FLUE SIMULATOR

BY SCANADA CONSULTANTS LIMITED

User's Manual

TO/À

Norbert Senf

FROM/DE

Don Fugler

DATE 21 Oct. 92

Well... you asked for it. Do not worry, there is a fair bit of duplication in the manuals. The programs are easy to use.

I have also sent an address on where to locate VENT-2.

Good luck. Call if you have problems.

Don Fugler

Please see me ☐ Je voudrais vous voir

For your information ☐ Pour information

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CMHC/SCHL 1932 6/84

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of one internal side of rectangular chimney
ection, m
of other internal side of rectangular chimney
ction, m
of chimney gas at average temperature and
arometric pressure, kg/m^3

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FLUE SIMULATOR

VERSION 4.2 - MARCH 1988
BY SCANADA CONSULTANTS LIMITED

User's Manual

March 30, 1988

BEFORE YOU RUN FLUE SIMULATOR

FIRST run **INSTALL** to set up FLUE SIMULATOR for your system:

With the supplied "PROGRAMS AND DATA FILES" disk in Drive A:, type -

INSTALL<ENTER>

NOTICE

Canada Mortgage and Housing Corporation commissioned Scanada Consultants Limited to develop the FLUE SIMULATOR program. It is intended to be used as a research tool and will be of interest to researchers and engineers in the building science community, the heating appliance industry and the energy supply industry. In view of its research nature, results obtained using FLUE SIMULATOR should not form the only basis for design or installation decisions, but should be supplemented by hard research data and practical experience. While CHMC and Scanada have strived to ensure that the algorithms and constants in FLUE SIMULATOR reflect reality and have conducted verifications and sensitivity analyses to this end, neither CMHC nor Scanada can accept any responsibility for the consequences of decisions based on use of FLUE SIMULATOR.

TABLE OF CONTENTS

LIST OF APPENDICES

WHAT IS THE FLUE SIMULATOR PROGRAM?

The FLUE SIMULATOR Program is the result of a research project undertaken by Scanada Consultants on behalf of Canada Mortgage and Housing Corporation (CMHC). The end product of the project was a model that dynamically simulates combustion products flow, air flow and heat transfer in a flue or other (near-) vertical duct all within a house of specified airtightness and exhaust fan flow characteristics. Energy Mines and Resources Canada (EMR) and CMHC sponsored the further development of the model to make it more comprehensive, and more easily usable by persons other than the original researchers.

This manual is intended to assist users in understanding how to make the necessary inputs to the model, control its operation, and understand the outputs. However, it does not attempt to explain the inner working of the model and its algorithms. Users wishing to learn more about the model in this regard are referred to the reports listed in Appendix I.

FLUE SIMULATOR takes into account the effect of:

- the size and mass of the flue pipe (vent connector) and chimney
- indoor/outdoor temperature differences
- the flue location (interior/exterior)
- the airtightness of the building envelope
- the location of make-up air openings
- other cross-envelope flows such as fans and fireplaces
- the vertical centre of leakage (see Page 7 for the explanation)
- wind action at the top of the flue and on the envelope
- openings in the flue pipe (barometric dampers and draft hoods)
- the presence of a mechanical draft inducer in the flue pipe
- furnace type (oil or gas) and its design characteristics
- the presence of flue dampers and caps

The program predicts flow rates and temperature changes in the system by iteratively calculating, for an instant in time, mass flows and pressure differences (including temperature-induced buoyancy differences) until the flows and pressures are consistent. Also, all mass flows in the furnace/flue/building system are balanced. Heat gains or losses are accounted for in a "temperature update" module, resulting in changes in buoyancy pressures, and a new balance is calculated.

FLUE SIMULATOR can be used to study the effect of factors such as the following on the rate and direction of flow in the flue:

- envelope airtightness
- exhaust fan flow rates
- changes in draft hood design
- light versus heavy flues
- interior versus exterior flues
- insulated versus uninsulated flues
- various sizes of air supply openings in the envelope
- various furnace firing rates
- effectiveness of passive ventilation ducts
- furnace efficiency
- shared flues
- wind
- thermostat settings (including setback)
- the use of mechanical draft inducer
- the use of various types of flue dampers
- the use of various types of flue caps
- sharing of vent connectors by furnaces and water heaters

FLUE SIMULATOR is intended primarily as a research tool for studying the performance of various furnace/flue systems and their interaction with the building and other mechanical systems. It is not intended to be a tutorial aid on the function of flues. It is assumed that the user of this program is already familiar with basic principles and terminology relating to space heating, ventilation and the function of the building envelope. However, a glossary of terms is provided in Appendix "E" since all terms are not uniformly understood to have the same meanings throughout the building and space heating industries.

PROGRAM LIMITATIONS

There are a number of residential heating appliances that cannot yet be modelled directly by FLUE SIMULATOR. These are:

- induced draft gas fired furnaces with no dilution devices
- condensing gas furnaces
- furnace heaters
- boilers

The FLUE SIMULATOR program could be modified by Scanada to handle each of these.

DIFFERENCES BETWEEN VERSION 4.2 AND VERSION 3.0

(Version 4.0 was an intermediate version which was not distributed. Version 4.1 was widely distributed but differed only slightly from Verson 4.2 in that it did not include an automated installation program and it had two minor "bugs" related to the graphic output which have been corrected.)

FLUE SIMULATOR Version 4.2 incorporates the following new modelling capabilities not present in Version 3.0:

- FLUE SIMULATOR can now model flues which are shared by furnaces and water heaters.
- The wind pressure coefficients and flow characteristics of the flue exit are now user inputs rather than built-in constants. Values of these inputs for a number of commercially available flue caps are included in Appendix H.
- FLUE SIMULATOR can now take into account the presence of a flue damper.
- FLUE SIMULATOR can now model oil furnaces with sealed flue pipes; i.e. flue pipes without barometric dampers.

In addition, a number of changes have been made to make the program easier to use. These include additional automated installation, error trapping, easier to read output graphs, additional help screens, improved file handling and the storing of user choices regarding graphical output with each input data file.

The program is now so large that it can no longer run under the BASIC interpreter - only the compiled version can be used. However, the BASIC version is included to permit user modification.

The non-graphic version of the input program has been dropped.

Despite the increase in size, the program now runs appreciably faster due to a number of programming improvements.

Version 4 will not read input data files from Version 3, since the Version 4 files are much longer.

FILES ON THE PROGRAM DISK

The FLUE SIMULATOR program disk has the following files:

- INSTALL.BAT - a DOS "batch" program to assist you in setting the FLUE SIMULATOR program on your system

  - RUN THIS ONE FIRST -

- INSTALL4.DAT - the file created by INSTALL.BAT
- FLUEIN4.EXE - the program which allows the user to create and modify the input data required by the model
- FLUE-G4.SLB - a library of graphic screens used by FLUEIN4
- FLUESIM4.EXE - the main simulator program which is automatically CHAINed by FLUEIN4
- BRUN20.EXE - a "run-time" library used with compiled programs
- USERLIB.EXE - a "run-time" library used with compiled programs
- DISPLAY.EXE - the program used to display and print saved graphs
- FLUESIM.BAT - a DOS "batch" program that executes the FLUE SIMULATOR programs in the proper order
- ASK.EXE - a public domain utility which is used in the INSTALL.BAT program
- CR - a file, containing only a carriage return, which is used in the INSTALL.BAT program

The compiled programs and data files are on one disk, ready for installation. The source .BAS files are on a separate disk.

In addition to the programs described above, the program disk includes a number of input data files, describing a variety of furnace/flue/house systems, which you can use as starting points in developing your own input data files. All involve essentially the same house - a two storey house of average airtightness. These files are as follows:

- OINTMAS .FM4 - oil furnace with interior masonry chimney
- GINTBVNT.FM4 - gas furnace with interior B-vent
- DRFTIND .FM4 - gas furnace with interior B-vent and draft inducing fan
- OINTAVNT.FM4 - oil furnace with interior A-vent
- OEXTAVNT.FM4 - oil furnace with exterior A-vent
- OEXTLIMS.FM4 - oil furnace with exterior lined masonry chimney
- GEXTBVNT.FM4 - gas furnace with exterior B-vent
- OEXTINFP.FM4 - oil furnace with exterior A-vent and insulated flue pipe
- LONGUNFP.FM4 - oil furnace with long uninsulated flue pipe and exterior A-vent
- LONGINFP.FM4 - oil furnace with long insulated flue pipe and exterior A-vent
- DYNHOUSE.FM4 - same as GINTBVNT.FM4 but with thermostat control of furnace
- EDAMPER.FM4 - gas furnace with exterior B-vent and electrically activated damper
- TDAMPER.FM4 - gas furnace with exterior B-vent and thermally activated damper
- SEALED.FM4 - sealed combustion chamber and sealed venting system on an oil fired furnace.
- DHW.FM4 - same as GINBVNT.FM4 but with flue shared by furnace and water heater

The contents of the disks are NOT copy-protected and may be copied for backup purposes. The user should make a backup copy before attempting to use the program. The original disk can then be stored in a safe place for use in replacing damaged or lost backups.

Note that the FLUE SIMULATOR disk you received from CMHC does not include the MS-DOS operating system since this is a proprietary product of Microsoft Corporation. Therefore the disk can not be used, as received, to "boot" your computer.

MINIMUM SYSTEM REQUIREMENTS

The following are the minimum hardware and software required to run FLUE SIMULATOR:

- IBM-PC or compatible computer
- 2 double-sided 360 kilobyte floppy disk drives
- PC/MS-DOS 3.0 or subsequent version
- an Epson-compatible dot-matrix printer capable of printing 233 characters per line in condensed mode or a utility program which can print sideways for shorter carriage printers

In order to be able to use the graphical output capabilities of FLUE SIMULATOR, it is necessary that your system incorporate an IBM Color/Graphics Adaptor (CGA) or equivalent. However, the program can be used without this by choosing tabular output.

The graphical output option of FLUE SIMULATOR will not work with the Hercules Monochrome/Graphics Adapter. It has not been tested with the IBM Enhanced Graphics Adapter or equivalents, but should work with any EGA board capable of CGA emulation.

The graphical input screens are a type of "pseudo-graphic" on the text screen and should work with any type of video adaptor. However, their appearance will be slightly different on a monochrome adapter than on a CGA.

The programs on your disk will not support a math co-processor chip such as the 8087.

THE "INSTALL" PROGRAM

Running the INSTALL.BAT program is the first thing you should do after reading this manual. It installs the FLUE SIMULATOR program and its related files on your system and edits a small file on the disk (INSTALL4.DAT) which records whether your system is capable of displaying 640 x 200 resolution graphics (which is provided by the COLOR/GRAPHICS ADAPTER and other video adapters with a COLOR/GRAPHICS emulation mode). The main program uses this information to avoid attempting to display graphics on a system that does not have this capability. The INSTALL4.DAT file also includes a record of whether you prefer to have the program's numeric output sent to the disk or to the printer.

With your computer booted and the supplied "PROGRAMS AND DATA" disk in Drive A:, type -

INSTALL<ENTER>

The INSTALL program will take over the installation process, asking you for occasional instructions. When used to install FLUE SIMULATOR on a hard disk, the INSTALL program DOES NOT alter the AUTOEXEC.BAT or CONFIG.SYS files. It creates a new directory called "FLUESIM" with a subdirectory call "FLUEDAT".

Alternate Configuration for a System With Two Floppy Disk Drives

Because the programs, runtime libraries, etc. take up almost an entire 360 K disk, there is not enough room on such a disk for the MS-DOS system, COMMAND.COM, and any utilities you might want to use, such as a graphics screen dump program (see "GRAPH" Outputs). It is therefore suggested that you set up a separate disk for booting your system. This FLUE SIMULATOR BOOT DISK could include a graphics screen dump program, which could be executed by an AUTOEXEC.BAT program, plus whatever software you require to read your system's hardware clock, etc. The FLUE SIMULATOR programs would then be on a separate disk which would replace the BOOT disk in Drive A:. This disk should include a copy of COMMAND.COM. Input (.FM4) and output (.PRN) files would be kept on a series of disks which would be used in Drive B:. A single such disk could include all input and output files for several simulations.

LOADING AND RUNNING FLUE SIMULATOR - OVERVIEW

Using FLUE SIMULATOR will involve the use of the compiled versions of the input and main programs. The source code is available mainly to allow you to modify the programs to suit your own needs (see MODIFYING FLUE SIMULATOR).

The general flow of information within the programs is illustrated on the chart on the following page. One must always start a FLUE SIMULATOR session by running the input module - FLUEIN4.EXE. (This can be done by typing FLUEIN4<ENTER> or, if you forget the name of the input program, typing FLUESIM<ENTER> will execute the FLUESIM.BAT batch file, which, in turn, executes FLUEIN4.EXE.) The program begins by asking which of the input data files it finds on the disk in the default drive you want to load. It is always necessary to load such a file to begin. Even if you want to create a new file, you must do so by modifying an existing file. Choose the file that you know to be closest to the conditions you want to simulate. Simply press the number of the file you want to load, followed by <ENTER>.

Once a data file is loaded, the input module presents the following main menu:

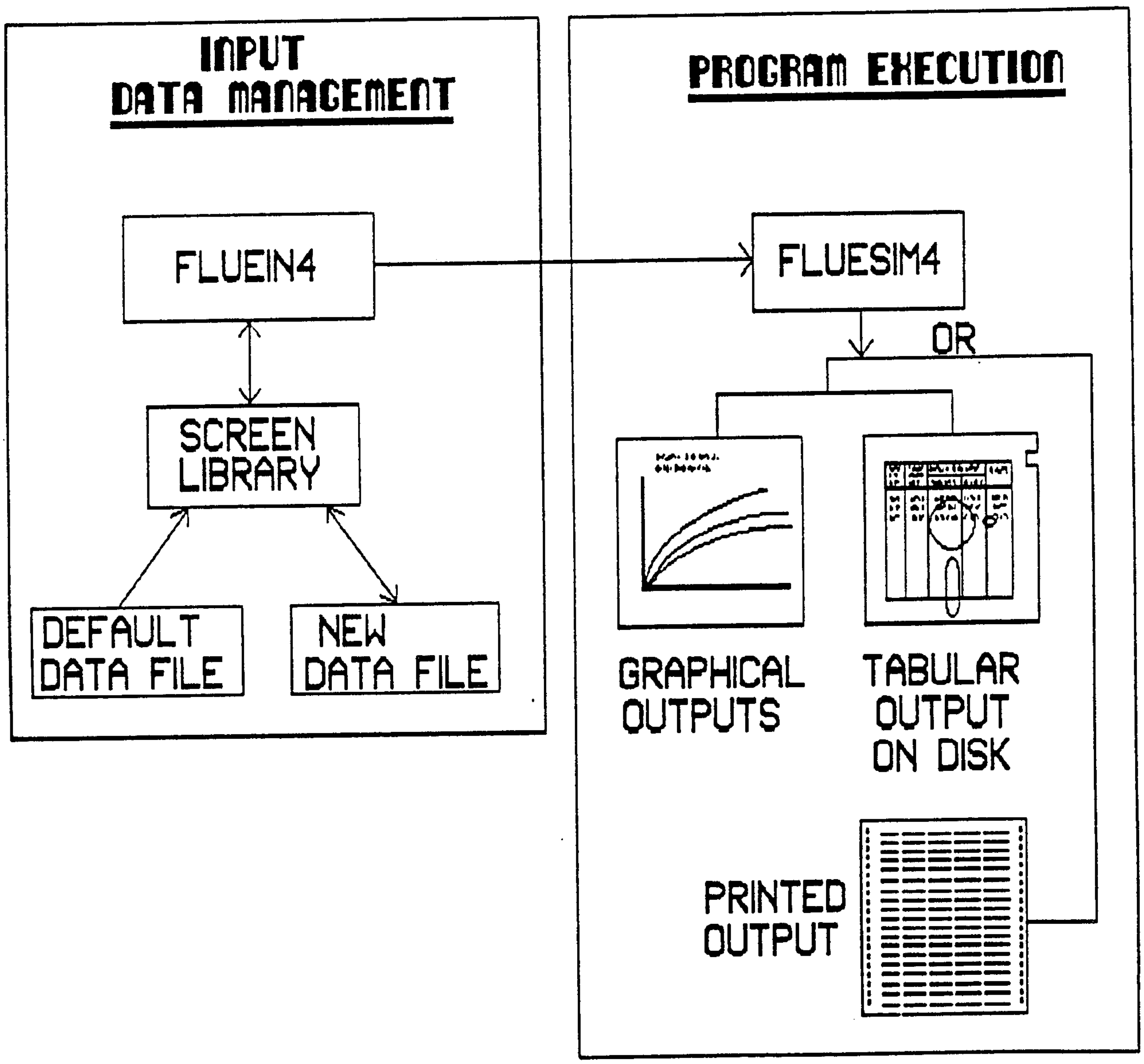
```
        1 - CHANGE FILE DATA
        2 - SET RUN TIME CONTROLS
        3 - SELECT GRAPHICS FORMATS OR PRINT CONTROLS
        4 - SAVE FILE
        5 - RUN PROGRAM
        6 - CONTINUE OR EXTEND SIMULATION
        7 - LOAD ANOTHER DATA FILE
        8 - QUIT
    YOUR SELECTION (NUMBER FROM 1 TO 8) -->
```

If you next select Option 1, you will be prompted to enter values for each item of input data and will be shown the value currently in memory as the default value for that item.

Before the main program is run, the new set of input data can be stored back to disk under the same or a new file name using Option 2 of the main menu. You can also save data at the end of a run so that that data as modified by FLUE SIMULATOR could be used as a new starting point for subsequent simulations.

The output options available under Option 3 are explained in the PROGRAM OUTPUTS section of this manual. If you select graphics output, and the information in the INSTALL4.DAT file says that your system is not capable of displaying graphics, a message to this effect will be displayed and you will not be able to proceed unless you select the "TABLES" output option or "QUIT" and correct the information in the INSTALL4.DAT file by re-installing FLUE SIMULATOR (see Page 9).

CHART OF INFORMATION FLOW



When Option 5 of the main menu is selected, the input module then runs the main simulation program and passes the values of the input data to it.

For each time step, the program searches for the furnace inlet flow rate and flue flow rate that satisfy the existing temperature/pressure states. Generally, 2 to 10 iterations are required for each time step. The number of required iterations decreases gradually when the flow approaches steady-state conditions, so that the calculation rate speeds up. However, at steady-state operation, the flow rates are high and the time steps are reduced so that the speed of simulation is nearly constant.

If you have selected the "TABLES" output option, at predetermined time intervals (i.e. simulation time intervals), the program will print a row of output data - various pressures, flows and temperatures. For simulations longer than about 10 s you have the option of skipping several time intervals between printouts - this allows the program to run faster and avoids printing data which is mostly repetitive as conditions approach steady state or change very little due to the fact that the program is using a very short calculation time interval.

If you have chosen the "TABLES" output option and are sending output directly to the printer, speed of execution is governed by the printer output. It may therefore be preferable to choose the briefest form of output -the "PRESSURE PARAMETER SUMMARY" choice on the first screen of the program. However, you may not want to sacrifice information for speed; in which case, you should choose the "DETAILED SUMMARY".

Speed of execution would of course benefit significantly from use of a print "spooler" or "buffer" (either hardware or software).

You also have the option of printing the output to a data file (e.g. GASDFALT.PRN) on your disk. This option also speeds up the execution of the program and allows you to store outputs on disk for future printing or deletion.

If you have chosen the "GRAPH" output option, a graph of the selected data versus time appears on the screen as the simulation proceeds. If the duration of your simulation is less than or equal to 60 seconds, the time step will be set at 0.1 seconds automatically. This is necessary to produce clear graphical outputs.

When the program has reached the elapsed (simulation) time specified at the outset, the computer "beeps" and the simulation stops.

If you have chosen the "GRAPH" output option, you are given a choice of printing the graph, saving the graph to disk, or exiting. The "EXIT" option returns you to the input module main menu. After a "PRINT" or a "SAVE" you also return to the input module main menu. "CONTINUE" allows you to continue drawing the graph.

If you have chosen the "TABLES" output option, the final outputs (see next section) are printed on completion of the simulation, the input module is CHAINed and you are returned to its main menu.

More detail on the various output options is provided in the PROGRAM OUTPUTS section of the manual.

Choosing Option 4, "SAVE FILE" will save the values of all the variables, as changed by the simulation, to disk. Assign the file a new name if you want to keep both the original and changed versions. If you use the original name you will be asked if you want to replace the file.

If you want to stop the execution of a simulation for any reason, press the <A> key (for abort). At the end of the next iteration, FLUE SIMULATOR will stop and the subsequent actions and options will be as described above for the situation where the simulation is allowed to go to completion, with the exception that the additional option of continuing the simulation is offered.

