	1	13	13.29
1	JAN	1	14	13.48
1	JAN	1	15	13.48
1	JAN	1	16	13.39
1	JAN	1	17	13.20
1	JAN	1	18	12.92
1	JAN	1	19	12.55
1	JAN	1	20	12.36
1	JAN	1	21	12.36
1	JAN	1	22	12.27
1	JAN	1	23	12.27
1	JAN	1	24	12.27

* DAILY TOTAL : 302.39 TONS : COMPRESSOR OFF : 0 HR

COM-PRESSOR	MONTH	DAY-TYPE	HOUR	TONAGE
1	JAN	2	1	12.27
1	JAN	2	2	12.27
1	JAN	2	3	12.27
1	JAN	2	4	12.18
1	JAN	2	5	12.18
1	JAN	2	6	12.18
1	JAN	2	7	12.08
1	JAN	2	8	12.08
1	JAN	2	9	12.27
1	JAN	2	10	12.64
1	JAN	2	11	12.92
1	JAN	2	12	13.20
1	JAN	2	13	13.29
1	JAN	2	14	13.48
1	JAN	2	15	13.48
1	JAN	2	16	13.39
1	JAN	2	17	13.20
1	JAN	2	18	12.92
1	JAN	2	19	12.55
1	JAN	2	20	12.36
1	JAN	2	21	12.36
1	JAN	2	22	12.27
1	JAN	2	23	12.27
1	JAN	2	24	12.27

* DAILY TOTAL : 302.39 TONS : COMPRESSOR OFF : 0 HR

Fig. 4.4 Hourly, Daily, and Monthly Compressor Loads

COM-PRESSOR	MONTH	DAY-TYPE	HOUR	TONAGE
2	JAN	1	1	15.35
2	JAN	1	2	15.33
2	JAN	1	3	15.31
2	JAN	1	4	14.92
2	JAN	1	5	14.91
2	JAN	1	6	14.89
2	JAN	1	7	15.08
2	JAN	1	8	15.28
2	JAN	1	9	16.15
2	JAN	1	10	17.66
2	JAN	1	11	19.15
2	JAN	1	12	20.34
2	JAN	1	13	20.74
2	JAN	1	14	21.53
2	JAN	1	15	21.53
2	JAN	1	16	21.12
2	JAN	1	17	19.45
2	JAN	1	18	18.31
2	JAN	1	19	16.50
2	JAN	1	20	15.77
2	JAN	1	21	15.77
2	JAN	1	22	15.40
2	JAN	1	23	15.39
2	JAN	1	24	15.37

* DAILY TOTAL : 411.23 TONS : COMPRESSOR OFF : 0 HR

COM-PRESSOR	MONTH	DAY-TYPE	HOUR	TONAGE
2	JAN	2	1	15.35
2	JAN	2	2	15.33
2	JAN	2	3	15.31
2	JAN	2	4	14.92
2	JAN	2	5	14.91
2	JAN	2	6	14.89
2	JAN	2	7	14.77
2	JAN	2	8	14.96
2	JAN	2	9	15.84
2	JAN	2	10	17.45
2	JAN	2	11	19.01
2	JAN	2	12	20.24
2	JAN	2	13	20.65
2	JAN	2	14	21.42
2	JAN	2	15	21.34
2	JAN	2	16	20.78
2	JAN	2	17	19.45
2	JAN	2	18	18.31
2	JAN	2	19	16.50
2	JAN	2	20	15.77
2	JAN	2	21	15.77
2	JAN	2	22	15.40
2	JAN	2	23	15.39
2	JAN	2	24	15.37

* DAILY TOTAL : 409.09 TONS : COMPRESSOR OFF : 0 HR

Fig. 4.4 (Continuation)

HOURLY CONSUMPTION IN KW

MONTH	DAY TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
**	1	214	215	215	216	216	216	216	214	211	210	210	209	209	209	209	209	211	212	213	213	213	214	214	214
1	2	217	218	218	219	219	219	219	217	214	212	210	209	209	209	210	211	214	215	216	216	216	217	217	217
**	1	210	211	211	211	212	212	212	209	209	208	208	207	207	207	207	207	206	207	207	207	208	208	209	210
2	2	213	214	214	214	215	215	215	212	210	208	207	206	206	206	206	207	209	210	210	210	211	211	212	213
**	1	209	210	210	211	211	212	210	208	208	207	207	207	207	207	206	207	204	206	205	206	206	207	208	208
3	2	212	213	213	214	214	215	213	211	209	207	206	206	206	206	206	207	207	209	208	209	209	210	211	211
**	1	207	208	209	209	210	209	209	207	207	206	206	206	206	206	206	206	203	203	203	204	204	205	206	206
4	2	210	211	212	212	213	212	212	210	208	206	206	205	205	205	205	206	206	206	206	207	207	208	209	209
**	1	203	204	204	205	205	204	206	205	205	204	205	205	205	205	205	206	201	201	200	200	200	201	201	202
5	2	206	207	207	208	208	207	207	207	206	204	205	204	204	204	204	205	204	204	203	203	203	204	204	205
**	1	254	255	255	255	255	255	260	260	259	259	262	262	261	261	261	261	255	255	251	252	252	253	253	254
6	2	257	258	258	258	258	258	261	261	260	259	262	262	262	261	261	261	258	258	254	255	255	256	256	257
**	1	253	253	254	254	254	254	259	259	258	258	261	261	261	261	261	261	254	254	251	251	251	252	252	253
7	2	256	256	257	257	257	257	260	260	259	258	261	261	261	261	260	260	257	257	254	254	254	255	255	256
**	1	253	253	253	254	254	254	259	259	258	258	261	261	261	261	261	261	255	255	251	251	252	252	252	253
8	2	256	256	256	257	257	257	260	260	259	258	261	261	261	261	261	261	258	258	254	254	255	255	255	256
**	1	254	255	255	255	255	256	261	260	259	258	262	261	261	261	261	261	256	256	252	253	253	254	254	254
9	2	257	258	258	258	258	259	261	261	260	259	262	262	261	261	261	261	259	259	255	256	256	257	257	257
**	1	205	205	206	206	206	207	207	206	206	206	206	206	206	206	206	206	203	203	203	203	203	204	204	204
10	2	208	208	209	209	209	210	210	207	205	205	205	205	205	205	205	205	206	206	206	206	206	207	207	207
**	1	211	211	211	212	212	212	212	210	209	208	208	208	208	207	208	208	207	208	208	209	209	209	209	210
11	2	214	214	214	215	215	215	215	213	210	207	207	207	207	206	207	208	210	211	211	212	212	212	212	213
**	1	215	216	217	217	217	217	217	214	212	210	210	210	210	210	210	210	213	214	214	214	215	215	215	215
12	2	218	219	220	220	220	220	221	217	215	212	211	210	210	210	211	213	216	217	217	217	218	218	218	218

Fig. 4.5 Hourly, daily, and monthly watt-hour meter.

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ZONE	MIN 1 HR HEAT GAIN (WHOLE YEAR) [BTU]	MAX 1 HR HEAT GAIN (WHOLE YEAR) [BTU]	DESIGN CFM	PRESENT CFM	MAXIMUM TONNAGE
1	317118.	489149.	21925.	48400.	71.6
2	-1468.	68802.	3084.	2875.	6.1

** DESIGN CONDITIONS

AIR HANDLER	MIN CFM	MIN ALFA	YEARLY MIN TEMP SUPP AIR	YEARLY MAX TEMP SUPP AIR	YEARLY MAX TONNAGE
1	2300.	.100	60.0	60.0	35.3
2	2827.	.100	43.5	79.3	42.5

COM-PRESSOR	YEARLY TOTAL (TONHRS)	YEARLY MAX TONNAGE
1	177646.6	35.3
2	231656.2	42.5
TOTAL	409302.8	

Fig. 4.6 Design Conditions

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MONTH	LIGHT POWER (KWH/BLDG)	EQPT POWER (KWH/BLDG)	AUX POWER (KWH)	COMP CHILLER (KWH)	ELEC HEATER (KWH)	HEAT PUMP (KWH)	ELEC METER (KWH)	GAS BOILER (KWHT)	ENERGY COST DOLLARS
JAN	.1455+05	.7477+05	.1824+05	.2167+05	.2874+05	.0000	.1580+06	.0000	.4739+04
FEB	.1455+05	.7477+05	.1824+05	.2472+05	.2296+05	.0000	.1551+06	.0000	.4654+04
MAR	.1455+05	.7477+05	.1824+05	.2543+05	.2142+05	.0000	.1544+06	.0000	.4632+04
APR	.1455+05	.7477+05	.1824+05	.2690+05	.1885+05	.0000	.1533+06	.0000	.4599+04
MAY	.1455+05	.7477+05	.1824+05	.3073+05	.1293+05	.0000	.1512+06	.0000	.4537+04
JUN	.1455+05	.7477+05	.1824+05	.5071+05	.3184+05	.0000	.1901+06	.0000	.5703+04
JUL	.1455+05	.7477+05	.1824+05	.5258+05	.2930+05	.0000	.1894+06	.0000	.5683+04
AUG	.1455+05	.7477+05	.1824+05	.5228+05	.2967+05	.0000	.1895+06	.0000	.5685+04
SEP	.1455+05	.7477+05	.1824+05	.4988+05	.3291+05	.0000	.1903+06	.0000	.5710+04
OCT	.1455+05	.7477+05	.1824+05	.2898+05	.1584+05	.0000	.1524+06	.0000	.4572+04
NOV	.1455+05	.7477+05	.1824+05	.2447+05	.2345+05	.0000	.1555+06	.0000	.4664+04
DEC	.1455+05	.7477+05	.1824+05	.2095+05	.3026+05	.0000	.1588+06	.0000	.4763+04
TOTAL	.1746+06	.8973+06	.2189+06	.4093+06	.2981+06	.0000	.1998+07	.0000	.5994+05

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Fig. 4.7 Monthly Energy Consumption and Cost

SECTION V
SEQUENCE OF CALCULATION OF THE MAIN PROGRAM

5.1 Description

The main program of ECP calculates the hourly heat gain or loss to each zone within a building according to the building architecture and structure details, local weather, position of the sun and scheduling of equipment, lights and people, etc. The heat loss/gain of the various zones determines the requirements on the air handlers or fan-coil units. From these requirements the energy consumption (electrical or thermal) of the air conditioning primary equipment is calculated. Moreover, the electric energy consumption due to lights, electronic and mechanical equipment and other auxiliaries are added to the computed energy consumption by the primary air conditioning equipment to give the total energy consumption of the building. The latter is used for comparison with actual readings from watt-hour meters to determine the accuracy of the simulation process.

The net heat gain to a zone calculated in the main program is the final result of augmenting direct solar radiation, infiltration, heat transmission through glass and walls and internal heat sources such as lights, electronic/mechanical equipment and people.

The main assumptions used in the main program are listed as follows:

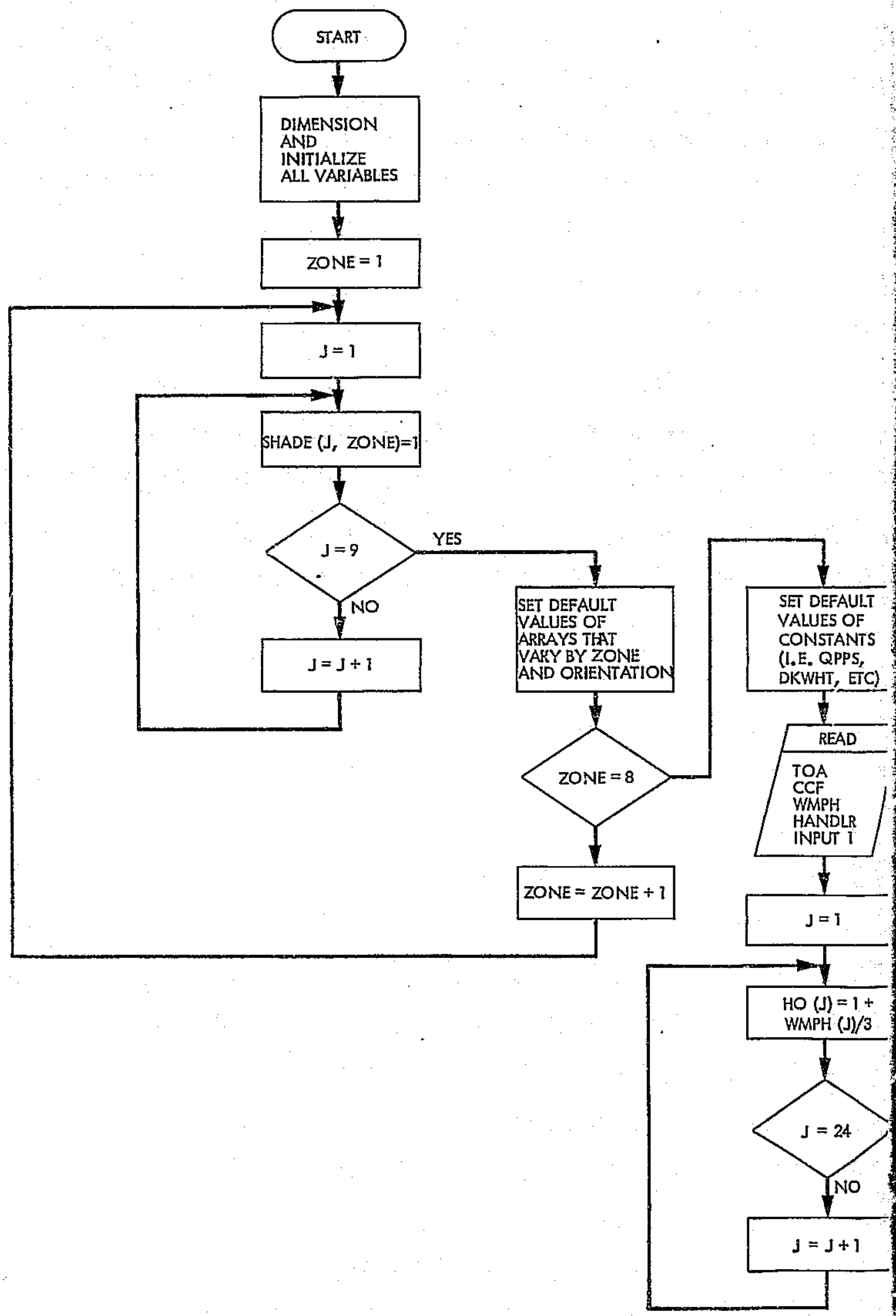
(1) The heat gain or loss to or from a zone is assumed totally sensible with negligible latent loads. The effects of outside air humidity changes are neglected.

(2) Scheduling of people, lights and electronic/mechanical equipment (other than air conditioning equipment) remains the same for each month throughout the year. Only variations in scheduling due to day type (weekday, weekend or holiday) are considered.

(3) The number of day type (2) augmenting holidays and weekends per year is taken as 114 days assuming 10 holidays per year. The average number of day type (2) per month is 114/12 or 9.5. The average number of days per month for day type (1) (weekdays) will then be (365 - 114)/12 or 20.9.

(4) The sources of heat gain to the zone due to electrical, mechanical equipment, incandescent and fluorescent lights, and people, are all assumed 100% convective to the air stream with no radiative portions.

A complete listing of the program and all of the subroutines are presented in Appendix A. A flow chart of the main program is presented in Fig. 5.1.



FOLDOUT FRAME

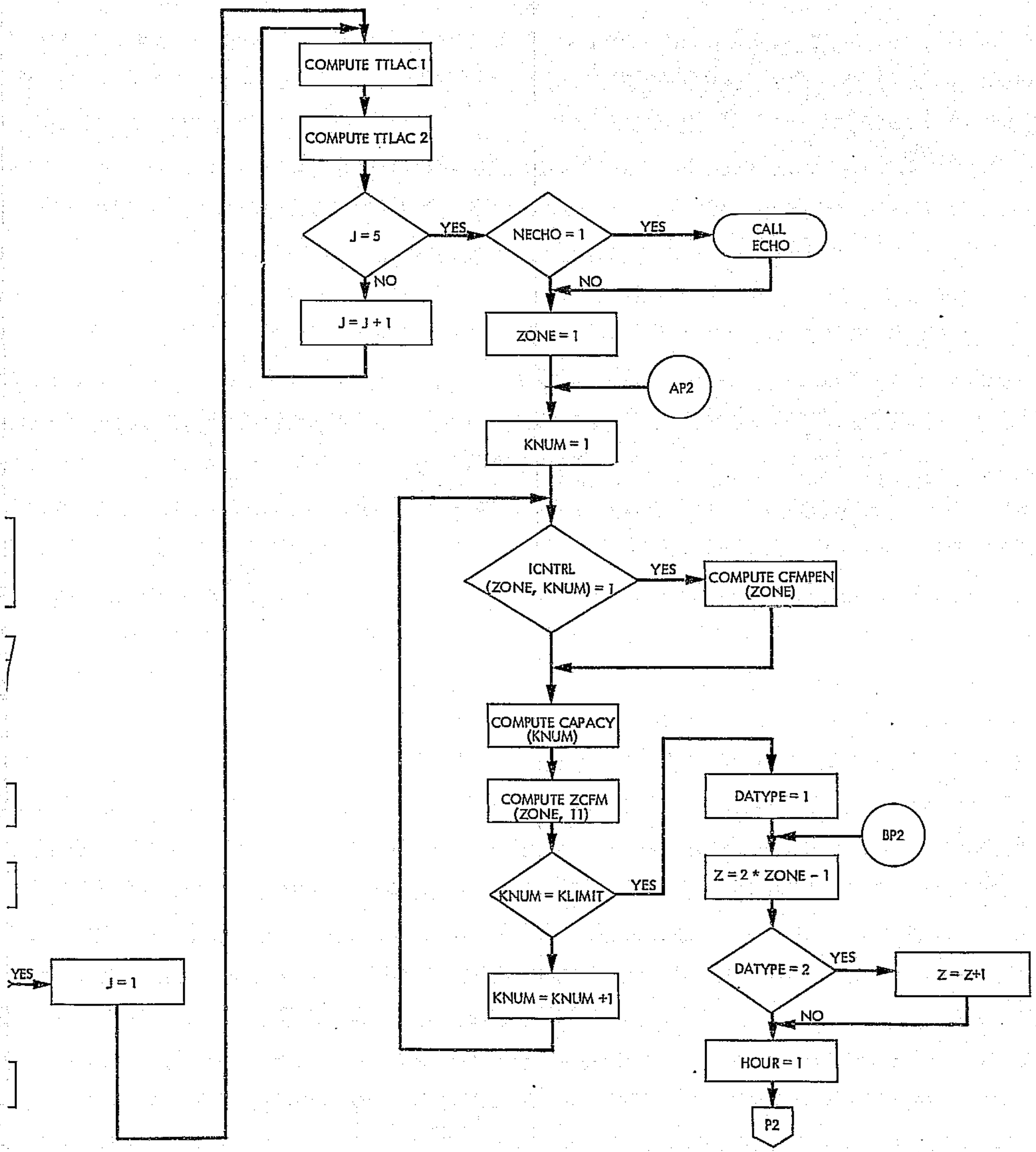


Figure 5-1. Main program flow chart

2 FOLDOUT FRAME

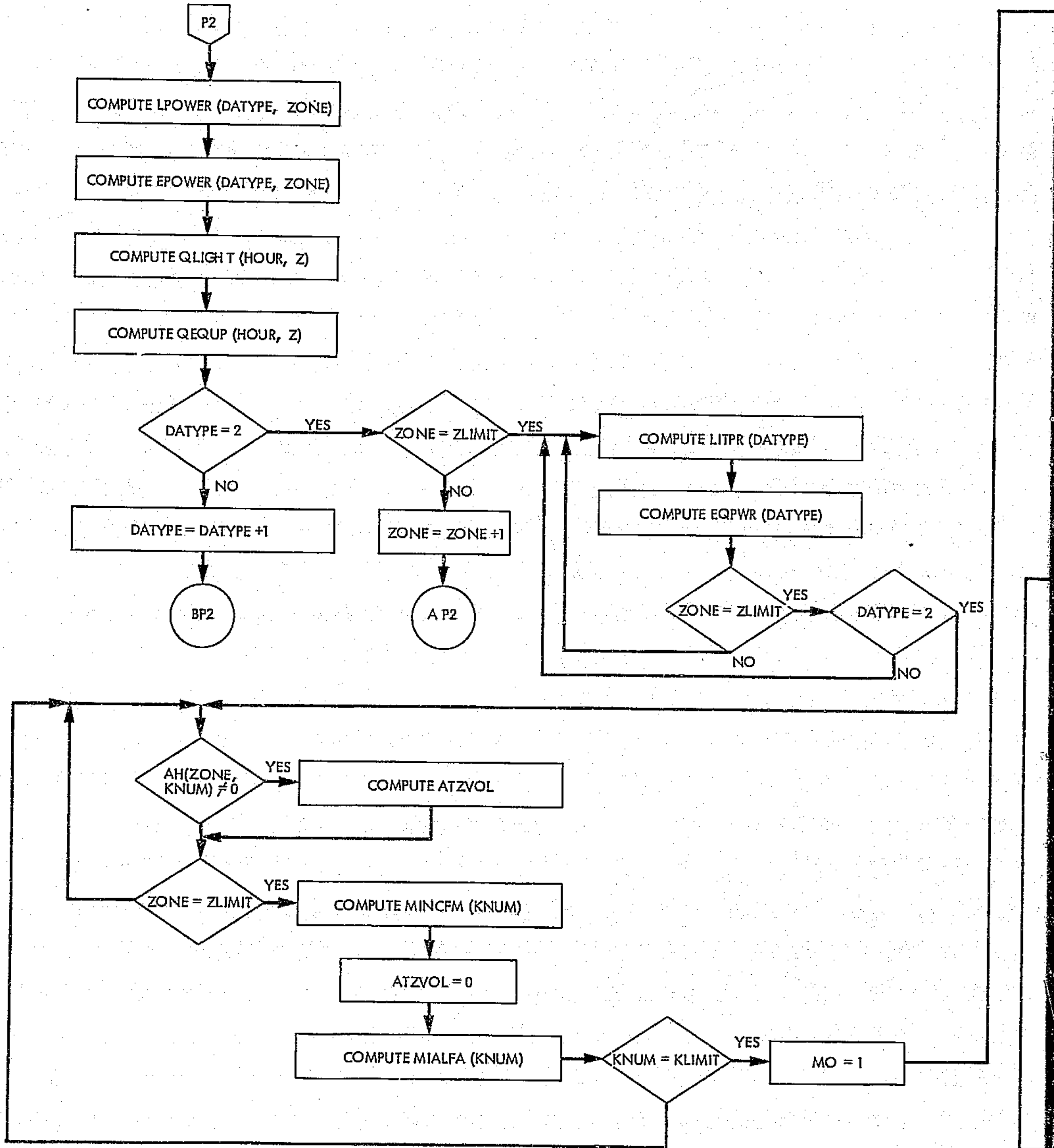
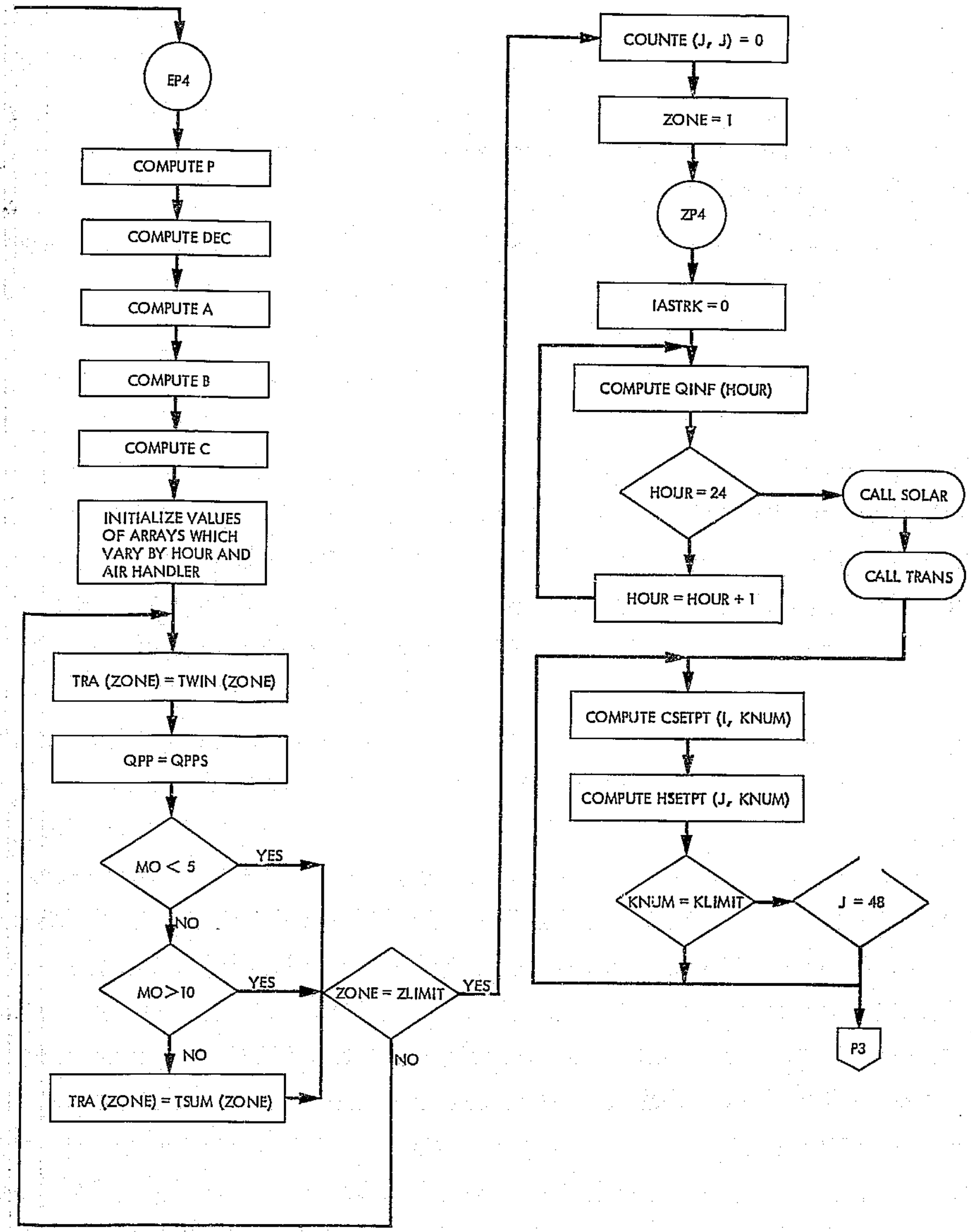
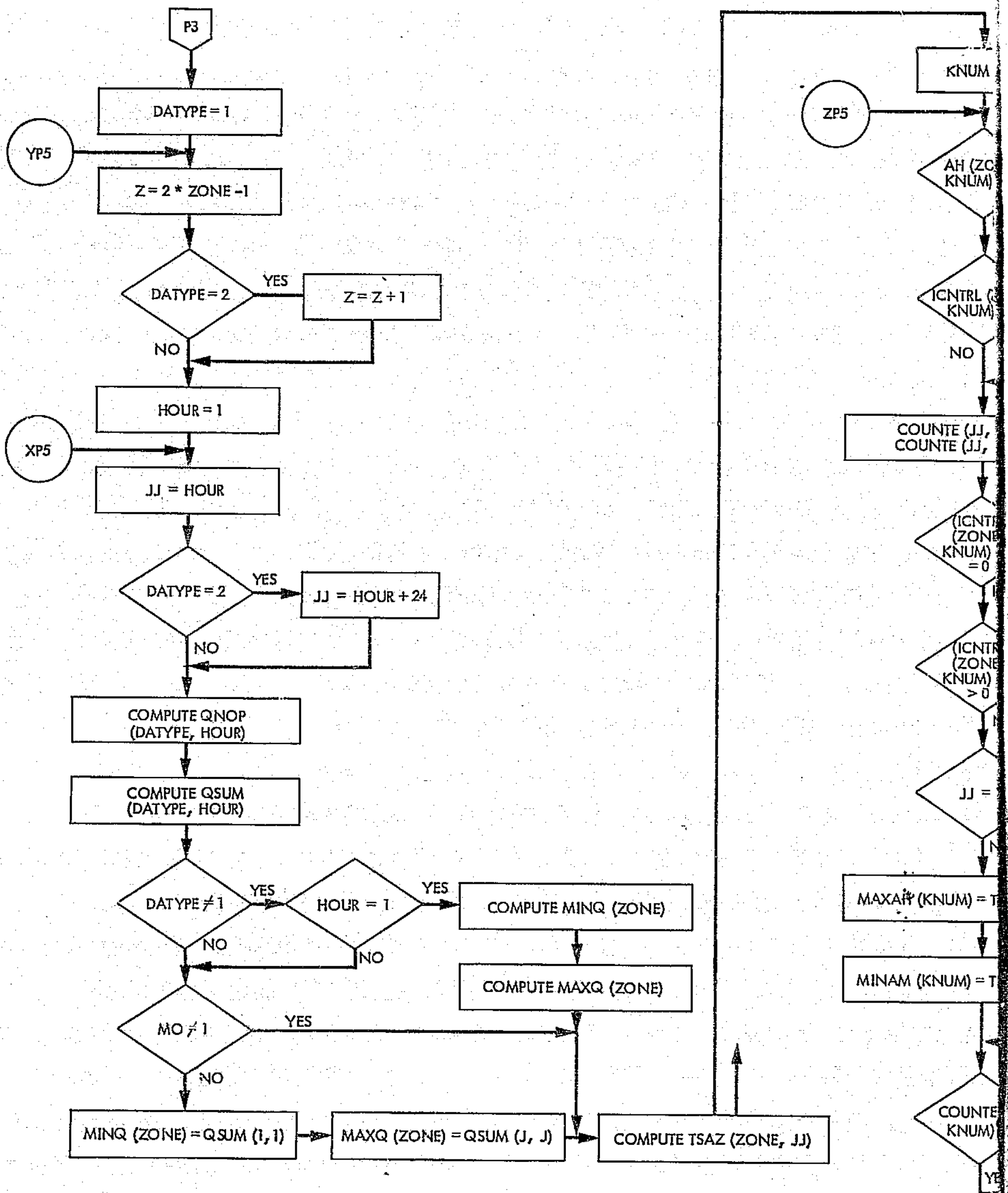


Figure 5-1. (Continuation)


EP4
COMPUTE P
COMPUTE DEC
COMPUTE A
COMPUTE B
COMPUTE C
INITIALIZE VALUES OF ARRAYS WHICH VARY BY HOUR AND AIR HANDLER
TRA (ZONE) = TWIN (ZONE)
QPP = QPPS
MO < 5
YES
NO
MO > 10
YES
NO
TRA (ZONE) = TSUM (ZONE)
ZONE = ZLIMIT
YES
NO
COUNTE (J, J) = 0
ZONE = 1
ZP4
IASTRK = 0
COMPUTE QINF (HOUR)
HOUR = 24
CALL SOLAR
CALL TRANS
HOUR = HOUR + 1
COMPUTE CSETPT (I, KNUM)
COMPUTE HSETPT (J, KNUM)
KNUM = KLIMIT
J = 48
P3



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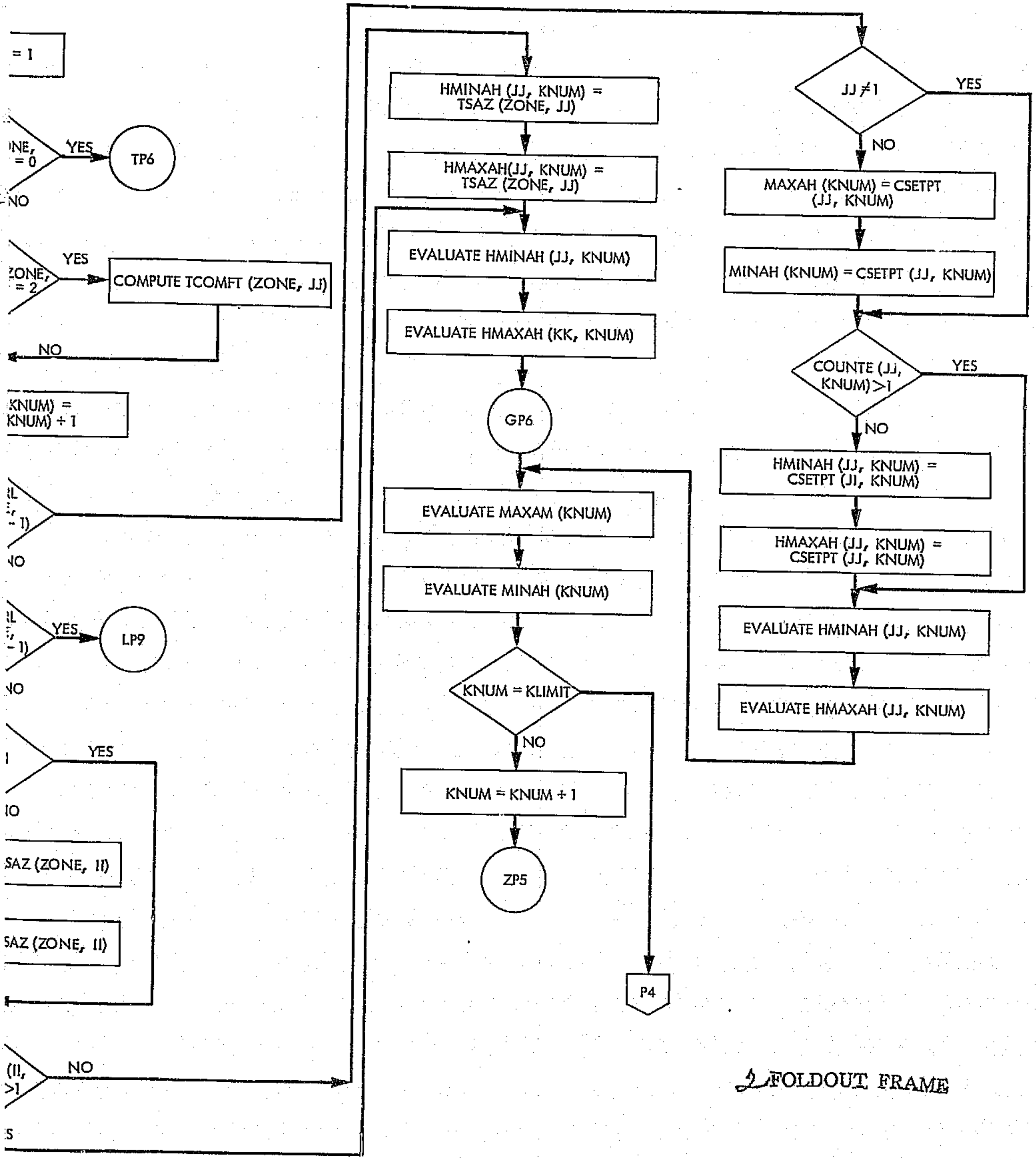

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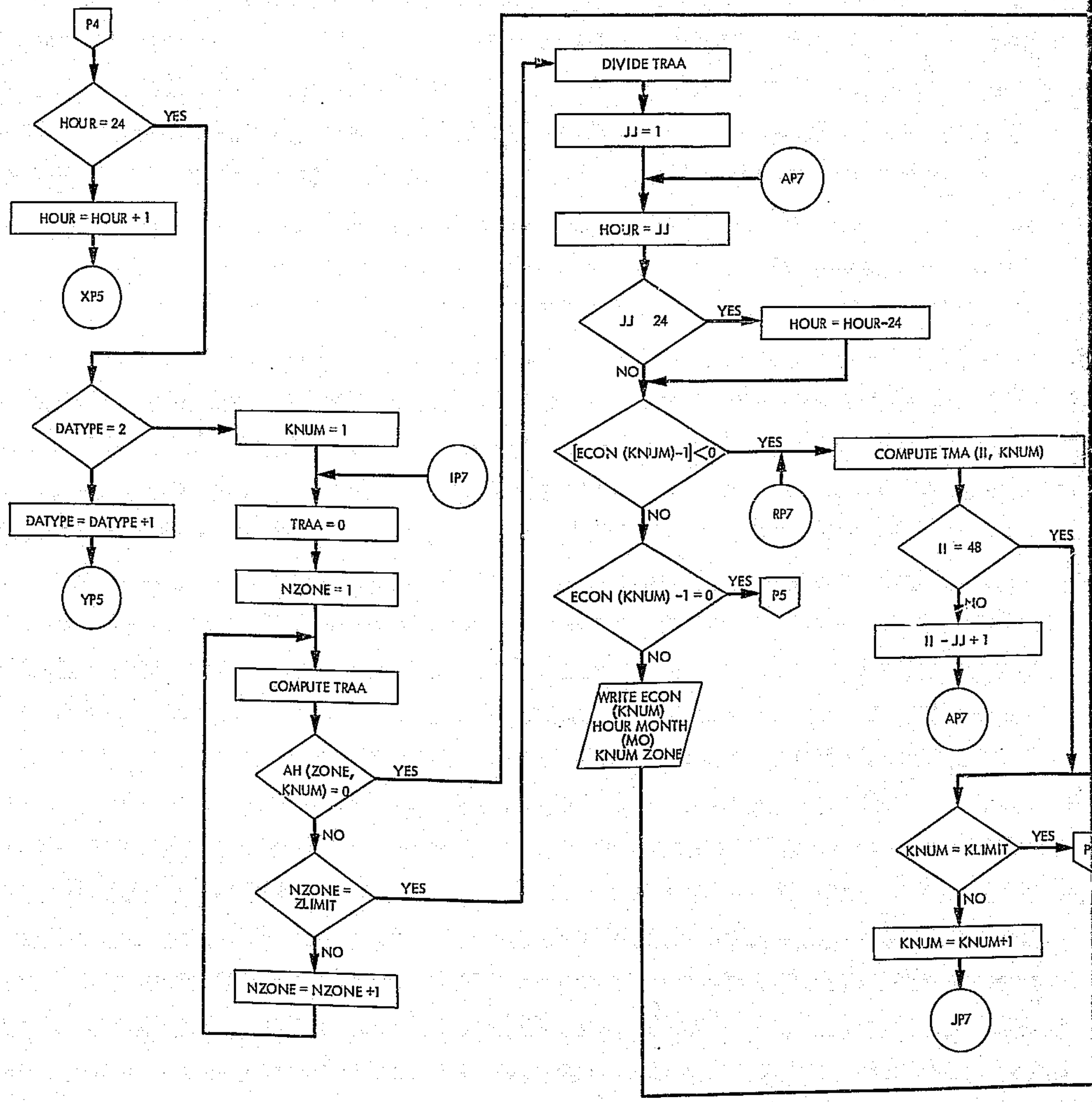

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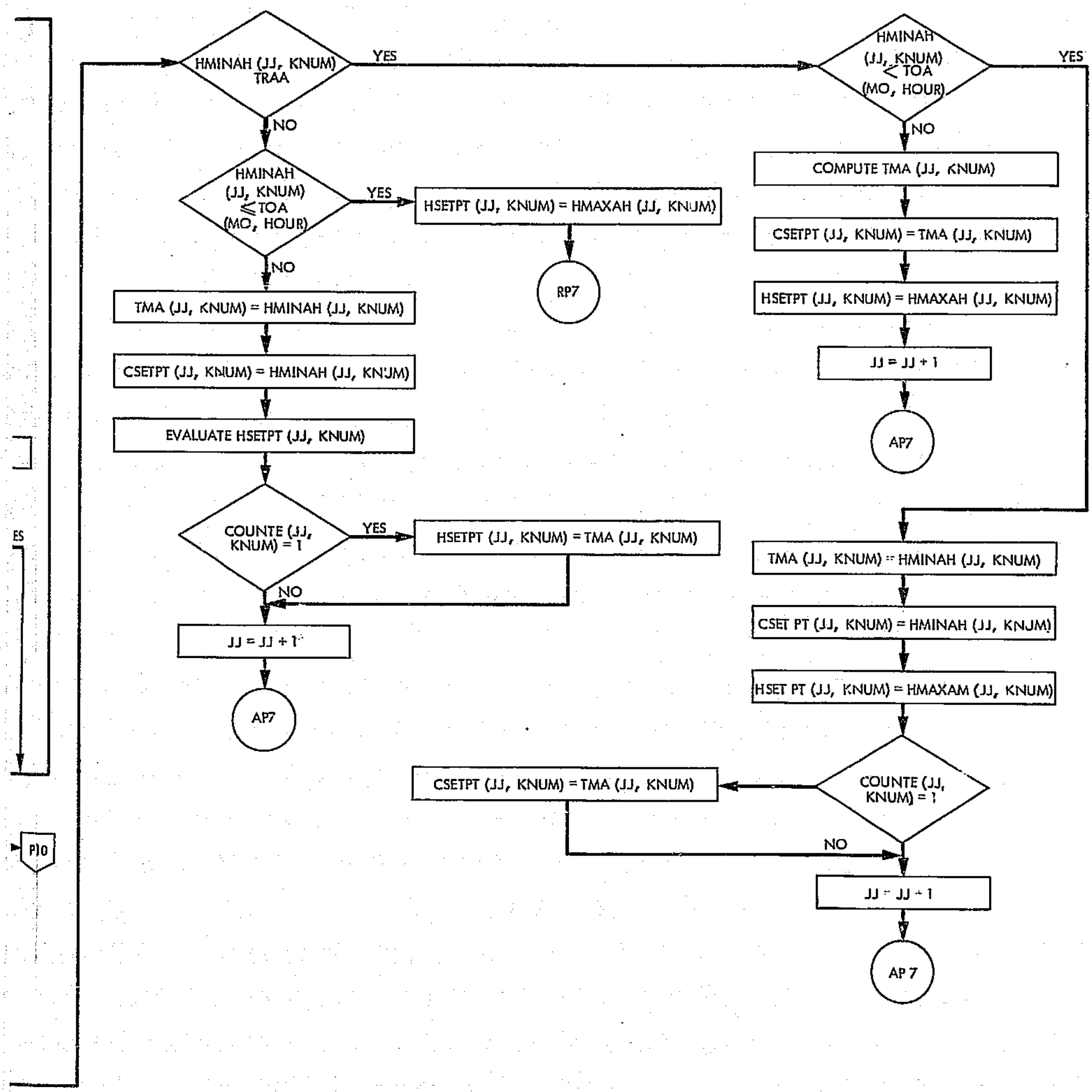

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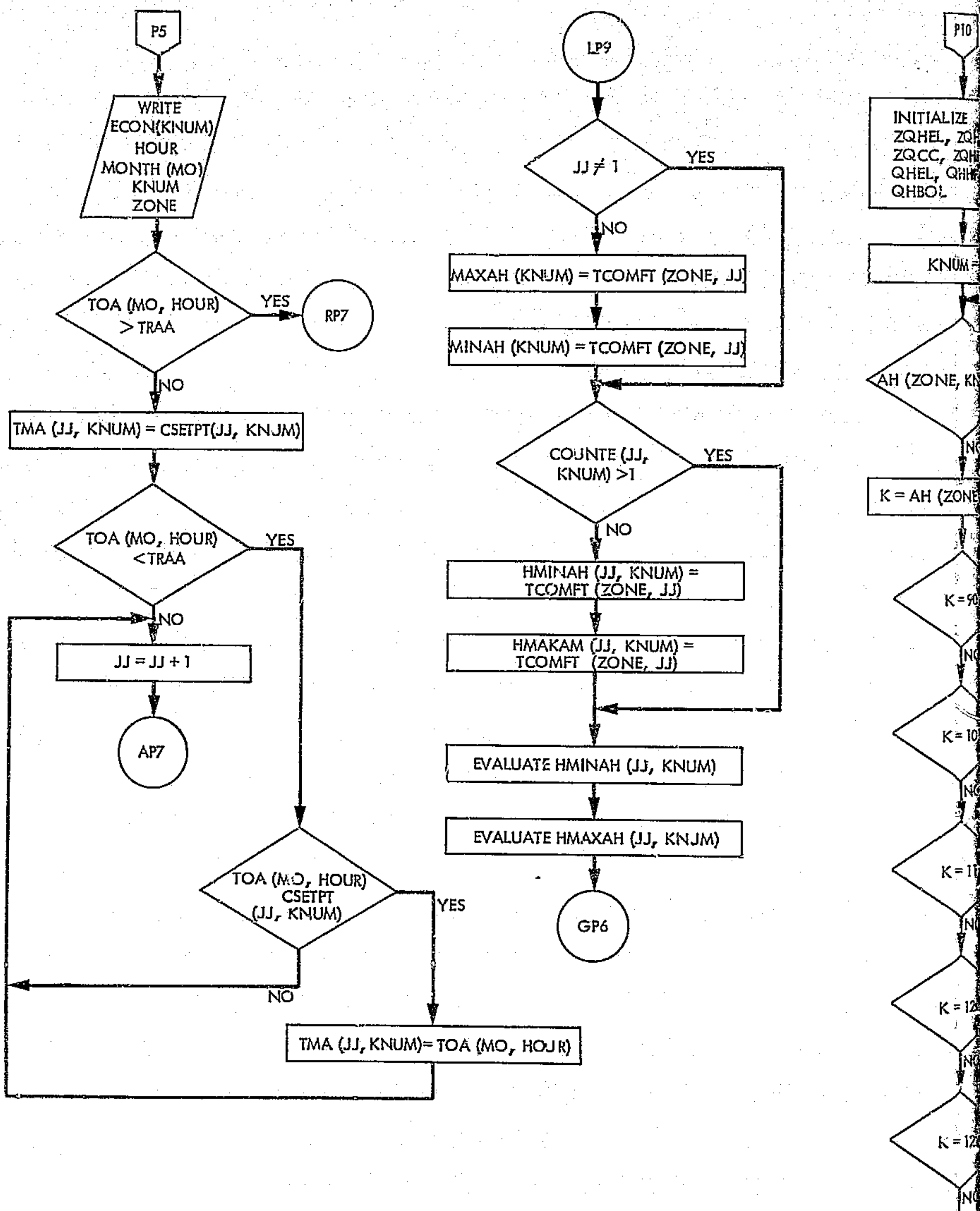

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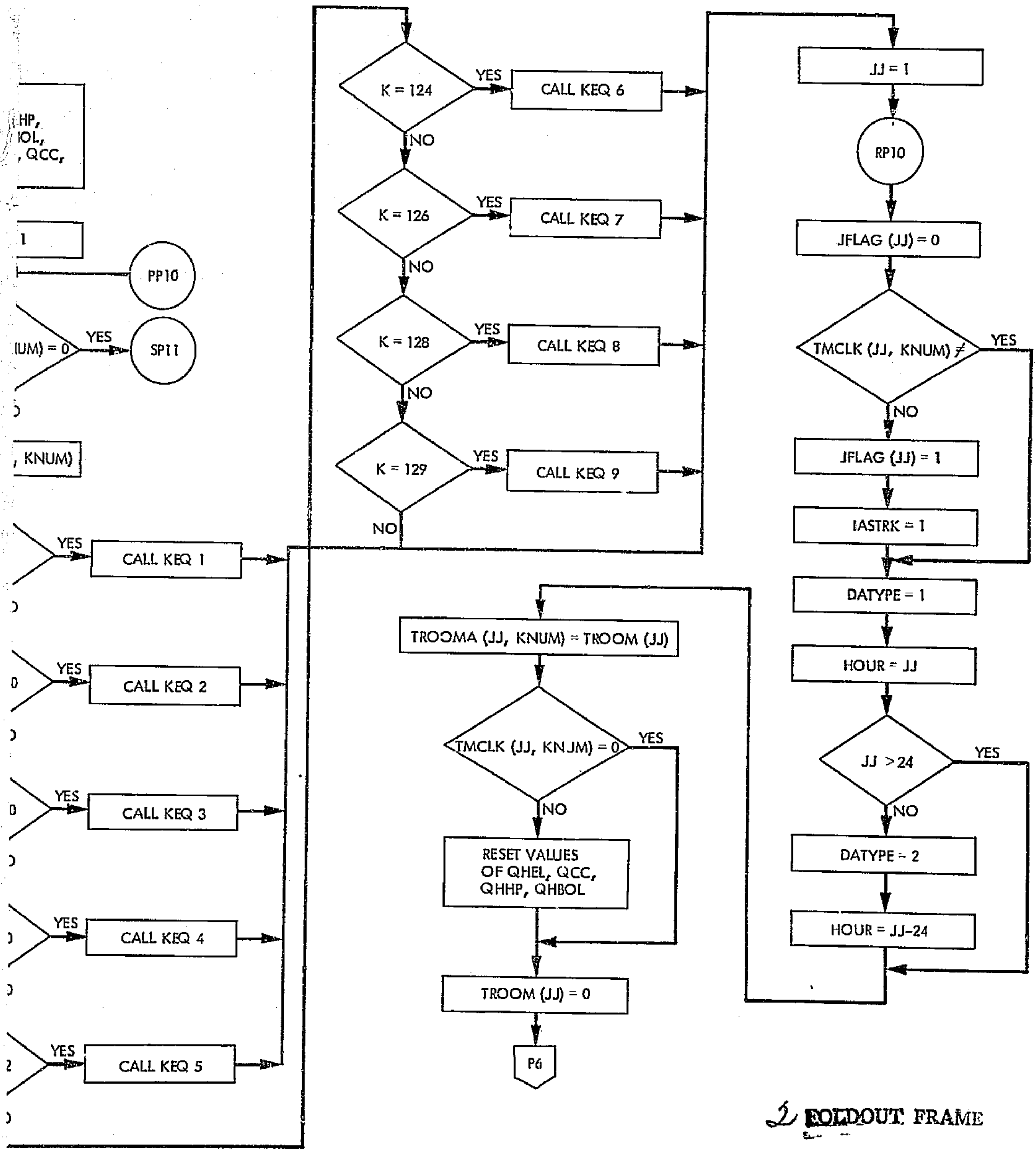

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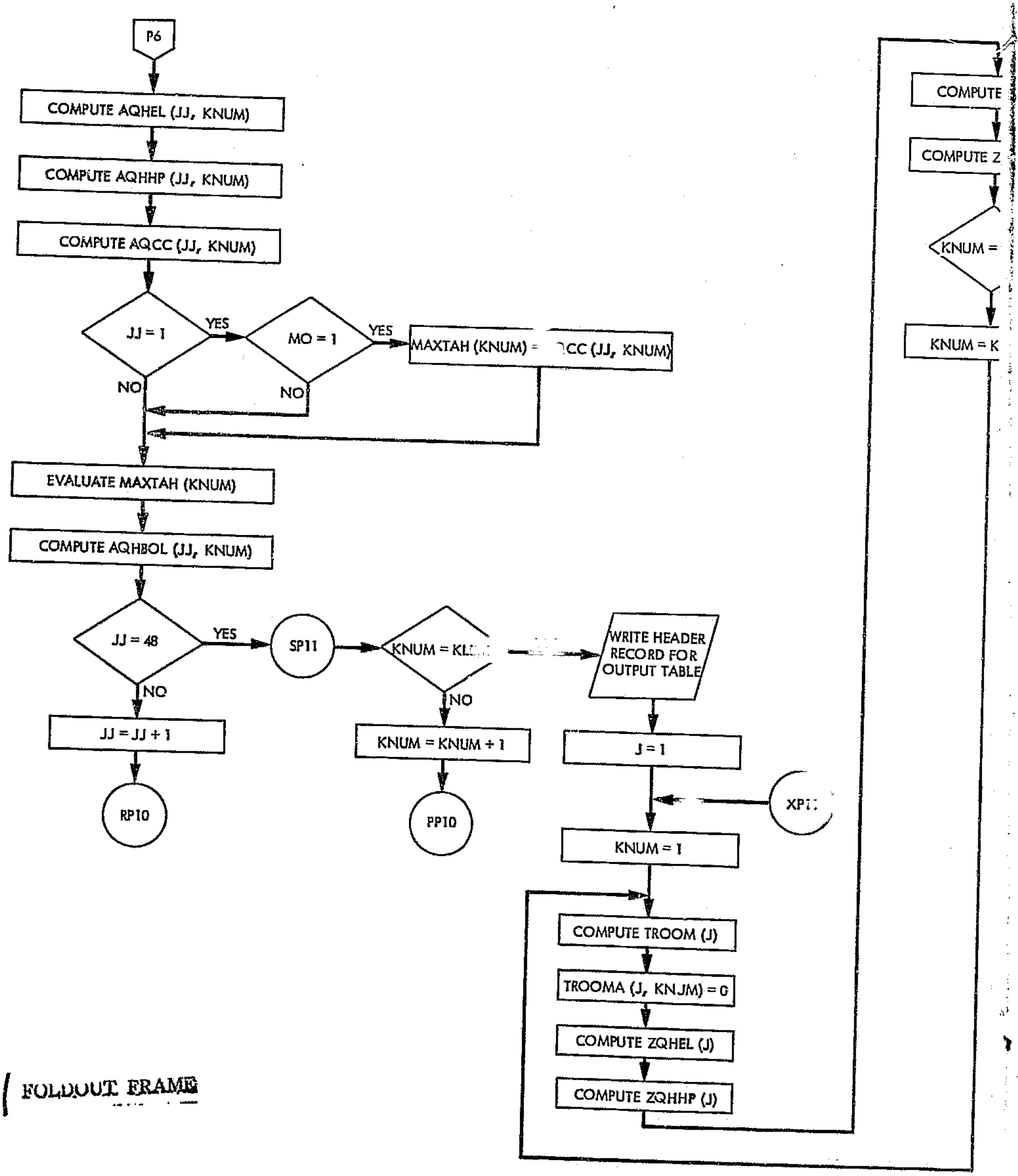

