CALCULATION OF HEAT TRANSMISSION

OF

WALLS AND WINDOWS

USING

THE GRAPPLE SYSTEM

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ABSTRACT

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This technical reports deals with the application of Computer-Aided Design to the calculation of heat transmission losses for walls, windows and doors. The author's view on the advantages and problems of the Grapple System and proposals regarding the use of the System with available hardware are presented. Computer outputs include graphical displays of temperature gradients through building members, wall and window cross-sections and three-dimensional building representations. Tables of results indicating overall heat loss, percentage glazing and building component surface areas are also available.

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INTRODUCTION

HEAT TRANSMISSION THROUGH WALLS AND WINDOWS USING THE GRAPPLE SYSTEM

The selection of a topic for any technical research work is generally founded on two criteria: personal preference and industrial requirement. This report was based on the following considerations: the subject would have to be related to Building Sciences, to deal with Energy Conservation, to have future career implications, and to be general, not specific, in nature. My experience in Plant Maintenance Engineering and Design has indicated there is a requirement for simple, accurate methods for investigating problem areas involving heat loss in existing buildings and structures in conception. The actual mathematics involved are simple, but tedious, and the information required is readily available, but difficult to decipher. These factors make the topic an excellent choice for Computer-Aided Design.

The aim of this report is two-fold: 1)to present the reader with the problems that are to be encountered when an engineer assumes the role of computer programmer/systems analyst and interacts with Grapple; 2)to provide designers with a tool that will reduce repetitive calculations, remove tedious information searches, reduce overall workload, and increase engineering design proficiency.

The obstacles encountered by a first-time Grapple System user increase the workload of any project. These range from problems involving poor documentation, limited instructions, hardware breakdown, and disk failure to difficulties regarding the use of a graphics package, the learning of a new computer language, and the introduction of an interactive system. A critical analysis of these points including relevant proposals will be discussed in this report.

The computer program developed provides two outputs:

i) Temperature gradient lines for walls, doors and windows;

ii) Tables representing relative heat losses for the various components of a model building.

In this project two packages are developed for standard frame and masonry walls and a free-design package is available for other wall constructions. Windows and doors are completed by a third program. The calculation of R-Values and the graphical display of a resulting temperature gradient lines are carried out by these four programs: FRAME, MASONRY, OTH, WINDOR.

The four computer packages have been amalgamated with an existing Grapple program, originally called COST2, developed by Professor J. Amkreutz of Concordia University's Center for Building Studies. COST2, now C.A.B.D., - an abbreviation for Computer-Aided Building Design, provides the framework for investigating problems related to the entire building structure with respect to heat transmission loss. Tables indicating overall heat loss, surface areas for components, resulting glazing percentages, and door area percentages are presented. Other features of the C.A.B.D. package are three-dimensional representations of the building and the ability to alter the viewpoint location.

These packages have been constructed in a flexible pattern so as to allow for future modifications and extensions. These could include: roof transmission losses, infiltration/exfiltration heat loss, and air change heat loss.

Chapter 1

Building Engineering

1:1 Background Synopsis

Construction has suffered setbacks owing to the recent energy crisis and the spiralling cost for fossil fuels. It has become obvious to builders, government, and property owners that attention must be paid to energy conservation requirements. Not only does this fact apply to petroleum-fueled construction projects but it also influences the construction and maintenance costs of hydro electric projects which, in turn, affect electricity rates.

In the past, the possibility of a three-fold increase in the price of petroleum products was not considered by industry. Poor foresight on the part of builders, developers and designers has obliged owners to assume responsibility for energy-obsolete buildings; the financial burden, in turn, has been passed on to the tenants, and in succession onto the economy.

Sophisticated methods are required to rapidly assess all realistic solutions to problem areas. Computer-Aided Design (CAD) provides the leverage to designers and engineers so that the numerous alternatives accompanying each design decision may be examined efficiently and effectively.

1:2 Computer-Aided Design

The title of a recent publication Computer Augmentation of Human Reasoning,[1] exemplifies, in my opinion, the implications of Computer-Aided Design. Two statements from authorities in this field summarize the current trends of thought.

"In the past ten years the computer has become a common tool in the architecture office. It commonly aids in structural and mechanical system analysis, in cost accounting and in editing of specifications". Charles M Eastman[2]

"The application of computer-aided design in architecture building lagged considerably behind applications in engineering. Hostility to the idea amongst architects, and ignorance of the potentials of computer technology, perhaps contributed to this; but the fundamental reason undoubtedly was economic".

William J. Mitchell[3]

The development of CAD commenced in the early '60s. At that time the majority of the research was sponsored by the automotive and aerospace industries. Since then CAD has expanded to almost all aspects of engineering; however, Computer-aided technology did not successfully penetrate the building field. The reasons for this are associated with problems inherent in the building sector: fragmentation of the industry, non-repetitiveness of work, and low design versus product cost ratio.

There are numerous reasons for using computers in building design. Visual and arithmetic modelling is performed at a fraction of the cost of calculations done by conventional methods. Sensitivity analysis allows the designer to ascertain the "weak links" of the structure and to modify his design accordingly. The computer affords the possibility of studying numerous design conceptions while conventional methods restrict the architect to one building layout. The speed of computers provides the decision makers with near instantaneous answers for alternatives to proposals and allows for less lead time between design steps. Computer technology also provides added benefits such as: hard documentation, standardized presentation and inexpensive data storage.

"Over recent years there has been a gradual change in emphasis in architectural CAD. Much of the research and development effort has gone into three separate but related areas: presentation of design results in graphical form, normally as drawings; database methodologies needed to provide a structure and form for the unique information required to describe the building; and simulation techniques used to ascertain the effect of design decisions on the building's performance. Little effort has gone into educating architects and designers in what can and cannot be expected from computers, let alone how to make use of existing facilities".

John Gero [4]

1:3 Heat Transmission

Most of the software programs that have been published in Computer-Aided Building Design are included in the following three texts:

i) Bibliography of Energy Conservation; Lee, Kaiman.[5]

ii) Bibliography of Computers in Environmental Design; Lee, Kaiman.[6]

iii) Computer Programs for the Building Industry International Directory.[7]

The first two indicate that a limited number of software programs are available for energy conservation involving the building enclosure system. Most of the articles deal with specific research but few with practical applications. The third publication provides a list of available programs for all sectors of building construction. However, the majority of these thirty or more programs deal specifically with heat gain and few even touch upon heating losses. In conventional heat calculation programs, the sizing of heating units requires the use of complicated programs but the actual input regarding the walls is a numeric value of R-12 or R-14* with little consideration for the exact value or the wall enclosure composition. There are no computer programs available that carry out temperature gradient line calculations in any programming language and there are no programs available for heat loss calculations in the Grapple Language.

A summary of pertinent programs along with abstracts is included in Appendix 1. Unfortunately, all of these programs are only available through time-sharing or by direct purchase, so their modelling system, output, or reliability cannot be readily assessed.

Note: In Imperial system R represents the inverse of the material's thermal conductance. It is expressed in units of (Fahrenheit degrees)(hours)(square foot)/BTU. In the Metric system the units are (Celsius degrees)(square meter)/Watt.

Chapter II

The Grapple System

2:1 Past

The Grapple Language (Graphical Application Programming Language) was developed in the early 1970s by Bell Northern Research. The "loaner program" was established by Public Works Canada (PWC) in 1977 in order to introduce Computer Aided Design (CAD) to the various sectors of the building industry. "Equipment loans were granted to various departmental, inter-departmental, educational, and private groups so as to expose the opportunity to a large community to participate in developmental work for the building industry and to attract new recruits to DPW by providing the opportunity for hands on experience".[8] It was then to be PWC's responsibility to provide backup documentation and technical support to the program participants. On this basis, Concordia University's Center for Building Studies (CBS) was introduced to the Grapple Language.

The principle feature of Grapple System is a draughting aid "DRAW 1"[9] which uses a cathode ray tube (CRT) display, and functions as an interface between draughtsmen and a tablet plotter. DRAW 1 is supplied with a storehouse of functions that allows the user to reproduce on the CRT most shapes, symbols, or figures required for his drawing. Once a facsimile of the required drawing is produced by the user on the screen it may be copied mechanically be means of a plotter.

2:2 Present

The present budget for the "loaner program" is 5.8 million dollars and there are over 40 participants in the program. These range from architectural consulting firms to universities. The funds are secured until March 1980; and the possibility for extending the program are positive and the participants have confirmed their acceptance of the program by their solid results. Waterloo University is working on municipal urban planning, while Murray and Murray and Partners Ltd., completed architectural drawings for a 20 million dollar RCMP project. The Faculty of Architecture at Nova Scotia Technical College employed the system for FORTRAN programming while Carleton University has produced a workable Bill of Materials program based on DRAW 1, as well as DRAW 1 and DRAW 2 Reference Manuals. Unfortunately, the majority of all work by participants, - with the exception of Concordia University, has been carried out by using the DRAW 1 package.

Progress is being made in the Research and Development field. Three dimensional Grapple is now in a preliminary stage and work will begin soon on raster-scan technology. A replacement for the IM70 is now in the development stage at Public Works Canada.

2:3 Future

The manufacture is seriously considering transferring the language onto a more dependable mini computer. The advent of the raster-scan will bring added dimensions to the visual displays and increase the flexibility of the language while reducing configuration costs. The attendance at the Concordia Grapple Seminar on 5 February, 1979 indicated enthusiastic support for the loaner program by all parties concerned.

> "In the next ten years CAD will become the normal way of designing products and technologists in the industrialized countries. As electronic technology progresses, the currently divergent approaches based on personal versus corporate computing power will tend to converge". Joseph Hatvany[10]

2:4 Hardware

Figure 2.1 gives a representation of the typical hardware installations (as a matter of interest, the drawing was produced using DRAW 1). The mini computer used is an IM/70 manufactured by Systems Approach Limited and consists of a central processing unit (CPU), 32K words of 16 bit core memory and four diskette drives. The CRT is manufactured by Tektronix and is capable of producing graphical displays (line representations). A flatbed or a drum plotter may also be used to produce the required sketches or "blueprints". A hardcopy unit is employed to obtain paper copies of screen displays; these copies have the added benefit of providing a quick method for capturing a drawing or text presentation. A digital tablet may be employed in conjunction with the CRT if work need be done from existing plans or if pen inputs would facilitate data entry. A high-speed printer is required to produce copies of program software.

2:5 Software

The Grapple Language contains many of the features of other computer languages. Aside from the graphical capabilities, its mathematical skills are comparable to Fortran IV, although its structure resembles ALGOL. Numerical data storage is excellent; unfortunately, only single-dimensional array storage is available.

The screen is divided into units and each one represents .089 millimetres; thus the screen's dimensions are 4096 x 3120 units. The language is graphics-oriented and it employs "primitive functions" as the basis for its structure A list of these primitives is included in Appendix 2. The language features 23 primitives which represent over 90 distinct tasks; however, the majority of the actual drawings are produced by the following primitives:

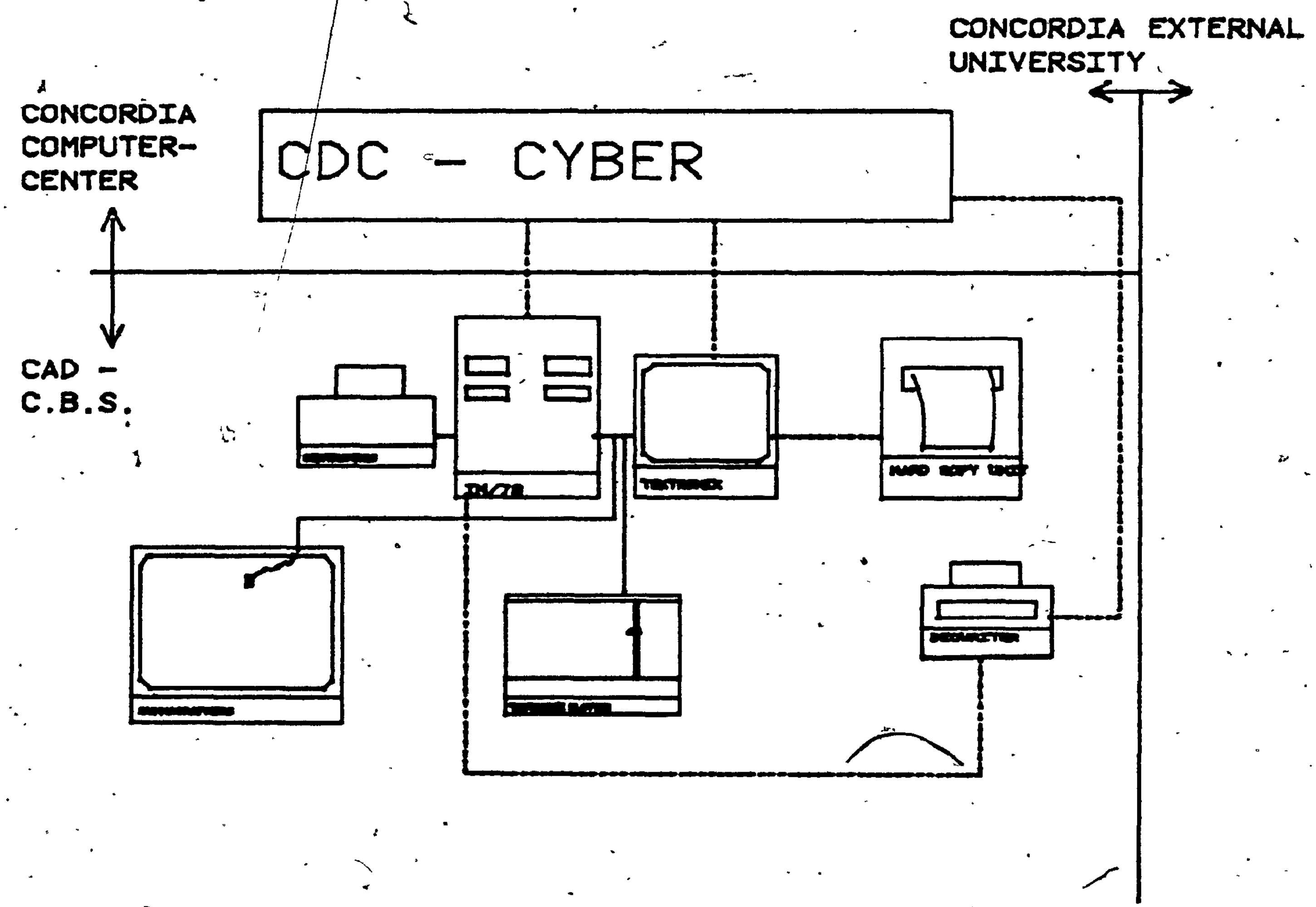


FIG 2.1 TYPICAL HARDWARE CONFIGURATION

S (X-coordinate, Y-coordinate), represents setting the cursor at the absolute coordinates X and Y

M (dx, dy), represents a relative move dx, dy

D (X1, Y1, X2, Y2), represents the drawing of a line from its present location to the absolute coordinates X1, Y1 and a line to X2, Y2

V(dx, dy), represents drawing a line at its present location with length dx, dy

T ( ) will type a particular text at the present location of the cursor. T('xxxxxx') will type xxxxxx. T(N(xxxx)) will type the actual value of xxxx

The language is function-oriented which implies that it is extremely structured. This facilitates the comprehension, changeability, maintenance, and revision of existing programs. It also allows for a rigid pattern of program layout which provides new programmers with a format that will aid their software composition.

The names of USER FUNCTIONS or ARRAYS may be combinations of letters, numbers or symbols (-,$,&,.) of up to 12 characters. The first symbol must be alphabetic and only the first 8 characters are significant. Functions will follow the form below and can be employed to draw a figure, write a text line, calculate a variable or perform some control action.

eg. FUNCTION: DRAWFIGURE,T('Typetext'),CALCULATE.X., S(0,0),V(100,100);

The user assigned FUNCTION then performs its task of drawing, typing or calculating when the imperative to do that routine is given.

eg. ....,..........,FUNCTION;

ARRAYS are used primarily for the storage of ordered data, while parameters allow for repetitive actions with variables.

eg. ARRAY: ⟨10⟩ (1,2,3,4,5,6,7,8,9,10);

eg. PARAMETER (ANSWER 1, ANSWER 2)

may imply 2 x ANSWER 1 + 3 x ANSWER 2

Numerous other working tools are available to users, such as modifiers, euphemisms and pseudo variables, but these will not be dealt with as clear explanations are provided in the Grapple Language Reference Manual.

One last feature to be described is the "MENU" option. This innovation allows for user input flexibility while still ctontrolling sequencing. At a suitable point in a program it may be necessary to carry out one of four or five functions; it is then the user's responsibility to decide which one is the most appropriate.

eg. RUNMENU (!CHOICE);

eg: CHOICE: ⟨5⟩(CHOICE 1,CHOICE 2,CHOICE 3,CHOICE 4,AGAIN);

The example given above would produce a vertical array of options at the bottom right corner of the screen; the operator could then make a cursor input of his preference. Examples of the actual screen displays can be seen in Appendix 11. On completion of this action, the function CHOICE 'X' would be carried out and the program would proceed again.

Chapter III

Heat Transmission Through Walls and Windows

3:1 Conceptual Framework

This project attempts to fulfill one aspect of the energy conservation evaluation of buildings: Heat Transmission Through Walls and Windows. The computer program is written in Grapple and the report deals with graphical and digital representations of conductive heat loss for both existing and proposed buildings. It is presently structured so that additions and modifications may be carried out easily. Future considerations might include; heat transmission through roofs, air infiltration through cracks, and air change heat loss.

After careful examination of the field (a summary of published programs is included in Appendix 1) and diagnostic analysis of the requirements, I have concluded that the program should be based on the following factors:

i) There are relatively few published computer programs dealing with heat transfer; my technical report deals primarily with heat transfer through walls, windows, and doors and it forms an integral part of the Center for Building Studies Computer-Aided Design Package.

ii) No computer program could be found that calculates the temperature gradient through a wall section; I have attempted to fulfill this requirement by using a graphical language at maximum to produce clear and concise representations of heat gradients, as well as accurate, well-presented tables of heat loss.

iii) Most computer programs deal with only one aspect of engineering, that of conceptual design; my program can be used in any facet of engineering:- design conception, maintenance engineering or problem analysis.

iv) Since wall construction is generally standard, I have produced two rigid packages for standard frame and masonry wall constructions.

v) Exceptions in wall construction generally follow a recognizeable pattern; the two flexible programs integrated in the package deal with any irregular structures.

vi) Personnel not familiar with computers are generally apprehensive about data processing; the Grapple Language features the "menu" option which formalizes sequencing and allows for simple function flow.

vii) Occasional user requirements differ from frequent user requirements; therefore, explanations are made available throughout the program through use of the HELP function in the menus or the TYPEOUT function at the start of each package.

viii) Personnel using package programs require special attention; in my program version, Menu option limit the data presented at any given time. In addition, the program is structured to follow a logical sequential pattern. Even though the results presented by this program are comparable to work completed by engineering technologists or engineers, the actual user's proficiency in thermal sciences need not be of that calibre.

ix) Most programs available in the thermal field are based on batch outputs, in this project the interactive features of a CRT provide a personalized and flexible working environment for the user.

Although the program may be used by itself, in its present form it constitutes only one portion of the University's CABD package. The flow pattern is detailed in Figure 3.1 and it shows this interdependant feature. All four programs are under the library name RVAL and can be entered separately or by calling specific functions while in C.A.B.D.

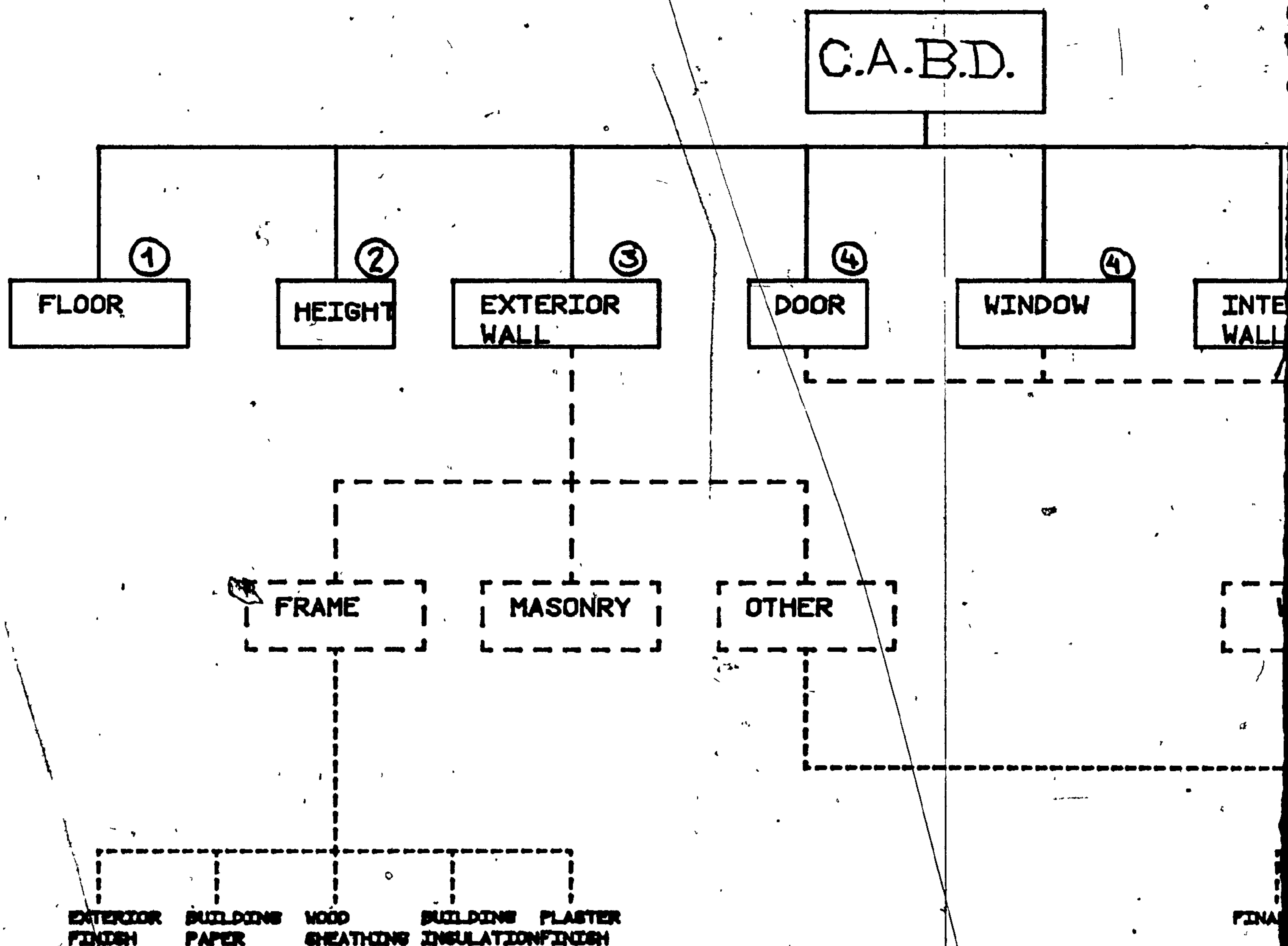
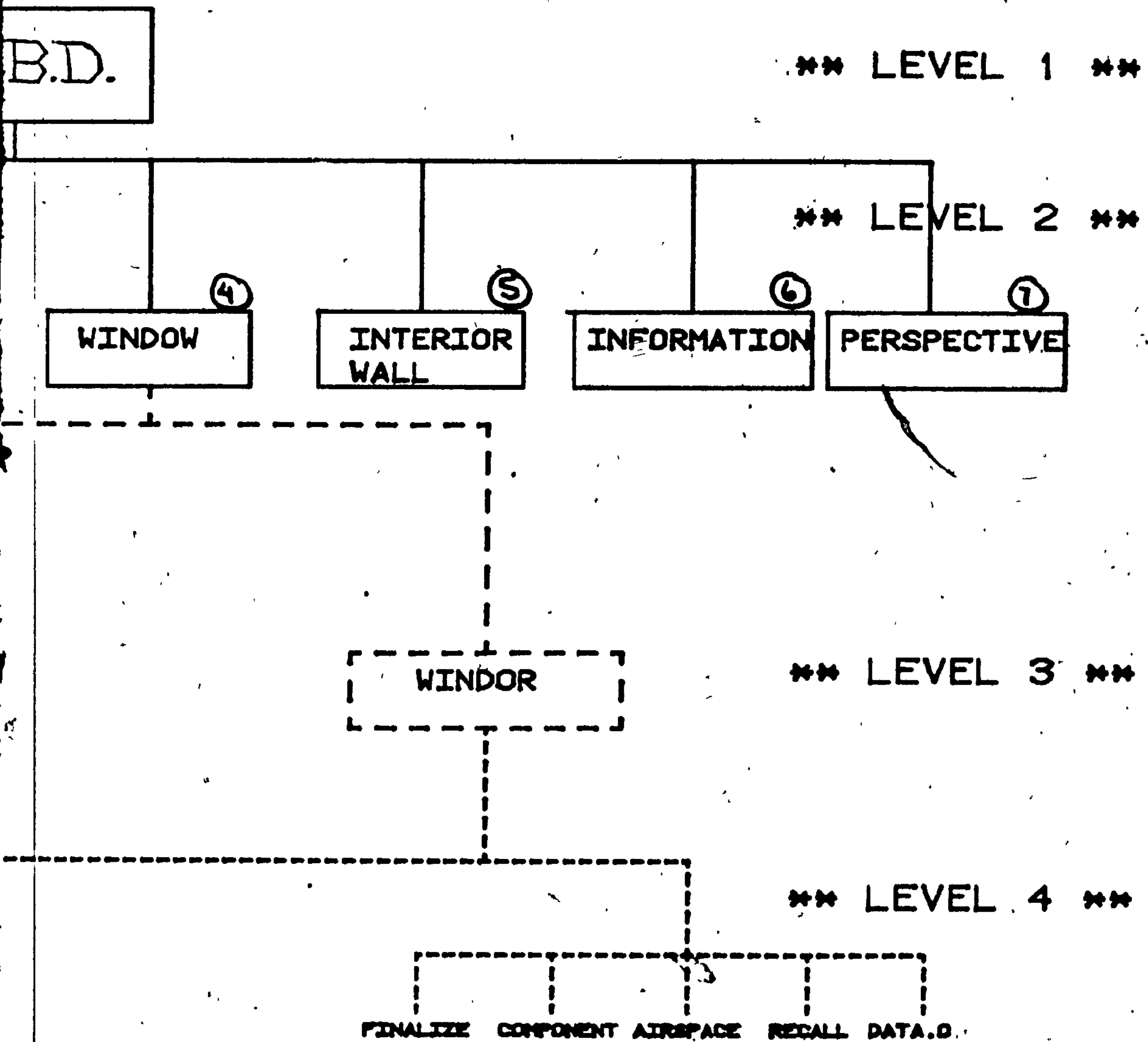


FIG. 3.1 PROGRAM NE



ROGRAM NETWORK

The information required is added in a logical sequence as the user builds up the model structure; presently this prototype is a rectangular enclosure with a flat roof. Although this is a limited design it will serve the needs of an encompassing package for the present time.