PROGRAM INPUTS

The program requires data describing the following categories of parameters:

- ambient conditions at start of the simulation which will remain unchanged during the simulation
  - e.g. exterior temperature, wind speed

- ambient conditions at start of the simulation which will be changed by the simulation
  - e.g. flue liner temperature, flue gas temperature

- physical dimensions and characteristics of the furnace, flue and building envelope

- time data
  - e.g. furnace on-time, initial time interval for calculations

The input module, FLUEIN4, prompts the user for all required input data. However, it is best to have this data prepared ahead of time in order to reduce computer use time. The forms in Appendix "F" can be copied and used for this purpose. They are replicas of the input screens displayed by FLUEIN4.

It is important to realize that each of the more than 180 user inputs is necessary to fully describe the system and conditions being simulated. Although the influence of some inputs is more significant than that of others, a change in any one of these inputs will result in a different outcome of the simulation. Therefore it is essential that you ensure that the data in the input file you use accurately reflects the system and conditions you wish to simulate. This is especially important when attempting to match FLUE SIMULATOR's predictions with the results of field or laboratory tests.

> **N.B.**
>
> It is also important to realize that each input data file contains a value for every variable used in FLUE SIMULATOR - several hundred variables. The data which is actually input by the user is only a fraction of the data in the file. The balance of the data was incorporated in the provided default files, or was generated by FLUE SIMULATOR in data files saved at the end of a simulation. Most of the hidden data is adjusted by FLUEIN4 in response to the user inputs; but, for a few of the variables, this adjustment can only be done by the iterative process in the FLUE SIMULATOR program. For example, a user might start with a file generated by a simulation involving a water heater that was on during

the simulation and simply change the water heater to standby for a new simulation; however, the flue gas, flue pipe, and flue structure temperatures in the data file would be inconsistent with the standby condition. If FLUE SIMULATOR were run for a short period in the standby mode, it would adjust these temperatures to be consistent with standby and the ensuing simulation would more closely model the situation the user intended. On the other hand, if the data were to be used without this "massaging" by FLUE SIMULATOR, the ensuing simulation would produce different, and possibly erroneous, results.

Thus it is possible for two users to input exactly the same data and get different results, if they start with different default files ... UNLESS ... FLUE SIMULATOR is used to process the data before a full-fledged simulation is undertaken.

Therefore, if you make any significant change in a data file, you should use FLUE SIMULATOR to process the data before attempting to simulate the new conditions. If the data represents a standby condition, FLUE SIMULATOR should be run for a short period in the standby mode and the file should be saved with the adjusted data. If the data represents a condition with the furnace or water heater firing, FLUE SIMULATOR should be run for a short period with this firing continuing. The length of this "short period" depends on the system being modelled. For systems involving furnaces with light heat exchangers and low thermal inertia flues, 300 seconds should suffice; for heavier systems, this period should be greater. Plotting temperatures during this preparatory simulation will allow you to judge when steady state conditions are being approached.

In light of the comments in the introduction regarding the background knowledge required for use of FLUE SIMULATOR, there are perhaps only a few of the inputs which require elaboration -

Firebox Leakage Area (Oil Furnaces)

If a value less than 0.001 m^2 is input here, the program will automatically assume that the furnace has the type of retrofit that is applied to oil furnaces in which the barometric damper is eliminated and the flue pipe and firebox are sealed.

Furnace Outlet Area

For oil furnaces, the area referred to here is simply the area of the furnace outlet breech. However, for gas furnaces it is the area of the smallest restriction(s) the products of combustion must pass through before leaving the furnace heat exchanger and entering the dilution port area. Often this area is hard to measure because the heat exchanger outlet(s) (there are often more than one and the total area is required) must be reached through the dilution port area and often the most easily reached openings are not the smallest restrictions - these are often recessed back into the heat exchanger. Nevertheless, it is necessary to have an accurate value for this area since it is an important determinant of the amount of excess air flow through the furnace and hence of total flow in the venting system.

Vertical Centre of Leakage

This term refers to a hypothetical elevation at which all the leaks in the envelope can be thought to be located - the vertical "centre of gravity" of the leaks. It is similar to the neutral pressure plane concept and, in fact, would be the same as the neutral pressure plane location if there were no chimney or wind. In the absence of field data, a reasonable assumption would be that the VCL is located midway between the exterior grade level and the top storey ceiling. However, if there were known large leaks above or below that point, the VCL would be located away from this midway point in the direction of those leaks.

Note that the location of the VCL is measured downwards from the top of the chimney.

Simulation Start Time

Normally a simulation start time of 0 would be used. However, if a long standby (say 60 s) before furnace start-up at time 0 were desired, then a start time of -60 s and a furnace turn-on time of 0 would be input.

Note that the "GRAPH" output does not begin plotting until time 0 is reached.

Another case where a non-zero start time might be used would be when the final conditions of a previous simulation had been stored as a data file and were to be used as starting conditions for another simulation. In this case it might be useful to input a start time equal to the finish time of the previous simulation. (This is done automatically if a run is interrupted by the abort key - <A> - and resumed later, as explained at the end of the next section.)

Furnace Thermostat Controls

The input data required is described on the FLUEIN4 screen. However, you should be aware that if a value of 0 is input for the furnace thermostat band, then the furnace will be turned on and off according to the times set in the "run time controls". On the other hand, if a value other than 0 is input for the furnace thermostat band, this will over-ride the furnace on and off times set in the "run time controls" and the furnace will be turned on and off in response to the simulated house temperature as it relates to the thermostat set point and band. The house temperature, in turn, is determined by the house heat loss characteristics and the outdoor temperature. At the start of the simulation, the indoor temperature will automatically be set to the thermostat setting minus half the band, over-riding the indoor temperature set on the ambient conditions screen.

House Heat Loss Characteristics

If the effects of thermostat control are to be simulated then you will have to specify the total house heat loss factor, heated air volume of the house and type of construction (light, medium or heavy). "Light" construction means typical wood-frame construction. "Medium" construction also means wood-frame but with massive elements; e.g. interior masonry or stone partitions, fireplace, etc. "Heavy" construction means solid masonry or concrete.

Fresh Air Intake

If you are modelling a house with no fresh air intake, simply input an area of 0. If the fresh air intake has no duct (i.e. it is simply a hole in the wall) input 0 for the number of elbows. If the fresh air intake uses flexible duct, then you will have to input an equivalent number of elbows based on resistance data for the type of duct used.

Flues Shared by Furnaces and Water Heaters

There are three items on this screen (Item 7 on the FILE CHANGE menu) that may require some amplification -

Standby Capacity

This refers to the combination of the pilot light output and the heat loss from the water in the tank.

Type of Connection (Y, T, B)

A "Y" connection refers to the most common type of connection between the furnace and water heater flue pipes (vent connectors) in which the two pipes come together at an angle of less than 90°. A "T" connection is one in which the water heater flue pipe connects to a straight section of the furnace flue pipe at 90°. A "B" (for BASE) connection is one in which the water heater flue pipe does not connect to the furnace flue pipe at all but enters the base of the chimney directly.

Connection: flue pipe element no.

Under FILE CHANGE menu Item 3, "FLUE PIPE/VENT CONNECTOR SPECIFICATIONS", you will have entered the number of separate straight sections connected by elbows that there are in the furnace flue pipe. Here you are asked to name which of these the water heater flue pipe is connected to. If the water heater is connected directly to the chimney base (a "B" connection), enter here a number one higher than the number of sections entered under Item 3.

Flue Caps

Appendix H includes wind pressure coefficients and friction factors for a number of common flue caps.

Because the research on which this data is based was unable to determine any systematic correlation between pressure coefficients with the flue blocked and unblocked, the user of the model must pick the flow coefficient that best suits the situation being investigated. If a low draft/low flue flow start-up is being investigated then the choice of the "blocked flue" wind pressure coefficient is recommended. For comparison of full heat-up/cool down simulations to field data, then the unblocked coefficients should be specified.

PROGRAM OUTPUTS

"TABLE" Outputs

The options available after you have chosen the "TABLE" output option are presented in a menu. There are several types of outputs that can be produced, both during the execution of a simulation and at its completion. The default output options are stored with each input file.

The outputs described below will either be sent to your printer or to a disk file, depending on which option you selected when running the INSTALL4 program. You can also override that selection for a particular simulation.

Outputs During the Execution of the Simulation

The user has the choice of two types of outputs to indicate the progress of calculations at each time step -

- detailed summary, and
- pressure parameter summary.

Detailed Summary

This gives a one line summary of the status of all system elements as the simulation marches through each time step. Outputs are:

- simulation time
- volumetric flow rates of the furnace, dilution device, flue, DHW, and envelope
- temperatures of
  - furnace heat-exchanger surface
  - stack gas
  - DHW branch
  - flue gas
    - after dilution
    - mean
    - exit (top)
  - flue liner
    - mean
- instantaneous furnace efficiency (i.e. heat delivered from heat exchanger to circulation air over that time step divided by heat input from fuel over same time step)
- mean flue film heat transfer coefficient
- mean flue flow friction factor
- location of probable condensation of water in the flue

Key outputs in the above list are the dilution flow, which indicates combustion product spillage when negative, and chimney flow rate, which indicates backdrafting when negative. Key cross-over conditions are identifiable in these outputs when the signs of the above flows change from negative to positive or vice versa.

Pressure Parameter Summary

This form of output shows the progress of the pressure parameters throughout the simulation. These show how the buoyancy and wind pressures are dissipated into envelope, furnace and flue friction losses. The program's pressure accounting process is thus revealed.

The absolute values of the net flue driving pressure, the furnace driving pressure, and dilution port pressure drop are all equal. (The differing signs are due to calculation conventions.) Cross-over conditions are indicated by the change in signs from one time step to the next. This particular output also illustrates that the net driving pressure of the furnace has to be negative in order to avoid spillage. Spillage occurs when the furnace is a more efficient chimney than the flue (e.g. low draft start-up).

System Parameter Table

This is a table produced just before the furnace is turned on. These parameters can be used to predict the performance of the furnace at start-up.

Detailed Final Status Printouts

At the end of a run, or before turning off the furnace, the program gives a summary of all calculated values; i.e. -

- gas and structure temperatures at each element along the flue-pipe and flue,
- air temperatures at each calculation point around the flow systems (see Figure 1 of Appendix "F" for location of calculation points),
- air densities,
- mass flow rates,
- volumetric flow rates,
- flow velocities, and
- the system pressure parameters.

This status table also shows all of the properties used in the calculation at each point.

Final Summary Printout

The final summary output simply lists many of the key inputs and outputs at the final time step of the simulation. Although it might be expected that the input information would be listed at the beginning of the program, these have been purposely located at the end so that all the time and paper will not have been wasted if you should decided to abort the run when initial outputs of the simulation indicate an undesired start-up situation. This feature will be useful when attempting to create a desired start-up condition by trial and error.

The numerous headings used on the various tabular outputs, which are necessarily somewhat cryptic, are defined in Appendix E.

"GRAPH" Outputs

The options available after you have chosen the "GRAPH" output option are presented in menus and are fairly straightforward. Perhaps only the following points need elaboration:

- The horizontal (time) axis is automatically scaled to suit the length of simulation you have chosen under Main Menu Option 5, "SET RUN TIME CONTROLS". Three scales are available - 60 s, 300 s and 1200 s

- The graph will have better resolution for the early part of the simulation if you choose a small time step in setting the run time controls. The program automatically adjusts the time step to suit the flue flow velocity once the simulation is underway; but choosing too large an initial time step can result in gaps in the early plotting. (To correct this problem for the 60 s. scale, a maximum 0.1 s. time step is imposed by the program.)

- In order to get a proper printout of a graph, it is necessary to load a graphic screen dump program prior to running FLUE SIMULATOR. If you omit this, pressing "P" at the end of the simulation will result in only the text characters on the graph being printed. If you foresee making extensive use of the graphics outputs, you may want to include instructions for loading a graphics screen dump program in an AUTOEXEC.BAT file - it is very frustrating to have spent half of an hour watching a graph develop just the way you wanted it to and then realize that you won't be able to print it.

  However, you can use the "SAVE" option to capture (BSAVE) the screen to disk. The file has the input file name with extension ".PIC". This file can be displayed and optionally printed using DISPLAY.EXE.

  The GRAPHICS.COM graphics screen dump program supplied with DOS works satisfactorily, but others are available which provide more flexibility in terms of size of the printed graph and its orientation on the page. For instance, "PRTSCR" by Domus Software Limited of Ottawa has the above-mentioned features and also allows the printing of the input graphics screens (for record purposes) on non-IBM-compatible printers.

- When you choose the "GRAPH" output option, the tabular data that would have been printed if you had chosen the "TABLE" option is saved to a disk file so that, if the graph indicates some interesting results, you will also have the results available in detailed numeric form. This file has the input file name with extension ".PRN". The

INSTALL4 program lets you select which drive the PRN file will be stored on. It is a good idea to have it stored on a "RAMDISK", such as that created by the VDISK.SYS program provided with PC/MS-DOS 3.0 or similar programs provided with many expansion boards. This will minimize the delay in program execution caused by the disk storage operation.

The .PRN file name extension was chosen to facilitate IMPORTing the file into a LOTUS 1-2-3 worksheet for further analysis.

The contents of the PRN file can be displayed on the screen when you are in DOS by placing the disk containing it in the default drive and typing -

TYPE filename.PRN <ENTER>

Use the "Ctrl"+"NumLock" key combination to pause the display.

The file can be printed by typing -

TYPE filename.PRN >PRN <ENTER>

ADDITIONAL CONSIDERATIONS IN USING FLUE SIMULATOR

Realistic Steady State Conditions Prior to Furnace Start-up

It may be difficult to make realistic assumptions for steady state conditions prior to furnace start-up. The program will work them out but you don't want it to have to do so every time if what you're really interested in is what happens after furnace start-up. Therefore run the simulator without furnace start-up for an elapsed time long enough to achieve steady state conditions. Then use the "SAVE FILE" option at the end of the run to store this set of finishing conditions for use as starting conditions in subsequent simulations. When using this file to start future runs, simply reset the RUN TIME CONTROLS as desired.

Gas Furnaces versus Oil Furnaces

FLUE SIMULATOR uses slightly different algorithms for oil furnaces than for gas furnaces. The essential differences are as follows:

Dilution Devices

Naturally aspirating gas furnaces have open-type draft hoods - either incorporated in the flue pipe or built in to the furnace. Such a device has a fixed opening for which the area and friction factor are the same (or nearly the same) whether the flow is into or out of the device. In FLUE SIMULATOR, the area of the opening and its friction factor are specified as inputs and remain fixed through the simulation.

On the other hand, the friction factor and area of opening of the barometric damper on an oil furnace vary with both the amount and direction of flow. FLUE SIMULATOR models the variation of these with amount of flow in the positive direction (i.e. flow into the flue pipe). It also takes into account the closing of the damper on reverse of the flow (i.e. flow out of the flue pipe). The input module asks for a percentage closure on reverse flow if you are simulating an oil furnace. It will not accept 100% closure. If a value of 0% is input for the closed area as a per cent of the open area, it will automatically be changed to 5%. This is because the algorithm would calculate an infinite velocity through the remaining 0 area opening and the program would crash. This remaining 5% opening can be thought of as leakage around the damper plate and other leakage areas in the flue pipe - probably a realistic assumption.

Fuel and Combustion Air Mass Flows

In modelling a gas furnace, the mass flow of the fuel is added to the mass flow of the combustion air inside the furnace. The combustion air flow is affected by friction factors of the furnace inlet and outlet and also by the buoyancy pressures calculated during the simulation. The key characteristic of the furnace that controls the quantity of combustion air and excess air flowing through the furnace is the size of the furnace exhaust ports. By trial and error it was found that exhaust ports sized to provide about 0.0004 m2 per kW of furnace capacity (e.g. 0.012 m2 for a 30 kW burner) yield approximately 130% excess air at steady state operation. Adjustments to the inlet area will be needed to achieve a target excess air, and the magnitude of this adjustment will depend on other characteristics of the system (e.g. furnace height, draft hood design, etc.). The fuel flow is assumed to be constant throughout the simulation and is only determined by the input firing rate.

In modelling an oil furnace, the fuel mass flow is added to the combustion air mass flow inside the furnace. The combustion air flow is determined by the burner blower and can be assumed to be essentially unaffected by the pressure drop across the blower. For oil furnaces, therefore, the combustion air flow is treated as a constant which is input as percentage of excess air. Some small leakage flow, to account for leaks around the burner/furnace connection and the flame inspection port, is calculated in when the burner is off. The user is therefore asked to input an area to represent this leakage area. It should be a small value - a minimum of 0.0015 m^2 is recommended.

The user can modify all these values iteratively to achieve the proper steady state operating temperatures, efficiency and excess air, in a manner similar to the process described above under "Refining Assumptions on Furnace Characteristics".

Effect of Interior Partitions and Doors

It may be of interest to model the effect of interior partitions with closed doors in separating the furnace/flue from the available leakage paths in the house envelope. In order to do this it is necessary to have data on the effect such a condition has on the effective leakage area of the envelope. This would be obtained by conducting an airtightness test on the house with the indoor pressure tap located in the furnace room and with the interior doors closed according to the condition that is to be modelled. It was felt that it would be a fruitless exercise to attempt to model such a condition using assumed values for the leakage areas and friction factors of interior partitions and doors since these values are likely to vary greatly from house to house and no typical values are available in the literature.

MODIFYING FLUE SIMULATOR

There are a number of reasons why the user might wish to modify the program. For example, the user might want a printout of data not included in the present printout (e.g. all flue liner temperatures over a full simulation run). The user might also wish to change some of the constants incorporated in the BASIC code such as the furnace friction factors or various heat transfer coefficients. Another possibility would be the introduction of a wider variety of event sequences.

Changing the Code

Whatever the reason for modifying the program, a user who is familiar with most standard dialects of BASIC should not find such modifications difficult as the program is relatively straightforward in terms of coding and is amply commented. To assist such modifications, the following additional aids have been provided:

- the complete program listing - Appendix "B"
- a list of variables with cross-references to the line numbers where each is used - Appendix "C"

The program is divided into sections as shown in Table 1.

Re-compiling the Modified Program

To use the program you will have to re-compile it after modification. You will, of course, have to have a PC/MS-DOS BASIC compiler. The following procedure assumes the use of the Microsoft QuickBASIC 2.0 compiler, although others may work as well:

- o Place the QuickBASIC 2.0 Compiler disk in Drive A:
- o Type - QB/L <enter>. (The "/L" loads the USERLIB.)
- o Load your version of FLUESIM4 and make any modifications.

  (Note: If you change the name of FLUESIM4 you will have to modify FLUEIN4 to CHAIN to that name.)

- o Compile the module to create an .EXE file.

You will need to have the file containing the runtime library on your disk for execution. This is called "BRUN20.EXE" for programs compiled by QuickBASIC 2.0. You will also need "USERLIB.EXE" on the disk.