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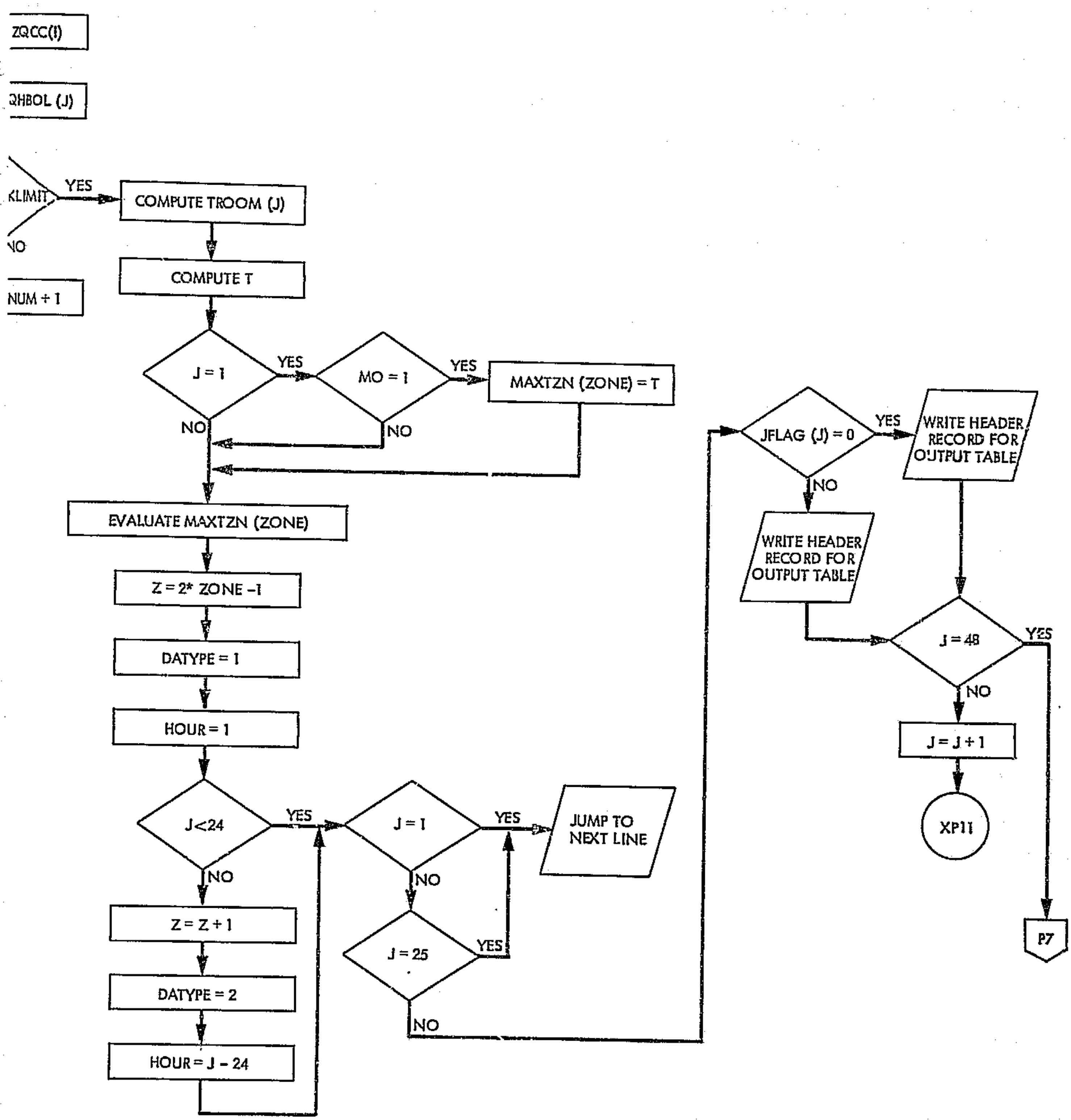

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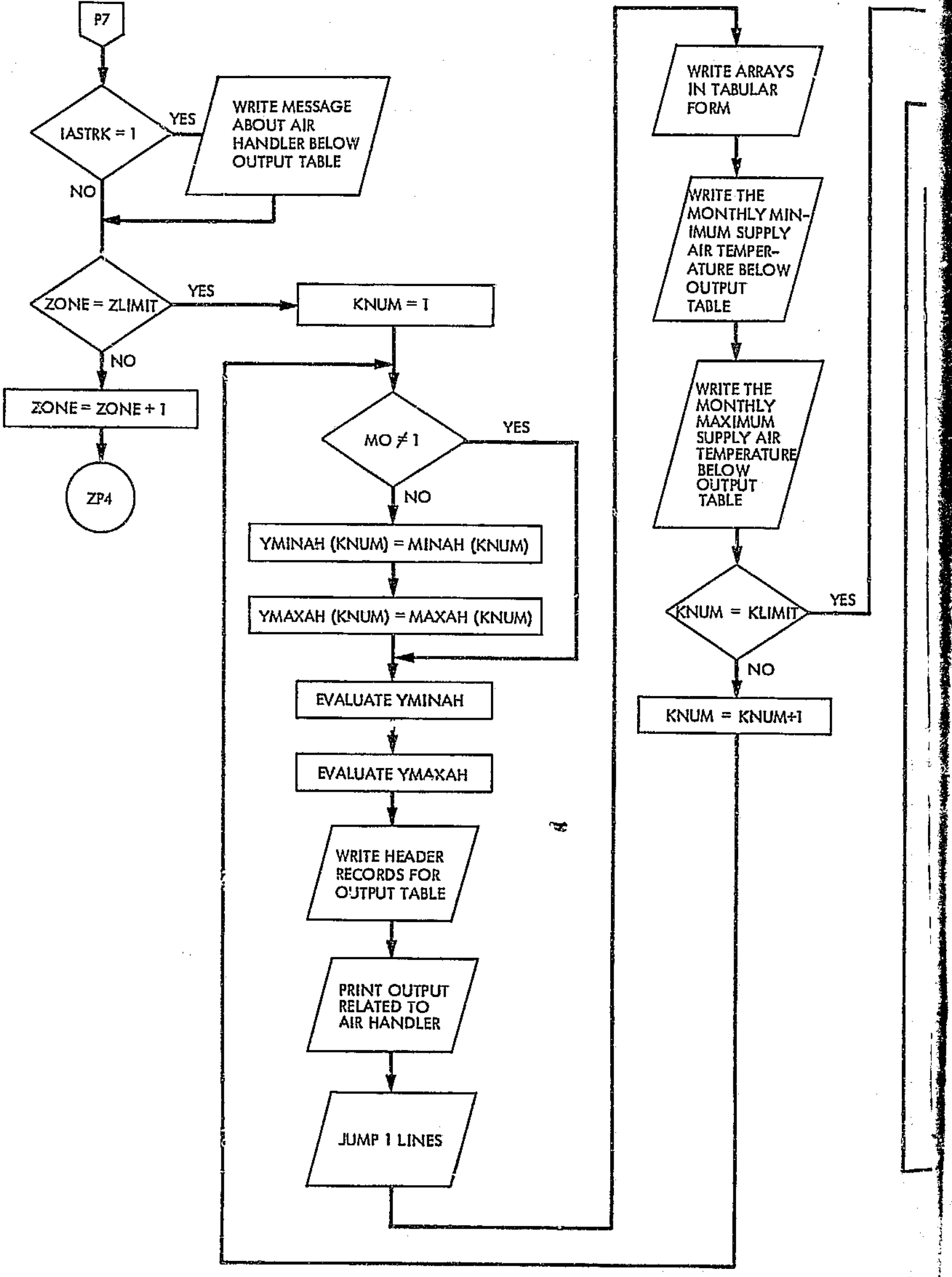

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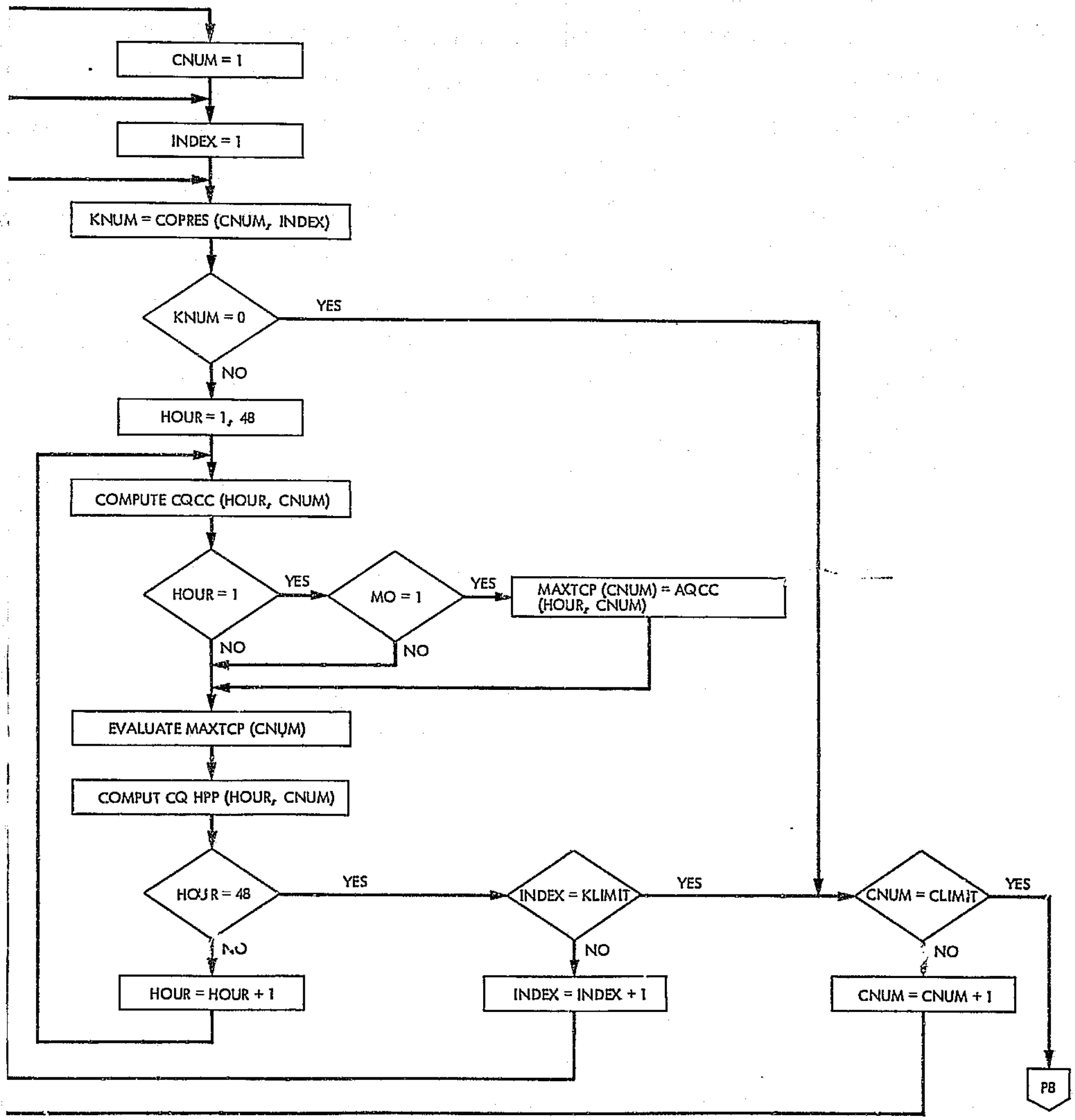

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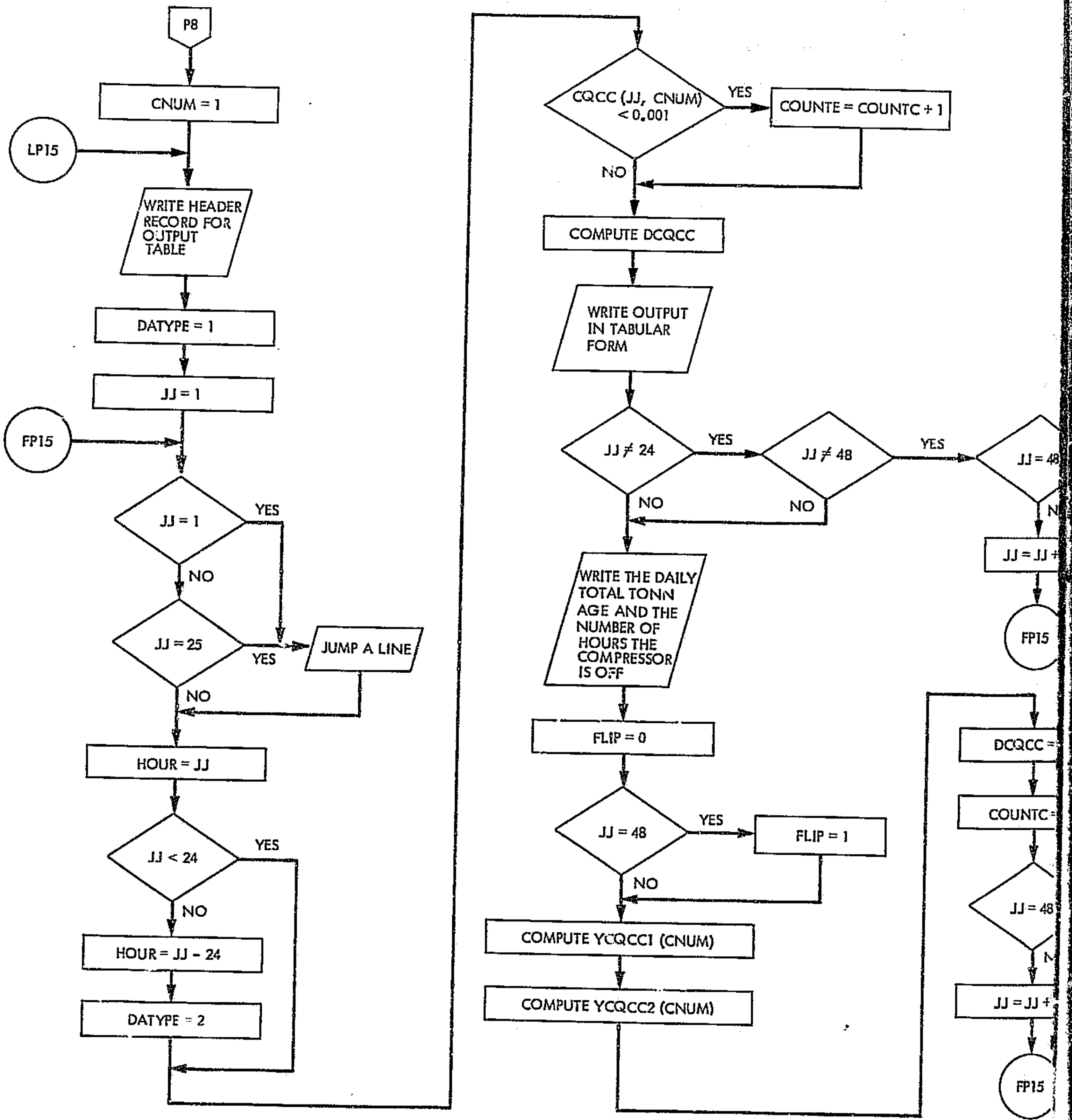

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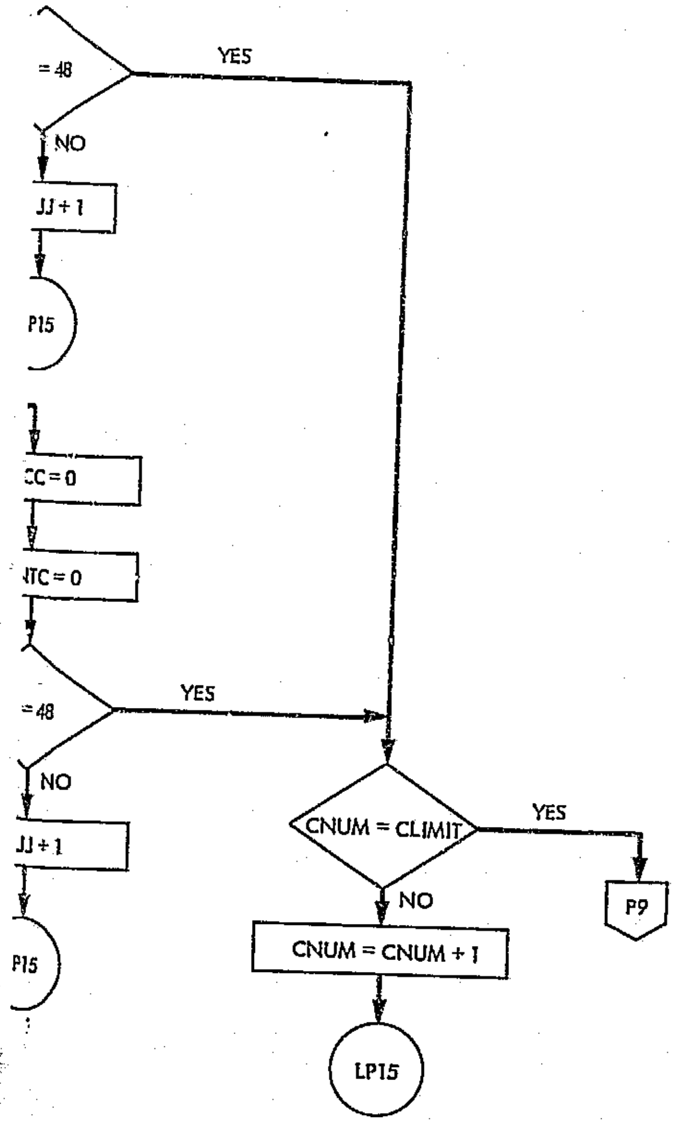

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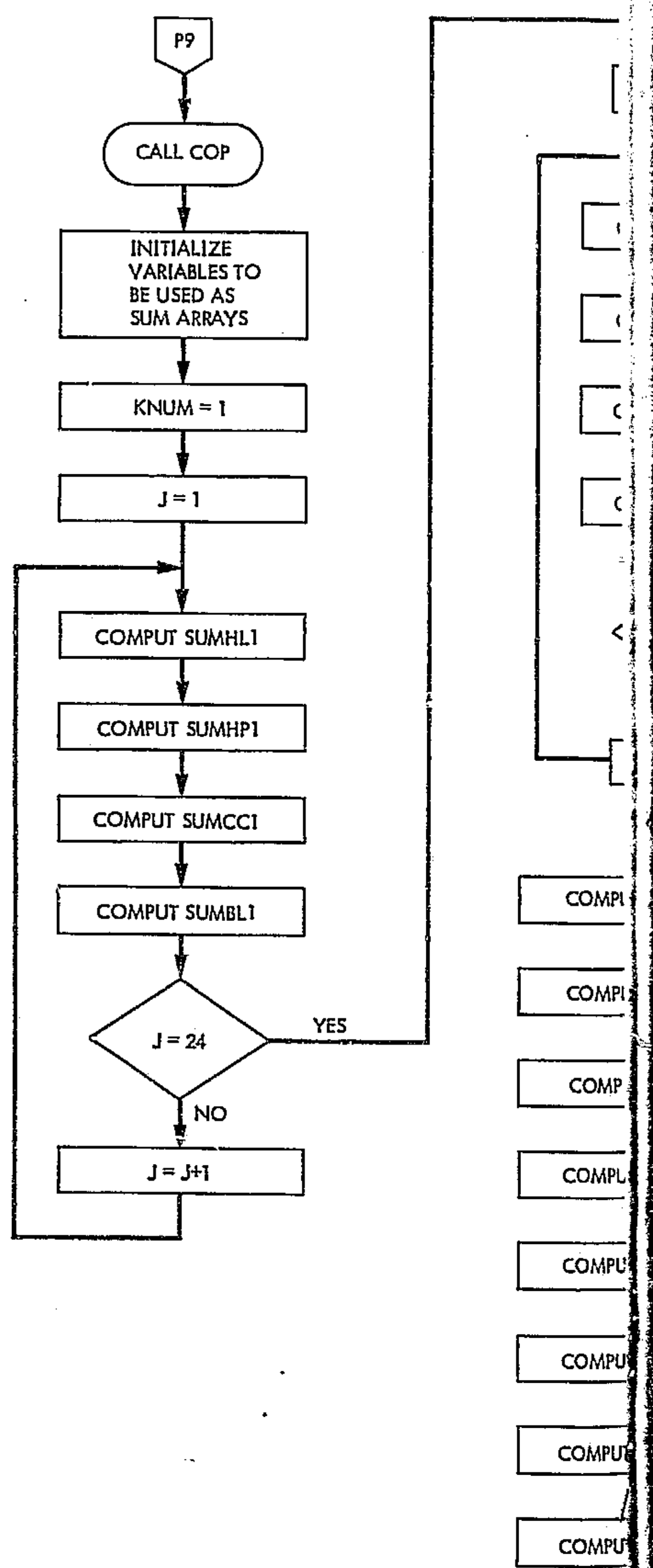

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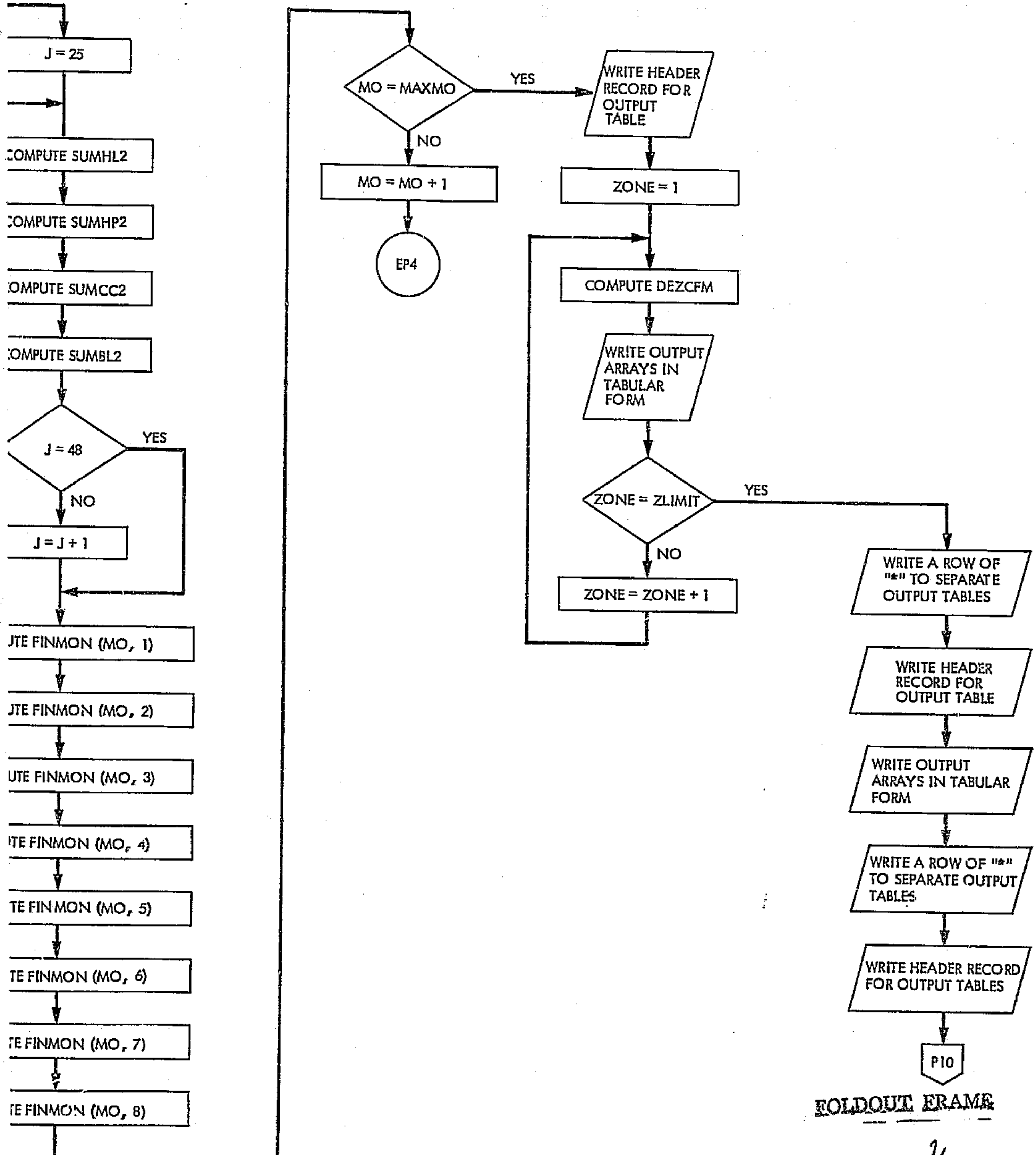

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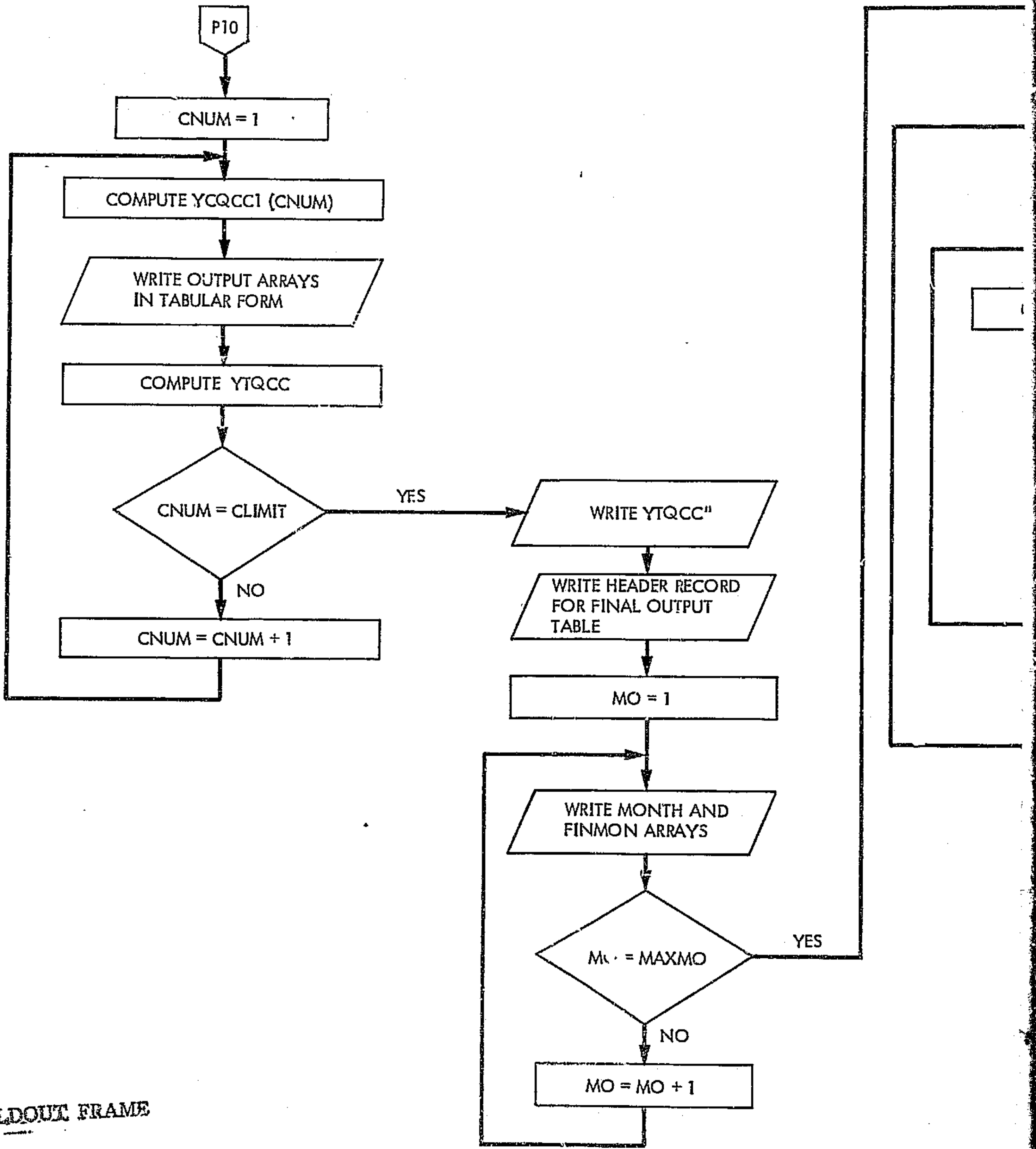

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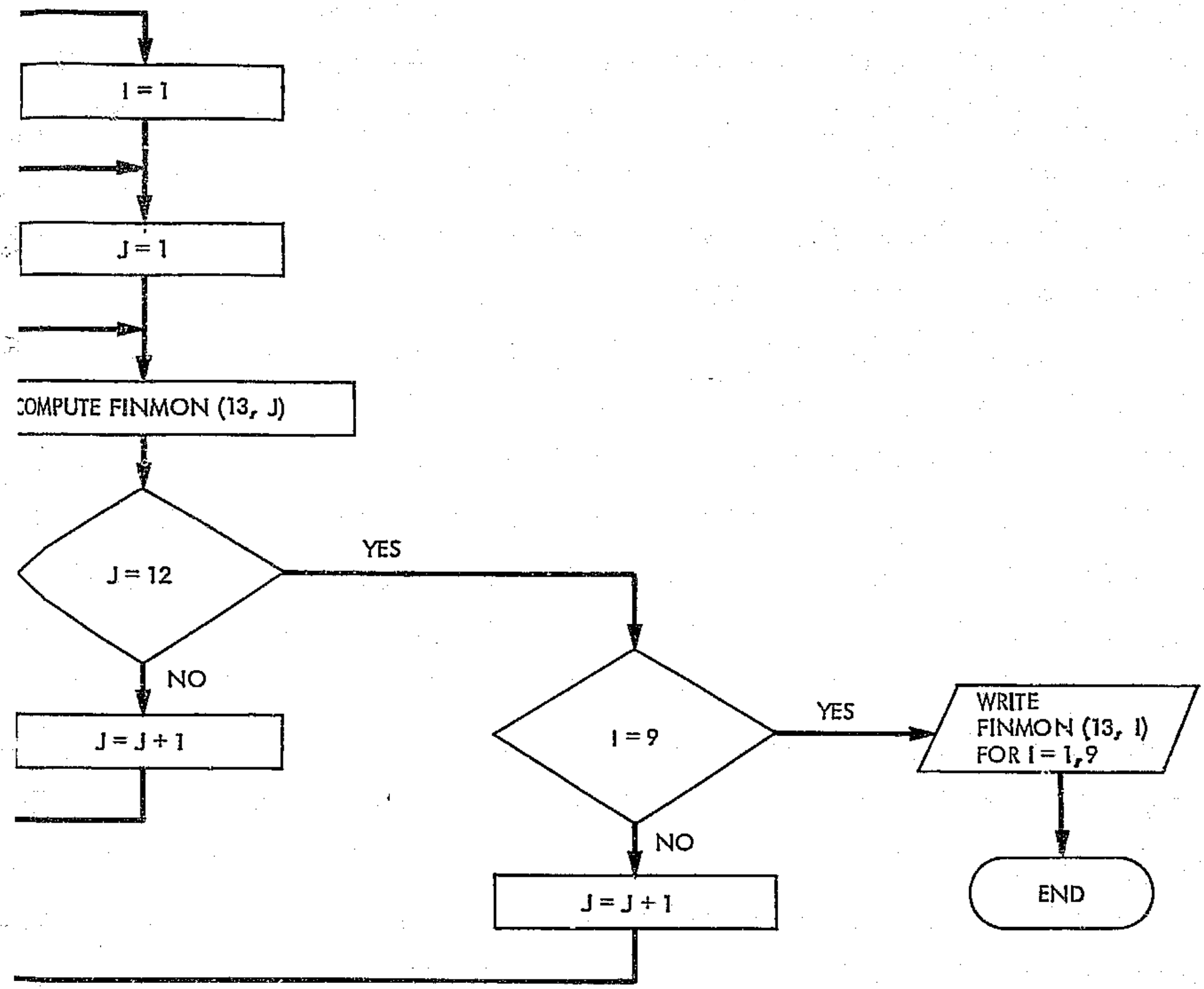

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5.2 Computation Procedure

1. Compute P,DEC, A, B, and C to be used in [solar] subroutine using the algorithm in ASHRAE model.ref(3).

   $$P = \frac{MO*\pi}{6}$$

   DEC = [0.2833 - 23.188*COS(P)-0.15*COS(2.*P)-0.211*SIN(P)+0.1155*SIN(2.*P]* π/180.

   A = [368.5+23.98*COS(P)-1.083*COS(2.*P)+4.893*SIN(P)-.722*SIN(2.*P)]

   B = [171.58-33.08*COS(P)+3.08*COS(2.*P)-10.34*SIN(P)+1.3*SIN (2.*P)] $*10^{-3}$

   C = [90.333-39.63*COS(P)+6.83*COS(2.*P)-10.651*SIN(P)+3.17*SIN(2.*P)]$x10^{-3}$

2. Compute infiltration heat gain/loss (QINF) assuming 1.2 air changes per hour

   QINF = VOL*.02(TOA-TRA)*MLT

3. Call [SOLAR] and [TRANS] subroutines to determine heat gain through walls and roofs and glass areas QWAL and QGLAS

4. Compute LPOWER, EPOWER, QLIGHT, QNOP, QEQUP and QSUM (on an hourly basis) for each zone:

   $$LPOWER = \sum_{i=1}^{24} KILGHT(i) + KFLGHT(i)$$

   $$EPOWER = \sum_{i=1}^{24} KEQUPE(i) + KEQUPM(i)$$

   QLIGHT = KILGHT*3413.+KFLGHT*4266

   (assuming fluorescent bulbs dissipate 25% more energy from ballasts)

   QNOP = NOP*QPP

   QEQUP = KEQUPE*3413.0+KEQUPM*341.3

   (assuming that mechanical equipment are dissipating 10% of its power in the form of heat)

   QSUM = QGLAS + QWAL + QINF + QLIGHT + QNOP + QEQUP

5. Compute total cfm for each zone when fed by more than air handler.

   $$ZCFM(total) = \sum_{i=1}^{10} Zcfm(i)$$

6. Compute temperature of supply air to zone

   TSAZ = TRA - QSUM/ZCFM(TOTAL)*MLT

7. Compute the supply air temperature for two-level rooms with air handlers feeding the comfort air only, plenum air only, or both. Compute the maximum and minimum values of (TSAZ) for each zone.

8. Compute the average temperature of return air (TRAA) associated with a given air handler. Averaging is done over all zones that are fed by the air handler.

$$TRAA = \frac{\sum_{i=1}^{ZLIMIT} TRA(i)ZCFM(i)}{\sum_{i=1}^{ZLIMIT} ZCFM(i)}$$

9. Compute mixed air temperature (TMA) based on the outside air economizer control schemes, and the return air temperature.

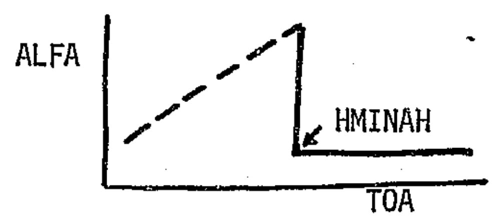
   With no outside air economizer

   TMA = ALFA*TOA+(1-ALFA)*TRAA

10. With Barber Coleman (DIGI-DAP) outside air economizer, the outside air and return air dampers are positioned to vary automatically the cold deck set point temperature according to the zone requiring the most cooling. The hot deck set point is automatically adjusted to match the zone that requires the most heating.

    i) Cooling mode (at least one zone is in cooling mode) when

    $$TRAA \geq HMINAH$$



- IF HMINAH $\leq$ TOA

  Dampers will be set at minimum position. The hot deck set point will be set at the supply air temperature for the zone requiring the most heating

  HSETPT = HMAXAH,
  ALFA = minimum value
  TMA = ALFA*TOA+(1-ALFA)*TRAA

- IF TOA $\leqslant$ HMINAH

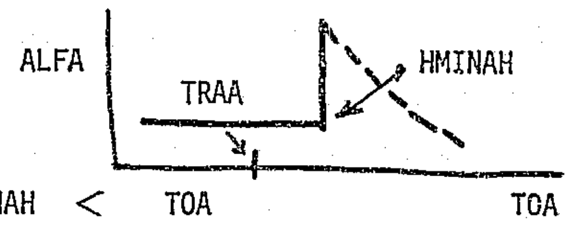
  Dampers will be automatically adjusted to vary the value of ALFA such that

  TMA = HMINAH
  CSETPT = HMINAH (cooling equipment are off)
  HSETPT = HMAXAH (heating will be only off for a single zone)

  and the minimum value allowed for HSETPT is 60^oF.

ii) Heating mode: when all zones in heating mode.

HMINAH > TRAA



- IF HMINAH < TOA

  TMA = HMINAH
  CSETPT = TMA (cooling is off for all zones)
  HSETPT = HMAXAH

- ELSE IF TOA $\leq$ HMINAH

  TMA = ALFA*TOA+(1-ALFA)*TRAA
  ALFA = minimum value
  CSETPT = TMA (cooling is off for all zones)
  HSETPT = HMAXAH

11. With Honeywell Type Outside Air Economizer

a) IF TOA $\geq$ TRAA

TMA = ALFA*TOA+(1-ALFA)*TRAA

b) IF TOA $\leq$ TRAA and TOA $\leq$ CSETPT

cooling is off

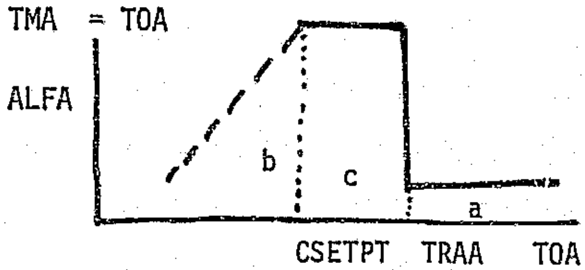
TMA = CSETPT

ALFA = (CSETPT-TRAA)/(TOA-TRAA)

c) IF TOA $\leq$ TRAA and TOA $\geq$ CSETPT

ALFA = 1.0

TMA = TOA



12. Call appropriate air handler subroutine to determine QHEL, QCC, QHBOL, QHHP, TROOM

13. Compute AQCC, AQHEL, AQHHP, AQHBOL sum of loads for 24 hours and all air handlers. Also calculate for each zone ZQCC, ZQHHP, ZQHBOL and ZQHEL.

$$AQCC = \sum_{i=1}^{24} \sum_{j=1}^{10} QCC(i,j) \quad , \quad ZQCC = \sum_{i=1}^{24} QCC(i)$$

$$AQHEL = \sum_{i=1}^{24} \sum_{j=1}^{10} QHEL(i,j) \quad , \quad ZQHEL = \sum_{i=1}^{24} QHEL(i)$$

$$AQHHP = \sum_{i=1}^{24} \sum_{j=1}^{10} QHHP(i,j) \quad , \quad ZQHHP = \sum_{i=1}^{24} QHHP(i)$$

$$AQHBOL = \sum_{i=1}^{24} \sum_{j=1}^{10} QHBOL(i,j) \quad , \quad ZQHBOL = \sum_{i=1}^{24} QHBOL(i)$$

14. Call [COP] subroutine to determine coefficient of performance of air conditioning equipment. Sum loads for Daytype 1 and Daytype 2 in SUMBL1, SUMBL2, SUMCC1, SUMCC2, SUMHL1, SUMHL2, SUMHP1 and SUMHP2.

15. Compute TTLAC1 and TTLAC 2 (sum of accessories for daytype one and daytype two)

$$TTLAC1 = \sum_{i=1}^{5} ACCERY(i) \qquad \text{(daytype 1)}$$

$$TTLAC2 = \sum_{i=1}^{5} ACCERY(i) \qquad \text{(daytype 2)}$$

16. Compute total load (sum over hour and zones) and multiply by daytype factor and determine total monthly energy consumption (FINMON) matrix.

17. Compute design conditions DEZCFM by:

$$DEZCFM = \text{maximum of} \left(\frac{MAXQ}{23*MLT} \right) \text{ and } \frac{|MINQ|}{15*MLT}$$

SECTION VI
SOLAR SUBROUTINE

6.1 Description

The [SOLAR] subroutine determines the position of the sun and calculates the different components (direct, diffuse and ground reflected) of solar radiation intensity incident on the outer surface of a building wall. The subroutine is composed of three parts: the first part depends on the day of the year, the second part depends on the time of day and the third part depends on the surface orientation.

The main assumptions used in the calculations are as follows:

(1) Ground reflectivity [GRREFL] is 0.2.

(2) Clearness number is 1.0. Clearness number is a multiplier of the direct normal intensity (IDN) which accounts for the effect of dry sky, high elevation, season and type of industry in the neighbourhood of the locality.

(3) The local solar time is assumed equal to the local civil time. The longitude correction (4 min/degree difference between local longitude and the longitude of the standard time meridian for that locality) and the equation of time (which is in the range of ± 14 minutes) are neglected.

Fig. 6.1 illustrates the solar and wall angles used in this subroutine. The flow chart is sketched in Fig. 6.2.

6.2 List of Variable Names

The following is an alphabetical list of variables used in the [SOLAR] subroutine.

All angles are measured in radians.

CCF	Cloud cover factor. CCF is the ratio of real solar irradiation to the clear day formula given by ASHRAE.
COSTH	Cosine of the angle (THETA) measured between the normal to the wall and the sun's ray.
HA	Hour angle measured from solar noon.
HALMT	Hour Angle Limit. The angle at which the sun rises or sets.
IDN	Direct Normal Intensity of the sun's energy received on a surface perpendicular to the sun's rays.
LAT	Latitude of the site (positive for a location north of the equator; negative for a location south of the equator).

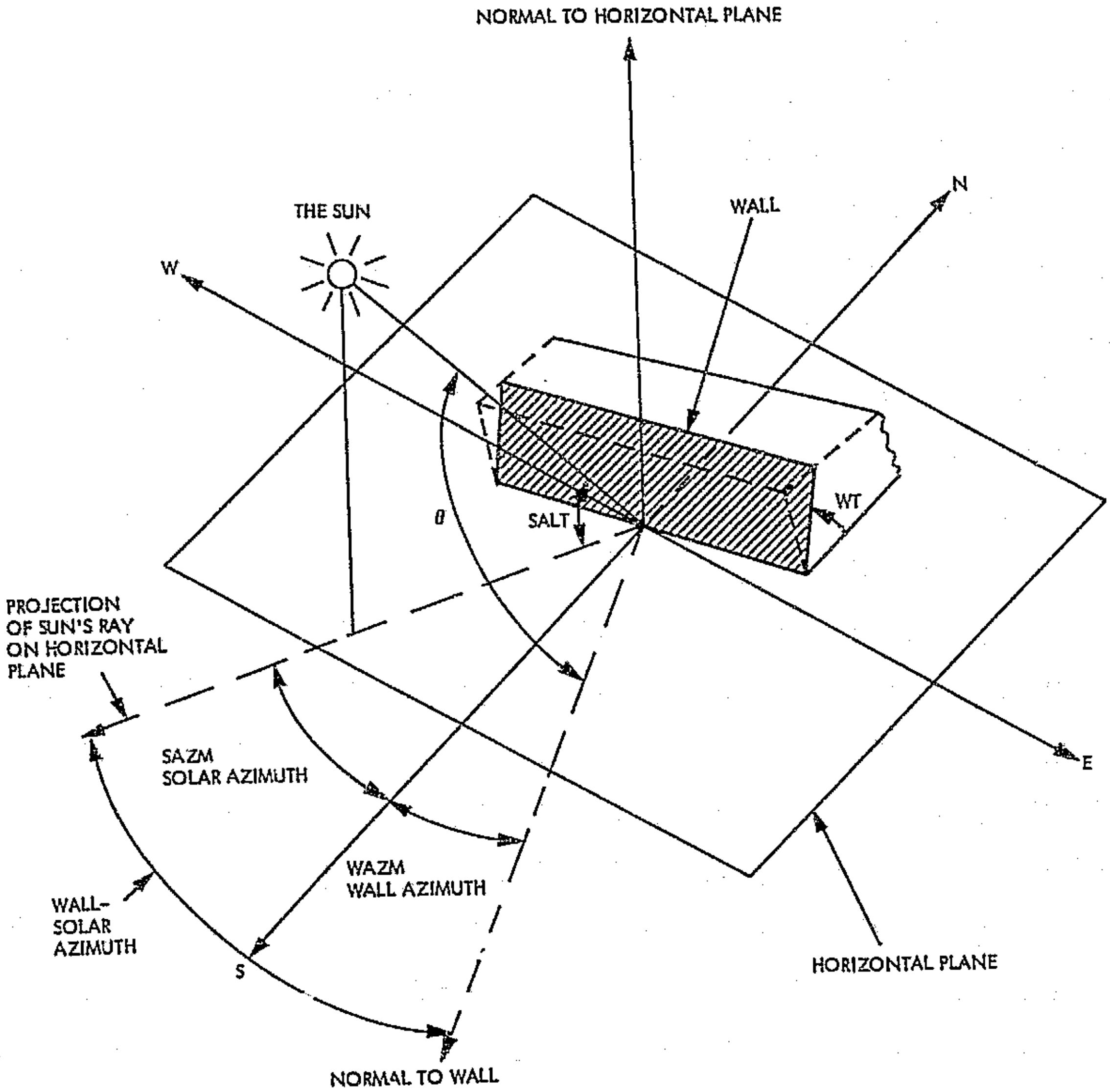


Figure 6-1. Solar and wall angles for [SOLAR] subroutine

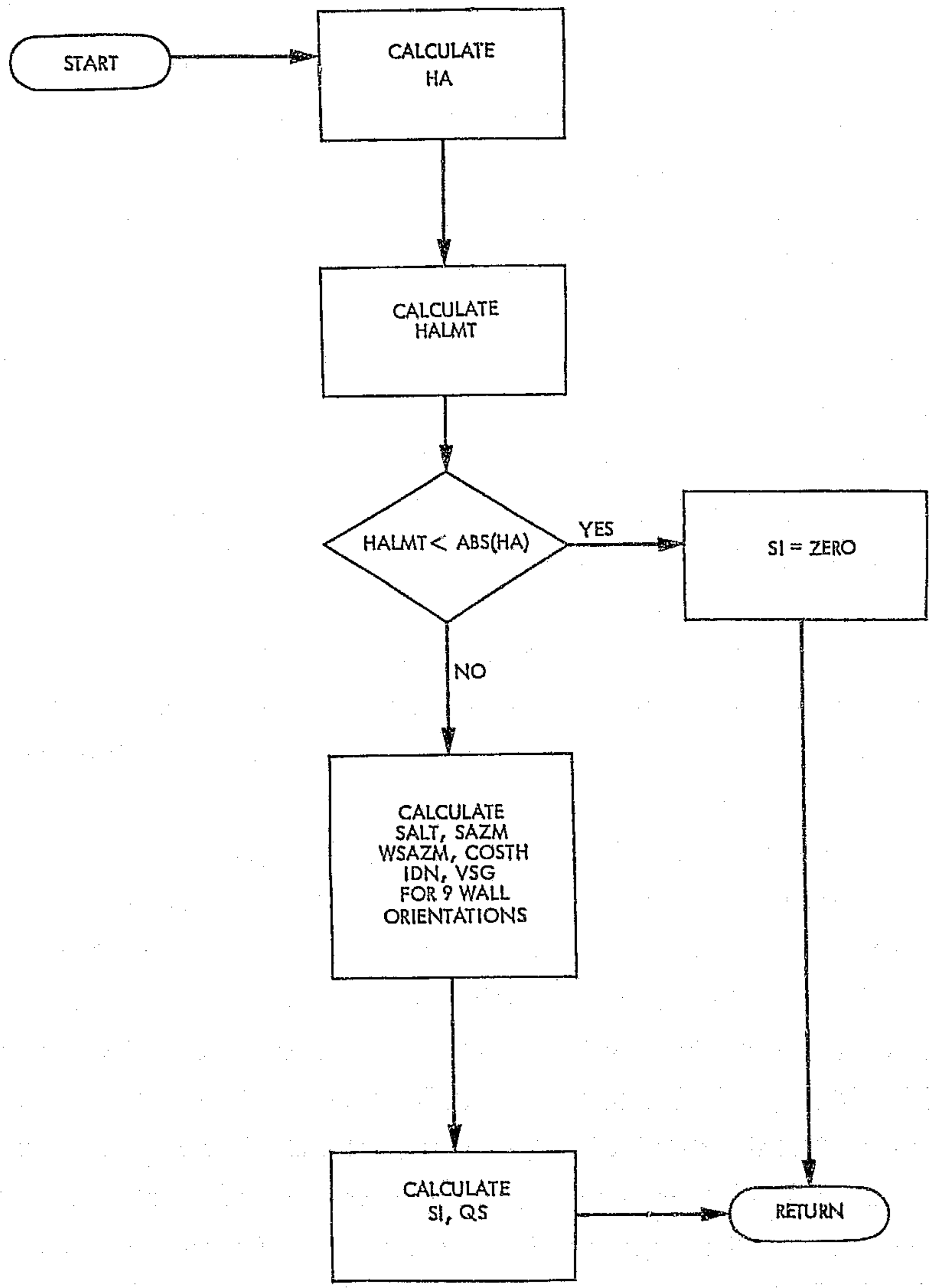


Figure 6-2. Flow chart for solar subroutine

MO Month

SALT Solar altitude angle. The angle between the sun's ray and the projection of the sun's ray on a horizontal surface.

SAZM Solar azimuth angle. The angle between the south direction and the projection of the sun's ray on the horizontal surface.

SI Total Solar Irradiation (direct, diffuse and ground reflected) on a wall for the given day of the month, hour of the day and surface orientation.

VSG View (geometric) factor. The fraction of the energy reflected from the ground which reaches the wall.

WAZM Wall azimuth angle. The angle between the projection of the normal to the wall on the horizontal plane and the direction south (positive for an angle west of south) according to the following table:

WAZM	±180	-135	-90	-45	0	45	90	135
ORIENTATION	N	NE	E	SE	S	SW	W	NW

WSAZM Wall-Solar Azimuth Angle. The angle between the projection of the normal to the wall on the horizontal plane and the projection of the sun's ray on the horizontal plane.

WT Wall tilt is the angle between the wall and the horizontal surface.

6.3 Calculation Procedure

(1) Calculate the hour angle (HA). It is positive in the morning and negative in the afternoon.

$$HA = (12 - HOUR)\,\frac{15\,\pi}{180} \qquad \text{radians}$$

(2) If the hour angle is smaller than the hour angle limit of sunrise or greater than the hour angle limit of sunset, the solar intensity is zero.

$$HALMT = \text{Cos}^{-1}(-0.7 \tan(DEC)) \qquad \text{radians}$$

$$\text{IF} |HA| > HALMT \text{ Than } SI = \text{Zero}$$

(3) Calculate solar altitude, solar azimuth and wall-solar azimuth angles and cosine the angle of incidence. The declination angle (DEC) is previously determined in the main program, Section 5.2.

SALT = SIN^{-1}[COS(LAT)COS(DEC)COS(HA)+SIN(LAT)SIN(DEC)] radian

SAZM = SIN^{-1}[COS(DEC)SIN(HA)/COS(SALT)] radian

WSAZM = SAZM+[WAZM(HA/|HA|)] radian

COSTH = [COS(SALT)COS(WSAZM)SIN(WT)]+[SIN(SALT)COS(WT)]

(4) Calculate direct normal solar radiation using the values of the constants A, B, and C previously calculated in the main program, Section 5.2.

IDN = A/exp(B/Sin(SALT)) Btu/hr.ft^2

(5) Calculate the view factor from wall surface to ground

VSG = (1 - Cos (WT))/2

(6) Calculate total solar irradiation (SI)

SI = IDN[COSTH +[C*(1-VSG)]+GRREFL*VSG[C + Sin (SALT)]] Btu/hr.ft^2

(7) For different wall orientations, the index (J) is given such that

Index J	8	7	6	5	1	2	3	4
Orientation	N	NE	E	SE	S	SW	W	NW
WAZM angle	±180	-135	-90	-45	0	45	90	135

or analytically

for J > 4 WAZM = $-\frac{PI}{4}$ (J-4)

J ≤ 4 WAZM = $\frac{PI}{4}$ (J-1)

(8) Calculate the heat transmitted (QS) through glass both directly by solar gain and indirectly by warm outside air:

QS = (SI*TAU*AGLAS*CCF)+[UGLASS*AGLAS(TOA-TRA)]

where

TAU: glass transmissivity

UGLASS: glass heat transfer coefficient, Btu/hr.ft^2°F

AGLAS: surface area of glass, ft^2

SECTION VII
TRANS SUBROUTINE

7.1 Description

The (TRANS) subroutine calculates the rate of heat transfer from the external environment through each exterior or interior wall and roof of a zone. Input Data include the construction details, (UNPHI) sub-program output, solar irradiation, outside air temperature, and the temperature of adjacent zones.

For exterior walls, the sol-air temperature method or Total Equivalent Temperature Difference method (TETD) with periodic (transient) heat flow through homogeneous walls is used. The sol-air temperature combines the effects of direct solar incidence and variable outside air temperature as shown in Fig. 7.1. It uses Fourier series expansion (harmonic analysis) where harmonics higher than first order are neglected. The analysis considers the time-wise change of thermal environment and the thermal storage in wall material. See Reference (4) for more details. A flow chart is provided in Fig. 7.2.

For interior walls, quasi-steady state heat transmission calculations are used. The U-Factors calculated in (UVPHI) subprogram are entered to (TRANS) subroutine as input data.