All thermal resistance values are taken from ASHRAE Handbook of Fundamentals.[12] The actual values listed represent the factors for a mean temperature of -18 degrees Celsius (0 degrees Fahrenheit). All data for window components is based on values for vertical plan windows with upwards heat flow and conductances of 56.8 Watts/(degrees Celsius difference) (square metre) or 10.00 BTU/(degrees Fahrenheit difference)(square foot) (hour) for architectural glass.

In order to ensure that adequate explanation is provided to the readers, four different project descriptions are included. A general program summary is given in this chapter. Line representations for the various packages are included in Appendices 3 to 6 included. The actual computer programs form Appendices 7 through 10 and a Programmed Instructional Package (PIP) is contained in Appendix 11.

3:2 Project Brief

A standard procedure for the input of data is sequenced in Fig 3.1. Briefly, the floor plan is drawn; then the height of the building is given. The menu option exterior wall (EWALL) is then chosen and a graphic display of this wall will appear on the screen. At this point the menu options FRAME, MASON, OTH appear. The user must now input the type of wall construction that best exemplifies that particular wall in the building. This choice will activate one of the two main subprograms; FRAME or OTH. FRAME is an extremely structured program that requires simple input of building component materials and their respective thicknesses. In contrast

OTH is loosely fabricated and allows the user to build up a wall system that best represents the actual or proposed structure.

3:3 Walls

FRAME is a file program that covers the two functions FRAME and MASON. Both of these functions follow the same program sequencing but differ slightly owing to different component structure and cross-sectional views. When called, each function displays a menu listing the names of wall ponents. Fig 3.1 gives a general idea of the choices and it is the user's responsibility to enter each of these members separately. As each menu option is entered a choice of standard building products will appear and the user will choose the most appropriate. Should no option resemble the material the user has in mind he may enter OTHR which will present him a list of some 50 construction materials. He must then enter the material name, its corresponding R-Value along with the thickness of the material. On completion of this task menu level 4 re-appears and the user continues in the same manner for the remaining components. Should he err in one of his entries, he may simply recall the subject component (menu level 4) and insert the correct data to eliminate any input errors. It is mandatory that all menu level 4 options by employed; however, if a component is not necessary, the option NIL is to be exercised. As air spaces may exist at any location in the wall structure the program is flexibly designed. Calling AIRSPACE activates a graphical representation of a typical wall section on the screen and it is the user's task to employ the hairline cursor to locate the various air spaces.

Once all building components have been utilized the program will automatically finalize the findings. The output is a table containing all input data, corresponding R-Values and a graphical representation of the wall section which includes air spaces and the final temperature gradient line drawn to scale.

In the OTH program the input of data is somewhat different as only three options are available: COMPONENT, AIR SPACE, FINALIZE. In this case the required wall section is constructed starting from the outside and working inwards. As each entry is made the user is asked pertinent questions regarding the type of material to be used, its thickness and its thermal characteristics. Again the function OTHR may be used to obtain a table of building materials. The user may insert AIRSPACES where they are required. As the entires are being made the user is presented with a graphical display of the wall as it is being fabricated. Once the user believes that the wall is built to his satisfaction he employs the menu option FINALIZE and a display similar to the one described in the preceeding paragraph will appear. At this point, the user exits the subprogram and is brought back into C.A.B.D. (menu level 2). It is now adviseable to enter data involving the doors and windows.

3:4 Windows and Doors

Keeping in mind that the user is still dealing with Wall "X", he will then choose the menu option for a ground floor door (DOORGFL), a higher story door (DOOROTH), or a window (WINDOW). Any one of these will call the WINDOR subprogram and the user may commence to compile data regarding window or door characteristics. Once this is accomplished it is the user's task to input the relative locations of that type of window or door on the particular wall he is dealing with. On completing this procedure menu level 2 appears and the user may proceed to input another door or window option. However, if he is satisfied that the particular wall is completed, the user may then proceed to the next wall and carry out the same process.

The program is structured such that if the user wishes to employ a window or door construction that has already been input he simply recalls (RECALL) the particular window/door and proceeds in the usual fashion. The DATA.W function may also be employed if a variety of windows and doors exist on file and the user has somehow forgotten pertinent data regarding a particular member. This function will recall all data input to date.

If the user has completed all inputs involving walls, windows and doors, he may proceed to utilize the various other functions available to him. Interior walls may be included (IWALL), perspective drawings may be completed (PERSP) and information regarding compiled data may be extracted (INFO).

The actual program layout has been detailed in Appendices 3, 4, 5, and 6, for C.A.B.D., FRAME, OTH and WINDOR respectively, so there is no need to delve into matters related to software. In these Appendices dashed lines represent user choice while solid lines portray automatic computer actions. User function names are included to inform the programmer which functions may be recalled through use of menu option TESTFUNC. A list of additional program features is included as Appendix 12.

Chapter IV

The Grapple System: Problems and Proposals

This chapter describes the problems encountered by a full-time user of the System, and gives suggestions that might be possible solutions to these difficulties. After personal experience, together with the opinions of numerous other users, I have concluded that the hardware, - primarily the mini computer, leaves much to be desired. Unfortunately, this is a factor beyond the control of most programmers, therefore, discussions regarding the possibility of a substitute for the IM/70 will not be included in this report. Only those factors which might be modified with no great difficulty will be examined.

4.1 Hardware

i) Mini Computer: Although I am not specialized in electronics engineering, I do understand the rudiments of heat flow, convection currents and heat transfer when it comes to the circulation of air. The IM/70 as depicted in figure 4.1 is constructed with the power bank located on the bottom of the unit and the diskette drives on top. Cooling for the diskette drives is provided by fans mounted in the rear of the unit blowing downwards, whereas for the

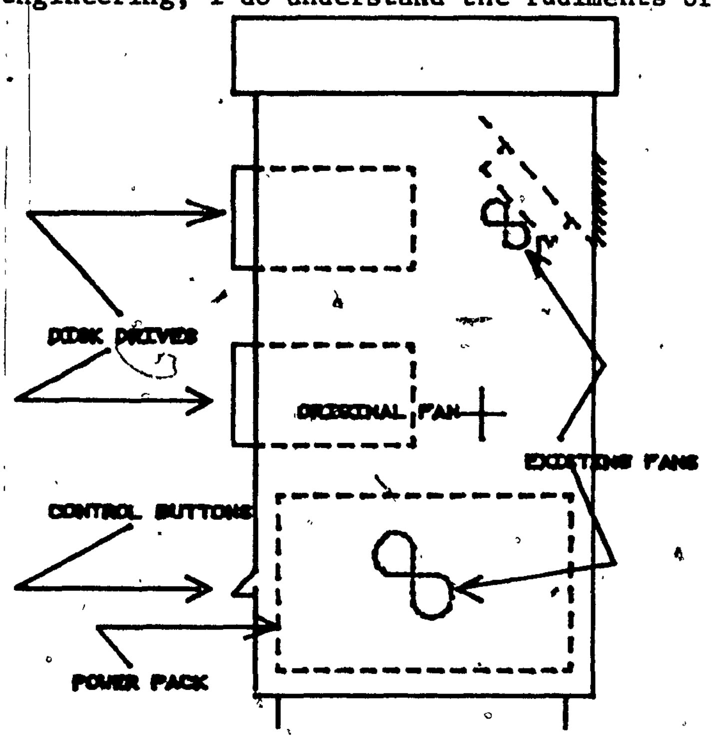


FIG. 4.1 CROSS-SECTION IM/70

power pack cooling air is supplied by fans mounted on one side and blowing over the equipment. Information from the manufacturer's brochure states that the unit generates 1000 watts of heat, which will rise and may have negative effects on the diskette drives themselves. All the manufacturers of the floppy disks (diskettes) state that their product should be stored in temperatures not exceeding 30 degrees C (125 degrees F). However, the rising heat from the power pack could easily exceed this temperature if the ventilation scheme is not adequately designed. A modification (see fig. 4.1) was made to the Concordia unit in December '78 by the manufacturer, this reduced the overheating experienced previously. Nevertheless, simple tests indicate that poor circulation still exists. The top fan, in effect, only re-circulated the hot rising air while the side blowers provide only minimal ventilation. A restructuring of the unit with the power pack on top of the machinery, with fans located near the fresh air intakes, and with an adequate air exhaust system could alleviate "downtime" on existing units and reduce the possibility of unnecessary complications.

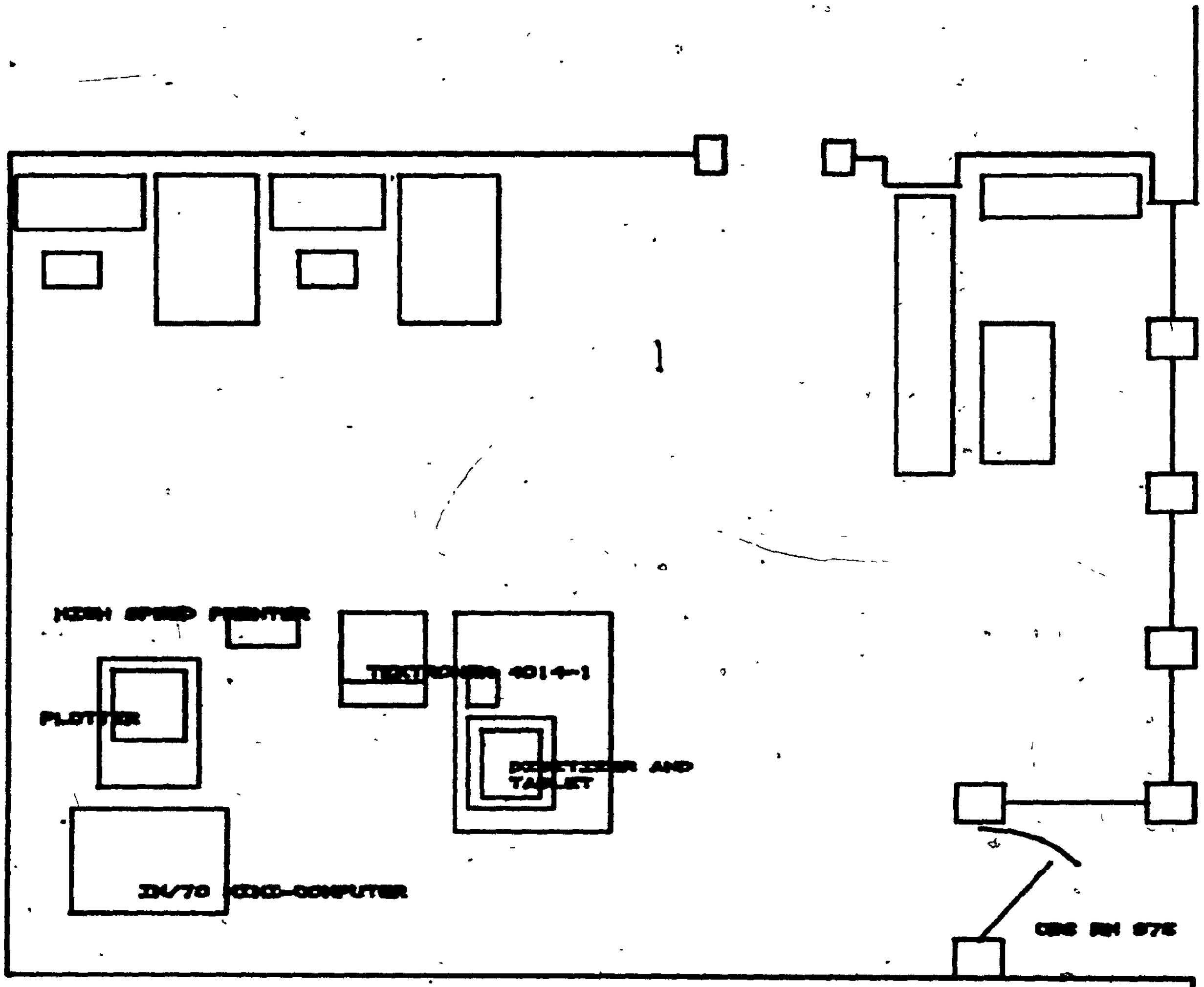
The lack of IM/70 sound control features adds to user stress. The six fans are the cause of most of the noise generated from the unit. This registered at 72.5 dBA at source and 62.4 dBA five feet away from the unit. These tests were conducted at the CBS Computer installation in BE Room 375. If a proper ventilation system were to be adopted the manufacturer might dispense with one or two of these redundant fans and sizably reduce the resulting sound pressure level. A sound absorbing material should be included in the design of the side panels and properly designed ventilation louvres (baffle type) should be included on the apparatus.

In my opinion, the layout of the equipment at Concordia is ideal when compared to other similar installations. One is provided with a spacious and quiet environment conducive to good work habits; the layout of the exemplary room is illustrated in figure 4.2. After working at Carleton University, Public Works Canada and at Murray and Murray and Partners Limited, I did realize just how disturbing the sound levels of the IM/70 and associated components could be when there is neither a generous spatial distribution of equipment nor a proper arrangement of the machinery.

Although the manufacturer states that air-conditioning is not necessary but desirable for human comfort, after visiting all of the above locations, I have concluded that the IM/70 could not function properly because of inadequate air-conditioning facilities. A problem arises as the installation of proper facilities not only increases costs but also adds to the high levels of noise; such is the case, for example, at Murray et al where a window air-conditioning unit is employed. If the IM/70 were properly designed as regards ventilation, air-conditioning should not be required. However, where larger installations are planned central air-conditioning should be considered.

The cost of maintaining the IM/70 is extremely high. A maintenance contract, including preventive maintenance inspections is available through the manufacturer for $213 per month. Services may also be purchased on a "as and when required" basis at a rate of $40 per hour and a set fee for replacement of defective parts (ex. Disk drive replacement-$200.) Public Works experience has shown that the two arrangements are equivalent over the long term. These operating expenses may be difficult to justify for the average consulting firm.

ii) Floppy Disks (Diskettes): Included in Appendix 13 is a comparison of floppy disks to other storage techniques. One can easily see that floppy disks are a quick and inexpensive means of storage and retrieval; practice, however, has shown that the life-span before disk errors appear is somewhat limited, in the forty to one hundred hour range. In order to remedy this



(Scale 1" = 10')

FIG 4.2 CBS GRAPPLE COMPUTER INSTALLATION shortcoming, I do believe that it is essential to keep an updated backup copy, for, on the basis of personal experience, I have concluded that copies should be produced each four hours in case of diskette failure, or at least every eight working hours. Unfortunately, maintaining a "fail-safe" system for floppy disks implies that additional costs and resources are required to ensure that the cataloguing of files is correct and that diskettes do not "crash" prematurely.

iii) Tektronix T 4014-1: This unit proved to be the most reliable component of the mini-computer system. As the T 4014-1 was new it was relatively fault-free. It did, however, have some power surge problems but these were remedied by the addition of a separate circuit. The only other difficulty involved a short in the panel board circuitry that was diagnosed and corrected by the CBS's resident electronics technician. Fortunately, the Center's unit still does not suffer the evils of advanced usage, these being primarily the loss of picture composition and lack of line definition. These difficulties do exist at the Carleton, Public Works and Murray et al installations.

As regards the CBS installation, I might suggest removing some fluorescent light bulbs directly above the CRT and installing a small keyboard light. This would produce a better picture as well as reduce eye strain for the user. Furthermore, parties interested in educational presentations of displays would greatly appreciate the enhanced clarity of the images.

iv) High Speed Printer: In order to perform proper software editing, some form of paper or hard copy is required. With the present configuration of hardware a hard copy takes approximately two to five minutes to run. This process occupies all components of the "mini" at that time. Also, there is no existing software package to print only the required portions of the program. I might suggest that a hard copy unit be employed for this task for the time as well as the paper saved would easily amortize the costs of the Tektronix copies.

4:2 Software

The advantages of the Grapple Language as a programming language were discussed in Chapter 2; in this section the weak points of the software package will be examined.

The major handicap debilitating the entire system is the lack of overall standardization. The Ad Hoc Grapple Users Association attempted to accomplish this task but did not succeed. Therefore, Grapple users are compelled to work as separate entities with little or no communication amongst themselves. In reaction to such a situation, I suggest the formation of a Group to handle the following functions:

i) Package Concept for Computer Aided Building Design: Draw 1 is a useful tool for the draughting aspect of design, but I feel that too much emphasis is placed on it at present. The Grapple System itself is extremely versatile but concentration is being focused only on its DRAW 1 capabilities. Its graphical presentation capacities should be expanded to new fields; principally the establishment of a Computer-Aided Building Design (CABD) Package. The package should be amalgamated to the requirements from the private, educational, and institutional sectors. A software exchange program should then exist whereby each associate would relay information on his or her submission to the package. In this way a collective front could be established for the users and a library of software programs could be available to all members.

ii) Adherence to One Language Version: Accepting one language version for a given period of time is necessary for the standardization of all work in the field and for the maintenance of upward compatability. Any variation of the base language should be avoided for a predetermined time frame so as to retain a solid working base for all users. One should also differentiate between the working language and Research and Development innovations. These R and D additions should be only included in the working language once compatability has been established and the majority of the users consent to the modifications.

iii) Standardized Format of Software Composition: An interactive association would be unable to function efficiently without this tool. Programs should be patterned according to an established plan and all users should strictly adhere to it, thus facilitating an exchange of software information amongst members. The plan would include program "layout", rules involving suggestions, use of primitives, sequencing of software and requirements for internal instructions. Standards such as those proposed by SIGGRAPH should be adopted.

iv) Effective Transmission of Information Involving Inaccuracies and Omissions: A simple and standard method is required whereby users could inform their colleagues of errors in the software language. These could be scrutinized by the Association and forwarded as bulletins to users.

v) Establishing a Pattern for Function Names: The establishment of a cognitive pattern of symbolism with a numeric code would facilitate the assimilation of a computer program (eg. RVAL4.3 may represent the user function in a fourth level menu option, the third function to be carried out. Its location in the software could be arranged accordingly).

vi) Seminars for Members: Membership seminars organized on a regular basis could keep users informed of all current activities, CAD news, government policy, and additions to the building package. Workshop groups could also be formed to study proposals for language upgrading requirements, for additions to the building package and for corrections to the software language.

vii) Training: Formalized training sessions for members should be available on a regular basis. The course format should be composed in conjunction with courses given at participating universities and they should deal with all aspects of CAD and Grapple programming.

Along the lines of present documentation both the Grapple Language Reference Manual and Draw 1 Primer Version 4 (Sept 78) do not reflect the requirements of new programmers or casual users; rather they seem to be dedicated only to experienced programmers. Since the language is relatively simple, so should be the source literature. Appendix 14 lists some documentation errors and discrepancies that were found while pursuing this project; although they may seem minor, each element represents time loss and user frustration.

The merits of the language have already been detailed: nevertheless, I do feel there are still a few changes that need be made to the existing package. Most of these deal with editing of programs. At present, syntax debugging is a long, tedious operation because the process can only isolate one error at a time. Once an error is found, the correction must be made in the "edit mode" and then the user must "run" the program again. This is carried out back and forth until the software is syntactically correct; only then will the program be executed. As the programming language is based primarily on user functions performing as entities, it would be more efficient if the changes or additions could be checked while in the edit mode, or at least, if the "debugger" could find one error per user function. Most Grapple programmers would confirm that ten minutes per hour of software editing could be saved if this process were implemented.

Every time an error in the software program is changed and filed the entire program is recopied onto the user disk. The life of a floppy disk is rated in how many passes over one track may be made before a disk error appears; if the syntactical checks could be done in one of the fashions explained above the life of a disk could be extended two or three-fold, thus improving reliability and reducing user frustration.

4:3 Center for Building Studies at Concordia

As indicated previously, the location and spatial planning is ideal and conducive to productive work habits; however, documentation and filing of information was previously neglected as there was no permanent staff member to carry out this function. Editions complementing existing documentation are being now issued from the Public Works Canada to all users; therefore, there will be a requirement for someone familiar with the Grapple language and the Computer Center organization to file new programs, to maintain floppy disk records, to monitor equipment performance and to instruct casual users. This task should only occupy four to ten hours per week and it is an essential requirement if progress is to be made in CABD at the Center for Building Studies.

4:4 User Problems

In addition to the problems mentioned in this Chapter the programmer must also face the following obstacles:

i) Working with a new language;

ii) Learning a graphical language; and,

iii) Using an interactive medium.

There is always a FORTRAN or BASIC programming background in the formation of every engineer. This tends to be a nuisance when learning a new language such as Grapple. As with any new tool one relies on past instructions to establish one's framework, but in the case of FORTRAN this is detrimental. If the programmer could put aside all previous computer experience and at the same time be made aware of all available tools in the new language this would make the learning process much easier.

It is not until four or five months' usage that one can think properly in a graphical language, and can benefit from the versatility of the graphical outputs. This involves in-depth research in the field as well as a project that has a requirement for a form of graphical display. Basically, any computer problem can be tackled with Grapple, but to use it to its fullest extent, graphics requires months of dedicated concentration in the field.

The interactive feature of a CRT display aids in "personalizing" the user/machine interface. Programs should be structured so the user benefits from this new vantage point. Programming in this manner requires adopting the role of a typical user and removing yourself from your programmer task. It requires formulating thought sequencing, hence software programming, in a manner conducive to the majority of program users and not to your personal idiosyncracies. This method is, in my opinion, far superior to working with sterile white computer paper or with a machine behind a glass wall that churns out batch jobs on request. A training process, however, is required to assist the software programmer in producing work that is useable and comprehensible to both himself and other software users.

Chapter V

Future Considerations

5:1 Hardware

Systems Approach Limited has confirmed the introduction of a new mini computer to replace the obsolete IM/70. A larger memory base will be available (10 megabyte) along with the reliability of the proven cartridge disk. Raster-scan technology will replace the out-dated storage-tube and will introduce new facets such as colour and selective erasure at a reduced price. "The Tektronix 4027 is now currently available in the United States at $8700. (US) and provides 63 colours as well as scroll graphics, alphanumerics and multipage graphics. Firmware can colour vectors, characters and symbols, as well as fill polygons".[13]

It is my opinion that in the next two years a turnaround will take place in this field with regards to hardware that will make the Grapple Language a reliable, well-functioning language. Provided, of course, that the present manufacturer keeps in pace with advancing technology.

5:2 Software

The establishment of a Grapple Group, distinct from direct government or supplier intervention, will aid software generation for all present users. The Group should concentrate on one language form, the establishment of language and programming standards and the formation of a collective software building package.

A study team to investigate CAD requirements in Canada is needed in order to direct the Grapple System onto a well-defined route. This study team should primarily investigate industrial requirements and should also touch upon government and educational needs. The outcome of this report would then provide the Grapple Group with a line of action and direct computer software generation along user requirements.

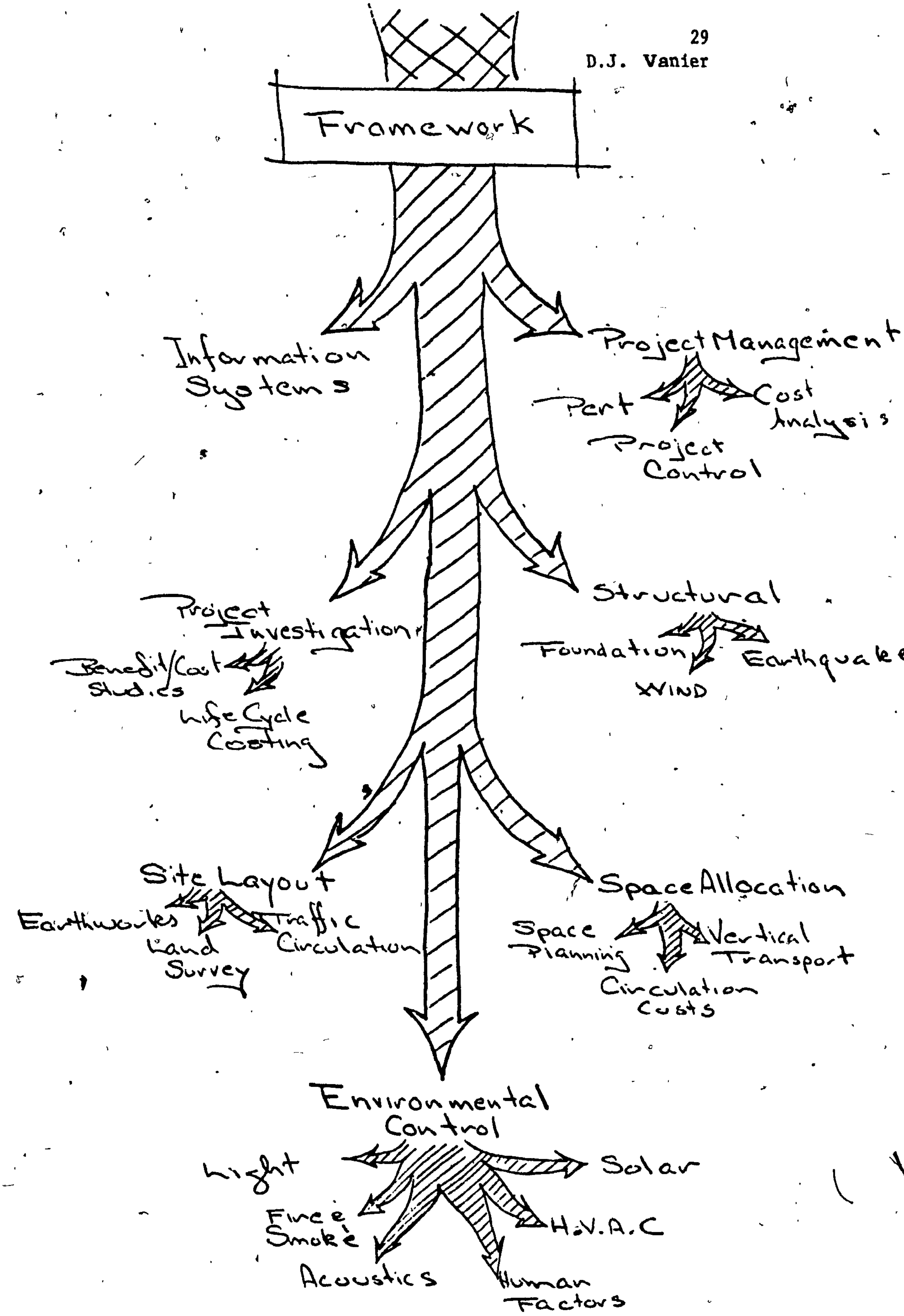


Fig. 5.1: C.A.B.D. Package

5:3 C.A.B.D. Package

After standards have been determined, it is essential that a package be formed to serve as a framework for all future software programs. DRAW 1 would be a good choice for this owing to its versatility. An arrangement such as that depicted in Figure 5.1 exemplifies the necessity of such a scheme.

In this manner all completed work would find its place in the overall network and this would allow other users easy access to the finished products. In turn, once a particular element is out-dated it might be replaced by a modified or updated version. The sub-programs would have to be capable of functioning alone, as well as functioning within the general framework.

5:4 Center for Building Studies

The foundations have been laid with regards to establishing an on-going Computer-aided design section at Concordia. Steps taken such as the recent February conference by the CBS have confirmed this establishment as being a forerunner in this rapidly-advancing field. All possible methods should be employed to continue this momentum, such as encouraging individuals with pertinent skills to join the Center's staff, organizing a follow-up seminar and obtaining funds for research in Computer-Aided Building Design.