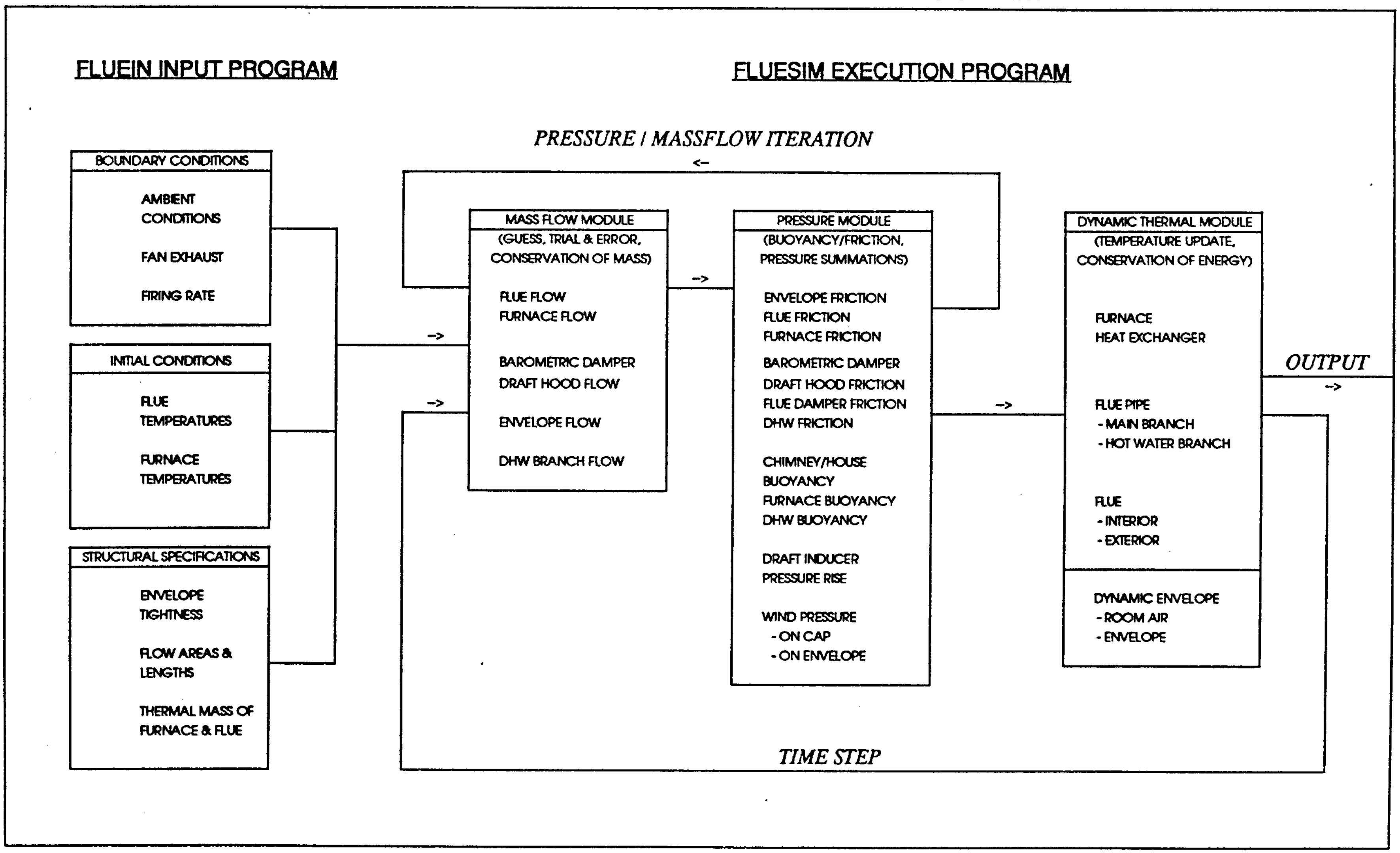
FIGURES

SHOWING CALCULATION

NODES IN THE

FLUESIM PROGRAM

BLOCK DIAGRAM OF THE FLUESIM PROGRAM



***** THE FURNACE IS ABOUT TO BE TURNED OFF. THE STATE OF ALL FLOW SYSTEMS IS AS FOLLOWS:

TIME = 240.1 SECONDS

TEMPERATURES OF THE FLUE GAS, LINER, AND STRUCTURE

	FP 1	FP 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10 ← See attached figure
FLUE GAS TEMP (C)	143.0	134.2	129.6	125.1	120.7	116.4	112.2	108.1	104.0	100.1
INNER LINER (C)	95.3	88.9	104.7	100.7	96.8	93.0	89.3	85.7	82.2	78.8
INSUL OR STRUCT (C)	20.0	20.0	40.3	38.5	36.8	35.2	33.7	32.2	30.8	29.5
OUTER STRUCTURE(C)	20.0	20.0	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0
SURROUNDING (DEG C)	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONDENSING TIME (%)	5.8	10.3	10.4	13.8	17.3	21.1	24.8	28.7	32.6	36.7

THE MASSFLOW SYSTEM PARAMETERS

<--------FLUE--------> <----ENVELOPE---><--DRAFT HOOD INLET-> <--------FURNACE-------->

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19 ← See attached figures
TEMPERATURE (DEG C)	0.0	100.1	114.3	143.0	152.3	152.3	0.0	0.0	20.0	20.0	20.0	152.3	20.0	20.0	20.0	1291.7	246.5	246.5	152.3
DENSITY (KG/M3)	1.29	0.95	0.91	0.85	0.83	0.83	1.29	1.29	1.21	1.21	1.21	0.83	1.21	1.21	1.21	0.23	0.68	0.68	0.83
MASS FLOW (KG/S)	0.038	0.038	0.038	0.038	0.038	0.038	0.037	0.037	0.037	0.016	0.016	0.016	0.021	0.021	0.021	0.022	0.022	0.022	0.022
VOLUME FLOW (M3/S)	0.029	0.040	0.042	0.045	0.046	0.046	0.029	0.029	0.031	0.013	0.013	0.019	0.018	0.018	0.018	0.099	0.033	0.033	0.027
FLOW VELOCITY (M/S)	0.00	3.88	4.02	4.32	4.42	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.44	0.10	0.03	2.97	0.00

PRESSURE PARAMETERS OF THE FLOW SYSTEMS

NET BUOYANCY	WIND EFFECT	ENVELOPE LOSS	FRICTION LOSS	NET DRIVING	FURN BUOYANCY	INLET DROP	OUTLET DROP	NET FURNACE	DILUTION PORT	DRAFT INDUCER	DHW INDUCED	DHW BUOYANCY
30.493	2.913	-0.712	-32.434	0.261	6.109	-0.351	-6.019	-0.261	-0.261	0.000	0.000	0.000

S U M M A R Y   T A B L E

OUTDOOR TEMPERATURE = 0 C
INDOOR TEMPERATURE = 20 C

STANDBY FIRING RATE = 220 W
FULL FIRING RATE = 29300 W
INSTANT. EFFICIENCY = 69.9 %

WIND SPEED & PRESSURE COEFFICIENTS:	SPEED (M/S)	PRESSURE COEFFICIENTS CHIM TOP	INSIDE HOUSE
HORIZONTAL COMPONENT	3.0	0.50	0.00
VERT. COMPONENT (+VE UP)	0.0	1.00	

Figure 1. Calculation Points, Flue Elements and Dimension Reference

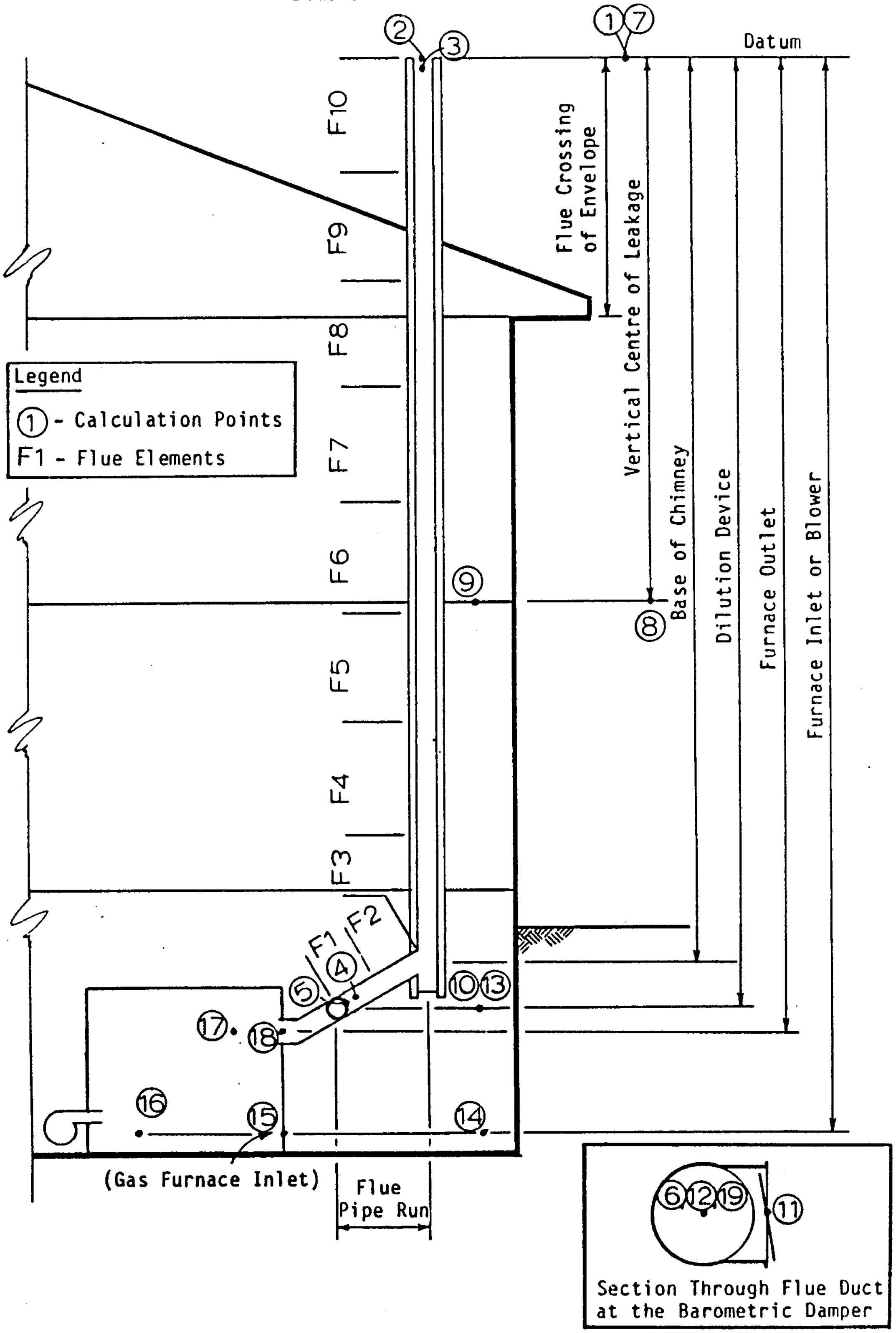
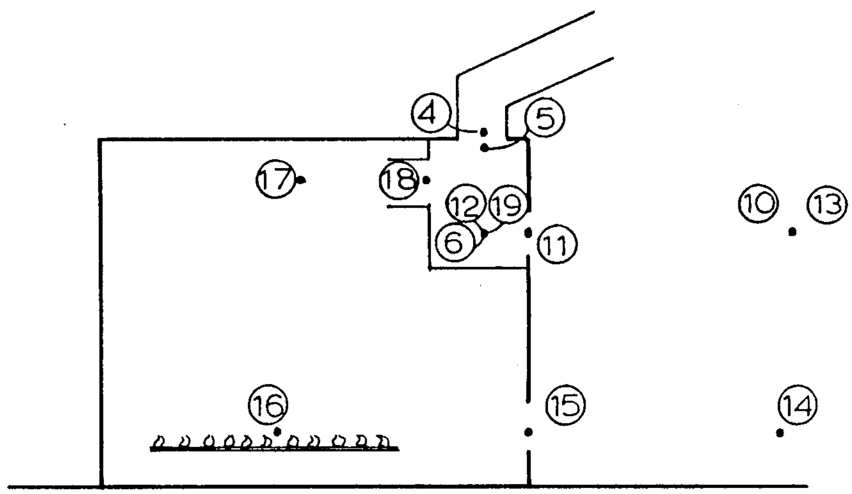
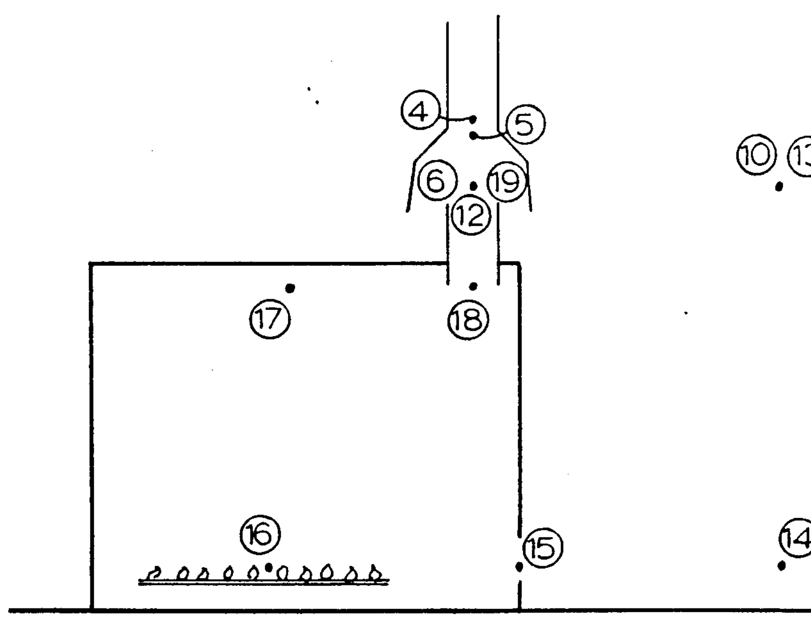


Figure 2. Calculation Points for a Gas Furnace



Gas Furnace with Built-in Draft Hood



Gas Furnace with Freestanding Draft Hood

THE CORE
ALGORITHMS
OF THE
FLUESIM MODEL

PARAMETERIZATION OF THE CORE ALGORITHMS OF THE MODEL

PRESSURE MODEL ALGORITHMS

The pressure parameters were derived by summing all pressure gains and drops along the two main flow circuits of the system: the chimney-house circuit and the furnace circuit. These circuits are defined by the calculation points in Figure 1 repeated on the next page:

Chimney-house: e - d - b - a - f - g - h - e 6060
Furnace: e - h - i - j - k - l - e 6200

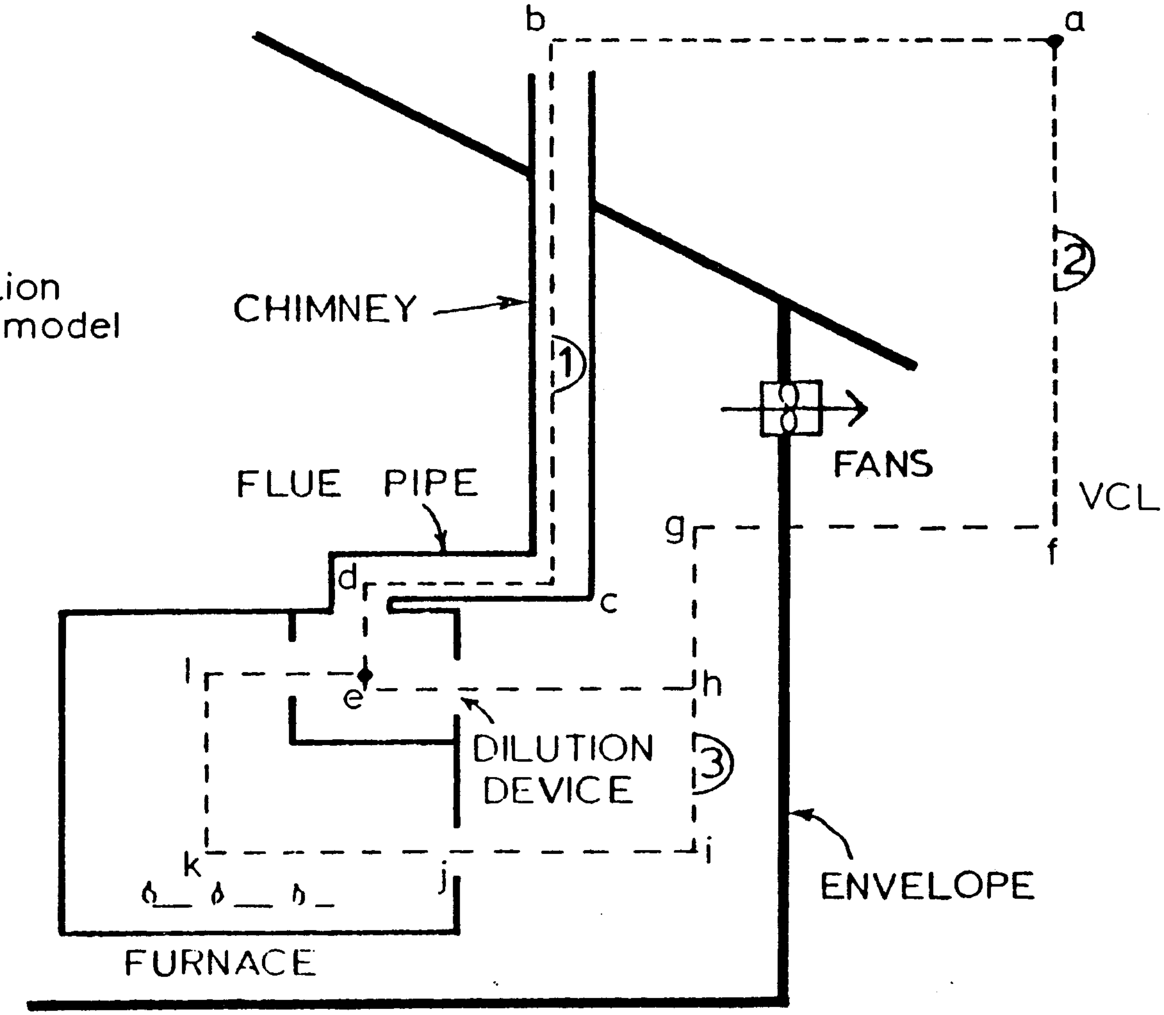
Each circuit has buoyancy pressure gains and friction pressure drops. The chimney- house circuit also has an induced pressure at the chimney top due to wind effects and an envelope pressure drop that is "amplified" by fan and fireplace air requirements that originally pass through the envelope.

CHIMNEY-HOUSE CIRCUIT

ΔP_{CH} = buoyancy rise + induced wind pressure - envelope pressure drop - friction pressure drop in the chimney - friction pressure through the dilution device = 0 (i.e. closed loop)

FIGURE 1.
FLOW MODEL
SCHEMATIC

Note: dashed lines show the 3 calculation paths for the flow model



$$\Delta P_{CH} = -\frac{P_{amb} \times g_c}{R} \times \left(\frac{H_c}{T_c} - \frac{VCL}{T_o} - \frac{(H_c - VCL)}{T_i}\right)$$
$$+ \left(C_{WH} \times \frac{\rho_o V_{WH}^2}{2}\right) + \left(C_{WV} \times \frac{\rho_o V_{WV}^2}{2}\right)$$
$$- \left(\frac{Q_{fan} + Q_{fireplace} + (Q_{chimney} \times \frac{T_o}{T_c})}{C}\right)^{1/n}$$
$$- \frac{474}{T_c}\left(\frac{Q_{chimney}}{ELA_c}\right)^2 - \frac{474}{T_{dil}}\left(\frac{Q_{dil}}{ELA_{dil}}\right)^2 = 0$$

FURNACE CIRCUIT

ΔP_f = buoyancy pressure rise - friction drops through furnace + friction drop through dilution device = 0 (closed loop)

$$\Delta P_f = -\frac{P_{amb} \times g_c}{R} \times \left(\frac{H_f}{T_f} - \frac{H_f}{T_i}\right)$$
$$- \frac{474}{T_i} \times \left(\frac{Q_{furnace}}{ELA_{fi}}\right)^2 - \frac{474}{T_f} \times \left(\frac{Q_{furnace}}{ELA_{fo}}\right)^2$$
$$+ \frac{474}{T_{dil}} \times \left(\frac{Q_{dil}}{ELA_{dil}}\right)^2 = 0$$

Note: In the application of the above equations, a check is made on whether each flow is positive or negative, and the sign of the friction pressure term is changed accordingly. This has to be done because the square of the flow rate in the friction terms negates the effect of the sign of that flow rate.

Symbols

R	-	gas constant of air (287 N · m/kg · K) = (287 Pa · m^3/kg · K)
P_{amb}	-	ambient pressure (Pa)
g_c	-	gravitational constant (m/sec^2)
H_c	-	height of chimney (from dilution device to top) (m)
H_f	-	height of furnace (furnace intake to dilution device) (m)
VCL	-	location of the envelope's Vertical Centre of Leakage (fixed, measured from chimney top)
C_{WH}	-	horizontal wind pressure coefficient
C_{WV}	-	vertical wind pressure coefficient
V_{WH}	-	horizontal component of wind speed (m/s)
V_{WV}	-	vertical component of wind speed (m/s)
ρ	-	density (kg/m^3)
Q_{fan}	-	fan flow rate (m^3/s)
$Q_{fireplace}$	-	fireplace flow rate (m^3/s)
$Q_{chimney}$	-	chimney flow rate (m^3/s)
Q_{dil}	-	dilution device flow rate (m^3/s)
ELA_C	-	equivalent leakage area of chimney (m^2)
ELA_D	-	equivalent leakage area of dilution device (m^2)
ELA_{Fi}	-	equivalent leakage area of furance inlet (m^2)
ELA_{Fo}	-	equivalent leakage area of furnace outlet (m^2)
T_o	-	outdoor temperature (K)
T_i	-	indoor temperature (K)
T_{dil}	-	mixing temperature in dilution device (K)
T_f	-	furnace stack gas temperature (K)
T_c	-	mean gas temperature in the chimney (K)

The equivalent leakage areas, based on a discharge coefficient of 0.611, can be calculated from the actual area "A" and the pressure coefficient of the flow "K" from:

$$ELA = A \times \frac{1.64}{(K)^{1/2}}$$

It will be noted that the proper operation of all systems (no spillage or backdraft) will occur if Q_{dil} is positive. If both sets of parameters are therefore equated to the dilution loss expression, it can be seen that, to meet the above condition, the summation of chimney/house buoyancy, wind, envelope and friction terms must be positive, and the summation of the furnace buoyancy and friction terms must be negative, and equal in magnitude to the result of the chimney/house summation. That is, the furnace must always be a less efficient "chimney" than the chimney/house system. Furthermore, the negative summation of furnace terms indicates that friction terms in the furnace must exceed buoyancy terms - which is only possible if the chimney is inducing additional flow through the furnace, over and above what would occur through its own buoyancy forces.