The main assumptions used in the sol-air temperature method and (TRANS) subroutine are:

(1) Walls or roofs have an infinite height, length (compared to the thickness) and the heat transfer is one dimensional.

(2) Walls or roofs are homogeneous with material properties (conductivity, specific heat, density and thermal diffusivity) that are constant with temperature. For walls or roofs of multilayer construction, average properties were calculated.

(3) Convective heat transfer coefficients on the inside and outside boundary layers of the wall surface are uniform and constant with temperature.

(4) The solar absorptivity of the outside wall surface is independent of the ray's angle of incidence and is constant with temperature.

(5) The variation of the outdoor air temperature and the total solar irradiation is periodic and identical with time on consecutive days.

(6) The internal zone thermal environment is unchanged from day to day.

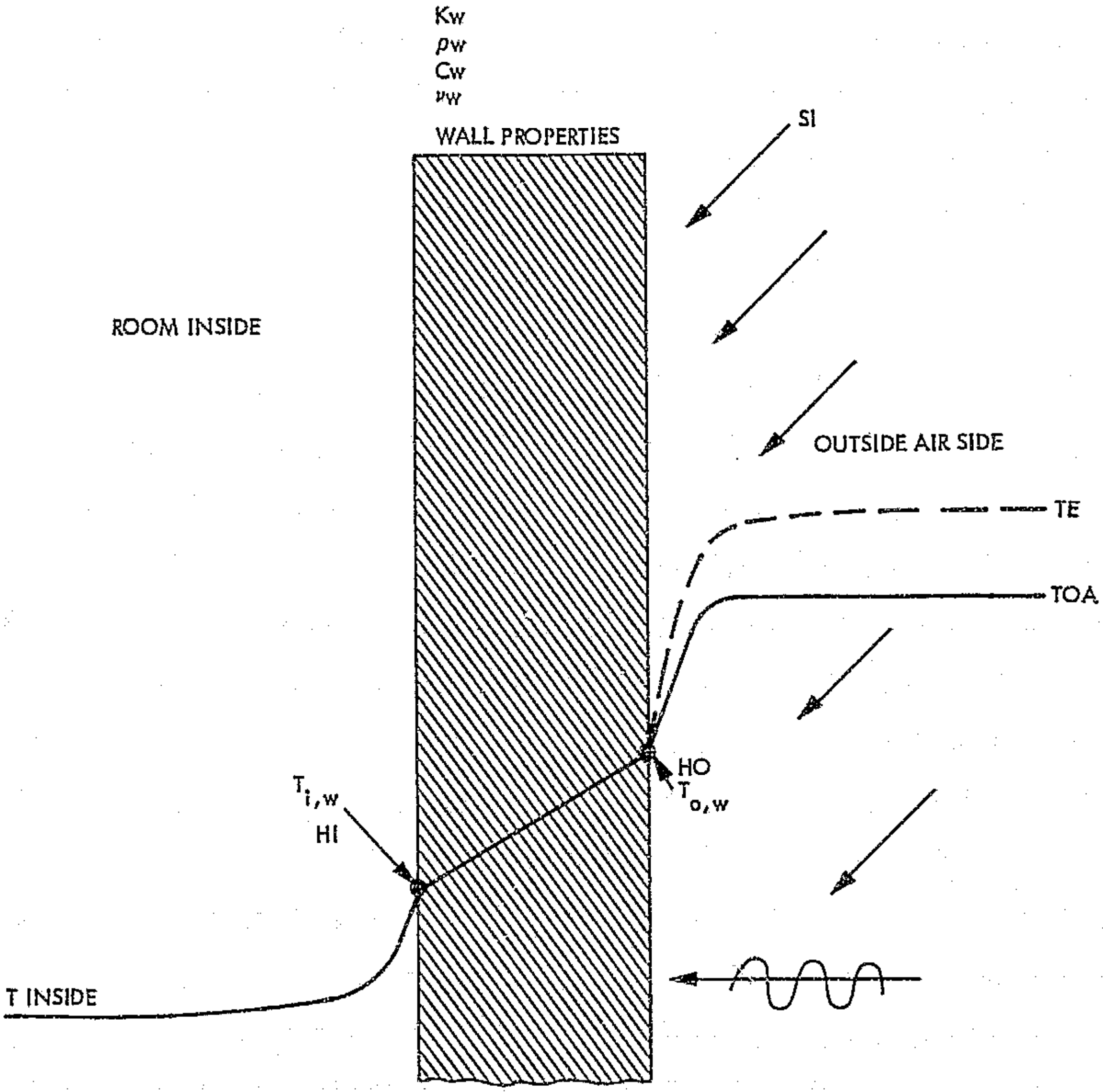


Figure 7-1. Wall temperatures in a one dimensional unsteady (periodic) heat transfer

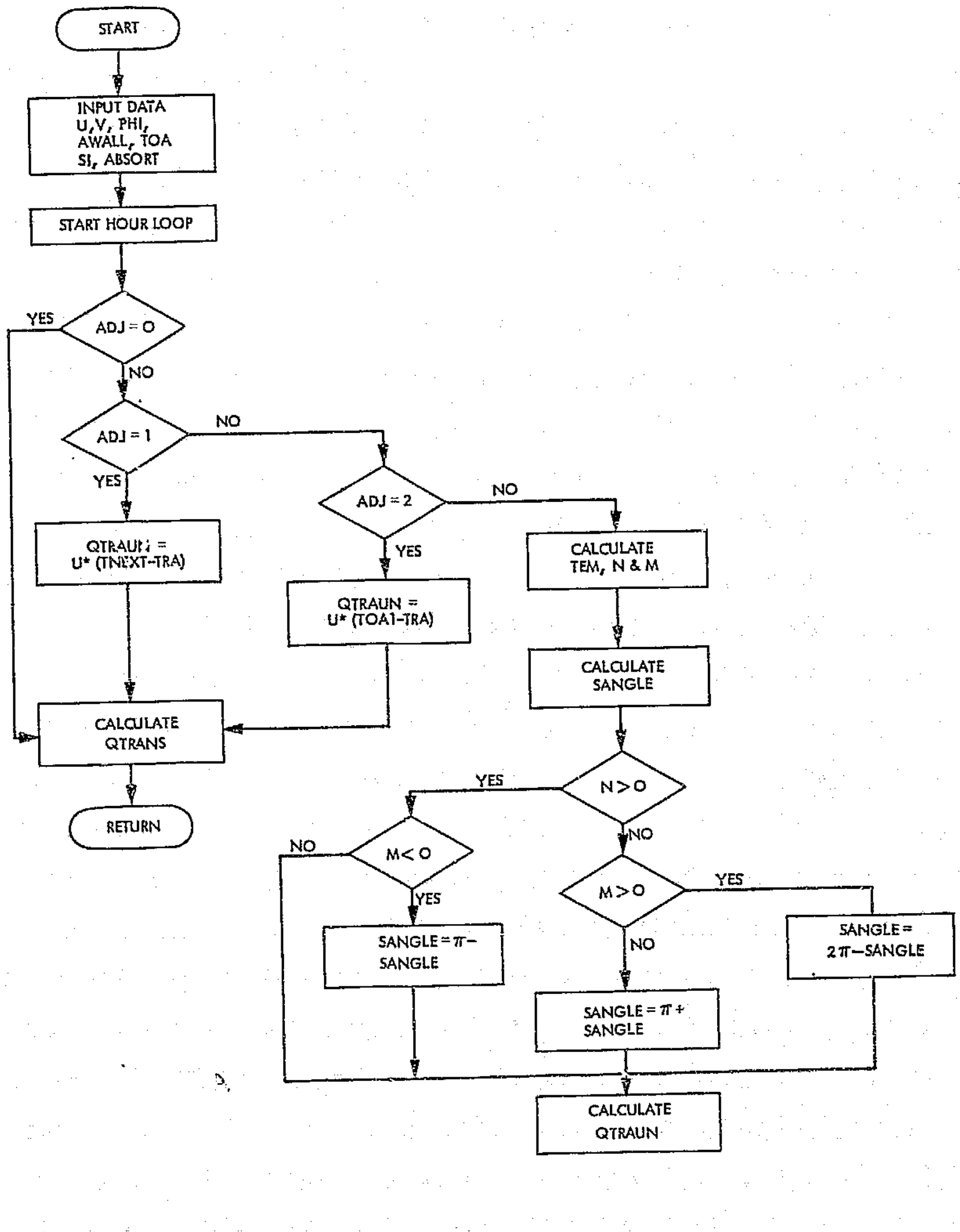


Figure 7-2. Flow chart of trans subroutine

7.2 List of Variables

ABSORT (or ALPHA)	Solar absorptivity, for exterior walls and roofs.
ADJ	Flag for adjacent zone condition. (ADJ can be 0, 1, 2, or 3)
H	Hour
HO	Heat transfer coefficient for outside wall surface, Btu/hr. ft^2 °F.
M	Fourier coefficient for (TE) expansion.
N	Fourier coefficient for (TE) expansion
PHI	Phase angle (or hour) for the heat transfer QTRAUN
QTRAUN	Heat transmission rate per unit-area, Btu/hr. ft^2
QTRANS	Total heat transmission through a zone boundary, Btu/hr
SANGLE	Phase angle for (TE) expression.
SHADE	Wall shade factor = unshaded area/total wall area
SI	Total solar radiation, Btu/hr. ft^2
TE	Sol-air temperature, °F.
TEM	Mean sol-air temperature, °F.
TNEXT	Next neighbour temperature for ADJ = 1, °F.
TOA1	Neighbour zone temperature for ADJ = 2, °F.
TOA	Outside air temperature, °F.
U	Overall heat transfer coefficient (mean), Btu/hr.ft^2°F.
V	Overall heat transfer coefficient (amplitude), Btu/hr.ft^2°F.

7.3 Computation Procedure

(TRANS) calculates the heat transmission per unit area (QTRAUN) through a wall depending on the conditions of adjacent zones:

(1) If ADJ=0, i.e., no wall or only a partition separating two air conditioned zones of the same temperature, then:

QTRAUN=0 Btu/hr.ft^2

(2) If ADJ=1, i.e., an interior wall separating the zone from an adjacent conditioned zone at constant and different air temperature (TNEXT):

QTRAUN = (TNEXT-TRA)*UWALL Btu/hr.ft^2

(3) If ADJ=2, i.e., an interior wall separating the zone from an adjacent unconditioned zone, typical of mechanical rooms

QTRAUN = (TOA1-TRA)*UWALL Btu/hr.ft^2
TOA1 = TOA IF TOA $\geq$ 70
= 70 IF TOA $<$ 70

(4) If ADJ=3, i.e., an exterior wall,

a) Calculate sol-air temperature

TE=TOA+(ABSORT*SI*SHADE)/HO $^\circ$F

b) Expand the temperature (TE) by Fourier Series with 24-hours period, in the form

$$TE(H)=TEM+M*COS\left(\frac{\pi}{12}H\right)+N*Sin\left(\frac{\pi}{12}H\right)+\ldots$$

at any hour (H)

The fourier expansion coefficients are as follows:

$$M = \sum_{i=1}^{24} TE(i)*COS(\pi i/12)/12$$

$$N = \sum_{i=1}^{24} TE(i)*SIN(\pi i/12)/12$$

$$TEM = \sum_{i=1}^{24} TE(i)/24$$

(c) Rewrite the above TE expression in the compact form

$$TE(H) = TEM + \left[\sqrt{M^2+N^2} * COS\left(\frac{\pi H}{12} - SANGLE\right) \right]$$

where

$$SANGLE = ARCTAN \left| N/M \right|$$

If $N<0$ and $M>0$ then $SANGLE = 2\pi - SANGLE$

If $N<0$ and $M<0$ then $SANGLE = \pi + SANGLE$

If $N>0$ and $M<0$ then $SANGLE = \pi - SANGLE$

(d) Calculate the transient heat flow per unit area

$$QTRAUN(H) = \left[U*(TEM - TRA) \right] + \left[V*\sqrt{(M^2 + N^2)}*COS(\pi H/12 - SANGLE - PHI) \right] \text{ Btu/hr ft}^2$$

The values of U, V, and PHI are given by (UVPHI) subprogram.

5. Calculate the total heat transmission through the walls and roof of a zone boundary

$$QTRANS = \sum_{i=1}^{9} QTRAUN(i)*AWALL(i)$$

The zone boundary is made up of 9 possible orientations.

SECTION VIII
AIR HANDLER - TYPE SUBROUTINES

8.1 General Assumptions

There are 9 subroutines available in ECP which characterize the different types of air-handler units (fan-coil units). The subroutines are as follows:

KEQ1 Single cold duct with terminal reheat.

KEQ2 Dual duct, multizone with mixing boxes, or single duct, multizone with mixing at the air handler.

KEQ3 Single cold duct with bypass and terminal reheat.

KEQ4 Heat pump with bypass control or single duct with alternately operating cooling and heating coils and bypass control.

KEQ5 Two-level room with cold plenum air and comfort air modulated by terminal reheat.

KEQ6 Two-level room with cold plenum air and comfort air modulated by mixing cold air and bypassed mixed air and terminal reheat.

KEQ7 Two-level room with cold plenum air and comfort air modulated by mixing cold and hot decks.

KEQ8 Single cold duct with fixed, bypassed return air and terminal reheat.

KEQ9 Two-level room with constant volume cold plenum air and variable volume comfort air at fixed hot deck temperature.

The main assumptions of the air handler subroutines are as follows:

1. The heating/cooling loads are assumed predominately sensible with negligible latent loads; the effects of outside air humidity changes are neglected.

2. Quasi-steady state conditions prevail for all heat transfer calculations.

3. The air-handler coils are ideal, i.e., they provide the zone heating/cooling as needed without heat losses.

4. The ducts are adiabatic, i.e., no heat exchange occurs between the ducts and their surroundings.

5. All air dampers are functioning according to their specifications with no leakage or malfunctions.

6. Air temperature rise due to energy dissipated by the air-handler fans is negligible.

7. Mixing of plenum air and comfort air in the main room is homogeneous.

For each subroutine an analytical description, a flow chart and a schematic of the heating/cooling mechanism are presented. Each calculation included in the analytical description is performed on an hourly basis.

8.2 KEQ1 Subroutine

This subroutine simulates the performance of type "one" air handler, a single cold duct with terminal reheat as shown in Fig. 8-1. Mixed air is cooled to a fixed set point at all times for all zones. The supply air temperature to a particular zone is modulated according to its load profile by a reheat coil located near the zone. A flow chart for the subroutine algorithm is shown in Fig. 8.2 and a sketch of the air temperature control mechanism is given in Fig. 8.3 on the psychrometric chart.

8.2.1 Calculation Procedure

1. Determine the temperature of the air leaving the cooling coil.

   If TMA < CSETPT
   Then SETLO = TMA
   Else SETLO = CSETPT

2. Determine the actual temperature of the supply air to the zone (TSAZN):

   If TSAZ < SETLO
   Then TSAZN = SETLO
   Else TSAZN = TSAZ

3. Compute the reheat coil heating load. With electric-type boilers

   QHEL = MLT* ZCFM (TSAZN-SETLO) Btu/hr

   QHBOL= 0.0

   With gas-fired boilers

   QHEL = 0.0
   QHBOL= MLT* ZCFM *(TSAZN-SETLO) Btu/hr

4. Calculate actual zone temperature. If the actual supply air to the zone does not equal the required supply air to the zone then the temperature of the room will differ from the design temperature

   If TSAZN ≠ TSAZ
   Then TROOM = TSAZN + QSUM/(MLT*ZCFM)
   Else TROOM = TRA

5. Determine the cooling load on the cooling coil

   QCC = MLT* ZCFM *(TMA-SETLO) Btu/hr

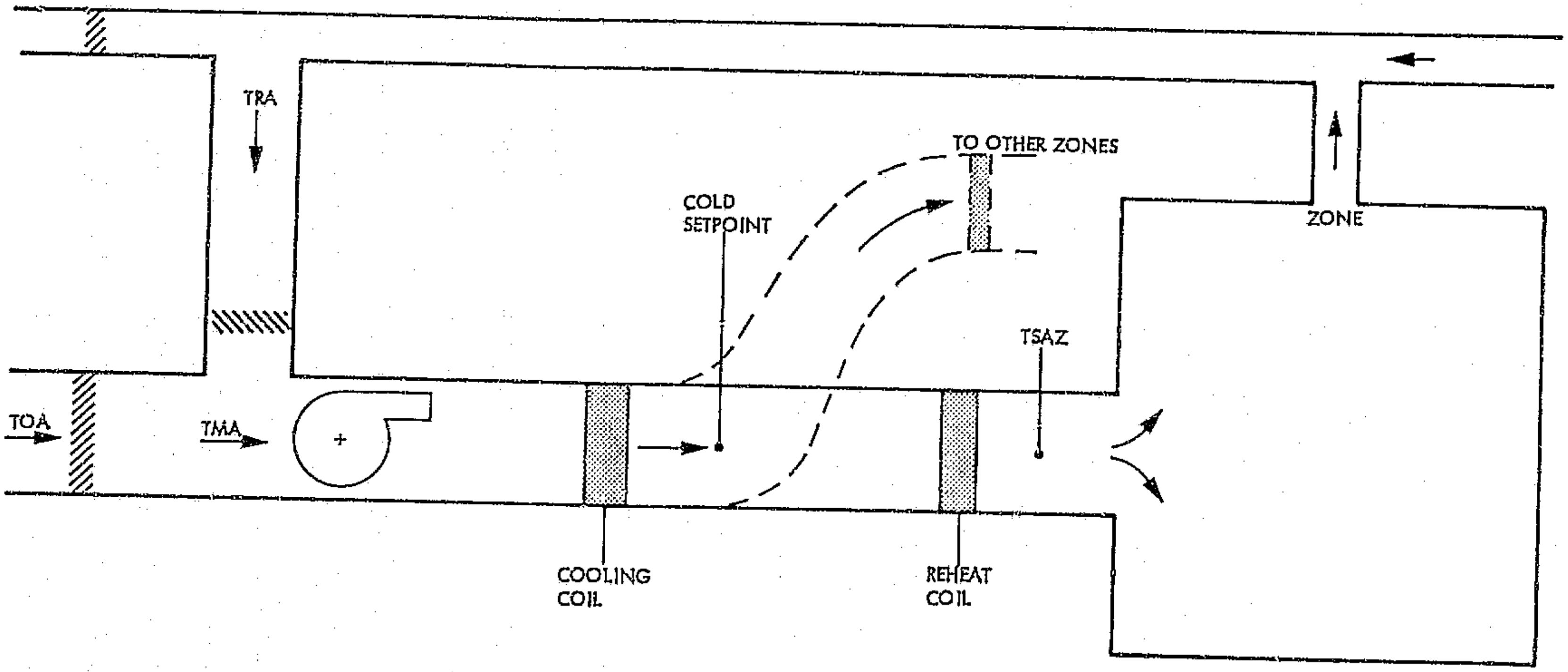


Figure 8-1. Type "1" air handler: single cold duct with terminal reheat

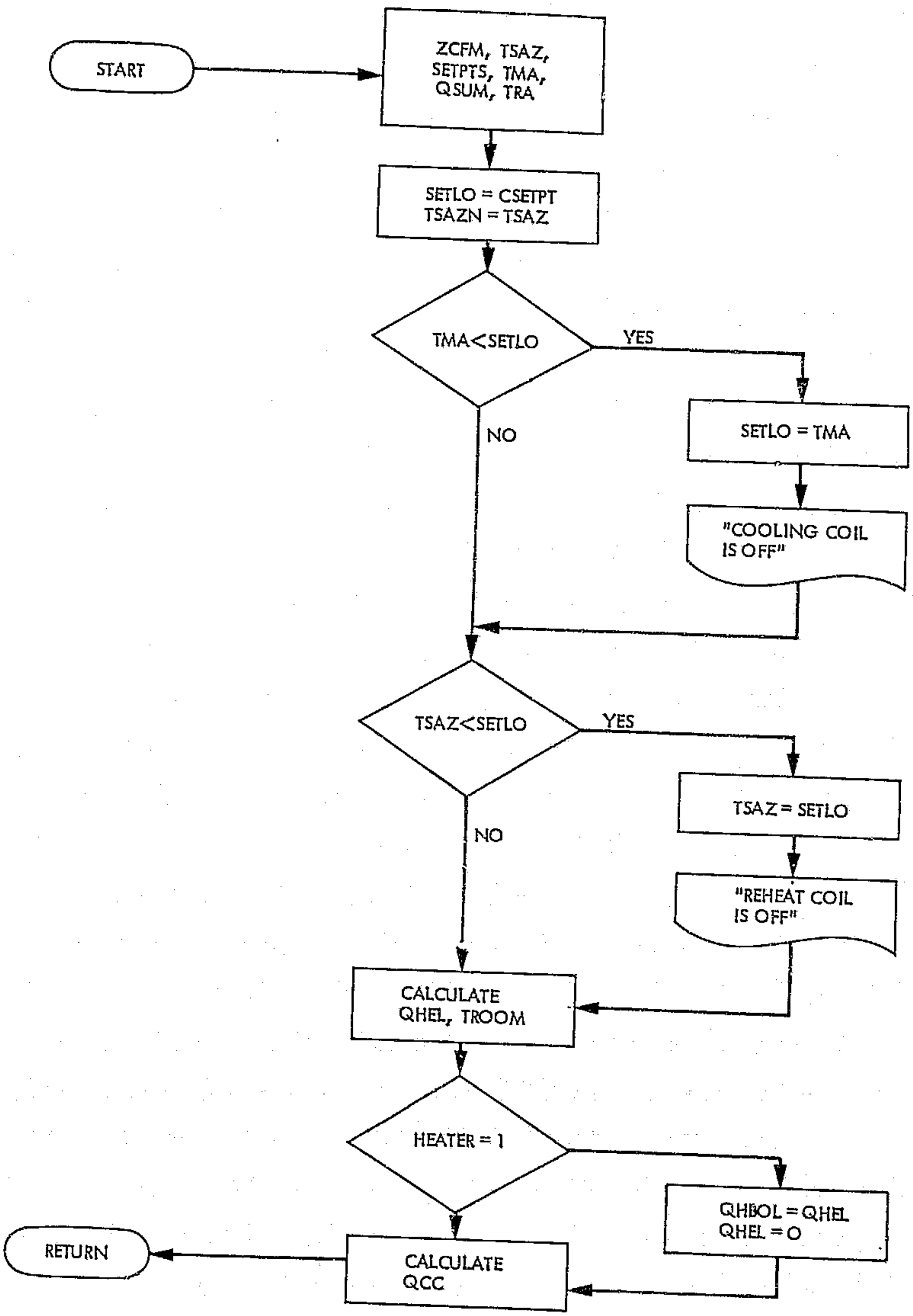


Figure 8-2. Flow chart of KEQ1 subroutine.

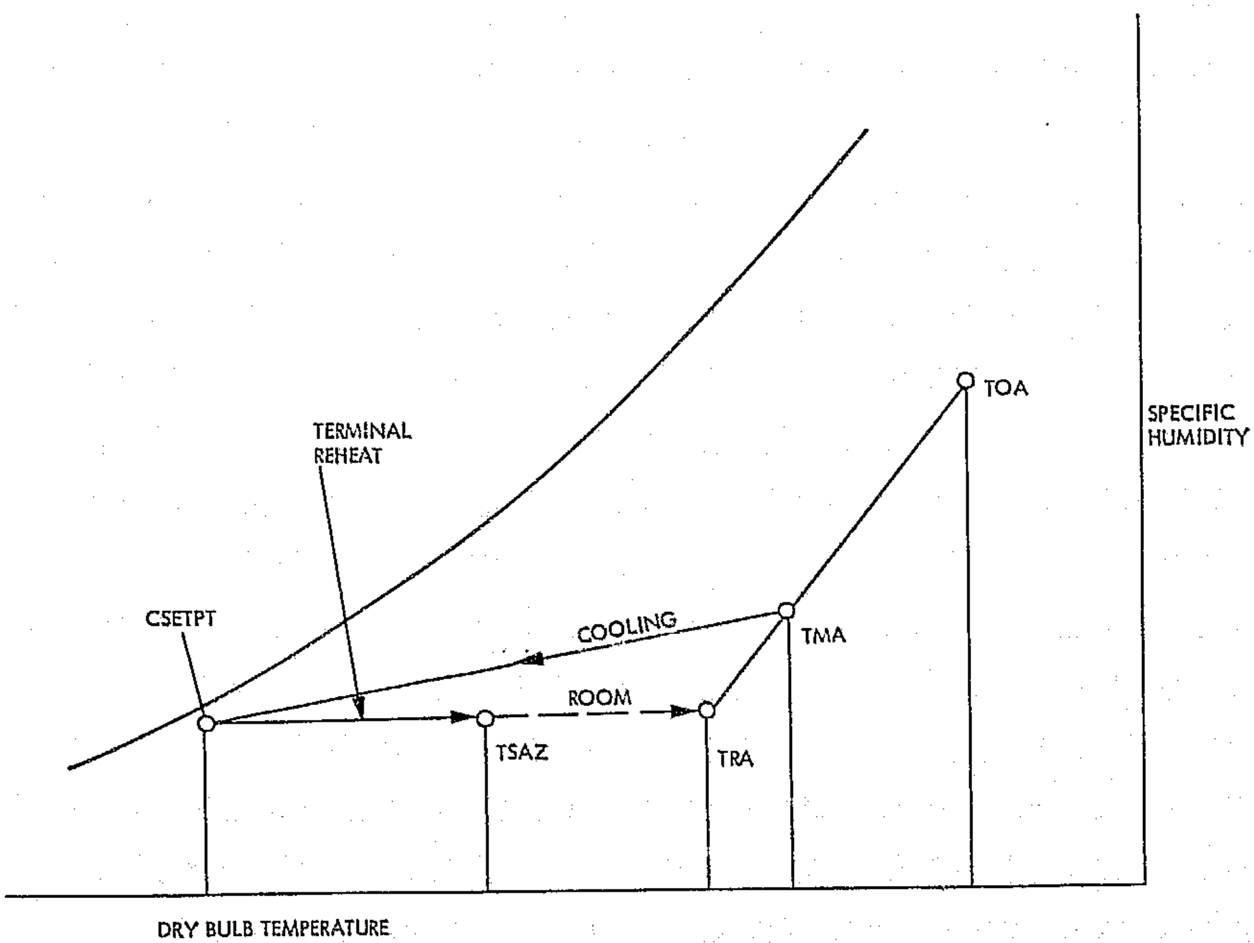


Figure 8-3. KEQ1 air temperature control on the psychrometric chart

8.3 KEQ2 Subroutine

This subroutine simulates the performance of type "two" air handler: dual duct, multizone, with mixing boxes or single duct, multizone with mixing at the air handler. Mixed air is divided and supplied to a heating coil and a cooling coil. The supply air temperature to a particular zone is modulated by mixing cold and hot air streams at the air handler or at the zone. A schematic of this type of air handler is shown in Fig. 8.4 and a flow chart for the subroutine algorithm is shown in Fig. 8.5. The process on the psychrometric chart is sketched in Fig. 8.6.

8.3.1 Calculation Procedure

1. Determine the temperature of the air leaving the cooling and heating coils:

   • If TMA < CSETPT
   Then SETLO = TMA
   Else SETLO = CSETPT

   • If TMA > HSETPT
   Then SETHI = TMA
   Else SETHI = HSETPT

2. Calculate the fraction of air which passes through the heating coils (XH).

   XH = (TSAZ - SETLO)/(SETHI - SETLO)

3. Determine the actual temperature of air supplied to the zone

   If XH > 1 then TSAZN = SETHI and XH = 1
   If XH < 0.0 then TSAZN = SETLO and XH = 0.0
   Else TSAZN = TSAZ

4. Compute the heating coils heating load. Distinguish between the different heating types.

   If HEATER = 1 then QHBOL = MLT*(ZCFM)*(XH)*(SETHI-TMA) Btu/hr
   QHEL = 0.0

   If HEATER = 0 then QHEL = MLT*(ZCFM)*(XH)*(SETHI-TMA) Btu/hr
   and QHBOL = 0.0

5. Determine cooling load on cooling coils

   QCC = MLT*(ZCFM)*(1-XH)*(TMA-SETLO) Btu/hr

6. Calculate actual temperature of room

   TROOM = TSAZN + QSUM/(MLT*ZCFM) ^{o}F

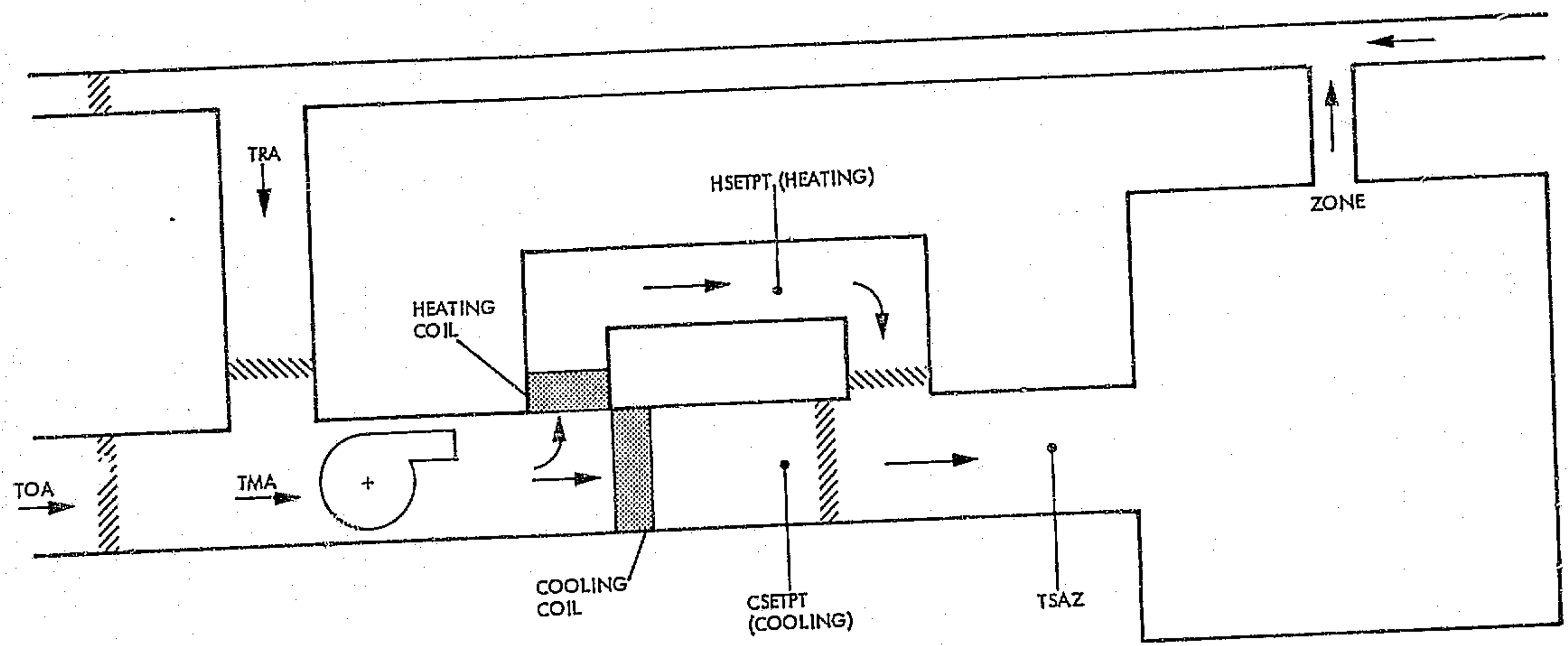


Figure 8-4. Type "2" air handler: dual duct multizone

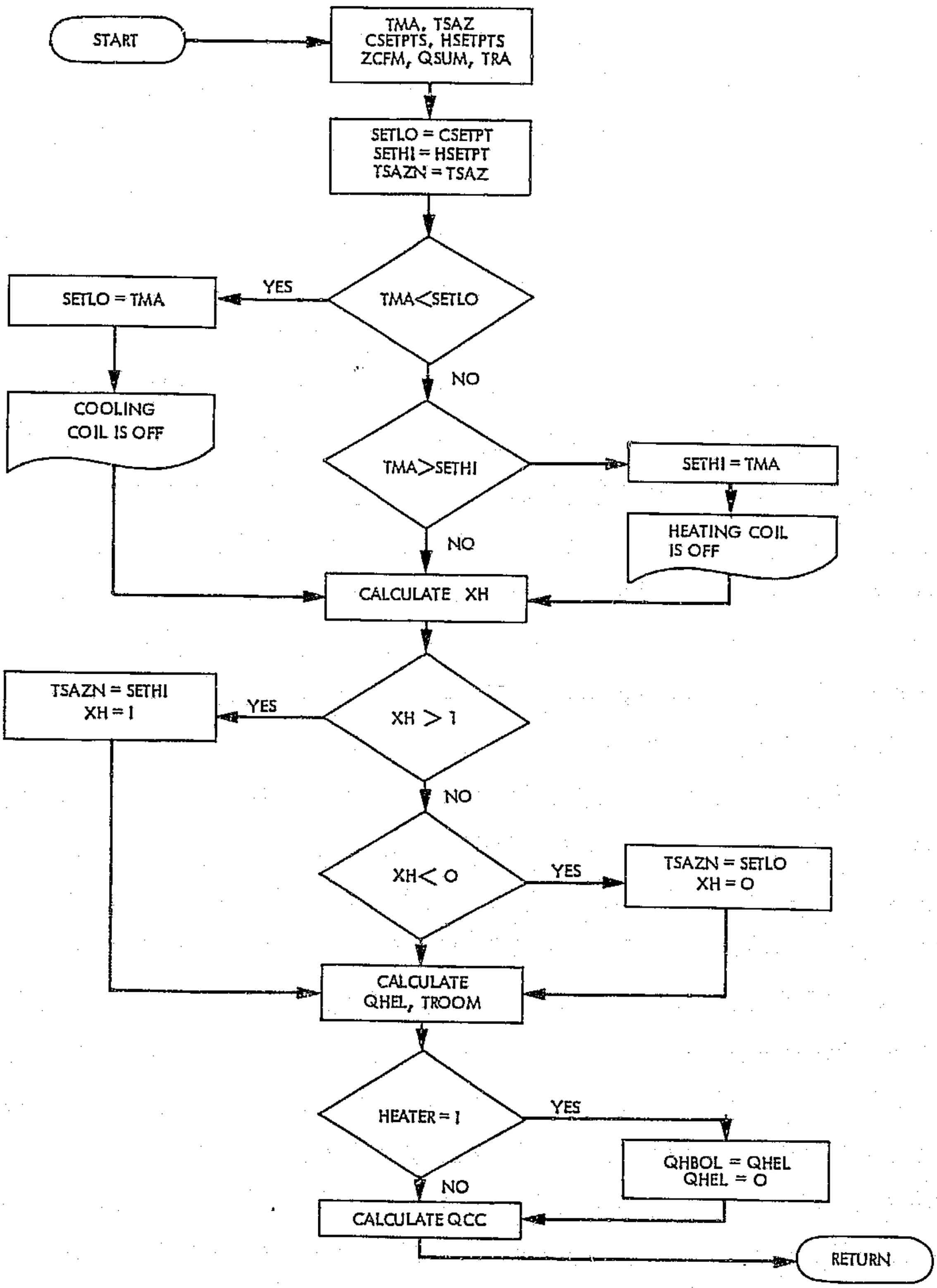


Figure 8-5. Flow chart of KEQ2 subroutine

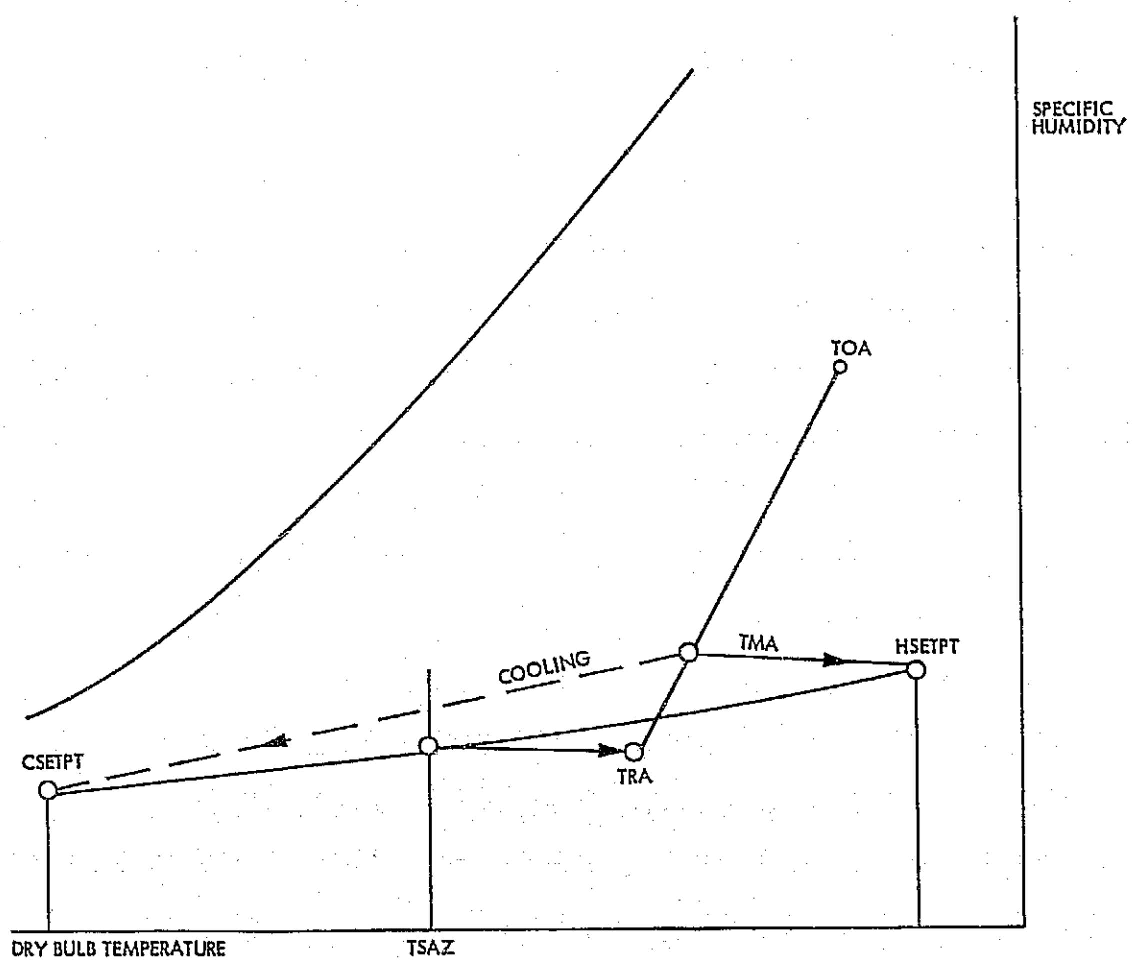


Figure 8-6. KEQ2 air temperature control on the psychrometric chart

8.4 KEQ3 Subroutine

This subroutine simulates the performance of "type three" air handler: a single cold duct with bypass and terminal reheat. Mixed air is cooled to a fixed set point for all zones. The supply air to a particular zone is modulated according to its load profile by mixing cooled air with bypassed mixed air with a reheat coil located at the air handler or near the zone. A schematic of this type of air handler is shown in Fig. 8.7. A flow chart of the subroutine algorithm is shown in Fig 8.8. The process is also sketched on the psychrometric chart as shown in Fig. 8.9.

8.4.1 Calculation Procedure

1. For heating mode (TSAZ > TMA):
   All air will bypass the cooling coil. Compute the heating load.

   If TSAZ > TMA then BF = 1
   QHEL = MLT*(TSAZ-TMA)*ZCFM   Btu/hr
   Set QHBOL = 0.0

   If HEATER = 1
   Then QHBOL = QHEL = MLT*(TSAZ-TMA)*ZCFM and
   Set QHEL = 0.0

2. For cooling mode; TSAZ < TMA
   If TSAZ < TMA and TMA < CSETPT
   then BF = 1
   QCC = QHEL = QHBOL = 0
   TSAZN = TMA
   cooling is off
   heating is off

3. For cooling mode; TSAZ < TMA
   If TMA ≧ CSETPT
   then compute the bypass factor (BF):

   BF = (TSAZ - CSETPT)/(TMA-CSETPT),
   TSAZN = TSAZ

4. For cooling mode TSAZ < TMA
   If TSAZ < CSETPT i.e. BF < 0,
   then BF = 0
   TSAZN = CSETPT

5. From 2, 3, or 4 determine the cooling load on the cooling coil and the actual temperature of the zone.

   QCC = MLT*(1-BF)*ZCFM*(TMA-CSETPT)   Btu/hr

   TROOM = TSAZN + QSUM/(MLT*ZCFM) ^{o}F

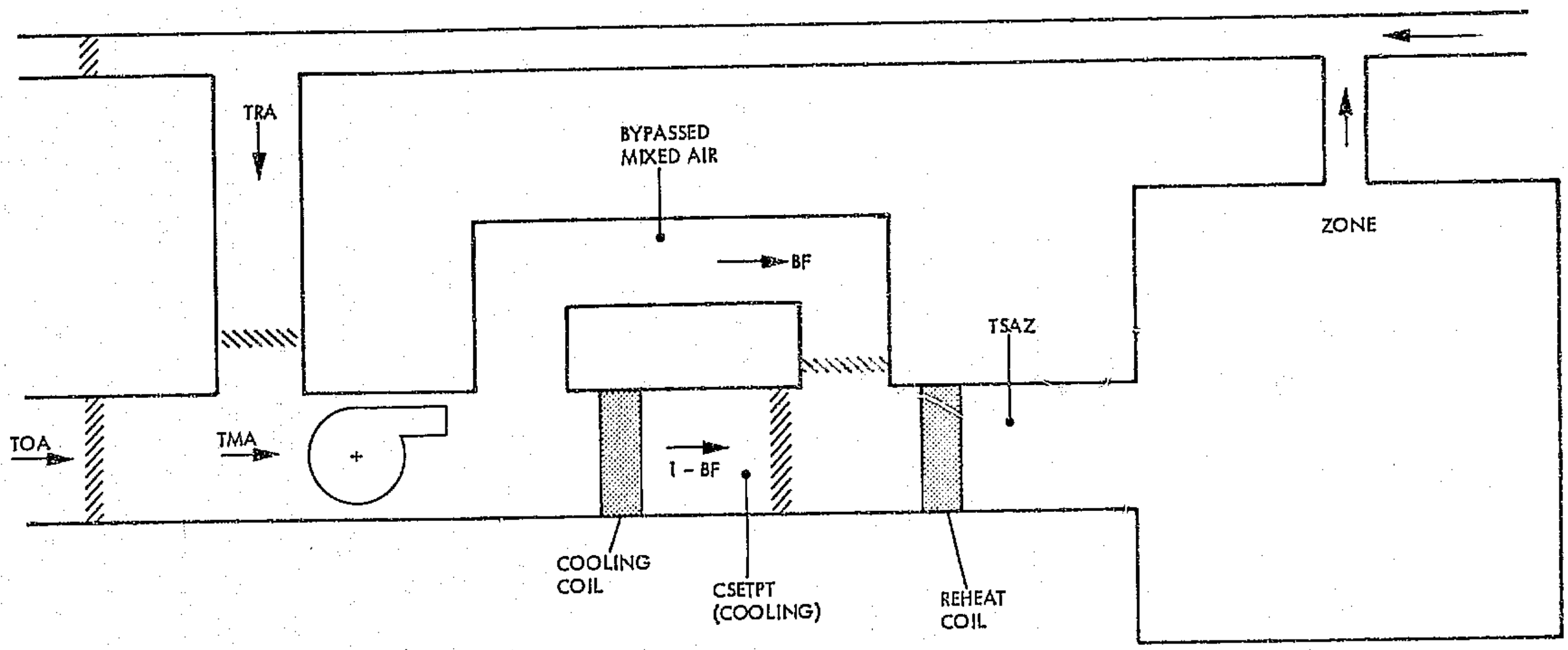


Figure 8-7. Single duct with bypass control and terminal reheat

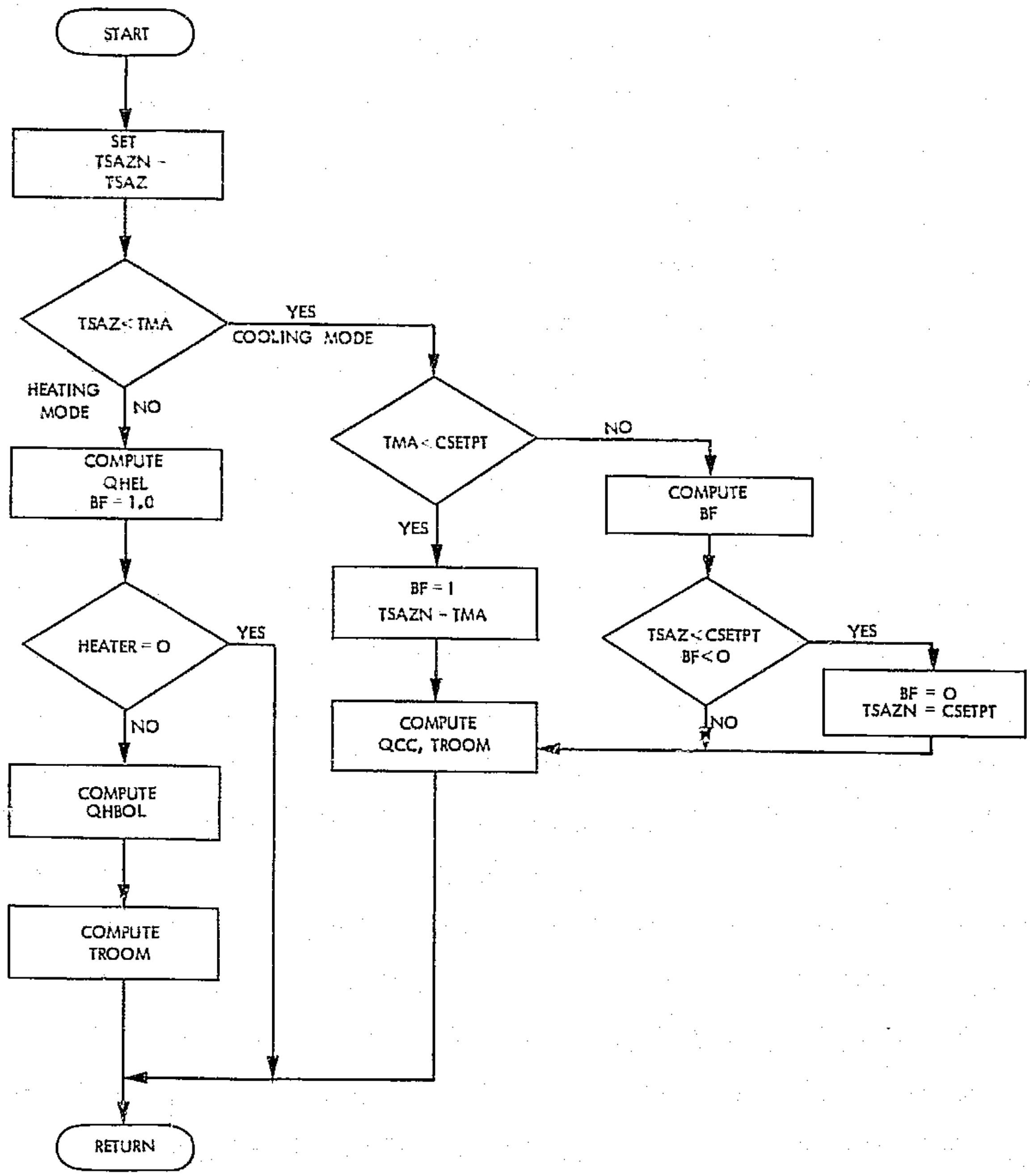


Figure 8-8. Flow chart of KEQ3 subroutine

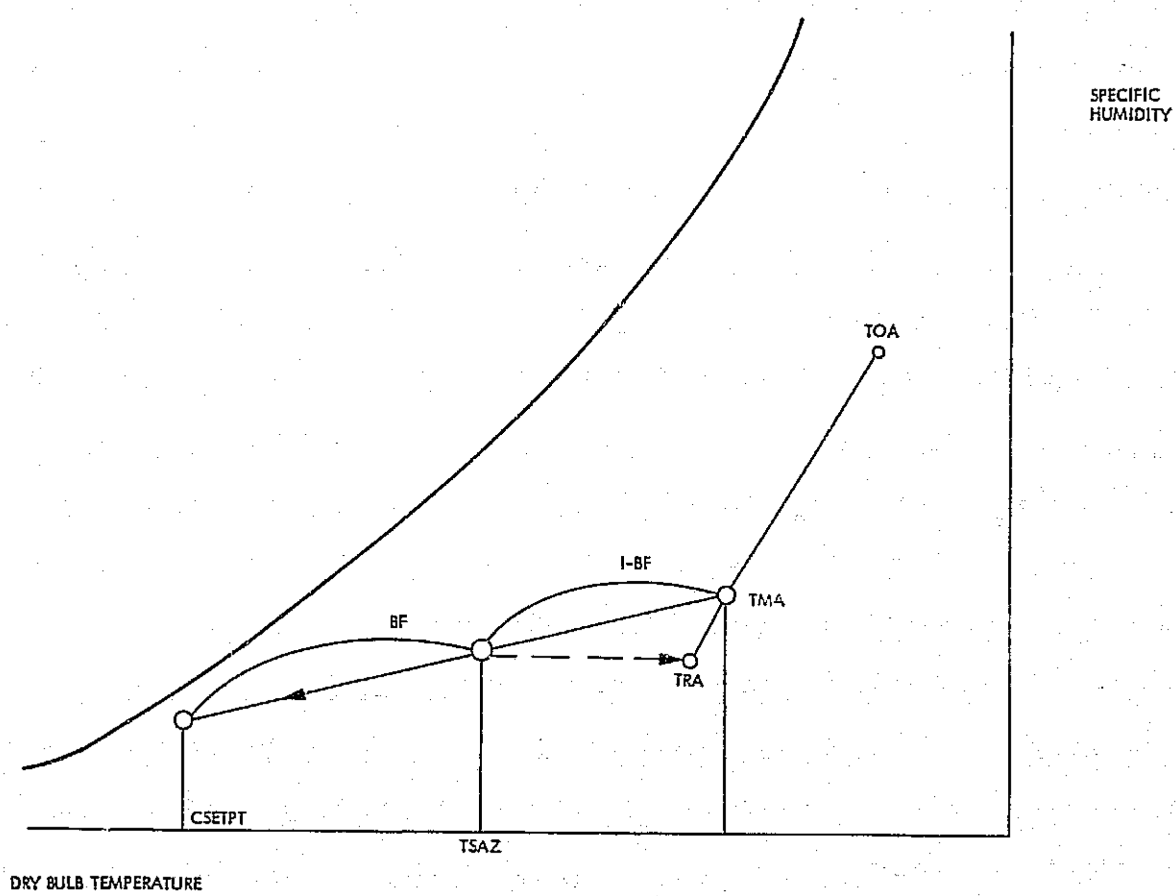


Figure 8-9. Schematic of KEQ3 processes on the psychrometric chart

8.5 KEQ4 Subroutine

This subroutine simulates the performance of type "four" air handler. A mixture of outside air and return air is supplied to a coil which may be used for heating or cooling depending on the operating mode. In either mode, supply air to the zones is modulated by mixing heated or cooled air with bypassed mixed air. This type of air handler can also fit the case of a heat pump with bypass control. A schematic of this type of air handler is shown in Fig. 8.10 and a flow chart of the subroutine algorithm is shown in Fig. 8.11. The process is sketched on the Psychrometric chart as given in Fig. 8.12.