Conclusion

The results of this technical report are the following:

1) Critical analysis of the Grapple system at Concordia University by a full-time programmer/analyst.

2) User-oriented computer program for the calculation of heat transmission loss through walls and windows.

The analysis was based on the user/machine interface and, specifically, on inherent flaws in the equipment, problems in documentation and obstacles to software generation. Once overcome, these difficulties should not reappear if adequate precautions are taken. However, many of the problems examined are beyond the control of most Grapple users; solutions lie within the scope of the decision-making powers of senior management at Public Works, Center for Building Studies or Systems Approach Limited. Until a collective force involving the sponsors, users, and supplier is organized, many man-years of frustration will occur and many man-years of work will be wasted.

This program provides engineers and designers with a fast, accurate, and simple method for calculating temperature gradients through walls and windows. Users are also presented with an efficient means of determining the relative heat loss for a model ~~building~~. Such assistance greatly enhances the problem-solving techniques of designers and decision-makers; as areas of difficulty regarding the building enclosure system might be readily assessed and poor design features could be quickly remedied.

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APPENDIX 1 SUMMARY OF COMPUTER PROGRAMS AVAILABLE 7

0660

Program name
Calculation of heat losses

References
123B

Language
Algol

Abstract
The program calculates the heat losses from a building and apportions them between the constituent rooms. It takes into account the direction and exposure of all external surfaces, and the effect of varying room temperatures and the resultant heat transfers

Source
Engineering Solutions Limited
Prudential House, Wellesley Road
Croydon Surrey
UK
Telephone 01-686 4173

Computer
CDC 6500
GEC 900

Availability
Sale,Hire Bureau service,Remote batch

0661

Program name
Radiation pipe sizing (1 and 2 pipe systems)

References
122G/J

Language
Algol

Abstract
A program for sizing and design of pipework for heating and cooling systems. Single or two-pipe systems can be tackled with any combination of pipe diameters in the range 0.3in to 48in. The program derives initial pipe sizes then obtains temperature patterns, calculating heat losses from the pipes until the system is balanced

Source
Engineering Solutions Limited
Prudential House, Wellesley Road
Croydon Surrey
UK
Telephone 01-686 4173

Computer
CDC 6500
GEC 900

Availability
Sale,Hire,Bureau service,Remote batch

0662

Program name
Cooling load program

References
EAS3

Language
Fortran

Abstract
The program calculates heat gain from solar radiation through windows It estimates hourly and maximum cooling load for each part (and for the whole) of the building, with various designs of window and associated elements. Sub-routines determine the effect of thermal storage and finish of internal walls, floors and ceilings The program can be run for any latitude, altitude and time of year

Source
Pilkington Brothers Limited
Prescot Road
St Helens Lancashire
WA10 3TT UK
Telephone St Helens 28882

Computer

Availability

0663

Program name
Obstructional shading

References
EAS5

Language
Fortran

Abstract
This program calculates, for each hour of the day the sun is above the horizon, the shadows onto a facade due to obstructions. Thus, the effects of shading by adjacent buildings, or by other parts of the building, on the cooling load may be determined. The program can be used in conjunction with the cooling load program (program 0662)

Source
Pilkington Brothers Limited
Prescot Road
St Helens Lancashire
WA10 3TT UK
Telephone St Helens 28882

Computer

Availability

0675

Program name
PSYCH

Abstract
PSYCH is a psychrometric analysis program for evaluating the properties of moist air. It calculates the mixed air temperature entering the cooling coil, the required dew-point temperature for the apparatus, the by-pass factor and the refrigerant cooling load

References

Source
Inatome and Associates, Inc
10140 West Nine Mile Road
Oak Park Michigan
48237 USA
Telephone Oak Park 313 542 4862

Availability
Sale, Bureau service, Time sharing

Language
Fortran IV

Computer
GE 635

0676

Program name
ACLOA

Abstract
ACLOA is for the calculation of heating and cooling loads. The program can be used over any five-month period to search for the month with the most severe requirements. The computer prints out the maximum peak load heat gain and air requirements for each room. The terminal reheat coil temperature rise is printed out for both summer and winter conditions

References

Source
Inatome and Associates, Inc
10140 West Nine Mile Road
Oak Park Michigan
48237 USA
Telephone Oak Park 313 542 4862

Availability
Bureau service, Time sharing, Sale

Language
Fortran IV

Computer
GE 635

0679

Program name
(5)6 8026C

Abstract
A program for calculating the non-steady state of heating or cooling in a building, and determining room temperatures in the absence of cooling

References

Source
Steensen and Varming
Strandvejen 130
Hellerup
DK 2900 Denmark
Telephone Hellerup (010 45) HE 9101

Availability
Hire

Language
Swift

Computer
Friden 5610

0686

Program name

Abstract
A program for calculating non-steady state heating and cooling loads, following DIN 4701

References

Source
Industrie Companie Kleinewefers GmbH
Melanchtonstrasse 5
415 Krefeld
Germany
Telephone Krefeld (010 49 2151) 8231

Availability

Language

Computer

0687

Program name
BENOIT

Abstract
A program for the calculation of steady state heat losses

References

Source
Dept SEDIT
Domaine de St Paul
78 Saint-Remy-Les-Chevreuse, Paris
France

Availability

Language
Fortran

Computer
IBM 1130

0688

Program name
ZELD

Abstract
A program for estimating the cooling properties of a building, with and without air-conditioning or ventilation

References

Source
Hungarian Institute of Building Science
David Frenc u6
Budapest XI
Hungary

Availability

Language
Algol

Computer

0689

Program name

Abstract
This program is used to calculate the maximum heating and air-conditioning load for a building. It also calculates running costs in terms of energy consumption

References

Source
Hungarian Institute of Building Science
David Frenc u6
Budapest XI
Hungary

Language

Computer

0692

Program name

Abstract
This program calculates the non-steady heat transfer through a multilayer wall

References

Source
Birger Ludwigson Ing
Byra AB Kungsportsavenyen
411 36 Goteborg
Sweden

Availability
Hire

Language
Algol

Computer
Facit EDP

0693

Program name
TEMPO

Abstract
A program to calculate the non-steady state heat transfer through a multilayer wall

References
R02001

Source
Industridata AB
Fack
Solna Sweden
171 20
Telephone Solna (010 46 8) 980350

Language
Fortran

Computer
Honeywell 6000

0700

Program name
HEATLOSS

Abstract
Programs to calculate the heating load of a building, according to the 1965 edition of the IHVE Guide

References
DB04

Source
Dale and Ewbank
8 Grape Street
London
WC2H 8BY UK
Telephone 01-836 2621

Language
Fortran

Computer
CDC 6400

0702

Program name
Building load study

Abstract
The program provides information on the heating and cooling of buildings for use in designing the mechanical system. Heat gains and losses are assessed from heat-transfer analysis of outside temperature, solar radiation, wind, building materials, glass, wall harmonics, thermal time-lag, ventilation and infiltration, internal heat gains, shading, building orientation and location

References

Source
Westinghouse Tele-computer
Systems Corporation
2040 Ardmore Boulevard
Pittsburgh Pennsylvania
15221 USA

Availability
Bureau service

Language
Fortran

Computer
IBM 360
CDC 6600

0703

Program name
HEAT

Abstract
The program calculates heat losses for rooms, giving sub-totals and totals, together with equipment ratings

References
L011

Source
Sanaco Computer Services
Woodlands Road
Birmingham
B8 3BD UK
Telephone 021-772 8331

Availability
Time sharing, Bureau service

Language
Basic

Computer
Honeywell G600

0704

Program name
The new ARC environmental package

Abstract
A set of programs to predict the environmental performance of a given building. It makes an analysis, either separately, or in any combination, of the effects of daylight, artificial light, sunlight, heat gains and losses and environmental temperature

References
No 5

Source
Design Office Consortium, c/o ARC Ltd
5 Jesus Lane
Cambridge
CB5 8BA UK
Telephone Cambridge 65015

Availability
Bureau service

Language
Fortran

Computer
Atlas 2
P/Tape reader(s)
P/Tape punch(s)
Teletype(s)
Lineprinter(s)

0713

Program name
Composite wall

Abstract
This program calculates variable heat flow through homogenous and composite walls and roofs/ceilings

References
160-602,603

Source
Technies Rekencentrum Polybit BV
Postbus 305, Archipelstraat 96
Nijmegen
Netherlands
Telephone Nijmegen 228382

Availability
Sale, Bureau service, Remote batch

Language
Fortran

Computer
CDC 6600

0714

Program name
Transmission and radiator choice

Abstract
Calculation of the heat losses and a choice of the suitable radiators of different makes

References
160-110

Source
Technies Rekencentrum Polybit BV
Postbus 305, Archipelstraat 96
Nijmegen
Netherlands
Telephone Nijmegen 228382

Availability
Sale,Bureau service,Remote batch

Language
Fortran

Computer
CDC 6600

0715

Program name
Total energy

Abstract
Total energy is an installation for generating out of mechanical power, generally converted into electric energy in which the heat release is utilised to its maximum economical extent. Estimation of the energy balance for every hour of the year, depending on the demand of electricity and heat for dimensioning heat power systems

References
160-115

Source
Technies Rekencentrum Polybit BV
Postbus 305, Archipelstraat 96
Nijmegen
Netherlands
Telephone Nijmegen 228382

Availability
Sale,Bureau service,Remote batch

Language
Fortran

Computer
CDC 6600

0716

Program name
INSUL

Abstract
This program calculates the owning and operating cost of a given roof or wall construction at varying thickness of insulation. The user inputs the wall or roof insulation conductivity factor, cost factors, fuel type, efficiency or fuel utilisation and degree-day factor. The optimum thickness of insulation is calculated together with incremental and cumulative savings

References

Source
Inatome and Associates, Inc
10140 West Nine Mile Road
Oak Park Michigan
48237 USA
Telephone Oak Park 313 542 4862

Availability
Bureau service,Time sharing,Sale

Language
Fortran
Basic

Computer
GE 635

0719

Program name
Air conditioning program

Abstract
This program operates on the same principles as the Cooling load program (program 0662) but includes the effects of solar heat gain through the windows and the opaque fabric, ventilation gain or loss, total gain, internal heat sources, and conduction loss or gain through the windows and the fabric

References
EAS7

Source
Pilkington Brothers Limited
Prescot Road
St Helens Lancashire
WA10 3TT UK
Telephone St Helens 28882

Availability

Language

Computer

0725

Program name
Heat load and radiator selection

Abstract
This program will calculate the heat losses of a building based upon the method described in DIN 4701:1959. If required, the dimensions of suitable radiators for each space in the building can also be calculated

References

Source
Ontwerp-en Adviesbureau Ing. Th. J. Mul
Dijkgraafstraat 12, Postbus 73
Krimpen a.d. Ijsel
Netherlands
Telephone Ijsel (010 31 1807) 4839

Availability
Bureau service

Language
Fortran

Computer
CDC 6500

APPENDIX 2 List of Language "Primitives"[11]

A	ARRAY	GRIT code reference
B	BLOCK	Blocking constant
C	CIRCLE	Circular figures
D	DRAW	Absolute vectors
E	EXTENT	Extent definition
F	FUNCTION	Mathematical Functions
G	GET	Get a pair of coordinates
H	HOUSEKEEPING	Housekeeping functions
I	IDENTIFY	Identify displayed element
K	KEYBOARD	Input from keyboard
L	LAYER	Layer selection
M	MOVE	Relative Move
N	NUMERIC, NAME	Conversion to character string
O	ORIGIN	Respecify Origin
P	PUT	File input and output
R	RADIAL	Radial vectors
S	SET	Absolute Move
T	TEXT	Text display
U	UNITS	Respecify Units
V	VECTOR	Relative draw
W	WINDOW	Specify viewing window
X	X-ORTHOGONAL	Alternate X and Y orthogonal lines
Y	Y-ORTHOGONAL	Alternate Y and X orthogonal lines

Appendix 3 **Line Representation: C.A.B.D.**

C.A.B.D.

- **Runmenu Level 2**
  - **FLOOR**
    - Requests scale
    - GRID1, GRID2, draws grid to scale
    - Requests bottom right and top left corner
    - Returns to menu Level 2
  - **HEIGHT**
    - Requests building height (meters)
    - Assigns appropriate arrays
    - Returns to menu Level 2
  - **EWALL** (exterior wall)
    - Requests which wall to be assessed
    - KATCH, draws chosen wall
    - Calls menu Level 3 (FRAME,MASON,OTH)
    - Returns to menu Level 2
  - **IWALL** (interior wall)
    - Requests the two end points of an interior wall. It keeps requesting inputs until the user returns to Menu
    - Returns to menu Level 2
  - **DOORGRFL, DOOROTHER** (doorground floor, other doors)
    - HINT, indicates which wall
    - DOOR, CALLS WINDOR (menu Level 4) program
    - KATCH, draws wall
    - GRID1 & 2, establishes grid for locating the doors
    - OPENING, draws doors when left hand corner is inputted
    - OUT, returns to Level 2 menu when cursor entry is made
  - **WINDOW**
    - HINT, indicates which wall is being assessed
    - WINDOR, calls menu Level 4 program
    - KATCH, draws wall
    - GRID 1 & 2, establishes grid for windows
    - OPENING, draws windows when left hand corner is inputted
    - OUT, returns to Level 2 menu when cursor entry is made
  - **DRAWFLOOR**
    - Draws floor layout
    - Returns to menu Level 2
  - **CLEAN**
    - Erases screen, re-displays menu Level 2
    - Returns to menu Level 2
  - **ROOF**
    - Not assigned

Continued

→**INFO**

Types pertinent information as per Appendix 5
Returns to menu Level 2

→**PERSP** (Perspective)

Calls Level 3 menu (VIEWMENU)
→Returns to menu Level 2

→**BACK**

Returns to Level 2 menu

→**PERSPECT**

Draws perspective drawing: ALPHA=O, BETA=O, DISTANCE= 1500 meters'
Returns to menu Level 3

→**PARALLEL**

Draws parallel drawing: ALPHA=O, BETA=O, DISTANCE= 1500 meters
Returns to menu Level 3

→**ALPHA**

Reassigns ALPHA, user input
Returns to menu Level 3

→**BETA**

Reassigns BETA, user input
Returns to menu Level 3

→**DISTANCE**

Reassigns DIST, user input
Returns to menu Level 3

APPENDIX 4 **Line Representation: FRAME**

```
FRAME
  |
  |--> FRAME1, counts the various types (TYPEFR)
  |--> Calls menu level 3 (EXTFIN,PAPER,SHEATH,INSUL,AIRSPACE,PLASTER)
  |  L-> Returns to menu level 1
  |- - > TESTFUNC, allows user to input function names
  |- - > EXTFIN---
  |- - > PAPER----     * Note   The runmenu option has been altered to afford the
  |- - > SHEATH---              advantage of calling a specific function independent
  |- - > INSUL----              of the cursor entry.
  |- - > AIRSPACE-
  |- - > PLASTER--
                 |-> List building materials plus NIL and OTHR options
                 |-> User makes input for component choice and thickness
                 |-> CONTINUE, inputs are recorded in arrays
                 |-> CALCULATE, calculates component R-Value
                 L-> SUMMATION,
                          |
  If options are not      |
  all entered             |--> CALCUL2, calculates total R-Value
                          |--> CHECKUP, lists input data
                          |--> RSULTFR, draws completed shape
                          |--> EXTFILM, draws exterior film representation
                          |--> RVALINE, draws heat gradient line
                          |--> INTFILM, draws interior film representation
                          L--> Returns to menu level 2
```

Appendix 5 **Line Representation: OTH**

```
OTH
 ├─>Types instructions
 ├─>Calls menu level 4
 │ └─>Returns to menu level 2
 │
 ├-->COMPONENT
 │      ├─>Requests component name, R-Value, thickness
 │      ├─>DRAWCOMP, draws component representation
 │      └─>Returns to menu level 4
 │
 ├-->AIR.SPACE
 │      ├─>Increases component-count (COMP)
 │      ├─>Requests thickness
 │      ├─>DRAWAIRS, draws air space representation
 │      └─>Returns to menu level 4
 │
 ├-->FINALIZE
 │      ├─>SCALE, draws appropriate scale for temperatures
 │      ├─>CALCULATE, calculates R-Values
 │      ├─>CHECKUP, lists components, thicknesses, and R-Values
 │      ├─>DRAWCOMP/DRAWAIRS, draws total figure
 │      ├─>EXFILMO,RVALINEO,INTFILMO, draws temperature gradient
 │      ├─>TRANSFRO, transfers all data to master array
 │      ├─>Displays array spaces available
 │      └─>Return to menu level 4
 │
 ├-->RECALL
 │      ├─>Asks which component is required
 │      ├─>Extracts data from master array and places in user array
 │      ├─>FINALIZE, (see above)
 │      └─>Return to menu level 4
 │
 ├-->ERASE
 │      ├─>Removes all input data from user array
 │      └─>Return to menu level 4
 │
 └-->DATA.O.
        ├─>Displays all relevent wall information
        ├─>This indicates wall type, components, R-Values and thicknesses
        └─>Return to menu level 4
```

Appendix 6 **Line Representation: Windor**

WINDOR
- → Counts window/door types (TYPEW)
- → Types instructions
- → Return to DOOR or WINDOW option of C.A.B.D.

--> **COMPONENT**
- → Counts components (COMPG)
- → ASKPANE, asks for component thickness
- → ASKSPAC, asks for spacing to next component
- → DRAWGLAS, draws representation
- → DRAWAIR, draws air space representation
- → REASS, reassigns last values
- → Return to menu level 4

--> **FINALIZE**
- → Stops counter for components
- → ASKSIZE, asks dimensions (door/window)
- → CALCULATE, calculates R-Values
- → $ERASE, prepares for presentation
- → CHECKUPG, lists components R-Values and thicknesses
- → SCALE, draws appropriate scale for temperatures
- → DRAWIND, draws final cross-sectional view
- → EXTFILM, RVALINE, INTFILM, draws temperature gradient
- → TRANSFRG, transfers all data to master array
- → Return to menu level 4

--> **RECALL.G.**
- → Asks which component is required
- → Extracts data from master array and places in the user array
- → FINALIZE (see above)
- → Return to menu level 4

--> **ERASE**
- → Removes all input data from user array
- → Return to menu level 4