THERMAL MODEL

All transient thermal equations for each element in the model have been reduced from the equations of page 8 and are written in the universal form:

$$dT_m = \left(\frac{\Delta T_{1m}}{\tau_{in}}\right) \cdot \left(1 - \left(\frac{\Delta T_{m2}}{\tau_{out}}\right) \Big/ \left(\frac{\Delta T_{1m}}{\tau_{in}}\right)\right) \cdot dt$$

where:

dT_m - change in temperature of mass m over time dt
ΔT_{1m} - temperature difference between mass 1 and mass m
ΔT_{m2} - temperature difference between mass m and mass 2
τ_{in} - time constant of heat flowing into the mass
τ_{out} - time constant of heat flowing out of the mass

It is interesting to note that $\left(\Delta T_{1m}/\tau_{in}\right)$ and $\left(\Delta T_{m2}/\tau_{out}\right)$ are the initial rates of temperature change (initial slopes on the temperature versus time curves) for incoming and outflowing heat. When the rates into and out of the mass are equal, the term goes $\left(1-\frac{\text{Rate out}}{\text{Rate in}}\right)$ to zero and there is no change in temperature of the mass. This is the condition of steady-state heat flow, which can be checked in the program to indicate that steady-state flow has been achieved.

Also, when the "Rate-out" is very much smaller than the "Rate-in", that ratio of those terms goes to zero. This indicates that the dynamics of the mass would depend primarily on incoming conditions. In this case, conditions on the other side of the mass do not have an impact on the problem and nodal points on that side of the network can be neglected from the calculation.

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY OF TERMS

airtightness
- the degree to which unintentional openings in the building envelope have been avoided

backdrafting
- a condition where all flow in the flue is downwards and all of the stack gases as well as the outside air flowing down the flue flow out the dilution device

chimney
- a primarily vertical shaft enclosing at least one flue

combustion air
- the air drawn or forced into the combustion chamber of a heating appliance for combustion of the fuel

combustion chamber
- a metal or refractory chamber located within a heating appliance and used to contain the combustion flame

combustion products
- the mixture of suspended particles and gases resulting from the complete and incomplete chemical reactions that take place during combustion of fuel in the presence of air

dilution air
- ambient or room air admitted to a venting system at the dilution device

dilution device

- a device for admitting room air to a venting system to mix with the stack gases for the purpose of controlling the draft at the heating appliance exit
- also referred to as a draft regulator or draft control device
- includes barometric dampers and draft hoods (draft diverters)

draft

- the difference between the pressure at a specific point in an appliance or venting device and the pressure of the ambient air at the same elevation outside the appliance or venting device

excess air

- that portion of the combustion air which is in excess of the amount required for complete (stoichiometric) combustion

flue

- an enclosed conduit for conveying flue gases out of a building
- often referred to as a vent in the context of gas heating

flue gases

- the mixture of stack gases and dilution air

flue pipe

- the conduit connecting the flue collar of a heating appliance to a chimney (This term is usually applied to oil furnaces although the definition of a gas furnace "vent connector" is identical.)

passive ventilation duct

- a vertical or near vertical duct passing through the top storey ceiling and intended to provide ventilation of the interior of the building by exhausting interior air under the influence of buoyancy- and wind-induced pressures without the use of fans
- also referred to as "dummy chimney"

spillage

- flow of stack gases out of the dilution device caused by a condition where flow in the flue is upwards but not of sufficient magnitude to remove all of the stack gases

stack gases

- the mixture of combustion products and excess air in its state as it leaves the heating appliance but before the introduction of dilution air

vent connector

- that part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device

APPENDIX B

PROGRAM LISTING

```
5     ' FLUE SIMULATOR DYNAMIC ANALYSIS PROGRAM   VERSION 4.1   6/87
6     ' BY SCANADA CONSULTANTS LIMITED
7     '
8     ' DEVELOPED BY  M.C. SWINTON     1985, 1986, 1987
9     '               M.D. MONETTE     1985
10    '               R.P. SINHA       1986, 1987
11    '               S.J. BORZA       1986
12    '               J.C. HAYSOM      1986, 1987
13    '               C.J. MACLARNON   1987
14    '
19     DEFINT J
20     DIM TN(20),TI(5,15),TF(5,15),RO(20),KE(20),HT(20),FPAR(10),AR(20)
         ,PAR(20),PB(20),ELA(10),VQ(20),FPDI2(5),CHDI2(5),FPHC(5),CHHC(5
         ),PRISE(5),PRUUN(5),DHF(15),DIA(5,15)
25     DIM FLENME$(100),DEW(15)
27     DIM CPWENV(5),ARD(5),HD$(13),ANDNO%(4),PATTRN%(4)
30     DIM MF(20),VF(20),VL(20),DI(20),U(5,15),A(5,15),M(5,15),EH(20),HC
         (5,15),OO(20),FM(20),FF(20),TW(5),DI2(5,15),CHM$(10),RISE(5),FP
         LN(5),ELTL(15),ELTS(15),ELTO(15),DENL(15),DENS(15),DENO(15),THC
         L(15),THCS(15),THCO(15),ELHT(20)
35    '
37     DIM N$(300),GTOUT(20),GPOUT(20),GFOUT(20),YNEW(5),YOLD(5),LT(5),Y
         $(3),TIT$(5),TTI$(12),PTI$(13),FTI$(12),TISET$(12)
38     DIM WCOEFH(6),WCOEFV(6),TIDHW(5,2),TFDHW(5,2)
39     DIM BOX%(10),TRI%(10),CIR%(10),DIAMND%(10)
40     COMMON TN(),TI(),TF(),RO(),KE(),HT(),FPAR(),AR(),PAR(),PB(),ELA()
         ,VQ(),FPDI2(),CHDI2(),FPHC(),CHHC()
50     COMMON MF(),VF(),VL(),DI(),U(),A(),M(),EH(),HC(),OO(),FM(),FF(),T
         W(),DI2(),CHM$(),ELHT(),SCSFLAG%,ENTRY%,PCODE%,TLFLAG%,RISE(),F
         PLN(),ELTL(),ELTS(),ELTO(),DENL(),DENS(),DENO(),THCL(),THCS(),T
         HCO()
60     COMMON MFIPOT,K1,UI,MU,CPAIR,GC,PIE,TA,GE,XD,VH,VV,PHC,PVC,DHF(),
         HF,PELHT,HH,DF,ADR,F$,FW,FANM,FIRM,MCOMP,Z1,Z2,U2AR,ER1,ER2,ER3
         ,ER4,X1,X2,X3,X4,Q6,GF
70     COMMON FT$,MASTER%,PRFLAG%,PRFLAG2%,C1,C2,TT$,Z$,P$,GD$,U1A,U2A,Q
         2,Q9,DOC$
75     COMMON FL1%,FL2%,P1%,P2%,P3%,P4%,TMP1%,TMP2%,TMP3%,TMP4%,THS,TMON
         OFF,FR1%,FR2%,FR3%,FR4%
80     COMMON  APRD,FICV,TCF2,F2,F1,SSEFF,TSSGE,CHIMT$,CHBOT,XPT,UF
90     COMMON  NE%,NELBOWS,NFPSEGS%,TFPLN,LNPP,LHC,C,N,T1,T9,VWIND,T6F,T
         MF,T7F,SCS,SEC,FS,AUFF,ST,PRFF$,PRCOND$,PRREG$,TITLE$,MOHE,HCHE
         ,M2CP,QF,FP,VWINDH,VWINDV,THETAW,PTC,VWINDT
91     COMMON FPELTL,FPELTS,FPELTO,FPDENL,FPDENS,FPDENO,FPTHCL,FPTHCS,FP
         THCO
92     COMMON CHELTL,CHELTS,CHELTO,CHDENL,CHDENS,CHDENO,CHTHCL,CHTHCS,CH
         THCO
93     COMMON EXAIR,MTFUEL,OU$,DIA(),DB,VCL,CC,RISET,ARINT,VCLINT,NELINT
         ,LEAKDIST,FLUEIN$,ICHTYPE%,COUNT%,FLENME$(),DRIVE$,HMASS$,MDI$,
         HVOL,HHC,HTC,DP0,CONST,ONTIME,DEW()
94     COMMON ELADHW,DHWC,DHWSBC,DHWEF,DHWAR,DHWFPLE,DHWFPH,DHWNEL,DHWTY
         PE$,DHWFPN,DHWO$,NDHWFP%,TDHW,MDHW,TIDHW(),FDAMP$,ARDAMP,FCAPNO
         ,WCOEFH(),WCOEFV(),FCAPL,DAMPACT$,DAMPTOP,DAMPTCL
97     TGYP=T9-(T9-T1)*(.12/2.1)     :
```

```
          FLUEDP=54! :
          ROOMDP=6!
98       CPWENV(1)=.7 :
          CPWENV(2)= -.5 :
          CPWENV(3) = -.7 :
          CPWENV(4) = -.3  :
          CPWENV(5) = 0!
99       FOR I% = 2 TO 5 :
              ARD(I%)=AR(I%) :
         NEXT
101      MASTER%=1234
102      ON ERROR GOTO 29000
103      PT=100:
          DIAMND%(0)=8:
          DIAMND%(1)=9:
          DIAMND%(2)=14352:
          DIAMND%(3)=-388:
          DIAMND%(4)=14460:
          DIAMND%(5)=16
104      TRI%(0)=7:
          TRI%(1)=4:
          TRI%(2)=14352:
          TRI%(3)=-388
105      CIR%(0)=9:
          CIR%(1)=9:
          CIR%(2)=0:
          CIR%(3)=0:
          CIR%(4)=28:
          CIR%(5)=127:
         CIR%(6)=-32513:
         CIR%(7)=127:
         CIR%(8)=28:
         CIR%(9)=0
106      BOX%(0)=6:
          BOX%(1)=3:
          BOX%(2)=-772:
          BOX%(3)=252 :
          BOX%(4)=0
107      OPEN OU$ FOR OUTPUT AS #2
108      PRINT #2, CHR$(15)
109      WIDTH #2,255
110      IF DHWC = 0 AND DHWSBC = 0
            THEN DHW$="N"
            ELSE DHW$="Y"
111      IF DHWTYPE$ = "Y"
            THEN KECON = 1.5
112      IF DHWTYPE$ = "T"
            THEN KECON = 2.5
113      IF DHWTYPE$ = "B"
            THEN KECON = 2.5
120      IF PRFLAG2%=5678
            THEN GOSUB 18500:
                  GOTO 3000
```

```
122     PRFLAG2%=0
125     '
158     '
170     CLS:
        PRINT:
        PRINT" EXECUTION OF THE  FLUE SIMULATOR  PROGRAM"
180               PRINT" -----------------------------------------"
190     T=TIMER :
         WHILE TIMER < T+1 :
         WEND
310     IF F1 = 0
           THEN F1=.000001
320     MFIPOT=0!
330     IF FT$="O" AND AR(15) > 0.001
           THEN MFIPOT=4
340     K1=.1
350     UI = 5*1.8 :
        UF = 5 *1.8
360     MU = .0000184
370     CPAIR = 1035
380     GC = 9.8
390     PIE=3.141593
400     TA = 273.15
410     GF = 0
420     XD = 0
421     YDEW=0
426     ONTIME=0
427     FOR Y%=1 TO NE%
428         DEW(Y%)=0
429     NEXT
430     CLS
440     RISET=ABS(CHBOT-HT(5))
441     ELAENV= 1.157 * ((353.6/(T1+TA)) ^ .5) * C * ((10) ^ (N - .5))
442     KEINT=(NELINT*1)+2.69+1
443     ELAINT=ARINT*1.64/SQR(KEINT)
444     VCL=((LNPP*ELAENV)+(VCLINT*ELAINT))/(ELAENV+ELAINT)
445     ELAENV=ELAENV+ELAINT
446     CC=ELAENV/((10^(N-.5))*1.157*(353.6/(T1+TA))^.5)
448     HT(8)=VCL :
        HT(9)=VCL
470     PRINT #2, "MODEL OF THE TRANSIENT PERFORMANCE OF FURNACE & FLUE I
          N NON-DESIGN FLOW CONDITIONS"
480     PRINT #2, "==================================================
          =========================="
490     PRINT #2, :
         PRINT #2, "PROGRAM DEVELOPED BY:  SCANADA CONSULTANTS LIMITED"
500     PRINT #2, "                      FOR:  CANADA MORTGAGE AND HOUSING COR
          PORATION"
510     PRINT #2, "                     DATE:  1984 - 1987"
520     PRINT #2, "==================================================
          =========================="
530     PRINT #2, :
         PRINT #2,
```

```
540     GOTO 1580
550     REM
1000    REM===========================================================
1010    REM                       TABLE OF CONTENTS
1020    REM===========================================================
1022    GOTO 2000 '-INITIALIZATION OF VARIABLES
1025    GOTO 3000 '-EXECUTION CONTROL
1030    GOTO 4000 '-FRICTION FACTORS AND ELA's OF THE SYSTEM
1040    GOTO 4500 '-INITIAL TEMPERATURE PROFILES FOR FLUE AND GAS FLOW N
          ETWORK
1050    GOTO 5000 '-MASS FLOW SUBROUTINE
1060    GOTO 6000 '-CALCULATION OF PRESSURE PARAMETERS
1070    GOTO 7000 '-FURNACE TRANSIENT HEAT TRANSFER ROUTINE
1080    GOTO 8000 '-SPECIFICATION OF ELEMENTAL PROPERTIES OF THE FLUE &
          FURNACE
1090    GOTO 9000 '-FLUE TRANSIENT HEAT TRANSFER ROUTINE
1100    GOTO 10000 '-FURNACE MASSFLOW CALCULATION
1105    GOTO 10500 '-MATH MODULE
1110    GOTO 11000 '-PARAMETER ANALYSIS AT FURNACE STARTUP
1120    GOTO 12000 '-TEMPERATURE UPDATE ROUTINE
1130    GOTO 12500 '-FLUE FILM HT. TRANSFER COEFFICIENT AND FRICTION FAC
          TORS
1140    GOTO 13000 '-OUTPUT ROUTINE TO PRINT TEMPERATURES OF FLUE ELEMEN
          TS
1150    GOTO 14000 '-FLOW NETWORK PARAMETER ROUTINE
1160    GOTO 15000 '-PHYSICAL CHARACTERISITCS OF THE SYSTEM
1170    GOTO 16000 '-GUIDE TO IDENTIFY NETWORK POINTS
1180    GOTO 17000 '-SUMMARY TABLE OUTPUT
1190    GOTO 18000 '-LINE SUMMARY OUTPUT FOR EACH CALCULATION INTERVAL
1200    GOTO 18500 '-HEADINGS FOR LINE SUMMARY
1220    GOTO 19000 '-FURNACE TURN-OFF INDICATOR
1230    GOTO 19500 '-FURNACE TURN-ON
1245    GOTO 20000 '-OUTPUT GRAPHICS ROUTINE
1250    GOTO 22000 '-DYNAMIC MODEL OF THE HOUSE ENVELOPE, WITH THERMOSTA
          T CONTROLS
1255    GOTO 22500 '-CODENSATION POTENTIAL MODULE
1257    GOTO 23000 '-HOT WATER HEATER BRANCH FLOW MODULE
1260    REM===========================================================
1270    REM
1500    REM===========================================================
1510    REM
1520    REM    BOUNDARY CONDITIONS AND INITIAL CONDITIONS TO START THE I
          TERATIONS
1530    REM
1540    REM===========================================================
1550    REM
1560    REM    BOUNDARY CONDITIONS
1570    REM
1580    IF THETAW = 0
           THEN PVC=1:
                 GOTO 1590
1583    IF THETAW < 0
           THEN SN = -1
```

```
        ELSE SN = 1
1585  PVC = SN * (PTC-PHC*(COS(THETAW*PIE/180!)^2))/(SIN(THETAW*PIE/180
        !)^2)
1590  VH = VWINDT * COS(THETAW*PIE/180!)
1600  VV = VWINDT * SIN(THETAW*PIE/180!)
1605  TFLEN=0
1610  FOR I%=1 TO NFPSEGS%:
          DHF(I%)=FPLN(I%):  SEGMENT LENGTH = FPLN
          TFLEN=TFLEN+DHF(I%):  TOTAL FLUE LENGTH =
      NEXT I%
1620  HF=CHBOT:
      PELHT=HF+3*HF/8
1630  HH=ABS(HT(19)-HT(15))
1644  FOR Y%=1 TO NE%
1645      IF Y% > NFPSEGS%
             THEN DHF(Y%)=HF/8:
                  TFLEN=TFLEN+DHF(Y%):
                  GOTO 1647
1646      DIA(1,Y%)= (2*SQR(AR(5)/PIE)) :
          GOTO 1648
1647      DIA(1,Y%)= (2*SQR(AR(2)/PIE))
1648      DI2(1,Y%)=(DIA(1,Y%)*PIE):
      NEXT Y%
1660  FOR ZZ%=1 TO NE%:
          ELHT(ZZ%)=PELHT-HF/8:
          PELHT=ELHT(ZZ%):
      NEXT ZZ%
1670  REM
1700  REM
1710  REM   PHYSICAL DATA IS READ IN
1720  REM
1730   GOSUB 4000          FP's, ELA's
1740   IF Z$ = "N"
         THEN  GOTO 1760
1750   GOSUB 15000  PHYSICAL CHARACTERISTICS
1760  REM
1770  REM   INITIAL TEMPERATURE PROFILES ARE READ IN
1780  REM
1790   GOSUB 4500
1800  REM
1810  REM   FIRING RATES OF THE FURNACE: F1 - STANDBY (PILOT)
1820  REM                                F2 - FULL FIRING RATE
1830  REM
1840  F$ = "NOT"
1850  FW=F1
1860   GOSUB 10020
1870  REM
1880  REM   COMPETING FANS & FIREPLACE CHIMNEY FLOWS
1890  REM
1900  FANM = (QF * RO(9)) / 1000
1910  FIRM = (FP * RO(9)) / 1000
1920  MCOMP = FANM + FIRM
1930  REM
```

```
2000   REM ==============================================================
2010   REM
2020   REM  INITIAL CONDITIONS FOR THE ITERATIVE PROCESS
2030   REM
2040   REM==============================================================
2050   REM
2060    GOSUB 8000
2070    GOSUB 9510
2080    Q6 = .022
2090    Q9 = .001
2095    IF AR(11) =< .005
           THEN Q6=.005:
                 Q9=.0051
2097    Q6LAST=Q6:
         Q9LAST=Q9
2100    IF FT$="G"
           THEN GOTO 2120
2110    IF F$="ON"
           THEN Q9=0
2120    Q1 = .026:
        ER1 = 2
2130    X3 = .01 :
        ER3 = 2
2135    IF FL1%=1 AND ST <= 60
           THEN SEC=.1
2140    SCS = SCS - SEC
2145    THS=T9+(TMONOFF/2)
2146    T9=THS-TMONOFF
2150    Z1 = Z2 - 1
2160    IF Z$ = "Y"
           THEN  GOTO 2180
2170    GOSUB 18500
2180    CLS
2185    IF FL1%=1
           THEN LOCATE 12,32:
                COLOR 15,0:
                PRINT "  CALCULATING   ":
                LOCATE 12,32:
                COLOR 31,0:
                PRINT "!":
                LOCATE 12,46:
                PRINT "!":
                LOCATE 14,32:
                COLOR 15,0:
                PRINT "  PLEASE WAIT":

           ELSE 3000
3000   REM:=============================================================
3010   REM
3020   REM  :     S T A R T   O F  E X E C U T I O N   L O O P
3030   REM
3040   REM==============================================================
3050   REM
```