8.5.1 Calculation Procedure

1. For heating mode, TMA < TSAZ
   and if TMA < HSETPT
   then QCC = 0
   BF = (TSAZ-HSETPT)/(TMA-HSETPT)
   TSAZN = TSAZ
   If BF < 0 then BF = 0
   TSAZN = HSETPT
   QHHP = MLT*ZCFM*(1-BF)(HSETPT-TMA), Btu/hr

2. For heating mode, TMA<TSAZ
   and if TMA ≥ HSETPT
   then BF = 1
   QCC = 0 cooling is off
   QHHP = QHEL = QHBOL = 0 heating is off
   TSAZN = TMA

3. For cooling mode, TMA≥TSAZ
   and if TMA > CSETPT
   Then BF = (TSAZ - CSETPT)/(TMA-CSETPT)
   TSAZN = TSAZ
   If BF < 0 then BF = 0
   TSAZN = CSETPT
   QCC = MLT*ZCFM*(1-BF)*(TMA-CSETPT) Btu/hr
   QHEL = QHBOL = QHHP = 0

4. For cooling mode, TMA ≥ TSAZ
   And if TMA ≤ CSETPT
   Then BF = 1
   QCC = 0 no cooling
   QHEL = QHBOL = QHHP no heating
   TSAZN = TMA

5. Calculate actual zone temperature.
   TROOM = TSAZN + QSUM/(MLT ZCFM) ^{o}F

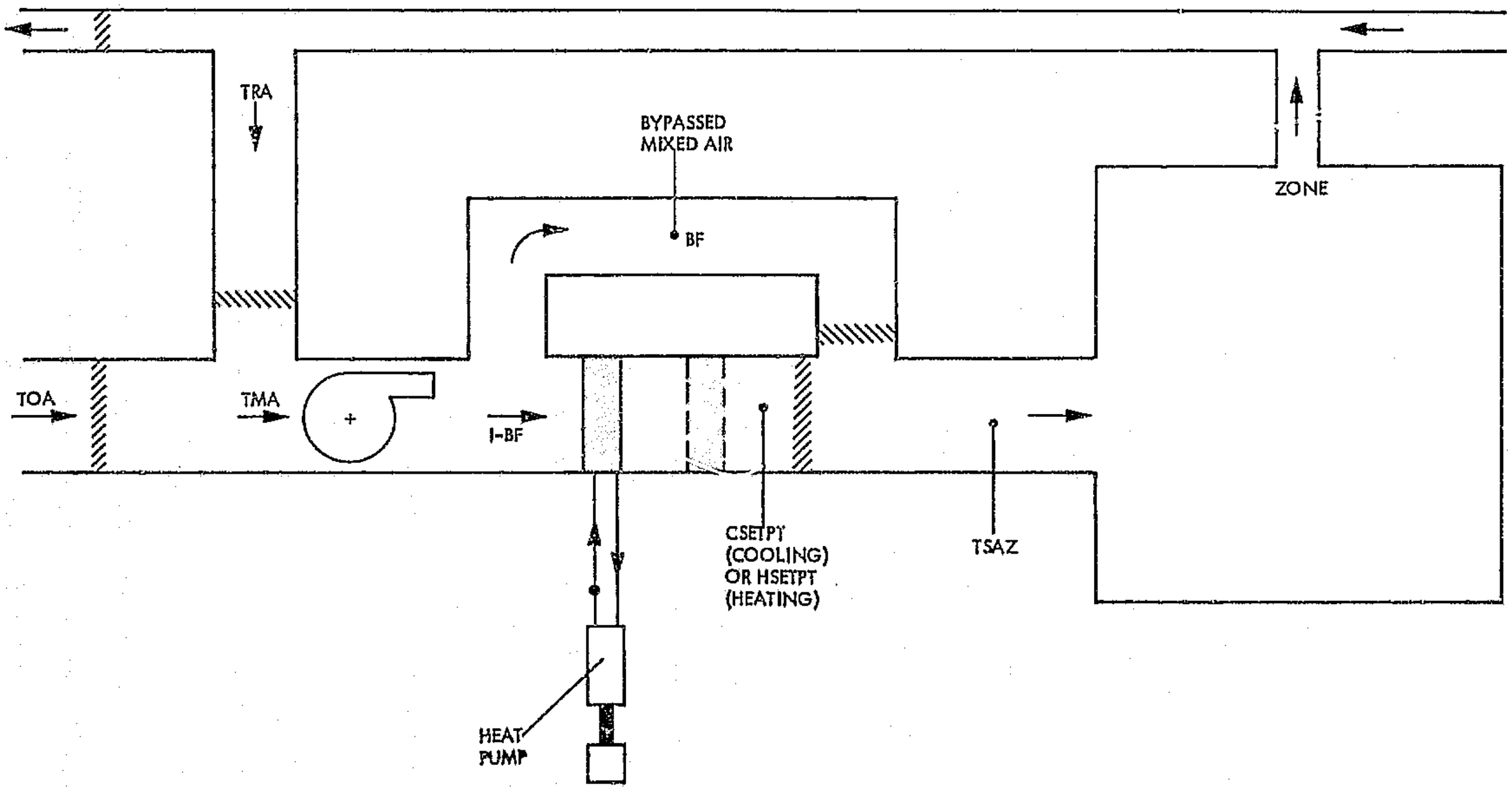


Figure 8-10. Type "four" air handler; heat pump or two separate cooling and heating coils with bypass control

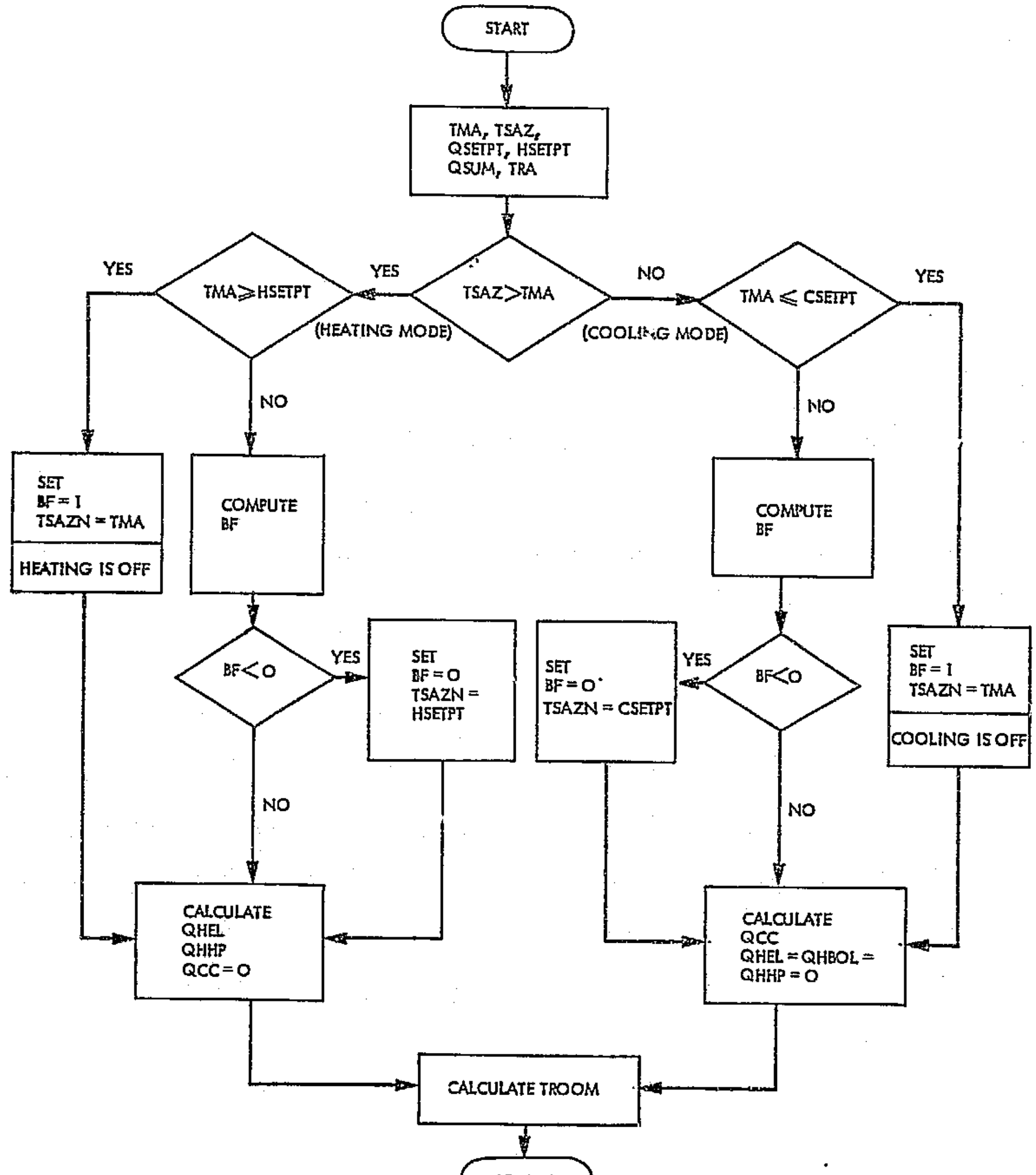


Figure 8-11. Flow chart for KEQ4 subroutine

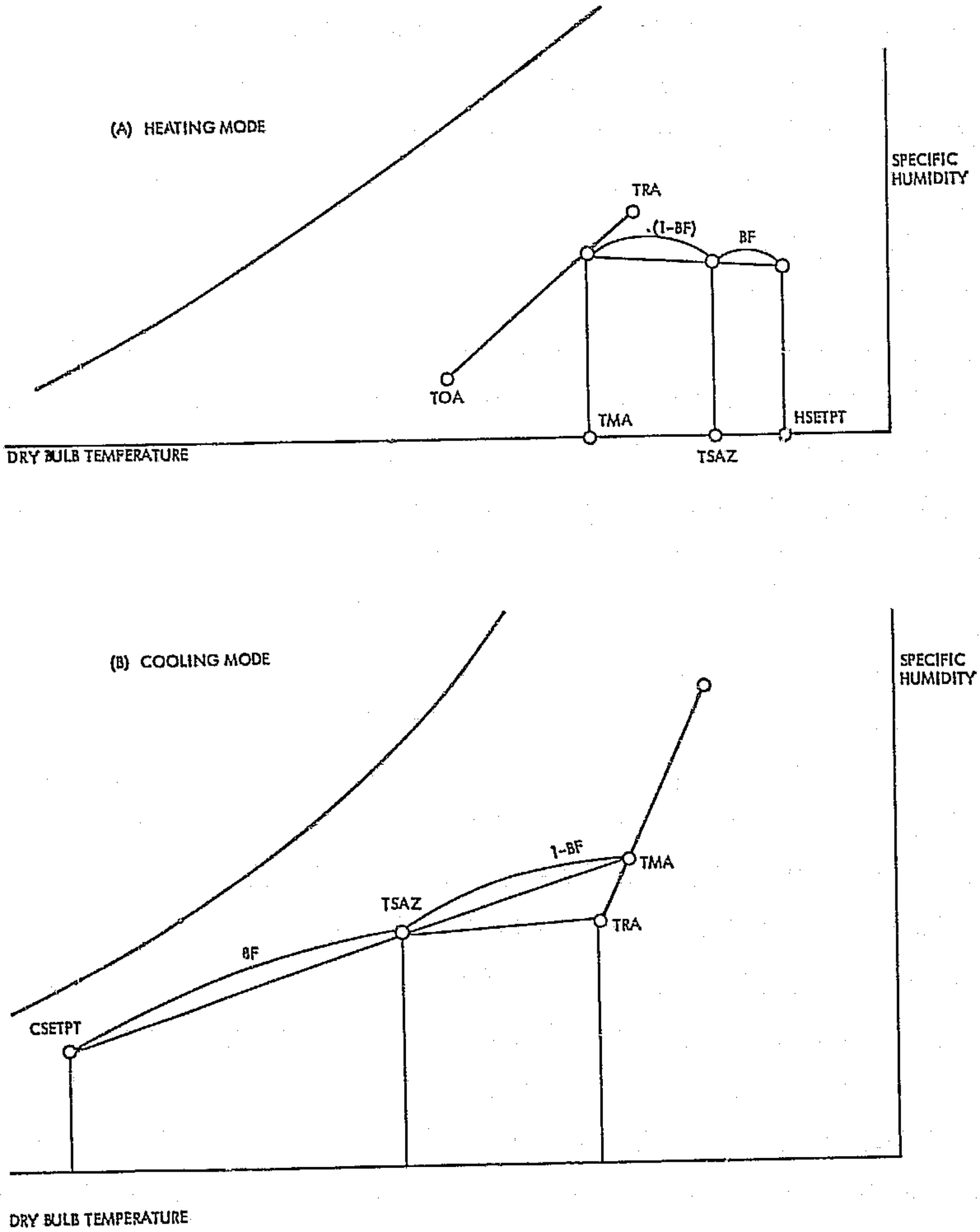


Figure 8-12. Schematic of the KEQ4 processes on the psychrometric chart

8.6 KEQ5 Subroutine

The KEQ5 subroutine simulates the performance of type "five" air handler: a two-level room, with cold plenum air and comfort air modulated by terminal reheat at the room. Mixed air at the air handler is cooled to a fixed set point for all zones. Cold air modulated by a reheat coil located near or at the zone is supplied directly to the main room. The required air temperature to the zone is achieved by complete mixing of plenum air and comfort air in the room. A schematic of this type of air handler is shown in Fig. 8.13 and a flow chart for the subroutine algorithm is given in Fig. 8.14. The process is sketched on the Psychrometric chart as illustrated in Fig. 8.15.

8.6.1 Calculation Procedure

1. Determine the set point temperature SETLO
   If TMA $<$ CSETPT
   Then SETLO = CSETPT
   Else SETLO = CSETPT

2. Calculate the temperature of comfort air (THOT) ^{o}F
   THOT = TSAZ-(SETLO)(1 - HFBRA) /HFBRA
   where
   $$\text{HFBRA} = \frac{\text{cfm comfort air}}{\text{cfm comfort air + cfm plenum air}} \neq 0$$

3. Compute heating and cooling loads on the coils:
   If THOT $<$ SETLO
   Then THOT = SETLO
   QHEL = QHBOL = QHHP = 0
   QCC = ZCFM*MLT*(TMA - SETLO) Btu/hr

   If THOT $\geq$ SETLO
   Then QCC = MLT*(ZCFM)*(TMA - SETLO) Btu/hr
   QHEL = MLT*ZCFM*HFBRA*(THOT - SETLO) Btu/hr

4. Calculate the two-level room temperature TROOM
   TROOM = (HFBRA*THOT) + (1-HFBRA)*SETLO + QSUM/(MLT*ZCFM) ^{o}F

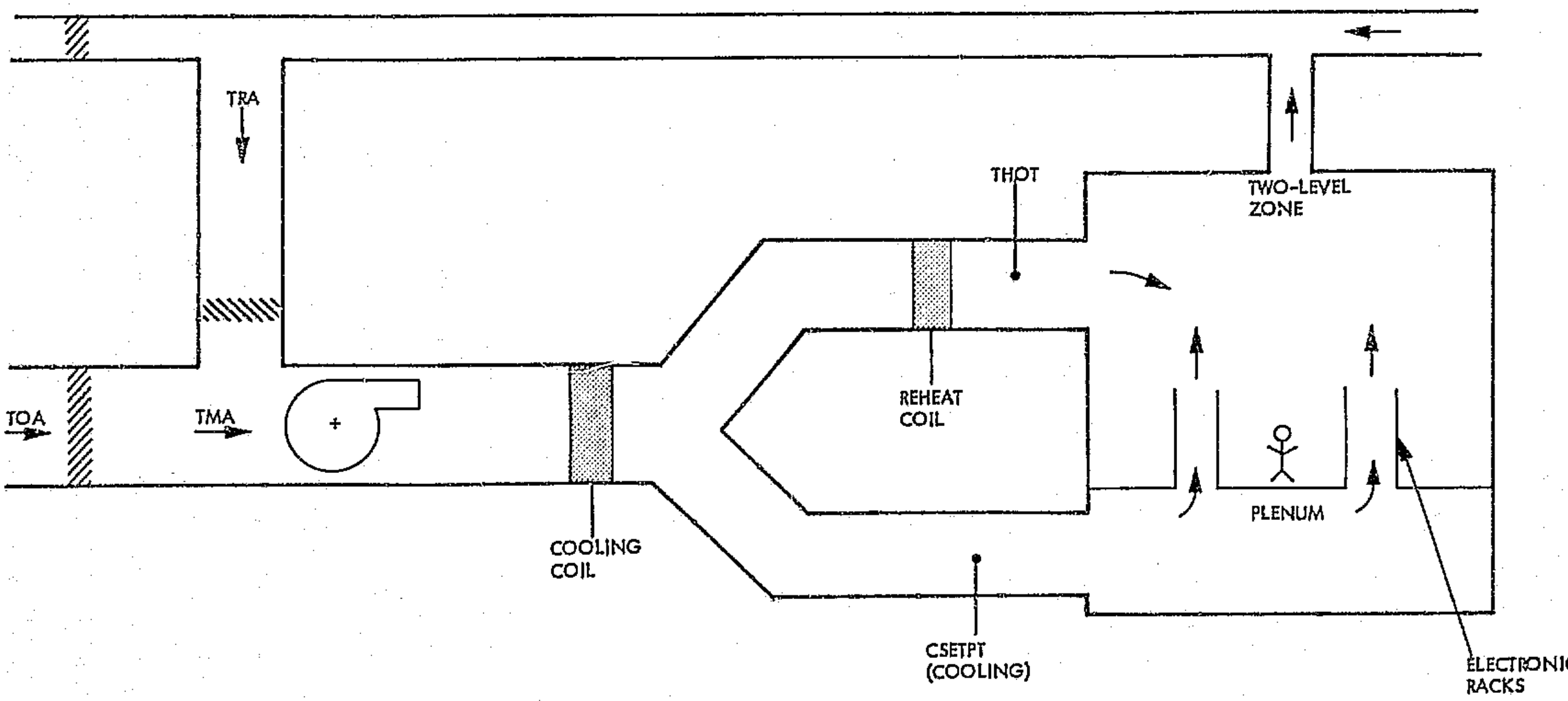


Figure 8-13. Two-level room with cold plenum air and comfort air modulated by terminal reheat

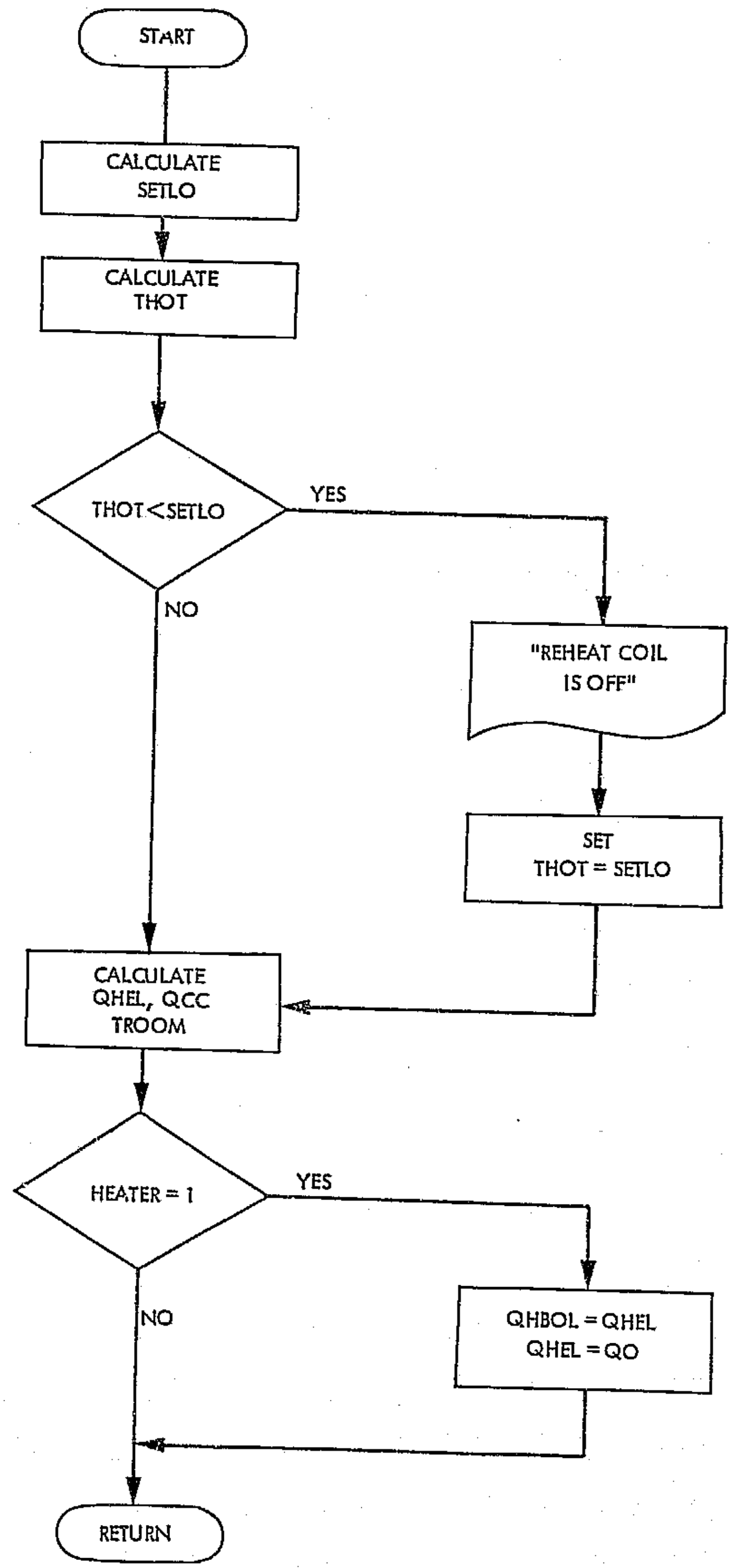


Figure 8-14. Flow chart for KEQ5 subroutine

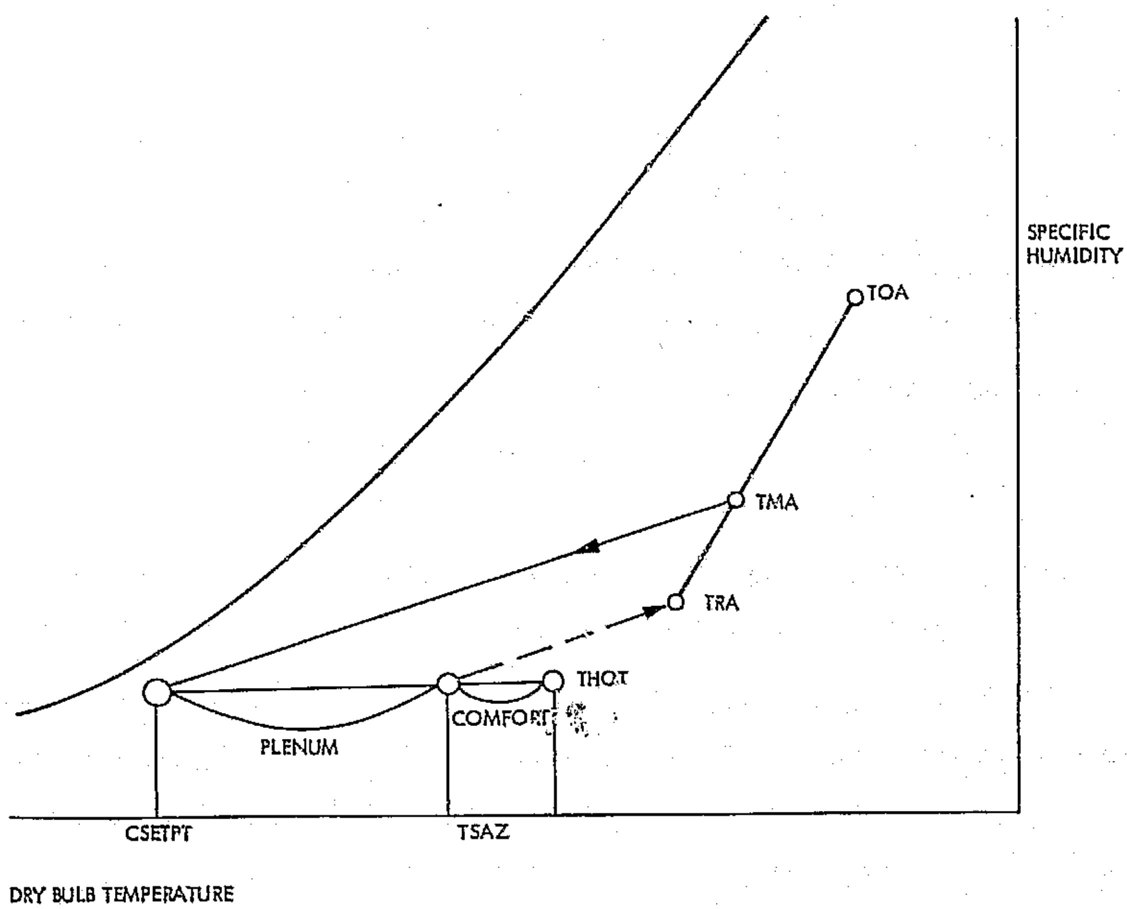


Figure 8-15. Schematic of KEQ5 processes on the psychrometric chart

8.7 KEQ6 Subroutine

The KEQ6 subroutine simulates the performance of type "six" air handler: a two-level room with cold plenum air and comfort air modulated by by-passed mixed air and terminal reheat. Mixed air at the air handler is cooled to a fixed set point for all zones. The "comfort" air to the second level is a mixture of cold air and bypassed mixed air and is modulated by a reheat coil located near or at the zone.

A schematic of this type of air handler is shown in Fig. 8.16 and a flow chart of the subroutine algorithm is given in Fig. 8.17. The process is sketched on the psychrometric chart as shown in Fig. 8.18.

8.7.1 Calculation Procedure

1. Determine the actual temperature of air leaving the cooling coils (SETLO)
   If TMA < CSETPT
   Then SETLO = TMA
   Else SETLO = CSETPT

2. Calculate the temperature of comfort air (THOT)
   THOT = TSAZ-(SETLO*(1-HFBR)) /HFBRA °F
   Where HFBRA = (cfm of comfort air)/(cfm of comfort air + cfm of plenum air)

3. Compute cooling and heating loads on the cooling and heating coils:
   (i) If THOT < SETLO
   Then CPF = 1
   THOT = SETLO
   QHBOL= QHEL = QHHP = 0 Reheat is off
   QCC= MLT*ZCFM*(TMA - SETLO)
   (ii) If SETLO ≤ THOT ≤ TMA and TMA ≠ SETLO
   Then CPF = (TMA - THOT)/(TMA - SETLO)
   QHBOL = QHEL = QHHP = 0
   QCC = MLT*(ZCFM)* [1 - HFBRA*(1 - CPF)] *(TMA - SETLO)
   (iii) If THOT >TMA then
   CPF = 0
   QHEL = MLT*ZCFM*(THOT - TMA)*HFBRA Btu/hr
   QCC = (MLT)*ZCFM*(1-HFBRA)*(TMA - SETLO) Btu/hr
   (iv) If TMA = SETLO
   Then QCC = 0
   QHEL = ZCFM*HFBRA*MLT*(THOT - TMA) Btu/hr

4. Calculate the actual room air temperature (TROOM)
   TROOM = (THOT * HFBRA) + ((1 - HFBRA) * SETLO) + QSUM/(MLT * ZCFM) °F

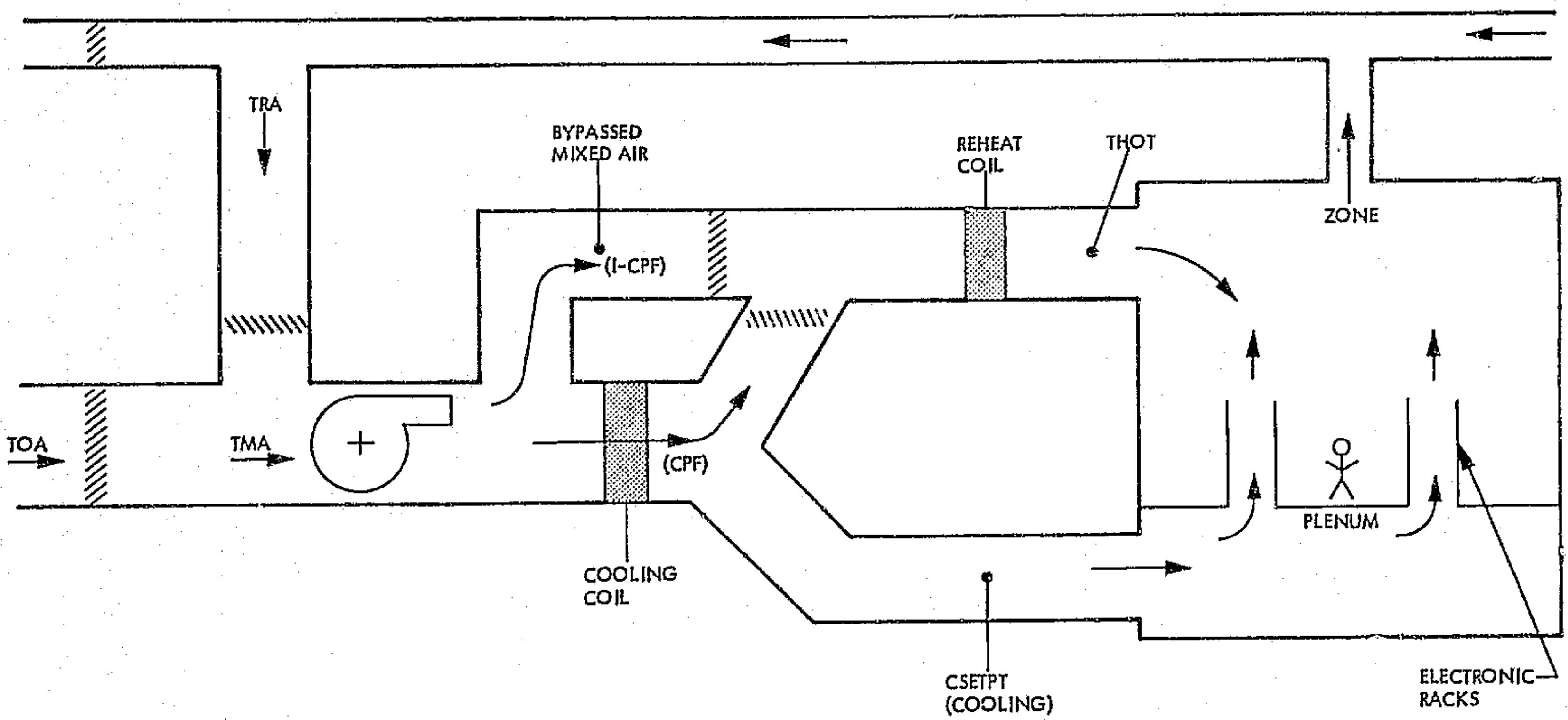


Figure 8-16. Two-level room with cold plenum air and comfort air modulated by mixed air and terminal reheat

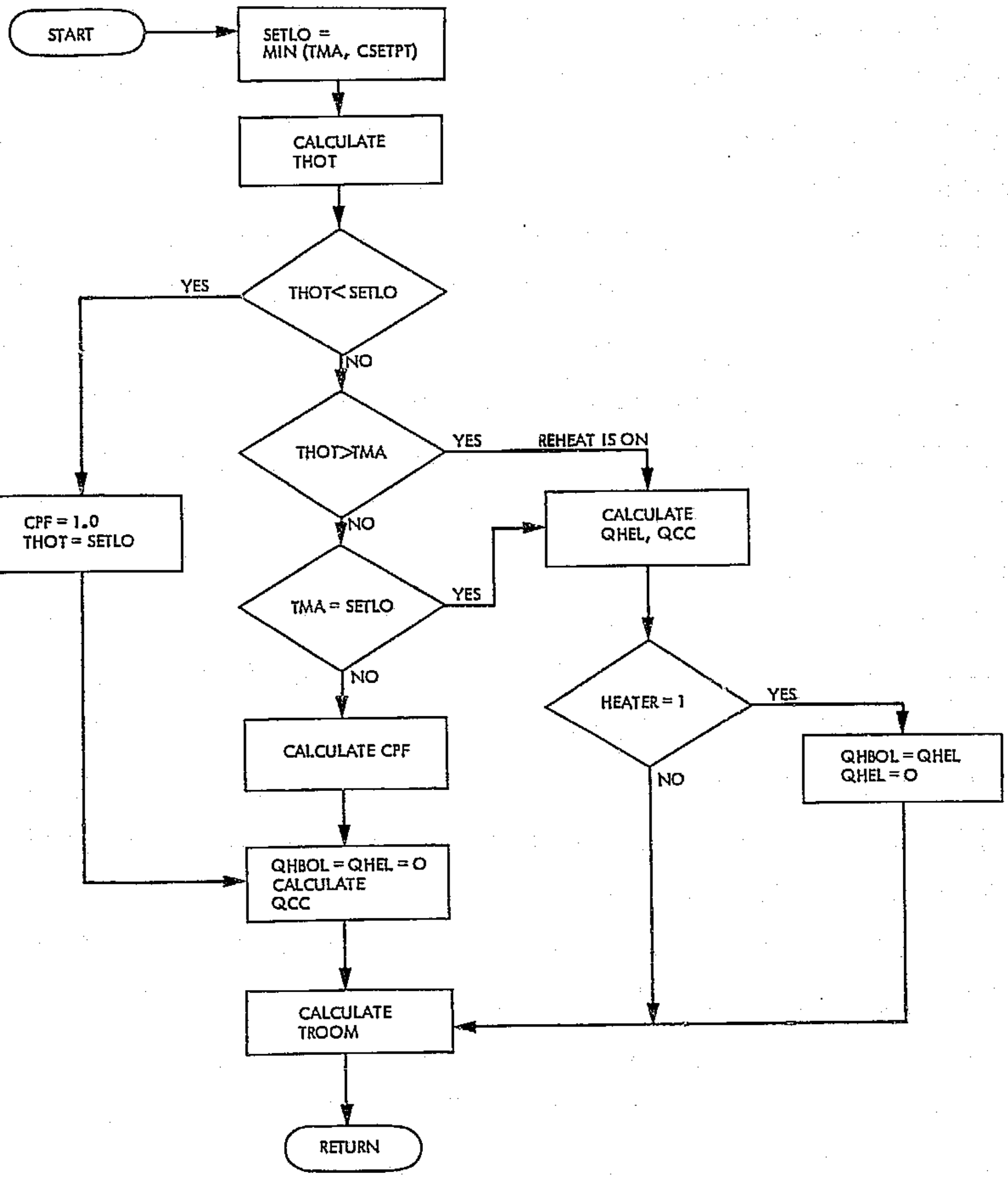


Figure 8-17. Flow chart of KEQ6 subroutine

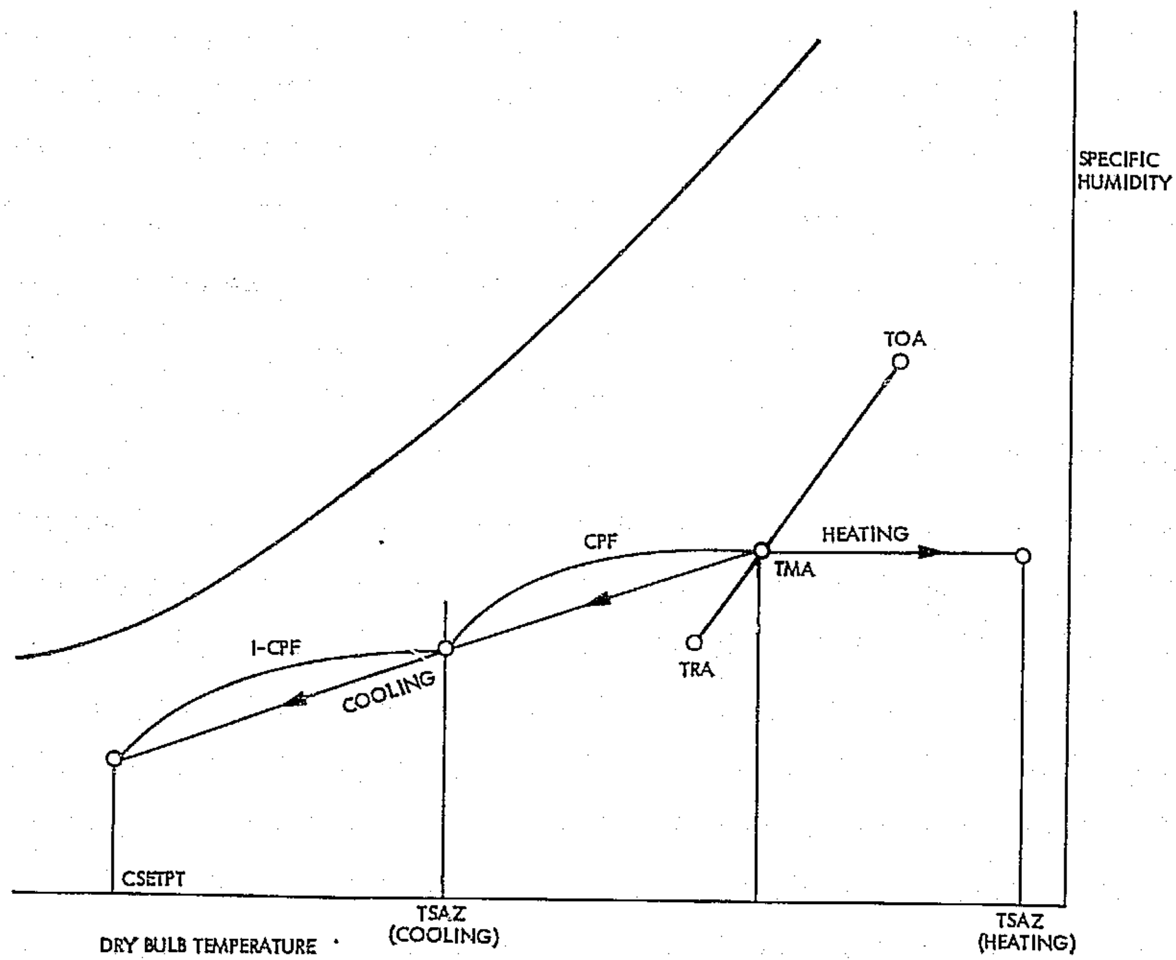


Figure 8-18. Schematic of KEQ6 processes on psychrometric chart

8.8 KEQ7 Subroutine

This subroutine simulates the performance of type "seven" air handler: a two-level room with cold plenum air and comfort air modulated by mixing cold and hot decks. Mixed air at the air handler is divided and supplied to a heating coil and a cooling coil. Mixing of comfort air and plenum air is assumed complete and perfect. A schematic of this type of air handler is shown in Fig. 8.19, and a flow chart for the subroutine algorithm is shown in Fig. 8.20. The process is also sketched on the psychrometric chart as shown in Fig. 8.21.

8.8.1 Calculation Procedure

1. Determine the actual temperature of air leaving the cooling coil (SETLO) and heating coil (SETHI).
   If TMA < SETLO then SETLO = TMA else SETLO = CSETPT
   If TMA > SETHI then SETHI = TMA else SETHI = HSETPT

2. Determine the temperature of comfort air (THOT)
   CFM1 = (1 - HFBRA)ZCFM= plenum air discharge
   CFM2 = HFBRA*ZCFM= comfort air discharge
   THOT = [TSAZ*(ZCFM) - (CFM1*SETLO)]/CFM2, CFM 2 ≠ 0

3. Determine the cooling coil pass factor (CPF), which is the amount of comfort air that passes through the cooling coil:
   (i) If THOT < SETLO
   Then CPF = 1.0
   THOT = SETLO
   (ii) If THOT > SETHI
   Then CPF = 0.0
   THOT = SETHI
   (iii) If SETHI ≥ THOT ≥ SETLO then
   CPF = (SETHI - THOT)/(SETHI - SETLO)

4. Calculate the heating and cooling loads on the coils:
   HLD = (1.0 - CPF)*CFM2*(SETHI - TMA)*MLT Btu/hr
   If HEATER = 0 then QHEL = HLD
   If HEATER = 1 then QHBOL = HLD
   QCC = [CFM1 + (CPF*CFM2)] * MLT * (TMA - SETLO) Btu/hr

5. Calculate the actual temperature of the room (TROOM).
   TROOM = (THOT*HFBRA) + (SETLO * (1.0 - HFBRA)) + QSUM/(MLT * ZCFM) ^{o}F

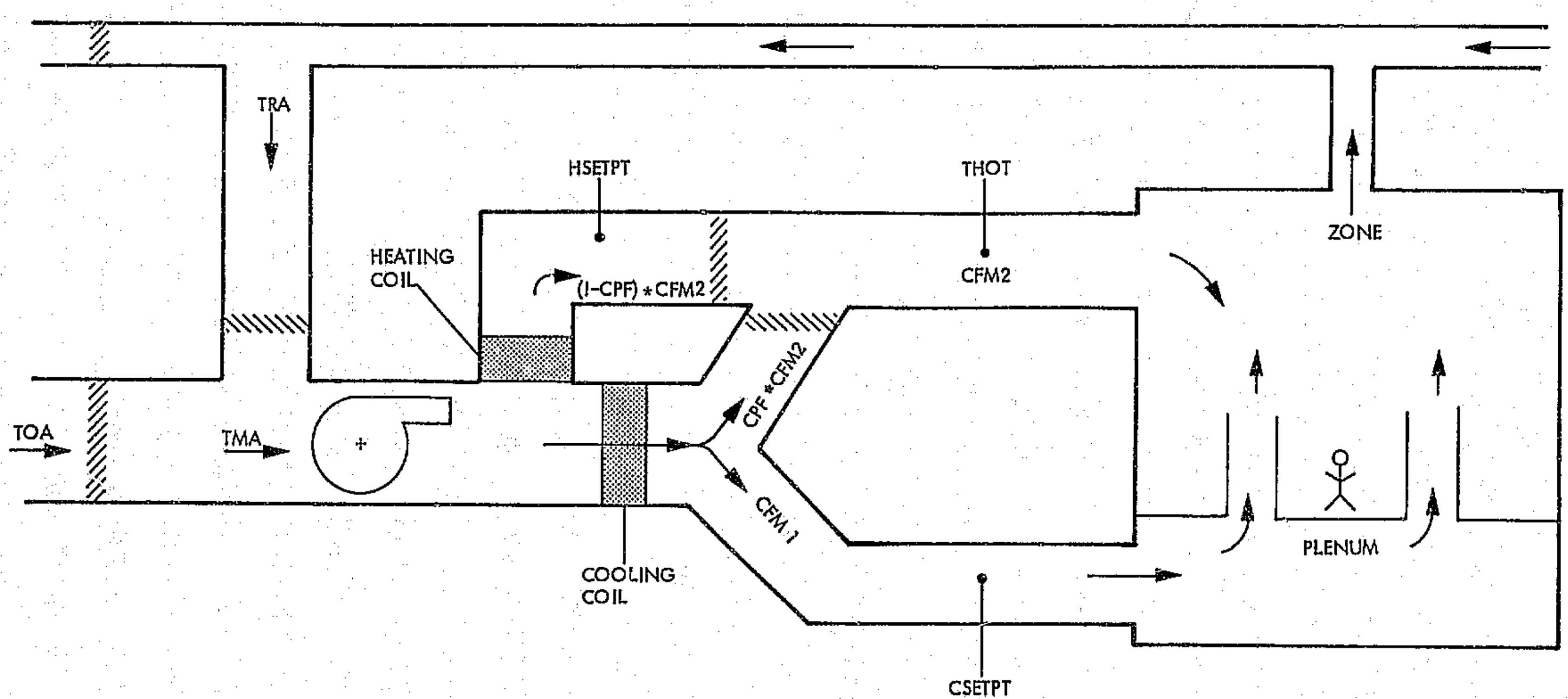


Figure 8-19. Two-level room with cold plenum air and comfort air modulated by mixing cold and hot decks

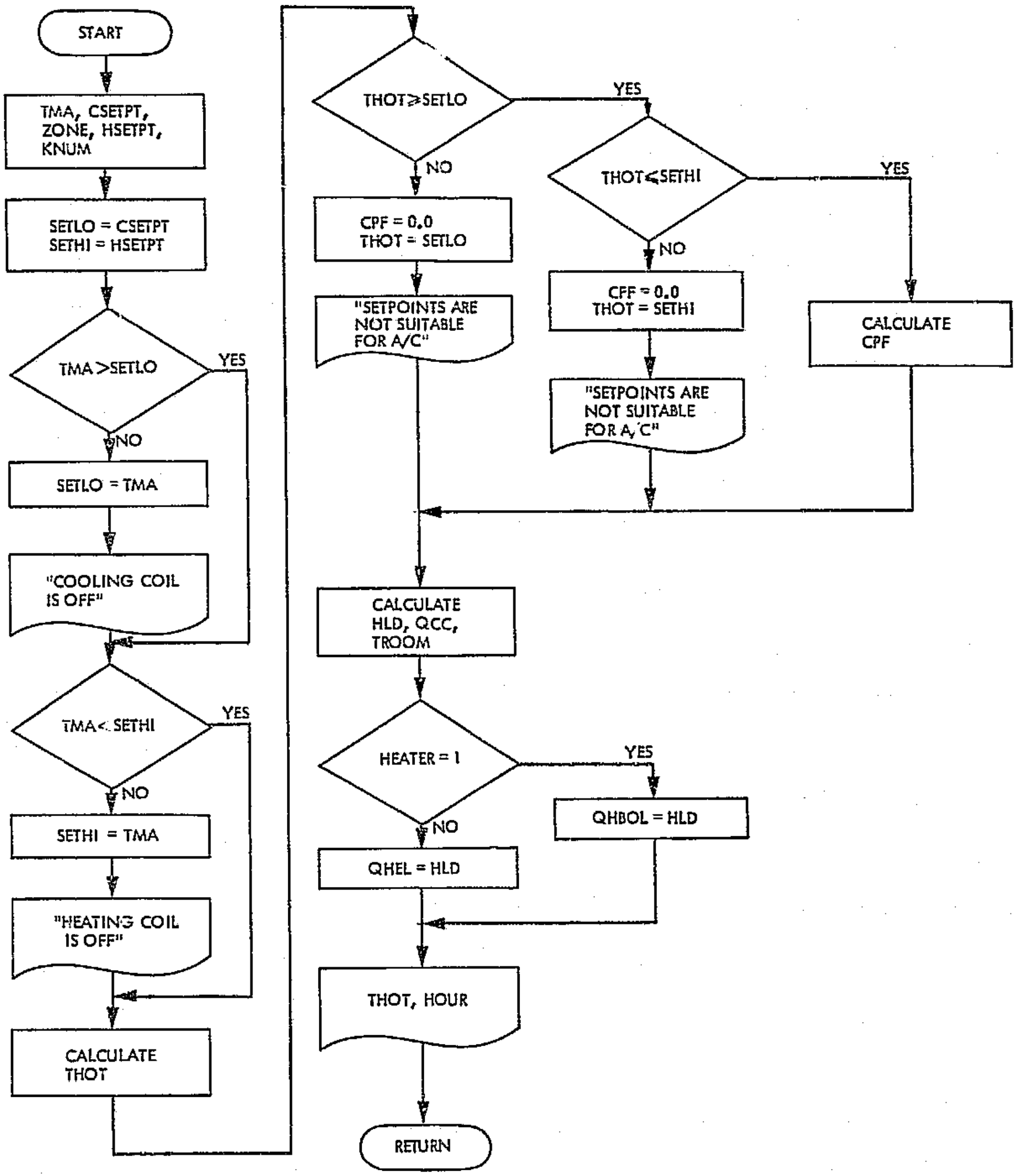


Figure 8-20. Flow chart of KEQ7 subroutine

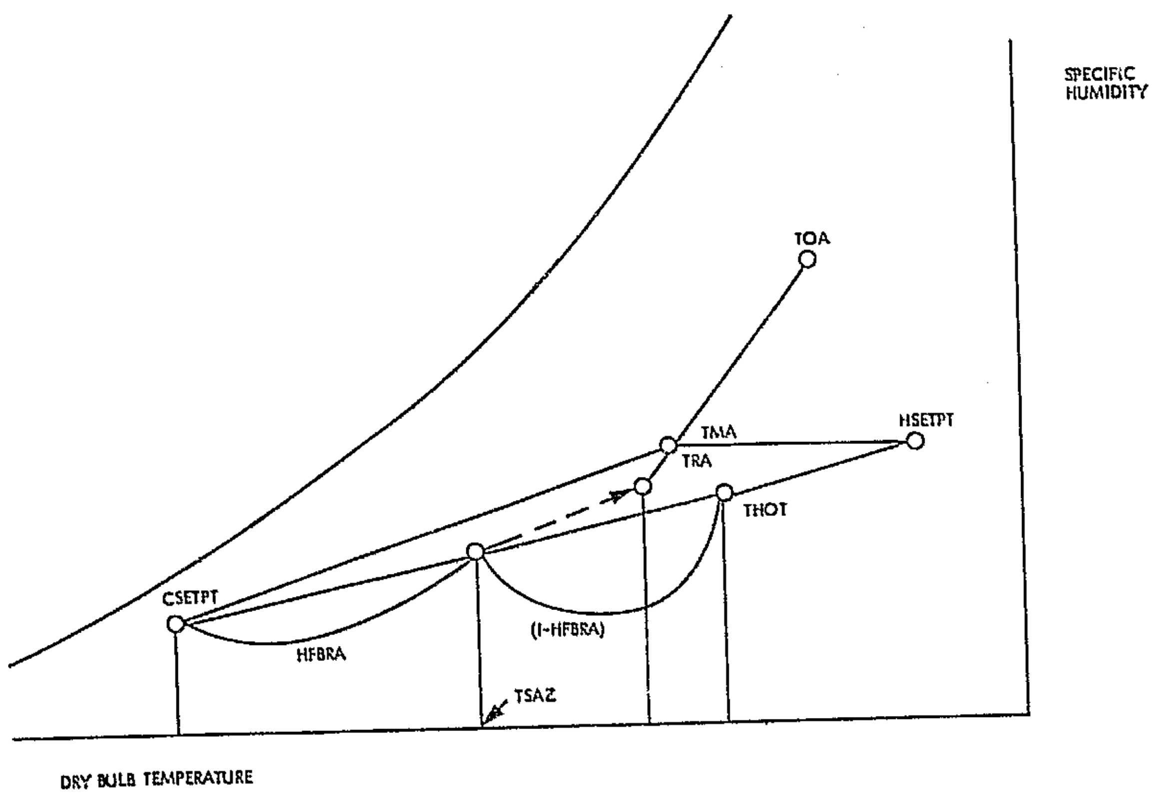


Figure 8-21. Schematic of KEQ7 processes on the psychrometric chart

8.9 KEQ8 Subroutine

This subroutine simulates the performance of type "eight" air handler: a single cold duct with fixed, bypassed return air and terminal reheat as shown in Fig. 8.22. Mixed air is supplied to all zones after being cooled. The supply air temperature to a particular zone is modulated by mixing return air with cold deck air and heating the final mixture with a reheat coil located near the zone. A flow chart of the subroutine algorithm is given in Fig. 8.23 and a schematic of the processes on the psychrometric chart is given in Fig. 8.24.

8.9.1 Calculation Procedure

1. Determine the actual temperature of air leaving the cooling coil (SETLO)
   If TMA $<$ CSETPT
   Then SETLO = TMA
   Else SETLO = CSETPT

2. Calculate the temperature of the air mixture (TMR) when mixing cold air with return air
   TMR = (HFBRA*TRA) + ((1.0 - HFBRA) * SETLO) ^{o}F
   Where HFBRA is the fraction of zone air discharge that is bypassed by return air.