--> **DATA.G.**
- → Displays all relevant window/door information
- → This includes type, components, R-Values and thicknesses
- → Return to menu level 4

```
**TOF**
C.A.B.D.:
SYSGPL,@ERASE,@RUNMENU(!MENU),1;
MENU:(13) FLOOR,EWALL,IWALL,DOORGRFL,DOOROTHER,WINDOW,ROOF,H
EIGHT,SEPAP,INFO,DRAWFLOOR,CLEAN,AGAIN);
CLEAN:@ERASE,S(0,0),1;
FLOOR:UP->FLAG1,S(0,0),S(10,250),
T('WHAT IS THE SCALE REQUIRED(1"=XXX METERS)?'),
@NUMERIC(K)->SKAL,S(0,0),
SKAL*2540*4096*254/100*45/10000/100->FAK,
    1->FLAG10,
GRID1,S(0,0),GRID2,S(0,0),
12->TOP,1->POC,
S(0,0),G,@SX->X1,@SY->Y1,G,@SX->X2,@SY->Y2,
S(0,0),
(X2-X1)*(Y2-Y1)*FAK*FAK->FLA,X1->PL(1),Y1->PL(2),
0->PL(3),
X2->PL(4),Y1->PL(5),0->PL(6),X2->PL(7),Y2->PL(8),0->PL(9),
X1->PL(10),Y2->PL(11),0->PL(12),12->PO(1),S(0,0),1;
HINT:S(0,0),&(WC>0)(
    S(2000,50),T('YOU ARE WORKING ON WALL #'),
    S(3000,50),T(N(WC))),
GRID1:S(0,0),S(1550,250),T('PLEASE LOCATE GRID START POINT')
    ,G,@SX->STAX,@SY->STAY,S(0,0);
GRID2:
    S(0,0),S(STAX,STAY-50),T('GRID SPACING=1 METER'),S(0,0),
    S(STAX,STAY),H(1,2,1/FAK,2,1/FAK),@GRID(20,1/FAK,1/FA
     K,20),H(2),S(0,0),S(STAX,STAY-150),&(FLAG10)(
     T('PLEASE LOCATE BOTTOM RIGHT THEN TOP LEFT POINT'),
     0->FLAG10)(
     T('PLEASE INDICATE BOTTOM LEFT CORNER')),
    S(0,0);
DRAWFLOOR:
    S(0,0),&(IWWC=0)(DFL)(DFLINT),S(0,0),1;
DFL:
SQU(X1,Y1,X2,Y2),(X2+X1)/2->PX,Y1-10->PY,S(PX,PY),
T('WALL 1'),Y2+10->PY,S(PX,PY),T('WALL 3'),X2+10->PX,
(Y2+Y1)/2->PY,S(PX,PY),T('WALL 2'),X1-150->PX,S(PX,PY),
T('WALL 4'),S(0,0);
EWALL:UP->FLAG3,&(FLAG2=0)(S(10,200),
T('SPECIFY BUILDING HEIGHT FIRST'))(S(10,150),
T('WHICH WALL'),@NUMERIC(K)->WC,@ERASE,S(0,0),KATCH,
     HINT,S(0,0),@RUNMENU(!CHOICEWL)),1;
KATCH:
&(2)(&(WC=1)(SQU(X1,Y1,X2,Y1+HI))
(&(WC=2)(SQU(X1,Y1,X1+Y2-Y1,HI+Y1))
(&(WC=3)(SQU(X1,Y1,X2,Y1+HI))
(&(WC=4)(SQU(X1,Y1,X1+Y2-Y1,HI+Y1))))));
CHOICEWL:(6)(OTH,FRAME,MASON,RECALLW,BACK,AGAIN);
HEIGHT:UP->FLAG2,&(FLAG1>0)
(S(10,100),T('BUILDING HEIGHT='),@NUMERIC(K)->HE,
HE/FAK->HI,
UPPL(1,X1,0,X2,HI),(X2-X1)*HE*FAK->AEW(1),
AEW(1)->AEW(3),UPPL(2,Y1,0,Y2,HI),
(Y2-Y1)*HE*FAK->AEW(2),AEW(2)->AEW(4),
UPPL(3,X2,0,X1,HI),
UPPL(4,Y2,0,Y1,HI))(S(10,200),T('SPECIFY FLOOR FIRST'),S(0,
0)),HINT,1;
ROOF:1;
UPPL(5):
&(&1=1)(&2->PL(TOP+1),Y1->PL(TOP+2),&3->PL(TOP+3
),&2->PL(TOP+4),
Y1->PL(TOP+5),&5->PL(TOP+6),&4->PL(TOP+7),
Y1->PL(TOP+8),&5->PL(TOP+9),&4->PL(TOP+10),
Y1->PL(TOP+11),&3->PL(TOP+12))
(&(&1=2)(X2->PL(TOP+1),&2->PL(TOP+2),&3->PL(TOP+3),
X2->PL(TOP+4),&2->PL(TOP+5),&5->PL(TOP+6),
X2->PL(TOP+7),&4->PL(TOP+8),&5->PL(TOP+9),
X2->PL(TOP+10),&4->PL(TOP+11),&3->PL(TOP+12))
(&(&1=3)(&2->PL(TOP+1),Y2->PL(TOP+2),&3->PL(TOP+3),
&2->PL(TOP+4),Y2->PL(TOP+5),&5->PL(TOP+6),
&4->PL(TOP+7),Y2->PL(TOP+8),&5->PL(TOP+9),
&4->PL(TOP+10),Y2->PL(TOP+11),&3->PL(TOP+12));
(&(&1=4)(X1->PL(TOP+1),&2->PL(TOP+2),
&3->PL(TOP+3),X1->PL(TOP+4),&2->PL(TOP+5),
&5->PL(TOP+6),X1->PL(TOP+7),&4->PL(TOP+8),
&5->PL(TOP+9),X1->PL(TOP+10),&4->PL(TOP+11),
&3->PL(TOP+12))))),
TOP+12->TOP,POC+1->POC,TOP->PO(POC);
OPENING:
S(0,0),G,@SX->WX,&(WX<3500)(@SY->WY,&(DFLAG)(Y1->WY),
HEIGH(TYPEW)/FAC+WY->YYY,WIDTH(TYPEW)/FAC+WX->XXX,
SQU(WX,WY,XXX,YYY),&(WC=1)(UPPL(1,WX,WY-Y1,XXX,YYY-Y1))
(&(WC=2)(UPPL(2,Y1+WX-X1,WY-Y1,Y1+XXX-X1,YYY-Y1))
(&(WC=3)(UPPL(3,X2-WX+X1,WY-Y1,X2-XXX+X1,
YYY-Y1))
(&(WC=4)(UPPL(4,Y2-WX+X1,WY-Y1,Y2-XXX+X1,YYY-Y1)))))),S(0,0)
;
WINDOW:0->DFLAG,0->WX,
&(FLAG3=0)(S(10,200),T('PLEASE CHOOSE A WALL FIRST'),1->RET)
(HINT,0->WIND,WINDOR,@ERASE,KATCH,GRID1,GRID2,OUT,
&&(WX<=3500)(OPENING,WINC+1->WINC,(XXX-WX)*(YYY-WY)*FA
K*FAK->AW(WINC),
AEW(WC)-AW(WINC)->AEW(WC),WC->WW(WINC)),3->RET),WINC-1->WINC
,S(0,0),RET;
OUT:S(0,0),S(2200,2000),
     T('WHEN YOU HAVE COMPLETED ONE WALL'),
     S(2200,1950),T('MAKE CURSOR ENTRY IN '),
     S(2200,1900),T('IN THIS SQUARE'),
     S(3500,1900),U(100,0,0,100,-100,0,0,-100),
)
```

```
DOORGRFL:HINT,
0->UX,&(UX<3500)
(1->DFLAG,DOOR,S(0,0))(1->RET),RET;
DOORFTHER:HINT,
0->UX,&(UX<3500)
(0->DFLAG,DOOR,S(0,0))(1->RET),RET;
DOOR:
&(FLAG2=0)(S(10,200),T('PLEASE CHOOSE A WALL FIRST'),
    1->RET)(1->WIND,WINDOR,SERASE,KATCH,GRID1,GRID2,OUT,
    &&(UX<3500)(OPENING,DOC+1->DOC,(XXX-UX)*(YYY-UY)*FAK
    *FAK->A
D(DOC),AEW(WC)-AD(DOC)->AEW(WC),WC->WD(DOC)),3->RET),S(0
0),DOC-1->DOC;
SQU(4):
S(0,0),S(&1,&2),D(&1,&4,&3,&4,&3,&2,&1,&2),S(0,0);
PERSP:
90->ALP,90->BET,2500->DIST,1->&MO,
    SERASE,SRUNMENU('VIEWMENU'),1;
VIEWMENU:(7)(ALPHA,BETA,DISTANCE,PARALLEL,PERSPECT,BACK,AGAI
N);
ALPHA:S(10,2000),T('ALPHA='),SNUMERIC(K)->ALP,1;
BETA:S(10,1900),T('BETA='),SNUMERIC(K)->BET,1;
DISTANCE:S(10,1800),T('DISTANCE='),SNUMERIC(K)->DIST,1;
PARALLEL:0->&MO,TRANS,1;
PERSPECT:1->&MO,TRANS,1;
BACK:SERASE,0;
TRANS:
S(0,0),&(FLAG2=0)(S(10,200),T('SPECIFY HEIGHT FIRST'))
(SERASE,S(0,0),VIEW,0->BOT,&(POC)
(POC-$BR+1->POINT,&(4)((4-$BR)*3+BOT->IN,
TRD3DE(PL(IN+1),PL(IN+2),PL(IN+3),XC,YC,ZC,CA,CB,SA),
WC*FAKT+TRX->UL($BR),VC*FAKT+TRY->VL($BR)),
S(UL(1),VL(1)),&(4)(D(UL($BR),VL($BR)),PO(POINT)->BOT))),S(0
,0);
VIEW:
(X2+X1)/2->XC,(Y2-Y1)/2->YC,
HI/2->ZC,
TRIG(ALP,BET),SERASE,S(0,0),MIND/DIST->FAKT;
TRIG(2):
SCOS(&1)->CA,SCOS(&2)->CB,SSIN(&1)->SA,SSIN(&2)->SB;
TRD3DE(9):
1->PICT,1->&AA,&1-&4->&X,&2-&5->&Y,&3-&6->&Z,&7*&8*&X+
&8*&8*&Y+SB*&Z->&QU,&(&QU>DIST)(0->PICT),
DIST-&QU->&Q,
&(DIST=0)(E-20->DIST),
&(&Q=0)(E-20->&Q),&(&MO\=0)(DIST/&Q->&AA),
-&AA*(&8*&X-&7*&Y)->WC,-&AA*(&7*SB*&X+SB*&8*&Y-&8*&Z)->VC;
```

```
INFO:0->LOSSCA,
S(500,2600),T('METER SQUARE'),S(1700,2600),T('BTU/HR'),
    T('RVALUE'),S(0,0),
    S(10,2550),T('FLOOR AREA EQUALS'),T(N(FLA)),
&(4)(4-$BR+1->CA,S(10,2500-(CA*50)),
    T('WALL '),T(N(CA)),T(' AREA= '),
     T(N(AEW(CA))),T('HEAT LOSS'),AEW(CA)/COLLECT(CA)*
     9.91*90->LOSS(CA),T(N(LOSS(CA))),T(N(COLLECT(CA)))),
      &(4)(LOSS($BR)+LOSSCA->LOSSCA),S(10,2200),
      T('TOTAL HEAT LOSS:WALLS'),T(N(LOSSCA)),
     0->AEWCA,0->AWCA,
     &(WINC)(AW($BR)+AWCA->AWCA),&(4)(AEW($BR)+AEWCA->AEWCA)
     AWCA/AEWCA*100->PERCENT,
2200->CB,&(WINC)(CB-100->CB,S(10,CB),
          WINC-$BR+1->CA,T('WINDOW '),T(N(CA)),T('IN WALL
'),T(N(WW(CA))),T(' AREA= '),T(N(AW(CA))),T('HEAT LOSS'),
     WW(CA)->GUESS,
   AW(CA)/COLLECTW(GUESS)*9.91*90->LOSSW(CA),T(N(LOSSW(CA))
     ),LOSSW(CA)+LOSSWCA->LOSSWCA,T(N(COLLECTW(GUESS)))),
    S(10,CB-100),T('TOTAL HEAT LOSS:WINDOWS'),T(N(LOSSWCA)),
 T('PERCENTAGE GLAZING='),T(N(PERCENT)),
     CB-100->CB,0->LOSSWCA,
&(DOC)(CB-100->CB,S(10,CB),DOC-$BR+1->CA,T('DOOR '),T(N(CA))
,
          T('IN WALL'),T(N(WD(CA))),T(' AREA= '),T(N(AD(CA
          ))),T('HEAT LOSS'),AD(CA)->GUESS,
  WD(CA)/COLLECTW(GUESS)*9.91*90->LOSSW(CA),T(N(LOSSW(CA)))
     ,LOSSW(CA)+LOSSWCA->LOSSWCA,T(N(COLLECTW(GUESS)))),
     S(0,0),
     S(10,CB-100),T('TOTAL HEAT LOSS:DOORS'),T(N(LOSSWCA)),
     T('PERCENTAGE DOORS'),0->ADCA,
     &(DOC)(AD($BR)+ADCA->ADCA),ADCA/AEWCA*100->PERCEND,
     T(N(PERCEND)),S(0,0),1;
IWALL:
0->UX,S(0,0),
DFLINT,&&(UX<3500)(G,$SX->UX,&(UX<3500)(INWC+1->INWC,S,$SX,$
SY),
$SX->PL(TOP+1),$SY->PL(TOP+2),0->PL(TOP+3),$SX->PL(TOP+4),
$SY->PL(TOP+5),HI->PL(TOP+6),$SX->IWX(INWC),
$SY->IWY(INWC),G,INWC+1->INWC,$SX->IWX(INWC),$SY->IWY(INWC),
 D($SX,$SY),$SX->PL(TOP+7),$SY->PL(TOP+8),
HI->PL(TOP+9),$SX->PL(TOP+10),$SY->PL(TOP+11),
0->PL(TOP+12),TOP+12->TOP,POC+1->POC,TOP->PO(POC),
S(0,0))),3;
DFLINT:
SQU(X1,Y1,X2,Y2),SROUND(INWC/2)->CA,&(CA)
(SROUND((CA-$BR)*2+1)->CB,
S(IWX(CB),IWY(CB)),D(IWX(CB+1),IWY(CB+1))),S(0,0);
>
```

```
[illegible]
LOSSU:<40>(0);LOSS:<40>(0);
GUESS:0;LOSSCA:0;LOSSUCA:0;FLAG:0:0;
PERCENT:0;PERCEND:0;AEUCA:0;AUCA:0;ADCA:0;UIND:0;
RET:0;Y1:0;Y2:0;X2:0;V2:0;IUC:0;UC:0;POT:0;POC:0;PX:0;PY:0;
XXC:0;[illegible]:0;INNC:0;TOP:0;STNY:0;STNX:0;
FLA:0;ME:200;UINC:0;DOC:0;HI:0;UX:0;UY:0;UP:1;DOWN:0;
FLAG1:0;FLAG2:0;FLAG3:0;IN:0;DOT:0;POINT:0;SAA:0;SX:0;SY:0;
S[illegible]:0;ACU:0;SO:0;SMO:0;ALP:0;BET:0;DIST:0;XC:0;YC:0;ZC:0;
CA:0;SPAL:0;CD:0;DA:0;SD:0;UC:0;UC:0;PICT:0;FAKT:0;DFLAG:0;
TRX:1000;FAK:0;TRY:1000;MIND:500;PICT:0;
PL:<200>(0);PO:<30>(0);AEU:<40>(0);AIU:<20>(0);AU:<40>(0);
IUX:<20>(0);IUY:<20>(0);
UD:<20>(0);UU:<40>(0);AD:<100>(0);UL:<4>(0);UL:<4>(0);
**EOF**
>
```

```
$1TOF$&
FRAME:
    $ERASE,SYSGPL,FRAME1,0;
RUNMENU(1):
    (DISP1(!&1),1->&FLAGI,G,
    &&(&FLAGI>0)&DOIT1(!&1,&PICK1(!&1));
&DISP1(1):
    &(&1(0)-1)
      (S(3520,100*$SR),T(N(&1($SR)))),
    S(3520,0),T('EXIT'),S(0,0);
&PICK1(1):
    &&($$X(3500)
      ($EXEQ(&1(0))->&IND,G),
    $ROUND($SY/100)->&IND,
    &(&IND)=&1(0))
      (&1(0)->&IND)
    (&(&IND>0)
      ($ERASE,S(3520,100*&IND),T(N(&1(&IND)))));
&DOIT1(1):  S(0,0),
    &(&IND)
  (&IND->SELECT,$EXEQ(!CONTINUE)->&FLAGI,S(0,0))
    (0->&FLAGI),
   S(0,0),
    &(&FLAGI=1)
     (&DISP1(!&1),G),
    &(&FLAGI=2)G;
&IND:0;
&FLAGI:0;
CONTINUE:
    WALCYC(!MATUAL(CYCLE)),VAR->RVAL1(CYCLE),
    CHCYC(!CHVAL(CYCLE)),
    &(SELECT=1)(LISTEM),LOCATION,0;
LISTEM:S(0,0),
    OTHR,S(0,0),
    T('WHAT IS THE NAME OF THE MATERIAL TO BE USED'),
    K->$BUF($),$BUF($)->CHOICE1(CYCLE),
    T(' WHAT IS THE RVALUE PER INCH'),
    $NUMERIC(K)->RVAL1(CYCLE);
LOCATION:
    MATFRA(CYCLE)->WALOCAT1(CYCLE),CYCLE->WALLPOS1(CYCLE),
    1->FLCHECK(CYCLE),&(SELECT\=2)(ASKTHICK)(0->RVAL1(CYCLE
    ),0->THICK1(CYCLE)),CALCULATE,SUMMATION;
SUMMATION:S(0,0),9->CYCLE,0->FCHECK,
    $ERASE,&(CYCLE)(FLCHECK($SR)
    +FCHECK->FCHECK),&((COMPONET-FCHECK)=0)(
    1->SCALE1,SCALE,CALCUL2,CHECKUPC,LISTHEAD,
    RSULTFR,0->RET)(1->RET),RET;
WALCYC(1):&1(SELECT)->VAR;
CHCYC(1):&1(SELECT)->CHOICE1(CYCLE);
```

```
CALCULATE:RVAL1(CYCLE)*THICK1(CYCLE)->RVALU1
     (CYCLE);
FLGCHECK:S(0,0),&(FLCHECK(CYCLE))(URNG);
URNG:S(0,150),T('YOU HAVE ALREADY SELECTED THIS COMPONENT'),
     S(0,100),T('IF YOU WISH TO CHANGE IT PLACE CURSOR'),
     S(0,50),T('OVER ITEM AND DEPRESS THE SPACING BAR'),S(0,
     0);
CHECKUPC:
     S(0,0),T('POSITION'),&(9)(T(N($SR))),
     S(0,50),T('WALL POSITION'),&(9)(T(N(WALLPOS1($SR)))),
     S(0,100),T('CHOICE OF MATL'),&(9)(T(N(CHOICE1($SR)))),
     S(0,150),T('RVALU OF COMP NT'),&(9)(T(N(RVALU1($SR)))),
     S(0,200),T('THICKNESS'),&(9)(T(N(THICK1($SR)))),
     S(0,250),T('WALL LOCAT'),&(9)(T(N(WALOCAT1($SR)))),
     S(0,300),T('FLCHECK'),&(9)(T(N(FLCHECK($SR)))),
     S(0,350),T('LOCAT'),&(9)(T(N(LOCAT($SR)))),
     S(0,400),T('LOCAT1'),&(9)(T(N(LOCAT1($SR)))),
     TRANSFR,S(0,0);
CHCKUPC:S(0,450),
     T('PARA ?'),$NUMERIC(K)->PARA,S(0,0),
     S(0,450),T('POSITION'),&(PARA)(T(N($SR))),
     S(0,500),T('WALLPOS'),&(PARA)(T(N(WALLPOS($SR)))),
     S(0,550),T('CHOICE'),&(PARA)(T(N(CHOICE($SR)))),
     S(0,600),T('RVALU'),&(PARA)(T(N(RVLUC($SR)))),
     S(0,650),T('THICK'),&(PARA)(T(N(THICKC($SR)))),
     S(0,700),T('WALLOCAT'),&(PARA)(T(N(WALLOCAT($SR))));
TRANSFR:9->CYCLE,
     &(CYCLE)(RVAL1($SR)->RVLC($SR+(CYCLE)*(TYPEFR-1)),
     RVALU1($SR)->RVLUC($SR+(CYCLE)*(TYPEFR-1)),
     CHOICE1($SR)->CHOICE($SR+(CYCLE)*(TYPEFR-1)),
     THICK1($SR)->THICKC($SR+(CYCLE)*(TYPEFR-1)),
     WALOCAT1($SR)->WALLOCAT($SR+(CYCLE)*(TYPEFR-1)),
     WALLPOS1($SR)->WALLPOS($SR+(CYCLE)*(TYPEFR-1));
RECALLU:T('WHICH TYPE DO YOU WISH TO HAVE RECALLED'),
     $NUMERIC(K)->TYPEFR,
     LOCAT(TYPEFR)->POSICH,
     LOCAT1(TYPEFR)->POSICH1,
     &(POSICH1-POSICH+1)(POSICH-$SR+1->INDEXC,
     RVLC(INDEXC)->RVAL1($SR-(TYPEFR*CYCLE)),
     RVLUC(INDEXC)->RVAL1($SR-(TYPEFR*CYCLE)),
     THICKC(INDEXC)->THICK1($SR-(TYPEFR*CYCLE)),
     CHOICE(INDEXC)->CHOICE1($SR-(TYPEFR*CYCLE)),
     WALLOCAT(INDEXC)->WALOCAT1($SR-(TYPEFR*CYCLE)),
     WALLPOS(INDEXC)->WALLPOS1($SR-(TYPEFR*CYCLE)));
FAC:3000/4096*254/100*45/10000/100*100;
FILMCOEF:.85;
CALCUL2:S(0,0),9->CYCLE,0->RVALUT(TYPEFR),
     &(CYCLE)(RVALU1($SR)+RVALUT(TYPEFR)->
     RVALUT(TYPEFR)),S(0,0),
     RVALUT(TYPEFR)+FILMCOEF->RVALUT(TYPEFR),
     RVALUT(TYPEFR)->COLLECT(UC);
>
```

```
LISTHEAD:S(0,0),S(0,550),T('FOR WALL TYPE $'),S(500,550),
     T(N(TYPEFR)),S(0,0),S(0,500),T('R-VALUE FOR WALL'),
     S(500,500),T('TOTAL'),T(N(RVALUT(TYPEFR))),S(0,0);
RSULTFF:S(0,0),S(0,0),
     &(CYCLE)(RVALU1(SSR)/RVALUT(TYPEFR)->SPAN(SSR),
     :6*SPAN(SSR)/FAC->YCORD(SSR)),S(0,0),RSULTFR1;
** 16 IS USED TO GIVE REALISTIC 'Y' SCALE
RSULTFR1:S(0,0),
     S(600,600),9->CYCLE,&(10)(0->XPT1(SSR)),
     &(CYCLE)
     (SSR->CLUE,DRFORM(!DRAWFORM),
     SEXEC(!DRAWF),THICK1(CLUE)/FAC->XPT1(CLUE),
     M(XPT1(CLUE)+50,0)),EXTFILM,RVALINE,INTFILM,
     S(0,0);
DRFORM(1):&1(CLUE)->DRAWF;
EXTFILM:S(0,0),
     9->CYCLE,S(0,200),
     .17*16/(RVALUT(TYPEFR))/FAC->YCRD,
     S(0,200),D(100,200),
     M(0,YCRD),
     SELLIPSE(100,YCRD,270,360),M(100,0),
     C(20,0,360),H(1,10,10,10,10),S(0,0);
**RVALINE:200+YCRD->YCORDI,S(200-XPT1(9),200+YCRD),
**     &(CYCLE)(YCORD(SSR)+YCORDI->YCORDI,
**     D(XPT2(SSR),YCORDI),C(20,0,360)),S(0,0);
RVALINE:S(200,200+YCRD),
     &+(5)(U(XPT1(SSR*2-1),YCORD(SSR*2-1)),C(20,0,360),
     SSR->CLUE1,
     &+(RVALU1(SSR*2-2)-0)(U(100,0))(&+(RVALU1(CLUE1*2-2)-9)
     ()(U(100+
     XPT1(CLUE1*2-2),YCORD(CLUE1*2-2)))),C(20,0,360));
INTFILM:
     C(20,0,360),
     .68*16/(RVALUT(TYPEFR))/FAC->YCRD1,
     H(2),M(100,0),SELLIPSE(100,YCRD1,180,90),M(0,YCRD1),
     U(100,0);
DRAWFORM:(9)(DRAWPLAST,DRAWAIR,DRAWINS,DRAWAIR,DRAWSHE,
     DRAWAIR,DRAWPAP,DRAWAIR,DRAWEXT);
DRAWEXT:&(8)(200*SSR->SPAC,S(200,SPAC),
     U(THICK1(CLUE)/FAC,200,0,-200,-THICK1(CLUE)/FAC,0)),
     S(200+XPT1(9),0);
DRAWPAP:&(8)(200*SSR->SPAC,S(0,SPAC),U(0,200),
     M(THICK1(CLUE)/FAC,0),U(0,-200));
DRAWSHE:&(8)(200*SSR->SPAC,S(0,SPAC),
     SRECT(THICK1(CLUE)/FAC,200),
     SSHADE(THICK1(CLUE)/FAC,200,50));
DRAWAIR:&(RVLUC(CLUE))0)(
     &(8)(S(0,SSR*200),T(N(AIRS(SSR))))));
AIRS:(8)(EE,CC,AA,PP,SS,RR,II,AA);

II:0;RR:0;SS:0;PP:0;AA:0;CC:0;EE:0;
DRAWINS:&(8)(200*SSR->SPAC,S(0,SPAC),
     SRECT(THICK1(CLUE)/FAC,200),
     SSHADE(THICK1(CLUE)/FAC,200,70));
DRAWPLAST:&(8)(200*SSR->SPAC,S(0,SPAC),
     SRECT(THICK1(CLUE)/FAC,200),
     SSHADE(THICK1(CLUE)/FAC,200,90));
ASKTHICK:S(0,50),T('WHAT IS THE THICKNESS'),
     SNUMERIC(K)->THICK1(CYCLE),S(0,0);
FRAME1:S(0,0),SERASE,9->CYCLE,6->COMPONET,
     &(CYCLE)(0->FLGCHECK(SSR)),TYPEFR+1->TYPEFR,
     TYPEFR*CYCLE->LOCAT1(TYPEFR),
     NUMFR,S(0,0),
     SRUNMENU(!MATFR),9->CYCLE,CYCLE*TYPEFR-1->
     LOCAT(TYPEFR),
** PUT IN DRAW FUNCTION AT THIS POINT
NUMFR:S(0,0),T('YOU ARE NOW WORKING ON TYPE $'),
     S(1000,0),T(N(TYPEFR));
MATFR:(9)(PLASTER,AIRSPACE,INSUL,SHEATH,PAPER,EXTFIN,
     TESTFUNC,BACKC,AGANC);
MATFRA:(9)(PLASTER,AIRSP,INSUL,AIRSP,SHEATH,AIRSP,PAPER,
     AIRSP,EXTFIN);
CHVAL:(9)(PLAST,AIRSP,INS,AIRSP,SHE,AIRSP,PAP,AIRSP,EXT);
MATVAL:(9)(PLASTVAL,AIRSP,INSVAL,AIRSP,SHEVAL,AIRSP,PAPVAL,
     AIRSP,EXTVAL);
TESTFUNC:K->SBUF(*),SCOMPILE(SBUF(*)),SC,SEXEC(SSF),2;
EXPLAIN:1;
EXTFIN:SERASE,9->CYCLE,FLGCHECK,RUNMENU(!EXT),1;
EXT:(8)(OTHR,NIL,ASBESTOS,PLYWOOD,LAPDWOOD,WOOD,ALUMINUM,
     AGANC);
EXTVAL:(8)(0,0,0.25,1.25,1.05,1.25,0,0);
ASBESTOS:0;PLYWOOD:0;LAPDWOOD:0;WOOD:0;ALUMINUM:0;
PAPER:SERASE,7->CYCLE,FLGCHECK,RUNMENU(!PAP),1;
PAP:(6)(OTHR,NIL,DRYFELT,TARFELT,POLETHLN,AGANC);
PAPVAL:(6)(0,0,0.06,0.12,0,0);
DRYFELT:0;TARFELT:0;POLETHLN:0;
SHEATH:SERASE,5->CYCLE,FLGCHECK,RUNMENU(!SHE),1;
SHE:(6)(OTHR,NIL,HARDWOOD,SOFTWOOD,PLYWOD,AGANC);
SHEVAL:(6)(0,0,0.91,1.25,1.25,0);
HARDWOOD:0;SOFTWOOD:0;PLYWOD:0;
INSUL:SERASE,3->CYCLE,FLGCHECK,RUNMENU('INS),1;
INS:(11)(OTHR,NIL,GLASWOL,COTTON,WODFBR,CELLGLAS,CORK,
     GLASFBR,POLYU,POLYSTY,AGANC);
INSVAL:(11)(0,0,3.12,3.85,4.00,2.86,4.00,4.76,5.88,4.55,0);
GLASWOL:0;COTTON:0;WODFBR:0;CELLGLAS:0;CORK:0;GLASFBR:0;
POLYU:0;POLYSTY:0;
PLASTER:SERASE,1->CYCLE,FLGCHECK,RUNMENU('PLAST),1;
PLAST:(6)(OTHR,NIL,GYPROC,GYPMLATH,PLSTER,AGANC);
PLASTVAL:(6)(0,0,.9,.13,.64,0);

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C:PROC:0;GYPMLATH:0;PLSTER:0;
AIRSPACE:IRAUFR1,0->UXC,0->RSPACE,2->CYCLE,
     FLGCHECK,
     S(0,53),T('LOCATE THE AIRSPACE ON THE DIAGRAM'),S(0,0),
     &&(UXC<=3500)(AIRSPC1),SUMMATION;
AIRSPC1:
     2->CYCLE,0,SBX->UXC,&(UXC<=3500)(SROUND(SBX/
     100)->RSPACE,1->FLCHECK(CYCLE),TRANS1,&(CYCLE<10)(
     S(C,0),ASKAIR,S(0,0))(
     T('YOU HAVE GONE BEYOND THE LIMITS OF THE DIAGRAM'),
     T('PLEASE MAKE ANOTHER SELECTION')),S(0,0));
ASKAIR:S(1000,0),T('WHAT IS THE THICKNESS OF THE AIRSPACE'),
     SNUMERIC(K)->THICK1(CYCLE),&(THICK1(CYCLE)
     .75)(1.16->RVALU1(CYCLE))(
     .9->RVAL1(CYCLE),
     THICK1(CYCLE)&RVAL1(CYCLE)->RVALU1(CYCLE)),
     CYCLE->WALLPOS1(CYCLE),MATFRA(CYCLE)->WALOCAT1(CYCLE),
     MATFRA(CYCLE)->CHOICE1(CYCLE),S(0,0);
TRANS1:
     &(RSPACE=4)(2->CYCLE),
     &(RSPACE=3)(4->CYCLE),
     &(RSPACE=2)(6->CYCLE),
     &(RSPACE=1)(8->CYCLE),
     &(RSPACE>4)(11->CYCLE);
    &(RSPACE<1)(11->CYCLE);
DRAWFP1:
     S(0,0),&(5)(S(2000,0),SSR*200->SPAC,
     S(80,200+SPAC),D(80,SPAC),D(40,SPAC),
     D(80,200+SPAC),S(150,200+SPAC),
     D(150,SPAC),S(210,SPAC),SRECT(80,200),
     S(310,SPAC),SRECT(80,200),
     S(410,SPAC),SRECT(80,200)),LABLFR1;
LABLFR1:
     S(80,1000),D(80,1700),T('EXTFIN'),
     S(150,1010),D(150,1600),T('PAPER'),
     S(250,1000),D(250,1500),T('SHEATHING'),
     S(350,1000),D(350,1400),T('INSULATION'),
     S(450,1000),D(450,1300),T('PLASTER FINISH');
AGANC:S(3300,2000),T('TRY AGAIN'),S(0,0),2;


OTHR:
STYPEOUT('EXTERIOR FINISH          RVAL/IN',B),
STYPEOUT(' ',B),
STYPEOUT('ASBESTOS-CEMENT BRD       0.25',B),
STYPEOUT('GYPSUM/PLASTER BRD        0.9',B),
STYPEOUT('PLYWOOD                   1.25',B),
STYPEOUT('STUCCO                    0.2',B),

STYPEOUT('WOOD FIBER BRD                 0.72',B),
STYPEOUT('WOOD,HARDWOOD FINISH           0.85',B),
STYPEOUT('',B),
STYPEOUT('BUILDING PAPER                     ',B),
STYPEOUT(' ',B),
STYPEOUT('PERMEABLE FELT                 0.24',B),
STYPEOUT('MOPPED FELT                    0.24',B),
STYPEOUT('POLYETHELYNE                   0.00',B),
STYPEOUT(' ',B),
STYPEOUT('SHEATHING COMPONENTS',B),
STYPEOUT(' ',B),
STYPEOUT('HARDWOOD                       0.91',B),
STYPEOUT('SOFTWOOD                       1.25',B),
STYPEOUT('PLYWOOD                        1.25',B),
STYPEOUT(' ',B),
STYPEOUT('INSULATION',B),
STYPEOUT('',B),
STYPEOUT('CELLULAR GLASS                 2.44',B),
STYPEOUT('CORKBOARD                      3.57',B),
STYPEOUT('COTTON FIBER                   3.84',B),
STYPEOUT('GLASSFIBER                     3.84',B),
STYPEOUT('MINERAL  WOOL                  3.12',B),
STYPEOUT('POLYURETHANE(EXPANDED)         5.88',B),
STYPEOUT('POLYSTYRENE(EXPANDED)          3.85',B),
STYPEOUT('WOOD  FIBERBOARD               2.38',B),
STYPEOUT('WOOD  SHREADED                 1.67',B),
STYPEOUT('',B),
STYPEOUT('PLASTERING MATERIALS',B),
STYPEOUT('',B),
STYPEOUT('CEMENT  PLASTER(SAND AGG)      0.20',B),
STYPEOUT('GYPSUM PLASTER(LIGHT AGG)      0.64',B),
STYPEOUT('               (SAND AGG)      0.18',B),
STYPEOUT('             (PERLITE AGG)     0.67',B),
STYPEOUT('SAND AGG ON METAL LATH         0.13',B),
STYPEOUT('SAND AGG ON WOOD LATH          0.30',B),
STYPEOUT('VERMICULATE AGG                0.57',B);
BACKC:SERASE,0;


IIIIIIIIIIIIIII
PARA:0,FCHECK:0,SELECT:0,POSICH:0,POSICH1:0,VAR:0,COMP.NET:0
;SCALE1:0,XPOS:0,YPOS:0,CALCUL1:0,UC:0,
INDEXC:0,DRAWF:0,CLUE1:0,YCRD:0,YCRD1:0,NUMAIR:0;
XPT1:0,POSITION:0,RET:0,TYPEFR:0,AIRSP:0,CYCLE:0,NIL:0;
FU:1,YCORDI:0,RSPACE:0,CLUE:0,RSPACE:0,SPACE:0,SPAC:0;
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**TOF**
MASON:
    S:3:PL,MORTAR1,0;
RUNMENUM(1):
    &T:SP1(:&1),1->&FLAGI,G,
    &(&FLAGI>0)&DOIT1(:&1,&PICK1(:&1));
&DISP1(1):
    &(&1:0)-1)
      (S(3520,100*SSR),T(N(&1(SSR)))),
    S(3520,0),T('EXIT'),S(0,0);
&PICK1(1):
    &(SSX<3500)
      (SEXEQ(&1(0))->&IND,G),
    SROUND(SSY/100)->&IND,
    &(SIND>=&1(0))
      (&1(0)->&IND)
    (&(&IND>0)
      (SERASE,S(3520,100*&IND),T(N(&1(&IND)))));
&DOIT1(1):  S(0,0),
    &(&IND>
   (&IND->SLECTM,SEXEQ('CNTINUE)->&FLAGI,S(0,0))
     (0->&FLAGI),
    S(0,0),
    &(&FLAGI=1)
     (&DISP1(:&1),G),
    &(&FLAGI=2)G;
&IND:0;
&FLAGI:0;
CNTINUE:
    VALCYM(!MATULM(CYCLM)),VRM->RVLM1(CYCLM),
    CHCYM(!CHULM(CYCLM)),
    &(SLECTM=1)(LISTMM),LOCATONM,0;
LISTMM:S(0,0),
    GTHR,S(0,0),
    T('WHAT IS THE NAME OF THE MATERIAL TO BE USED'),
    K->SBUF(*),SBUF(*)->CHOICM1(CYCLM),
    T(' WHAT IS THE RVALUE PER INCH'),
    SNUMERIC(K)->RVLM1(CYCLM);
LOCATONM:
    MATNOR(CYCLM)->WALOCTM1(CYCLM),CYCLM->WALLPSM1(CYCLM),
    1->FLCHCKM(CYCLM),&(SLECTM\=2)(ASKTHCKM)(0->RVLM1(CYCL
    M),0->THCKM1(CYCLM)),CALKULATM,SUMATIONM;
SUMATIONM:S(0,0),7->CYCLM,0->FCHCKM,
    SERASE,&(CYCLM)(FLCHCKM(SSR)
    +FCHCKM->FCHCKM),&((COMPONTM-FCHCKM)=0)(
    1->SCALE1,SCALE,CALCUL1,CHCKUPC,LISTHEDM,
    RSULTMO,0->RET)(1->RET),RET;
VALCYM(1):&1(SLECTM)->VRM;
CHCYM(1):&1(SLECTM)->CHOICM1(CYCLM);
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CALKULATM:RVLM1(CYCLM)*THCKM1(CYCLM)->RVLMU1
    (CYCLM);
FLGCHCKM:S(0,0),&(FLCHCKM(CYCLM))(WRNG);
WRNG:S(0,150),T('YOU HAVE ALREADY SELECTED THIS COMPONENT'),
    S(0,100),T('IF YOU WISH TO CHANGE IT PLACE CURSOR'),
    S(0,50),T('OVER ITEM AND DEPRESS THE SPACING BAR'),S(0,
    0);
CHCKUPC:
    S(0,0),T('POSITION'),&(7)(T(N(SSR))),
    S(0,50),T('WALL POSITION'),&(7)(T(N(WALLPSM1(SSR)))),
    S(0,100),T('CHOICE OF MATL'),&(7)(T(N(CHOICM1(SSR)))),
    S(0,150),T('RVALU OF COMP NT'),&(7)(T(N(RVLMU1(SSR)))),
    S(0,200),T('THICKNESS'),&(7)(T(N(THCKM1(SSR)))),
    S(0,250),T('WALL LOCTM'),&(7)(T(N(WALOCTM1(SSR)))),
    S(0,300),T('FLCHCKM'),&(7)(T(N(FLCHCKM(SSR)))),
    S(0,350),T('LOCTM'),&(7)(T(N(LOCTM(SSR)))),
    S(0,400),T('LOCTM1'),&(7)(T(N(LOCTM1(SSR)))),
    TRANSFRM,S(0,0);
CHKKUPC:S(0,450),
    T('PARM ?'),SNUMERIC(K)->PARM,S(0,0),
    S(0,450),T('POSITION'),&(PARM)(T(N(SSR))),
    S(0,500),T('WALLPSM'),&(PARM)(T(N(WALLPSM(SSR)))),
    S(0,550),T('CHOICM'),&(PARM)(T(N(CHOICM(SSR)))),
    S(0,600),T('RVALU'),&(PARM)(T(N(RVLUM(SSR)))),
    S(0,650),T('THICK'),&(PARM)(T(N(THCKMC(SSR)))),
    S(0,700),T('WALLOCTM'),&(PARM)(T(N(WALLOCTM(SSR))));
TRANSFRM:7->CYCLM,
    &(CYCLM)(RVLM1(SSR)->RVLM(SSR+(CYCLM)*(TYPEMO-1)),
    RVLMU1(SSR)->RVLUM(SSR+(CYCLM)*(TYPEMO-1)),
    CHOICM1(SSR)->CHOICM(SSR+(CYCLM)*(TYPEMO-1)),
    THCKM1(SSR)->THCKMC(SSR+(CYCLM)*(TYPEMO-1)),
    WALOCTM1(SSR)->WALLOCTM(SSR+(CYCLM)*(TYPEMO-1)),
    WALLPSM1(SSR)->WALLPSM(SSR+(CYCLM)*(TYPEMO-1)));
RECALUM:T('WHICH TYPE DO YOU WISH TO HAVE RECALLED'),
    SNUMERIC(K)->TYPEMO,
    LOCTM(TYPEMO)->POSCHM,
    LOCTM1(TYPEMO)->POSCHM1,
    &(POSCHM1-POSCHM+1)(POSCHM-SSR+1->INDEXM,
    RVLM(INDEXM)->RVLM1(SSR-(TYPEMO*CYCLM)),
    RVLUM(INDEXM)->RVLM1(SSR-(TYPEMO*CYCLM)),
    THCKMC(INDEXM)->THCKM1(SSR-(TYPEMO*CYCLM)),
    CHOICM(INDEXM)->CHOICM1(SSR-(TYPEMO*CYCLM)),
    WALLOCTM(INDEXM)->WALOCTM1(SSR-(TYPEMO*CYCLM)),
    WALLPSM(INDEXM)->WALLPSM1(SSR-(TYPEMO*CYCLM)));
FAC:3800/4096*254/100*45/10000/100*100;
FILMCOEF:.85;
CALCUL1:S(0,0),7->CYCLM,0->RVLUTM(TYPEMO),
    &(CYCLM)(RVLMU1(SSR)+RVLUTM(TYPEMO)->
    RVLUTM(TYPEMO)),S(0,0),
    RVLUTM(TYPEMO)+FILMCOEF->RVLUTM(TYPEMO),
    RVLUTM(TYPEMO)->COLLECT(WC);
)
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COLLECT:(10)(0);
LISTHEDM:S(0,0),S(0,550),T('FOR WALL TYPE $'),S(500,550),
     T(N(TYPEMO)),S(0,0),S(0,500),T('R-VALUE FOR WALL'),
     S(500,500),T('TOTAL'),T(N(RVLUTM(TYPEMO))),S(0,0);
RSULTMO:S(0,0),S(0,0),
     $(CYCLM)(RVLMW1(SSR)/RVLUTM(TYPEMO)->SPNM(SSR),
     16*SPNM(SSR)/FAC->YCRDM(SSR)),S(0,0),RSULTMO1;
** 16 IS USED TO GIVE REALISTIC 'Y' SCALE
RSULTMO1:S(0,0),
     S(600,600),7->CYCLM,&(7)(0->XPTM(SSR)),
     &(CYCLM)
     (SSR->CLUM,DRFRMM(!DRAWMOR),
     $EXEQ(!DRAWM),THCKM1(CLUM)/FAC->XPTM(CLUM),
     P(XPTM(CLUM)+50,0)),EXTFLMM,RVALINM,INTFLMM,
     S(0,0);
DRFRMM(1):&1(CLUM)->DRAWM;
EXTFLMM:S(0,0),
     7->CYCLM,S(0,200),
     .17*16/(RVLUTM(TYPEMO))/FAC->YCRM,
     S(0,200),D(100,200),
     M(0,YCRM),
     $ELLIPSE(100,YCRM,270,360),M(100,0),
     C(20,0,360),H(1,10,10,10,10),S(0,0);
RVALINM:S(200,200+YCRM),
     &+(4)(V(XPTM(SSR*2-1),YCRDM(SSR*2-1)),C(20,0,360),
     SSR->CLUM1,
     &+(RVLMW1(SSR*2-2)=0)(V(100,0))(&+(RVLMW1(CLUM1*2-2)=7)
     (V(100+
     XPTM(CLUM1*2-2),YCRDM(CLUM1*2-2)))),C(20,0,360));
INTFLMM:
     C(20,0,360),
     (60*16/(RVLUTM(TYPEMO))/FAC->YCRM1,
     H(2),M(100,0),$ELLIPSE(100,YCRM1,180,90),M(0,YCRM1),
     V(100,0));
DRAWMOR:(7)(DRWPLASTM,DRAWAIR,DRAWINMS,DRAWAIR,DRAWSTRUC,
     DRAWAIR,DRAWFACE);
DRAWFACE:S(200,0),100->HIIT,DRAWFAC1,S(200+XPTM(8),0);
DRAWFAC1:&(8)(200*SSR->SPAC,S(0,SPAC+200),
     V(THCKM1(CLUM)/FAC,0,0,-HIIT,-THCKM1(CLUM)/FAC,
     0,0,HIIT),M(THCKM1(CLUM)/FAC/8,-HIIT),V(THCKM1(CLUM)
     /FAC*3/4,0,0,-HIIT/2,-THCKM1(CLUM)/FAC*3/4,0,0,HIIT/2))
     ,M(-THCKM1(CLUM)/FAC/8,0));
DRAWSTRUC:130->HIIT,DRAWFAC1,100->HIIT,M(50,0);
DRAWAIR:&(RVLUM(CLUM)>0)(
     &(8)(S(0,SSR*200),T(N(AIRS(SSR)))));
AIRS:(8)(EE,CC,AA,PP,SS,RR,II,AA);
II:0,RR:0,SS:0,PP:0,AA:0,CC:0,EE:0;
DRAWINMS:&(8)(200*SSR->SPAC,S(0,SPAC),
     $RECT(THCKM1(CLUM)/FAC,200),
     $SHADE(THCKM1(CLUM)/FAC,200,70));

DRWPLASTM:&(8)(200*SSR->SPAC,S(0,SPAC),
     $RECT(THCKM1(CLUM)/FAC,200),
     $SHADE(THCKM1(CLUM)/FAC,200,90));
ASKTHCKM:S(0,50),T('WHAT IS THE THICKNESS'),
     $NUMERIC(K)->THCKM1(CYCLM),S(0,0);
MORTAR1:S(0,0),$ERASE,7->CYCLM,5->COMPONTM,
     &(CYCLM)(0->FLGHCKM(SSR)),TYPEMO+1->TYPEMO,
     TYPEMO*CYCLM->LOCTM1(TYPEMO),
     NUMMO,S(0,0),
     $RUNMENU(!MATMO),7->CYCLM,CYCLM*TYPEMO-1->
     LOCTM(TYPEMO);
NUMMO:S(0,0),T('YOU ARE NOW WORKING ON TYPE $'),
     S(1000,0),T(N(TYPEMO));
MATMO:(8)(PLASTM,AIRSPACE,INSM,STRUCT,FACEING,
     TESTFUNC,BACKC,AGANC);
MATMOR:(7)(PLASTM,AIRSP,INSM,AIRSP,STRUCT,AIRSP,
     FACEING);
CHWLM:(7)(PLSTM,AIRSP,INM,AIRSP,STR,AIRSP,FACE);
MATVLM:(7)(PLSTVAL,AIRSP,INMVAL,AIRSP,STRVAL,AIRSP,
     FACEVAL);
TESTFUNC:K->$BUF(*),$COMPILE($BUF(*)),$C,$EXEQ($SF),2;
EXPLAIN:1;
FACEING:$ERASE,7->CYCLM,FLGCHCKM,RUNMENU(!FACE),1;
FACE:(9)(OTHR,NIL,FACEBRICK,STONE,COMMONBRICK,CONCRETE,
     STUCCO,CONKRETEBLOC,AGANC);
FACEVAL:(9)(0,0,.11,.08,.20,.08,.2,.1,0);
FACEBRICK:0;STONE:0;COMMONBRICK:0;CONCRETE:0;STUCCO:0;
CONKRETEBLOC:0;
STRUCT:$ERASE,5->CYCLM,FLGCHCKM,RUNMENU(!STR),1;
STR:(8)(OTHR,NIL,CONCRETE,C.BLOK.CNDER,C.BLOK.LITE,
     C.BLOK.SAND,C.BLOK.FILLD,AGANC);
STRVAL:(8)(0,0,0.08,.16,.2,.1,.06,0);
C.BLOK.CNDER:0;C.BLOK.LITE:0;C.BLOK.SAND:0;C.BLOK.FILLD:0;
INSM:$ERASE,3->CYCLM,FLGCHCKM,RUNMENU(!INM),1;
INM:(11)(OTHR,NIL,GLASWOL,COTTON,WODFBR,CELLGLAS,CORK,
     GLASFBR,POLYU,POLYSTY,AGANC);
INMVAL:(11)(0,0,3.12,3.85,4.00,2.86,4.00,4.76,5.88,4.55,0);
GLASWOL:0;COTTON:0;WODFBR:0;CELLGLAS:0;CORK:0;GLASFBR:0;
POLYU:0;POLYSTY:0;
PLASTM:$ERASE,1->CYCLM,FLGCHCKM,RUNMENU(!PLSTM),1;
PLSTM:(6)(OTHR,NIL,GYPROC,GYPMLATH,PLSTER,AGANC);
PLSTVAL:(6)(0,0,.9,.13,.64,0);
GYPROC:0;GYPMLATH:0;PLSTER:0;
AIRSPACE:DRAWMO1,0->WXC,0->RSPACE,2->CYCLM,
     FLGCHCKM,
     S(0,50),T('LOCATE THE AIRSPACE ON THE DIAGRAM'),S(0,0),
     &&(WXC<=3500)(AIRSPC1),SUMATIONM;
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AIPSPC1:
     2->CYCLM,G,80X->UXC,&(UXC<=3500)(8ROUND(80X/
     100)->RSPACE,1->FLCHCKM(CYCLM),TRANS1,&(CYCLM<10)(
     S(0,0),ASKAIR,S(0,0))(
     T('YOU HAVE GONE BEYOND THE LIMITS OF THE DIAGRAM'),
     T('PLEASE MAKE ANOTHER SELECTION')),S(0,0));
ASKAIR:S(1300,0),T('WHAT IS THE THICKNESS OF THE AIRSPACE'),
     $NUMERIC(K)->THCKM1(CYCLM),1->RVLM1(CYCLM),
     THCKM1(CYCLM)*RVLM1(CYCLM)->RVLMU1(CYCLM),
     CYCLM->WALLPSM1(CYCLM),MATNOR(CYCLM)->WALOCTM1(CYCLM),
     MATNOR(CYCLM)->CHOICM1(CYCLM),S(0,0);
TRANS1:
     &(RSPACE=5)(2->CYCLM),
     &(RSPACE=4)(4->CYCLM),
     &(RSPACE=2)(6->CYCLM),
     &(RSPACE>5)(11->CYCLM),&(RSPACE=1)(11->CYCLM),
     &(RSPACE=3)(11->CYCLM),&(RSPACE<1)(11->CYCLM);
DRAWMG1:
     S(0,0),&(5)(S(2000,0),80R*200->SPAC,
     S(120,SPAC+200),U(0,-10,-10,0,0,-80,10,0,0,-20,
     -10,0,0,-80,10,0,0,-10),
     S(180,SPAC+200),U(0,-10,10,0,0,-80,-10,0,0,-20,
     10,0,0,-80,-10,0,0,-10),S(220,SPAC+200),
     U(0,-90,10,0,0,-20,0,-10,0,-90),
     S(320,SPAC+200),U(0,-90,-10,0,0,-20,0,10,0,-90),
     S(420,SPAC),$RECT(80,200),S(520,SPAC),
     $RECT(80,200)),LABLM01;
LABLM01:
     S(150,1000),D(150,1700),T('EXTERIOR FACING'),
     S(350,1010),D(350,1600),T('STRUCTURAL'),
     S(450,1000),D(450,1500),T('INSULATION'),
     S(550,1000),D(550,1300),T('PLASTER FINISH');
AGANC:S(3300,2800),T('TRY AGAIN'),S(0,0),2;

OTHR:
$TYPEOUT('EXTERIOR FINISH            RVAL/IN',B),
$TYPEOUT(' ',B),
$TYPEOUT('ASBESTOS-CEMENT BRD         0.25',B),
$TYPEOUT('GYPSUM/PLASTER BRD          0.9',B),
$TYPEOUT('PLYWOOD                     1.25',B),
$TYPEOUT('STUCCO                      0.2',B),
$TYPEOUT('WOOD FIBER BRD              0.72',B),
$TYPEOUT('WOOD,HARDWOOD FINISH        0.85',B),
$TYPEOUT(' ',B),
$TYPEOUT('BUILDING PAPER                  ',B),
$TYPEOUT(' ',B),
$TYPEOUT('PERMEABLE FELT              0.24',B),
$TYPEOUT('MOPPED FELT                 0.24',B),

$TYPEOUT('POLYETHELYNE                      0.00',B),
$TYPEOUT(' ',B),
$TYPEOUT('SHEATHING COMPONENTS',B),
$TYPEOUT(' ',B),
$TYPEOUT('HARDWOOD                          0.91',B),
$TYPEOUT('SOFTWOOD                          1.25',B),
$TYPEOUT('PLYWOOD                           1.25',B),
$TYPEOUT(' ',B),
$TYPEOUT('INSULATION',B),
$TYPEOUT(' ',B),
$TYPEOUT('CELLULAR GLASS                    2.44',B),
$TYPEOUT('CORKBOARD                         3.57',B),
$TYPEOUT('COTTON FIBER                      3.84',B),
$TYPEOUT('GLASSFIBER                        3.84',B),
$TYPEOUT('MINERAL  WOOL                     3.12',B),
$TYPEOUT('POLYURETHANE(EXPANDED)            5.88',B),
$TYPEOUT('POLYSTYRENE(EXPANDED)             3.85',B),
$TYPEOUT('WOOD  FIBERBOARD                  2.38',B),
$TYPEOUT('WOOD  SHREADED                    1.67',B),
$TYPEOUT(' ',B),
$TYPEOUT('PLASTERING MATERIALS',B),
$TYPEOUT(' ',B),
$TYPEOUT('CEMENT  PLASTER(SAND AGG)         0.20',B),
$TYPEOUT('GYPSUM PLASTER(LIGHT AGG)         0.64',B),
$TYPEOUT('                (SAND AGG)        0.18',B),
$TYPEOUT('              (PERLITE AGG)       0.67',B),
$TYPEOUT('SAND AGG ON METAL LATH            0.13',B),
$TYPEOUT('SAND AGG ON WOOD LATH             0.30',B),
$TYPEOUT('VERMICULATE AGG                   0.57',B);
BACKC:$ERASE,0;

****************
RVLUM:<100>(0);XPT:<100>(0);XPTM:<8>(0);RVLM:<100>(0);
RVLM1:<7>(0);RVLMU1:<7>(0);THCKMC:<100>(0);THCKM1:<7>(0);
CHOICM:<100>(0);CHOICM1:<7>(0);WALLOCTM:<100>(0);
WALOCTM1:<7>(0);WALLPSM:<100>(0);WALLPSM1:<7>(0);
FLCHCKM:<7>(0);RVLUTM:<10>(0);LOCTM1:<10>(0);LOCTM:<10>(0);
SPNM:<100>(0);AIR:<7>(0);YCRDM:<100>(0);
HIIT:0;TYPEMO:0;AIRSP:0;CYCLM:0;NIL:0;XPSM:0;YPSM:0;
UXC:0;PARM:0;FCHCKM:0;SLECTM:0;POSCHM:0;POSCHM1:0;
VRM:0;COMPONTM:0;UC:0;INDEXM:0;DRAWM:0;CLUM:0;YCRM:0;YCRM1:0
;YCRDM1:0;FU:1;XPTI:0;POSITION:0;RET:0;NUMAIR:0;
RSPACE1:0,SCALE1:0;CLUM1:0;RSPACE:0;SPACE:0;SPAC:0;EXP:0;
**EOF**
>
```

```
**TOF**
OTH:$ERASE,SYSOPL,S(0,0),0->FLGO,
     2000->XCLUE,0->COMP,TYPEO+1->TYPEO,
$TYPEOUT('IN THIS MENU OPTION YOU CAN BUILD UP THE',B),
$TYPEOUT('WALL COMPONENTS BY YOURSELF. THIS IS DONE',B),
$TYPEOUT('SIMPLY BY STARTING WITH THE OUTSIDE ',B),
$TYPEOUT('COMPONENTS OF THE WALL AND BY WORKING ',B),
$TYPEOUT('INWARDS. A MENU OPTION WILL APPEAR AND YOU',B),
$TYPEOUT('CAN SELECT ONE OF TWO ALTERNATIVES',B),
$TYPEOUT('    THIS IS DONE AS WITH OTHER MENU CHOICES',B),
$TYPEOUT('WITH THE EXCEPTION THAT AS YOU INPUT A',B),
$TYPEOUT('YOUR CHOICE A SMALL DRAWING WILL BE MADE TO',B),
$TYPEOUT('GIVE YOU AN IDEA OF WHAT YOUR WALL WILL',B),
$TYPEOUT('RESEMBLE. THE MENU WILL NOW APPEAR.',B),
$TYPEOUT('WHEN YOU ARE THROUGH WITH COMPONENTS',B),
$TYPEOUT('JUST PRESS THE FINALIZE OPTION',B),
$TYPEOUT('THE WALL COMPONENTS ARE SPACED BY ',B),
$TYPEOUT('50 SCREEN UNITS SO AS NOT TO CONFUSE',B),
$TYPEOUT('THE DIAGRAM.AIRSPACES WILL BE INDICATED',B),
$TYPEOUT('IN AN OBVIOUS FASHION',B),
$TYPEOUT('YOU ARE NOW WORKING ON TYPE #',N(TYPEO),B),
     S(2000,0),T('YOU ARE WORKING ON WALL #'),
     S(0,0),
     S(3000,0),T(N(WC)),S(0,0),
     $RUNMENU(OTHRTYPE),S(0,0),1;
OTHRTYPE:<7>(AIR.SPACE,CMPONENT,RECALL,FINALIZE,
     MATERIALS,DATA.O,AGANO);
MATERIALS:$ERASE,OTHR,1;
DATA.O:
     S(150,(TYPEO+1)*50),T('TYPE'),
     S(400,(TYPEO+1)*50),T('RVAL TOTAL'),
     S(900,(TYPEO+1)*50),T('WALL COMPONENTS'),
     S(0,0),&(TYPEO)(S(200,$SR*50),T(N($SR))),
     &(TYPEO)(S(400,$SR*50),T(N(RVALUTO($SR)))),
     &(TYPEO)(S(700,$SR*50),&(10)(T(N(NAME($SR))),
     T(' ')),S(0,0),1;
FINALIZE:
     &((COMP/2-$ROUND(COMP/2)=0))(
     T('YOU HAVE ENDED WITH AN INTERIOR AIRSPACE'),1->RTO)(
     &(RECALF)(COMP1(TYPEO+1)-COMP1(TYPEO)->COMP,
     COMP->COMP2)(COMP->COMP2),
     S(0,0),0->RVALUTO(TYPEO),SCALE,COLCULATE,CHECKUP,
     S(600,600),&+(COMP)(S(XCLUE1($SR),200),$SR->COMP,
     &(TYPE=$SR))(DRAWCOMP)(DRAWAIRS),
     M(50,0)),S(1800,500),EXTFILMO,RVALINEO,INTFILMO,
     &(RECALF)(TRANSFRO,1->RTO)(
     TRANSFRO,S(2000,0),
     T(N(100-COMP3)),T('ARRAY SPACES ARE REMAINING'),
     S(0,0),0->RTO),0->RECALF),RTO;

RECALL:1->RECALF,
     S(0,0),S(1000,100),
     T('WHICH WALL TYPE DO YOU WISH TO HAVE RECALLED'),
     S(0,0),TYPEO->HOLD,
     $NUMERIC(K)->PULLBACK,PULLBACK->TYPEO,
     RVALUTO(TYPEO)->RVALUTO(HOLD),
     &(PULLBACK\=0)(
     COMP1(PULLBACK+1)->PULL1,
     &(PULLBACK=1)(0->PULL2)
     (COMP1(PULLBACK)->PULL2),PULL1->INDEX,
     &(PULL1-PULL2)(PULL1-$SR+2->PULL3,
     THICK(INDEX)->THICK10($SR),RVAL(INDEX)->RVAL10($SR),
     RVALU(INDEX)->RVALU10($SR),NAME2(INDEX)->NAME($SR),
     YCRD10(INDEX)->YCORD($SR),
     TYPE2(INDEX)->TYPE($SR),XCLUE2(INDEX)->XCLUE1($SR),
     INDEX-1->INDEX),S(0,0),
     FINALIZE),S(0,0),HOLD->TYPEO,0;
AIR.SPACE:COMP+1->COMP,0->TYPE(COMP),
     S(0,0),S(0,200),
     T('WHAT IS THE THICKNESS OF THE AIR SPACE'),
     $NUMERIC(K)->THICK10(COMP),AIRSP->NAME(COMP),
     &(THICK10(COMP)>.75)(.8->RVAL10(COMP),
     1.16->RVALU10(COMP))
     (.9->RVAL10(COMP),
     THICK10(COMP)*RVAL10(COMP)->RVALU10(COMP)),
     S(XCLUE,200),$$AX->XCLUE1(COMP),M(THICK10(COMP)/FACO/2,
     0),DRAWAIRS,
     XCLUE+100+(THICK10(COMP))/FACO->XCLUE,S(0,0),1;
CMPONENT:COMP+1->COMP,1->TYPE(COMP),
     &(FLGO=1)($ERASE,0->FLGO),
     S(0,0),S(0,500),T('WHAT IS THE MATERIAL USED'),
     K->$BUF(1),$BUF(1)->NAME(COMP),
     S(0,450),T('WHAT IS THE THICKNESS OF THE MATL'),
     $NUMERIC(K)->THICK10(COMP),
     S(0,400),T('WHAT IS THE R-VALUE OF THE MATL'),
     $NUMERIC(K)->RVAL10(COMP),
     THICK10(COMP)*RVAL10(COMP)->RVALU10(COMP),
     S(XCLUE,400),$$AX->XCLUE1(COMP),
     DRAWCOMP,
     XCLUE+100+(THICK10(COMP))/FACO->XCLUE,S(0,0),1;
DRAWAIRS:
     S(0,0),&(8)(S(0,$SR*200+400),T(N(AIRSO($SR)))),
     S(0,0);
AIRSO:<8>(EEE,CCC,AAA,PPP,SSS,RRR,III,AAA);
III:0;RRR:0;SSS:0;PPP:0;AAA:0;CCC:0;EEE:0;
DRAWCOMP:
     S(0,0),&(10)(200*$SR+100->SPAC,S(0,SPAC),
     $RECT(THICK10(COMP)/FACO,200),
     $SHADE(THICK10(COMP)/FACO,200,50+(5*COMP))),
     S(0,0);
```

```
CHECKUP:S(0,0),
     S(1000,0),T('POSITION'),&(10)(T(N(SSR))),
     S(1200,50),T('RVALUE OF THE WALL'),
     &(10)(T(N(RVALU10(SSR)))),S(1000,100),
     T('THICKNESS(INCH)'),&(10)(T(N(THICK10(SSR)))),
     S(1000,150),T('COMP NAME'),&(10)(T(N(NAME(SSR)))),
     S(1000,200),
     T('WALL TYPE'),T(N(TYPEO)),T('RVAL TOTAL'),T(N(RVALUTO(
     TYPEO))),S(0,0);
TRANSFRO:
     COMP3->COMP1(TYPEO),
     &(COMP2)(XCLUE1(SSR)->XCLUE2(SSR+COMP3),
     0->XCLUE1(SSR),
     THICK10(SSR)->THICK(SSR+COMP3),0->THICK10(SSR),
     YCORD(SSR)->YCRD10(SSR+COMP3),0->YCORD(SSR),
     RVAL10(SSR)->RVAL(SSR+COMP3),0->RVAL10(SSR),
     RVALU10(SSR)->RVALU(SSR+COMP3),0->RVALU10(SSR),
     NAME(SSR)->NAME2(SSR+COMP3),0->NAME(SSR),
     TYPE(SSR)->TYPE2(SSR+COMP3),0->TYPE(SSR)),
     COMP2+COMP3->COMP3,2000->XCLUE,1->FLGO,0->COMP;
COLCULATE:0->RVALUTO(TYPEO),
     &(COMP2)(RVALU10(SSR)+RVALUTO(TYPEO)->
     RVALUTO(TYPEO)),RVALUTO(TYPEO)+FILMCOF->
     RVALUTO(TYPEO),RVALUTO(TYPEO)->COLLECT(UC);
EXTFILMO:
     .17*18/(RVALUTO(TYPEO))/FACO->YCRDO,
     D(100,0),M(0,YCRDO),
     SELLIPSE(100,YCRDO,270,360),M(100,0),
     C(20,0,360),H(1,10,10,10,10);
INTFILMO:
     C(20,0,360),
     .68*18/(RVALUTO(TYPEO))/FACO->YCRDO1,
     H(2),M(100,0),SELLIPSE(100,YCRDO1,180,90),
     M(0,YCRDO1),U(100,0);
RVALINEO:
     0->YCRDI,0->INDEX1,
     &+(COMP2)(INDEX1+1->INDEX1,RVALU10(INDEX1)/RVALUTO(
     TYPEO)->SPAN(INDEX1),
     12*SPAN(INDEX1)/FACO->YCORD(INDEX1),YCORD(INDEX1)+YCRD
     I->YCRDI,&+(TYPE(INDEX1)=0)()(U(THICK10(INDEX1)/FACO,
     YCORD(INDEX1)),C(20,0,360)),&+(TYPE(INDEX1+1)=0)()(
     &+(TYPE(INDEX1))(U(100,0))(U(THICK10(INDEX1)/FACO+200,
     YCORD(INDEX1))),C(20,0,360)));
SCALE:
     S(0,0),S(1200,500),
     T('YOU MUST CHOOSE DESIGN TEMPERATURES YOU WISH TO'),
     S(1200,450),T('WORK WITH. THEY ARE PRESENTLY SET AT'),
     S(1200,400),T('-20 deg F (-15 C) AND 72 deg F (15 C)'),
     S(1200,350),T('DO YOU WISH TO CHANGE THESE (Y/N)?'),
     72->HIGH1,15->HIGH2,-20->LOW1,-15->LOW2,
     SNUMERIC(K)->YESNO,&(YESNO)(S(1200,300),
     T('WHAT VALUE WILL YOU USE AS OUTDOOR TEMP'),
     SNUMERIC(K)->LOW1,S(1200,250),
     T('AND AS INDOOR TEMPERATURE ?'),
     SNUMERIC(K)->HIGH1),SERASE,&+(SCALE1=0)(S(1400,2800))(
     S(250,2950)),
     T('F deg    C deg'),S(0,0),
     SROUND((HIGH1-LOW1)/10)->DIFF1,
     &(DIFF1+1)(SSR->RRR,&+(SCALE1=1)(S(250,RRR*220+650))(
     S(1400,RRR*220+300)),T(N((SROUND(HIGH1/10)*10))),
     S(0,0),
     &+(SCALE1=1)(S(450,RRR*200+850))(S(1600,RRR*200+500)),
     T(N(SROUND(HIGH2))),HIGH1-10->HIGH1,
     HIGH2-2->HIGH2,S(0,0)),S(0,0),&+(SCALE1=1)(S(650,650))(
     S(1700,300)),STMARK(
     100,15,0,110,2*(DIFF1+1),0),S(0,0),&+(SCALE1=1)(S(50,10
     50))(S(1200,700)),*(.3)(TEMP),S(0,0),
     &+(SCALE1=1)(S(1250,550))(S(2400,200)),T('THICKNESS'),
     S(0,0);
TEMP:S(0,0),U(0,100,0,-50,100,0),M(-100,200),
   U(0,-100,50,0,0,50,0,-50,50,0,0,100),M(0,100),
   U(-100,0,50,50,-50,50,100,0),M(0,100),
   U(-100,0,0,50),M(25,0),C(25,180,0),M(25,0),
   U(0,-50),M(50,250),U(0,-100,-50,0,0,50,0,-50,-50,0,
    0,100),M(100,100),U(-100,0,0,50),M(25,0),C(25,180,0),
    M(25,0),U(0,-50,50,50),M(0,100),U(-100,30,100,30),
    M(0,100),U(-100,0,0,50,0,-100),M(0,150),
    U(50,0),M(0,50),C(50,-90,90),M(0,50),U(-50,0),
    M(100,50),U(-100,0,0,50),M(25,0),C(25,180,0),M(25,0),
    U(0,-50,50,50),M(0,200),U(0,-100,-50,0,0,50,0,-50,
    -50,0,0,100);

     ************************
     HIGH1:0;HIGH2:0;LOW1:0;LOW2:0;DIFF1:0;YESNO:0;
     INDEX1:0;YCRDO:0;YCRDO1:0;YCRDI:0;
     FILMCOF:.85;
     SPAN:<10>(0);YCORD:<10>(0);PULL1:0;PULL2:0;PULL3:0;
     PULLBACK:0;INDEX:0;XCLUE:0;
     RVALUTO:<10>(0);TYPEO:0;FACO:.01;SPAC:0;
     XCLUE1:<10>(0);XCLUE2:<100>(0);COMP1:<10>(0);
     )
```

```
**TAF**
WINDOR:S(0,0),SYSGPL,$ERASE,1+TYPEW->TYPEW,
STYPEOUT('          ****************************                ',B),
STYPEOUT('WW      WW II NN      NN DDDD      OOO      RRRR',B),
STYPEOUT('WW      WW II NNN     NN DD  DD  OO   OO  RR  RR',B),
STYPEOUT('WW  WW  WW II NN NN NN DD  DD OO     OO RR   RR',B),
STYPEOUT('WWW  WWW II NN    NNN DD  DD OO     OO RRRRRR',B),
STYPEOUT('WWW  WWW II NN     NN DD  DD OO   OO  RR RR',B),
STYPEOUT('W      W  II NN     NN DDDD     OOO    RR  RR',B),
STYPEOUT('          ******************************     ',B),
STYPEOUT('       THIS PROGRAM IS SIMILAR TO THE 'OTHR',B),
STYPEOUT('PROGRAM WHERE YOU INPUT THE MATERIAL STARTING',B),
STYPEOUT('FROM THE EXTERIOR OF THE BUILDING AND WORKING',B),
STYPEOUT('YOUR WAY INWARDS. THE ONLY EXCEPTION IS THAT',B),
STYPEOUT('IN THIS PROGRAM THE SOFTWARE WILL AUTOMATICALLY',B
),STYPEOUT('PRODUCE THE REQUIRED AIRSPACES.',B),
STYPEOUT('       GLASS THICKNESSES DO VARY WITHIN THE ',B),
STYPEOUT('THE WINDOW ITSELF BUT THE DIFFERENCES IN THE',B),
STYPEOUT('THERMAL CHARACTERISTICS ARE MINIMAL. PLEASE ',B),
STYPEOUT('ENSURE THAT THE AIRSPACES ARE CORRECTLY SIZED',B),
STYPEOUT('AS THEY ARE CRUCIAL TO THE OVERALL R-VALUE OF',B),
STYPEOUT('OF THE WINDOW. AIR SPACES SMALLER THAN',B),
STYPEOUT('.1 INCH TEND TO BE TOO SMALL TO REPRESENT',B),
STYPEOUT('AS THE TYPING OF THE COMPONENT NAME WILL',B),
STYPEOUT('OVERFLOW THE SPACE AVAILABLE.',B),
STYPEOUT('       GLASS PANE THICKNESSES ARE NOMALLY',B),
STYPEOUT('EXPRESSED IN UNITS CALLED DIAMONDS',B),
STYPEOUT('A SMALL COMPARISON TABLE IS INCLUDED BELOW',B),
STYPEOUT('            ********              ',B),
STYPEOUT('SINGLE DIAMOND                .1 INCH',B),
STYPEOUT('DOUBLE DIAMOND                .2 INCH',B),
STYPEOUT('TRIPLE DIAMOND                .3 INCH',B),
STYPEOUT(' ',B),
STYPEOUT('       THE PROGRAM WILL NOW BEGIN,IT WILL PROVIDE',B
),STYPEOUT('A DIAGRAM OF THE WINDOW BEING BUILT UP. ',B),
STYPEOUT('KEEP PRESSING THE COMPONENT FUNCTION FOR ',B),
STYPEOUT('SUCCESSIVE GLASS COMPONENTS UNTIL YOU ARE ',B),
STYPEOUT('SATISFIED WITH THE RESULTS.THEN PRESS FINALIZE',B),
,STYPEOUT('THE SOFTWARE PROGRAM WILL COMPENSATE FOR ',B),
STYPEOUT('THE INTERIOR AND EXTERIOR FILM COEFF',B),
STYPEOUT('              **********          ',B),
STYPEOUT('THIS SECTION IS ALSO USED FOR ** DOOR  ** CALCS',B
),
STYPEOUT('WHEN YOU WISH TO INPUT DOORS JUST FOLLOW THE',B),
STYPEOUT('SAME PROCEDURES AS LISTED ABOVE',B),
STYPEOUT('YOU ARE NOW WORKING ON TYPE #',N(TYPEW),B),
   0->COMPG,S(0,0),
   &(WIND=0)(0->WND(TYPEW))(1->WND(TYPEW)),
   2000->XCLUEG(1),$RUNMENU(!GLASWORK);
GLASWORK:(5)(COMPNENT,ERASE,FINALIZG,BACKG,AGAIN);

ERASE:S(0,0),TYPEW-1->TYPEW,2000->XCLUEG(1),
   &(COMPG)(0->THCKW1(SSR),0->TYPEAG(SSR),0->RVLU1(SSR),
   0->RVLWW1(SSR),0->XCLUEG(SSR+1),0->TYPEG(SSR)),
   0->COMPG,$ERASE,S(0,0),2000->XCLUEG(1),1;
COMPNENT:S(0,0),&(TYPEW)1)(&(COMPG=0)($ERASE)),
   COMPG+1->COMPG,
   ASKPANE,ASKSPAC,DRAWGLAS,DRAWAIRG,REASS,S(0,0),1;
FINALIZG:S(0,0),ASKSIZE,ASSIGN,
   CALCULW,$ERASE,SCALE,CHECKWPG,DRAWIND,S(1800,300),
   EXTFLMW,RVALINW,INTFLMW,S(0,0),TRANSFRG,
   STYPEOUT(' ',B),
   STYPEOUT(' ',B),
   STYPEOUT('            ********          ',B),
   STYPEOUT('YOU ARE NOW WORKING ON TYPE',N(TYPEW+1),B),
 STYPEOUT('IF YOU ARE THROUGH WITH THE WINDOW PORTION',B),
STYPEOUT('PRESS EXIT AND YOU WILL RETURN TO A PREVIOUS MENU
',B),S(0,0),1->RET,RET;
TRANSFRG:S(0,0),COMPG3->COMPG1(TYPEW),
   &(COMPG)(XCLUEG(SSR)->XCLUEG1(SSR+COMPG3),0->XCLUEG(SSR
   ),TYPEG(SSR)->TYPEG1(SSR+COMPG3),0->TYPEG(SSR),
   TYPEGLAS(SSR)->TYPEGLA1(SSR+COMPG3),0->TYPEGLAS(SSR),
   TYPEAG(SSR)->TYPEAG1(SSR+COMPG3),0->TYPEAG(SSR),
   THCKW1(SSR)->THICK2(SSR+COMPG3),0->THCKW1(SSR),
   RVLU1(SSR)->RVAL2(SSR+COMPG3),0->RVLU1(SSR),
   RVLWW1(SSR)->RVALU2(SSR+COMPG3),0->RVLWW1(SSR)),
   COMPG2+COMPG3->COMPG3,
   0->COMPG,2000->XCLUEG(1);
ASKSIZE:S(0,0),&(WND(TYPEW))(S(0,400),
   T('WHAT IS THE DOOR HEIGHT'))
   (S(0,400),T('WHAT IS THE WINDOW HEIGHT')),
   $NUMERIC(K)->HEIGH(TYPEW),
   &(WND(TYPEW))(S(0,350),T('WHAT IS THE DOOR WIDTH'))
   (S(0,350),T('WHAT IS THE WINDOW WIDTH')),
   $NUMERIC(K)->WIDTH(TYPEW),
   HEIGH(TYPEW)*WIDTH(TYPEW)->AREAS1,CHAN,S(0,0);
AREAS1:0,
CHAN:$ROUND(AREAS1*1000)/1000->AREAS(TYPEW);
ASKPANE:S(0,0),&(WND(TYPEW))(S(0,50),
   T('WHAT IS THE DOOR THICKNESS'
   ),1.25->RVLU1(COMPG),1->TYPEAG(COMPG))
   (S(0,50),T('WHAT IS THE THICKNESS OF THE PANE'),
**  RVALUE OF WOOD=1.25
   .2->RVLU1(COMPG),1->TYPEAG(COMPG)),
**   RVALUE OF GLASS=.2
   $NUMERIC(K)->THCKW1(COMPG),THCKW1(COMPG)*RVLU1(COMPG)
   ->RVLWW1(COMPG),
   XCLUEG(COMPG)+(THCKW1(COMPG)
   )/FCW->XCLUEG(COMPG+1),COMPG+1->COMPG,S(0,0);
```