MAIN ROUTINE

```
3060   FOR S% = 1 TO 20002
3065       IF S% > 20000
              THEN S% = 11
3070       SCS = SCS + SEC
3075       IF FL1%=1
              THEN 3100
              ELSE 3080
3080       CLS
3090       LOCATE 1,1 :
            PRINT USING"TIME =######.#  (s)   TIME STEP = #.### (s)";S
             CS;SEC
3100       Z1 = Z1 + 1
3110       IF SCS >  = FS AND F$ = "NOT"
              THEN F$ = "ON":
                   Z1 = 0:
                   S%=1:
                    GOSUB 19500
3112       IF F$="ON"
              THEN ONTIME=ONTIME+SEC
3150       U2A=U2AR
3160       IF TMF < 120
              THEN U2A=U2AR*.58
3170       IF F$="OFF" AND TMF < 125
              THEN U2A=U2AR*.58
3180       ITER=0
3185       IF S% < 5 AND AR(11) > .005
              THEN GOSUB 10500
3190       IF FT$="G"             FURNACE TYPE: INDICATOR
              THEN GOTO 3210
3200       IF F$="ON"
              THEN Q9=0
3202      REM
3204      REM  SUBROUTINES 5000, 6000:  CALCULATION OF MASS FLOWS USI
            NG "CONTINUITY", PRESSURES USING BERNOULLI +
3206      REM
3210       GOSUB 5000
3220       GOSUB 6000
3230      REM
3240      REM        CONVERGENCE ROUTINES
3250      REM
3260       ITER=ITER+1
3270       C1 = PB(5) + PB(10)       PRESSURE PARAMETERS
3280       IF ABS(C1) > 1E+11
              THEN Q9=.002:
                    X3 = .003 :       CHECKS FOR
                    ER3=.16 :       <- ERROR IN MASS FLOW
                    Q6=.02 :
                    Q1=.026 :
                    ER1=.2 :
                    GOTO 3190
3290       IF  ABS (C1) < .001
              THEN GOTO 3390
3300       IF ITER > 100
```

```
            THEN PRINT #2,"*** ITERATION CONVERGENCE PROBLEMS -- FLO
              W RATES OF LAST TIME STEP USED":
                  GOTO 3520
3310      Q2 = Q6:
          ER2 = C1
3320      IF ER1 = ER2
             THEN Q9=.002:
                   X3 = .003 :
                   ER3=.16 :
                   Q6=.02 :
                   Q1=.026 :
                   ER1=.2 :
                   GOTO 3190
3340      Q6 = (Q2 * ER1 - Q1 * ER2) / (ER1 - ER2)
3350     REM:  IF ITER > 50 THEN  Q6 = (Q6 + 1.2 * Q2) / 2.2
3355      IF FL1%=1
             THEN 3370
             ELSE 3360
3360     REM PRINT USING"##. FLUEFLOW (Kg/S) AND ERRFUNCTION (PA) =
            #.####  #.#### ###.###";ITER,Q2,MDHW,ER2
3370      Q1 = Q2:
          ER1 = ER2
3380      GOTO 3190
3390      C2 = PB(9) - PB(10)
3400      IF ABS(C2) > 1E+11
             THEN Q9=.002:
                   X3 = .003 :
                   ER3=.16 :
                   Q6=.02 :
                   Q1=.026 :
                   ER1=.2 :
                   GOTO 3190
3410      IF  ABS (C2) < .001
             THEN GOTO 3520
3420      ER4 = C2:
          X4 = Q9
3430      IF ER3 = ER4
             THEN Q9=.002:
                   X3 = .003 :
                   ER3=.16 :
                   Q6=.02 :
                   Q1=.026 :
                   ER1=.2 :
                   GOTO 3190
3440      Q9 = (X4 * ER3 - X3 * ER4) / (ER3 - ER4)
3445      IF FL1%=1
             THEN 3460
             ELSE 3450
3450     REM PRINT USING"##. FURN INLET FLOW (Kg/S) AND ERRFUNCTION
            (PA) = #.####  ###.###";ITER,X4,ER4
3460      X3 = X4:
          ER3 = ER4
3470     REM
```

```
3480       GOTO 3190
3490      REM
3500      REM         END OF CONVERGENCE ROUTINE
3510      REM
3520       Q6LAST=Q6 :
            Q9LAST = Q9 :
            DHWLAST = MDHW
3525      REM
3530      REM         OUTPUT OF CALCULATION RESULTS
3540      REM
3545       GOSUB 18000
3550       IF SCS >= ST
              THEN GOSUB 3750 :
                    GOTO 3670
3552       IF TMONOFF<>0
              THEN GOSUB 3800 :
                    GOTO 3640
3560       IF SCS >= AUFF AND F$= "ON"
              THEN F$="OFF":
                   Z1=0:
                   S%=1:
                    GOSUB 19000
3640       GOSUB 7000
3650       GOSUB 9000
3653       IF DHW$ = "Y"
              THEN GOSUB 24000
3655       GOSUB 22500
3660       ABORT$=INKEY$:
            IF ABORT$="A" OR ABORT$="a"
              THEN GOTO 3670
3662   NEXT S%
3663  REM
3664  REM============================================================
3665  REM      E N D   O F   E X E C U T I O N   L O O P
3666  REM ============================================================
3667  REM
3670   BEEP:
       SCSFLAG%=1:
       IF FL1%=1
          THEN GOSUB 3675
          ELSE 3671
3671   CLOSE #2:
       CLS:
       LOCATE 20,60:
       COLOR 19,0:
       PRINT"Please Standby":
       COLOR 7:
       CHAIN FLUEIN$ :
      REM ,30000,ALL
3672   END
3673  REM  PRINTOUT CONTROL SUBROUTINES
3674  REM  SCREEN GRAPHICS PRINT OPTION
3675   LOCATE 1,13:
```

```
        PRINT "Press 'P' for PRINT, 'S' for SAVE"
3676    LOCATE 2,13:
        IF SCS>=ST
           THEN PRINT "'E' for EXIT                    "
           ELSE PRINT "'E' for EXIT or 'C' to CONTINUE"
3677    JUNK$=INKEY$:
        IF JUNK$=""
           THEN 3677
3678    IF JUNK$="E" OR JUNK$="e"
           THEN 3696
           ELSE 3679
3679    IF JUNK$="P" OR JUNK$="p"
           THEN JUNK$="P" :
                 GOTO 3690
           ELSE 3680
3680    IF JUNK$="S" OR JUNK$="s"
           THEN 3690
           ELSE 3681
3681    IF JUNK$="C" OR JUNK$="c"
           THEN 3682
           ELSE 3677
3682    LOCATE 1,13:
        PRINT "                                "
3683    LOCATE 2,13:
        PRINT "                                "
3684    GOTO 3662
3690    LOCATE 1,13:
        PRINT USING"\                                   \";TITLE$
3692    LOCATE 2,13:
        PRINT USING"DATE: \                         \";DATE$
3693    IF JUNK$="P"
           THEN CALL PRTSC   :
                 GOTO 3696 :
                REM:  ASM=-51973.8
3694    CHK$=".":
         LOCDOT=INSTR(DOC$,CHK$):
         FAULT$=LEFT$(DOC$,LOCDOT-1) :
          REM:  PRTSCR%=VARPTR(ASM)
3695    DEF SEG=&HB800 :
         BSAVE DRIVE$+FAULT$+".PIC",0,16384 :
         DEF SEG :
                  REM:  CALL ABSOLUTE(PRTSCR%)
3696    CLS:
        SCREEN 0,0:
        RETURN
3750   REM:  FINAL SYSTEM PRINTOUTS
3754    GOSUB 15000
3756    GOSUB 13000
3758    GOSUB 14000
3760    GOSUB 17000
3762    RETURN
3800   REM      CONTROL OF DYNAMIC HOUSE ANALYSIS
3802    IF T9>THS AND F$="ON"
```

```
            THEN 3804
            ELSE 3806
3804    F$="OFF":
        RNGTM=0:
        OFTIM=SCS:
        Z1=0:
        S%=1:
        GOSUB 19000
3806    GOSUB 22010
3830    RETURN
4000   REM==========================================================
4010   REM
4020   REM          FRICTION FACTORS AND ELA's OF THE SYSTEM
4030   REM
4040   REM==========================================================
4050   REM
4060   REM          FLOW FRICTION FACTORS
4070   REM
4080   FOR X% = 1 TO 19
4090        READ KE(X%)
4100   NEXT X%
4110    DATA  0,1.,1.4,1.0 ,0.5,0,0,0,0,0,4.0,0,0,0,3.0,0,0,2.0,0
4120    KE(2)=FCAPL
4125    KE(4)=(NELBOWS*.5)
4130   REM
4140   REM
4150   REM
4160    ADR = AR(11) * APRD / 100
4170   REM
4180   REM   E Q U I V A L E N T   L E A K A G E   A R E A S
4190   REM
4200   REM    1 - CHIMNEY ELA
4210   REM    2 - DILUTION PORT ELA (DESIGN FLOWS)
4220   REM    3 - DILUTION PORT ELA (REVERSE FLOW)
4230   REM    4 - FURNACE INLET ELA
4240   REM    5 - FURNACE OUTLET ELA
4250   REM    6 - FLUE-PIPE ELA
4260    ELA(1) = ARD(3)* ((2.68 / (KE(3) + KE(2))) ^ .5)
4270    ELA(2) = (AR(11) * ((2.68 / KE(11)) ^ .5)) :
       REM  +(DHWAR*((2.68/3.68)^.5))
4280    ELA(3) = (ADR    * ((2.68 / KE(11)) ^ .5)) :
       REM  +(DHWAR*((2.68/3.68)^.5))
4290    ELA(4) = AR(15) * ((2.68 / KE(15)) ^ .5)
4300    ELA(5) = AR(18) * ((2.68 / KE(18)) ^ .5)
4305    ELA(6) = ARD(5)* ((2.68 / (KE(4) + KE(5))) ^ .5)
4306    ELADHW = DHWAR*((1-.096)^2) * ((2.68 / (.45*DHWNEL + 1! + KECON))
          ^ .5)
4310    RETURN
4500   REM==========================================================
4510   REM
4520   REM          INITIAL TEMPERATURE PROFILES FOR FLUE
4530   REM                 AND GAS FLOW NETWORK
4540   REM
```

```
4550  REM=============================================================
4560  REM
4570  REM
4580  REM
4590  REM
4600  REM
4610  REM         CHIMNEY STRUCTURE & SURROUNDINGS TEMPERATURES
4620  REM
4640  FOR X% = 1 TO NE%
4650       TI(5,X%) = T1:
           IF X%<(NFPSEGS%+1)
              THEN TI(5,X%)=T9:
                   GOTO 4662
4660       IF ELHT(X%)>(XPT+HF/16) AND X%<NE%
              THEN TI(5,X%)=T9
4662       IF SCSFLAG%=1
              THEN GOTO 4680
4664       IF ELHT(X%)<(XPT+HF/16) OR  X%=NE%
              THEN GOTO 4680
4670       TI(4,X%) = TI(5,X%):
           IF TI(3,X%) < TI(4,X%)
              THEN TI(3,X%)=TI(4,X%):
                   TI(2,X%)=TI(3,X%)
4680  NEXT X%
4690  FOR X% = 1 TO NE%
4700       IF X%<(NFPSEGS%+1)
              THEN EH(X%)=RISE(X%):
                   GOTO 4720
4710       EH(X%)=(HF/(NE%-NFPSEGS%))
4720  NEXT X%
4730  REM
4740  REM COMPUTE DENSITY TERMS FOR GAS FLOW NETWORK POINTS(19)
4750  REM
4760  FOR X% = 1 TO 19
4765       IF X% = 2 OR X% = 3
              THEN RO(X%)=353.6/(TT+TA) :
                    GOTO 4780
4770       RO(X%) = 353.6 / (TN(X%) + TA)
4780  NEXT
4790   RETURN
5000  REM ============================================================
5010  REM
5020  REM            MASS FLOW  SUBROUTINE
5030  REM
5040  REM ============================================================
5050  REM
5060  REM            CALCULATION OF MASS PARAMETERS
5070  REM
5075   IF ITER > 99
         THEN Q6=Q6LAST :
               Q9=Q9LAST :
               MDHW = DHWLAST :
               IF Q9 = 0
```

```
                THEN Q9=Q6
5080   MF(6) = Q6
5090   MF(19) = Q9 + MTFUEL
5092   IF DHW$="N"
          THEN MDHW = 0 :
                TDHW=T9 :
                GOTO 5100
5095   IF ABS(C1) < .001
          THEN GOSUB 23000 :
                MDHW = (.3*MDHW +.7*DHWLAST):
               REM  - THE HOT WATER BRANCH
5100   FOR X% = 1 TO 3
           MF(X%) = MF(6)+MDHW
5120   NEXT
5125   MF(4) = MF(6) :
        MF(5)=MF(6)
5130  REM
5140   FOR X% = 10 TO 12
           MF(X%) = MF(6) - MF(19)
5160   NEXT
5170  REM
5180   FOR X% = 13 TO 14
           MF(X%) = MF(19) - MTFUEL
5200   NEXT
5210   MF(15)=MF(19)-MTFUEL
5220  REM
5230   FOR X% = 16 TO 18
           MF(X%) = MF(19)
5250   NEXT
5260  REM
5270   FOR X% = 7 TO 9
           MF(X%) = MF(10) + MF(13) + MCOMP + MDHW
5290   NEXT
5300  REM
5310   FOR X% = 1 TO 19
           VF(X%) = MF(X%) / RO(X%)
5330   NEXT
5340  REM
5350  REM
5360  REM:------VELOCITIES--------
5370  REM
5380   FOR X% = 1 TO 19
5390       IF AR(X%) < .0004
              THEN VL(X%) = 0 :
                    GOTO 5410
5400       VL(X%) = VF(X%) / AR(X%)
5405       IF X%>1 AND X% < 6
              THEN VL(X%)=VF(X%)/ARD(X%)
5410   NEXT X%
5420   IF VF(11) < 0
          THEN VL(11) = VF(11) / ADR
5430   RETURN
6000  REM===========================================================
```

$T_N \doteq$ TEMP OF EACH NETWORK PT

$T_A = 273$ (KELVINS @ 0°C)

TT = UTILITY TO OUTPUT MEAN FLUE TEMP

$$\cancel{PB1 = 353.6\,GC\left(\left(\left(HF + RISET + |HT_6 - HT_5| - |VCL|\right)\right)\right.}$$

$$PB_1 = \frac{353.6}{GC}\left(\left\{\frac{HF + RISET + |HT - HT_5| - |V_{CL}|}{TN_9 + T_A \text{ (KELVINS)}}\right\}\right.$$