3. Determine the actual supply air temperature to the zone (TSAZN)
   If TSAZ $<$ TMR
   Then TSAZN = TMR
   Else TSAZN = TSAZ

4. Calculate the heating load on the reheat coil. If the required supply air to the zone is higher than TMR then the reheat coil is activated and the heating load is calculated.
   If TSAZ $\geq$ TMR
   Then HLD = ZCFM*MLT*(TSAZN - TMR) Btu/hr
   If HEATER = 1 then QHBOL = HLD
   If HEATER = 0 then QHEL = HLD

5. Calculate the cooling load and the actual temperature of the room
   QCC = ZCFM * MLT * (1 - HFBRA) * (TMA - SETLO). Btu/hr
   TROOM = TSAZN + QSUM/(MLT * ZCFM) ^{o}F

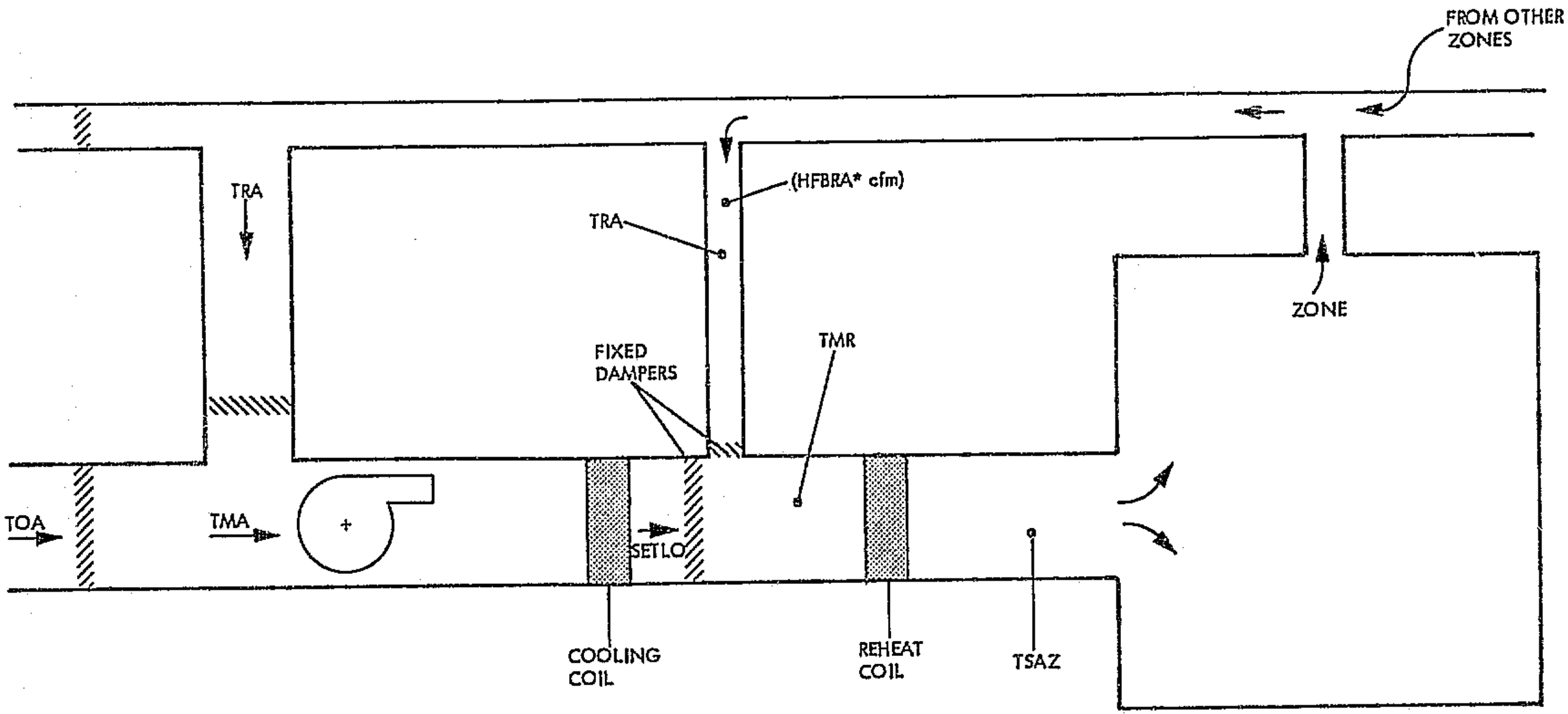


Figure 8-22. Single cold duct with fixed, bypass return air and terminal reheat

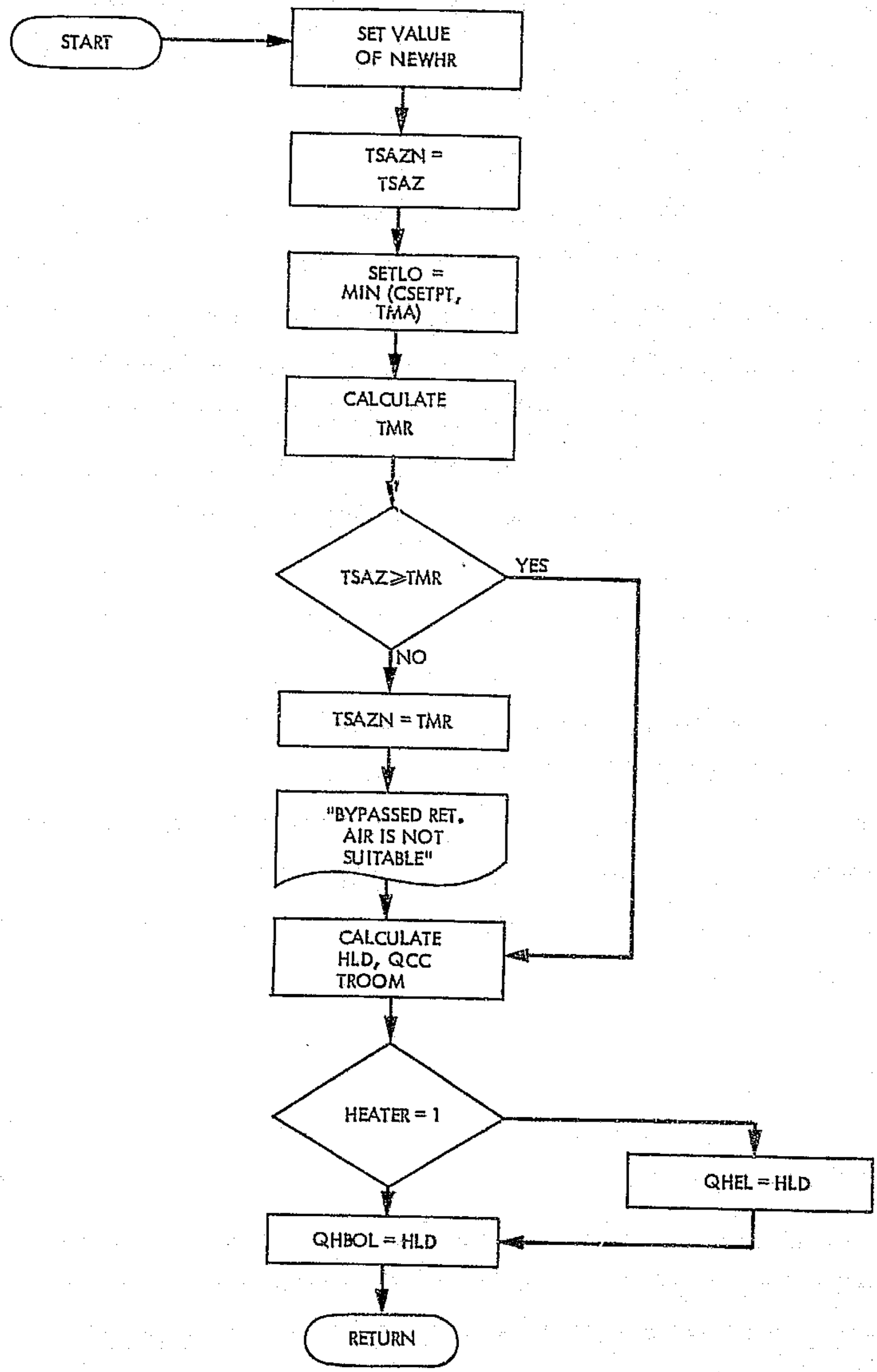


Figure 8-23. Flow chart of KEQ8 subroutine

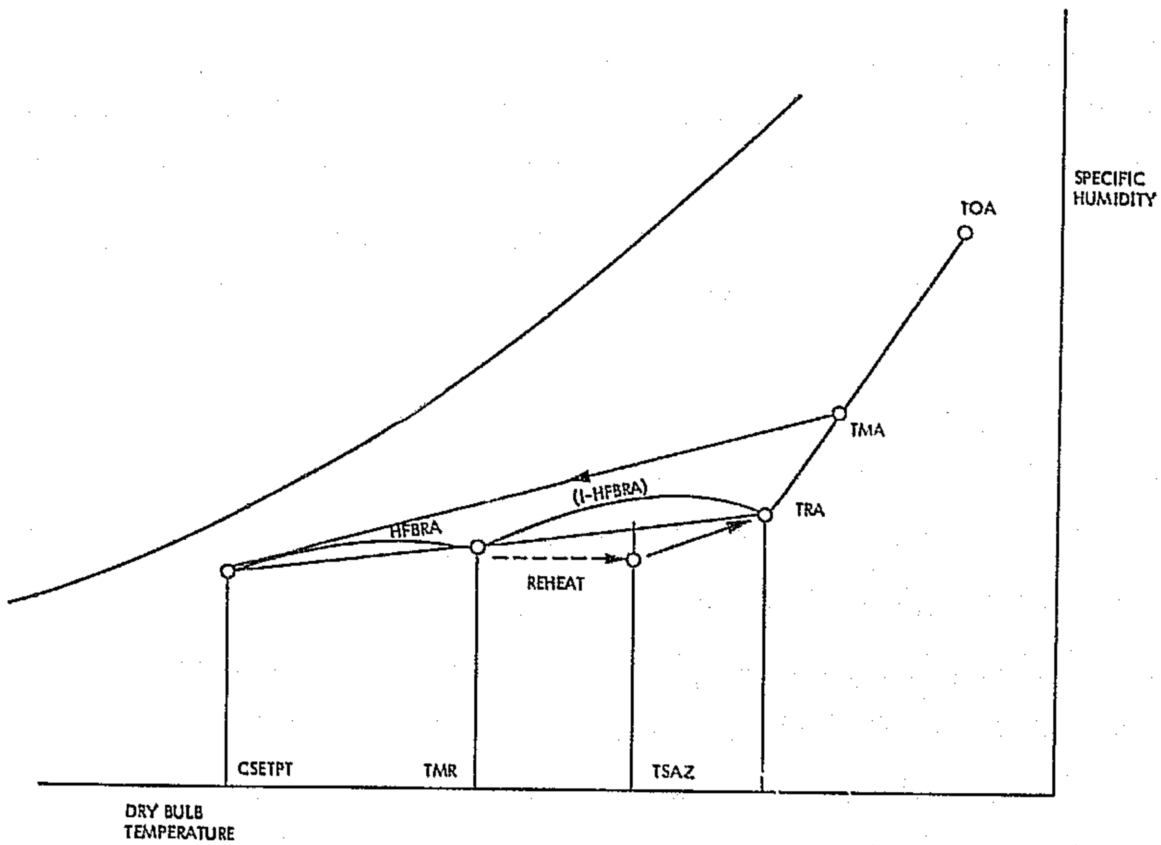


Figure 8-24. Schematic of KEQ8 processes on the psychrometric chart

8.10 KEQ9 Subroutine

This subroutine simulates the performance of type "nine" air handler: a two-level room with constant volume cold plenum air rate and variable volume comfort air rate at fixed temperature. Cold plenum air is supplied at constant discharge to the main room through the electronic equipment racks. Variable volume hot deck temperature is supplied directly to the main room. Mixing of plenum and comfort air is assumed perfect and complete. A schematic of the air handler is shown in Fig. 8.25 and a flow chart of the subroutine algorithm is given in Fig 8.26. A schematic of the processes on the psychrometric chart is given in Fig. 8.27.

8.10.1 Calculation Procedure

1. Determine CFM1 and CFM2
   CFM2 = HFBRA*ZCFM = maximum comfort air discharge
   CFM1 = ZCFM - CFM2

2. Determine the supply air temperature to the zone (TSAZ1) assuming no comfort air at all is provided.
   TSAZ1 = TRA - QSUM/ (CFM1 *MLT)
   If TSAZ1 < 50 then TSAZ1 = 50

3. If TSAZ1 ≤ TPAM then the variable volume damper is closed. Cooling set point is automatically adjusted to be TSAZ1.
   (a) If ECON = 0 then go to item (e)
   (b) If ECON ≠ 0 and TOA > TRA then go to item (e)
   (c) If ECON ≠ 0 and TSAZ1 ≤ TOA ≤ TRA
       Then TMA = TOA and go to item (e)
   (d) If ECON ≠ 0 and TOA < TSAZ1
       Then TMA = TSAZ1 and go to item (e)
   (e) Determine cooling and heating loads and the actual room temperature
       QCC = CFM1*(TMA - TSAZ1) *MLT Btu/hr
       QHEL = 0.0
       QHBOL = 0.0
       TROOM = TSAZ1 + QSUM/CFM1*MLT ^{o}F
       Return to the main program.

4. If TSAZ1 > TPAM ECON =1 and TMA ≠ CSETPT then
   (a) If ECON = 0 go to item (e)
   (b) If ECON ≠ 0 and TOA > TRA go to item (e)
   (c) If ECON ≠ 0 and TPAM ≤ TOA ≤ TRA then
       TMA = TOA , go to item (e)
   (d) If ECON ≠ 0 and TOA < TPAM then
       TMA = TPAM, go to item (e)
   (e) Determine the actual cold and hot deck temperatures, SETLO and SETHI
       SETLO = MIN(TMA,TPAM)
       SETHI = MAX(TMA,HSETPT)
   (f) Determine the variable air discharge for comfort air, VCFM2
       VCFM2 = | CFM1*(TRA-TPAM)/(SETHI-TRA)| - |QSUM/MLT*(SETHI-TRA)| ,cfm
       If VCFM2 < 0 then VCFM2 = 0
       If VCFM2 > CFM2 then VCFM2 = CFM2

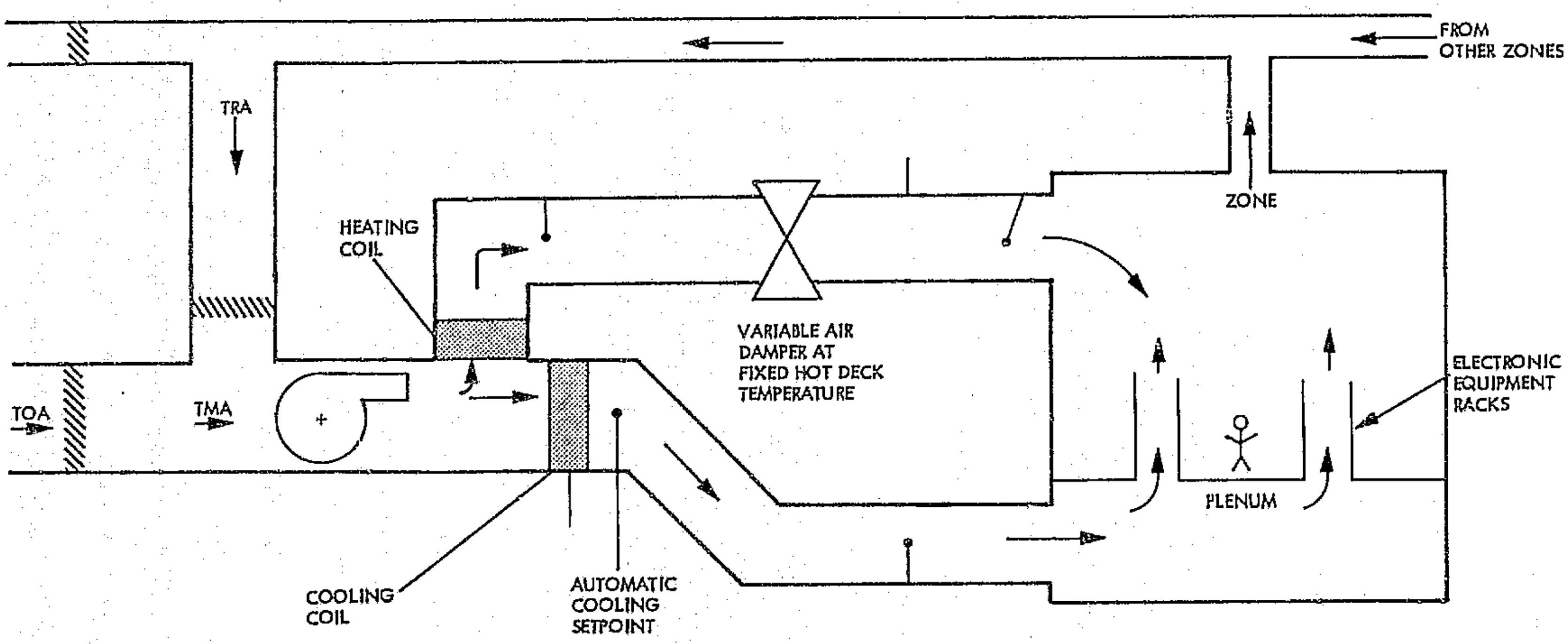


Figure 8-25. Two-level room with constant flow cold plenum air and variable volume comfort air at fixed temperature

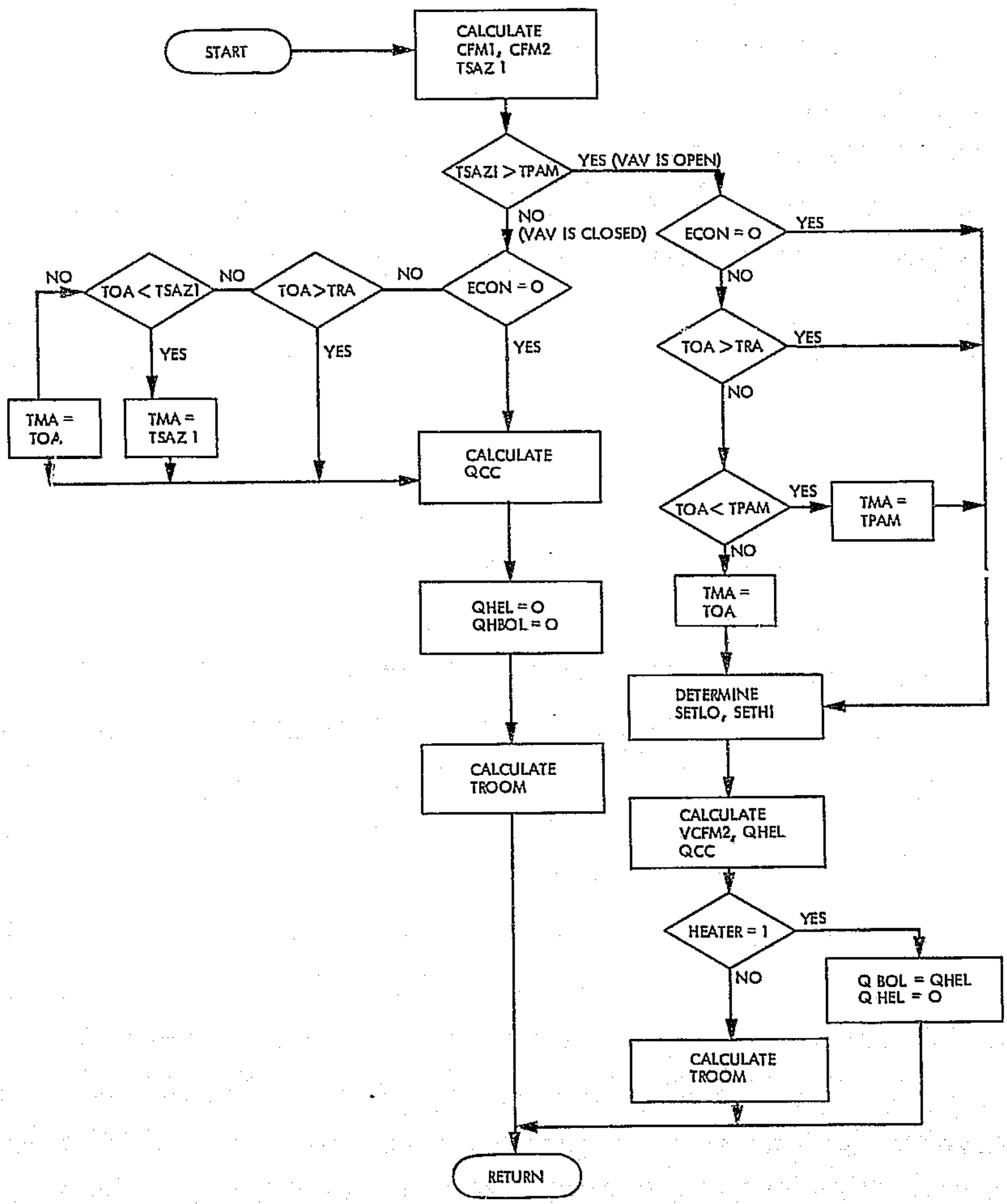


Figure 8-26. Flow chart of KEQ9 subroutine

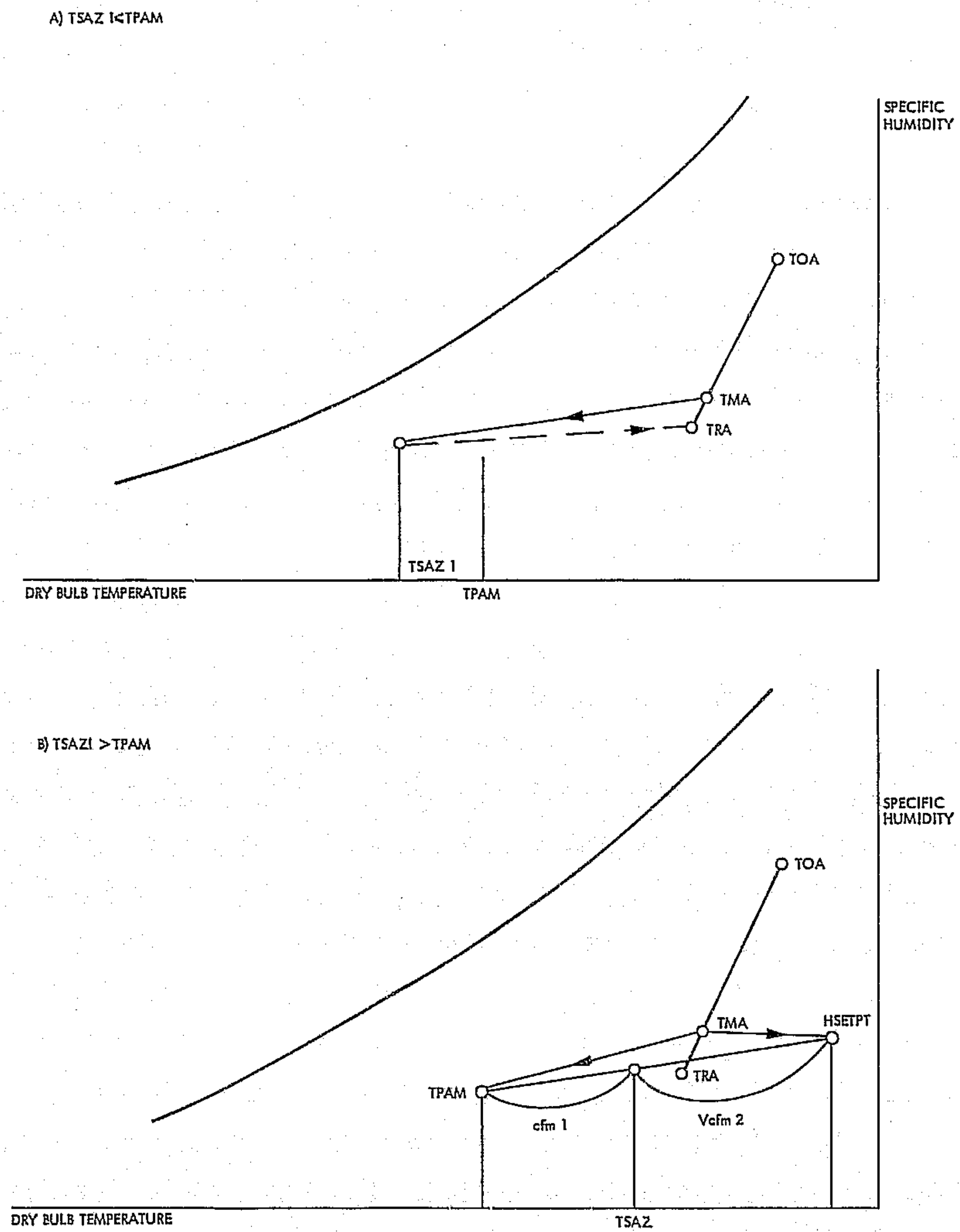


Figure 8-27. Schematic of KEQ9 processes on the psychrometric chart

g. Determine QHEL, QHBOL, QCC and TROOM

- If HEATER = 0 then
  QHEL = VCFM2*MLT*(SETHI - TMA) Btu/hr
  QHBOL = 0.0
- If HEATER = 1 then
  QHEL =0.0
  QHBOL = VCFMZ*MLT*(SETHI - TMA) Btu/hr
- QCC = MLT*CFM1*(TMA - SETLO) Btu/hr
- TROOM = |(VCFM2*SETHI) + (CFM1*SETLO) + (QSUM/MLT)| / (CFM1 + VCFM2) °F

Return to main program

SECTION IX
COP SUBROUTINE

9.1 Description

The coefficient of performance (COP) subroutine calculates the actual electric energy consumed by the compressor in electric-driven vapor compression refrigeration equipment. Both cooling (refrigeration) and heating (heat pump) modes are considered. The air handler heating or cooling loads, as computed from the main program ar converted in (COP) to the corresponding electrical consumption by the primary equipment.

Changes in equipment performance due to outside air temperature variations and inefficiencies due to partial load operation are considered.

9.2 Refrigeration Performance

Figure 9.1 illustrates the four basic components of a vapor compression refrigeration cycle: the compressor, condenser, evaporator and expansion (throttling) valve. Heat (Qe) is extracted from the space to be cooled to produce a phase change of the refrigerant from liquid to vapor. The vapor is compressed in a compressor from point (B) to (C) before it enters the condenser. In the condenser, the vapor (C) is condensed to liquid (D) while rejecting heat to the ambient air. The liquid is throttled to point (A) where the cycle is repeated. The mechanical work required in the compressor is

$$W = Q_c - Q_e$$

The coefficient of performance is defined as

$$(COP) = \frac{\text{refrigeration effect}}{\text{compressor work}} = \frac{Q_e}{Qc - Qe}$$

For an ideal Carnot cycle, the COP is given by

$$(COP)_{\substack{\text{Carnot}\\ \text{refrigeration}}} = \frac{Te}{Tc-Te}$$

where Tc and Te are the absolute temperatures of the condenser, and the evaporator, respectively.

Practically, a finite temperature difference in the condenser and the evaporator is assumed as shown in Fig. 9.2.

The following assumptions are made

1. In the cooling mode, the condensation temperature (T_c) in the condenser is assumed 40°F above the ambient air temperature (TOA).
2. In the cooling mode, the evaporation temperature (T_e) in the evaporator is below the desired cooling set point by 10°F.
3. The relative efficiency of an actual refrigerator compared to the ideal Carnot refrigerator is 49%. The relative efficiency value was abstracted from average conditions of air-cooled and water cooled chillers.

4. The electric power consumed, in cooling mode, per ton of refrigeration (PPT) is assumed constant for all partial loading down to 40% of the full tonnage of each compressor stage. On or below 40% of full loading, the refrigerator is assumed to consume a constant energy level corresponding to 40% of full load. Compressors are assumed to be made of two stages only with full cooling capacity delivered when the second stage is on.

$$(COP)_{act} = 0.49\ \frac{CSETPT + 450}{TOA\text{-}CSETPT + 50}$$

For example, if CSETPTis chosen to be 55.0^{o}F then the electric power (KWe) per 1 ton of refrigeration (12,000 Btu/hr) is

$$PPT = KWe/Ton' = 7.18*(TOA - 5.0)/505$$

9.3 Heat Pump Performance

Fig. 9.3 illustrates the cycle of events for the heat pump which are reversed between the condenser and the evaporator compared to Fig. 9.2. The heat is extracted from the relatively cold outside air and is pumped to the space air by providing the mechanical work in the compressor (W). The coefficient of performance for the heat pump is given by:

$$(COP)_{heat\ pump} = \frac{\text{heating effect}}{\text{compressor work}} = \frac{Qc}{Qc\text{-}Qe}$$

For an ideal Carnot cycle, the (COP) is given by

$$(COP)_{\substack{Carnot \\ heat\ pump}} = \frac{Tc}{Tc\text{-}Te}$$

where T is the absolute temperature.

Figure 9.3 shows the operating temperatures of a heat pump cycle allowing for a finite temperature difference in the condenser and the evaporator. The following assumptions are made:

1. In the heating mode, the condensation temperature (TC), in the condenser, is assumed 40^{o}F above the desired hot deck set point temperature (HSETPT).
2. In the heating mode, the evaporation temperature Te, in the evaporator, is assumed below the outside air temperature (TOA) by 10^{o}F.
3. The relative efficiency of an actual heat pump compared to the ideal Carnot's heat pump is 49%.
4. The electric power consumed (PPK) in heating mode, per 1 kilowatt (thermal) is assumed constant for all partial loading down to 40% of the full heating capacity of the machine. On or below 40% of full loading, the heat pump is assumed to consume an energy level corresponding to 40% of full load. For heating mode, the compressor is assumed to be single stage.

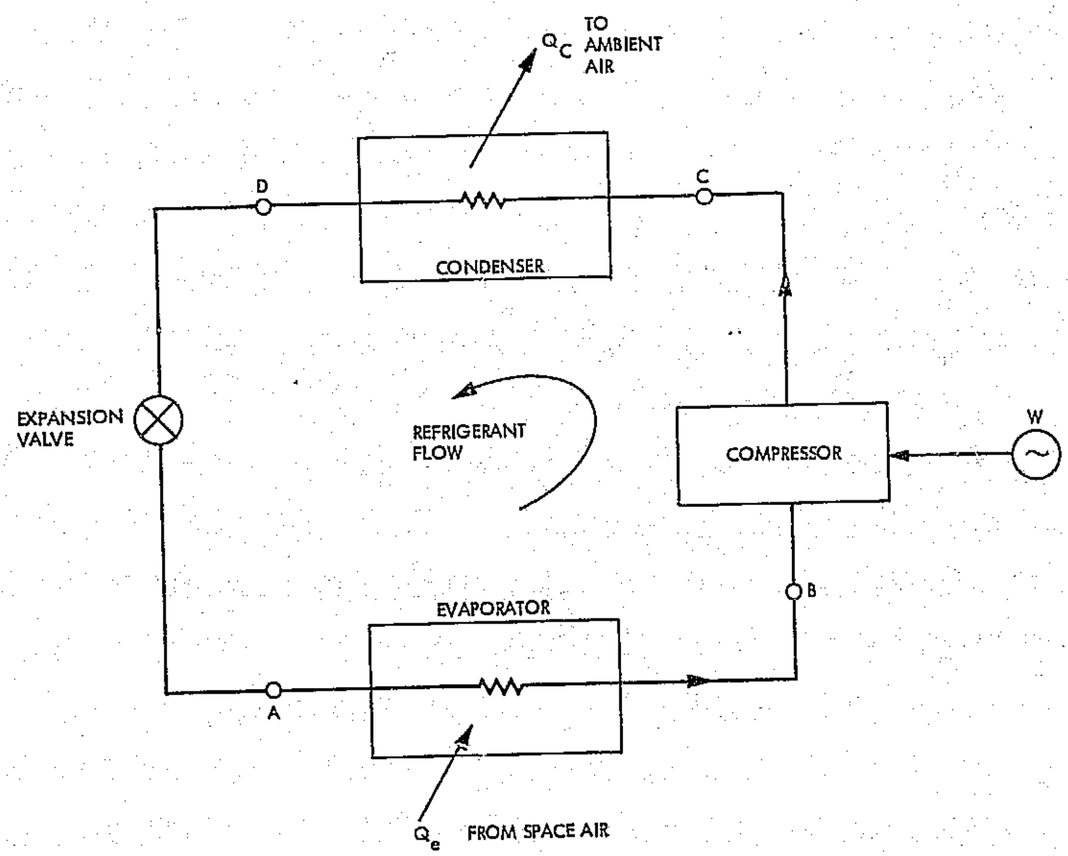


Figure 9-1 Refrigeration cycle

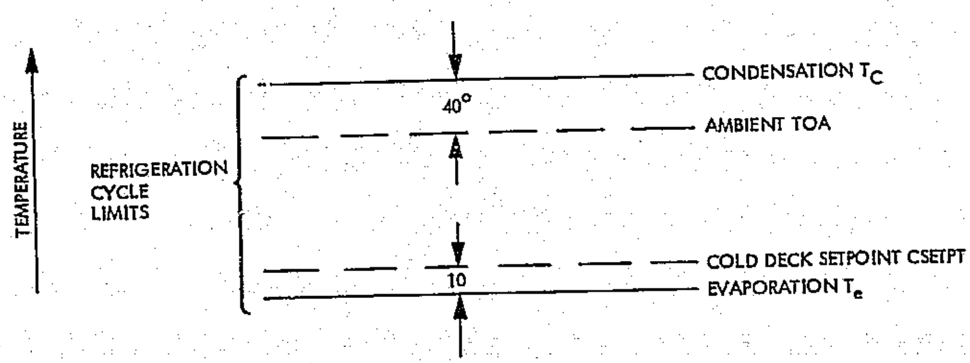


Figure 9-2. Operating temperatures of a refrigeration cycle

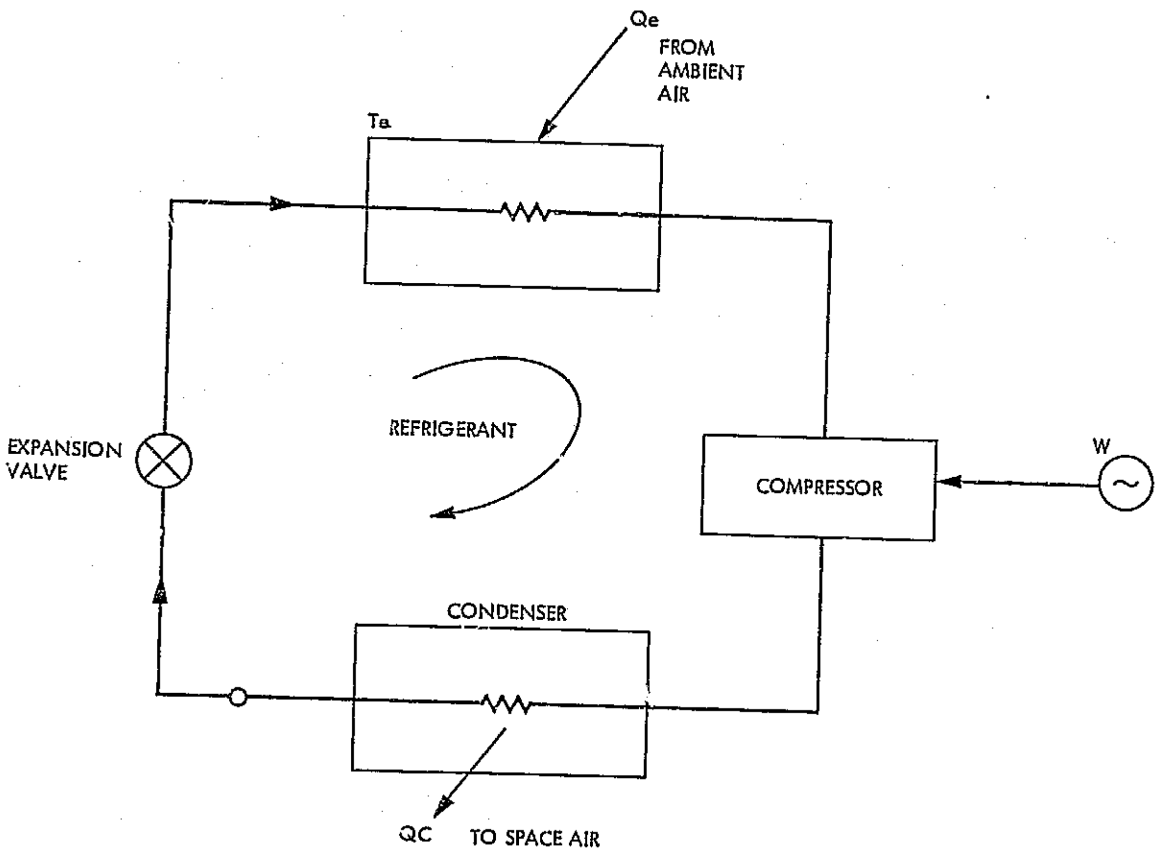


Figure 9-3 Heat pump cycle (Heating mode)

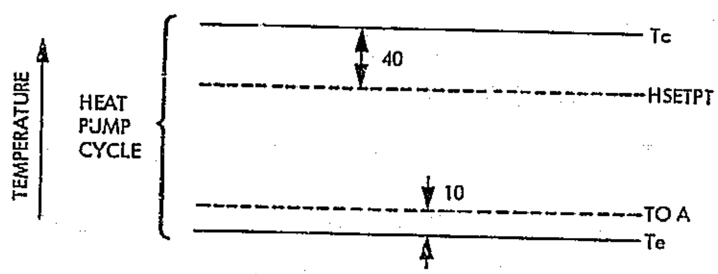


Figure 9-4. Operating temperatures of a heat pump cycle

Accordingly,

$$(COP)_{actual} = .49* \frac{(HSETPT + 500)}{(HSETPT - TOA + 50)}$$

9.4 Variables List

Variable	Description
C	cooling load, tons
CDSIZ1	fraction of first stage cooling load
CSETPT	cold deck set point, ^{o}F
CQCC	compressor cooling load in Btu/hr or KWe
CQHHP	heat pump heating load, Btu/hr or KWe
FFC1	fraction of full load of first stage (cooling)
FFC2	fraction of full load of second stage (cooling)
FFH	fraction of full heating capacity (heat pump)
HSETPT	hot deck set point, ^{o}F
PPK	electric power per KW_t (heat pump), KWe
PPT	electric power per TONS (cooling), KWe
SIZE(1)	first-stage compressor SIZE, TONS
SIZE(2)	second stage compressor SIZE, TONS
SIZE(3)	heat pump capacity (Btu/hr)
TOA	outside air temperature, ^{o}F

9.5 Computation Procedure

1. Convert the compressor cooling load CQCC(Btu/hr) to tons of refrigeration

   C = CQCC/12000 tons

2. Calculate the power per ton of refrigeration

   PPT = 7.18*(TOA- 5.0)/505

3. Determine the partial loading of each compressor stage
   a. If the required cooling tons (C) is less than the size of stage 1 (SIZE1) then only the first stage is loaded and the fraction of full cooling capacity of stage 1 is:
   $FFC1 = \text{maximum}\left(0.4, \frac{C}{SIZE\ 1}\right)$ and FFC2 = 0.0
   b. If C > [SIZE1 + SIZE2] then write a warning message,
   CQCC(in KWe) = PPT*C

c. If [SIZE1 + SIZE2] > C > SIZE 1 then
C2 = (C - SIZE1)/SIZE2
where C2 is the fraction of full cooling capacity of stage 2.
FFC2 = maximum (0.4,C2)

4. Calculate the electrical consumption of the compressor, in KWe
CQCC = PPT*(FFC1*SIZE1 + FFC2*SIZE2)

5. If a heat pump is used for heating, calculate the power per kilowatt thermal assuming 85^{o} hot deck set point.
PPK = (135.0 - TOA)/(.49*585) KWe/KWt

6. Calculate the fraction of full load for the heat pump and the electric power consumption.
FFH = CQHHP/SIZE3

a. If FFH < 0.4 then
FFH = 0.4
CQHHP = (0.4*SIZE3*PPK)/3413.0 KWe

b. If FFH ≥ 0.4 then
CQHHP = CQHHP*PPK/3413.0 KWe

The subroutine flow chart is sketched in Fig. 9.5.

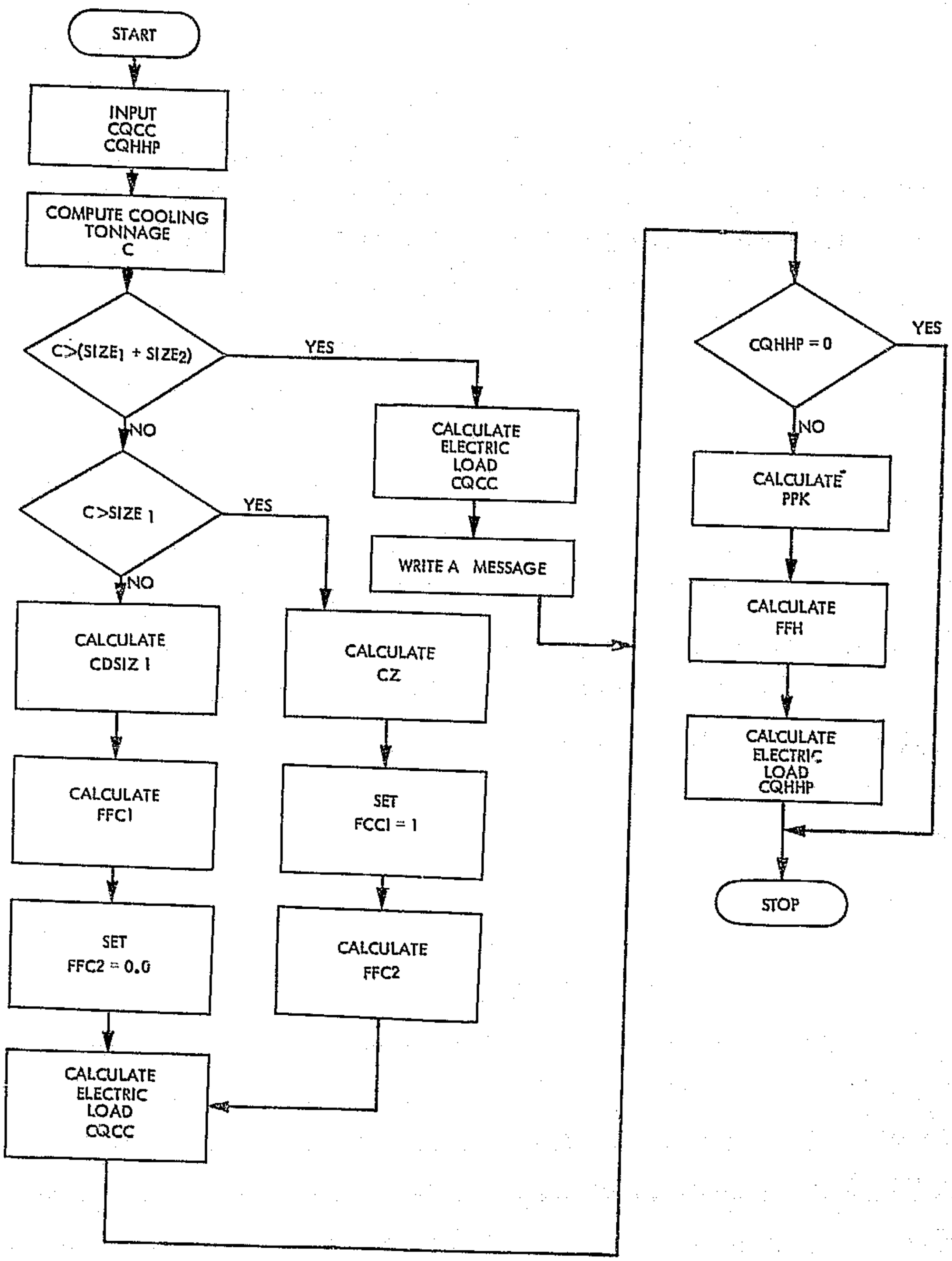


Figure 9-5. Flow chart of [COP] subroutine

REFERENCES

1. Technical Guidelines for Energy Consumption. Final report No. AFCEC-TR-TI-12 for period Dec. 75 - March 77. Published Buildings Environmental Div., NBS Dept. of Commerce, Washington D. C. 20234

2. Chen, S.Y.S., "Existing Load and Energy Programs", Heating-piping and Air Conditioning, Dec. 75, pp. 35 - 39.

3. American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals, 1972.

4. Threlkeld, J. L., "Thermal Environmental Engineering" Prentice-Hall Inc., New Jersey, 1962.

APPENDIX "A"

PROGRAM LISTING

A.1 List of Program Variables

The following Table A.1 provides a brief description of the program variables.

TABLE A.1 List of Program Variables

Variable	Description
A	Solar radiation parameter, Btu/hr.ft^2
ABSORT (or ALPHA)	Outside wall solar absorptivity
ACCERY	Daily energy consumption by accessories, KWH_e
ADJ	Adjacent zone identifier
AGLAS	Glass area, ft^2
AH	Air handler type identifier
ALFA	Outside air to total air discharge ratio
AQCC	Air handler cooling load on cooling coils, Btu/hr
AQHBOL	Air handler heating load on gas-fired boilers, Btu/hr
AQHEL	Air handler heating load on electric heaters, Btu/hr
AQHHP	Air handler heating load on heat pump, Btu/hr
ATZVOL	Summation of zones volume fed by common air handler, ft^3
AWAL / AWALL	Wall (or roof) surface area, ft^2
B	Solar radiation extinction coefficient
BF	Bypass factor
BLDG	Alpha-numeric name of building under study
BOLEFF	Combustion efficiency for gas-fired boilers
C	Diffuse radiation parameter
C	Compressor cooling load in tons
C2	Second stage compressor cooling load in tons
CAPACY	Total air circulation of a given air handler, cfm
CCF	Cloud cover factor
CDSIZ1	Fraction of full load on first stage compressor
CFM1	Plenum air discharge
CFM2	Comfort air discharge
CLIMIT	Maximum number of compressors
CLK	Time clock
CNUM	Compressor number or index

TABLE A.1 (cont'd)

Variable	Description
COP	Coefficient of performance
COPRES	Compressor-air handler distribution index
COUNTC	Compressor counter flag
COUNTE	Counter index
CPF	Cooling coil pass-factor
CQCC	Compressor cooling load for all air handlers, Btu/hr
CQHHP	Compressor heating load for all air handlers, Btu/hr
CSETPT	Cold deck set point temperature, ^{o}F
DATYPE,DYTP	Type-of-day identifier
DCQCC	Sum of cooling loads on compressors for 24 hrs.
DEC	Declination angle, radian
DEZCFM	Design value of zone CFM
DKWHE	Cost of KWH_e in dollars
DKWHT	Cost of KWH_t in dollars
DT	Temperature difference = (TOA-TRA)
ECHO	Subroutine to echo input data
ECON	Outside air economizer cycle identifier
EPOWER	Daily sum of electrical energy in zone consumed by electrical and mechanical equipment, KWHe/daytype
EQPWR	Daily sum of electrical energy in building consumed by electrical and mechanical equipment, KWHe/daytype
EYE	Flag or index
FFC1	Fraction of full load for first compressor stage
FFC2	Fraction of full load for second compressor stage
FFH	Fraction of full load for heat pump
FINMON	Monthly energy consumption and cost matrix
FLIP	Flag
FLOAT	Flag

TABLE A.1 (cont'd)

Variable	Description
GRREFL	Ground reflectivity
H, HOUR	Hour index
HA	Hour angle, radian
HALMT	Hour angle at sunrise or sunset, radian
HANDLR	Air handler namelist
HEAT, HEATER	Type of air handler heating source identifier
HF, HFBRA	Air discharge ratio for special air handlers
HLD, HLOAD	Heating load on heating coils, Btu/hr
HMAXAH	Maximum supply air temperature for multizones fed by a given air handler, ^{o}F
HMINAH	Minimum supply air temperature for multizones fed by a given air handler, ^{o}F
HO	Convective heat transfer coefficient for outside wall surface, $Btu/hr.ft^{2}\,^{o}F$
HSETPT	Hot deck set point temperature, ^{o}F
I,II	Index
IASTRK	Index
ICNTRL	Index for two-level zones
IDN	Direct normal solar radiation, $Btu/hr.ft^{2}$
INDEX	Index
ISET, IZ	Parameters for ECHO subroutine
J,JJ	Index
JFLAG	Index
K	Index
KEQ1	First air handler subroutine (K=1)
KEQ2	Second air handler subroutine (K=2)

TABLE A.1 (cont'd)

Variable	Description
KEQ3	Third air handler subroutine (K=3)
KEQ4	Fourth air handler subroutine (K=4)
KEQ5	Fifth air handler subroutine (K=5)
KEQ6	Sixth air handler subroutine (K=6)
KEQ7	Seventh air handler subroutine (K=7)
KEQ8	Eighth air handler subroutine (K=8)
KEQ9	Ninth air handler subroutine (K=9)
KEQUPE	Kilowatt of electrical equipment, KW_e
KEQUPM	Kilowatt of mechanical equipment, KW_e
KFLGHT	Kilowatt of fluorescent lights, KW_e
KLIMIT	Maximum number of air handlers in the building
KNUM	Air handler number or index
L	Index
LAT,LAT1	Latitude of the location, radian
LITPR	Daily sum of energy consumed by lights in a building KWHe/daytype
LPOWER	Daily sum of energy consumed by lights in a zone, KWHe/daytype
M	Parameter in ECHO subroutine
MAXAH	Maximum supply air temperature to all zones fed by a given air handler
MAXMO	Maximum number of months for program run
MAXQ	Maximum value of net heat gain QSUM
MAXTCP	Maximum cooling tonnage of a given compressor, tons of refrigeration
MAXTZN	Maximum zone cooling load per year, tons
MIALFA	Minimum ratio of outside ventilation air to total circulated air for a given air handler
MINAH	Minimum supply air temperature to all zones fed by a given air handler
MINCFM	Minimum outside ventilation air for a given air handler, cfm
MINQ	Minimum value of net heat gain QSUM
MLT	Altitude multiplier for [density*specific heat] product
MO,MONTH	Month index

TABLE A.1 (cont'd)

Variable	Description
N	Parameter for ECHO subroutine
NECHO	Index for ECHO subroutine
NEWHR	Hour index
NOP	Number of persons occupying a zone
NZONE	Number of zone
P	Parameter = PI*MO/6
PI	Constant π
PHIRF	Phase angle for heat transmission through roof, radian
PHIWL	Phase angle for heat transmission through wall, radian
PPK	Power per kilowatt (therm) for heat pumps, KW_e
PPT	Power per tons of refrigeration, KW_e
QCC	Zone cooling load by cooling coil, Btu/hr
QEQUP	Zone heat gain due to electrical and mechanical equipment, Btu/hr
QGLAS	Zone heat gain through glass areas, Btu/hr
QHBOL	Zone heating load by gas-fired boilers, Btu/hr
QHEL	Zone heating load by electric boilers, Btu/hr
QHHP	Zone heating load by heat pump, Btu/hr
QINF	Zone heat-gain/loss by infiltration, Btu/hr
QLIGHT	Zone heat gain by light sources, Btu/hr
QNOP	Zone heat-gain from people, Btu/hr
QPP	Heat dissipated per person, Btu/hr
QPPS	Heat dissipated per person in summer, Btu/hr
QPPW	Heat dissipated per person in winter, Btu/hr
QS	Zone heat gain by solar and ambient air effects through glass area only, Btu/hr
QSUM	Sum of zone heat-gain/loss, Btu/hr
QTRANS	Total heat transmission through walls and roofs, Btu/hr
QTRAUN	Transmission heat gain to zone by sol-air temperature method, for a given wall, $Btu/hr.ft^2$
QWAL	Heat transmission through zone walls and roofs, Btu/hr

TABLE A.1 (cont'd)

Variable	Description
REHEAT	Zone index identifying the type of terminal reheating system
RI	Index
SALT	Solar altitude angle, radian
SANGLE	Solar transmission angle
SAZM	Solar azimuth
SETHI	Heating coil set point temperature, ^oF
SETLO	Cooling coil set point temperature, ^oF
SETPTS	Set point temperatures, ^oF
SHADE	Ratio of wall unshaded area to total area
SI	Solar intensity, Btu/hr.ft^2
SIZE	Compressor cooling/heating capacity
STAR	Index
SUMBL1	Sum of gas-fired boiler loads on daytype 1
SUMBL2	Sum of gas-fired boiler loads on daytype 2
SUMCC1	Sum of cooling compressor loads on day 1
SUMCC2	Sum of cooling compressor loads on day 2
SUMHL1	Sum of electric heater loads on day 1
SUMHL2	Sum of electric heater loads on day 2
SUMHP1	Sum of heat pump loads on day 1
SUMHP2	Sum of heat pump loads on day 2
T	Zone cooling load in tons
TA	Glass solar transmissivity
TCOMFT	Supply air temperature to a zone from a given air handler
TE	Sol-air temperature, ^oF
TEM	Average Sol-air temperature for 24-hours, ^oF
THOT	Comfort air temperature of air fed into two-level room
TMA	Mixed air temperature at the air handler, ^oF
TMCLK	Index for time clock operation
TMR	Mixed air temperature at the zone in (KEQ8) subroutine

TABLE A.1 (cont'd)

Variable	Description
TNEXT	Temperature of next neighbouring zone ADJ=1, ^oF
TOA	Outside air temperature, ^oF
TOA1	Special zone temperature for ADJ=2, ^oF
TPAM	Max-plenum air temperature, ^oF
TRA	Zone return air temperature, ^oF
TRAA	Average return air temperature for zones fed by a given air handler
TROOM, TROOMA	Room temperature, ^oF
TSAZ, TSAZN	Supply air temperature to zone, ^oF
TSUM	Inside summer design temperature, ^oF
TTLAC1	Daily total energy consumed by accessories for daytype 1
TTLAC2	Daily total energy consumed by accessories for daytype 2
TWIN	Inside winter design temperature, ^oF
U	Overall heat transfer coefficient, Btu/hr. $ft^{2o}F$
UGLASS	Overall heat transfer coefficient for glass, Btu/hr.$ft^{2o}F$
UR, UW	Overall heat transfer coefficient for roof and walls, Btu/hr.$ft^{2o}F$
V	Amplitude of periodic heat transfer coefficient, Btu/hr.$ft^{2o}F$
VCFM2	Variable air volume for comfort
VOL	Zone volume, ft^3
VRF, VWL	Amplitude of periodic heat transfer coefficient for roof and walls, Btu/hr.$ft^{2o}F$
VSG	View factor between reflected solar energy and the ground
WAZM	Wall-azimuth angle
WMPH	Wind speed, mph
WSAZM	Wall-solar azimuth angle
WT	Wall tilt angle

TABLE A.1 (cont'd)

Variable	Description
YCQCC1	Yearly total energy consumption by compressor in daytype (1)
YCQCC2	Yearly total energy consumption by compressor in daytype (2)
YMAXAH	Yearly maximum supply air temperature to zones (MAXAH), ^{o}F
YMINAH	Yearly minimum supply air temperature to zones (MINAH), ^{o}F
YTQCC	Yearly total summation of cooling tons for all compressors
Z,ZN, ZONE	Zone index
ZCFM	Zone air discharge, cfm
ZLIMIT,ZLMT	Maximum number of zones in building
ZQCC	Zone share of cooling coil load, Btu/hr
ZQHBOL	Zone share of heating coil load using gas-boiler, Btu/hr
ZQHEL	Zone share of heating coil load using electric heater, Btu/hr
ZQHHP	Zone share of heating coil load using heat pump, Btu/hr