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ASKSPAC:
     S(0,0),&(UNB(TYPEU))(S(0,100),
     T('WHAT IS THE SPACING TO THE NEXT DOOR'))(
     S(0,100),
     T('WHAT IS THE SPACING TO THE NEXT WINDOW')),
     NUMERIC(K)->THCKU1(COMPG),
     &(THCKU1(COMPG)=0)()(
     S(0,0),&(UNB(TYPEU)=0)(S(0,150),
     T('IS THE SPACING HERMETICALLY SEALED'),
     NUMERIC(K)->TYPEG(COMPG),&(TYPEG(COMPG))(
     1.24->RULU1(COMPG))(.9->RULU1(COMPG)))(
     .9->RULU1(COMPG)),
     &(THCKU1(COMPG)>.75)(1.16->RULUU1(COMPG))(
     THCKU1(COMPG)*RULU1(COMPG)->RULUU1(COMPG)));
DRAUGLAS:
     S(0,0),S(XCLUEG(COMPG-1),400),#RECT(THCKU1(COMPG-1)/
     FCU,2000),#SHADE(THCKU1(COMPG-1)/FCU,2000,50),S(0,0);
DRAUAIRG:S(0,0),S(0,500),
     &(THCKU1(COMPG)\=0)(S(0,0),
     &(TYPEG(COMPG))(&(0)(S(XCLUEG(COMPG)+((THCKU1(COMPG))/
     FCU)/2-20,SSR*200+700),
     T(N(AIRG(SSR)))))
     (&(0)(S(XCLUEG(COMPG)+((THCKU1(COMPG))/FCU)/2-20,SSR*
     200+550),T(N(SEAL(SSR)))))),S(0,0);
REASS:
     XCLUEG(COMPG)+(THCKU1(COMPG))/FCU->XCLUEG(COMPG+1),
     &(THCKU1(COMPG)=0)(COMPG-1->COMPG);
TOPBOT:S(0,0),
     (XCLUEG(COMPG+1)+XCLUEG(1)+THCKU1(COMPG)/FCU)/2->SHADOU
     ,S(SHADOU-200,400),D(SHADOU+200,400),M(-400,-50),
     #SHADE(400,50,50),
     S(SHADOU-200,2400),D(SHADOU+200,2400),M(-400,0),
     #SHADE(400,50,50),S(0,0);
ASSIGN:&(UNB(TYPEU))(TYPEUIND(6)->TYPEGLAS(TYPEU))(
   &(COMPG=1)(TYPEUIND(1)->TYPEGLAS(TYPEU)),
     &(COMPG=3)(TYPEUIND(2)->TYPEGLAS(TYPEU)),
     &(COMPG=5)(TYPEUIND(3)->TYPEGLAS(TYPEU)),
     &(COMPG)=7)(TYPEUIND(4)->TYPEGLAS(TYPEU)),
     &(COMPG<1)(TYPEUIND(5)->TYPEGLAS(TYPEU)));
TYPEUIND:<6>(SINGLE,DOUBLE,TRIPLE,MULTI,ERROR,DOORSS);
CALCULU:
     0->RUALUTG(TYPEU),
     &(COMPG)(RULUU1(SSR)+RUALUTG(TYPEU)->
     RUALUTG(TYPEU)),RUALUTG(TYPEU)+FILMCU
     ->RUALUTG(TYPEU),
     RUALUTG(TYPEU)->COLLECTU(TYPEU);
DRAUIND:S(0,0),
     COMPG->COMPG2,
     &(COMPG2)(SSR+1->COMPG,&(TYPEAG(SSR))(DRAUGLAS)(
     COMPG-1->COMPG,DRAUAIRG)),COMPG2->COMPG,
     TOPBOT,S(0,0);
EXTFLMU:S(0,0),
     .17*18/(RUALUTG(TYPEU))/FCU->YCRDU,
     S(0,200),D(100,200),M(0,YCRDU),
     #ELLIPSE(100,YCRDU,270,360),M(100,0),
     C(20,0,360),H(1,10,10,10,10);
RUALINU:0->YCRDU,0->INDXU1,S(0,0),
     &+(COMPG)(INDXU1+1->INDXU1,RULUU1(INDXU1)/RUALUTG
     (TYPEU)*18/FCU->YCORD1(INDXU1),YCORD1(INDXU1)+
     YCORDU->YCORDU,U(THCKU1(INDXU1)/FCU,YCORD1
     (INDXU1)),C(20,0,360));
INTFLMU:S(0,0),
     C(20,0,360),
     .68*18/(RUALUTG(TYPEU))/FCU->YCRDU1,
     H(2),M(100,0),#ELLIPSE(100,YCRDU1,180,90),
     M(0,YCRDU1),U(100,0),S(0,0);
CHECKUPG:S(0,0),S(1000,0),T('COMPONENT'),
     S(1000,0),T('COMPONENT'),&(COMPG)(T(N(SSR))),
     S(1000,50),T('RUALU'),&(COMPG)(T(N(RULUU1(SSR)))),
     S(1000,100),T('TYPE AIRSPACE'),&(COMPG)(T(N(TYPEG(SSR))
   )),
     S(1000,150),T('THICKNESS'),&(COMPG)(T(N(THCKU1(SSR)))),
     S(1000,200),T(N(TYPEGLAS(TYPEU))),T('RUAL TOTAL TYPE $'
     ),S(1800,200),T(N(TYPEU)),T('  '),T(N(RUALUTG(TYPEU))),
     S(0,0);