$$\left. + \frac{|V_{CL}|}{TN_1 + T_A} - \frac{H_F + RISE_T}{TT + TA} - \frac{|HT_6 - HT_5|}{TN_6 + T_A}\right)$$

```
6010  REM
6020  REM                    CALCULATION OF PRESSURE PARAMETERS
6030  REM
6040  REM==============================================================
                                                    RISET= Connector
                                                           Rise
6050  REM
6060  REM   LOOP #1:   FLUE PIPE - VENT OR CHIMNEY - CAP - OUTDOORS - E
        NVELOPE - INDOORS DOWN TO DILUTION DEVICE------
                                                       GC=g
6070  REM                                              HF= Ch.Ht.
6080   ELA(1) = ARD(3)* ((2.68 / (KE(3) + KE(2))) ^ .5)
6085   ELA(6) = ARD(5)* ((2.68 / (KE(4) + KE(5))) ^ .5)
6090   TT = ((353.6 * GC * (HF +RISET)) / GF) - TA       OUTPUTS MEAN FL.TEMP
6100   PB(1) = (353.6 * GC * (((HF + RISET + ABS(HT(6)-HT(5)) - ABS (VC
        L )) / (TN(9) + TA)) + (ABS (VCL) / (TN(1) + TA)) - ((HF + RIS
        ET) / (TT + TA)) - (ABS(HT(6)-HT(5)) / (TN(6) + TA)))
6110   SN = 1:  WIND
        IF VV < 0
          THEN SN = 0 - 1
6120   PB(2) = (((PHC+CPWENV(LEAKDIST)) * .5 * RO(1) * (VH ^ 2)) + (SN *
          PVC * .5 * RO(1) * ( ABS (VV) ^ 2)))  WIND
6130   SN = 1:
        IF MF(8) < 0
          THEN SN= 0 - 1
6140   PB(3) = 0 - SN * ((( ABS (MF(8)) / RO(8)) /CC) ^ (1 / N))
6150   IF VF(4) >= 0
          THEN  SNFP=1
          ELSE  SNFP =-1
6160   SN = 1:
        IF VF(3) < 0
          THEN SN = 0 - 1
6170   PB(4) = 0 -(SN * (473.8 / (TT + TA)) * (( ABS (VF(3) / ELA(1)) ^
         2))) -(SNFP * (473.8 /(TN(5)+TA)) * (( ABS (VF(4) / ELA(6)) ^ 2
         )))
6172   IF MDI$="Y" AND F$="ON"
          THEN PB(11)=((CONST * VF(5)^2) + DP0)
          ELSE PB(11)=0 :
               REM:  DRAFT INDUCER
6180   PB(5) = PB(1) + PB(2) + PB(3) + PB(4) + PB(11)
6190  REM
6200  REM  LOOP #2:  OUTSIDE FURNACE -FURNACE INLET - UP THROUGH FURNAC
         E - OUT TO MIXING AREA IN DILUTION DEVICE-------
6210  REM
6220   TEF = (2 / ((1 / (TN(16) + TA)) + (1 / (TN(17) + TA)))) - TA
6230   PB(6) = (353.6 * GC * ((HH / (TN(9) + TA)) - ((HH +(HT(19)-HT(18)
         )) / (TEF + TA)) + ((HT(19)-HT(18)) / (TN(19) + TA))))
6240   SN = 1
6250   IF VF(15) < 0
          THEN SN = 0 - 1
6260   IF FT$="G"
          THEN GOTO 6280
6270   IF F$="ON"
          THEN GOTO 6290
6280   PB(7) = 0 - SN * (473.8 * ((ABS (VF(15)) / ELA(4)) ^ 2) / (TN(15)
          + TA))
```

```
6290   PB(8) = 0 - SN * (473.8 * ((ABS (VF(18)) / ELA(5)) ^ 2) / (TN(18)
          + TA))
6300   PB(9) = PB(6) + PB(7) + PB(8)
6310  REM
6320  REM      CLOSING LOOPS #1 & #2  THROUGH THE DILUTION DEVICE
6330  REM
6340   SN = 1:
       II = 2
6350   IF VF(11) < 0
          THEN SN = 0 - 1:
               II = 3:
               GOTO 6360
6355   IF FT$="O" AND AR(11) > 0.005
          THEN KBD=7*(1-EXP(-VF(11)/.01)):
               ELA(2)=AR(11)*((2.68/KBD)^.5)
6360   PB(10) = 0 - SN * (473.8 * (( ABS (VF(11)) / ELA(II)) ^ 2) / (TN(
         11) + TA))
6370   IF FT$="G"
          THEN GOTO 6410
6380   IF F$ <> "ON"
          THEN GOTO 6410
6390   PB(9)=PB(10)
6400   PB(7)=PB(9)-PB(8)-PB(6)
6410   RETURN
7000  REM ==========================================================
7010  REM
7020  REM       FURNACE TRANSIENT HEAT TRANSFER MODEL
7030  REM
7040  REM ==========================================================
7050  REM
7060   TN(16) = T9 + (FW  / (CPAIR * ABS (MF(16)+0.0000001)))
7070   M6 = 0.85*FICV * (353.6 / (T6F + TA))
7080   IF TN(16) > 3000
          THEN TN(16) = 3000:
                PRINT #2, "WARNING: INSUFFICIENT FURNACE AIR FLOW -- INC
                 OMPLETE COMBUSTION"
7090   INDT% = 3
7100   ITW =(M6*CPAIR + MFIPOT*500) /  ABS ((MF(16)+0.000001)*CPAIR):
       OTW= (M6 * CPAIR + MFIPOT*500) / U1A
7110   D1TM = TN(16) - T6F:
       D2TM = T6F - TMF:
        IF VL(18) < 0
          THEN D1TM = TN(17) - T6F
7115   D3TM=0! :
        ITDHW=10000!
7120    GOSUB 12020
7130   D6F = T6F + DTM
7140   INDT% = 2:
       ITW = M2CP / U1A:
       OTW = M2CP / U2A
7150   D1TM = T6F - TMF:
       D2TM = TMF - T9
7155   D3TM=0! :
```

```
         ITDHW=10000!
7160     GOSUB 12020
7170    TMF = TMF + DTM
7180    M7 = .15 * FICV * RO(17)
7190    INDT% = 3
7200    ITW = M7 /  ABS (MF(17)+0.0000001):
        OTW= M7 * CPAIR / ABS(MF(17)+0.0000001)
7210    D1TM = T6F - TN(17):
        D2TM = 0:
         IF VL(17) < 0
           THEN D1TM = TN(6) - TN(17)
7215    D3TM=0! :
         ITDHW=10000!
7220     GOSUB 12020
7230    T7F = TN(17) + DTM
7240    T6F = D6F
7250    TN(17) = T7F
7260    TN(18) = TN(17)
7270   REM
7280   REM
7290   REM
7300    IF MF(6) = 0
           THEN  GOTO 7340
7310    TN(6) = ((MF(18) *CPAIR* (TN(18) + TA)) + (MF(11) *CPAIR* (TN(11)
           + TA)) ) / (MF(6)*CPAIR)
7320    IF MF(10) < 0
           THEN TN(6) = TN(18) + TA
7330    IF MF(10) < 0 AND MF(6) < .0000001
           THEN TN(6) = ((MF(18) * (TN(18) + TA)) + ( ABS (MF(5)) * (TN(5
             ) + TA))) / (MF(18) +  ABS (MF(5)))
7340    IF MF(18) < 0
           THEN TN(6) = (TN(5) + TA)
7350    TN(6) = TN(6) - TA
7360    TN(19) = TN(6):
        TN(12) = TN(6)
7370    IF MF(5) > 0
           THEN TN(5) = TN(6)
7380    TN(11) = T9
7390    IF MF(11) < 0
           THEN TN(11) = TN(6)
7400    IF MF(17) < 0
           THEN TN(18) = TN(6)
7410    RETURN
8000   REM ===========================================================
8010   REM
8020   REM   SPECIFICATION OF ELEMENTAL PROPERTIES OF THE FLUE & THE FUR
          NACE
8030   REM
8040   REM ===========================================================
8050   REM
8060    FOR Y% = 1 TO NE%
8070         U(1,Y%) = UI
8080         U(2,Y%)=THCL(Y%)
```

```
8090        U(3,Y%)=THCS(Y%)
8100        U(4,Y%)=THCO(Y%)
8110       REM
8120       REM      ALL  "M"   "HC" "A" TO BE SPECIFIED HERE
8130       REM
8140        FOR J=1 TO 4
8145            IF DI2(J,Y%)=0
                   THEN A(J,Y%)=A(J-1,Y%) :
                         GOTO 8170
8150            IF Y%<(NFPSEGS%+1)
                   THEN A(J,Y%)=DHF(Y%)*DI2(J,Y%):
                        GOTO 8170
8160            A(J,Y%)=HF*DI2(J,Y%)/8
8170        NEXT J
8180       REM:A(1,Y)=A(2,Y)*.98
8190        HC(1,Y%) = CPAIR
8200       REM
8210        M(2,Y%)=DENL(Y%)*A(2,Y%)*ELTL(Y%)
8220        M(3,Y%)=DENS(Y%)*A(3,Y%)*ELTS(Y%)
8230        M(4,Y%)=DENO(Y%)*A(4,Y%)*ELTO(Y%)
8240    NEXT Y%
8250   REM
8260   REM      SPECIFICATION OF FLUEPIPE PROPERTIES
8270   REM
8280    FOR Y% = 1 TO NFPSEGS%
8305        IF M(3,Y%)=0
               THEN M(3,Y%) = M(3,NE%):
                    U(3,Y%)=U(3,NE%):
                    HC(3,Y%)=HC(3,NE%):
                    FPI$="U"
8306        IF M(4,Y%)=0
               THEN M(4,Y%) = M(4,NE%):
                    U(4,Y%)=U(4,NE%):
                    HC(4,Y%)=HC(4,NE%):
                    FPI$="U"
8320    NEXT Y%
8330   REM
8340   REM      CHECK OF TIME CONSTANTS
8350   REM
8355    IF FL1%=1
           THEN 8460
           ELSE 8360
8360    CLS :
         PRINT "OUTFLOW TIME CONSTANTS OF CHIMNEY ELEMENTS FROM LINER TO
          SURROUNDINGS:":
        PRINT
8370    FOR J = 2 TO 4
8380        TZ = (M(J,NE%) * HC(J,NE%)) / (U(J,NE%) * A(J,NE%))
8390        PRINT USING"FROM POINT ##  TO POINT ## :  ######.";J,J+1,TZ

8400    NEXT J
8410    PRINT :
          PRINT "INFLOW TIME CONSTANTS OF CHIMNEY ELEMENTS FROM LINER TO
          SURROUNDINGS:":
```

```
        PRINT
8420   FOR J = 2 TO 4
8430        TZ = (M(J,NE%) * HC(J,NE%)) / (U(J - 1,NE%) * A(J - 1,NE%))
             :
           REM SAME COMMENT ABOUT NE% AS LINE 8380
8440        PRINT USING"FROM POINT ##  TO POINT ## :  ######.";J-1,J,TZ

8450   NEXT J
8455    T=TIMER:
       WHILE TIMER < T+3 :
       WEND
8460   REM
8470   REM           FURNACE PHYSICAL PROPERTIES
8480   REM
8490    UTA=(F2*SSEFF)/((TSSGE-T9))
8500    U1A = 4 * UTA
8510    U2A=1/((1/UTA)-(1/U1A))
8520    U2AR=U2A
8530    RETURN
9000   REM=============================================================
9010   REM
9020   REM   TRANSIENT HEAT TRANSFER MODEL OF THE FLUE
9030   REM   PARAMETERIZED TEMPERATURE ALGORITHMS ARE CALLED IN SUBROUTI
          NE 12000
9040   REM
9050   REM ============================================================
9060   REM
9070    KE(3)=0
9075    KE(4)=(NELBOWS*.5)
9076    JUNCTLOSS=1.
9077    IF DHW$="Y" AND DHWFPN <= NFPSEGS%
           THEN KE(4)=((NELBOWS+JUNCTLOSS)*0.5)
9080    UF = 0
9090   REM
9100   REM
9110   FOR Y% = 1 TO NE%
9120       REM  FLUE GAS ELEMENT MASS = VOLUME x DENSITY
9130        IF Y%<(NFPSEGS%+1)
              THEN M(1,Y%) = ((ARD(4) * DHF(Y%)) * (353.6 / (TI(1,Y%)
                + TA)))
9140        IF Y%>NFPSEGS%
              THEN M(1,Y%)=((ARD(3)*(HF/8))*(353.6/(TI(1,Y%)+TA)))
9150       REM
9160       REM  SUBROUTINE 12500 CALCULATES THE HEAT TRANSFER COEFFICI
             ENTS NEEDED FOR THE FOLLOWING WORK & FRICTION FACTORS FOR
              THE PRESSURE LOSS ROUTINE
9170       REM
9180        GOSUB 12500
9190        IF Y% = 1
              THEN TB = TN(5)
9200        IF Y% = 1
              THEN  GOTO 9220
9210        TB = TI(1,(Y%- 1))
9220        IF MF(5) > 0
```

```
             THEN  GOTO 9250
9230     IF Y%= NE%
            THEN TB = TN(1):
                  GOTO 9250
9240     TB = TI(1,(Y%+ 1))
9250     INDT% = 1
9255     IF DHW$="Y" AND Y% <= DHWFPN
            THEN MFIN=MF(5)
            ELSE MFIN=MF(3)
9260     ITW = M(1,Y%) /  ABS (MFIN)
9270     OTW = (M(1,Y%) * HC(1,Y%) / (U(1,Y%) * A(1,Y%)))
9280     D1TM = TB - TI(1,Y%)
9290     D2TM = TI(1,Y%) - TI(2,Y%)
9291     ITDHW=10000
9292     D3TM=0!
9293     IF DHW$ = "Y" AND DHWFPN = Y%
            THEN 9294
            ELSE 9300
9294     IF MDHW <= 0
            THEN 9300
9295     ITDHW = (M(1,Y%)/ABS(MDHW))
9296     D3TM =TIDHW(1,NDHWFP%)-TI(1,Y%)
9300     GOSUB 12020
9310     TF(1,Y%)= TI(1,Y%) + DTM
9320     FOR J = 2 TO 4
9330         INDT% = 2
9340         ITW = (M(J,Y%) * HC(J,Y%) / (U(J - 1,Y%) * A(J - 1,Y%
               )))
9350         OTW = (M(J,Y%) * HC(J,Y%) / (U(J,Y%) * A(J,Y%)))
9360         D1TM = TI(J - 1,Y%) - TI(J,Y%)
9370         D2TM = TI(J,Y%) - TI(J + 1,Y%)
9375         ITDHW=10000! :
              D3TM = 0!
9380         GOSUB 12020
9390         TF(J,Y%) = TI(J,Y%) + DTM
9395         IF FPI$="U"
                THEN GOTO 9400
                ELSE GOTO 9410
9400         IF Y% <(NFPSEGS%+1) AND J > 2
                THEN TF(J,Y%) = TN(9)
9410     NEXT J
9420 NEXT Y%
9430 FOR Y% = 1 TO NE%
9440     FOR J = 1 TO 4
9450         TI(J,Y%) = TF(J,Y%)
9460     NEXT J
9470 NEXT Y%
9490  UF = UF / NE%
9500 REM
9510 REM    CALCULATE NEW COLUMN WEIGHT OF THE FLUE GAS BASED ON THE N
       EW FLUE TEMPERATURES------
9520 REM
9530  GF = 0!
```

```
9535   GFF= 0!
9540  FOR Y% = 1 TO NE%
9550      RW = 353.6 / (TI(1,Y%) + TA)
9560      GF = GF + (RW * GC * EH(Y%))
9565      IF Y% > NFPSEGS%
             THEN GFF = GFF + (RW * GC * EH(Y%))
9570  NEXT Y%
9575   TT = ((353.6 * GC * (HF +RISET)) / GF) - TA
9576   TTFF= ((353.6 * GC * HF ) / GFF) - TA
9580  REM
9590  REM
9600   TN(4) = TI(1,1)
9610   IF MF(5) < 0
          THEN TN(5) = TN(4)
9620   TN(3) = TTFF
9630   TN(2) = TI(1,NE%)
9640  REM
9650  REM            NEW DENSITIES
9660  REM
9670  FOR X% = 1 TO 19
9680      RO(X%) = 353.6 / (TN(X%) + TA)
9690  NEXT X%
9692  REM     NEW FLOW AREAS ACCOUNTING FOR DISPLACEMENT THICKNESS
9693   ARD(2)=PIE*(DIA(1,NE%)^2)/4:
       ARD(3)=ARD(2):
       ARD(4)=PIE*(DIA(1,1)^2)/4:
       ARD(5)=ARD(4)
9695   IF FDAMP$="N"
          THEN GOTO 9900
9710   IF FT$="G" AND SCS > (AUFF+14)
          THEN ARD(5)=ARDAMP
9715   IF FT$="O" AND SCS > (AUFF+120)
          THEN ARD(5)=ARDAMP
9720   IF F$ = "NOT"
          THEN ARD(5)=ARDAMP
9730   IF DAMPACT$<>"T"
          THEN GOTO 9900
9740   IF TI(1,1) < DAMPTCL
          THEN ARD(5) = ARDAMP:
                GOTO 9900
9750   IF TI(1,1) > DAMPTOP
          THEN ARD(5) = ARD(4):
                GOTO 9900
9760   ARD(5) = ARDAMP + (ARD(4)-ARDAMP)*(TI(1,1)-DAMPTCL)/(DAMPTOP-DAMP
         TCL)
9900    RETURN
10000 REM=============================================================
10010 REM
10020 REM :                 FURNACE MASSFLOW CALCULATIONS
10030 REM
10040 REM=============================================================
10050 REM
10060  FU=FW*3.413
```

```
10070  MGAS = ( INT (1000 * FU * (20.5 / 3.6E+09) + .5)) / 1000
10080  QGAS = MGAS / (RO(9) * .589)
10090  QGAS = ( INT (10 * QGAS * 1000 + .5)) / 10
10100  MTOIL= ( INT (1000 * FU * ((24.8+342*((EXAIR/100)+1)) / 3.6E+09)
         + .5)) / 1000
10110  MOIL=  ( INT (1000 * FU * ((24.8+  0) / 3.6E+09) + .5)) / 1000
10120  IF F$<>"ON"
          THEN MTOIL=0!   :
                MOIL=0!
10130  MTFUEL=MGAS :
        IF FT$="O"
          THEN MTFUEL=MTOIL
10140  MFUEL =MGAS :
        IF FT$="O"
          THEN MFUEL=MOIL
10150  QFUEL=QGAS :
        IF FT$="O"
          THEN QFUEL = MOIL / .97
10160  RETURN
10490 REM=============================================================
10495 REM
10500 REM      MATH MODULE TO IMPROVE CONVERGENCE OF ITERATION
10505 REM
10507 REM=============================================================
10510 REM
10514  AREFF=1/((.5/ARD(3))+(.5/ARD(5)))
10515  ELA1 = AREFF * ((2.68 / (KE(2) + KE(3) + KE(4) + KE(5))) ^ .5)
10520  TT = ((353.6 * GC * (HF +RISET)) / GF) - TA
10525  PB(1) = (353.6 * GC * (((HF + RISET + ABS(HT(6)-HT(5)) -  ABS (VC
         L )) / (TN(9) + TA)) + ( ABS (VCL ) / (TN(1) + TA)) - ((HF + RI
         SET) / (TT + TA)) - (ABS(HT(6)-HT(5)) / (TN(6) + TA))))
10530  SN = 1:
        IF VV < 0
          THEN SN = 0 - 1
10535  PB(2) = (((PHC+CPWENV(LEAKDIST)) * .5 * RO(1) * (VH ^ 2)) + (SN *
         PVC * .5 * RO(1) * ( ABS (VV) ^ 2)))
10540  TEF = (2 / ((1 / (TN(16) + TA)) + (1 / (TN(17) + TA)))) - TA
10545  PB(6) = (353.6 * GC * ((HH / (TN(9) + TA)) - ((HH +(HT(19)-HT(18)
         )) / (TEF + TA)) + ((HT(19)-HT(18)) / (TN(19) + TA))))
10550  B1=(TN(1)+TA)/(CC*(TN(9)+TA))
10555  B2=(TN(1)+TA)/(CC*(TT   +TA))
10560  TTF =-TA+((KE(4)+KE(5)+KE(2))/((KE(4)/(TN(4)+TA)) + (KE(5)/(TN(5)
         +TA)) + (KE(2)/(TN(2)+TA))))
10565  B3=(473.8/(TT+TA))*((TTF+TA)/((TT+TA)*ELA1))^2
10570  B4=473.8/((TN(11)+TA)*ELA(2)^2)
10575  B5=PB(1)+PB(2)
10580  B6=473.8*(TN(15)+TA)/(((TEF+TA)*ELA(4))^2)
10585  B7=473.8*(TN(18)+TA)/(((TEF+TA)*ELA(5))^2)
10590  B8=-B4
10595  B9=PB(6)
10600  B10=353.6/(TEF+TA)
10605  B11=353.6/(TN(11)+TA)
10610  B12=353.6/(TT+TA)
```

```
10615 '
10620 '
10625  BA=B5+(B2^2/(4*B3))-(B1*(QF+FP)/1000)
10630  BB=B9+(B6*(QFUEL/1000)^2)/(1+(B6/B7))
10635  BC=(B7*B10*(QFUEL)/1000)/(B6+B7)  -  (B2*B12)/(2*B3)
10640 '
10645 '
10650  Z0=(BC + (B12*SQR(ABS(BA/B3))) - (B10*SQR(ABS(BB/(B6+B7)))))/B11
10655 '
10660  ZCOR=(B4/B11) * ((B12/SQR(ABS(BA*B3))) + (B10/SQR(ABS(BB*(B6+B7))
         )))
10665  QDIL=Z0-(.5*Z0^2)*ZCOR
10670  QFLUE = SQR(ABS((BA-B4*QDIL^2)/B3))-(B2/(2*B3))
10675  QFURN = SQR(ABS((BB+B4*QDIL^2)/(B6+B7))) - (B7*(QFUEL/1000)/(B6+B
         7))
10680  CHHK1= ((B1*(QF+FP)/1000) + (B2*QFLUE) + (B3*QFLUE^2) + (B4*QDIL^
         2) - B5)
10685  CHHK2 = (B6*QFURN^2) + (B7*(QFURN+QFUEL/1000)^2) + (B8*QDIL^2) -
         B9
10690  CHHK3 = (B10*QFURN) + (B11*QDIL) - (B12*QFLUE)
10700  QFLUE=QFLUE*(353.6/(TT+TA))
10705  QFURN=QFURN*(353.6/(TEF+TA))
10710  QDIL=QDIL*(353.6/(TN(11)+TA))
10715  Q6=QFLUE
10716  Q9=QFURN
10720 '
10730  ER1=ER1+.5:
        ER3=ER3+.5
10735  RETURN
11000 REM ============================================================
11010  REM
11020  REM        P A R A M E T E R   A N A L Y S I S
11030  REM                 AT FURNACE STARTUP
11040  REM
11050  REM ============================================================
11060  IF TMONOFF <> 0
          THEN 11540
11070  PRINT #2, :
        PRINT #2,
11080  PRINT #2, "S Y S T E M   P A R A M E T E R S"
11090  PRINT #2, "==================================":
        PRINT #2,
11100  REM
11110  PAR(1) =   INT (100 * (((QF + FP) / (1000 *CC)) ^ (1 / N)) + .5)
         / 100
11120  SN = 1:
        IF VV < 0
          THEN SN = 0 - 1
11130  PAR(2) = 0 +  INT (100 * (((PHC+CPWENV(LEAKDIST)) * .5 * RO(1) *
         (VH ^ 2)) + (SN * PVC * .5 * RO(1) * ( ABS (VV) ^ 2))) + .5) /