A.2 Listing of Program Source

13592*VIC(1).ECP-VA

```
C       FIRST PART OF THE ECP PROGRAM COMPUTES THE HEATING AND
C       COOLING LOAD FOR BUILDINGS
C
C
        DIMENSION  TOA(12,24),QWAL(24),SI(24,9),VOL(8)
        DIMENSION  CCF(12),QINF(24),HFBRA(8),TSUM(8),TWIN(8)
        DIMENSION QGLAS(24),QSUM(2,24),QNOP(2,24),WMPH(24),HO(24)
        DIMENSION QLIGHT(24,16),QEQUP(24,16),CAPACY(10)
        DIMENSION ACCERY(2,5),ALFA(10),QHEL(48,10)
        DIMENSION AQHEL(48,10),QHHP(48,10),AQHHP(48,10),QCC(48,10)
        DIMENSION AQCC(48,10),QHBOL(48,10),AQHBOL(48,10)
        DIMENSION SETPTS(2,10),SIZE(3,10),TMA(48,10),TSAZ(8,48)
        DIMENSION CSETPT(48,10), HSETPT(48,10)
        DIMENSION EPOWER(2,8),TCOMFT(8,48),EQPWR(2)
        DIMENSION UR(8),UW(8),PHIRF(8),PHIWL(8),VRF(8),VWL(8),TRA(8)
        DIMENSION TROOM(48),MONTH(12),FINMON(13,9),TROOMA(48,10)
        DIMENSION COPRES(10,10),COCC(48,10),COHHP(48,10)
        DIMENSION YCOCC1(10),YCOCC2(10),YMAXAH(10),YMINAH(10)
        DIMENSION HMAXAH(48,10), HMINAH(48,10)
        DIMENSION COUNTE(48,10),CFMPEN(8)
        DIMENSION QSUMNU(2,24),TSAZNU(8,48)
        DIMENSION KWH(24,24)
        DATA IBLANK /' '/
        INTEGER IP(8)
        IMPLICIT INTEGER (Z)
        REAL ZQHEL(48),ZQHHP(48),ZQCC(48),ZQHBOL(48)
        REAL MINCFM(10),MIALFA(10)
        REAL MAXAH(10),MINAH(10),MAXTZN(8),MAXTAH(10),MAXQ(8),MINQ(8)
        REAL MAXTCP(10)
        REAL NOP(24,16),KILGHT(24,16),KFLGHT(24,16),KEQUPE(24,16),KEQUPM(2
       74,16),LITPR(2),LAT,MLT
        REAL ZCFM(8,11),LPOWER(2,8)
        INTEGER ECON(10),FLIP,TMCLK(48,10)
        INTEGER REHEAT(8),HEATER(10),AH(8,10),ICNTRL(8,10)
        INTEGER DATYPE,HOUR,ADJ(9,8),JFLAG(48)
        INTEGER COUNTC,CLIMIT,CNUM,COPRES,COUNTE
        COMMON/AREA/ AWAL(9,8),AGLAS(9,8),TNEXT(8,8),SHADE(9,8)
        COMMON/WALL/ UR,UW,PHIRF,PHIWL,HO,VRF,VWL,ABSORT
        COMMON/DEC/ P,DEC,A,B,C,MO
        COMMON/K/ QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
        COMMON/CONST/MLT
        COMMON/ALL/BLDG,KLIMIT,ZLIMIT,VOL,TSUM,TWIN,AH,ALFA,
       ?            SIZE,COPRES,CLIMIT
        COMMON/CNT/ IP,QSUMNU,TRAA
        NAMELIST/HANDLR/ AH,SETPTS,SIZE,HEATER,REHEAT,KLIMIT,ZLIMIT,
       +    ACCERY,BLDG,ALFA,MAXMO,ECON,HFBRA,ZCFM,COPRES,CLIMIT,
       +  DKWHE,DKWHT,MLT,TMCLK,ICNTRL
        NAMELIST/INPUT1/ AWAL,AGLAS,VOL,TSUM,TWIN,ABSORT,     # 2/6/78
       +  UR,UW,PHIRF,PHIWL,VRF,VWL,ADJ,NOP,KILGHT,KFLGHT,KEQUPE,KEQUPM
       +,LAT,TPAM,NECHO,TAU,GRREFL,UGLASS,BOLEFF
       ?,TNEXT,SHADE
        COMMON/CONST2/LAT,TAU,GRREFL,UGLASS
        DATA /PI/3.14159/
        DATA MONTH/'JAN','FEB','MAR','APR','MAY','JUN','JUL','AUG',
       A    'SEP','OCT','NOV','DEC'/
C
```

ORIGINAL PAGE IS OF POOR QUALITY

```
      C
      C
      C
      C
      C**************    SET DEFAULT VALUES    ******************
      C
            DO 2 ZONE=1,8
            DO 1 J=1,9
            SHADE(J,ZONE)=1.
          1 CONTINUE
            TP(ZONE)=0
            CFMPEN(ZONE)=0.
            VOL(ZONE)=5500.
            TSUM(ZONE)=75.
            TWIN(ZONE)=75.
            UR(ZONE)=0.1
            UW(ZONE)=0.21
            PHIPF(ZONE)=1.3
            PHIWL(ZONE)=1.1
            VRF(ZONE)=0.05
          2 VWL(ZONE)=0.05
            ABSORT=.62
            QPPS=220.0
            QPPW=290.0
            TPAM=62.
            MAXMO=12
            NECHO=0
            LAT=.611
            TAU=0.88
            UGLASS=1.13
            GRREFL=0.2
            DKWHE=.03
            DKWHT=.012
            HLT=.97
            BOLEFF=.8
      C
      C*****************************************
      C
      C
      C@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
      C
      C    INPUT WEATHER DATA, NAMELIST $HANDLR,$INPUT1
      C
            READ(5,502) ((TOA(I,J), J=1,24), I=1,12)
            READ(5,501)  ( CCF(K), K=1,12)
            READ(5,502) (WMPH(L), L=1,24)       # 2/6/78
            READ(5,HANDLR)
            READ(5,INPUT1)
        501 FORMAT( 12F6.2)
        502 FORMAT(24F3.0)
      C
      C     COMPUTE WALL AND ROOF HEAT TRANSFER COEFFICIENT ACCORDING
      C     TO WIND SPEED
      C
            DO 4 I=1,24
          4 HO(I)=1.+WMPH(I)/3.
      C
```

```
C
C     SUM ACCESSORIES CONTRIBUTION
C     TTLAC1:  TOTAL ACCESSORIES IN KWE FOR DAYTYPE 1
C     TTLAC2:  TOTAL ACCESSORIES IN KWE FOR DAYTYPE 2
C
      DO 5 I=1,5
      TTLAC1=TTLAC1+ACCERY(1,I)
    5 TTLAC2=TTLAC2+ACCERY(2,I)
C
C
C     ECHO INPUT DATA IN PROPER FORMAT IF SO DESIRED
C
      IF(NECHO.EQ.1) CALL ECHO(NOP,KILGHT,KFLGHT,KEQUPE,
     ?   KEQUPM,LAT,ECON,TMCLK,ADJ,SETPTS)
C
C
C
C     COMPUTE CAPACITY IN CFM OF THE AH AND TOTAL CFM TO THE ZONES
C
      DO 20 ZONE=1,ZLIMIT
      DO 10 KNUM=1,KLIMIT
      CAPACY(KNUM)=ZCFM(ZONE,KNUM)+CAPACY(KNUM)
      ZCFM(ZONE,11)=ZCFM(ZONE,KNUM)+ZCFM(ZONE,11)
   10 CONTINUE
C
C     SUM LIGHTING IN KW AND EQUIPMENT LOADS IN KW
C     COMPUTE MINIMUM PERCENTAGE OF OUTSIDE AIR FOR AIRHANDLERS
C
C
      DO 15 DATYPE=1,2
      Z=2*ZONE-1
      IF (DATYPE.EQ.2) Z=Z+1
      DO 15 HOUR=1,24
      LPOWER(DATYPE,ZONE)=LPOWER(DATYPE,ZONE)+KFLGHT(HOUR,Z)
     ?                    +KILGHT(HOUR,Z)
      EPOWER(DATYPE,ZONE)=EPOWER(DATYPE,ZONE)+KEQUPE(HOUR,Z)
     ?                    +KEQUPM(HOUR,Z)
      QLIGHT(HOUR,Z)=KILGHT(HOUR,Z)*3413.+KFLGHT(HOUR,Z)*4266.
      QEQUP(HOUR,Z)=3413.*(KEQUPE(HOUR,Z)+.1*KEQUPM(HOUR,Z))
   15 CONTINUE
   20 CONTINUE
      DO 23 DATYPE=1,2
      DO 23 ZONE=1,ZLIMIT
      LITPR(DATYPE)=LITPR(DATYPE)+LPOWER(DATYPE,ZONE)
      EQPWR(DATYPE)=EQPWR(DATYPE)+EPOWER(DATYPE,ZONE)
   23 CONTINUE
C
      DO 30 KNUM=1,KLIMIT
      DO 25 ZONE=1,ZLIMIT
      IF(AH(ZONE,KNUM).NE.0) ATZVOL=ATZVOL+VOL(ZONE)
   25 CONTINUE
      MINCFM(KNUM)=MAX(ATZVOL/20.,.1*CAPACY(KNUM))
      ATZVOL=0.
      MIALFA(KNUM)=MINCFM(KNUM)/CAPACY(KNUM)
   30 CONTINUE
C
C
```

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```
C*   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
C     BEGIN MONTH BY MONTH CALCULATION
C *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
C
C     INITIALIZE KILOWATT-HOUR TABLE TO ZERO
C
C
      DO 3333 K=1,24
      DO 3333 LAX=1,24
      KWH(K,LAX)=0
 3333 CONTINUE
C
C     COMPUTE ACCESSORIES IN KW PER HR
C
      ACERY1=0
      ACERY2=0
      DO 3338 I=1,5
      ACERY1=ACERY1+ACCERY(1,I)
      ACERY2=ACERY2+ACCERY(2,I)
 3338 CONTINUE
C
C
      DO 90000 MO=1,MAXMO
C
C     COMPUTE VARIABLES P,DEC,A,B,C FOR SOLAR SUBROUTINE
C
      P=PI*MO/6.
      DEC=(0.2833-23.188*COS(P)-0.15*COS(2.*P)-0.211*SIN(P)
     A    +0.1155*SIN(2.*P))*PI/180.
      A=368.5+23.98*COS(P)-1.083*COS(2.*P)+4.893*SIN(P)-.722*SIN(2.*P)
      B=(171.58-33.08*COS(P)+3.08*COS(2.*P)-10.34*SIN(P)+1.3*SIN(2.*P))
     A    *1.E-03
      C=(90.333-39.63*COS(P)+6.83*COS(2.*P)-10.651*SIN(P)+3.17*SIN(2.*P)
     A    )*1.E-03
C
C
C [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]
C
C
C     SET INITIAL VALUES
C
      DO 33 HOUR=1,48
      DO 33 KNUM=1,KLIMIT
      AQHEL(HOUR,KNUM)=0.
      AQCC(HOUR,KNUM)=0.
      AQHHP(HOUR,KNUM)=0.
      AQHSOL(HOUR,KNUM)=0.
   33 CONTINUE
C
      DO 34 HOUR=1,48
      DO 34 CNUM=1,CLIMIT
      CQCC(HOUR,CNUM)=0.
      CQHHP(HOUR,CNUM)=0.
   34 CONTINUE
      DO 37 I=1,48
      DO 37 J=1,10
   37 COUNTE(I,J)=0
```

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```
      C
      C     SET DESIGN CONDITIONS FOR SUMMER/WINTER MONTHS
      C
            DO 35 ZONE=1,ZLIMIT
            TRA(ZONE)=TWIN(ZONE)
            OPP=OPPW
            IF(MO.LE.5.OR.MO.GE.10)GO TO 35
            TRA(ZONE)=TSUM(ZONE)
            OPP=OPPS
         35 CONTINUE
      C
      C     BEGIN ZONE BY ZONE EVALUATION OF THE HEATING/COOLING
      C     LOADS! AND EQUIPMENT ENERGY CONSUMPTIONS
      C
      C
            DO 500 ZONE=1,ZLIMIT
            IASTRK=0
      C
      C     SEARCH FOR ICNTRL EQUAL TO 1 FOR THIS ZONE
      C
            DO 38 KNUM=1,KLIMIT
            IF(ICNTRL(ZONE,KNUM) .EQ. 1) IP(ZONE)=1
         38 CONTINUE
      C
      C
      C
      C
      C
      C
      C     COMPUTE INFILTRATION LOAD
      C
            DO 1010 HOUR=1,24
       1010 QINF(HOUR)=VOL(ZONE)*.02*MLT*(TOA(MO,HOUR)-TRA(ZONE))
      C
      C     COMPUTE TRANSMISSION LOADS THRU WALLS AND ROOFS AND SOLAR LOADS
      C     THRU GLASSES
      C
            CALL SOLAR(TRA(ZONE),CCF,TOA,SI,QGLAS,ZONE)
            CALL TRANS(TRA(ZONE),TOA,SI,QWAL,ADJ,ZONE)
      C
      C
      C     HOURLY HEATING AND COOLING COIL SETPOINTS
            DO 39 I=1,48
            DO 39 KNUM=1,KLIMIT
            CSETPT(I,KNUM)=SETPTS(1,KNUM)
            HSETPT(I,KNUM)=SETPTS(2,KNUM)
         39 CONTINUE
      C
      C
      C     HEATING/COOLING LOADS
      C
            DO 1050 DATYPE=1,2
            Z=2*ZONE-1
            IF (DATYPE.EQ.2) Z=Z+1
            DO 1050 HOUR=1,24
            II=HOUR
            IF(DATYPE.EQ.2) II=HOUR+24
```

```
            QNOP(DATYPE,HOUR)=NOP(HOUR,Z)*QPP
            QSUM(DATYPE,HOUR)=QGLAS(HOUR)+QWAL(HOUR)+QINF(HOUR)+QLIGHT(HOUR,Z)
     2                 +QNOP(DATYPE,HOUR)+QEQUP(HOUR,Z)
            QSUMNU(DATYPE,HOUR)=QSUM(DATYPE,HOUR)
      C
      C
      C     BEGIN EQUIPMENT LOADS CALCULATIONS
      C
            IF(.NOT.(DATYPE.EQ.1 .AND. HOUR .EQ. 1)) GO TO 45
            IF(MO.NE.1) GO TO 50
            MINQ(ZONE)=QSUM(1,1)
            MAXQ(ZONE)=QSUM(1,1)
            GO TO 50
         45 MINQ(ZONE)=MIN(MINQ(ZONE),QSUM(DATYPE,HOUR))
            MAXQ(ZONE)=MAX(MAXQ(ZONE),QSUM(DATYPE,HOUR))
         50 CONTINUE
      C
      C     COMPUTE TSAZ: TEMP OF SUPPLY AIR TO ZONE
      C
            TSAZ(ZONE,II)=TRA(ZONE)-QSUM(DATYPE,HOUR)/(ZCFM(ZONE,II)*MLT)
            TSAZNU(ZONE,II)=TSAZ(ZONE,II)
      C
      C     COMPUTE NEW QSUM FOR AIRHANDLER FEEDING THE ZONE WITH ANOTHER
      C     AIRHANDLER FEEDING PLENUM ONLY ( ICNTRL=1)
      C
            KTU=2*KLIMIT
            DO 56  KK=1,KTU
            IF(KK .GT. KLIMIT) GO TO 57
            IF(AH(ZONE,KK) .EQ. 0) GO TO 56
            IF(ICNTRL(ZONE,KK) .NE. 1) GO TO 56
            QSUMNU(DATYPE,HOUR)=QSUMNU(DATYPE,HOUR)-(ZCFM(ZONE,KK)*MLT*
     A      (TRA(ZONE)-CSETPT(II,KK)))
            GO TO 56
      C
      C     COMPUTE MAX AND MIN TSAZ FOR AIRHANDLER FEEDING SEVERAL ZONES
      C
         57 KK1=KK-KLIMIT
            IF(AH(ZONE,KK1) .EQ. 0) GO TO 56
            COUNTE(II,KK1)=COUNTE(II,KK1)+1
            IF(IP(ZONE) .NE. 1) GO TO 1040
            IF(ICNTRL(ZONE,KK1)-1) 1020,1030,1020
       1020 TSAZNU(ZONE,II)=TRA(ZONE)-QSUMNU(DATYPE,HOUR)/(MLT*
     A      (ZCFM(ZONE,KK1)))
            GO TO 1040
       1030 TSAZNU(ZONE,II)=CSETPT(II,KK1)
       1040 IF(II .EQ. 1) MINAH(KK1)=TSAZNU(ZONE,II)
            IF(II .EQ. 1) MAXAH(KK1)=TSAZNU(ZONE,II)
            IF(COUNTE(II,KK1) .GT. 1) GO TO 1060
            HMINAH(II,KK1)=TSAZNU(ZONE,II)
            HMAXAH(II,KK1)=TSAZNU(ZONE,II)
       1060 HMINAH(II,KK1)=MIN(HMINAH(II,KK1),TSAZNU(ZONE,II))
            HMAXAH(II,KK1)=MAX(HMAXAH(II,KK1),TSAZNU(ZONE,II))
            MAXAH(KK1)=MAX(MAXAH(KK1),HMAXAH(II,KK1))
            MINAH(KK1)=MIN(MINAH(KK1),HMINAH(II,KK1))
         56 CONTINUE
       1050 CONTINUE
      C
```

```
C .    EVALUATE THA (TEMP OF MIXTURE AIR)/AH/HOUR
C      COMPUTE TEMP OF RETURN AIR
C
       DO 80 KNUM=1,KLIMIT
       TRAA=0.
       DO 60 NZONE=1,ZLIMIT
       TRAA=TRA(NZONE)*ZCFM(NZONE,KNUM)+TRAA
       IF(AH(ZONE,KNUM) .EQ. 0) GO TO 80
    60 CONTINUE
       TRAA=TRAA/CAPACY(KNUM)
       DO 75 II=1,48
       HOUR=II
       IF(II.GT.24)HOUR=HOUR-24
       IF(ECON(KNUM)-1)70,65,61
C
C      BARBER-COLMAN TYPE ECONOMISER
C
    61 WRITE(6,604) ECON(KNUM),HOUR,MONTH(MO),KNUM,ZONE
       IF(HMINAH(II,KNUM).GT.TRAA)GO TO 63
C      IN COOLING MODE
       IF(HMINAH(II,KNUM).LE.TOA(MO,HOUR))GO TO 62
       THA(II,KNUM)=HMINAH(II,KNUM)
       CSETPT(II,KNUM)=HMINAH(II,KNUM)
       HSETPT(II,KNUM)=MAX(HMAXAH(II,KNUM),60.)
       IF(COUNTE(II,KNUM) .EQ. 1) HSETPT(II,KNUM)=THA(II,KNUM)
       GO TO 75
    62 HSETPT(II,KNUM)=HMAXAH(II,KNUM)
       GO TO 70
C      IN HEATING MODE
    63 IF(HMINAH(II,KNUM).LT.TOA(MO,HOUR)) GO TO 64
       THA(II,KNUM)=ALFA(KNUM)*TOA(MO,HOUR)+(1.-ALFA(KNUM))*TRAA
       CSETPT(II,KNUM)=THA(II,KNUM)
       HSETPT(II,KNUM)=HMAXAH(II,KNUM)
       GO TO 75
    64 THA(II,KNUM)=HMINAH(II,KNUM)
       CSETPT(II,KNUM)=HMINAH(II,KNUM)
       HSETPT(II,KNUM)=HMAXAH(II,KNUM)
       IF(COUNTE(II,KNUM) .EQ. 1) CSETPT(II,KNUM)=THA(II,KNUM)
       GO TO 75
C
C      HONEYWELL TYPE ECONOMISER
C
    65 IF(TSAZ(ZONE,II) .GT.TRAA) GO TO 70
       WRITE(6,604)  ECON(KNUM),HOUR,MONTH(MO),KNUM,ZONE
       IF(TOA(MO,HOUR).GT.TRAA) GO TO 70
       THA(II,KNUM)=CSETPT(II,KNUM)
       IF(TOA(MO,HOUR) .LE. TRAA.AND. TOA(MO,HOUR) .GE.CSETPT(II,KNU
      +M)) THA(II,KNUM)=TOA(MO,HOUR)
   604 FORMAT('  ECON=',I1,' IS ON AT HOUR =',I3,3X,'IN ',A4,1X,
      ?'FOR AIR-HANDLER',I3,2X,'FEEDING ZONE',I2)
       GO TO 75
C
C      NO ECONOMISER
C
    70 THA(II,KNUM)=ALFA(KNUM)*TOA(MO,HOUR)+(1.-ALFA(KNUM))*TRAA
    75  CONTINUE
    80 CONTINUE
```

```
      C
      C     SET INITIAL VALUES FOR EQUIPMENT LOADS
      C
            DO 85 HOUR=1,48
            ZQHEL(HOUR)=0
            ZQHHP(HOUR)=0
            ZQCC(HOUR)=0
            ZQHBOL(HOUR)=0
            DO 85 KNUM=1,KLIMIT
            QHEL(HOUR,KNUM)=0
            QHHP(HOUR,KNUM)=0
            QCC(HOUR,KNUM)=0
            QHBOL(HOUR,KNUM)=0
         85 CONTINUE
      C
      C
      C     TEST ZCFM ELEMENTS FOR NONZERO VALUE AND CALL APPROPRIATE SUBRTN
      C     TO COMPUTE A/C EQUIPMENT LOADS
      C
            DO 136 KNUM=1,KLIMIT
            IF(AH(ZONE,KNUM).EQ.0) GO TO 136
      C
            K=AH(ZONE,KNUM)
            GO TO(90,100,110,120,122,124,126,128,129),K
      90    CALL KEQ1(KNUM,ICNTRL,TCOMFT,ZONE,QHEL,QCC,QHBOL,TROOM)
            GO TO 130
      100   CALL KEQ2(KNUM,ICNTRL,TCOMFT,ZONE,QHEL,QCC,QHBOL,TROOM)
            GO TO 130
      110   CALL KEQ3(QHBOL,QCC,QHEL,KNUM,ICNTRL,TCOMFT,ZONE,TROOM)
            GO TO 130
      120   CALL KEQ4(QCC,QHEL,QHHP,QHBOL,ZONE,KNUM,ICNTRL,TCOMFT,TROOM)
            GO TO 130
        122 CALL KEQ5(KNUM,ICNTRL,ZONE,QHEL,QCC,QHBOL,TROOM)
            GO TO 130
        124 CALL KEQ6(KNUM,ICNTRL,ZONE,QHEL,QCC,QHBOL,TROOM)
            GO TO 130
        126 CALL KEQ7(KNUM,ICNTRL,ZONE,QCC,QHBOL,QHEL,TROOM)
            GO TO 130
        128 CALL KEQ8(KNUM,ICNTRL,ZONE,QCC,QHBOL,QHEL,TROOM,TRA(ZONE))
            GO TO 130
      129   CALL KEQ9(KNUM,ICNTRL,ZONE,QHEL,QCC,QHBOL,TOA,ECON,MO,TPAH,TROOM,
           *          TRA(ZONE))
        130 DO 235 II=1,48
            JFLAG(II)=0
            IF(TMCLK(II,KNUM) .EQ. 1) JFLAG(II)=1
            IF(TMCLK(II,KNUM) .EQ. 1) IASTRK=1
            DATYPE=1
            HOUR=II
            IF(II .GT. 24) DATYPE=2
            IF(II .GT. 24) HOUR=II-24
            TROOMA(II,KNUM)=TROOM(II)
            IF(TMCLK(II,KNUM) .EQ. 0)  GO TO 233
      C
      C     TIME CLOCK IS ON, IMPLIES EQUIPMENT IS OFF
      C
            QHEL(II,KNUM)=0.
            QCC(II,KNUM)=0.
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```
      QHHP(II,KNUM)=0.
      QHBOL(II,KNUM)=0.
  233 TROOM(II)=0
C
C     EQUIPMENT IS ON ; SUM ZONE EQUIPMENT LOADS TO AH EQUIPMENT
C     LOADS AND COMPUTE MAX TONNAGE FOR AIRHANDLER
C
      AQHEL(II,KNUM)=AQHEL(II,KNUM)+QHEL(II,KNUM)
      AQHHP(II,KNUM)=AQHHP(II,KNUM)+QHHP(II,KNUM)
      AQCC(II,KNUM)=AQCC(II,KNUM)+QCC(II,KNUM)/12000.
      IF(II .EQ. 1 .AND. MO .EQ. 1) MAXTAH(KNUM)=AQCC(II,KNUM)
      MAXTAH(KNUM)=MAX(MAXTAH(KNUM),AQCC(II,KNUM))
      AQHBOL(II,KNUM)=AQHBOL(II,KNUM)+QHBOL(II,KNUM)
  235 CONTINUE
  136 CONTINUE
C
      WRITE(6,133)
  133 FORMAT('1',T3,'MO',T6,'ZONE',T11,'DAY=  HR',T20,'INFILTN',T30,
     ?'GLASS',T37,'TRANSMI N',T49,'LIGHT',T56,'POEPLE',T64,
     ?'EQUIPMENT',T75,'NE'  HEAT SUPPLIED RESULTANT COOLING',
     ?T112,'HEATER BOILEF    PUMP'/T11,'TYPE',T21,'(BTU)',T30,'(BTU)',
     ?T39,'(BTU)',T49,'(BTU)',T57,'(BTU)',T66,'(BTU)',T77,'(BTU)',
     ?'  AIR TEMP  RM TEMP   (TONS)   (BTU)  (BTU)   (BTU)')
C
C     COMPUTE PROPER ROOM TEMP, ZONE MAX TONNAGE, AND PRINT OUTPUT
C
      DO 134 I=1,48
      DO 410 KNUM=1,KLIMIT
      TROOM(I)=TROOM(I)+TROOMA(I,KNUM)*ZCFM(ZONE,KNUM)
      TROOMA(I,KNUM)=0.
      ZQHEL(I)=QHEL(I,KNUM)+ZQHEL(I)
      ZQHHP(I)=ZQHHP(I)+QHHP(I,KNUM)
      ZQCC(I) =ZQCC(I) +QCC(I,KNUM)
      ZQHBOL(I)=ZQHBOL(I)+QHBOL(I,KNUM)
  410 CONTINUE
      TROOM(I)=TROOM(I)/ZCFM(ZONE,11)
      T=ZQCC(I)/12000.
      IF(I .EQ. 1 .AND. MO .EQ. 1) MAXTZN(ZONE)=T
      MAXTZN(ZONE)=MAX(MAXTZN(ZONE),T)
      Z=2*ZONE-1
      DATYPE=1
      HOUR=I
      IF(I.LE.24) GO TO 132
      Z=Z+1
      DATYPE=2
      HOUR=I-24
C
C
  132 IF(I .EQ. 1 .OR. I .EQ. 25)WRITE(6,666)
  666 FORMAT(/)
      IF(JFLAG(I) .EQ. 0) GO TO 137
      WRITE(6,131) MONTH(MO),ZONE,DATYPE,HOUR,QINF(HOUR),QGLAS(HOUR),
     ?QWAL(HOUR),QLIGHT(HOUR,Z),QMOP(DATYPE,HOUR),QEQUP(HOUR,Z),
     ?QSUM(DATYPE,HOUR),TSAZ(ZONE,I),TROOM(I),T,ZQHEL(I),ZQHBOL(I),
     ?ZQHHP(I)
  131 FORMAT(1X,A3,2I4,I5,1X,7F9.0,2F9.1,1X,'*',F7.2,3F8.0)
  138 FORMAT(//' * ASTRISK INDICATES TIMES AIRHANDLER IS OFF DUE TO TIME
```

```
     +  CLOCK'//)
        GO TO 134
  137 WRITE(6,135) MONTH(MO),ZONE,DATYPE,HOUR,QINF(HOUR),QGLAS(HOUR),
     ?QWAL(HOUR),QLIGHT(HOUR,Z),QNOP(DATYPE,HOUR),QEQUP(HOUR,Z),
     ?QSUM(DATYPE,HOUR),TSAZ(ZONE,I),TROOM(I),T,ZQHEL(I),ZQHBOL(I),
     ?ZQHHP(I)
  135 FORMAT(1X,A3,2I4,I5,1X,7F9.0,2F9.1,1X,F8.2,3F8.0)
  134 CONTINUE
      IF(IASTRK .EQ. 1) WRITE(6,138)
C
C
  500 CONTINUE
C
C     END ZONE BY ZONE CALCULATION
C
C
C   [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]  [*]
C
C     PRINT AIRHANDLER RELATED INFORMATIONS
C
C
      DO 700 KNUM=1,KLIMIT
      IF(MO.NE.1) GO TO 580
      YMINAH(KNUM)=MINAH(KNUM)
      YMAXAH(KNUM)=MAXAH(KNUM)
  580 YMINAH(KNUM)=MIN(YMINAH(KNUM),MINAH(KNUM))
      YMAXAH(KNUM)=MAX(YMAXAH(KNUM),MAXAH(KNUM))
      WRITE(6,610)
  610 FORMAT(1H1,2X,'AIR=',2X,'MO  DAY= HR  TEMP OF',4X,'COOLING',
     ?'   HEATER   BOILER    PUMP',T71,'MIN TSAZ',T84,'MAX TSAZ'/
     ?  1X,'HANDLER',5X,'TYPE',5X,
     ?'MIXED AIR',4X,'(TONS)',T46,'(BTU)',T55,'(BTU)',T63,'(BTU)',
     ?  T72,'(DEG F)',T85,'(DEG F)'//)
C
      WRITE(6,615) (KNUM,MONTH(MO),HOUR,TMA(HOUR,KNUM),AQCC(HOUR,KNUM),
     ?AQHEL(HOUR,KNUM),AQHBOL(HOUR,KNUM),AQHHP(HOUR,KNUM),
     ?  HMINAH(HOUR,KNUM),HMAXAH(HOUR,KNUM),HOUR=1,24)
  615 FORMAT(I5,4X,A3,3X,'1',I4,F8.1,4X,F8.2,1X,3F9.0,
     + 5X,F6.2,5X,F6.2)
C
      WRITE(6,666)
C
      WRITE(6,620)(KNUM,MONTH(MO),HOUR,TMA(HOUR,KNUM),AQCC(HOUR+24,KNUM)
     ?,AQHEL(HOUR+24,KNUM),AQHBOL(HOUR+24,KNUM),AQHHP(HOUR+24,KNUM),
     ? HMINAH(HOUR+24,KNUM),HMAXAH(HOUR+24,KNUM),HOUR=1,24)
  620 FORMAT(I5,4X,A3,3X,'2',I4,F8.1,4X,F8.2,1X,3F9.0,
     +  5X,F6.2,5X,F6.2)
C
      WRITE(6,625) MINAH(KNUM)
C
      WRITE(6,630) MAXAH(KNUM)
  625 FORMAT(T20,'* MONTHLY MIN SUPPLY AIR TEMP =',F5.1)
C
  630 FORMAT(T50,'* MONTHLY MAX SUPPLY AIR TEMP =',F5.1)
  700 CONTINUE
C
C     SUM COOLING LOADS FOR COMPRESSORS AND COMPUTE THE MAX TONNAGE
```

```
      C     PER COMPRESSOR
      C
      C
            DO 800 CNUM=1,CLIMIT
            DO 750 INDEX=1,KLIMIT
            KNUM=COPRES(CNUM,INDEX)
            IF(KNUM.EQ.0) GO TO 800
            DO 750 HOUR=1,48
            CQCC(HOUR,CNUM)=CQCC(HOUR,CNUM)+AQCC(HOUR,KNUM)
            IF(HOUR .EQ. 1 .AND. MO .EQ. 1) MAXTCP(CNUM)=AQCC(HOUR,CNUM)
            MAXTCP(CNUM)=MAX(MAXTCP(CNUM),CQCC(HOUR,CNUM))
            CQHHP(HOUR,CNUM)=CQHHP(HOUR,CNUM)+AQHHP(HOUR,KNUM)
        750 CONTINUE
        800 CONTINUE
      C
      C     COMPUTE DAILY TOTAL TONNAGE, HOURS OF WHICH THE COMPRESSOR
      C     IS OFF AND YEARLY CUMMULATED TOTAL TONNAGE
      C
            DO 900 CNUM=1,CLIMIT
            WRITE(6,632)
            DATYPE=1
            DO 900 II=1,48
            IF(II.EQ.1.OR.II.EQ.25) WRITE(6,666)
            HOUR=II
            IF(II.LE.24) GO TO 950
            HOUR=II-24
            DATYPE=2
        950 IF(CQCC(II,CNUM).LT.0.001)COUNTC=COUNTC+1
            DCQCC=DCQCC+CQCC(II,CNUM)
            WRITE(6,633) CNUM,MONTH(MO),DATYPE,HOUR,CQCC(II,CNUM)
            IF(II.NE.24.AND.II.NE.48) GO TO 900
            WRITE(6,634)DCQCC,COUNTC
            FLIP=0
            IF(II.EQ.48)FLIP=1
            YCQCC1(CNUM)=YCQCC1(CNUM)+DCQCC*FLOAT(1-FLIP)
            YCQCC2(CNUM)=YCQCC2(CNUM)+DCQCC*FLOAT(FLIP)
            DCQCC=0.
            COUNTC=0
        900 CONTINUE
        632 FORMAT(1H1,T3,'COM=',T11,'MONTH',T18,'DAY=  HOUR  TONAGE',/
          ?        1X,'PRESSOR',T18,'TYPE')
        633 FORMAT(I5,6X,A3,2I6,F9.2)
        634 FORMAT(1H+,T47,'* DAILY TOTAL :',F8.2,' TONS',T79,'!',
          ?T85,'COMPRESSOR OFF : ',I2,' HR'///)
      C
      C     CALL COP AUBROUTINE TO COMPUTE COOLING LOADS IN KW BASED
      C     ON THE REFRIGERATION COP
      C
            CALL COP(CQCC,CQHHP,TOA,CLIMIT,SIZE,MO)
      C
      192   SUMHL1=0.0
            SUMHP1=0.0
            SUMCC1=0.0
            SUMBL1=0.0
            SUMHL2=0.0
            SUMHP2=0.0
            SUMCC2=0.0
```

```
              SUMBL2=0.0
      C
      C       SUM A/C EQUIPMENT LOADS IN KW FOR DAYTYPE 1 & 2
      C
              DO 210 KNUM=1,KLIMIT
              DO 200 I=1,24
              SUMHL1=SUMHL1+AQHEL(I,KNUM)/3413.
              SUMHP1=SUMHP1+AQHHP(I,KNUM)
              SUMCC1=SUMCC1+AQCC(I,KNUM)
        200   SUMBL1=SUMBL1+AQHBOL(I,KNUM)/(BOLEFF*3413.)
      C
              DO 205 I=25,48
              SUMHL2=SUMHL2+AQHEL(I,KNUM)/3413.
              SUMHP2=SUMHP2+AQHHP(I,KNUM)
              SUMCC2=SUMCC2+AQCC(I,KNUM)
        205   SUMBL2=SUMBL2+AQHBOL(I,KNUM)/(BOLEFF*3413.)
        210   CONTINUE
      C
      C       FILL OUT MONTH ENERGY CONSUMPTIONS AND ENERGY COST
      C
              FINMON(MO,1)=LITPR(1)*20.9+LITPR(2)*9.5
              FINMON(MO,2)=EQPWR(1)*20.9+EQPWR(2)*9.5
              FINMON(MO,3)=TTLAC1*20.9+TTLAC2*9.5
              FINMON(MO,4)=SUMCC1*20.9+SUMCC2*9.5
              FINMON(MO,5)=SUMHL1*20.9+SUMHL2*9.5
              FINMON(MO,8)=SUMBL1*20.9+SUMBL2*9.5
              FINMON(MO,6)=SUMHP1*20.9+SUMHP2*9.5
              FINMON(MO,7)=FINMON(MO,1)+FINMON(MO,2)+FINMON(MO,3)+FINMON(MO,4)
             * +FINMON(MO,5)+FINMON(MO,6)
              FINMON(MO,9)=FINMON(MO,7)*DKWHE+FINMON(MO,8)*DKWHT
      C
      C       COMPUTE THE KWH FOR THE BUILDING
      C
              DO 3337 K=1,24
              LAX=MO*2-1
              KWT1=0
              KWT2=0
              CH1=0
              CH2=0
              LZ=2*ZLIMIT
              DO 3335 N=1,LZ
              IF(MOD(N,2) .EQ. 1) GO TO 3336
              KWT2=KWT2+KILGHT(K,N)+KFLGHT(K,N)+KEQUPE(K,N)+KEQUPM(K,N)
              GO TO 3335
       3336   KWT1=KWT1+KILGHT(K,N)+KFLGHT(K,N)+KEQUPE(L,N)+KEQUPM(K,N)
       3335   CONTINUE
              DO 3339 KNUM=1,KLIMIT
              CH1=CH1+AQHEL(K,KNUM)/3413.+AQHHP(K,KNUM)+AQCC(K,KNUM)
              CH2=CH2+AQHEL(K+24,KNUM)/3413.+AQHHP(K+24,KNUM)+AQCC(K+24,KNUM)
       3339   CONTINUE
              KWH(K,LAX)=KWT1+ACERY1/24.+CH1
              LAX=LAX+1
              KWH(K,LAX)=KWT2+ACERY2/24.+CH2
       3337   CONTINUE
      90000   CONTINUE
      C
      C*   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *   *
```

```
C
C     END MONTH BY MONTH EVALUATIONS
C
C
C     PRINT KWH TABLE
C
      WRITE(6,777) (K,K=1,24)
  777 FORMAT('1',// 10X,' HOURLY  CONSUMPTION  IN  KW',//
     +  7X,'DAY' /1X,'MONTH TYPE ',24(2X,I2,1X))
      LM=2*MAXMO
      DO 40000  LAX=1,LM
      IF(MOD(LAX,2) .EQ. 1) GO TO 779
      L=LAX/2
      M=2
      GO TO 801
  779 L=IBLANK
      M=1
  801 WRITE(6,778) L,M,( KWH(K,LAX), K=1,24 )
  778 FORMAT(/ 2X,I2,5X,I1,2X,24(1X,I4))
40000 CONTINUE
C  *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *    *
C
      WRITE(6,690)
  690 FORMAT(1H1,115('*')/1H0,'ZONE        MIN 1 HR        MAX 1 HR',
     ?T43,'DESIGN',T57,'PRESENT',T72,'MAXIMUM'/
     ?T11,'HEAT GAIN',6X,'HEAT GAIN',T44,'CFM',T59,'CFM',T72,'TONNAGE',
     ?/T10, '(WHOLE YEAR)',3X,'(WHOLE YEAR)'/T13,'(BTU)',T28,'(BTU)'//)
C
C     COMPUTE DESIGN CFM FOR ZONES AND PRINT SUMMARIES FOR ZONE
C     AIRHANDLER AND COMPRESSOR RELATED INFORMATIONS
C
      DO 840 ZONE=1,ZLIMIT
      DEZCFM=MAX(MAXO(ZONE)/(23.*MLT), ABS(MINO(ZONE)/(15.*MLT)))
      WRITE(6,695)ZONE,MINO(ZONE),MAXO(ZONE),DEZCFM,ZCFM(ZONE,11),
     +  MAXTZN(ZONE)
  840 CONTINUE
      WRITE(6,655)
C
      WRITE(6,696)
      WRITE(6,697)(KNUM,MINCFM(KNUM),MIALFA(KNUM),YMINAH(KNUM),
     ?YMAXAH(KNUM),MAXTAH(KNUM),KNUM=1,KLIMIT)
C
  695 FORMAT(I4,F13.0,F15.0,8X,F8.0,6X,F8.0,9X,F6.1/)
  696 FORMAT(1H0,T4,'** DESIGN CONDITIONS'//,
     A  1X,'AIR',T34,3('YEARLY',5X)/,
     +  1X,'HANDLER',1X,'MIN CFM',
     ?3X,'MIN ALFA',T33,'MIN TEMP    MAX TEMP',T57,'MAX'/T33,
     ? 'SUPP AIR    SUPP AIR',T55,'TONNAGE'/)
  697 FORMAT(/I3,F12.0,5X,F5.3,2X,3F11.1)
      WRITE(6,655)
  655 FORMAT(1H0,115('*'))
C
      WRITE(6,680)
  680 FORMAT(///115('*')/1H0,T4,'COM-',T15,'YEARLY',T28,'YEARLY'/
     ?1X,'PRESSOR',T15,'TOTAL',T29,'MAX'/T13,'(TONHRS)',T27,'TONNAGE',/)
      DO 850 CNUM=1,CLIMIT
      YCOCC1(CNUM)=YCOCC1(CNUM)*20.9+YCOCC2(CNUM)*9.5
```

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```
              WRITE(6,685)CNUM,YCOCC1(CNUM),MAXTCP(CNUM)
              YTOCC=YTOCC+YCOCC1(CNUM)
          685 FORMAT(I5,5X,F10.1,5X,F6.1/)
          650 CONTINUE
              WRITE(6,677)YTOCC
          677 FORMAT(/T3,'TOTAL',F13.1/1H0,115('*'))
        C
              WRITE(6,220)
        220   FORMAT('1',115('*')/'0',T15,'LIGHT',T28,'EQPT',T42,'AUX',
             * T54,'COMP',T68,'ELEC',T81,'HEAT',T94,'ELEC',T107,'GAS',/1X,'MONTH
             *',T15,'POWER',T28,'POWER',T41,'POWER',T53,'CHILLER',T67,
             * 'HEATER',T81,
             *'PUMP',T93,'METER',T106,'BOILER',T118,'ENERGY COST'/1X,T13,
             * '(KWH/BLDG)',T26,'(KWH/BLDG)',T41,5('(KWH)',8X),T106,'(KWHT)',
             *  T119,'DOLLARS'/)
        C
        C      PRINT MONTH BY MONTH ENERGY CONSUMPTIONS, YEARLY TOTAL ENERGY
        C      CONSUMPTIONS, AND YEARLY ENERGY COST FOR THE BUILDING
        C
               DO 240 MO=1,MAXMO
        240    WRITE(6,245)MONTH(MO),(FINMON(MO,I),I=1,9)
        245    FORMAT('0',T5,A3,T13,9(E10.4,3X))
               DO 260 I=1,9
               DO 250 J=1,12
        250    FINMON(13,I)=FINMON(13,I)+FINMON(J,I)
        260    CONTINUE
               WRITE(6,270)(FINMON(13,I),I=1,9)
        270    FORMAT('0',T5,'TOTAL',T13,9(E10.4,3X)/'0',130('*'))
               STOP
               END
        C
        C****************************************************************************
        C
        C             END PROGRAM
        C
        C****************************************************************************
        C
```

@PRT,S VIC.ECHO=V

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ORIGINAL PAGE IS
OF POOR QUALITY

```
13592*VIC(1).ECHO-V
C       SUBROUTINE ECHO WILL ECHO THE INPUT DATA AND PRINT OUT IN PROPER
C       FORMAT
        SUBROUTINE ECHO(NOP,KILGHT,KFLGHT,KEQUPE,KEQUPM,LAT,ECON,
     +  THCLK,ADJ,SETPTS)
        DIMENSION  NOP(24,16),KILGHT(24,16),KFLGHT(24,16),KEQUPE(24,16)
        DIMENSI    KEQUPM(24,16),ECON(10),AH(8,10),SETPTS(2,10),SIZE(3,10)
        DIMENSION  HEATER(10),HFRRA(8),ZCFM(8,11),VOL(8),TSUM(8),TWIN(8)
        DIMENSION  UR(8),UW(8),COPRES(10,10),ALFA(10),FC(10),CLK(48)
        DIMENSION ADJ(9,8),CSETPT(48,10),HSETPT(48,10),HO(24)
        INTEGER  ECON,COPRES,ZLMT,ZLIMIT,AH,CLIMIT,HEATER,THCLK(48,10)
        INTEGER ADJ
        COMMON/AREA/ AWAL(9,8),AGLAS(9,8),THEXT(8,8),SHADE(9,8)
        COMMON/WALL/ UR,UW,PHIRF,PHIWL,HO,VRF,VWL,ABSORT
        COMMON/K/ QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,XH,HFRRA
        COMMON/ALL/ BLDG,KLIMIT,ZLIMIT,VOL,TSUM,TWIN,AH,ALFA,SIZE,COPRES,
     +    CLIMIT
        REAL NOP,KILGHT,KFLGHT,KEQUPE,KEQUPH,LAT,LAT1
        DIMENSION  QSUM(2,24),TSAZ(8,48),TMA(48,10),PHIRF(8),PHIWL(8)
        DIMENSION  VRF(8),VWL(8),HEAT(10)
        DATA /PI/3.14159/
C
C
        LAT1=LAT*180./PI
        WRITE(6,1000) BLDG, ZLIMIT, KLIMIT, AHS      LAT1
 1000 FORMAT(1H1,' *** ENERGY CONSUMPTION ESTIMATION FOR BUILDING ',A4/
     +    ' ***  NUMBER OF MACROZONES                          = ',I5,/,
     +    ' ***  NUMBER OF AIRHANDLERS                         = ',I5,/,
     +    ' ***  ABSORPTIVITY OF WALLS AN                      = ',F5.2,/,
     +    ' ***  LATTITUDE ANGLE FOR THE LOCATION              = ',F5.0,/)
        WRITE(6,1100)
 1100 FORMAT(/ 50('*'),'  ZONE  INPUT  DATA ',55('*'),//,
     +  ' ***  WALL AREA IN SQ. FT. ',/,
     +  ' ORIENTATION',T19,'S',T25,'SW',T31,'W',T37,'NW',T43,'SE',T49,
     +  'E',T55,'NE',T61,'N',T65,'ROOF',/,'     ZONE')
        DO 1200 I=1,ZLIMIT
        WRITE(6,1150)  I, (AWAL(...), J=1,9)
 1150 FORMAT( I6,5X,9F6.0)
 1200 CONTINUE
        WRITE(6,1210)
 1210 FORMAT(//' *** WALL ADJACENT COND    ONS ',T40,
     +  ' 0 FOR NO WALL OR PARTITIONS',
     +  /,T40,' 1 FOR AN INTERIOR                NTING A CONSTANT TEMP',/,
     +  T40,' 2 FOR AN INTERIOR                 ING A UNCONDITIONED ZONE',/,
     +  T40,' 3 FOR AN EXTERIOR                ED TO AMBIENT',//,
     +  ' ORIENTATION',T19,'S',T25,'SW',T31,'W',T37,'NW',T43,'SE',T49,
     +  'E',T55,'NE',T61,'N',T65,'ROOF',/,'     ZONE')
        DO 1230 I=1,ZLIMIT
        WRITE(6,1220) I,(ADJ(J,I),J=1,9)
 1220 FORMAT(I6,8X,9(I5,1X))
 1230 CONTINUE
C
        ISET=0
        DO 1250 M=1,9
        DO 1250 N=1,8
 1250 IF(ADJ(M,N) .EQ. 1) ISET=1
        IF(ISET .EQ. 0) GO TO 1290
```

```
      WRITE(6,1260)
 1260 FORMAT(//' *** ADJACENT TEMPERATURE',/,
     +  ' ORIENTATION',T19,'S',T25,'SW',T31,'W',T37,'NW',T43,'SE',T49,
     +  'E',T55,'NE',T61,'N',T65,'ROOF',/,'    ZONE')
      DO 1280 I=1,ZLIMIT
      WRITE(6,1270) I,(TNEXT(J,I),J=1,8)
 1270 FORMAT(I6,8X,8F6.1)
 1280 CONTINUE
 1290 WRITE(6,1292)
 1292 FORMAT(//' *** FRACTION OF UNSHADED AREA OF WALL',/,
     +  ' ORIENTATION',T19,'S',T25,'SW',T31,'W',T37,'NW',T43,'SE',T49,
     +  'E',T55,'NE',T61,'N',T65,'ROOF',/,'    ZONE')
      DO 1296 I=1,ZLIMIT
      WRITE(6,1295) I, (SHADE(J,I),J=1,9)
 1295 FORMAT(I6,8X,9F6.1)
 1296 CONTINUE
      WRITE(6,1300)
 1300 FORMAT( //, ' *** GLASS AREA IN SQ. FT. ',/,
     +  ' ORIENTATION',T19,'S',T25,'SW',T31,'W',T37,'NW',T43,'SE',T49,
     +  'E',T55,'NE',T61,'N',T65,'ROOF',/,'    ZONE')
      DO 1350 I=1,ZLIMIT
      WRITE(6,1150) I, (AGLAS(J,I), J=1,9)
 1350 CONTINUE
      WRITE(6,1400)
 1400 FORMAT( //,T51,'SCHEDULE',//,' ** OCCUPANCY LOAD',/)
      WRITE(6,1500)
 1500 FORMAT( T7,'DAY',/,' ZONE TYPE',T14,'1',T19,'2',T24,'3',T29,'4',
     + T34,'5',T39,'6',T44,'7',T49,'8',T54,'9',T58,'10',T63,'11',T68,
     + '12',T73,'13',T78,'14',T83,'15',T88,'16',T93,'17',T98,'18',T103,
     + '19',T108,'20',T113,'21',T118,'22',T123,'23',T128,'24'/)
      ICOUNT=0
      ZLMT=2*ZLIMIT
      DO 1600 I=1,ZLMT
      IZ=(I+1)/2
      ICOUNT=ICOUNT+1
      WRITE(6,1550) IZ, ICOUNT, (NOP(J,I), J=1,24)
 1550 FORMAT( I4,2X,I3,1X,24F5.1)
      IF( ICOUNT .EQ. 2) ICOUNT=0
 1600 CONTINUE
      WRITE(6,1700)
 1700 FORMAT(/' ** FLUORESCENT LIGHT IN KW ',/)
      WRITE(6,1500)
      DO 1800 I=1,ZLMT
      IZ=(I+1)/2
      ICOUNT=ICOUNT+1
      WRITE(6,1550) IZ, ICOUNT, ( KFLGHT(J,I), J=1,24)
      IF( ICOUNT .EQ. 2) ICOUNT=0
 1800 CONTINUE
      WRITE(6,1900)
 1900 FORMAT(/' ** INCANDESCENT LIGHT IN KW ',/)
      WRITE(6,1500)
      DO 2000 I=1,ZLMT
      IZ=(I+1)/2
      ICOUNT=ICOUNT+1
      WRITE(6,1550) IZ, ICOUNT, ( KILGHT(J,I),J=1,24)
      IF( ICOUNT .EQ. 2) ICOUNT=0
 2000 CONTINUE
```

```
          WRITE(6,2100)
     2100 FORMAT(/' ** ELECTRICAL EQUIPMENT LOAD IN KW',/)
          WRITE(6,1500)
          DO 2200 I=1,ZLMT
          IZ=(I+1)/2
          ICOUNT=ICOUNT+1
          WRITE(6,1550) IZ, ICOUNT, (KEQUPE(J,I),J=1,24)
          IF(ICOUNT .EQ. 2) ICOUNT=0
     2200 CONTINUE
          WRITE(6,2300)
     2300 FORMAT(/' ** MECHANICAL EQUIPMENT LOAD IN KW',/)
          WRITE(6,1500)
          DO 2400 I=1,ZLMT
          IZ=(I+1)/2
          ICOUNT=ICOUNT+1
          WRITE(6,1550) IZ, ICOUNT, (KEQUPM(J,I),J=1,24)
          IF( ICOUNT .EQ. 2) ICOUNT=0
     2400 CONTINUE
          WRITE(6,2500)
     2500 FORMAT(/'  MACROZONE',T46,'1',T54,'2',T62,'3',T70,'4',T78,'5',
         +  T86,'6',T94,'7',T102,'8',/)
          WRITE(6,2600)  (VOL(I),I=1,ZLIMIT)
          WRITE(6,2700)  (TSUM(I),I=1,ZLIMIT)
          WRITE(6,2800)  (TWIN(I),I=1,ZLIMIT)
          WRITE(6,2900)  (UR(I),I=1,ZLIMIT)
          WRITE(6,3000)  (UW(I),I=1,ZLIMIT)
     2600 FORMAT( ' VOLUME OF ZONE IN CU. FT.                  ',8F8.1)
     2700 FORMAT( ' SUMMER INSIDE DESIGN CONDITION (DEG F)',8F8.2)
     2800 FORMAT( ' WINTER INSIDE DESIGN CONDITION (DEG F)',8F8.2)
     2900 FORMAT( ' HEAT TRANSFER COEFF FOR WALLS           ',8F8.2)
     3000 FORMAT( ' HEAT TRANSFER COEFF FOR ROOFS           ',8F8.2)
C
C
          WRITE(6,3100)
     3100 FORMAT(//50('*'),' AIR HANDLER DATA ',60('*'),/,
         +  ' ** AIR HANDLER TYPE '/)
          WRITE(6,3200)
     3200 FORMAT(' AIRHANDLER NO.',T21,'1',T29,'2',T37,'3',T45,'4',T53,
         + '5',T61,'6',T69,'7',T77,'8',T85,'9',T92,'10',/,T5,'ZONE')
          DO 3300 I=1,ZLIMIT
          WRITE(6,3250) I, (AH(I,J), J=1,KLIMIT)
     3250 FORMAT( I8,7X,10(I6,2X))
     3300 CONTINUE
          WRITE(6,3310)
     3310 FORMAT(//' ** AIR HANDLER SCHEDULE WITH TIME CLOCK    '/)
          WRITE(6,3320)
     3320 FORMAT( T7,'DAY',/,'  AH  TYPE',T14,'1',T19,'2',T24,'3',T29,'4',
         + T34,'5',T39,'6',T44,'7',T49,'8',T54,'9',T58,'10',T63,'11',T68,
         + '12',T73,'13',T78,'14',T83,'15',T88,'16',T93,'17',T98,'18',T103,
         + '19',T108,'20',T113,'21',T118,'22',T123,'23',T128,'24'/)
          DO 3350 I=1,KLIMIT
          DO 3340 J=1,48
          CLK(J)=' ON'
          IF(TMCLK(J,I) .EQ. 1)  CLK(J)='OFF'
     3340 CONTINUE
          JJ=1
          WRITE(6,3345) I,JJ,(CLK(KK),KK=1,24)
```