XXXXXXXXXXXXXXXXXXX
TYPEG1:<100>(0);
THICK2:<100>(0);
RUAL2:<100>(0);
RUALU2:<100>(0);
RULUU1:<20>(0);
AIRG:<8>(EE,CC,AA,PP,SS,RR,II,AA);
EE:0;CC:0;AA:0;PP:0;SS:0;RR:0;II:0;
SEAL:<6>(DD,EE,LL,AA,EE,SS);
DD:0;LL:0;
AREAS:<100>(0);
FCU:.01;
AGAIN:S(3300,2800),T('TRY AGAIN'),1;
TYPEU:0;
HEIGH:<10>(0);WIDTH:<10>(0);NUMBER:<13>(0);
>
```

***** Appendix 11 Program Instruction Package (PIP) *****

1. This PIP is an aid to software users who have limited experience with the Grapple System.

2. The following three disks are required:

   Drive 0: Grapple SYSRES disk with $ELLIPSE, $GRID, and $SHADE

   Drive 1: GRIT Disk

   Drive 2: Must contain: C.A.B.D. RVAL, OTH RVAL, FRAME RVAL, MASON RVAL, and WINDOR RVAL.

3. Boot the system (see IM/70 instructions if complications arise) and "GRAPPLE" should appear on the screen. The symbol CR means "hit the carriage return".

4. Enter on the first line: /LIB RVAL 2 CR

   A prompt (>) will appear, then enter: C.A.B.D.; CR

5. The program will begin to compile, as the four subprograms have been amalgamated some terms will be "redefined" but this does not affect the actual running of the program.

6. Once the program is ready to run the first menu option (see page 1) will appear and the user will place the hairline cursor, operated by the thumbwheels to the right of the keyboard, over his choice in the menu and then "enter" (i.e. hit the spacing bar) that item.

7. Whenever the hairline cursor appears; a screen input is required. Whereas, whenever the alpha cursor appears (a small flashing square) a numeric or a word input is required.

8. If you wish to capture a screen presentation, the "COPY" toggle at the top right of the keyboard may be employed.

9. As long as the equipment is "clicking" the minicomputer is functioning. Compiling the program should take approximately 5 minutes.

10. If the compiled version is available (it will be listed as C.A.B.D. GRIT on disc #2); one enters the following information:

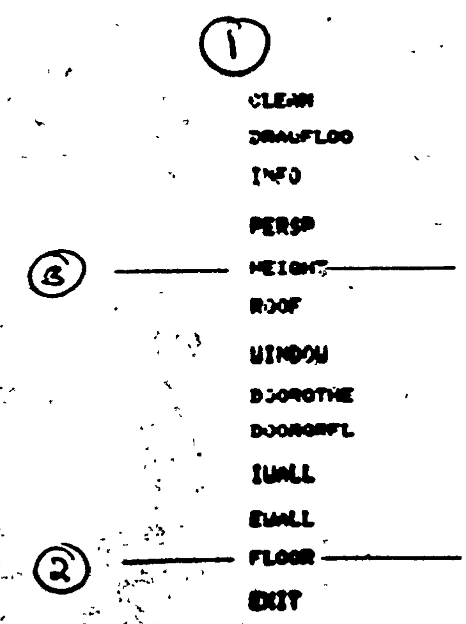
/RES C.A.B.D. 2 CR

when the prompt appears enter

C.A.B.D.; CR

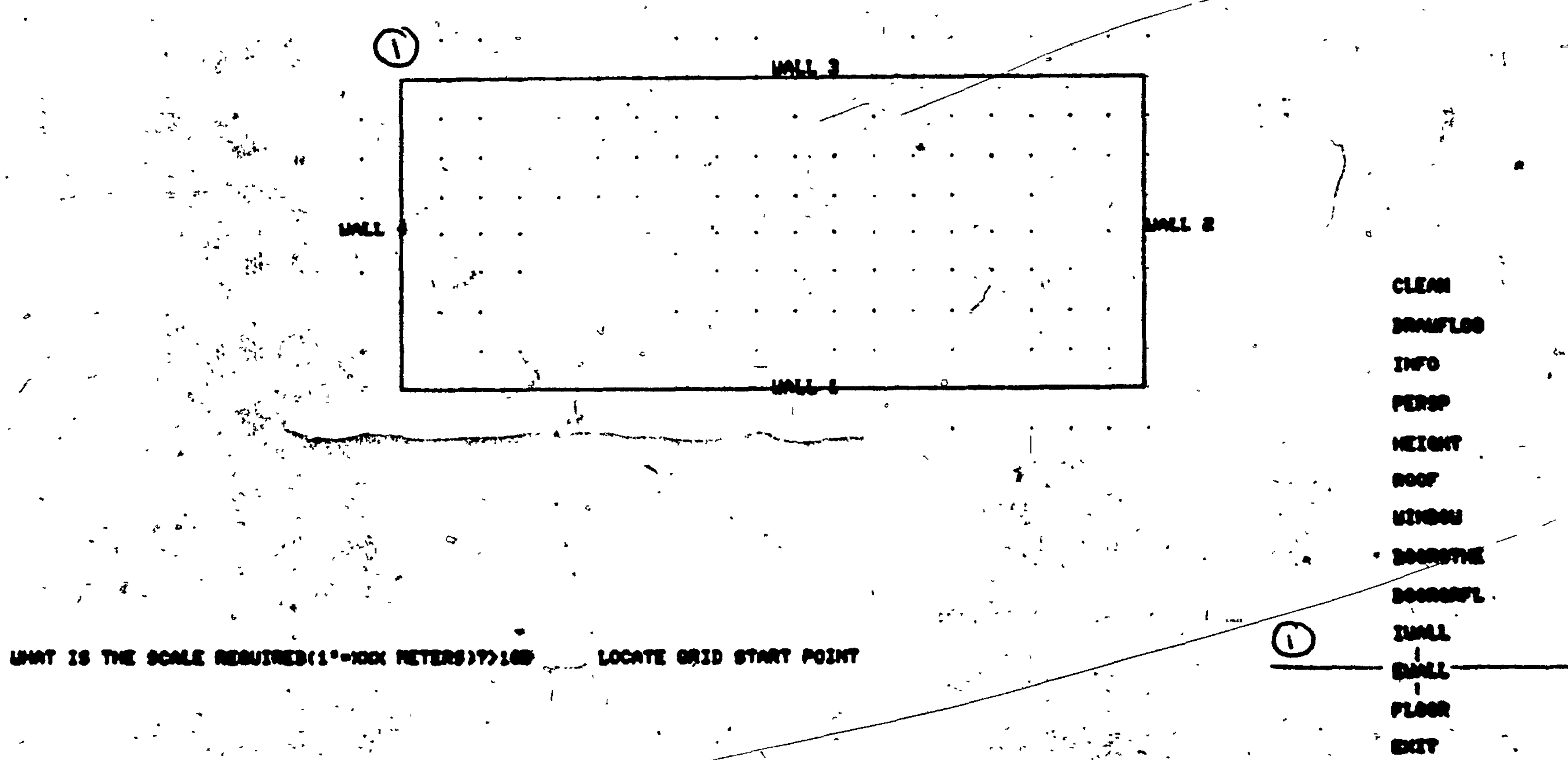
***** PAGE 1 *****

1. This is an example of the menu option at menu level 1.
2. The option"floor"is exercised first and a grid will be requested so a floor layout may be obtained.
3. The option "height" is then entered at which time the actual height in meters will be requested.
4. Go to page 2.



***** PAGE 2 *****

1. The actual floor plan is drawn to scale and the exterior wall component may now be entered.
2. Go to page 3.



***** PAGE 3 *****

1. At this level the menu options for the various wall types are displayed.
2. These are:

   FRAME: For frame wall construction
   MASON: For masonry walls
   OTH: Is a free-design package

3. In this instance the menu option OTH will be input.
4. Go to page 4.

(1) BACK
SHORTCUT
RECALLU
MASON
FRAME
(3) OTH
EXIT

IN THIS MENU OPTION YOU CAN BUILD UP THE WALL COMPONENTS BY YOURSELF. THIS IS DONE SIMPLY BY STARTING WITH THE OUTSIDE COMPONENTS OF THE WALL AND BY WORKING INWARDS. A MENU OPTION WILL APPEAR AND YOU CAN SELECT ONE OF TWO ALTERNATIVES
THIS IS DONE AS WITH OTHER MENU CHOICES WITH THE EXCEPTION THAT AS YOU INPUT A YOUR CHOICE A SMALL DRAWING WILL BE MADE TO GIVE YOU AN IDEA OF WHAT YOUR WALL WILL RESEMBLE. THE MENU WILL NOW APPEAR.
WHEN YOU ARE THROUGH WITH COMPONENTS JUST PRESS THE FINALIZE OPTION
THE WALL COMPONENTS ARE SPACED BY 50 SCREEN UNITS SO AS NOT TO CONFUSE THE DIAGRAM.AIRSPACES WILL BE INDICATED IN AN OBVIOUS FASHION
YOU ARE NOW WORKING ON TYPE 01

(1)

***** PAGE 4 *****

1. After this menu option OTH is called the typing to the left of the screen will appear. These are instructions for the user to indicate the sequencing of the sub-program.
2. In the case of the OTH program the user must always commence and end with the "COMPONENT" function.
3. Go to page 5.

DATA.0

FINALIZE

RECALL

(2) COMPONENT

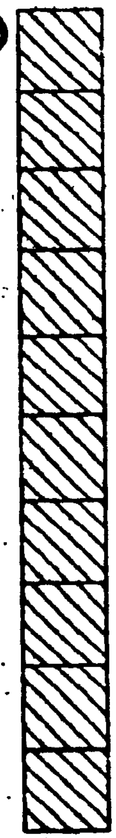
AIR.SPAC

EXIT

***** PAGE 5 *****

IN THIS MENU OPTION YOU CAN BUILD UP THE
WALL COMPONENTS BY YOURSELF. THIS IS DONE
SIMPLY BY STARTING WITH THE OUTSIDE
COMPONENTS OF THE WALL AND BY WORKING
INWARDS. A MENU OPTION WILL APPEAR AND YOU
CAN SELECT ONE OF TWO ALTERNATIVES
THIS IS DONE AS WITH OTHER MENU CHOICES
WITH THE EXCEPTION THAT AS YOU INPUT A
YOUR CHOICE A SMALL DRAWING WILL BE MADE TO
GIVE YOU AN IDEA OF WHAT YOUR WALL WILL
RESEMBLE. THE MENU WILL NOW APPEAR.
WHEN YOU ARE THROUGH WITH COMPONENTS
JUST PRESS THE FINALIZE OPTION
THE WALL COMPONENTS ARE SPACED BY
50 SCREEN UNITS SO AS NOT TO CONFUSE
THE DIAGRAM.AIRSPACES WILL BE INDICATED
IN AN OBVIOUS FASHION
YOU ARE NOW WORKING ON TYPE 01

(2)



1. Once the option "COMPONENT" is entered the three questions to the left of the screen will appear.
2. These are answered one at a time and when this is completed, a representation of the wall component will be drawn.
3. At this point the user has the option of entering another component or an AIRSPACE;this is dependant on the type of wall he is dealing with.In this example AIRSPACE was entered.
4. Go to page 6.

(1)

WHAT IS THE MATERIAL USED>ASBESTOS
WHAT IS THE THICKNESS OF THE MATL>2
WHAT IS THE R-VALUE OF THE MATL>2

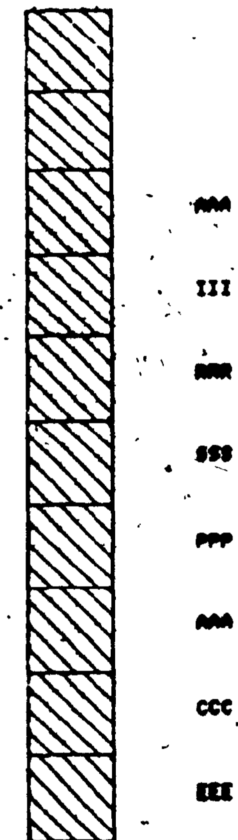
DATA.0
FINALIZE
RECALL
COMPONENT
(3) AIR.SPAC
EXIT

***** PAGE 6 *****

IN THIS MENU OPTION YOU CAN BUILD UP THE WALL COMPONENTS BY YOURSELF. THIS IS DONE SIMPLY BY STARTING WITH THE OUTSIDE COMPONENTS OF THE WALL AND BY WORKING INWARDS. A MENU OPTION WILL APPEAR AND YOU CAN SELECT ONE OF TWO ALTERNATIVES
THIS IS DONE AS WITH OTHER MENU CHOICES WITH THE EXCEPTION THAT AS YOU INPUT A YOUR CHOICE A SMALL DRAWING WILL BE MADE TO GIVE YOU AN IDEA OF WHAT YOUR WALL WILL RESEMBLE. THE MENU WILL NOW APPEAR.
WHEN YOU ARE THROUGH WITH COMPONENTS JUST PRESS THE FINALIZE OPTION
THE WALL COMPONENTS ARE SPACED BY 50 SCREEN UNITS SO AS NOT TO CONFUSE THE DIAGRAM.AIRSPACES WILL BE INDICATED IN AN OBVIOUS FASHION
YOU ARE NOW WORKING ON TYPE 81

WHAT IS THE MATERIAL USED>ASBESTOS
WHAT IS THE THICKNESS OF THE MATL>2
WHAT IS THE R-VALUE OF THE MATL>2

(1) WHAT IS THE THICKNESS OF THE AIR SPACE>2



(2)

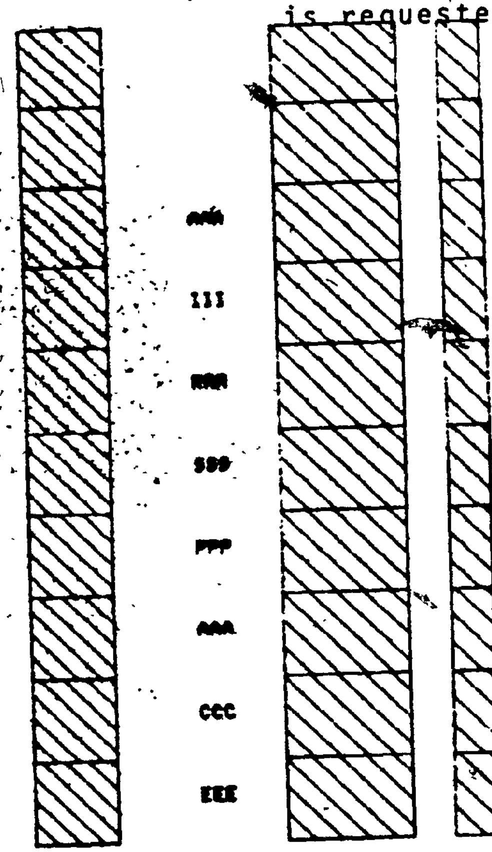
1. Entering the option AIRSPACE will allow the user to input the thickness of the airspace in the wall structure. This can either be a wall cavity or a construction fault.
2. Once this is entered a representation of the airspace is drawn on the screen.
3. Now the other wall components may be entered. This is continued until the user believes the wall is to his satisfaction.
4. Go to page 7.

BATH.0
FINALIZE
RECALL
COMPONENT (3)
AIR.SPAC
EXIT

***** PAGE 7 *****

1. Once the wall is complete "FINALIZE" is input and the temperature scale is requested.
2. The temperature limits are set at 72°F and -20°F but these may be altered.
3. The temperature gradient line can now be drawn.
4. Go to page 8.

IN THIS MENU OPTION YOU CAN BUILD UP THE
WALL COMPONENTS BY YOURSELF. THIS IS DONE
SIMPLY BY STARTING WITH THE OUTSIDE
COMPONENTS OF THE WALL AND BY WORKING
INWARDS. A MENU OPTION WILL APPEAR AND YOU
CAN SELECT ONE OF TWO ALTERNATIVES
THIS IS DONE AS WITH OTHER MENU CHOICES
WITH THE EXCEPTION THAT AS YOU INPUT A
YOUR CHOICE A SMALL DRAWING WILL BE MADE TO
GIVE YOU AN IDEA OF WHAT YOUR WALL WILL
RESEMBLE. THE MENU WILL NOW APPEAR.
WHEN YOU ARE THROUGH WITH COMPONENTS
JUST PRESS THE FINALIZE OPTION
THE WALL COMPONENTS ARE SPACED BY
50 SCREEN UNITS SO AS NOT TO CONFUSE
THE DIAGRAM.AIRSPACES WILL BE INDICATED
IN AN OBVIOUS FASHION
YOU ARE NOW WORKING ON TYPE 81



WHAT IS THE MATERIAL USED>ASBESTOS
WHAT IS THE THICKNESS OF THE MATL>2
WHAT IS THE R-VALUE OF THE MATL>2

WHAT IS THE THICKNESS OF THE AIR SPACE>2

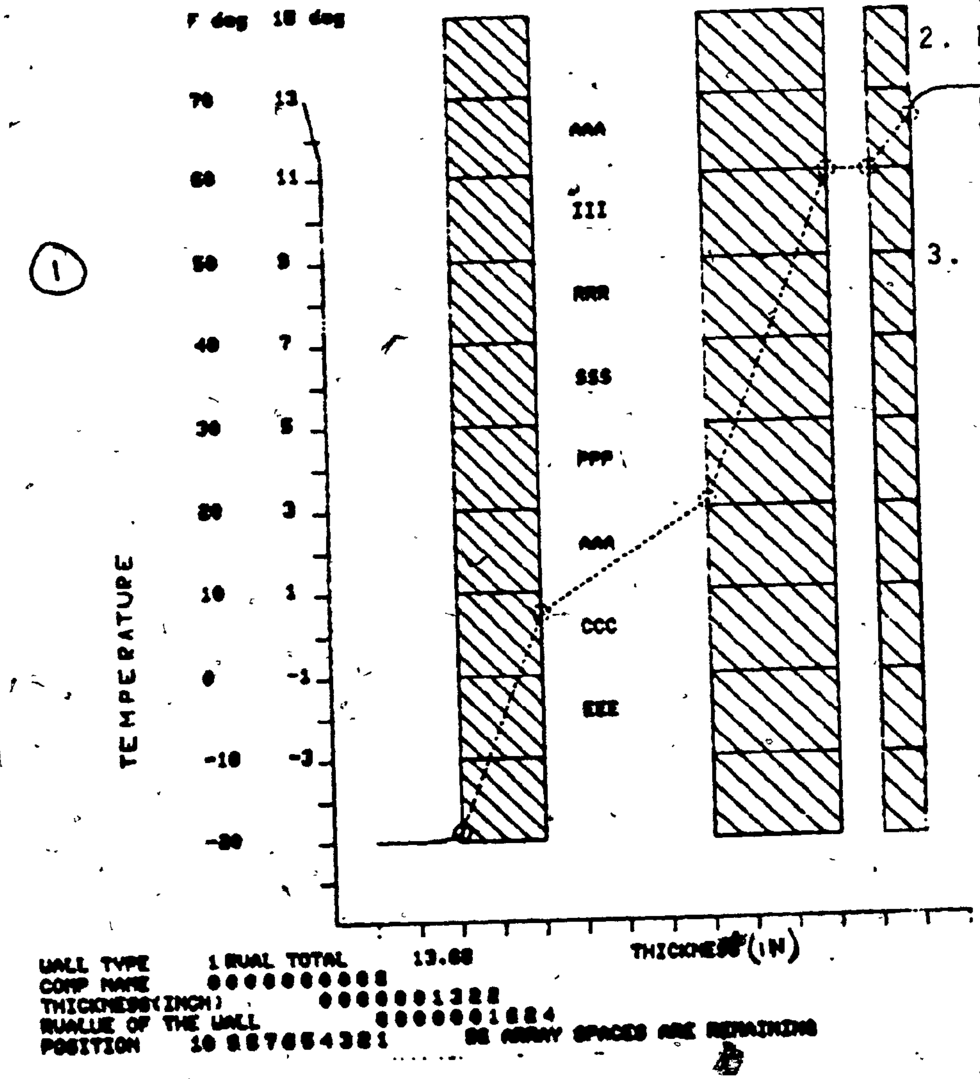
(2)
YOU MUST CHOOSE DESIGN TEMPERATURES YOU WISH TO
WORK WITH. THEY ARE PRESENTLY SET AT
-20 deg F (-15 C) AND 72 deg F (18 C)
DO YOU WISH TO CHANGE THESE (Y/N)?

(1)
DATA.S
FINALIZE
RECALL
CMPONENT
AIR.SPAC
EXIT

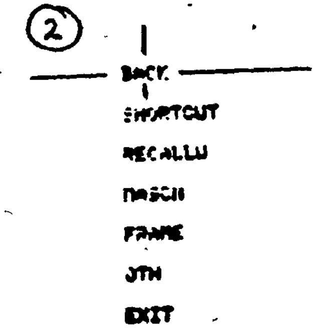
***** PAGE 8 *****

1. At this point the gradient line is drawn and various other information is displayed. The user may now return to the C.A.B.D. program by input of "BACK".
2. He must keep in mind that he must now input data regarding the windows that are required in that particular wall of the building.
3. Go to page 9.

(1)



(2)



WINDOR

THIS PROGRAM IS SIMILAR TO THE 'OTH' PROGRAM WHERE YOU INPUT THE MATERIAL STARTING FROM THE EXTERIOR OF THE BUILDING AND WORKING YOUR WAY INWARDS. THE ONLY EXCEPTION IS THAT IN THIS PROGRAM THE SOFTWARE WILL AUTOMATICALLY PRODUCE THE REQUIRED AIRSPACES.

GLASS THICKNESSES DO VARY WITHIN THE THE WINDOW ITSELF BUT THE DIFFERENCES IN THE THERMAL CHARACTERISTICS ARE MINIMAL. PLEASE ENSURE THAT THE AIRSPACES ARE CORRECTLY SIZED AS THEY ARE CRUCIAL TO THE OVERALL R-VALUE OF OF THE WINDOW. AIR SPACES SMALLER THAN .1 INCH TEND TO BE TOO SMALL TO REPRESENT AS THE TYPING OF THE COMPONENT NAME WILL OVERFLOW THE SPACE AVAILABLE.

GLASS PANE THICKNESSES ARE NORMALLY EXPRESSED IN UNITS CALLED DIAMONDS. A SMALL COMPARISON TABLE IS INCLUDED BELOW

SINGLE DIAMOND	.1 INCH
DOUBLE DIAMOND	.2 INCH
TRIPLE DIAMOND	.3 INCH

THE PROGRAM WILL NOW BEGIN. IT WILL PROVIDE A DIAGRAM OF THE WINDOW BEING BUILT UP. KEEP PRESSING THE COMPONENT FUNCTION FOR SUCCESSIVE GLASS COMPONENTS UNTIL YOU ARE SATISFIED WITH THE RESULTS. THEN PRESS FINALIZE. THE SOFTWARE PROGRAM WILL COMPENSATE FOR THE INTERIOR AND EXTERIOR FILM COEFF

THIS SECTION IS ALSO USED FOR ** DOOR ** CALCS WHEN YOU WISH TO INPUT DOORS JUST FOLLOW THE SAME PROCEDURES AS LISTED ABOVE

YOU ARE NOW WORKING ON TYPE $6

***** PAGE 9 *****

1. After "WINDOW" has been entered the "WINDOR" sub-program is called and the instructions to the left of the screen appear.
2. This program is similar to OTH with the exception that there is no requirement to enter the airspaces as this is done automatically by the computer.
3. The ERASE function may be exercised if a mistake is made on the input of data.
4. Go to page 10.

BACKG
FINALIZE
ERASE
COMPNENT
EXIT

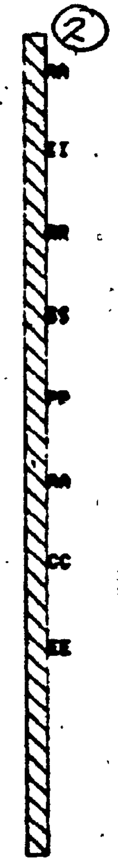
***** PAGE 10 *****

1. After entering component the three questions to the left of the screen will appear.
2. The representation of the glass component and the required airspace "SEALED" or "AIRSPACE" will be drawn. This process is continued until the window representation is as required.
3. The user may now exercise the "FINALIZE" option. The temperature scale required will be requested and the resulting temperature gradient curve will be drawn.
4. Go to page 11.

(1)

IS THE SPACING HERMETICALLY SEALED (Y/N)??1
WHAT IS THE SPACING TO THE NEXT PANE>.5
WHAT IS THE THICKNESS OF THE PANE>.5

(2)

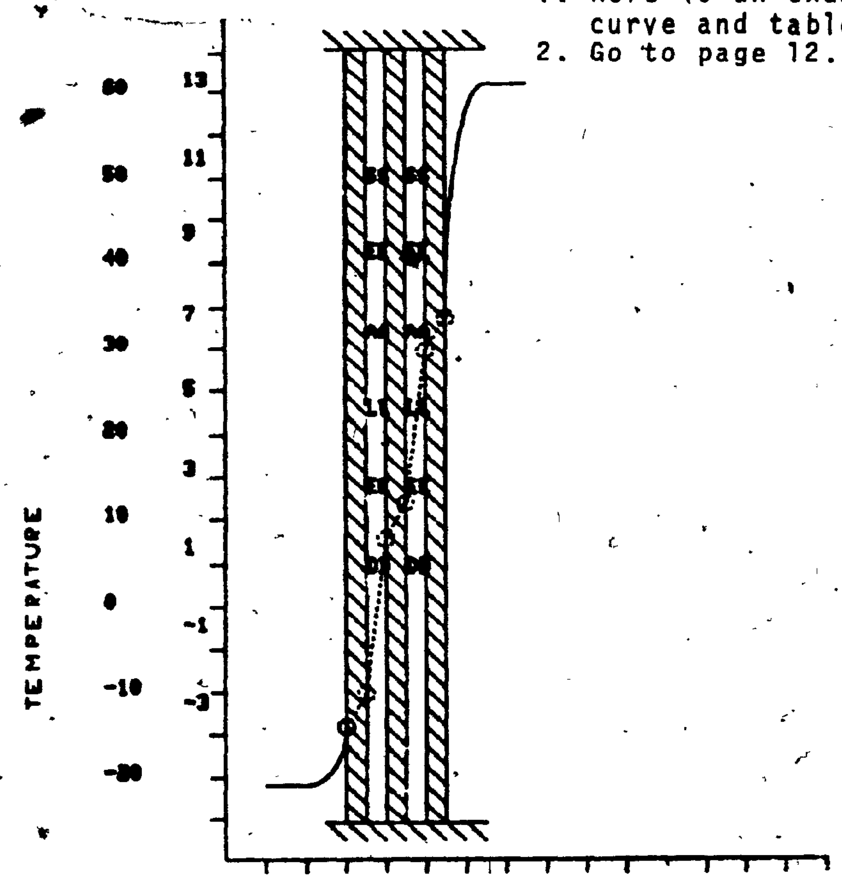


(3)

BACKG
FINALIZE
ERASE
COMPONENT
EXIT

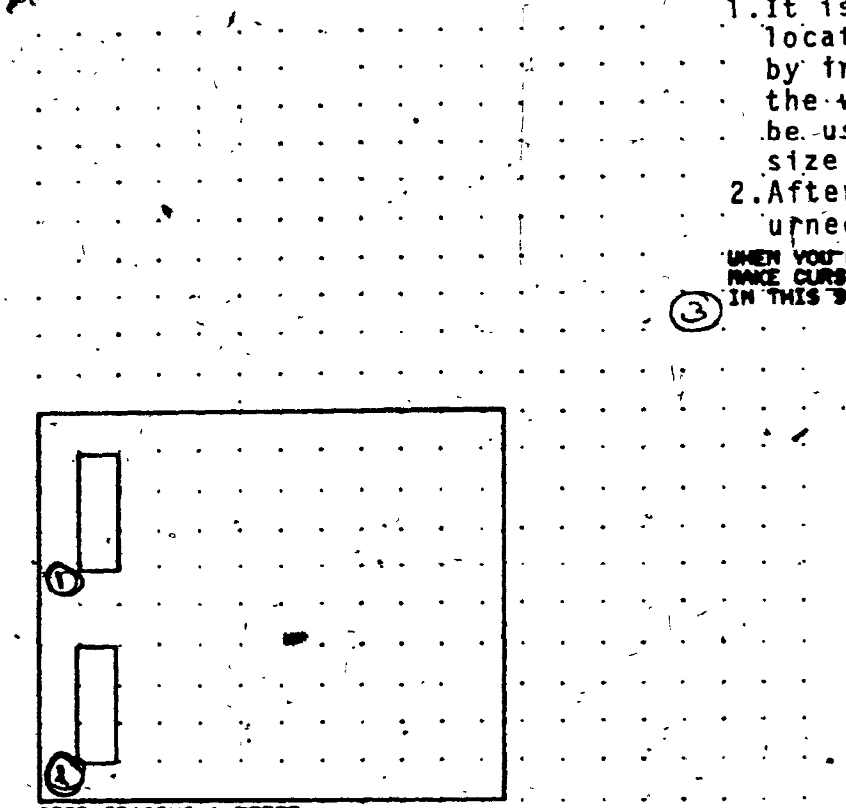
***** PAGE 11 *****

1. Here is an example of the resulting curve and table.
2. Go to page 12.



TRIPLE RVAL TOTAL TYPE 01
THICKNESS .5 .5 .5 .5 .5
TYPE AIRSPACE 00000
RVALU .1 .45 .1 .45 .1
COMPONENT 54321

1. It is now time to enter the actual location of the windows. This is done by indicating the lower left corner of the window with the cursor. The grid can be used to give an approximation of the size.
2. After this is completed the user is returned to the menu level 2.
3. Go to page 13.



GRID SPACING=1 METER

PLEASE INDICATE BOTTOM LEFT CORNER

PLEASE LOCATE GRID START POINT

(1)

YOU ARE NOW WORKING ON TYPE 8 1

***** PAGE 13 *****

1. Having completed on wall of the building the user may now start on the other walls.
2. In this case wall#2 was input and the user selected the "FRAME" option.
3. At this point the FRAME menu appears.
4. In this sub-program the user must input all the options listed with the exception of TESTFUNC(this is explained in Appendix 12).
5. As each of these options are used a display of various building materials appear and the user then makes his choice and inputs the actual thickness of the component.
6. If the user is not satisfied with the choice of materials given he may exercise the OTHR option and a list of common building products will appear. The user must then input the choice of product, it's thickness, and it's R-Value.
7. If a building component is not existing, the option NIL is to be exercised.
8. Go to page 14.

(2)