         100
11140  PAR(3) = PAR(2) - PAR(1)
11150  PAR(4) =  INT (100 * (353.6* GC * (((HF -  ABS (VCL )) / (TN(9) +
          TA)) + ( ABS (VCL ) / (TN(1) + TA)) - (HF / (TT + TA)))) + .5)
          / 100
```

```
11155  IF MDI$="Y"
          THEN PB(11)=((CONST * VF(5)^2) + DP0)
          ELSE PB(11)=0 :
               REM:  DRAFT INDUCER
11160  PAR(5) =  INT (100 * (PAR(4) + PAR(3)+PB(11)) + .5) / 100
11170  L1A = AR(15) * (2.68 / KE(15)) ^ .5
11180  L2A = AR(18) * (2.68 / KE(18)) ^ .5
11190  IF L1A <.01
          THEN L1A=1000000!
11200  PAR(6) =  INT (1000 * (1 / ((1 / L1A) + (1 / L2A))) + .5) / 1000
11209  AREFF=1/((.5/ARD(3))+(.5/ARD(4)))
11210  L1A = AREFF * ((2.68 / (KE(2) + KE(3) + KE(4) + KE(5))) ^ .5)
11220  PAR(7) =  INT (1000 * L1A + .5) / 1000
11230  L1A = ADR * (2.68 / KE(11))^ .5
11240  PAR(8) =  INT (1000 * L1A + .5) / 1000
11250  L1A = 1.157 * (RO(1) ^ .5) *CC * ((10) ^ (N - .5))
11260  PAR(9) =  INT (1000 * L1A + .5) / 1000
11270  PAR(10) =  INT (.5 + 1000 * PAR(8) /PAR(7) ) / 1000
11280  PAR(11) =  INT (.5 + F2 / (1000 * PAR(6)))
11290  PAR(12) =  INT (.5 + M2CP / U1A)
11300  PAR(13) =  INT (10 * (M(2,NFPSEGS%+1)*HC(2,NFPSEGS%+1) / (U(1,NFP
         SEGS%+1) * A(1,NFPSEGS%+1))) + .5) / 10
11350  HD$(1)="ENVELOPE ADVERSE PRESS.(FANS & FIREPLACE)  (Pa):"
11360  HD$(2)="WIND INDUCED DRIVING PRESSURE              (Pa):"
11370  HD$(3)="NET BOUNDARY DRIVING PRESSURE              (Pa):"
11380  HD$(4)="CHIMNEY/HOUSE BUOYANCY PRESSURE AT STANDBY (Pa):"
11390  HD$(5)="NET DRIVING PRESSURE PARAMETER (AT STANDBY)(Pa):"
11400  HD$(6)="FURNACE EQUIVALENT LEAKAGE AREA OF FLOW    (m2):"
11410  HD$(7)="CHIMNEY EQUIVALENT LEAKAGE AREA OF FLOW    (m2):"
11420  HD$(8)="E.L.A.  OF REVERSE FLOW OF DILUTION PORT   (m2):"
11430  HD$(9)="ENVELOPE EQUIVALENT LEAKAGE AREA AT 10 PA  (m2):"
11440  HD$(10)="DILUTION PORT/CHIMNEY E.L.A.   RATIO      (--):"
11450  HD$(11)="FURNACE HEAT FLOW DENSITY PARAMETER     (kW/m2):"
11460  HD$(12)="FURNACE HEAT TRANSFER TIME CONSTANT         (s):"
11470  HD$(13)="CHIMNEY LINER HEAT TRANSFER TIME CONSTANT   (s):"
11472  FOR X% = 1 TO 13
11473      IF X%=5 AND MDI$="Y"
              THEN PRINT #2, USING"DRIVING PRESSURE OF THE DRAFT INDUC
                ER       (Pa): ####.#";((CONST * VF(5)^2)+DP0)
11475      IF X%=6
              THEN PRINT #2,
11476      PRINT #2,HD$(X%);:
           IF X%>5 AND X%<10
              THEN PRINT #2, USING" ####.###";PAR(X%)
              ELSE PRINT #2, USING" ####.#";PAR(X%)
11478  NEXT X%
11480  PRINT #2, :
        PRINT #2,
11490  PRINT #2, "FLUE LOCATION:  ";:
       IF CHIMT$="I"
          THEN PRINT #2, "INTERIOR"
          ELSE PRINT #2, "EXTERIOR"
11500  PRINT #2, "CHIMNEY FLOW DIRECTION AT STANDBY: ";
```

```
11510   IF VL(4) < 0
           THEN  PRINT #2, "REVERSED  ("; INT (100 * VL(4) + .5) / 100;"
             M/S)":
                 GOTO 11530
11520   PRINT #2, " UPWARD   ("; INT (100 * VL(4) + .5) / 100;" m/s)"
11530   PRINT #2,
11540   GOSUB 18570
11550   RETURN
12000 REM ==========================================================
12010 REM
12020 REM              T E M P E R A T U R E   U P D A T E
12030 REM :              ---PARAMETERIZED ALGORITHMS---
12040 REM
12050 REM ==========================================================
12060 REM
12070   IF INDT% = 1 AND SEC > .9 * ABS (ITW)
           THEN SEC = .9 * ABS (ITW)
12075   IF INDT% = 1 AND SEC > .9 * ABS (ITDHW)
           THEN SEC = .9 * ABS (ITDHW)
12080   IF INDT% > 1 AND SEC > .3 * ABS (ITW)
           THEN SEC = .3 * ABS (ITW)
12090   IF INDT% > 1 AND SEC > .3 * ABS (OTW)
           THEN SEC = .3 * ABS (OTW)
12170   DTM = ((D1TM/ITW) + (D3TM/ITDHW) - (D2TM/OTW)) * SEC
12190   RETURN
12500 REM ==========================================================
12510 REM
12520 REM : FLUE FILM HEAT TRANSFER COEFFICIENT & FRICTION FACTORS
12530 REM :              AS A FUNCTION OF REYNOLDS NUMBER
12540 REM
12550 REM ==========================================================
12560 REM
12570   IF Y%<(NFPSEGS%+1)
           THEN V = (DHF(Y%)) / (M(1,Y%) /  ABS (MF(5)))
12580   IF Y%>=(NFPSEGS%+1)
           THEN V = (HF/8) / (M(1,Y%) /  ABS (MF(5)))
12590   RE = (353.6 / (TI(1,Y%) + TA)) * V * DIA(1,Y%) / MU
12600   U(1,Y%) = 1.8*(.0238 / DIA(1,Y%)) * (.021 * (.78 ^ .5) * RE ^ .8)
12610   FF(Y%) = DHF(Y%)*((38700! / RE) ^ 1.24)/10
12620   IF (TI(1,Y%) - TI(2,Y%)) < 10
           THEN FF(Y%) = K1*DHF(Y%)
12630   IF FF(Y%) <(K1*DHF(Y%))
           THEN FF(Y%)=(K1*DHF(Y%))
12640   IF U(1,Y%) < UI
           THEN U(1,Y%)= UI
12650   IF Y% < (NFPSEGS%+1)
           THEN KE(4)=KE(4)+FF(Y%)
           ELSE KE(3)=KE(3)+FF(Y%)
12660   UF = UF + U(1,Y%)
12662   DIA(1,Y%)=(DI2(1,Y%)/PIE)*(1-.096):
        IF Y%<(NFPSEGS%+1)
           THEN A(1,Y%)=(PIE*DIA(1,Y%))*DHF(Y%)
           ELSE A(1,Y%)=(PIE*DIA(1,Y%))*HF/8
```

```
12670  RETURN
12680 REM
12690 REM=============================================================
12700 REM
12710 REM :              E N D   O F   C A L C U L A T I O N S
12720 REM
12730 REM=============================================================
13000 REM=============================================================
13010 REM
13020 REM :         O U T P U T   R O U T I N E S    B E G I N
13030 REM : ROUTINE TO PRINT OUT TEMPERATURES OF THE FLUE ELEMENTS
13040 REM
13050 REM=============================================================
13060 REM
13070  D$ =  CHR$ (4):
       REM  : CTRLD VALUE
13110  PRINT #2, :
        PRINT #2, :
        PRINT #2, USING"TIME = ######.# SECONDS";SCS
13120  PRINT #2, "================================":
        PRINT #2,
13130  PRINT #2, :
        PRINT #2, "TEMPERATURES OF THE FLUE GAS, LINER, AND STRUCTURE":
        PRINT #2, "-----------------------------------------------------
         ---":
        PRINT #2,
13140  PRINT #2, TAB( 23);
13150  FOR X% = 1 TO 9
13155      IF X% <= NFPSEGS%
              THEN PRINT #2, "   FP";X%;:
                   GOTO 13170
13160      PRINT #2, "    F";X%;
13170  NEXT
13180  FOR X% = 10 TO NE%
13190      PRINT #2, "   F";X%;
13200  NEXT
13210  PRINT #2, ""
13220  PRINT #2,
13230  PRINT #2, "FLUE GAS TEMP (C)";
13240  PRINT #2, TAB(22);
13250  FOR X% = 1 TO NE%
13260      PRINT #2, USING "   ###.#";TI(1,X%);
13270  NEXT X%
13280  PRINT #2, ""
13290  PRINT #2, "INNER LINER    (C)";
13300  PRINT #2, TAB(22)
13310  FOR X% = 1 TO NE%
13320      PRINT #2, USING"   ###.#";TI(2,X%);
13330  NEXT X%
13340  PRINT #2, ""
13350  IF IND10 = 1
          THEN GOTO 13700
13360  PRINT #2, "INSUL OR STRUCT (C)";
```

```
13370  PRINT #2, TAB(22)
13380  FOR X% = 1 TO NE%
13390      PRINT #2, USING"   ###.#";TI(3,X%);
13400  NEXT X%
13410  PRINT #2, ""
13420  PRINT #2, "OUTER STRUCTURE(C)";
13430  PRINT #2, TAB(22)
13440  FOR X% = 1 TO NE%
13450      PRINT #2, USING"   ###.#";TI(4,X%);
13460  NEXT X%
13470  PRINT #2, ""
13480  PRINT #2, "SURROUNDING (DEG C)";
13490  PRINT #2, TAB(22)
13500  FOR X% = 1 TO NE%
13510      PRINT #2, USING"   ###.#";TI(5,X%);
13520  NEXT X%
13530  PRINT #2, ""
13570  PRINT #2,:
       PRINT#2,
13580  PRINT #2, "CONDENSING TIME (%)";
13590  PRINT #2, TAB(22)
13600  FOR X% = 1 TO NE%
13610      PRINT #2, USING"   ###.#";(DEW(X%)*100/(ONTIME+.000001));
13620  NEXT X%
13630  PRINT #2, ""
13700  RETURN
14000 REM ==========================================================
14010 REM
14020 REM     FLOW NETWORK PARAMETER OUTPUT
14030 REM
14040 REM ==========================================================
14050 REM
14060  PRINT #2, :
       PRINT #2, "THE MASSFLOW SYSTEM PARAMETERS"
14070  PRINT #2, "------------------------------"
14080  GOSUB 16020:
        PRINT #2, :
        PRINT #2, TAB( 23);
14090  FOR X% = 1 TO 19
14100      PRINT #2, USING"       ##";X%;
14110  NEXT
14120  PRINT #2, "":
        PRINT #2,
14130  PRINT #2,
14140  PRINT #2, "TEMPERATURE (DEG C)";
14150  PRINT #2, TAB(23)
14160  FOR X% = 1 TO 19
14170      PRINT #2, USING"  ####.# ";TN(X%);
14180  NEXT X%
14190  PRINT #2, ""
14200  PRINT #2, "DENSITY (KG/M3)    ";
14210  PRINT #2, TAB(23)
14220  FOR X% = 1 TO 19
```

```
14230       PRINT #2, USING"    ##.##";RO(X%);
14240 NEXT X%
14250  PRINT #2, ""
14260  PRINT #2, :
        PRINT #2, "MASS FLOW (KG/S)      ";
14270  PRINT #2, TAB(23)
14280 FOR X% = 1 TO 19
14290       PRINT #2, USING"    #.###";MF(X%);
14300 NEXT X%
14310  PRINT #2, ""
14320  PRINT #2, "VOLUME FLOW (M3/S) ";
14330  PRINT #2, TAB(23)
14340 FOR X% = 1 TO 19
14350       PRINT #2, USING"    #.###";VF(X%);
14360 NEXT X%
14370  PRINT #2,
14380  PRINT #2, "FLOW VELOCITY (M/S)";
14390  PRINT #2, TAB(23)
14400 FOR X% = 1 TO 19
14410       PRINT #2, USING"  ###.## ";VL(X%);
14420 NEXT X%
14430  PRINT #2, ""
14440  PRINT #2, :
        PRINT #2,
14450  PRINT #2, "PRESSURE PARAMETERS OF THE FLOW SYSTEMS"
14460  PRINT #2, "---------------------------------------"
14470  PRINT #2, "          NET BUOYANCY      WIND EFFECT      ENVELOPE LO
          SS     FRICTION LOSS    NET DRIVING     FURN BUOYANCY      INLET
           DROP       OUTLET DROP      NET FURNACE      DILUTION PORT
          DRAFT INDUCER    DHW INDUCED    DHW BUOYANCY"
14480 FOR X% = 1 TO 11
14490       PRINT #2, USING"          ###.###";PB(X%);
14500 NEXT X%
14510  PRINT #2, USING"        ###.###";(-DPDIL-DPFP),-DPBUO
14530  RETURN
14540 REM
15000 REM ==========================================================
15010 REM
15020 REM    PRINTOUT OF PHYSICAL CONSTANTS OF ALL SYSTEMS
15030 REM
15040 REM ==========================================================
15050 REM
15060  WIDTH #2,255
15070  PRINT #2, "PHYSICAL CHARACTERISTICS OF THE SYSTEM"
15080  PRINT #2, "---------------------------------------":
        PRINT #2,
15090  GOSUB 16000
15100  PRINT #2,  TAB( 23);
15110 FOR X% = 1 TO 19
15120       PRINT #2, USING"      ##";X%;
15130 NEXT
15140  PRINT #2, "":
        PRINT #2,
```

```
15150  PRINT #2, "DISTANCE->DATUM (M)";
15160  PRINT #2,  TAB(23);
15170  FOR X% = 1 TO 19
15180      PRINT #2, USING"    ##.##";ABS(HT(X%));
15190  NEXT X%
15200  PRINT #2, ""
15210  PRINT #2, "AREA OF OPENING (M2)";
15220  PRINT #2,  TAB(23);
15230  FOR X% = 1 TO 19
15240      PRINT #2, USING"    #.###";AR(X%);
15250  NEXT X%
15260  PRINT #2, ""
15270  PRINT #2, "K FACTOR NORMAL";
15280  PRINT #2,  TAB(23);
15290  FOR X% = 1 TO 19
15300      PRINT #2, USING"      #.#";KE(X%);
15310  NEXT X%
15320  PRINT #2, ""
15330  RETURN
16000 REM ==========================================================
16010 REM
16020 REM : GUIDE TO IDENTIFY NETWORK POINTS
16030 REM
16040 REM ==========================================================
16050 REM
16060  PRINT #2,  TAB( 31)
16070  PRINT #2, "<-------------------F L U E------------------->";
16080  PRINT #2, " <--------E N V E L O P E------>";
16090  PRINT #2, "<--DRAFT HOOD INLET->";
16100  PRINT #2, " <--------------------F U R N A C E-----------------
         ----->"
16110  RETURN
16120 REM
17000 REM ==========================================================
17010 REM
17020 REM :     SUMMARY TABLE OUTPUT
17030 REM
17040 REM ==========================================================
17050 REM
17060  FOR X% = 1 TO 19
17070      FM(X%) = ( INT (1000 * MF(X%)+ .5)) / 1000
17080      TN(X%) = ( INT (10 * TN(X%) +  .5)) / 10
17090      VQ(X%) = ( INT (10 * VF(X%) * 1000)) / 10
17100  NEXT X%
17110  PRINT #2, CHR$(18)
17120  PRINT #2, :
        PRINT #2,
17130  PRINT #2, "S U M M A R Y   T A B L E"
17140  PRINT #2, "-------------------------"
17150  PRINT #2,
17160  PRINT #2, USING"OUTDOOR TEMPERATURE      =    #### C";T1
17170  PRINT #2, USING"INDOOR  TEMPERATURE      =    #### C";T9
17180  PRINT #2,
```

```
17190  PRINT #2, USING"STANDBY FIRING RATE       = ###### W";F1
17200  PRINT #2, USING"FULL FIRING RATE          = ###### W";F2
17210  FE = 100 * U2A * (TMF - T9)/ (FW+.00001) :
        IF FE > 100
          THEN FE = 100
17220  PRINT #2, USING"INSTANT.  EFFICIENCY      =  ###.# %";FE
17230  PRINT #2, :
        PRINT #2,
17240  PRINT #2,"WIND SPEED & PRESSURE             SPEED      PRESSURE COEFFI
         CIENTS"
17250  PRINT #2,"COEFFICIENTS:                     (M/S)       CHIM TOP     IN
         SIDE HOUSE"
17260  PRINT #2,"---------------------              -----      --------     --
         ----------"
17270  PRINT #2, USING"HORIZONTAL COMPONENT             ###.#       ##.##
            ##.##";VH;PHC;CPWENV(LEAKDIST)
17280  PRINT #2, USING"VERT. COMPONENT (+VE UP)         ###.#       ##.##";VV
         ;PVC
17290  PRINT #2, :
        PRINT #2,
17300  PRINT #2, "FLOW RATES:                         L/S       KG/S"
17310  PRINT #2, "-----------                         ---       ----"
17320  E1 =  INT(((MF(16)/(353.6/TA)) - ((286 * FW * 3.413) / 3.6E+09))/
          (2.625* FW * 3.413 / 3.6E+09))
17330  E2 =  INT(((MF(6)/(353.6/TA)) - ((286 * FW * 3.413) / 3.6E+09)) /
          (2.625* FW * 3.413 / 3.6E+09))
17340  IF E1>1000
          THEN E1=0 :
                E2=0
17350  PRINT #2,
17360  PRINT #2, USING"FUEL FLOW                        ####.###    #.###";QF
         UEL;MGAS
17370  PRINT #2, USING"FURNACE OUTLET FLOW              ####.#      #.### (##
         ## % EXCESS AIR)";VQ(18);FM(18);E1
17380  PRINT #2, USING"DILUTION FLOW INTO HOOD          ####.#      #.###";VQ
         (10);FM(10)
17390  PRINT #2, USING"FLUE INLET FLOW                  ####.#      #.### (##
         ## % EXCESS AIR)";VQ(5);FM(5);E2
17400  PRINT #2,
17410  PRINT #2, USING"FAN FLOW                         ####.#      #.###";QF
         ;FANM
17420  PRINT #2, USING"FIREPLACE FLOW                   ####.#      #.###";FP
         ;FIRM
17430  PRINT #2, USING"INCREMENTAL ENVELOPE FLOW        ####.#    ###.###   (A
         T OUTDOOR TEMPERATURE)";VQ(8);FM(8)
17440  PRINT #2, USING"INDUCED PRESSURE DROP ACROSS THE ENVELOPE = ##.#
         Pa";PB(3)
17450  PRINT #2, :
        PRINT #2, :
        PRINT #2, "TEMPERATURES:"
17460  PRINT #2, "--------------":
        PRINT #2,
17470  PRINT #2, USING"FURNACE FLAME TEMPERATURE  = ####.  C";TN(16)
```

```
17480  PRINT #2, USING"FURNACE EXIT  TEMPERATURE  =  ###.# C";TN(17)
17490  PRINT #2, USING"FLUE GAS T. AFTER DILUTION =  ###.# C";TN(6)
17500  TT = 0:
       TQ = 0
17510  FOR Y% = 1 TO NE%
17520      TT = TT + TI(1,Y%)
17530      TQ = TQ + TI(2,Y%)
17540  NEXT Y%
17545  TT=TT/NE%:
       TQ=TQ/NE%
17550  PRINT #2, USING"MEAN FLUE GAS TEMPERATURE =   ###.# C";TT
17560  PRINT #2, USING"MEAN FLUE LINER TEMPERATURE=  ###.# C";TQ
17570  PRINT #2, :
        PRINT #2, :
        PRINT #2,
17580  PRINT #2, "THERMAL PROPERTIES OF FURNACE & CHIMNEY"
17590  PRINT #2, "---------------------------------------":
        PRINT #2,
17600  PRINT #2, USING"HEAT CAPACITY OF FURNACE HEAT EXCHANGER
           = #####.  W.S/C";M2CP
17610  PRINT #2, USING"DESIGN HEAT TRANSFER RATE FROM GAS TO FURN HEAT-E
         XCH= #####.  W/C";U1A
17620  PRINT #2, USING"FURNACE HEAT TRANSFER TIME CONSTANT
           = #####.  SECS";M2CP / U1A
17630  PRINT #2, USING"FURNACE HEAT TRANSPORT TIME CONSTANT (FINAL CONDI
         T) = #####.# SECS";M6 / (MF(16)+0.000001)
17640  PRINT #2,
17650  PRINT #2, "AT THE BASE OF THE CHIMNEY:                        FLU
         E GAS        LINER          SLEEVE       STRUCTURE"
17660  PRINT #2, "-------------------------                         ---
         -----        -----          ------       ---------"
17670  PRINT #2, "HEAT TRANSFER COEFF. 'U' (W/(M2.C))          ";:
       PRINT #2, USING"   #######.###";UF;U(2,NFPSEGS%+1);U(3,NFPSEGS%+1
         );U(4,NFPSEGS%+1)
17680  PRINT #2, "ELEMENTAL SURFACE AREA 'A' (M2)              ";:
       PRINT #2, USING"    ######.###";A(1,NFPSEGS%+1);A(2,NFPSEGS%+1);A
         (3,NFPSEGS%+1);A(4,NFPSEGS%+1)
17690  PRINT #2, "ELEMENTAL MASS 'M' (KG)                      ";:
       PRINT #2, USING"   #######.###";M(1,NFPSEGS%+1);M(2,NFPSEGS%+1);M
         (3,NFPSEGS%+1);M(4,NFPSEGS%+1)
17700  PRINT #2, "HEAT CAPACITY OF MATERIALS 'CP'  (W.S/KG.C)";:
       PRINT #2, USING"   #######.#  ";HC(1,NFPSEGS%+1);HC(2,NFPSEGS%+1)
         ;HC(3,NFPSEGS%+1);HC(4,NFPSEGS%+1)
17710  PRINT #2, "HEAT TRANSFER TIME CONSTANTS-OUT (S)         ";
17720  FOR J = 1 TO 4
17725      IF J=1