```
      3345 FORMAT(I4,2X,[illegible],1X,24(2X,A3))
           JJ=JJ+1
           WRITE(6,3345) I,JJ,(CLK(KK),KK=25,48)
      3350 CONTINUE
           WRITE(6,3400)
      3400 FORMAT(/' ** AIR QUANTITY DISTRIBUTION IN CFM '/)
           WRITE(6,3200)
           DO 3500 I=1,ZLIMIT
           WRITE(6,3450) I, (ZCFM(I,J), J=1,KLIMIT)
      3450 FORMAT( I8,3X,10F8.1)
      3500 CONTINUE
           DO 3600 I=1,KLIMIT
           EC(I)='YES'
           HEAT(I)='ELEC'
           IF( ECON(I) .NE. 1) EC(I)='NO'
           IF( HEATER(I) .EQ. 1) HEAT(I)='GAS'
      3600 CONTINUE
           WRITE(6,3700)  (SETPTS(1,J),J=1,KLIMIT)
      3700 FORMAT(//' AIRHANDLER NO.',T29,'1',T37,'2',T45,'3',T53,'4',T61,
          + '5',T69,'6',T77,'7',T85,'8',T92,'9',T99,'10',/,
          + ' COLD DECK SETPOINT        ',10F8.2)
           WRITE(6,3800) ( SETPTS(2,J),J=1,KLIMIT)
           WRITE(6,3900) ( ALFA(J), J=1,KLIMIT)
           WRITE(6,4000) ( EC(J),J=1,KLIMIT)
           WRITE(6,4100) ( HEAT(J),J=1,KLIMIT)
      3800 FORMAT( ' HOT DECK SETPOINT        ',10F8.2)
      3900 FORMAT( ' PERCENT VENT AIR         ',10F8.2)
      4000 FORMAT( ' OUTSIDE AIR ECONOMIZER ',4X,10(A4,4X))
      4100 FORMAT( ' TYPE OF HEATING IN AH  ',3X,10(A4,4X))
     C
     C
     C
           WRITE(6,4200)
      4200 FORMAT(//50('*'),' COMPRESSOR DATA ',60('*'),/,
          + ' ** COMPRESSOR/AIRHANDLER DISTRIBUTION'/)
           DO 4400 I=1,CLIMIT
           WRITE(6,4300) I, (COMPRES(I,J),J=1,10)
      4300 FORMAT('  AIR HANDLER NO. CONNECTED TO ',I3,'  COMPRESSOR',10I5)
      4400 CONTINUE
           WRITE(6,4500)  ( SIZE(1,J),J=1,CLIMIT)
      4500 FORMAT(//' SIZE OF CONDENSERS AND HEAT PUMP',/' COMPRESSOR NO.',
          + T29,'1',T37,'2',T45,'3',T53,'4',T61,'5',T69,'6',T77,'7',T85,'8',
          * T92,'9',T99,'10',/' FIRST CONDENSER TONNAGE',10F8.2)
           WRITE(6,4600) ( SIZE(2,J), J=1,CLIMIT)
      4600 FORMAT( ' 2ND CONDENSER TONNAGE  ',10F8.2)
           WRITE(6,4700) ( SIZE(3,J),J=1,CLIMIT)
      4700 FORMAT( ' SIZE OF HEAT PUMP(BTU/H) ',10F8.1,///)
           WRITE(5,4800)
      4800 FORMAT( 130('*')///)
           RETURN
           END
```

@PRT,S VIC.SOLAR-V

```
13592*VIC(1).SOLAR-V
C      SOLAR SUBROUTINE COMPUTES THE SOLAR INTENSITY AND THE SOLAR ENERGY
C      INFLOW INTO THE SPACE THRU THE GLASS, ACCORDING TO THE SUN POSITION,
C      THE SURFACE ORIENTATION AND THERMAL PROPERTIES OF THE GLASS SURFACE.
C      THE SUBROUTINE WILL PERFORM THE COMPUTATION FOR 24 HOUR PERIOD AND
C      THE RESULT WILL BE IN THE ARRAYS SI(HR,ORN) AND QSUM(HR)
C      ASHRAE MODEL OF 1972 IS BEING USED IN THE SUBROUTINE TO COMPUTE
C      THE SOLAR INTENSITY
C
       SUBROUTINE  SOLAR(TRA,CCF,TOA,SI,QSUM,ZN)
       COMMON/DEC/ P,DEC,A,B,C,HO
       COMMON/AREA/ AWAL(9,8), AGLAS(9,8)
       REAL  IDN
       INTEGER ZN
       REAL LAT
       DATA  /PI/3.14159/
       DIMENSION TOA(12,24), SI(24,9), QSUM(24),CCF(12)
       COMMON/CONST2/LAT,TAU,GRREFL,UGLASS
C
C      SET INITIAL VALUES TO ZERO
C
       DO 100 I=1,24
       QSUM(I)=0.0
       DO 100 J=1,9
       SI(I,J)=0.0
   100 CONTINUE
C
C      COMPUTE THE HOUR ANGLE FOR SUNRISE TO SUNSET TO DETERMINE THE DAYLENGTH
C      AND COMPARE WITH THE HOUR ANGLE TO SEE WHETHER THE SUN IS PRESENT
C
       HALHT=ACOS(-TAN(LAT)*TAN(DEC))
       DO 600  I=1,24
       SALT=0.
       IDN=0.
       HA=(12-I)*15.*PI/180.
       DT=TOA(MO,I)-TRA
       IF(ABS(HA) .GT.HALHT) GO TO 1000
C
C      COMPUTE SUN RELATED VARIABLES SALT,IDN,SAZH
C
       SALT=ASIN(COS(LAT)*COS(DEC)*COS(HA)+SIN(LAT)*SIN(DEC))
       IF( SALT .LT. .02) GO TO 1000
       IDN=A/EXP(B/SIN(SALT))
       SAZH=ASIN(COS(DEC)*SIN(HA)/COS(SALT))
C
C      COMPUTE THE INCIDENT SOLAR INTENSITY ACCORDING TO THE WALL ORIENTATION,
C      THE SOLAR ENERGY THRU THE GLASS AND THE TOTAL SOLAR ENERGY INTO THE
C      SPACE
C
  1000 CONTINUE
       QSUM(I)=0.0
       DO 500 J=1,9
       IF( ABS(AWAL(J,ZN)).LT. .01 ) GO TO 500
       WT=PI/2.
       IF( J .GE. 9) WT=0.0
       VSG=(1.-COS(WT))/2.
       WAZM=(J-1)*PI/4.
```

```
      IF(ABS(HA) .LT. 0.001)  HA=0.001
      IF( J .GT. 4)  WAZM=-(J-4)*PI/4.
      WSAZM=SAZM+(WAZM*HA/ABS(HA))
      COSTH=COS(SALT)*COS(WSAZM)*SIN(WT)+SIN(SALT)*COS(WT)
      IF( COSTH .LT. .0001) COSTH=0.0
      SI(I,J)=IDN*(COSTH+(C*(1.-VSG))+(GRREFL*VSG*(C+SIN(SALT))))
      QS=SI(I,J)*TAU*AGLAS(J,ZN)*CCF(MO)+UGLASS*AGLAS(J,ZN)*DT
      QSUM(I)=QSUM(I)+QS
  500 CONTINUE
  600 CONTINUE
      RETURN
      END
```

@PRT,S   VIC.TRANS-V

```
C       TRANS SUBROUTINE COMPUTES THE TRANSMISSION LOADS THRU WALLS
C       AND ROOFS
C
C
C       SI         SOLAR INTENSITY (BTU/HR-FT**2)
C       TE         SOLAR-AIR TEMPERATURE
C       TEI        IDEALISED FORM OF TE
C       QTRAUN     TRANSMISSION LOAD PER UNIT AREA
C       QTRANS     TOTAL TRANSMISSION LOAD
C       UROOF      OVERALL HEAT TRANSFER COFFF. OF ROOF(BTU/HR-FT-DEGF)
C       UWALL      OVERALL HEAT TRANSFER COFFF. OF WALL(BTU/HR-FT-DEGF)
C       V          FACTOR IN THE AMPLITUDE OF QTRANS DUE TO THERMAL
C                  DIFFUSIVITY OF WALL
C       PHI        PHRASE ANGLE IN THE ARGUMENT OF QTRANS DUE TO THERMAL
C                  DIFFUSIVITY OF WALL
C       HO         HEAT TRANSFER COEFF. OF OUTSIDE WALL(BTU/HR-FT**2-DEGF)
      SUBROUTINE TRANS(TRA,TOA,SI,QTRANS,ADJ,ZONE)
      REAL  M,N
      INTEGER ADJ(9,8),ZONE
      DIMENSION  TOA(12,24), SI(24,9),QTRANS(24),SHADE(9,8)
      DIMENSION  QTRAUN(24,9),TE(24),TOAI(24),HO(24)
      DIMENSION UROOF(8),UWALL(8),PHIRF(8),PHIWL(8),VRF(8),VWL(8)
      COMMON/WALL/ UROOF,UWALL,PHIRF,PHIWL,HO,VRF,VWL,ALPHA
      COMMON/AREA/ AWALL(9,8),AGLAS(9,8),TNEXT(8,8),SHADE
      COMMON/DEC/ P,DEC,A,B,C,HO
      DATA /PI/3.14159/
C
C     THE 24*9 ELEMENTS IN THE ARRAYS ARE FOR THE 24 HOURS OF THE DAY
C     AND THE 9 ORIENTATIONS OF THE WALL
C
C     STRIP THE PROPER OUTSIDE TEMP FOR CALCULATIONS
C
C     ADJ = 0 MEANS THERE IS NO WALL OR ONLY PARTITION THERE
C     ADJ = 1 MEANS THERE IS AN INTERIOR WALL ADJOINING A CONSTANT
C           TEMPERATURE ZONE
C     ADJ = 2 MEANS THERE IS AN INSIDE WALL THERE
C     ADJ = 3 MEANS THERE IS AN OUTSIDE WALL THERE
C
      DO 5 I=1,24
      QTRANS(I)=0
      DO 5 J=1,9
      QTRAUN(I,J)=0
    5 CONTINUE
C
C
C [*]     [*]     [*]     [*]     [*]     [*]     [*]     [*]     [*]     [*]     [*]
C
C
      DO 40 J=1,9
      TEM=0.
      M=0.
      N=0.
      INDEX=ADJ(J,ZONE)+1
      GO TO (40,30,20,10),INDEX
```

```
C     IF THERE IS NO WALL THERE  JUMP ONE STEP
C
C*************************************************************************
C     WE DO THE NEXT 2 LOOPS IF THE WALL IS AN EXTERIOR WALL              *
C                                                                         *
   10 DO 12 I=1,24                                                        *
      TOA1(I)=TOA(MO,I)                                                   *
      TE(I)=TOA1(I)+ALPHA*SI(I,J)*SHADE(J,ZONE)/HO(I)                     *
      TEM=TEM+TE(I)/24.
      RI=I
      M=M+TE(I)*COS(PI*RI/12.)/12.
      N=N+TE(I)*SIN(PI*RI/12.)/12.                                        *
   12 CONTINUE
C                                                                         *
C            +          +          +          +
C
      U=UWALL(ZONE)
      V=VWL(ZONE)
      PHI=PHIWL(ZONE)
      IF( J .EQ. 9) U=UROOF(ZONE)
      IF( J .EQ. 9)  V=VRF(ZONE)
      IF( J .EQ. 9)  PHI=PHIRF(ZONE)
C                                                                         *
C            +          +          +          +
C
      DO 15 I=1,24
      RI=I
      SANGLE=ATAN(ABS(N/M))
      IF(N .LT. 0. .AND. M .GT. 0.)SANGLE=2.*PI-SANGLE
      IF(N .LT. 0. .AND. M .LT. 0.)SANGLE=PI+SANGLE
      IF(N .GT. 0. .AND. M .LT. 0.)SANGLE=PI-SANGLE
      QTRAUN(I,J)=U*(TEM-TRA)+V*SQRT(M*M+N*N)*COS(PI*RI/12.-SANGLE        *
     +    -PHI)                                                           *
   15 CONTINUE                                                            *
C
C*************************************************************************
      GO TO 40
C
C#########################################################################
C
C     WE GET TO THE NEXT DO LOOP IF WALL IS AN INTERIOR ONE
C                                                                         #
   20 DO 25 I=1,24
      IF(TOA1(I) .LT. 70.) TOA1(I)=70.
      QTRAUN(I,J)=UWALL(ZONE)*(TOA1(I)-TRA)
   25 CONTINUE
C
C#########################################################################
C
      GO TO 40
C
C!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C
C     THIS LOOP IS FOR WALL WITH CONSTANT TEMPERATURE
C
   30 DO 35 I=1,24
      QTRAUN(I,J)=(TNEXT(J,ZONE)-TRA)*UWALL(ZONE)
```

```
   35 CONTINUE
C
CIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
   40 CONTINUE
C
C     MULTIPLY AREA OF WALL TO QTRAUN TO GET TOTAL HEAT TRANSMISSIION LOAD
C
      DO 60 I=1,24
      DO 50 J=1,9
      QTRANS(I)=QTRANS(I)+QTRAUN(I,J)*AWALL(J,ZONE)
50    CONTINUE
   60 CONTINUE
      RETURN
      END
```

@PRT,S VIC.KE01-VA

13592*VIC(1).KEQ1-VA

```
      C   HEATING/COOLING LOAD CALCULATION FOR TYPE 1 AIR-HANDLER (SINGLE DUCT PLUS
      C   TERMINAL REHEAT)
      C
      C
      C
      C   KNUM=THE KNU**TH AIR-HANDLER IN THE BUILDING
      C   QHEL  = HEATING LOAD (ELECTRICAL) IN BTU
      C   QHHP  = HEATING LOAD (THERMAL) IN BTU
      C   QCC   = COOLING LOAD (ELECTRICAL) IN BTU
      C   NZONE = THE NZONE'TH ZONE IN THE BUILDING
      C
      C
            SUBROUTINE KEQ1(KNUM,ICNTRL,TCOMFT,NZONE,QHEL,QCC,QHBOL,TROOM)
            DIMENSION QSUMNU(2,24)
            INTEGER IP(8)
            COMMON/CNT/ IP,QSUMNU,TRAA
            COMMON/K/   QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
            DIMENSION  QSUM(2,24),TSAZ(8,48),TMA(48,10),ZCFM(8,11),
           /QHEL(48,10), QHBOL(48,10),QCC(48,10),TROOM(48)
            DIMENSION CSETPT(48,10),HSETPT(48,10),TCOMFT(8,48)
            INTEGER HEATER(10),REHEAT(8),ICNTRL(8,10)
            REAL MLT
            COMMON/CONST/MLT
      C
      C   START COMPUTATION OF QHEL,QCC AND QHBOL
      C
            DO 10 I=1,48
            SETLO=CSETPT(I,KNUM)
            J=1
            K=0
            IF (I.GT.24) J=2
            IF (I.GT.24) K=24
            NEWHR=I-K
            IF(NEWHR .EQ. 1)WRITE(6,20)
            TSAZN=TSAZ(NZONE,I)
            IF(IP(NZONE) .NE. 1) GO TO 2000
            TSAZN=CSETPT(I,KNUM)
            IF(ICNTRL(NZONE,KNUM) .NE. 1) TSAZN=TRAA-(QSUMNU(J,I-K)/
           A  (MLT*ZCFM(NZONE,KNUM)))
       2000 IF(TMA(I,KNUM) .LT. CSETPT(I,KNUM)) GO TO 200
            GO TO 300
        200 SETLO=TMA(I,KNUM)
            WRITE(6,250)J,NEWHR,NZONE
      250   FORMAT(1X,'TMA LESS THAN LOWER SET POINT, COOLING COIL OFF.',3X,
           *'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ1)')
        300 IF(TSAZN .LT. SETLO) GO TO 400
            GO TO 100
        400 TSAZN=SETLO
       20   FORMAT('0')
            WRITE(6,450)J,NEWHR,NZONE
      450   FORMAT(1X,'TSAZ LESS THAN LOWER SET POINT, REHEAT COIL OFF',3X,
           *'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ1)')
      100   QHEL(I,KNUM)=MLT*ZCFM(NZONE,KNUM)*(TSAZN-SETLO)
      C
             TROOM(I)=TSAZN+QSUM(J,I-K)/(MLT*ZCFM(NZONE,KNUM))
             IF(ICNTRL(NZONE,KNUM) .EQ. 2)
```

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```
     +TROOM(I)=TSAZN+QSUMNU(J,I-K)/(MLT*ZCFM(NZONE,KNUM))
      IF(ICNTRL(NZONE,KNUM) .EQ. 1) TROOM(I)=TRA
C
C    THESE 2 IF STATEMENTS ARE PUT IN FOR THE CONVERSION BETWEEN A 24X2 MATRIX
C     AND A 48 ELEMENT VECTOR
C
      IF (REHEAT(NZONE).NE.0.AND.REHEAT(NZONE).NE.1) GO TO 98
      IF (REHEAT(NZONE).EQ.1) QHBOL(I,KNUM)=QHEL(I,KNUM)
      IF (REHEAT(NZONE).EQ.1) QHEL (I,KNUM)=0
C
C   THESE IF STATEMENTS SERVE TO SORT THE HEATING LOAD INTO THE CORRECT
C   CATAGORY ACCORDING TO THE HEATER TYPE (ELECTRICAL OR GAS-FIRED)
C
      QCC (I,KNUM)=MLT*ZCFM(NZONE,KNUM)*(TMA(I,KNUM)-SETLO)
      GO TO 10
   98 WRITE(6,99)NZONE
   99 FORMAT(' ERROR IN HEATER-TYPE,CHECK INPUT',3X,'ZONE:',I2,3X,'(KEQ1
     *)')
      RETURN
   10 CONTINUE
      RETURN
      END
```

*PRT,S   VIC.KEQ2-VA

13592*VIC(1).KEQ2-VA

```
      C    HEATING/COOLING LOAD CALCULATION FOR TYPE 2 AIR-HANDLER (DUAL-DUCT,MULTIZONE
      C    WITH MIXING BOXES ,OR SINGLE-DUCT WITH MIXING IN THE AIR-HANDLER)
      C
      C
      C    KNUM    = THE KNUM'TH AIR-HANDLER IN THE BUILDING
      C    QHEL    = HEATING LOAD (ELECTRICAL) IN BTU
      C    QHHP    = HEATING LOAD (THERMAL) IN BTU
      C    QCC     = COOLING LOAD (ELECTRICAL) IN BTU
      C    NZONE   = THE NZONE'TH ZONE IN THE BUILDING
      C
      C
      C
      C
            SUBROUTINE KEQ2(KNUM,ICNTRL,TCOMFT,NZONE,QHEL,QCC,QHBOL,TROOM)
            COMMON/K/  QSUM,TSAZ,THA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
            DIMENSION QSUMNU(2,24)
            COMMON/CNT/IP,QSUMNU,TRAA
            INTEGER IP(8)
            DIMENSION  QSUM(2,24),TSAZ(8,48),THA(48,10),ZCFM(8,11),
           /           QHEL(48,10),QHBOL(48,10),
           /           QCC(48,10),TROOM(48),XH(48)
            DIMENSION  CSETPT(48,10),HSETPT(48,10),TCOMFT(8,48)
            INTEGER    HEATER(10),REHEAT(8),ICNTRL(8,10)
            REAL MLT
            COMMON/CONST/MLT
      C
      C    START COMPUTATION OF QHEL,QCC AND QHBOL
      C
            DO 10 I=1,48
            J=1
            K=0
            IF (I.GT.24) J=2.
            IF (I.GT.24) K=24
            NEWHR=I-K
            IF(NEWHR .EQ. 1)WRITE(6,5)
      5     FORMAT('0')
      C
      C    THESE 2 IF STATEMENT ARE PUT IN FOR THE CONVERSION BETWEEN A 24X2 MATRIX
      C    AND A 48-DIMENSIONAL VECTOR
      C
            SETLO=CSETPT(I,KNUM)
            SETHI=HSETPT(I,KNUM)
            TSAZN=TSAZ(NZONE,I)
            IF(IP(NZONE) .NE. 1) GO TO 2000
            TSAZN=CSETPT(I,KNUM)
            IF(ICNTRL(NZONE,KNUM) .NE. 1) TSAZN=TRAA-(QSUMNU(J,I-K)/
           A  (MLT*ZCFM(NZONE,KNUM)))
       2000 IF(THA(I,KNUM) .GE. CSETPT(I,KNUM))GO TO 30
            SETLO=THA(I,KNUM)
            WRITE(6,20)SETLO,J,NEWHR,NZONE
      20    FORMAT(1X,'COOLING COIL NOT WORKING.  LOWER SETPOINT=THA=',
           *F6.2,3X,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ2)')
      30    IF(THA(I,KNUM) .LE. HSETPT(I,KNUM))GO TO 50
            SETHI=THA(I,KNUM)
            WRITE(6,40)SETHI,J,NEWHR,NZONE
      40    FORMAT(1X,'HEATING COIL NOT WORKING.  UPPER SET POINT=THA=',F6.2
```

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```
     *,3X,'DAY-TYPE:'I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ2)')
  50  XH(I)=(TSAZN-SETLO)/(SETHI-SETLO)
      IF(XH(I) .GT. 1.)GO TO 900
      IF(XH(I) .LT. 0.)GO TO 990
      IF (HEATER(KNUM).NE.0.AND.HEATER(KNUM).NE.1)GO TO 98
 103 QCC (I,KNUM) = MLT*ZCFM(NZONE,KNUM)*(1-XH(I))*(TMA(I,KNUM)-
     /SETLO)
      QHEL (I,KNUM)= MLT*ZCFM(NZONE,KNUM)*XH(I)*(SETHI-TMA(I
     /,KNUM))
      TROOM(I)=TSAZN+QSUM(J,I-K)/(MLT*ZCFM(NZONE,KNUM))
      IF(ICNTRL(NZONE,KNUM) .EQ. 1) TROOM(I)=TRAA
      IF(ICNTRL(NZONE,KNUM) .EQ. 2) TROOM(I)=TSAZN+QSUMNU(J,I-K)/
     A    (MLT*ZCFM(NZONE,KNUM))
    1 IF (HEATER(KNUM).EQ.1) QHBOL(I,KNUM)=QHEL(I,KNUM)
      IF (HEATER(KNUM).EQ.1) QHEL(I,KNUM)=0
C
C   THESE IF STATEMENTS SERVE TO SORT THE HEATING LOAD INTO THE CORRECT
C   CATAGORY ACCORDING TO THE HEATER TYPE (ELECTRICAL OR GAS-FIRED).
C
      GO TO 10
  98 WRITE (6,99) HEATER(KNUM),NZONE
  99 FORMAT( ' ERROR IN HEATER TYPE,CHECK INPUT',3X,'HEATER=',I2,3X,'ZO
     *NE:',I2,3X,'(KEQ2)')
      GO TO 500
  10 CONTINUE
 500  RETURN
 900 TSAZN=SETHI
      XH(I)=1.
      GO TO 103
 990 TSAZN=SETLO
      XH(I)=0.
      GO TO 103
      END
```

@PRT,S   VIC.KEQ3-VA

```
13592*VIC(1).KEQ3-VA
C      KEQ3 SUBROUTINE COMPUTES THE COMPRESSOR COOLING LOAD,BOILER HEATING
C      LOAD AND ELECTRIC HEATER LOAD FOR A TYPE 3 AIR HANDLER.!THIS SUBROUTINE
C      WILL PERFORM THE COMPUTATION FOR 24 HOURS OF DAYTYPE ONE AND DAYTYPE
C      TWO. THE RESULT IS RETURNED TO THE MAIN PROGRAM IN THREE ARRAYS:
C      QCC(HOUR,KNUM),QHBOL(HOUR,KNUM),QHEL(HOUR,KNUM).
C      QHEL=ELECTRIC HEATER LOAD(BTU)
C      QCC=COMPRESSOR COOLING LOAD(BTU)
C      QHBOL=BOILER HEATING LOAD(BTU)
C      BF=BYPASS FACTOR
C
       SUBROUTINE KEQ3(QHBOL,QCC,QHEL,KNUM,ICNTRL,TCOMFT,ZONE,TROOM)
       DIMENSION QSUMNU(2,24)
       INTEGER IP(8)
       COMMON/CNT/ IP,QSUMNU,TRAA
       COMMON/K/QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
       INTEGER ZONE,DYTP,HEATER(10),REHEAT(8),FLAG,ICNTRL(8,10)
       DIMENSION QHEL(48,10),QCC(48,10),QHBOL(48,10),TCOMFT(8,48)
       DIMENSION ZCFM(8,11),TSAZ(8,48),TMA(48,10),QSUM(2,24),
      +          TROOM(48)
       DIMENSION  CSETPT(48,10),HSETPT(48,10)
       REAL MLT
       COMMON/CONST/MLT
C
C      INITIALIZE VALUES TO ZERO
       DYTP=0
       DO 100 J=1,48
       QHEL(J,KNUM)=0.0
       QCC(J,KNUM)=0.0
       QHBOL(J,KNUM)=0.0
100    CONTINUE
C      WRITE(6,400)
150    DYTP=DYTP+1
       DO 650 J=1,24
       IF(J .EQ. 1)WRITE(6,5)
5      FORMAT('0')
       I=J
       FLAG=0
       IF (DYTP.EQ.2)I=J+24
C
C      TEST TO DETERMINE IF COOLING OR HEATING IS NEEDED.
C
       TSAZN=TSAZ(ZONE,I)
       IF(IP(ZONE) .NE. 1) GO TO 2000
       TSAZN=CSETPT(I,KNUM)
       IF(ICNTRL(ZONE,KNUM) .NE. 1) TSAZN=TRAA-(QSUMNU(DYTP,J)/
      A  (MLT*ZCFM(ZONE,KNUM)))
 2000  IF (TSAZN.LT.TMA(I,KNUM)) GO TO 200
C
C      COMPUTE ELECTRIC HEATER LOAD
C
       QHEL(I,KNUM)=ZCFM(ZONE,KNUM)*MLT*(TSAZN-TMA(I,KNUM))
       BF=1
       IF (HEATER(KNUM).EQ.0)GO TO 650
C
C      COMPUTE BOILER LOAD
C
```

```
          QHBOL(I,KNUM)=QHEL(I,KNUM)
          QHEL(I,KNUM)=0.0
          GO TO 250
C
C         DETERMINE IF COOLING SETPOINT IS SUITABLE AND COMPUTE COMPRESSOR
C         COOLING LOAD
C
  200 IF(THA(I,KNUM) .LE. CSETPT(I,KNUM)) GO TO 1000
      BF=(TSAZN-CSETPT(I,KNUM))/(THA(I,KNUM)-CSETPT(I,KNUM))
      IF(TSAZN.LT.CSETPT(I,KNUM))FLAG=1
      IF(FLAG.EQ.1)BF=0.0
      IF(FLAG .EQ. 1) TSAZN=CSETPT(I,KNUM)
      IF(FLAG.EQ.1)WRITE(6,600)DYTP,J,ZONE
      GO TO 1100
 1000 BF=1
      TSAZN=THA(I,KNUM)
      WRITE(6,1050)DYTP,J,ZONE
 1050  FORMAT(1X,'THA LESS THAN LOWER SET POINT, COOLING COIL OFF',3X,
     *'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ3)')
 1100 QCC(I,KNUM)=ZCFM(ZONE,KNUM)*MLT*(1.-BF)*(THA(I,KNUM)-
     +            CSETPT(I,KNUM))
  250  TROOM(I)=TSAZN + QSUM(DYTP,J)/(MLT*ZCFM(ZONE,KNUM))
       IF(ICNTRL(ZONE,KNUM) .EQ. 1) TROOM(I)=TRAA
       IF(ICNTRL(ZONE,KNUM) .EQ. 2) TROOM(I)=TSAZN+QSUMNU(DYTP,J)/
     A  (MLT*ZCFM(ZONE,KNUM))
  600  FORMAT(1X,'SETPOINTS ARE UNSUITABLE FOR ROOM DESIGN CONDITIONS',3X
     *,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ3)')
  650  CONTINUE
       IF (DYTP.EQ.1) GO TO 150
       RETURN
       END
```

@PRT,S   VIC.KEQ4-VA

```
13592*VIC(1).KEQ4-VA
      C     KEQ4 SUBROUTINE COMPUTES THE COMPRESSOR COOLING LOAD,AND HEATING
      C     LOAD FOR HEAT PUMP OR DOUBLE COIL H/C SYSTEM WITH BY-PASS CONTROL.
      C     THIS SUBROUTINE WILL PERFORM THE COMPUTATION FOR 24 HOURS OF DAYTYPE ONE
      C     AND DAYTYPE TWO. THE RESULT IS RETURNED TO THE MAIN PROGRAM IN THE
      C     ARRAYS: QCC(HOUR,KNUM),QHHP(HOUR,KNUM)
      C     QCC=COMPRESSOR COOLING LOAD(BTU)
      C     QHHP=HEAT PUMP HEATING LOAD(BTU)
            SUBROUTINE KEQ4(QCC,QHEL,QHHP,QHBOL,ZONE,KNUM,ICNTRL,TCOMFT,TROOM)
            DIMENSION QSUMNU(2,24)
            INTEGER IP(8)
            COMMON/CNT/ IP,QSUMNU,TRAA
            COMMON/K/QSUM,TSAZ,THA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
            DIMENSION TSAZ(8,48),ZCFM(8,11),THA(48,10),QSUM(2,24)
            DIMENSION  CSETPT(48,10),HSETPT(48,10)
            DIMENSION QCC(48,10),QHHP(48,10),TCOMFT(8,48)
            DIMENSION TROOM(48),QHEL(48,10),QHBOL(48,10)
            INTEGER ZONE,DYTP,HEATER(10),REHEAT(8),STAR,EYE,ICNTRL(8,10)
            REAL MLT
            COMMON/CONST/MLT
      C
      C     INITIALIZE VALUES TO ZERO
      C
            DYTP=0
      200   DYTP=DYTP+1
      250   DO 700 J=1,24
            IF(J .EQ. 1)WRITE(6,5)
      5     FORMAT('0')
            I=J
            STAR=0
            EYE=0
            IF (DYTP.EQ.2)I=J+24
      C
      C     TEST TO DETERMINE IF COOLING OR HEATING IS NEEDED
      C
            TSAZN=TSAZ(ZONE,I)
            IF(IP(ZONE) .NE. 1) GO TO 2000
            TSAZN=CSETPT(I,KNUM)
            IF(ICNTRL(ZONE,KNUM) .NE. 1) TSAZN=TRAA-(QSUMNU(DYTP,J)/
           A   (MLT*ZCFM(ZONE,KNUM)))
       2000 IF (TSAZN.GT.THA(I,KNUM))GO TO 300
      C
      C     SYSTEM IS IN COOLING MODE
      C
            IF(THA(I,KNUM) .LE. CSETPT(I,KNUM)) GO TO 260
            BF=(TSAZN-CSETPT(I,KNUM))/(THA(I,KNUM)-CSETPT(I,KNUM))
            IF(BF.GT.1.)EYE=1
            IF(EYE.EQ.1)BF=1
            IF(BF.LT.0.)STAR=1
            IF (STAR .EQ. 1)BF=0.
            IF(STAR.EQ.1)TSAZN=CSETPT(I,KNUM)
            IF (STAR.EQ.1 )WRITE(6,650)DYTP,J,ZONE
            GO TO 280
        260 BF=1
            TSAZN=THA(I,KNUM)
            WRITE(6,270)DYTP,J,ZONE
      270   FORMAT(1X,'THA LESS THAN LOWER SET POINT, COOLING COIL OFF',3X,
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
     *'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ4)')
 280  QCC(I,KNUM)=ZCFM(ZONE,KNUM)*(1.-BF)*MLT*(THA(I,KNUM)
     +  -CSETPT(I,KNUM))
      GO TO 400
C
C     SYSTEM IS IN HEATING MODE
C
  300 IF(THA(I,KNUM) .GE. HSETPT(I,KNUM)) GO TO 350
      BF=(TSAZN-HSETPT(I,KNUM))/(THA(I,KNUM)-HSETPT(I,KNUM))
      IF (BF .LT.0.) STAR=1
      IF (STAR .EQ. 1)BF=0.
      IF ( STAR .EQ. 1) WRITE(6,650)DYTP,J,ZONE
      IF(STAR.EQ.1)TSAZN=HSETPT(I,KNUM)
      GO TO 380
  350 BF=1
      TSAZN=THA(I,KNUM)
      WRITE(6,370)DYTP,J,ZONE
 370  FORMAT(1X,'THA GREATER THAN UPPER SET POINT, HEATING COIL IS OFF',
     *3X,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ4)')
  380 HLOAD=ZCFM(ZONE,KNUM)*MLT*(1.-BF)*(HSETPT(I,KNUM)
     ?-THA(I,KNUM))
      IF(HEATER(KNUM)-1) 381,382,383
  381 QHEL(I,KNUM)=HLOAD
      QHBOL(I,KNUM)=0
      QHHP(I,KNUM)=0
      GO TO 400
  382 QHEL(I,KNUM)=0
      QHBOL(I,KNUM)=HLOAD
      QHHP(I,KNUM)=0
      GO TO 400
  383 QHEL(I,KNUM)=0
      QHBOL(I,KNUM)=0
      QHHP(I,KNUM)=HLOAD
 400  TROOM(I)=TSAZN+QSUM(DYTP,J)/(MLT*ZCFM(ZONE,KNUM))
      IF(ICNTRL(ZONE,KNUM) .EQ. 1) TROOM(I)=TRAA
      IF(ICNTRL(ZONE,KNUM) .EQ. 2) TROOM(I)=TSAZN+QSUMNU(DYTP,J)/
     A  (MLT*ZCFM(ZONE,KNUM))
 650  FORMAT(1X,'SET POINTS ARE UNSUITABLE FOR ROOM DESIGN CONDITIONS',
     *3X,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ4)')
 700  CONTINUE
      IF (DYTP.EQ.1) GO TO 200
      RETURN
      END
```

@PRT,S   VIC.KEQ5-VA

```
13592*VIC(1).KEQ5-VA
      C    HEATING/COOLING LOAD CALCULATION FOR TYPE 5 AIR-HANDLER
      C
      C
      C    KNUM   = THE KNUM'TH AIR-HANDLER IN THE BUILDING
      C    NZONE  = THE NZONE'TH ZONE IN THE BUILDING
      C    QHEL   = ELECTRICAL HEATING LOAD IN BTU
      C    QHBOL  = BOILER  HEATING LOAD IN BTU
      C    QCC    = ELECTRICAL COOLING LOAD IN BTU
      C    HF     = FRACTION OF THE TOTAL CFM OF THE ZONE WHICH COMES FROM TERMINAL
      C               REHEAT
      C    THOT   = TEMPERATURE OF THE AIR LEAVING THE TERMINAL HEATER
            SUBROUTINE KEQ5(KNUM,ICNTRL,NZONE,QHEL,QCC,QHBOL,TROOM)
            DIMENSION QSUMNU(2,24)
            INTEGER IP(8),ICNTRL(8,10)
            COMMON/CNT/ IP,QSUMNU,TRAA
            DIMENSION  QSUM(2,24),TSAZ(8,48),TMA(48,10),ZCFM(8,11),
           *           QHEL(48,10),QHBOL(48,10),QCC(48,10),TROOM(48),
           *           HFBRA(8)
            DIMENSION CSETPT(48,10),HSETPT(48,10)
            COMMON/K/  QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
            INTEGER    HEATER(10),REHEAT(8)
            REAL       MLT
            COMMON/CONST/MLT
      C
      C     START COMPUTATION
      C
            IF(HFBRA(NZONE) .EQ. 0)GO TO 110
            IF(REHEAT(NZONE).NE.0.AND.REHEAT(NZONE).NE.1) GO TO 98
            DO 10 I=1,48
            J=1
            K=0
            IF(I.GT.24) J=2 .
            IF(I.GT.24) K=24
            NEWHR=I-K
            IF(NEWHR .EQ. 1)WRITE(6,1)
      1     FORMAT(1H1)
            TSAZN=TSAZ(NZONE,I)
            IF(IP(NZONE) .NE. 1) GO TO 2000
            TSAZN=CSETPT(I,KNUM)
            IF(ICNTRL(NZONE,KNUM) .NE. 1) TSAZN=TRAA-(QSUMNU(J,I-K)/
           A    (MLT*ZCFM(NZONE,KNUM)))
       2000 SETLO=MIN(TMA(I,KNUM),CSETPT(I,KNUM))
            THOT=(TSAZN-SETLO*(1.-HFBRA(NZONE)))/HFBRA(NZONE)
            IF(THOT.LT.SETLO)GO TO 95
      5     QHEL(I,KNUM)=MLT*ZCFM(NZONE,KNUM)*HFBRA(NZONE)*(THOT-SETLO)
            QCC(I,KNUM) =MLT*ZCFM(NZONE,KNUM)*(TMA(I,KNUM)-SETLO)
            TROOM(I)=(HFBRA(NZONE)*THOT)+(1.-HFBRA(NZONE))*SETLO+QSUM(J,I-K)/
           *(MLT*ZCFM(NZONE,KNUM))
            IF(IP(NZONE) .EQ. 1)
           *TROOM(I)=(HFBRA(NZONE)*THOT)+(1.-HFBRA(NZONE))*SETLO+QSUMNU(J,I-K)
           */(MLT*ZCFM(NZONE,KNUM))
      C
      C  IF THE HEATER IS THE GAS-FIRED TYPE, STORE THE HEATING LOAD IN QHBOL
      C
            IF(REHEAT(NZONE).EQ.1) QHBOL(I,KNUM)=QHEL(I,KNUM)
            IF(REHEAT(NZONE).EQ.1) QHEL(I,KNUM)=0.
```

```
   10 CONTINUE
      RETURN
   95 WRITE(6,96)J,NEWHR,NZONE
96    FORMAT(1X,'REHEAT COIL IS OFF',3X,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,
     *'ZONE:',I2,3X,'(KEQ5)')
      THOT=SETLO
      GO TO 5
98    WRITE(6,100)J,NEWHR,NZONE,KNUM
100   FORMAT(1X,'ERROR IN HEATER TYPE. CHECK INPUT.',3X,'DAY-TYPE:',
     *I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'KNUM:',I2,3X,'(KEQ5)')
      RETURN
110   WRITE(6,120)KNUM,NZONE
120   FORMAT(1X,'ERROR IN HERRA FOR THIS AIR-HANDLER',3X,'KNUM:',
     *I2,3X,'ZONE:',I2,3X,'CHECK INPUT',3X,'(KEQ5)')
      RETURN
      END

@PRT,S   VIC.KEQ6-VA
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```
13592*VIC(1).KEQ6-VA
C     HEATING/COOLING LOAD CALCULATION FOR TYPE 6 AIR-HANDLER
C
C
C     KNUM   = THE KNUM'TH AIR-HANDLER IN THE BUILDING
C     NZONE  = THE NZONE'TH ZONE IN THE BUILDING
C     QHEL   = ELECTRICAL HEATING LOAD IN BTU
C     QHBOL  = BOILER HEATING LOAD IN BTU
C     QCC    = ELECTRICAL COOLING LOAD IN BTU
C     HF     = FRACTION OF THE TOTAL  FM OF THE ZONE THAT COMES FROM TERMINAL
C              REHEAT
C     THOT   = TEMPERATURE OF THE AIR LEAVING THE TERMINAL HEATER IN DEG F
C     CPF    = COOLING COIL PASS FACTOR
C
C
      SUBROUTINE KEQ6(KNUM,ICNTRL,NZONE,QHEL,QCC,QHBOL,TROOM)
      DIMENSION QSUMNU(2,24)
      INTEGER IP(8),ICNTRL(8,10)
      COMMON/CNT/ IP,QSUMNU,TRAA
      DIMENSION  QSUM(2,24),TSAZ(8,48),TMA(48,10),ZCFM(8,11),TROOM(48),
     /             QHEL(48,10),QHBOL(48,10),QCC(48,10)
     *        ,HFBRA(8)
      DIMENSION CSETPT(48,10),HSETPT(48,10)
      INTEGER    HEATER(10),REHEAT(8)
      COMMON/K/ QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
      REAL MLT
      COMMON/CONST/MLT
C
C     START COMPUTATION
C
      IF(REHEAT(NZONE).NE.0.AND.REHEAT(NZONE).NE.1) GO TO 97
C
C   HEATER HAS TO BE EITHER 1 (GAS-FIRED BOILER TYPE) OR 0 (ELECTRIC HEATER)
C
      IF(HFBRA(NZONE) .EQ. 0)GO TO 100
      DO 10 I=1,48
      J=1
      K=0
      IF(I.GT.24) J=2
      IF(I.GT.24) K=24
      NEWHR=I-K
      IF(NEWHR .EQ. 1)WRITE(6,3)
    3 FORMAT('0')
      QHBOL(I,KNUM)=0.
      QHEL(I,KNUM)=0.
      TSAZN=TSAZ(NZONE,I)
      IF(IP(NZONE) .NE. 1) GO TO 2000
      TSAZN=CSETPT(I,KNUM)
      IF(ICNTRL(NZONE,KNUM) .NE. 1) TSAZN=TRAA-(QSUMNU(J,I-K)/
     A  (MLT*ZCFM(NZONE,KNUM)))
 2000 SETLO=MIN(TMA(I,KNUM),CSETPT(I,KNUM))
      THOT=(TSAZN-SETLO*(1.-HFBRA(NZONE)))/HFBRA(NZONE)
      CPF=(TMA(I,KNUM)-THOT)/(TMA(I,KNUM)-SETLO)
      IF(THOT.LT.SETLO) GO TO 95
      IF(THOT.GT.TMA(I,KNUM))  GO TO 105
      IF(TMA(I,KNUM) .EQ. SETLO)  CPF=0.
      GO TO 6
```

```
  105 CPF=0.
      QHEL(I,KNUM)=MLT*ZCFM(NZONE,KNUM)*(THOT-THA(I,KNUM)*HFBRA(NZONE))
      GO TO 6
   95 CPF=1.
      THOT=SETLO
    6 QCC(I,KNUM)=MLT*ZCFM(NZONE,KNUM)*(1.-HFBRA(NZONE)*(1.-CPF))
     / *(THA(I,KNUM)-SETLO)
C
C  IF THE HEATER IS THE GAS-FIRED TYPE,STORE THE HEATING LOAD IN THE MATRIX
C  'QHBOL'
C
      IF(REHEAT(NZONE).EQ.1) QHBOL(I,KNUM)=QHEL(I,KNUM)
      IF(REHEAT(NZONE).EQ.1) QHEL (I,KNUM)=0.
    9 TROOM(I)=(THOT*HFBRA(NZONE))+SETLO*(1.-HFBRA(NZONE))+QSUM(J,I-K)
     */(MLT*ZCFM(NZONE,KNUM))
      IF(IP(NZONE) .EQ. 1) TROOM(I)=(THOT*HFBRA(NZONE))+SETLO*
     *  (1.-HFBRA(NZONE))+QSUMNU(J,I-K)/(MLT*ZCFM(NZONE,KNUM))
   10 CONTINUE
      RETURN
   97 WRITE(6,98) NZONE,KNUM
   98 FORMAT(1X,'ERROR IN HEATER TYPE, PLEASE CHECK INPUT.',
     *3X,'ZONE:',I2,3X,'KNUM:',I2,3X,'(KEQ6)')
      RETURN
  100 WRITE(6,110)KNUM,NZONE
  110 FORMAT(1X,'ERROR IN HFBRA FOR THIS AIR-HANDLER.',3X,'KNUM:',
     *I2,3X,'ZONE:',I2,3X,'(KEQ6)',3X,'CHECK INPUT')
      RETURN
      END
```

@PRT,S   VIC.KEQ7-VA

```
13592*VIC(1).KEQ7-VA
      SUBROUTINE KEQ7(KNUM,ICNTRL,ZONE,QCC,QHBOL,QHEL,TROOM)
      DIMENSION QSUMNU(2,24)
      INTEGER IP(8),ICNTRL(8,10)
      COMMON/CNT/ IP,QSUMNU,TRAA
C     SINGLE COLD DUCT AND SINGLE HOT DUCT AIR HANDLER WHERE THE HOT AND COLD
C     DECKS ARE MIXED IN THE ROOM
      DIMENSION  QCC(48,10),QHBOL(48,10),QHEL(48,10),
     *           TMA(48,10),TSAZ(8,48),ZCFM(8,11),TROOM(48)
      DIMENSION CSETPT(48,10),HSETPT(48,10)
      DIMENSION  QSUM(2,24),HFBRA(8)
      INTEGER    HEATER(10),REHEAT(8),ZONE,HOUR,DATYPE
      COMMON/K/QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
      LOGICAL WRIIT
      REAL MLT
      COMMON/CONST/MLT
C
      CFM2=HFBRA(ZONE)*ZCFM(ZONE,KNUM)
      CFM1=ZCFM(ZONE,KNUM)-CFM2
      IF(CFM2 .LE. 0)GO TO 300
      DO 200 DATYPE=1,2
      DO 100 HOUR=1,24
      IF(HOUR .EQ. 1)WRITE(6,3)
    3 FORMAT('0')
      IF(DATYPE .EQ. 1)GO TO 5
      NEWHR=HOUR+24
      GO TO 10
    5 NEWHR=HOUR
   10 WRIIT=.FALSE.
C
C     CHECK THE PROPER HOT AND COLD DECK SETPOINTS AND COMPUTE THE TEMP
C     OF COMFORT AIR
C
      TSAZN=TSAZ(KNUM,NEWHR)
      IF(IP(ZONE) .NE. 1) GO TO 2000
      TSAZN=CSETPT(NEWHR,KNUM)
      IF(ICNTRL(ZONE,KNUM) .NE. 1) TSAZN=TRAA-QSUMNU(DATYPE,HOUR)/
     A (MLT*ZCFM(ZONE,KNUM))
 2000 SETLO=CSETPT(NEWHR,KNUM)
      SETHI=HSETPT(NEWHR,KNUM)
      IF(TMA(NEWHR,KNUM) .GE. CSETPT(NEWHR,KNUM)) GO TO 14
      SETLO = TMA(NEWHR,KNUM)
      WRITE(6,12)SETLO,DATYPE,HOUR,ZONE
   12 FORMAT(1X,'COOLING COIL NOT WORKING.  LOWER SETPOINT=TMA=',
     *F6.2,3X,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ7)')
   14 IF(TMA(NEWHR,KNUM) .LE. HSETPT(NEWHR,KNUM))GO TO 18
      SETHI = TMA(NEWHR,KNUM)
      WRITE(6,16)SETHI,DATYPE,HOUR,ZONE
   16 FORMAT(1X,'HEATING COIL NOT WORKING.  UPPER SETPOINT=TMA=',F6.2,3X
     *,'DAY-TYPE:',I2,3X,'HOUR:',I2,3X,'ZONE:',I2,3X,'(KEQ7)')
   18 THOT=((TSAZN*ZCFM(ZONE,KNUM))-(CFM1*SETLO))/
     *CFM2
      IF(THOT .GE. SETLO) GO TO 20
      CPF=1.0
      THOT=SETLO
      WRIIT=.TRUE.
      GO TO 40
```

```
      20    IF(THOT .LE. SETHI)GO TO 30
            CPF=0.0
            THOT=SETHI
            WRIIT=.TRUE.
            GO TO 40
      C
      C     COMPUTE THE A/C EQUIPMENT LOADS AND THE PROPER ROOM TEMP
      C
      30    CPF=(SETHI-THOT)/(SETHI-SETLO)
      40    HLD=(1.0-CPF)*CFM2*(SETHI-TMA(NEWHR,KNUM))*MLT
            QCC(NEWHR,KNUM)=(CFM1+(CPF*CFM2))*MLT*(TMA(NEWHR,KNUM)-SETLO)
            TROOM(NEWHR)=(THOT*HFBRA(ZONE))+(SETLO*(1.-HFBRA(ZONE)))+
           *QSUM(DATYPE,HOUR)/(MLT*ZCFM(ZONE,KNUM))
            IF(IP(ZONE) .EQ. 1) TROOM(NEWHR)=(THOT*HFBRA(ZONE))+(SETLO*
           A  (1.-HFBRA(ZONE)))+QSUMNU(DATYPE,HOUR)/(MLT*ZCFM(ZONE,KNUM))
            IF(HEATER(KNUM) .EQ. 1)GO TO 50
            QHEL(NEWHR,KNUM)= HLD
            GO TO 55
      50    QHBOL(NEWHR,KNUM)= HLD
         55 CONTINUE
      100   CONTINUE
      200   CONTINUE
            RETURN
      300   WRITE(6,310)CFM2,HFBRA(ZONE),KNUM
      310   FORMAT(1X,'ERROR IN HFBRA FOR THIS AIR-HANDLER. CHECK INPUT',
           *3X,'CFM2:',F8.3,3X,'HFBRA:',F8.4,3X,'KNUM:',I2,3X,'(KEQ7)')
            RETURN
            END
@PRT,S  VIC.KEQ8-VA
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13592*VIC(1).KEQ8-VA
          SUBROUTINE KEQ8(KNUM,ICNTRL,ZONE,QCC,QHBOL,QHEL,TROOM,TRA)
          DIMENSION QSUMNU(2,24)
          INTEGER IP(8),ICNTRL(8,10)
          COMMON/CNT/ IP,QSUMNU,TRAA
C         FIXED BYPASS OF RETURN AIR TO BE MIXED WITH COLD DUCT AND TERMINAL
C         REHEAT
          DIMENSION  QCC(48,10),QHBOL(48,10),QHEL(48,10),
         *           TMA(48,10),TSAZ(8,48),ZCFM(8,11)
          DIMENSION CSETPT(48,10),HSETPT(48,10)
          DIMENSION  QSUM(2,24),TROOM(48),HFBRA(8)
          INTEGER    HEATER(10),REHEAT(8),HOUR,ZONE,DATYPE
          COMMON/K/  QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
          REAL MLT
          COMMON/CONST/MLT
          DO 200 DATYPE=1,2
          DO 100 HOUR=1,24
          IF(HOUR .EQ. 1)WRITE(6,5)
5         FORMAT('0')
          IF(DATYPE .EQ. 1)GO TO 10
          NEWHR=HOUR+24
          GO TO 20
10        NEWHR=HOUR
20        TSAZN=TSAZ(ZONE,NEWHR)
          IF(IP(ZONE) .NE. 1) GO TO 2000
          TSAZN=CSETPT(NEWHR,KNUM)
          IF(ICNTRL(ZONE,KNUM) .NE. 1) TSAZN=TRAA-QSUMNU(DATYPE,HOUR)/
         A  (MLT*ZCFM(ZONE,KNUM))
     2000 SETLO=MIN(CSETPT(NEWHR,KNUM),TMA(NEWHR,KNUM))
          TMR=(HFBRA(ZONE)*TRA)+((1.-HFBRA(ZONE))*SETLO)
          IF(TSAZN .GE. TMR) GO TO 40
          TSAZN=TMR
          WRITE(6,30)TMR,DATYPE,HOUR,ZONE
       30 FORMAT(1X,'BYPASSED RETURN AIR RATIO IS NOT SUTIABLE FOR A/C',
         13X,'TMR=',F6.2,3X,'DAYTYPE=',I2,3X,'HOUR=',I2,3X,'ZONE=',
         1I2,3X,'(KEQ8)')
C
C         COMPUTE A/C EQUIPMENT LOADS AND THE PROPER ROOM TEMP
C
       40 HLD=ZCFM(ZONE,KNUM)*MLT*(TSAZN-TMR)
          QCC(NEWHR,KNUM)= ZCFM(ZONE,KNUM)*MLT*(1.0-HFBRA(ZONE))
         A  *(TMA(NEWHR,KNUM)-SETLO)
          TROOM(NEWHR)=TSAZN+QSUM(DATYPE,HOUR)/MLT/ZCFM(ZONE,KNUM)
          IF(ICNTRL(ZONE,KNUM) .EQ. 1) TROOM(NEWHR)=TRAA
          IF(ICNTRL(ZONE,KNUM) .EQ. 2) TROOM(NEWHR)=TSAZN+QSUMNU(DATYPE,
         AHOUR)/(MLT*ZCFM(ZONE,KNUM))
          IF(REHEAT(ZONE) .EQ. 1)GO TO 50
          QHEL(NEWHR,KNUM)= HLD
          GO TO 100
50        QHBOL(NEWHR,KNUM)= HLD
100       CONTINUE
200       CONTINUE
          RETURN
          END

@PRT,S    VIC.KEQ9-VA
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13592*VIC(1),KEQ9-VA
C   HEATING/COOLING LOAD CALCULATION FOR TYPE 9 AIR-HANDLER (CONSTANT VOLUME
C   PLENUM AIR AND VARIABLE VOLUME COMFORT AIR AT FIXED TEMPERATURE
C
C
C   KNUM   = THE KNUM TH AIR HANDLER IN THE BUILDING
C   NZONE  = THE NZONE TH ZONE IN THE BUILDING
C   QHEL   = ELECTRICAL HEATING LOAD IN BTU
C   QHBOL  = BOILER HEATING LOAD IN BTU
C   QCC    = ELECTRICAL COOLING LOAD IN BTU
C   HFBRA     = FRACTION OF THE TOTAL CFM OF THE ZONE THAT COMES FROM TERMINAL
C             REHEAT
C   VCFM2  = VARIABLE AIR VOLUME OF CFM OF HEATING
C   TPAM   = MAXIMUM PLENUM AIR TEMPERATURE
C   TROOM  = ROOM TEMPERATURE
C
C
      SUBROUTINE KEQ9(KNUM,ICNTRL,NZONE,QHEL,QCC,QHBOL,TOA,ECON,MO,TPAM,
     *                TROOM,TRA)
      DIMENSION QSUMNU(2,24)
      INTEGER IP(8),ICNTRL(8,10)
      COMMON/CNT/IP,QSUMNU,TRAA
      DIMENSION  QSUM(2,24),TSAZ(8,48),TMA(48,10),ZCFM(8,11),TROOM(48),
     /           QHEL(48,10),QHBOL(48,10),QCC(48,10),
     /           TOA(12,24),HFBRA(8),STORE(2,24)
      DIMENSION CSETPT(48,10),HSETPT(48,10)
      INTEGER    HEATER(10),REHEAT(8),ECON(10)
      COMMON/K/  QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT,HFBRA
      REAL MLT
      COMMON/CONST/MLT
C
C   START COMPUTATION
C
C   CHECK HEATER:
C
      IF(HEATER(KNUM).NE.0.AND.HEATER(KNUM).NE.1) GO TO 7
C
C   HEATER HAS TO BE EITHER 1 (GAS FIRED BOILER TYPE) OR 0 (ELECTRIC HEATER)
C
      CFM2=HFBRA(NZONE)*ZCFM(NZONE,KNUM)
      CFM1=ZCFM(NZONE,KNUM)-CFM2
C
C   CFM1 IS THE PORTION OF ZCFM FOR COOLING,CFM2 IS THE PORTION FOR HEATING
C
      DO 5 I=1,48
      J=1
      K=0
      IF(I.GT.24) J=2
      IF(I.GT.24) K=24
      IF(I.EQ.1.OR.I.EQ.25) WRITE(6,10)
10    FORMAT('0')
C
C   THE TWO IF STATEMENTS TAKE CARE OF THE CONVERSION BETWEEN 2*24 AND 1*12
C   MATRICES
C
      TSAZ1=TRA-QSUM(J,I-K)/(MLT*CFM1)
      IF(IP(NZONE) .EQ. 1) TSAZ1=TRA-QSUMNU(J,I-K)/(MLT*CFM1)
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      IF(TSAZ1 .LT. 50.) TSAZ1=50.
      IF(TSAZ1.GT.TPAM) GO TO 3
      IF(ECON(KNUM) .EQ. 0)GO TO 11
      IF(TOA(MO,I-K) .GT. TRA)  GO TO 11
      IF(TOA(MO,I-K) .LE. TRA .AND. TOA(MO,I-K) .GE. TSAZ1) GO TO 9