```
BACKC
TESTFUNC
EXTFIN
PAPER
SHEATH
INSUL
AIRSPACE
PLASTER
EXIT
```

EXTERIOR FINISH	RVAL/IN
ASBESTOS-CEMENT BRD	0.25
GYPSUM PLASTER BRD	0.9
PLYWOOD	1.25
STUCCO	0.2
WOOD FIBER BRD	0.78
WOOD,HARDWOOD FINISH	0.88
BUILDING PAPER	
PERMEABLE FELT	0.84
MOPPED FELT	0.24
POLYETHELYNE	0.00
SHEATHING COMPONENTS	
HARDWOOD	0.91
SOFTWOOD	1.25
PLYWOOD	1.25
INSULATION	
CELLULAR GLASS	2.44
CORKBOARD	3.57
COTTON FIBER	3.84
GLASSFIBER	3.84
MINERAL WOOL	3.12
POLYURETHANE(EXPANDED)	5.88
POLYSTYRENE(EXPANDED)	3.85
WOOD FIBERBOARD	2.38
WOOD SHREADED	1.67
PLASTERING MATERIALS	
CEMENT PLASTER(SAND AGG)	0.20
GYPSUM PLASTER(LIGHT AGG)	0.64
(SAND AGG)	0.18
(PERLITE AGG)	0.67
SAND AGG ON METAL LATH	0.13
SAND AGG ON WOOD LATH	0.38
VERMICULATE AGG	0.57

WHAT IS THE NAME OF THE MATERIAL TO BE USED>

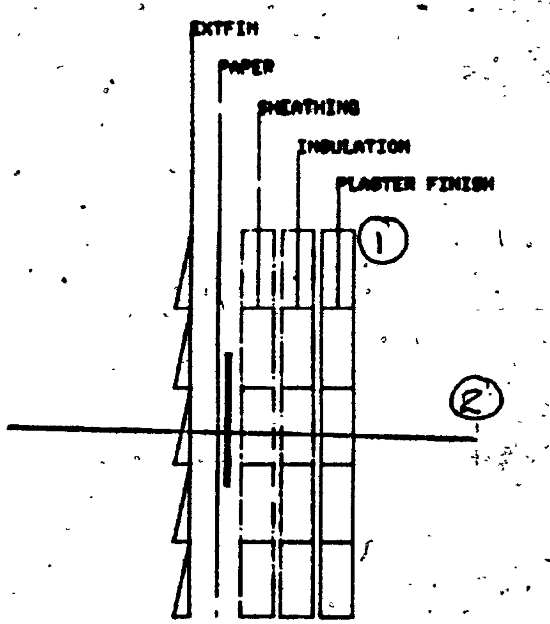
OTHR

***** PAGE 14 *****

1. This is the example of the list of products that appears when the option OTHR is used.
2. If airspaces are existant in the wall structure this option can be entered at any time.
3. Go to page 15.

***** PAGE 15 *****

1. When AIRSPACE is called the picture to the left of the screen will appear.
2. It is the user's responsibility to enter the actual location of the airspaces with the hairline cursor.
3. Once all of the menu componentsare completed the finalization of the wall will take place.
4. Go to page 16.

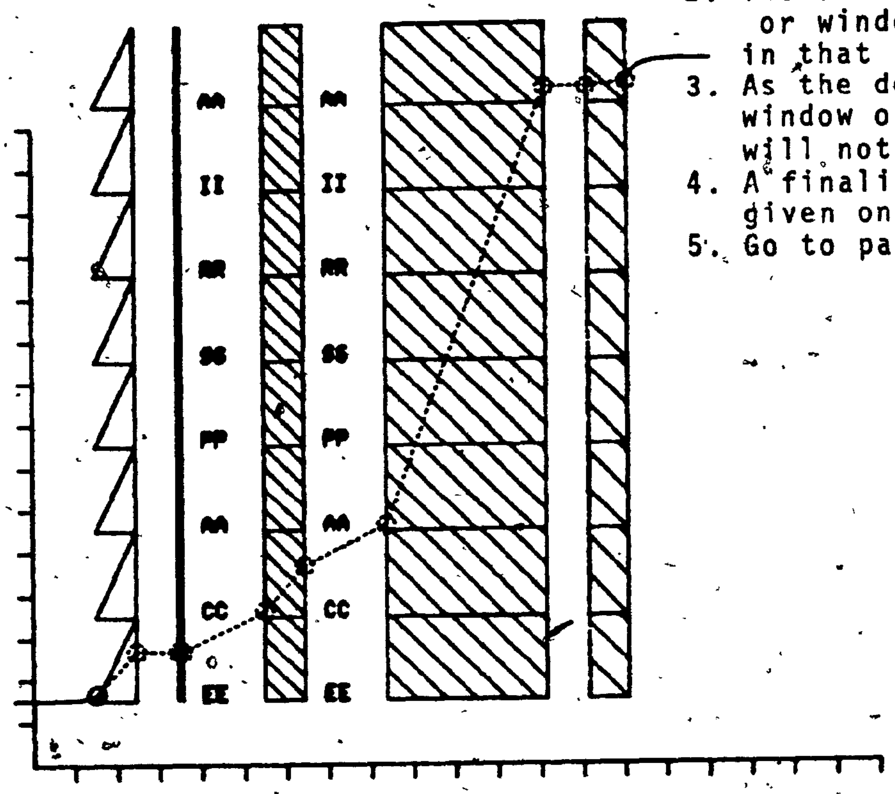


LOCATE THE AIRSPACE ON THE DIAGRAM

BACKC
TESTFUNC
EXTFIN
PAPER
SHEATH
INSUL
AIRSPACE
PLASTER
EXIT

1. Here is an example of the resulting curve and the summation table.
2. The user may now enter one of the door or window components that are existing in that particular wall.
3. As the door option is similar to the window option previously explained, this will not be discussed.
4. A finalization of the door option is given on the next page.
5. Go to page 17.

(1)




```
FOR WALL TYPE 8 1
R-VALUE FOR WALLTOTAL   18.38

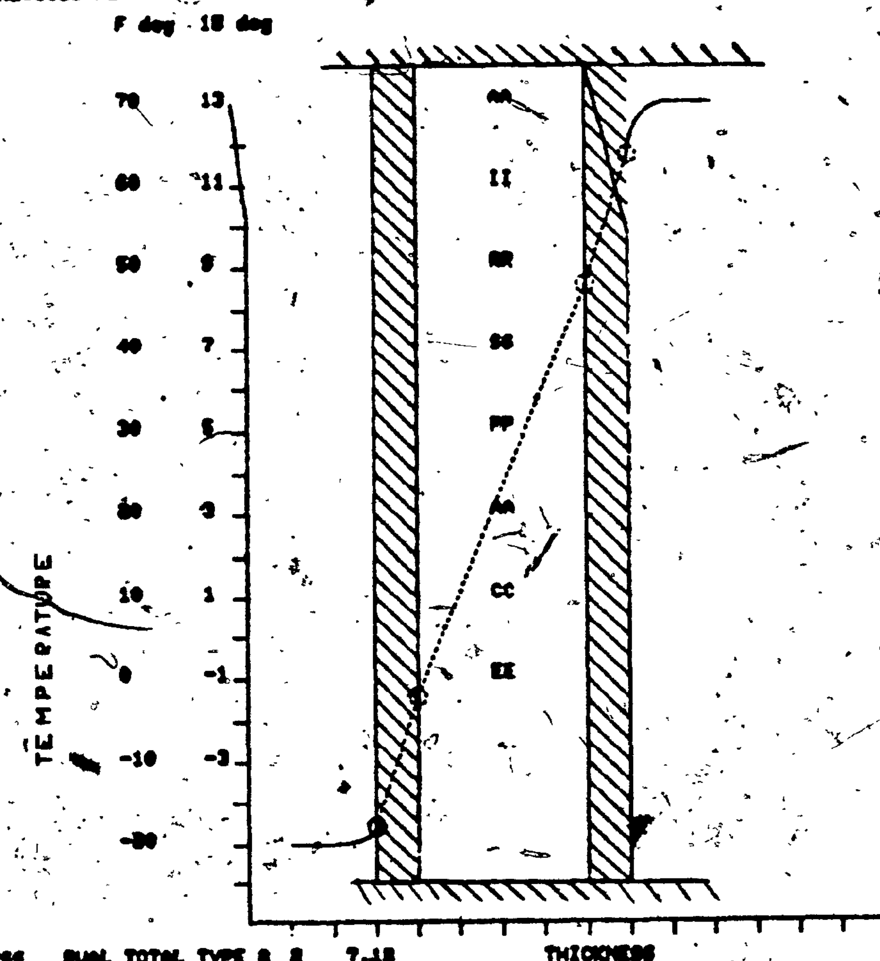
LOCAT1    0 0 0 0 0 0 0 0 9
LOCAT    0 0 0 0 0 0 0 0 0
FLCHECK      1 0 1 0 1 0 1 1 1
WALL LOCAT          EXTFIN     0 PAPER    AIRSP    SHEATH    AIRSP    INSUL    0 PLASTER
THICKNESS        1 0 .1 1 1 1 4 0 1
RVALU OF COMP NT           1.25    0 0 1.16    1.25   1.16   12.48    0 .13
CHOICE OF MATL          WOOD   0 POLETHLN    AIRSP   SOFTWOOD    AIRSP    GLASWOL    0 GYPRLATH
WALL POSITION         8 0 7 6 5 4 3 0 1
POSITION        9 8 7 6 5 4 3 2 1
```

(2)

```
BACKC
TESTFUNC
EXTFIN
PAPER
SHEATH
INSUL
AIRSPACE
PLASTER
EXIT
```

YOU ARE NOW WORKING ON TYPE3
IF YOU ARE THROUGH WITH THE WINDOW PORTION
PRESS EXIT AND YOU WILL RETURN TO THE PREVIOUS MEN

***** PAGE 17 *****
1. Go to page 18.



DOORSS RVAL TOTAL TYPE 8 2
THICKNESS 1 4 1
TYPE AIRSPACE 0 1 0
RVALU 1.25 4 1.25
COMPONENT 3 2 1

BACKG
GLASSW
DOORS
EXIT

YOU ARE NOW WORKING ON TYPE 8 1

[illegible]

TESTFUNC

FACEING

STRUCT

INSUL

AIRSPACE

PLASTR

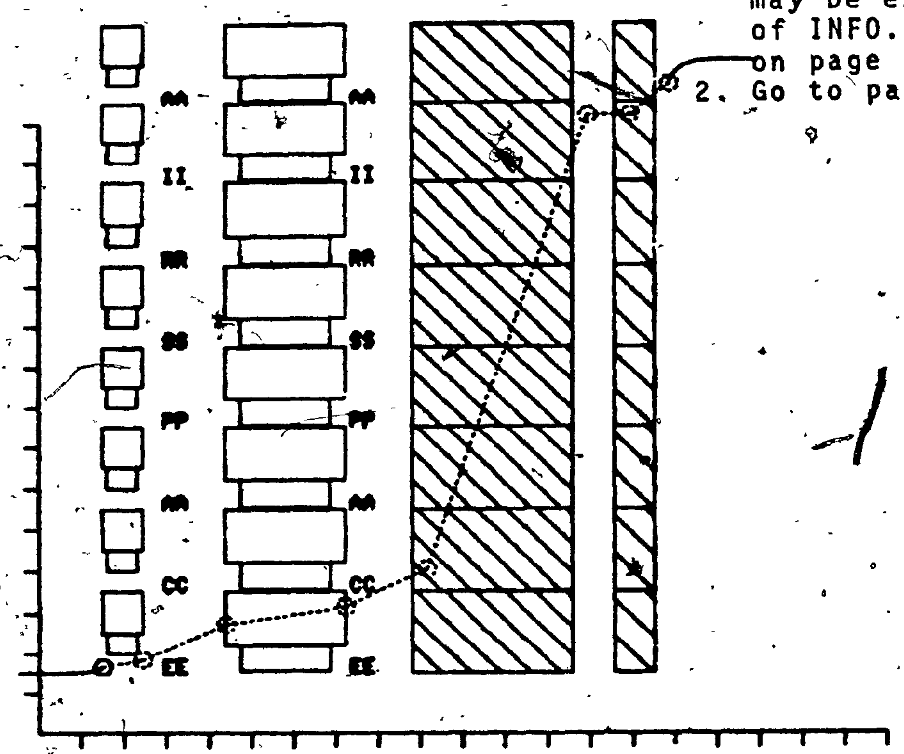
EXIT

***** PAGE 18 *****

1. The user has now input wall#3 and he has chosen the MASON option for this wall.
2. This sub-program is similar to the FRAME option so it will not be explained in depth.
3. The menu choice is similar to FRAME but the choice of building products is somewhat different, as is the cross-sectional view for AIRSPACE.
4. The resulting temperature gradient curve is shown on page 19.
5. Go to page 19.

***** PAGE 19 *****

1. After all four walls have been defined and all the windows have been input, information requarding the heat loss may be extracted. This is done by use of INFO.Once this is called the table on page 20 will appear.
2. Go to page 20.



(1)

FOR WALL TYPE 8 1
R-VALUE FOR WALLTOTAL 16.81

LOCTH1 0000007
LOCTH 0000000
FLCHCKR 1010111
WALL LOCTH FACING AIRSP STRUCT AIRSP INSM 8PLASTR
THICKNESS 1131401
RVALU OF COMP NT .8 1.46 1 12.46 8.8
CHOICE OF MATL COMMONBR AIRSP C.BLOK.C AIRSP GLASWOL 8GYPROC
WALL POSITION 7654301
POSITION 7654321

(2)

BACKC
TESTFUNC
FACEING
STRUCT
INSM
AIRSPACE
PLASTR
EXIT

***** PAGE 20 *****

1. Pertanent data regarding the heat losses of the walls, windows, and doors are provided. Overall heat loss and glazing percentages are also given.
2. Go to page 21.

```
                                      METER SQUARE
FLOOR AREA EQUALS           289.081

WALL   1 AREA=   229.046   HEAT LOSS   23100.3   8.84
WALL   2 AREA=   281.369   HEAT LOSS   22908.3   7.84
WALL   3 AREA=   284.865   HEAT LOSS   11858.7   16.91
WALL   4 AREA=   178.517   HEAT LOSS   9197.1   16.73

TOTAL  67874.5   PERCENTAGE GLAZING       9.86432

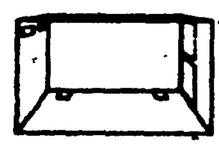
WINDOW    1 IN WALL     1  AREA=    0 HEAT LOSS    0 2.06
WINDOW    2 IN WALL     1  AREA=    6 HEAT LOSS    2810.44   0
WINDOW    3 IN WALL     1  AREA=    6 HEAT LOSS    2810.44   .95
WINDOW    4 IN WALL     1  AREA=    5.99999   HEAT LOSS   2810.44   .95
WINDOW    5 IN WALL     1  AREA=    5.99999   HEAT LOSS   2810.44   2.1
WINDOW    6 IN WALL     2  AREA=    3 HEAT LOSS              .95
WINDOW    7 IN WALL     2  AREA=    3 HEAT LOSS              0
WINDOW    8 IN WALL     4  AREA=    25 HEAT LOSS   23471.1   0
WINDOW    9 IN WALL     4  AREA=    25 HEAT LOSS   23471.1   0
TOTAL  57383.9
DOOR   1 IN WALL    3  AREA=   3.75  HEAT LOSS   2816.53   2.05
DOOR   2 IN WALL    3  AREA=   3.74999   HEAT LOSS   2816.53   0
TOTAL  5633.06   PERCENTAGE DOORS      .906029
```

BTU/HR RVALUE

CLEAN
DRAWFLOO
INFO
PERSP
HEIGHT
ROOF
WINDOW
DOOROTHE
DOOROPFL
IWALL
EWALL
FLOOR
EXIT

***** PAGE 21 *****

1. On this page the perspective package menu option is shown. The following pages of this appendix are dedicated to the 3-D packages. These pages show the flexibility fo the viewer's location with respect to the model building.
2. The viewer's distance from the object, the horizontal viewing angle, and the vertical viewing angle may be altered by input of DISTANCE,BETA,or ALPHA.
3. Parallel or perspective drawings may be diplayed if required.
4. CONTINUE.



(1)

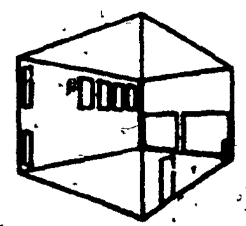
BACK

(3) PERSPECT
PARALLEL

(2) DISTANCE
BETA
ALPHA

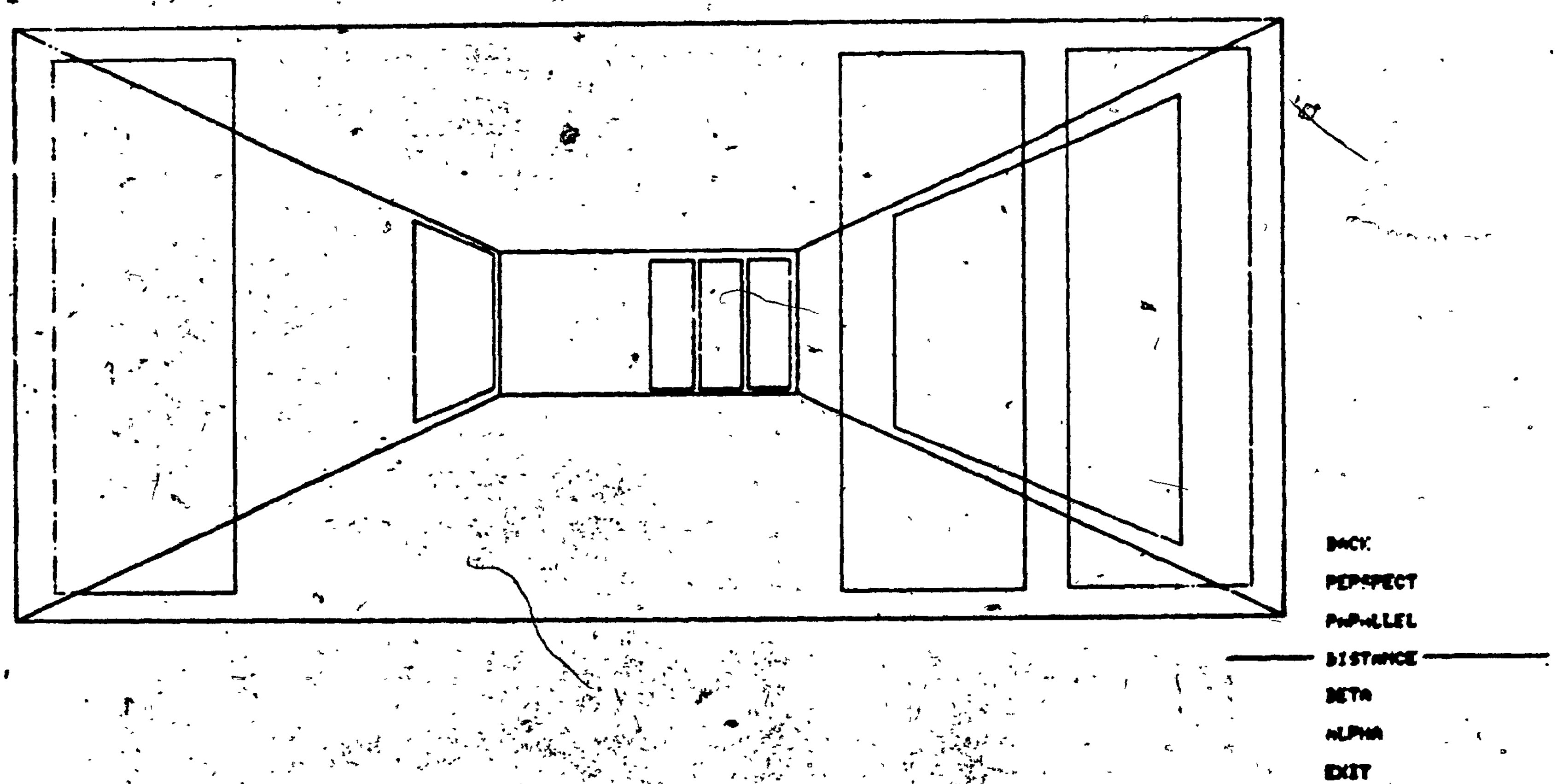
EXIT

***** PAGE 22 *****

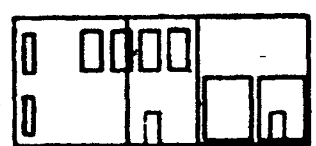


BACK
PERSPECT
PARALLEL
DISTANCE
BETA
ALPHA
EXIT

***** PAGE 23 *****



***** PAGE 24 *****

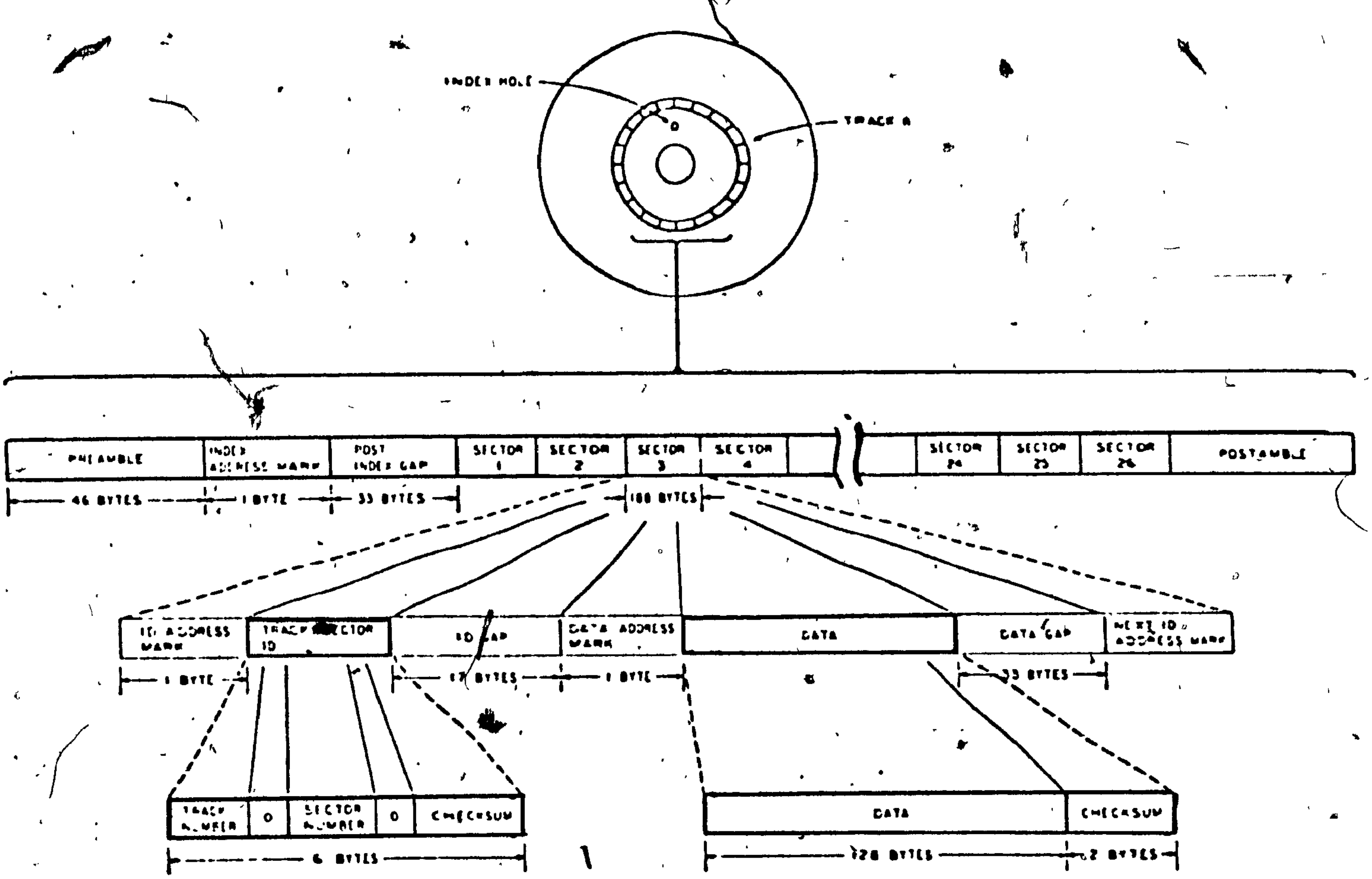


BACK
PERSPECT
PARALLEL
DISTANCE
BETA
ALPHA
EXIT

Appendix 12 | **Additional Program Features**

Array Overflow	As the master data bank contains 100 elements the array overflow will indicate how many spaces exist after each entry. Error 76 will appear if the arrays are overloaded.
Change	In FRAME this function will delete the previous entry and superimpose the new values in its place; it is called to action by hitting the same wall component a second time; this is only possible in FRAME and MASONRY.
Checkup	CHECKUP(G) can be used in TESTFUNC or in the interactive mode to view what exists in the master array.
Data Search	(DATA.GEN,DATA.O,DATA.W) are functions used to recall existing inputs in storage. DATA.GEN will output all information while the sub data storage will supply those of their subgroup. This is required when the RECALL function is to be employed.
Erase	ERASE is a menu option available to the user who wishes to delete a series of entries prior to finalization owing to an input error. It is available in all programs.
Grid	GRID indicators are available in C.A.B.D. to properly scale diagrams for both walls and floor layout.
Information	INFO provides a table with heat losses, window, doors and wall areas, percentage glazing, door surface area and corresponding R-Values.
Interior/Exterior	The ELLIPSE function is used to simulate the surface air films on interior and exterior walls.
Master Array	All entries are placed in a user array and only when the composition is finalized is the information transfered to the master array (100 elements).
Metric	METRIC allows the user to transfer to metric inputs or metric displays. All filing and base software is done in Imperial units as pertinent data is not available in Metric units.
Picture	The actual wall cross-sections are laid out so as not to confuse the user with a complex diagram. All wall components are separated by 50 screen units to accomplish this task. This does not affect the final heat gradient line.
Recalling	RECALL allows the operator to retrieve any previously stored information. This can first be done by calling DATA.GEN, DATA.O, DATA.FR, DATA.W., then calling RECALL.
Scaling	SCALE is an automatic function that allows the user to adjust the scale on the output temperature gradient curves depending on requirements for design temperatures. It is available in all functions.
Software Layout	Program was organized so as to clearly present the sequence of work. All user functions are set out from the body of the typing and generally are located in a position on the program that is corresponds to their position in the program sequenced. All array and variable initializations are located at the bottom of the program.

Technique	IBM 2315 Cartridge Disk	IBM 3740 Floppy	Digital Cassette	Audio Cassette	Units
Data Capacity	48.	3.0	6.0	0.84	Million bits (unformatted)
Average or Typical Access Time	.035	.45	20	120*	Seconds (* = manually controlled)
Data Transfer Rate	2500	250	10.	0.3	k bps
Price of Commercial Package Drive + Power + Controller	$8000	$1500	$1000**	$100	**Note that personal computing digital cassettes can be much cheaper than commercial drives
System Cost per Unit Data Rate	.32	.6	10	33.3	cents per bps
System Cost per Unit Storage	.016	.05'	016	.012	cents per bit stored
Media Cost	$100	$8.	$4.	$4.	(unit quantity prices)
Storage Cost	1.7	2.2	0.55	3.9	cents/kilobyte of media



The IBM 3740 floppy disk format. The format is "soft" sectored, meaning that data written in the track controls the organization of information on each track. Each of the 77 data tracks on the floppy disk contains data, address and control fields grouped together to form "sectors." Each sector contains a sequence of fields, identical to those of the other sectors, which are further broken down into individual data bytes. One complete track is shown in this illustration. The index hole provides the only hardware synchronization in this format.

Appendix 12 Examples: Documentation Errors

Typical Errors in Grapple Reference Manual

Page 7 to 14 — States that for the Grapple Editor first two characters are significant and the shortest form is underlined, this is not true in all the cases.

Page 9 — .String1..String2[.[n[m]]] could be simplified to .String1.String2. 0 0

Page 10 — FILE: no reference is made to booting the system with /QUIT. Without this the filing will not be completed.

Page 9 to 12 — No examples are given for the Grapple Editor, this should be revised to read:

CHANGE letter or string ex: ._____.______.0 0
DELETE ex: D5 CR
LOCATE ex: /String 1

Page 13 — STATUS tells how many sectors are left and how many K grit words exist but no reference is made to what this means.
SYSCOPY m n[g] should read SYSCOPY n m[g]
What does COPY fni lni dni fno lno dno mean to a new user? It should be of the form COPY filename libname discnumber to filename libname discnumber.

Page 31 — It could not be ascertained how many array elements were necessary for the mathematical functions. I only tried exponential X**Y but F(8,X,Y) did not work and F(8) did.

Page 42 — Appendix number for the K-primitive was left blank. It should be Appendix VI.

Page 64 — It says $$AX, $$AY, $$LX, $$LY are always specified in one hundredths of an inch whereas it should be in screen units.

Page 76 — "Not Equal" is not defined properly. It should read \=

Page 89 to 90 — Not all errors that may appear are defined.

Documentation Errors in Grapple System Libraries

Reference Manual

Page 7 — Detail: Line 1 should read;
$ELLIPSE(4):&($ABS(&1)>$ABS(&2))($ABS(&1)->&MAX)($ABS(&2)->&MAX),

Page 15 — Detail: Line 10 should read;
($EXEQ(&1(0))->&IND,G),

NOTES

[1]Margo A. Sass and William D. Wilkinson, eds., Symposium on Computer Augmentation of Human Reasoning (Washington: Spartan Books, 1965).

[2]Charles M. Eastman, ed, Spatial Synthesis in Computer-Aided Design (London: Applied Science Publishers, 1975), p. 17.

[3]William J. Mitchell, Computer-Aided Architectural Design (New York: Petrocelli/Charter, 1977), p. 15.

[4]John Gero, "CAD – the next ten years," Computer-Aided Design, Nov. 1978, p. 347.

[5]Kaiman Lee, Bibliography of Energy Conservation in Architecture, (Boston: Environmental Design and Research Center, 1977).

[6]Kaiman Lee, Bibliography of Computers Programs in Environmental Design, (Boston: E D R C, 1974).

[7]Goeffrey Hutton and Michael Roston, Computer Programs for the Building Industry - International Directory, (New York: McGraw-Hill, 1974).

[8]University Equipment Loan Program for Development of Computer-Aided Design, by Public Works Canada (Ottawa: n. p., 1978), p. 5.

[9]DRAW 1 Primer, Version 4 (Sep 78) Guidelines Series #23, Public Works Canada (Ottawa; n. p., 1978).

[10]Joseph Hatvany, "CAD-the next ten years," Computer-Aided Design, Nov. 1978, p. 347.

[11]Grapple Language Reference Manual (Version 2.1 May 1977), by Public Works Canada (Ottawa: n. p., 1977), p. 28.

[12]American Society of Heating, Refridgeration, and Air-Conditioning Engineers-Handbook of Fundamentals, (New York: ASHRAE, 1967), pp. 419 - 456.

[13]"Many graphics products unveiled at National Computer Conference 78", Computer-Aided Design, Sep. 1978, p. 340.

[14]Hutton and Roston, pp. 279 - 350.

[15]Ira Rampil, "A Floppy Disk Tutorial," BYTE, Dec. 1977, pp. 25 - 32.

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Harper, Neil G., Computer Applications in Architecture and Engineering. New York: McGraw-Hill, 1978.

Negroponti, Nicholas. Soft Architecture Machines. Cambridge: The MIT Press, 1975.

Use of Computers for Environmental Design Related to Buildings. By Department of Commerce (U.S.). Washington: KUSUDA NBS BSS 39. 1974.