      THA(I,KNUM)=TSAZ1
      GO TO 11
    9 THA(I,KNUM)=TOA(MO,I-K)
 11   TSAZ1=MIN(THA(I,KNUM),TSAZ1)
      IF(TSAZ1 .LT. THA(I,KNUM)) GO TO 3
      QCC(I,KNUM)=CFM1*MLT*(THA(I,KNUM)-TSAZ1)
      QHEL(I,KNUM)=0
      QHBOL(I,KNUM)=0
      TROOM(I)=TSAZ1+QSUM(J,I-K)/(CFM1*MLT)
      IF(IP(NZONE) .EQ. 1) TROOM(I)=TSAZ1+QSUMNU(J,I-K)/(CFM1*MLT)
      STORE(J,I-K)=0.
      GO TO 5
  3   IF(ECON(KNUM) .EQ. 0)GO TO 4
      IF(TOA(MO,I-K) .GT. TRA) GO TO 4
      IF(TOA(MO,I-K) .LE. TRA .AND. TOA(MO,I-K) .GE. TPAM )  GO TO 6

      THA(I,KNUM)=TPAM
      GO TO 4
    6 THA(I,KNUM)=TOA(MO,I-K)
  4   SETLO=MIN(THA(I,KNUM),TPAM)
      SETHI=MAX(THA(I,KNUM),HSETPT(I,KNUM))
      VCFM2= CFM1*(TRA-TPAM)/(SETHI-TRA)-QSUM(J,I-K)/MLT/
     /(SETHI-TRA)
      VCFM2=MAX(VCFM2,0.)
      VCFM2=MIN(CFM2,VCFM2)
      QHEL(I,KNUM)=VCFM2*MLT*(SETHI-THA(I,KNUM))
      IF(HEATER(KNUM).EQ.1) QHBOL(I,KNUM)=QHEL(I,KNUM)
      IF(HEATER(KNUM).EQ.1) QHEL (I,KNUM)=0
      QCC(I,KNUM)=MLT*CFM1*(THA(I,KNUM)-SETLO)
      TROOM(I)=(VCFM2*SETHI+CFM1*SETLO+QSUM(J,I-K)/MLT)/
     /(CFM1+VCFM2)
      IF(IP(NZONE) .EQ. 1) TROOM(I)=(VCFM2*SETHI+CFM1*SETLO+
     A       QSUMNU(J,I-K)/MLT)/(CFM1+VCFM2)
      IF(IP(NZONE) .EQ. 1) TROOM(I)=(VCFM2*SETHI+CFM1*SETLO+
     A  QSUMNU(J,I-K)/MLT)/(CFM1+VCFM2)
      STORE(J,I-K)=VCFM2
    5 CONTINUE
      WRITE(6,16)
   16 FORMAT(1H1,3X,'KEQ9',T16,'** VARIABLE VOLUME OF HEATED',
     ?' AIR **'/3X,4(1H=)//T19,4HHOUR,T27,'DAY-TYPE 1',T39,
     ?'DAY-TYPE 2'/T29,'(CFM)',T40,'(CFM)'/)
C
      WRITE(6,26) (I,STORE(1,I),STORE(2,I),I=1,24)
   26 FORMAT(I21,1X,2F12.0)
      WRITE(6,36) KNUM,NZONE
   36 FORMAT(//1H0,T12,1HV,T18,1HV/T13,1HV,T17,1HV/T14,3HVVV,
     ?6(/T15,1HH),/T12,'V  H  V'/T12,'VV H VV'/T13,5HVTTTV/
     ?T14,3HVVV,T21,'AIR-HANDLER NO',I2,' FEEDING ZONE',I2/T15,1HV)
      RETURN
  7   WRITE(6,8) KNUM,NZONE
  8   FORMAT(1X,'ERROR IN HEATER TYPE, CHECK INPUT,'3X,'KNUM:',I2,
```

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```
     *3X,'ZONE;',I2,7X;'(KED9)')
      RETURN
      END
```

@PRT,S VIC.COP-V

```
13592*VIC(1).COP-V
      C     SUBROUTINE COP COMPUTES THE COOLING LOADS IN KW BASED ON THE
      C     LOADING FACTOR AND THE COP OF THE REFRIGERATION SCHEME
      C
            SUBROUTINE COP(CQCC,COHHP,TOA,CLIMIT,SIZE,MO)
            COMMON/K/QSUM,TSAZ,TMA,ZCFM,CSETPT,HSETPT,HEATER,REHEAT(8)
            DIMENSION QSUM(2,24),TSAZ(8,48),TMA(48,10),ZCFM(8,11),
           *CQCC(48,10),COHHP(48,10),TOA(12,24),SIZE(3,10)
            DIMENSION  CSETPT(48,10),HSETPT(48,10)
            INTEGER HEATER(10),REHEAT,HOUR,CLIMIT,CNUM
      C
      C     THIS PORTION OF THE PROGRAM IS FOR ALL CLDS
      C
            DO 5 CNUM=1,CLIMIT
            DO 4 HOUR=1,48
            IF(CQCC(HOUR,CNUM) .EQ. 0) GO TO 4
            JJ=0
            IF(HOUR.GT.24) JJ=24
            NEWHR=HOUR-JJ
      C
      C     COMPUTE COOLING LOAD IN TONNAGE, POWER PER TON OF REFRIGERATION!
      C     TEST HOW MANY COMPRESSORS ARE NEEDED
      C
            C=CQCC(HOUR,CNUM)/12000.
            PPT=7.18*(TOA(MO,NEWHR)-5.)/505.
            IF(C .GT. SIZE(1,CNUM)+SIZE(2,CNUM)) GO TO 900
            IF(C .GT. SIZE(1,CNUM)) GO TO 1
            CDSIZ1=C/SIZE(1,CNUM)
            FFC1=AMAX1(0.4,CDSIZ1)
            FFC2=0.
            IF(HOUR .EQ. 1 .OR. HOUR .EQ. 25)WRITE(6,10)
      10    FORMAT('0')
            GO TO 3
      C
      C     SECOND COMPRESSOR IS ON, TEST FOR CUT OFF POINT AT 0.4 OF CAPACITY
      C
          1 C2=(C-SIZE(1,CNUM))/SIZE(2,CNUM)
            FFC1=1.
            FFC2=AMAX1(0.4,C2)
            IF(HOUR .EQ. 1 .OR. HOUR .EQ. 25)WRITE(6,10)
      3     CQCC(HOUR,CNUM)=PPT*(FFC1*SIZE(1,CNUM)+FFC2*SIZE(2,CNUM))
          4 CONTINUE
          5 CONTINUE
      C
      C     THIS PORTION OF THE PROGRAM IS FOR HEAT PUMPS ONLY
      C
            DO 60 CNUM=1,CLIMIT
            DO 50 HOUR=1,48
            IF(COHHP(HOUR,CNUM) .EQ. 0)GO TO 50
            NEWHR=HOUR
            IF(HOUR .LE. 24)GO TO 35
            NEWHR=HOUR-24
      C
      C     COMPUTE PPK AND FFH
      C
         35 PPK=(135.-TOA(MO,NEWHR))/.49/585.
            FFH=COHHP(HOUR,CNUM)/(SIZE(3,CNUM))
```

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```
          IF(FFH .LT. 0.4)GO TO 40
          COHHP(HOUR,CNUM)=(COHHP(HOUR,CNUM)*PPK)/3413.0
          GO TO 50
   40     COHHP(HOUR,CNUM)=0.4*SIZE(3,CNUM)*PPK/3413.0
   50     CONTINUE
   60     CONTINUE
          GO TO 2222
      900 WRITE(6,999)NEWHR
  999     FORMAT(' LOAD EXCEEDS COMPRESSOR CAPACITY. CHECK COMPRESSOR SIZE I
         *NPUT',3X,'HOUR=',I2,3X,'(COP)')
          COCC(HOUR,CNUM)=PPT*C
          IF(HOUR .EQ. 1 .OR. HOUR .EQ. 25)WRITE(6,10)
          GO TO 4
     2222 RETURN
          END
```

@PRT,S VIC.ECP2/WEATHER

APPENDIX "B"

BLANK FORMS OF INPUT DATA TABLES

APPENDIX B

BLANK FORMS OF INPUT DATA TABLES

Two different sets of input data tables are required. The first set, Tables B-1 to B-41 are intended for use by personnel who have little or no familiarity with the computer program terminology. The second set constitutes the translation of the first set for use by the machine operator and is presented in the example given in Section 3.4.2. Only the first set is given next.

TABLE B-1 OUTSIDE AIR DRY BULB TEMPERATURE (TOA)

	HOUR																							
MONTH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								

Outside air dry bulb temperature, in Deg. F. One representative day in each month shall be selected. Twenty-four values of outside air dry bulb temperature correspond to twenty-four hours of the selected day of each month. If day per day data are available, an average day in each month shall be used only. All data boxed shall be filled with no blanks.

TABLE B-2 CLOUD COVER FACTOR (CCF)

MONTH	1	2	3	4	5	6	7	8	9	10	11	12
CCF												

Cloud cover factor is a number varying from 0.0 to 1.0. (Zero) means no solar energy available for the full month due to heavy clouds, rain etc. The value "unity" means that the total solar energy per unit area falling on earth's surface is identical with that predicted theoretically from ASHRAE model on clear days. Cloud cover factor thus presents the ratio of actual accumulated daily solar energy incident on the location to that calculated using the theoretical model by ASHRAE (ASHRAE Fundamentals Handbook 1972). If no solar insolation data are available, the cloud cover factor shall be approximated by an estimated guess of the percentage area of clear sky on the selected average day of the month. Twelve cloud cover factors are required corresponding to 12 months, i.e., one value presents each month weather on the average. All data boxes shall be filled with no blanks.

TABLE B-3 WIND VELOCITY (WMPH)

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
WIND, MPH																								

Wind speed in miles per hr. 24 values are needed corresponding to 24 hours of a representative day of the year. The values shall indicate whether the site is windy or not. If data are not available for averaging the whole year, measurements of wind velocity on one day may be sufficient. All data blocks shall be filled with no blanks.

TABLE B-4 BUILDING NAME (BLDG)

BUILDING	

An alphabetic and/or numeric name of the building under study. A maximum of six alphanumeric characters shall be used in addition to single quotation marks.

TABLE B-6 TOTAL NUMBER OF AIR HANDLERS (KLIMIT)

NO. OF AH	

The maximum number of active air handlers per building shall not exceed 10. If this number exceeds 10, then the building shall be divided into sections each having a maximum of 10 air handlers.

TABLE B-8 TOTAL NUMBER OF ZONES (OR MACROZONES) (ZLIMIT)

NO. OF ZONES	

The maximum number of zones per building shall not exceed 8. If there are more than 8 zones, grouping of several zones into macrozones having only the same air handler type (Table B-15) shall be done.

TABLE B-10 TOTAL NUMBER OF COMPRESSORS (CLIMIT)

No. OF COMPRESS.	

The maximum number of vapor-compression refrigeration compressors used is 10 per building.

TABLE B-5 COST PER kWh_e (DKWHE)

$/$kWh_e$	

Unit cost of electric energy in U. S. dollars as purchased from a utility company or generated in house.

TABLE B-7 COST PER kWh_t (DKWHT)

$/$kWh_e$	

Unit cost of thermal energy used for heating purposes. Natural gas, liquiffed petroleum products or diesel oil are common fuels for heating.

TABLE B-9 LATITUDE (LAT)

LATITUDE	RAD.

Local latitude shall be converted to radians by multiplying the latitude in degrees times 0.0175.

TABLE B-11 PRESSURE

PRESSURE	in. HG

Local pressure in inches of mercury shall be used. The pressure is 29.92 in. Hg. at sea level.

TABLE B-12 ZONE VOLUME, (VOL)

ZONE	1	2	3	4	5	6	7	8
VOLUME ft^3								

The zone volume in ft^3 shall be calculated as the sum of volumes of rooms that constitute the zone even if the rooms are physically located far from each other. The room boundaries used in calculating the volume are the "living" boundaries not including attics (unless they are occupied) or return air ceiling plenums etc. Non-applicable boxes shall be left blank.

TABLE B-13 ZONE DESIGN TEMPERATURE IN SUMMER, (TSUM)

ZONE	1	2	3	4	5	6	7	8
SUMMER ^oF								

The zone temperature in summer (in Deg F) can be the summer design value, the summer thermostat setting, or the actual room air temperature measured and averaged over the summer season. Non-applicable boxes shall be left blank.

TABLE B-14 ZONE DESIGN TEMPERATURE IN WINTER, (TWIN)

ZONE	1	2	3	4	5	6	7	8
WINTER, ^oF								

The zone temperature in winter (in Deg F) can be the winter design value, the winter thermostat setting, or the actual room air temperature measured and averaged over the winter season. Non-applicable boxes shall be left blank.

TABLE B-15 AIR HANDLER TYPE (AH)

AIR HANDLER \ ZONE	1	2	3	4	5	6	7	8
1st								
2nd								
3								
4								
5			1					
6								
7								
8								
9								
10								

The air handler type is an integer number varying from 1 to 9. The air handler type identifies the mechanism by which the air temperature leaving a specific air handler is modulated to match zone needs. The nine types of air handler are as follows. Only <u>one</u> of the following 9 numbers shall be selected.

1. Single cold duct with terminal reheat at the zone
2. Dual duct, multizone with mixing boxes or single duct, multizone with mixing hot/cold air at the air handler section
3. Single cold duct with bypass control around the cooling coil and terminal reheat at the zone
4. Heat pump with bypass control, or single duct with alternately operating cooling and heating coils with bypass control
5. Two-level room (plenum and main room) with cold plenum air and comfort air modulated with terminal réheat.
6. Two-level room with cold plenum air and comfort air modulated by a mixture of cold air with bypassed mixed air with terminal reheat
7. Two level room with cold plenum air and comfort air modulated by mixing cold and hot decks
8. Single cold deck with fixed bypassed return air with terminal reheat
9. Two level room with constant volume cold plenum air and variable volume comfort air at fixed hot deck temperatures.

There can be as much as 10 air handlers per building and as much as 8 zones fed by a single air handler. Non applicable boxes shall be left blank. If the 3rd. zone is fed by the fifth air handler through a single cold duct with terminal reheat of the zone, then air handler type (1) shall fill in the fifth row and 3rd. column as shown.

TABLE B-16 COLD/HOT DECKS SETPOINT TEMPERATURE (SETPTS)

AIR HANDLER	COLD	HOT
1 (first)		
2 (second)		
3		
4		
5		
6		
7		
8		
9		
10		

Cold/hot deck set points (^oF) are the air temperatures set for air leaving the cooling coil (in the cold deck) and/or that for air leaving heating coils (in the hot deck). There can be as much as 10 air handlers per building. Cold set point is usually adjusted around 55^{o}F, and hot set point is usually adjusted around 80^{o}F. These values are only used as guidelines and shall be substituted for actual field data only is set points are not known.

TABLE B-17 MAXIMUM ALLOWABLE PLENUM AIR TEMPERATURE (TPAM)

MAXIMUM PLENUM TEMPERATURE	^{o}F

This is only applicable for two-level room conditioned by two streams of air; plenum air for cooling electronic racks, etc. and comfort air. If no value is given, the program will assume 62^{o}F.

TABLE B-18 TYPE OF HEATING FOR TERMINAL REHEAT COILS (REHEAT)

ZONE	1	2	3	4	5	6	7	8
REHEAT								

This table applies only to Zones that are associated with air handler type 1, 3, 5, 6 and 8 (as in table B-15) which have terminal reheat coils. A maximum of 8 zones per building shall be used. Type of reheat in the heating coils shall be 0, 1, 2 or N/A as follows:

0 For electric reheat
1 For gas-fired reheat
2 For heat pumps (in heating mode)
N/A For a non-applicable case

TABLE B-19 AIR FLOW RATIO FOR SPECIAL ZONES (HFBRA)

ZONE	1	2	3	4	5	6	7	8
AIR RATIO								

This table applies only to zones associated with air handler types 5, 6, 7, 8 or 9 (see table B-15). For zones fed by an air handler type 5, 6, 7 or 9 (i.e., two level zones) the ratio of comfort air discharge (cfm) to total air discharge (cfm) supplied to the zone shall be used. The total air discharge to these zones is the sum of plenum and comfort air flows. For zones fed by an air handler type 8 (see table 15), the ratio of bypassed return air (cfm) to total air discharge (cfm) supplied to the zone shall be used. (N/A) shall be used for a non applicable case. Measurements of air flow in cfm in the various ducts shall be made or may be substituted by design values shown in as-built drawings.

TABLE B-20 TYPE OF HEATING IN AIR HANDLER HEATING COILS (HEATER)

AIR HANDLER	1	2	3	4	5	6	7	8	9	10
HEATER										

Table B-20 allows (10) air handlers per building. The type of heating in each air handler shall be 0, 1, 2 or N/A as follows:

0 for electric heaters
1 for gas-fired boilers
2 for heat pump (in heating mode)
N/A for a non-applicable case

TABLE B-21 OUTSIDE AIR TO TOTAL AIR RATIO (ALFA)

AIR HANDLER	1	2	3	4	5	6	7	8	9	10
OUTSIDE AIR RATIO										

Table B-21 allows (10) air handlers per building. The outside air ratio is the ratio of fresh outside air discharge (cfm) to total air discharge (mixed air) handled by the air handler. The ratio will be a number varying from 0.0 to 1.0. Zero values means no ventilation by fresh outside air and 100% recycled return air. The value of (1) means that 100% of the air leaving the air handler is outside air with no return air recycled. Non-applicable boxes shall be left blank. Measurements of outside air discharge in cfm is required.

TABLE B-22 TYPE OF OUTSIDE AIR ECONOMIZER CONTROLS (ECON)

AIR HANDLER	1	2	3	4	5	6	7	8	9	10
ECONO. TYPE										

Table B-22 allows for 10 air handlers per building. The outside air economizer cycle controls shall be 0, 1 or 2 as follows: Other cases shall be identified and listed in alphabetic form according to manufacturer's name. However, the value (2) can be used as a starting point.

0 no economizer
1 for Honeywell-type economizer control
2 for Barber-Coleman (DIGI-DAP) type control

TABLE B-23 AIR DISCHARGE/DISTRIBUTION (ZCFM)

AIR HANDLER \ ZONE	1	2	3	4	5	6	7	8
1(first)								
2(second)								
3								
4								
5								
6								
7								
8								
9								
10								

Table B-23 shows how the air discharge (in ft^3/min) is divided between zones. A maximum of 10 air handlers per building and a maximum of 8 zones fed by a single air handler are allowed. Buildings with more than 8 zones per air handler shall be grouped into Macrozones. Zones that see the type of air handler identical (from table 15) can be grouped into one macrozone with one total cfm. A zone (or macrozone) can be fed by more than one air handler. Non-applicable boxes shall be considered zero. Measurements of air flow in cfm in the various ducts and zones shall be made or may be substituted by design values shown in as-built drawings.

TABLE B-24 REFRIGERATION/HEAT PUMP - COMPRESSOR CAPACITY (SIZE)

COM-PRESSOR NUMBER \ SIZE	FIRST STAGE COMPRESSOR (TONS)	SECOND STAGE COMPRESSOR (TONS)	HEAT PUMP (HEATING MODE) (BTU/HR)
1 (first)			
2 (second)			
3			
4			
5			
6			
7			
8			
9			
10			

Table B-24 gives information about the air conditioning equipment size. There can be as much as 10 compressors per building. Two stages (two columns) are only listed with the second stage giving the full compressor tonnage when on. Compressors having more than two stages shall be approximated by dividing the full load tonnage by 2 and entering the result in each of the 2 columns. The third column is reserved for compressors that can switch cooling/heating operation (heat pump). The data to be entered in the third column are the heat pump capacity in Btu/hr when operating in heating mode. "Blank" or "zero" values shall be used otherwise.

TABLE B-25 AIR HANDLER - COMPRESSOR ARRANGEMENT (COPRES)

Air Handler No. / Compressor No.	1	2	3	4	5	6	7	8	9	10
1	X				X	X				
2										
3										
4										
5										
6										
7										
8										
9										
10										

Table B-25 gives information about which compressor is feeding a specific air handler and vice versa. A maximum of 10 air handlers can be fed by a single compressor, and a maximum of 10 compressors per building are allowed. For example, the first compressor is feeding air handlers number 1, 5 and 6.

TABLE B-26 TWO-LEVEL ROOM INDEX (ICNTRL)

AIR HANDLER \ ZONE	1	2	3	4	5	6	7	8
1st								
2nd								
3								
4								
5								
6								
7								
8								
9								
10								

Table B-26 applies primarily to two-level zones (or rooms) such as control rooms. The index differentiates between the various air handlers in supplying a two-level zone and supplying a single-level zone. The index can be an integer 0, 1 or 2, according to the following. The index shall be taken (zero) if the zone is a single-level (simple) zone fed by one or more air handlers supplying each the same air temperature (not necessarily with equal air discharge). The index shall be taken (zero) also if the zone is a two-level zone fed by two air streams (cold plenum air and comfort air) of different temperatures coming from a single air handler. (The air handler/zone type in this case can be 5, 6, 7 or 9 as in Table B-15.) For two-level zones fed by two or more air streams (single comfort air stream and multiple cold plenum streams) the following indexes apply: Index equals (1) shall be given to each air handler participating in supplying the plenum air, Index equals (2) shall be given to the air handler which is feeding the comfort air only (see bottom sketches). Non-applicable cases shall be left blank. If "index" equals 1 or 2, the air handler type (see Table B-15) can only be 1, 2, 3, 4, or 8.

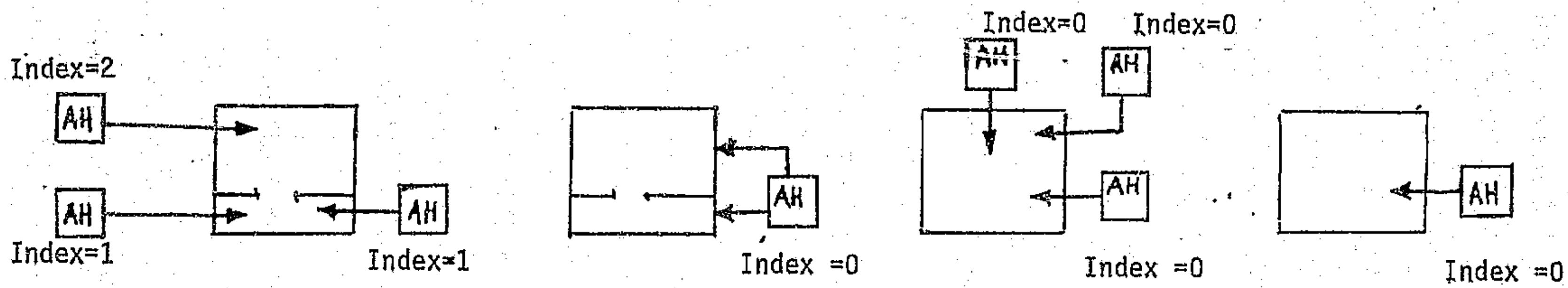


TABLE B-27 NET WALL AREA (AWAL)

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1									
2									
3									
4									
5									
6									
7									
8									

The net wall area in square feet (excluding glass areas) of each zone shall be grouped according to orientation S-South, SW South-west, W West, NW North-west, SE South-east, E East, NE North-east and N North. In a zone of irregular geometric shape combining rooms that are distantly apart, similar orientation walls shall be grouped and summed. Only zone wall areas and orientations that are either next to a non-air-conditioned area (such as outside air, mechanical rooms, etc.) or next to a constant temperature room are included. Floors are assumed insulated and not losing or gaining heat from sub levels, therefore not needed. Non-applicable boxes shall be left blank. Contour measurements of walls, roof dimensions are needed. For zones having two (or more) walls having the same orientation but adjacent to different neighbouring zones, use can be made of one (or more) of the 9 orientations in the table that is otherwise zero. The program will not differentiate wall orientations unless the wall is an exterior (see Table B-30).

TABLE B-28 OUTSIDE WALL SURFACE ABSORPTIVITY (ABSORT)

SOLAR ABSORPTIVITY	

The solar absorptivity of outside walls facing the sun (a dimensionless value) depends on the paint color. The value shall either be estimated from any heat radiation textbook or by measuring the wall reflectivity and substituting in [absorptivity = 1 - reflectivity]. A black painted wall, for example, has 0.95 absorptivity.

TABLE B-29 GLASS AREA (AGLAS)

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1									
2									
3									
4									
5									
6									
7									
8									

The glass area in square feet in each zone shall be grouped according to orientation. Glass areas include windows, glass doors, etc. Same comments as of Table B-27 apply.

TABLE B-30 - ADJACENT CONDITION OF WALL (ADJ)

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1									
2									
3									
4									
5									
6									
7									
8									

This table identifies the nature of neighboring zones and whether these are air-conditioned or not and how. The adjacent condition shall be an integer 0, 1, 2 or 3 according to the following cases:

0 means no wall exists or there is a thin partition between two air-conditioned zones having always the same temperature.

1 case of an interior wall/partition next to a room with a constant all year around temperature (see table 32 also)

2 case of an interior wall/partition adjacent to a non-conditioned room (typically a mechanical room housing boilers, pumps etc.). The non-conditioned neighbour room is exposed to the ambient air temperature fluctuations

3 case of an exterior wall exposed to ambient air temperature fluctuations in addition to solar radiation

Tables B-27, B-29, B-30, B-31, and B-32 shall be completed simultaneously. Non-applicable boxes shall be left blank.

TABLE B-31 FRACTION OF UNSHADED PORTION OF WALL (SHADE)

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)	ROOF
1									
2									
3									
4									
5									
6									
7									
8									

Table B-31 gives information about the percentages of shading and unshading exterior walls by overhangs. Since the shaded/unshaded areas vary throughout the day and with the season in a complex manner, the data supplied to this table shall be considered as an approximate observation for the year. Each wall or roof in a particular zone shall be associated with a shade number. The shade number to be used in Table B-31 shall be the ratio of unshaded area of a wall to its total wall area. This ratio varies from zero for completely shaded walls to 1.0 for unshaded walls. Non-applicable boxes shall be left blank. Unshaded fractions are taken as yearly average.

TABLE B-32 TEMPERATURE OF CONSTANT TEMPERATURE NEIGHBOUR (TNEXT)

ZONE	S(1)	SW(2)	W(3)	NW(4)	SE(5)	E(6)	NE(7)	N(8)
1								
2								
3								
4								
5								
6								
7								
8								

Temperatures of neighbouring zones (in deg. F) shall only be listed whenever the adjacent table (Table B-30) shows ADJACENT = 1. This means that the neighbouring zone is at a constant temperature all year round. Table B-32 does not apply to any other cases and shall be left blank if ADJACENT = 1 condition is not met.

TABLE B-33 NUMBER OF PERSONS IN ZONE (NOP)

ZONE	DAYTYPE \ HR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																								
	2																								
2	1																								
	2																								
3	1																								
	2																								
4	1																								
	2																								
5	1																								
	2																								
6	1																								
	2																								
7	1																								
	2																								
8	1																								
	2																								

Two daytypes are listed; 1) a weekday (Monday through Friday) are considered of day type (1). 2) a week-end and holidays are considered of daytype (2). The type of activities in each daytype may vary according to the work load. Twenty-four values are listed corresponding to 24 hrs of day. The number of persons occupying the conditioned zone shall be estimated (on an hourly basis) for only two representative days, one for each daytype. Non-applicable boxes shall be left blank.

TABLE B-34 INCANDESCENT LIGHT POWER AND SCHEDULE IN KILOWATT (KILGHT)

ZONE	DAYTYPE \ HR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																								
	2																								
2	1																								
	2																								
3	1																								
	2																								
4	1																								
	2																								
5	1																								
	2																								
6	1																								
	2																								
7	1																								
	2																								
8	1																								
	2																								

The magnitude and schedule of light power in each zone shall be given hourly (for 24 hours) for only two representative days per year. Daytype 1 presents a regular weekday type and daytype 2 presents a weekend (or a holiday) type. The electric kilowatt for incandescent light bulbs shall be summed over all the bulbs inside the conditioned zone. External light bulbs shall not be considered in this table, but rather be included in Table B-38. Non-applicable blocks shall be left blank.

TABLE B-35 FLUORESCENT LIGHT POWER AND SCHEDULE IN KILOWATT (KFLGHT)

ZONE	DAYTYPE \ HR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																								
	2																								
2	1																								
	2																								
3	1																								
	2																								
4	1																								
	2																								
5	1																								
	2																								
6	1																								
	2																								
7	1																								
	2																								
8	1																								
	2																								

Table B-35 has the same comment/description as Table B-34 except that data related to fluorescent light power are listed instead of the incandescent ones. Tables B-34 and B-35 are necessary in calculating the electric energy consumed in lighting and their effect on air conditioning.

TABLE B-36 ELECTRICAL EQUIPMENT POWER AND SCHEDULE IN KILOWATT (KEQUPE)

ZONE	DAYTYPE \ HR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																								
	2																								
2	1																								
	2																								
3	1																								
	2																								
4	1																								
	2																								
5	1																								
	2																								
6	1																								
	2																								
7	1																								
	2																								
8	1																								
	2																								

The electrical/electronics equipment wattage and schedule inside each zone shall be given hourly (for 24 hours) for only two representative days per year. Daytype 1 is a regular weekday type and daytype 2 is a weekend (or a holiday) type. Electric wattage is additive for all equipment inside the conditioned zone. External electronic/electrical equipment power shall not be considered in Table B-26 but rather be included in Table B-38. Non-applicable blocks shall be left blank. Data may be provided by name plate capacities assuming full load operation or else measured.

TABLE B-37 MECHANICAL EQUIPMENT POWER AND SCHEDULE IN KILOWATT (KEQUPM)

ZONE	DAYTYPE \ HR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																								
	2																								
2	1																								
	2																								
3	1																								
	2																								
4	1																								
	2																								
5	1																								
	2																								
6	1																								
	2																								
7	1																								
	2																								
8	1																								
	2																								

Table B-37 has the same comments/description as Table B-36 but is concerned with data related to mechanical equipment instead. Data may be provided by manufacturers namelist capacity assuming full load operation or else measured. Non-applicable blocks shall be left blank. Only mechanical equipment which contribute to room heat gain, excluding air conditioning equipment, shall be entered.

TABLE B-38 DAILY ENERGY CONSUMPTION BY AUXILIARY EQUIPMENT (ACCERY)

ACCESSORIES (KWH)	DAYTYPE 1	DAYTYPE 2
AIR HANDLER FANS		
CONDENSER FANS		
BOILER PUMPS		
EXTERNAL LIGHTS		
OTHER		

Auxiliary equipment is here defined as that equipment outside the air conditioned zone space which does not affect the heating/cooling load calculations though necessary to run the system. Auxiliary equipment affects directly the watt hour meter reading. The load profile and schedule for such equipment can be quite complex and an approximate daily energy consumption is sufficient. Table B-38 identifies some of the auxiliary equipment such as air handlers fans, condenser fans, boiler pumps, external lighting, etc. Data can be found by multiplying the full load name plate kilowatt times the average number of working hours per day. Two days (daytype 1 and daytype 2), if different, shall represent the accessories energy consumption for similar daytypes. Non-applicable blocks shall be left blank. Refrigeration compressors, electric and gas heaters should be excluded from this table.

TABLE B-39 TIME CLOCK SCHEDULE (TMCLK)

		HOUR																							
AH NO.	DAYTYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1																								
	2																								
2	1																								
	2																								
3	1																								
	2																								
4	1																								
	2																								
5	1																								
	2																								
6	1																								
	2																								
7	1																								
	2																								
8	1																								
	2																								
9	1																								
	2																								
10	1																								
	2																								

Table B-39 gives the time clock schedule which controls the air handler operation only. Other time clocks which are connected to light bulbs or electronics equipment shall alter the power levels with schedule and will appear indirectly in tables B-34, B-35, B-36, and B-37. Two representative days per year are considered daytype (1) and daytype (2). Time clock indicator shall be either (0) or (1). Zero means the time clock is OFF and the air handler/compressor equipment are still on. The value (1) means that the time clock is triggered and the air handler/compressor equipment is OFF. Non-applicable blocks shall be left blank.

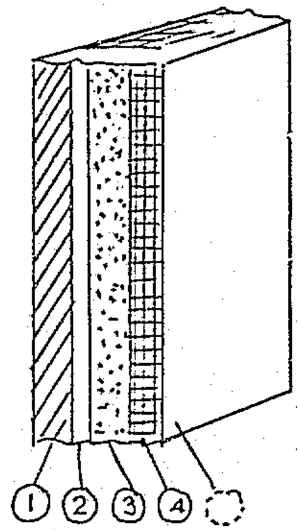
TABLE B-40 WALL CROSS SECTION DESCRIPTION

LAYER	THICKNESS INCH	LAYER MATERIAL DESCRIPTION
1		
2		
3		
4		

TABLE B-41 ROOF CROSS SECTION DESCRIPTION

LAYER	THICKNESS INCH	LAYER MATERIAL DESCRIPTION
1		
2		
3		
4		

In Tables B-40 and B-41 only ONE wall and ONE roof shall be examined for each building. Layer thicknesses (in inches) and material description are required. An air space shall be considered as a layer. The entire roof description starting from the inside (living) space to the outside ambient air shall be described. Sketches are recommended to clarify the construction. For each layer material the values of specific heat, thermal conductivity and density must be provided.



APPENDIX " C "

APPENDIX C

UVPHI SUB-PROGRAM

The (UVPHI) sub-program calculates the overall heat transfer coefficients: mean (U), amplitude (V), and phase lag (Ø) for walls and roofs. Multilayer wall or roof is presented by an average set of properties as if it were homogeneous. The final result of the sub-program (U, V and Ø) will be used as input to the (TRANS) sub-routine discussed in Section VII. The analytical description is explained in reference (4).

C.1 Variables List

The variables used are listed alphabetically as follows:

Variable	Description
A	coefficient, dimensionless
B	coefficient, dimensionless
DENSE	layer density, Lb/ft^3 (F10.3)
EDENSE	equivalent wall (or roof)density, Lb/ft^3
ESHEAT	equivalent wall (or roof) specific heat, Btu/Lb^oF
HI	convective heat transfer coefficient for the inside surface, $Btu/hr\ ft^2$
HO	convective heat transfer coefficient for the outside surface, $Btu/hr\ ft^{2o}F$
KSUBW	equivalent thermal conductivity for wall (or roof), $Btu/hr\ ft^oF$
NUSUBW	equivalent thermal diffusivity for wall (or roof), ft^2/hr
PHI,PHIW,PHIRF	phase angle for wall or roof, radian
RESIST	layer thermal resistivity, ft^2hr^oF/Btu
RLAYER	number of layers in roof (F10.0)
SIGMA	coefficient, ft^{-1}
SL	coefficient, dimensionless
SPHEAT	layer specific heat, Btu/lb^oF(F10.3)
THICK	layer thickness, ft (F10.3)
TRESIS	total thermal resistance for a wall (or roof), ft^2hr^oF/Btu
TTHICK	total thickness of a wall (or roof), ft
U, UWL, URF	U-factor or overall heat transfer coefficient for wall (or roof), $Btu/hr.ft^{2o}F$
V,VWL,VRF	V-factor, or amplitude of heat transfer coefficient for wall (or roof), $Btu/hr.ft^{2o}F$
WIND	wind speed, mph (F10.0)
WLAYER	number of layers in wall (F10.0)
Y	coefficient, dimensionless
Z	coefficient, dimensionless

C.2 Input Data Cards

The four data items: THICK, DENSE, RESIST and SPHEAT should be punched on one data card per layer using only 10 columns per data item. The cards corresponding to the layers in the roof shall be first, followed by the cards corresponding to the layers in the wall. A sample data deck is shown in Fig. C-1. The data items WIND, RLAYER, and WLAYER should be put on one data card using 10 columns only, and all constitute the first card as shown in Fig. C-1. The first card indicates 9 mph wind speed, 3 roof layers and 2 wall layers. The three data cards following data card 1 give the thickness, density, thermal resistivity, and specific heat for each layer of the roof. Data cards 5 and 6 give the thickness, density, thermal resistivity and specific heat of the two layers of the wall.

C.3 Computation Procedure

1. Calculate the total thickness, thermal resistance, the equivalent density and specific heat.

$$TTHICK = \sum_i THICK(i) \qquad ft$$

$$EDENSE = \sum_i \frac{DENSE(i)*THICK(i)}{TTHICK} \qquad Lb/ft^3$$

$$TRESIS = \sum_i RESIST(i) \qquad hr.ft^{2\,o}F/Btu$$

(including the two air boundary layers on the inside and outside surfaces)

$$ESHEAT = \sum_i \frac{THICK(i)*DENSE(i)SPHEAT(i)}{TTHICK*EDENSE} \qquad Btu/Lb^oF$$

2. Calculate the overall U-factor for the wall (or roof).

$$U = \frac{1}{TRESIS} \qquad Btu/hr.ft^{2\,o}F$$

or UWL
URF

3. Calculate the outer surface and inner surface heat transfer coefficients, assumed as follows:

$$HO \approx 1.0 + WIND/3 \qquad Btu/hr.ft^{2\,o}F$$

$$HI \approx 1.0 \quad \text{(still air)} \qquad Btu/hr.ft^{2\,o}F$$

4. Calculate the equivalent thermal conductivity and diffusivity.

$$KSUBW = \frac{TTHICK}{TRESIS - (1/HI) - (1/HO)} \qquad Btu/hr.ft^oF$$

$$NUSUBW = \frac{KSUBW}{(EDENSE)*(ESHEAT)} \qquad ft^2/hr$$

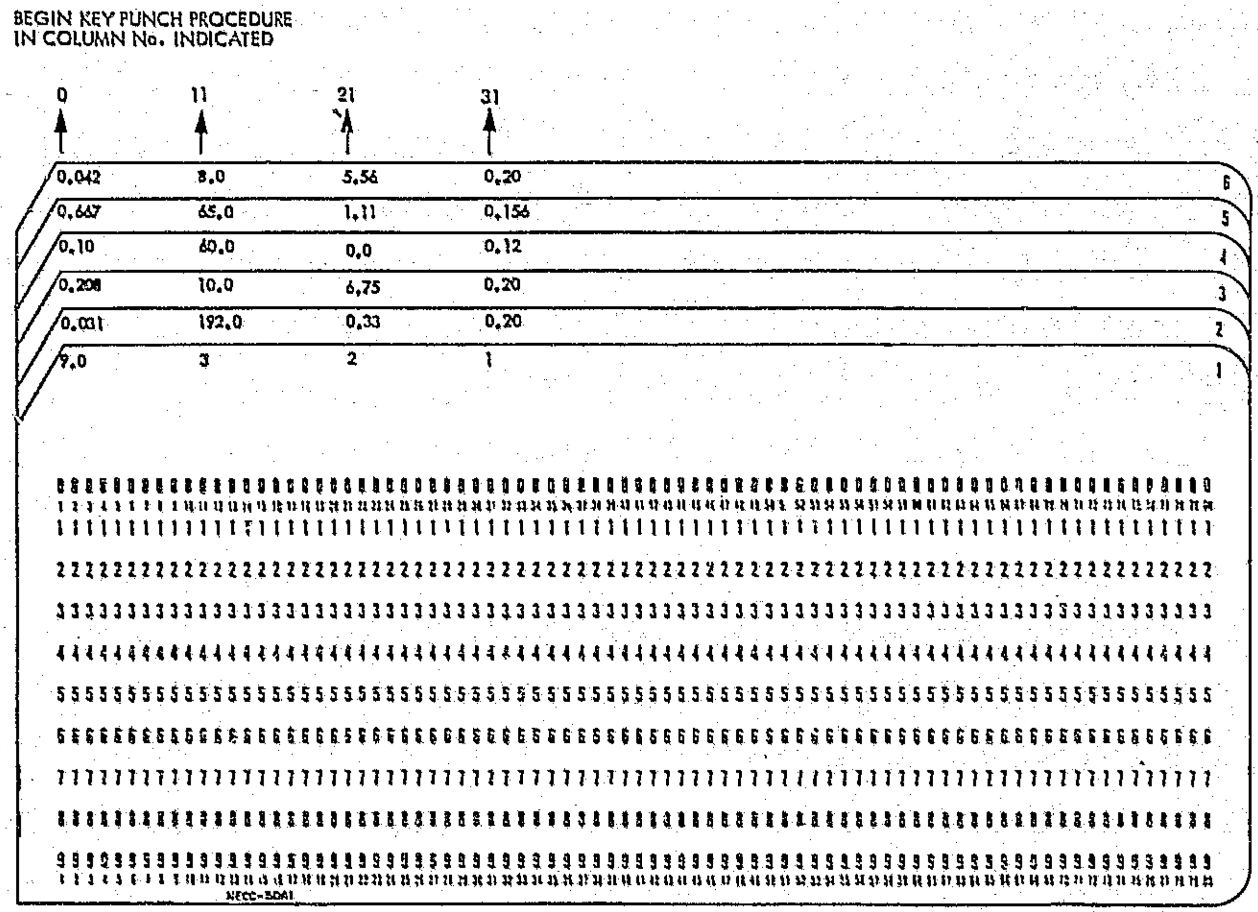


Figure C-1. A typical data deck for UVPHI subprogram

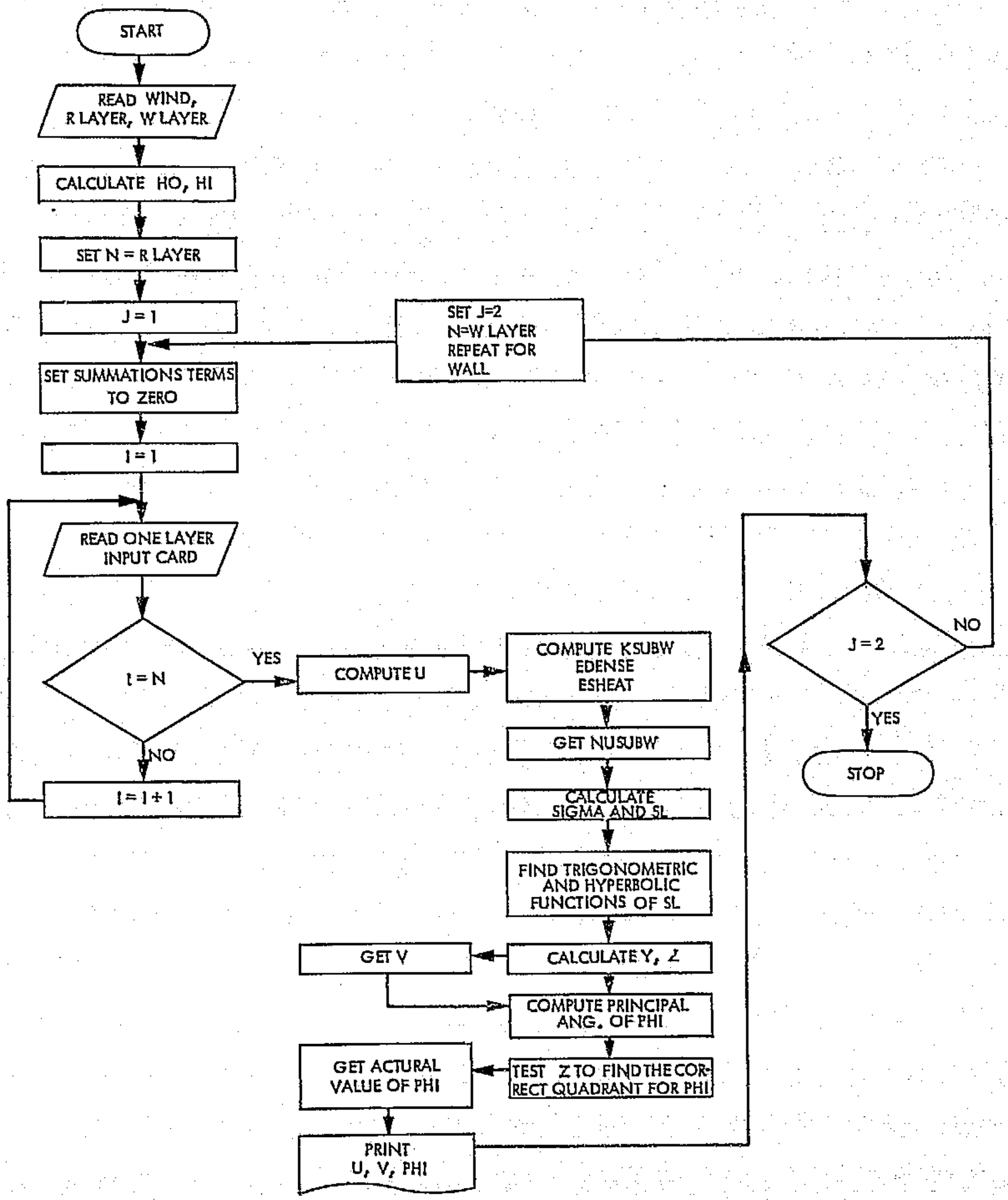


Figure C-2. Flow chart for UVPHI subprogram

5. Calculate SIGMA and SL coefficients defined as:

$$SIGMA = \sqrt{\pi/(24*NUSUBW)}$$

$$SL = SIGMA*TTHICK$$

6. Calculate the trigonometric and hyperbolic functions of SL needed to determine angle (PHI)

$$CO = COS\ (SL)$$
$$SI = SIN(SL)$$
$$HCO = COSH(SL)$$
$$HSI = SINH(SL)$$

7. Calculate A, B, Y and Z coefficients defined as:

$$A = (HI*HO)/2*(SIGMA*KSUBW)^2$$
$$B = (HI + HO)/(SIGMA * KSUBW)$$
$$Z = \left[(A+1)*SI*HCO\right] - \left[(A-1)*CO*HSI\right] + \left[B*SI*HSI\right]$$
$$Y = \left[(A+1)*CO*HSI\right] + \left[(A-1)*SI*HCO\right] + \left[B*CO*HCO\right]$$

8. Calculate the V-factor from Y and Z.

$$V = (HI*HO)/\left| SIGMA*KSUBW\sqrt{(Y^2+Z^2)}\right|$$
or (VWL)
(VKF)

9. Determine (PHI)

$$PHI = TAN^{-1}\left| Z/Y\right|$$
or (PHIWL
PHIRF)

If $Z<0$ and $Y>0$ then $PHI = 2\pi - PHI$

If $Z<0$ and $Y<0$ then $PHI = \pi + PHI$

If $Z>0$ and $Y<0$ then $PHI = \pi - PHI$

The flow chart is sketched in Fig. C.2 for reference.

C.4 Example of U, V and PHI calculations:

Tables C.1 and C.2 lists the data collected about one exterior wall and one roof respectively for the example building G-86 previously discussed in Section III.

Table C.1 Construction details of one exterior wall for the example building G-86.

LAYER	MATERIAL	THICKNESS (FT)	DENSITY Lb/ft^3	THERMAL RESISTANCE ft^2hr^oF/Btu	SPECIFIC HEAT Btu/Lb^oF
1	moving air	-	0.07	0.25	0.24
2	concrete block	0.667	65	1.11	0.156
3	insulation	0.3	8	9	0.2
4	acoustic tile	0.063	20	1.89	0.3
5	still air	-	0.07	1.0	0.24

Table C.2 Construction details of one zone roof for the example building G-86

LAYER	MATERIAL	THICKNESS (in, ft)	DENSITY Lb/ft^3	THERMAL RESISTANCE ft^{2}hr^{o}F/Btu	SPECIFIC HEAT Btu/lb^{o}F
1	moving air	--	0.07	0.25	0.24
2	built-up roof	0.03	192	0.33	0.2
3	insulation	0.167	11	5.56	0.2
4	insulation	0.208	6	4.2	0.2
5	metal deck	0.012	489	0.0	0.12
6	air space	2.0	0.07	2	0.24
7	suspended ceiling	0.063	20	1.89	0.3
8	still air	--	0.07	1.00	0.24

The wind velocity WIND = 9 mph
RLAYER = 8
WLAYER = 5

Following the computation procedure given in Section C.3. The values of U, V and PHI were as follows:

UW = 0.075472 Btu/hr.ft^2^{o}F
VW = 0.01807 Btu/hr.ft^2^{o}F
PHIWL = 2.9624 radian

UR = 0.06566 Btu/hr.ft^2^{o}F
VRF = 0.037787 Btu/hr.ft^2^{o}F
PHIRF = 1.7041 radian

The computer program that calculates the parameters U, V, and PHI is listed next for use prior to the processing of the ECP program.

```
13592*VIC(1).UVPHI
C      A PROGRAMME FOR THE COMPUTATION OF U,V AND PHI,VALUES THAT ARE RELATED
C      TO THE THERMAL PROPERTIES OF A WALL
C
C    THICK = THICKNESS OF A LAYER IN FT
C    DENSE = DENSITY OF THAT LAYER IN LB/CU FT.
C   RESIST = THERMAL RESISTANCE OF THAT LAYER IN Q.FT.*HOUR*DEG F PER BTU
C   SPHEAT = SPECIFIC HEAT OF THAT LAYER IN BTU PER LB PER DEG F
C        U = HEAT TRANSFER COFFICIENT OF WALL IN BTU PER HR*FT*(DEG F)
C        V = FACTOR (DUE TO THERAML DIFFISIVITY OF WALL) IN THE AMPLITUDE OF
C            THE AMOUNT OF HEAT TRANSFERRED
C      PHI = PHARSE LAG IN TRANSMTSSION
C     WIND = VELOCITY OF WIND IN MILES
C   WLAYER = NO. OF LAYERS THE WALL HAS
C   RLAYER = NO. OF LAYERS THE ROOF HAS
C
      REAL KSUBW, NUSUBW
      READ(5,100) WIND,RLAYER,WLAYER
      HO=1.+WIND/3.
      HI=1
      N=RLAYER
C
C   IN THE FOLLOWING DO-LOOP, J=1 IS FOR THE ROOF AND J=2 FOR THE WALLS
C
      DO 20 J=1,2
      TTHICK=0.
      THASS=0.
      TSHEAT=0.
      TRESIS=0.
C
C
C
C
      DO 10 I=1,N
      READ (5,101) THICK,DENSE,RESIST,SPHEAT
      TTHICK =TTHICK+THICK
      THASS  =THASS+THICK*DENSE
      TSHEAT =TSHEAT+THICK*DENSE*SPHEAT
      TRESIS =TRESIS+RESIST
   10 CONTINUE
      U=1./TRESIS
      KSUBW=TTHICK/(TRESIS-1./HO-1./HI)
      EDENSE=THASS/TTHICK
      ESHEAT=TSHEAT/TTHICK/EDENSE
      NUSUBW=KSUBW/EDENSE/ESHEAT
      SIGMA =SQRT(3.14159/24./NUSUBW)
      SL    =SIGMA*TTHICK
      CO=COS(SL)
      SI=SIN(SL)
      HCO=COSH(SL)
      HSI=SINH(SL)
      A=HI*HO/2./(SIGMA*KSUBW)**2
      B=(HI+HO)/SIGMA/KSUBW
      Y=(A+1)*CO*HSI+(A-1)*SI*HCO+B*CO*HCO
      Z=(A+1)*SI*HCO-(A-1)*CO*HSI+B*SI*HSI
      V=HI*HO/SIGMA/KSUBW/SQRT(Y*Y+Z*Z)
      PI=3.14159
```

```
      PHI=ATAN(ABS(Z/Y))
      IF(Z.LT.0..AND.Y.GT.0.)PHI=2*PI-PHI
      IF(Z.LT.0..AND.Y.LT.0.)PHI=PI+PHI
      IF(Z.GT.0..AND.Y.LT.0.)PHI=PI-PHI
      IF(J.EQ.2)GO TO 1
      WRITE(6,102)
      GO TO 2
    1 WRITE(6,103)
    2 WRITE (6,105)
      WRITE (6,104) U,V,PHI
      N=WLAYER
   20 CONTINUE
  100 FORMAT(3F10.0)
  101 FORMAT (4F10.3)
  102 FORMAT (//32X,' ROOF'//)
  103 FORMAT (/////32X,' WALL'//)
  104 FORMAT(F16.5,F23.5,F24.5)
  105 FORMAT ('            U          ','                V          ','
     +        PHI          ')
      STOP
      END
```

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