              THEN TW(J) = (M(J,NFPSEGS%+1) * HC(J,NFPSEGS%+1)) / (UF
                * A(J,NFPSEGS%+1)):
                   GOTO 17740
17730      TW(J) = (M(J,NFPSEGS%+1) * HC(J,NFPSEGS%+1)) / (U(J,NFPSEGS
             %+1) * A(J,NFPSEGS%+1))
17740      PRINT #2, USING"   #######.#  ";TW(J);
17750  NEXT J
```

```
17760  PRINT #2,
17770  PRINT #2, "HEAT TRANSFER TIME CONSTANTS-IN  (S)        ";
17780  PRINT #2,       "              ";
17790 FOR J = 2 TO 4
17800      TW(J) = (M(J,NFPSEGS%+1) * HC(J,NFPSEGS%+1)) / (U(J - 1,NFP
             SEGS%+1) * A(J - 1,NFPSEGS%+1))
17810      PRINT #2, USING"    #######.#   ";TW (J);
17820 NEXT J
17830  PRINT #2, :
        PRINT #2, :
        PRINT #2,
17840  PRINT #2,"ENVELOPE CHARACTERISTICS:       WITHOUT     WITH"
17850  PRINT #2,"-----------------------        AIR INTAKE  AIR INTAKE
         (IF ANY)"
17855  PRINT #2,"                               ----------  ----------"
17860  PRINT #2, USING"FLOW COEFFICIENT (M3/(S.PA^N) = #.####      #.###
         #";C;CC
17870  PRINT #2, USING"FLOW EXPONENT    (--)          = #.###       #.###
         ";N;N
17880  PRINT #2, USING"LOCATION OF VCL BELOW CHIM TOP= #.##        #.##(
         m)";ABS(LNPP);ABS (VCL )
17930  PRINT #2, :
        PRINT #2, :
        PRINT #2,
17940  PRINT #2,"HOT WATER HEATER SPECS. FOR A SHARED FLUE ARRANGEMENT"
17950  PRINT #2,"-----------------------------------------------------":
       PRINT #2,
17955  IF DHW$ = "N"
          THEN PRINT #2,"-----  NONE  -----" :
                GOTO 17999
17958  IF DHWO$="O" OR DHWO$="o"
          THEN PRINT #2, "HOT WATER HEATER IS ON, OPERATING AT STEADY ST
            ATE CONDITIONS"
          ELSE PRINT #2, "HOT WATER HEATER IS AT STANDBY"
17960  PRINT #2,:
       PRINT #2, USING"BURNER CAPACITY (W)            =######.";DHWC
17965  PRINT #2, USING"STANDBY CAPACITY (W)           =######.";DHWSBC
17970  PRINT #2, USING"HEATER EFFICIENCY (%)          =   ###.";DHWEF*100
17980  PRINT #2, USING"AREA OF THE DHW FLUE-PIPE (m2)=    #.#####";DHWA
         R
17999  RETURN
18000 REM==============================================================
18010 REM
18020 REM :         LINE SUMMARY OUTPUT FOR EACH CALCULATION INTERVAL
18030 REM
18040 REM==============================================================
18050 REM
18070 REM
18080  OO(1) = SCS
18090  OO(2) = SCS / (M2CP / U1A)
18100  OO(3) = VF(18) * 1000
18110  OO(4) = VF(10) * 1000
18120  OO(5) = VF(3) * 1000
```

```
18130  OO(6) = VF(8) * 1000
18140  OO(7) = PB(3)
18150  OO(8) = TMF
18160  OO(9) = TN(17)
18170  OO(10) = TN(6)
18180  TT = 0:
       TQ = 0
18190  FOR Y%= 1 TO NE%
18200      TT = TT + TI(1,Y%)
18210      TQ = TQ + TI(2,Y%)
18220  NEXT Y%
18230  TT = TT / NE%
18240  TQ = TQ / NE%
18250  OO(11) = TT
18260  OO(12) = TI(1,NE%)
18270  OO(13) = TQ
18280  FE = 100 * U2A * (TMF - T9)/(FW+.00001)
18290  IF ABS(FE) > 100
          THEN FE=100
18300  OO(14) = FE
18310  OO(15) = UF
18320  OO(16) = KE(2)+KE(3)+KE(4)+KE(5)
18325  IF FL1%=1
          THEN GOSUB 20000
18326  IF SCS>=ST
          THEN GOTO 18328
18327  IF Z1<Z2 AND S%>11
          THEN GOTO 18460
18328  Z1=0
18330  IF P$ = "D"
          THEN  GOTO 18400
18340  PRINT #2, USING"          #####.#";SCS  ;
18350  FOR X% = 1 TO 11
18360      PRINT #2, USING"        ###.###";PB(X%);
18370  NEXT X%
18380  PRINT #2, USING"        ###.###";(-DPDIL-DPFP),-DPBUO
18390  GOTO 18460
18400  FOR X% = 1 TO 16
18410      IF X%=2
              THEN PRINT #2, USING"      ##.###";OO(X%);:
                   GOTO 18430
18420      PRINT #2, USING"      ####.#";OO(X%);
18425      IF X% = 4
              THEN PRINT #2, USING"      ####.#";QDHW*1000;
18428      IF X% = 10
              THEN PRINT #2, USING"      ####.#";TDHW;
18430  NEXT X%
18440  IF YDEW > 0
          THEN PRINT #2, USING"      ## AND UP";YDEW
          ELSE PRINT #2,"         ----"
18459 REM: IND10=1 : GOSUB 13230 : IND10=0
18460  RETURN
18500 REM===================================================
```

```
18510 REM
18520 REM :      HEADINGS FOR LINE SUMMARY
18530 REM
18540 REM============================================================
18550 REM
18560  PRINT #2,  CHR$ (15)
18570  PRINT #2, :
        PRINT #2, :
        PRINT #2, :
        PRINT #2,:
       PRINT #2,"C A S E:  ";
18580  IF FT$="G"
          THEN PRINT #2,"  GAS FURNACE   - ";
18590  IF FT$="O"
          THEN PRINT #2,"  OIL FURNACE   - ";
18600  PRINT #2, TITLE$;:
       PRINT #2,"                     DATE: ";DATE$
18610  PRINT #2, "==============================================================
         ==============================================================
         ==== ":
        PRINT #2, :
        PRINT #2,
18620  IF P$ = "P"
          THEN GOTO 18670
18630  PRINT #2, "         TIME      TIME(IN #    FURNACE     DILUTION
         HOT WATER    CHIMNEY     INC. ENVEL  ENVELOPE    FURNACE      FU
         RNACE    MIXING        ";
18632  PRINT #2, "DHW BRANCH  MEAN FLUE   GAS EXIT    MEAN FLUE   INSTAN
         T.    FLUE FILM    FLUE      CONDENSATION"
18640  PRINT #2, "         (s)        FURN. T-C)   FLOW(L/s)   FLOW(L/s)
         BRANCH(L/s)  FLOW(L/s)   FLOW(L/s)   PRES DROP   HT-EX TEMP  EX
         IT TEMP    TEMP(C)       ";
18642  PRINT #2, "TEMP (C)    GAS TEMP    TEMP (C)    LINER TEMP  EFFICI
         ENCY  LOSS COEFF  FRICTION   AT ELEMENT:"
18650  PRINT #2, " "
18660  GOTO 18680
18670  PRINT #2, "               TIME       NET BUOYANCY    WIND EFFECT
         ENVELOPE LOSS  FRICTION LOSS   NET DRIVING   FURN BUOYANCY   IN
         LET DROP    OUTLET DROP    NET FURNACE    DILUTION PORT   DRAFT
         INDUCER    DHW INDUCED    DHW BUOYANCY"
18680  RETURN
18690 REM
19000 REM ==========================================================
19010 REM
19020 REM :     FURNACE  TURN-OFF INDICATOR
19030 REM
19040 REM ==========================================================
19050 REM
19055  IF TMONOFF > 0
          THEN 19110
19060  PRINT #2,:
       PRINT #2, "***** THE FURNACE IS ABOUT TO BE TURNED OFF.  THE STAT
         E OF ALL FLOW SYSTEMS IS AS FOLLOWS:"
```

```
19070  GOSUB 13000
19080  GOSUB 14000
19090  GOSUB 17000
19100  PRINT #2, :
        PRINT #2, :
        PRINT #2,
19110  PRINT #2, "***** FURNACE WAS JUST TURNED OFF ******"
19120  PRINT #2, :
        PRINT #2, :
        PRINT #2,
19130  GOSUB 18500
19150  FW=F1
19160  GOSUB 10000
19170  RETURN
19500 REM=============================================================
19510 REM
19520 REM :   FURNACE TURN ON
19530 REM
19540 REM=============================================================
19550 REM
19560  FW=F2
19570  GOSUB 10000
19580  PRINT #2, :
        PRINT #2, "******* FURNACE WILL BE TURNED ON AT ";( INT (100 * S
         CS + .5) / 100);" SECONDS *******"
19590  IF TMONOFF > 0
          THEN 19600
          ELSE GOSUB 11000
19600  RETURN
19610 REM
20000 REM:=====================================================
20010 REM
20020 REM: GRAPH PLOTTER ROUTINE
20030 REM
20040 REM:=====================================================
20050 REM
20070  IF AXIS=0
          THEN 20080
          ELSE 21300
20080  CLS
20090  SCREEN 2
20100  KEY OFF
20102  N$(0) = "BR2H2U6E2R3F2G4E4D6G2L3BR7"
20104  N$(1) = "BR1R2U9G2E2D9R2BR5"
20106  N$(2) = "BU9R6D4L6D5R6BR3"
20108  N$(3) = "BU9R6D4L4R4D5L6BR9"
20110  N$(4) = "BU9BR4G4R6L2U4D9BR5"
20112  N$(5) = "R6U5L6U4R6BD9BR3"
20114  N$(6) = "U5D5R6U5L6U4R6BD9BR3"
20116  N$(7) = "BU9R6D2G4D3BR7"
20118  N$(8) = "U9R6D4L4R4D5L6BR9"
20120  N$(9) = "BU5U4R6D4L6R6D5L6BR9"
20122  N$(10) = N$(1) + N$(0)
```

```
20124   N$(15) = N$(1) + N$(5)
20126   N$(20) = N$(2) + N$(0)
20128   N$(30) = N$(3) + N$(0)
20130   N$(40) = N$(4) + N$(0)
20132   N$(50) = N$(5) + N$(0)
20134   N$(60) = N$(6) + N$(0)
20136   N$(120) = N$(1) + N$(2)+N$(0)
20138   N$(180) = N$(1) + N$(8)+N$(0)
20140   N$(240) = N$(2) + N$(4)+N$(0)
20142   N$(300) = N$(3) + N$(0)+N$(0)
20180   LT(1)=&HFFFF
20182   PATTRN%(1)=32767
20184   ANDNO%(2)=96:
        PATTRN%(2)=771
20186   ANDNO%(3)=128:
        PATTRN%(3)=511
20188   ANDNO%(4)=192:
        PATTRN%(4)=63
20190   PTI$(1)="CHIM/HOUSE BUOYANCY"
20192   PTI$(2)="FLUE FRICTION LOSS"
20194   PTI$(3)="FURNACE BUOYANCY"
20196   PTI$(4)="FURNACE OUTLET LOSS"
20198   PTI$(5)="ENVELOPE LOSS"
20200   PTI$(6)="NET DRIVING PRESS."
20202   PTI$(7)="FURNACE INLET LOSS"
20204   PTI$(8)="NET FURNACE DRIVE "
20206   PTI$(9)="DILUTION PORT LOSS"
20208   PTI$(10)="WIND EFFECT"
20209   PTI$(11)="DRAFT INDUCER"
20210   PTI$(12)="DHW INDUCED"
20211   PTI$(13)="DHW BUOYANCY"
20212   TTI$(1)="FURN. STACK GAS TEMP."
20214   TTI$(2)="DILUTION MIXING TEMP."
20216   TTI$(3)="MEAN FLUE GAS TEMP."
20218   TTI$(4)="FLUE EXIT GAS TEMP."
20220   TTI$(5)="MEAN FLUE LINER TEMP."
20222   TTI$(6)="FURN. HEAT-EXCH. TEMP."
20224   TTI$(7)="ROOM TEMP. x 10      "
20225   TTI$(8)="DHW FLUE GAS TEMP."
20226   FTI$(1)="FURNACE FLOW"
20228   FTI$(2)="DILUTION FLOW"
20230   FTI$(3)="CHIMNEY FLOW"
20232   FTI$(4)="NET ENVELOPE FLOW"
20234   FTI$(5)="DHW FLOW"
21000   AXIS=1
21002   TIT$(0) = "TEMPERATURE vs. TIME"
21004   TIT$(1) = "PRESSURE vs. TIME"
21006   TIT$(2) = "FLOW RATE vs. TIME"
21008   A$ = TIT$(FL2% )
21010   LOCATE 25, (80 - LEN(A$)) * .5
21012   PRINT A$
21014   IF ST>300
           THEN B$=" TIME (MIN.)"
```

```
         ELSE B$ = "TIME (SECS)"
21016  LOCATE 23, INT(80 - LEN(B$)) * .5
21018  PRINT B$
21020  PSET(90,15)
21022  DRAW "D148 R465"
21024  IF FL2%=1 OR FL2%=2
         THEN 21026
         ELSE 21028
21026  LINE (90,115)-(550,115),,,257
21028  PSET (110,163)
21030  IF FL2%=1
         THEN 21032
         ELSE 21044
21032  FOR X%= 1 TO 9
21034      A%=163-16*X%
21036      PSET (90,A%)
21038      DRAW "L8"
21040  NEXT
21042  GOTO 21054
21044  FOR X% = 1 TO 12
21046      A% = 163 - 12 * X%
21048      PSET(90,A%)
21050      DRAW "L8"
21052  NEXT
21054  PSET(90,115)
21056  IF ST<=70
         THEN  YY% =6:
               A% = 76:
               NSCAL% =10:
               J=6:
              SCAL=76:
              XSCAL=7.6:
              ANDFACT%=16
21058  IF ST<=310 AND ST>70
         THEN  YY% = 5 :
               A% = 92 :
               NSCAL% = 60 :
               J=10:
              SCAL=46:
              XSCAL=1.53:
              ANDFACT%=4
21060  IF ST>310
         THEN  YY%=4 :
               A%=115:
               NSCAL%=5 :
               J=8:
              SCAL=57:
              XSCAL=.38:
              ANDFACT%=1
21062  FOR X% = 1 TO J
21064      B% = 90 + SCAL * X%
21066      PSET(B%,163)
21068      DRAW "D2"
```

```
21070 NEXT
21072 VAR% = 0
21074 FOR X% = 0 TO YY%
21076      B% = 87 + A% * X%
21078      B$ = STR$(B%)
21080      DRAW "BM" + B$ + ",174"
21082      DRAW "S 3;" + N$(VAR%)
21084      VAR% = VAR% + NSCAL%
21086 NEXT
21088 T$ = Y$(FL2%)
21090 Y$(0) = "TEMPERATURE C"
21092 Y$(1) = "PRESSURE  Pa "
21094 Y$(2) = " FLOW  L-S    "
21096 FOR X% = 1 TO 13
21098      LOCATE X% + 3,3
21100      PRINT MID$(T$,X%,1)
21102 NEXT
21104 YTEMP$= "  0 50100150200250300"
21106 YFLO$ = "-50-25  0 25 50 75100"
21108 YPRS$ = "-15-10 -5  0  5 10 15 20 25 30"
21110 IF FL2%  = 0
         THEN  YNUMS$ = YTEMP$:
              YSCAL=.48
21112 IF FL2%  = 1
         THEN  YNUMS$ = YPRS$:
              YSCAL=3.2
21114 IF FL2%  = 2
         THEN  YNUMS$ = YFLO$:
              YSCAL=.96
21116 IF FL2%=1
         THEN 21118
         ELSE 21134
21118 PP%=1:
      P%=21
21120 FOR X%= 1 TO 10
21122      LOCATE P%,8
21124      PRINT MID$(YNUMS$,PP%,3)
21126      P%=P%-2
21128      PP%=PP%+3
21130 NEXT
21132 GOTO 21150
21134 PP% = 1
21136 P% = 21
21138 FOR X% = 1 TO 7
21140      LOCATE P%,8
21142      PRINT MID$(YNUMS$,PP%,3)
21144      P% = P% - 3
21146      PP% = PP% + 3
21148 NEXT
21150 T$ = Y$(FL2%)
21152 Y$(0) = "TEMPERATURE C"
21154 Y$(1) = "PRESSURE  Pa "
21156 Y$(2) = " FLOW  L-S    "
```

```
21158  FOR X% = 1 TO 13
21160      LOCATE X% + 4,3
21162      PRINT MID$(T$,X%,1)
21164  NEXT
21166  IF FL2%=0
          THEN 21168
          ELSE 21176
21168  TISET$(1)=TTI$(TMP1%)
21170  TISET$(2)=TTI$(TMP2%)
21172  TISET$(3)=TTI$(TMP3%)
21174  TISET$(4)=TTI$(TMP4%)
21176  IF FL2%=1
          THEN 21178
          ELSE 21186
21178  TISET$(1)=PTI$(P1%)
21180  TISET$(2)=PTI$(P2%)
21182  TISET$(3)=PTI$(P3%)
21184  TISET$(4)=PTI$(P4%)
21186  IF FL2%=2
          THEN 21187
          ELSE 21194
21187  TISET$(1)=FTI$(FR1%)
21188  TISET$(2)=FTI$(FR2%)
21189  TISET$(3)=FTI$(FR3%)
21190  TISET$(4)=FTI$(FR4%)
21194  FOR X%=1 TO 4
21196      LOCATE X%,56:
           PRINT TISET$(X%)
21198  NEXT
21199  PUT (405,2),BOX%:
        PUT (405,10),TRI%:
        PUT (405,16),CIR%:
        PUT (405,25),DIAMND%
21200  LINE (384,8*1-4)-(430,8*1-4)
21202  FOR X%=2 TO 4
21204      FOR XX%=384 TO 430
21206          IF XX% AND ANDNO%(X%)/32
                  THEN 21208
                  ELSE PSET (XX%,8*X%-4)
21208      NEXT XX%
21209  NEXT X%
21300 REM
21302 REM      PLOTTING BEGINS
21304 REM
21305  XNEW=SCS
21346  IF SCS < 0 OR SCS > 1200
          THEN 21940
21348  GTOUT(1)=OO(9)
21350  GTOUT(2)=OO(10)
21352  GTOUT(3)=OO(11)
21354  GTOUT(4)=OO(12)
21356  GTOUT(5)=OO(13)
21358  GTOUT(6)=OO(8)
```

```
21360  GTOUT(7)=T9*10!
21361  GTOUT(8)=TDHW
21362  GPOUT(1)=PB(1)
21364  GPOUT(2)=PB(4)
21366  GPOUT(3)=PB(6)
21368  GPOUT(4)=PB(8)
21370  GPOUT(5)=PB(3)
21372  GPOUT(6)=PB(5)
21374  GPOUT(7)=PB(7)
21376  GPOUT(8)=PB(9)
21378  GPOUT(9)=PB(10)
21380  GPOUT(10)=PB(2)
21382  GPOUT(11)=PB(11)
21522  GPOUT(12)=(-DPDIL-DPFP)
21523  GPOUT(13)=-DPBUO
21526  GFOUT(1)=OO(3)
21527  GFOUT(2)=OO(4)
21528  GFOUT(3)=OO(5)
21529  GFOUT(4)=OO(6)
21530  GFOUT(5)=QDHW*1000!
21850  IF FL2%=0
          THEN YNEW(1)=GTOUT(TMP1%):
               YNEW(2)=GTOUT(TMP2%):
               YNEW(3)=GTOUT(TMP3%):
               YNEW(4)=GTOUT(TMP4%):
               YST=163
21860  IF FL2%=1
          THEN YNEW(1)=GPOUT(P1%):
               YNEW(2)=GPOUT(P2%):
               YNEW(3)=GPOUT(P3%):
               YNEW(4)=GPOUT(P4%):
               YST=115
21870  IF FL2%=2
          THEN YNEW(1)=GFOUT(FR1%):
               YNEW(2)=GFOUT(FR2%):
               YNEW(3)=GFOUT(FR3%):
               YNEW(4)=GFOUT(FR4%):
               YST=115
21875   PSET ((XNEW*XSCAL)+90,YST-INT(YNEW(1)*YSCAL))
21877  PT1=XNEW*XSCAL+90
21880  FOR OP% = 1 TO 4
21882      IF ABS((XNEW-XOLD)*XSCAL)>16 OR ABS((YNEW(OP%)-YOLD(OP%))*Y
             SCAL)>16
              THEN LINE (XOLD*XSCAL+90,YST-INT(YOLD(OP%)*YSCAL))-(PT1,
                YST-INT(YNEW(OP%)*YSCAL)),,,PATTRN%(OP%):
                   GOTO 21900
21884      LINE (XOLD*XSCAL+90,YST-INT(YOLD(OP%)*YSCAL))-(PT1,YST-INT(
             YNEW(OP%)*YSCAL))
21886      IF OP%=1
              THEN 21900
21887      IF PT1 < PT-40 AND PT1 <> PT
              THEN GOTO 21909
21888      IF (SCS*10) AND (ANDNO%(OP%)/ANDFACT%)
```

```
           THEN PRESET ((XOLD*XSCAL)+90,YST-INT(YOLD(OP%)*YSCAL))
21900     IF PT1 < PT
           THEN GOTO 21909
21901     PT=PT+50
21902     YT1 = YST-2-INT(YNEW(1)*YSCAL):
           YT2 = YST-2-INT(YNEW(2)*YSCAL):
           YT3 = YST-4-INT(YNEW(3)*YSCAL):
           YT4 = YST-3-INT(YNEW(4)*YSCAL)
21903     IF YT1 > 0 AND YT1 < 200 AND PT1 < 630
           THEN PUT (PT1,YT1),BOX%
21904     IF YT2 > 0 AND YT2 < 200 AND PT1 < 630
           THEN PUT (PT1,YT2),TRI%
21905     IF YT3 > 0 AND YT3 < 200 AND PT1 < 630
           THEN PUT (PT1,YT3),CIR%
21906     IF YT4 > 0 AND YT4 < 200 AND PT1 < 630
           THEN PUT (PT1,YT4),DIAMND%
21909     YOLD(OP%) = YNEW(OP%)
21910 NEXT
21920 XOLD = XNEW
21930 XNEW=SCS
21940 LOCATE 1,13:
      PRINT USING"TIME  = ######.#   s";SCS
21941 IF TMONOFF > 0
        THEN GOTO 21945
21942 LOCATE 2,13:
      PRINT USING"TIME  STEP = #.### s";SEC
21945 IF TMONOFF > 0
        THEN LOCATE 2,13:
             PRINT USING"ROOM TEMP = ##.## C    ";T9
21950 RETURN
22000 REM===================================================================
22010 REM:EXPONENTIAL MODEL OF THE THERMAL CHARACTERISTICS OF THE HOUSE
        ENVELOPE
22020 REM===================================================================
22022 IF HMASS$= "L"
        THEN HHC= 24000!*1630
22024 IF HMASS$= "M"
        THEN HHC= 55000!*1300
22026 IF HMASS$= "H"
        THEN HHC= 10000!*1000
22030 EA = 4 * ((HVOL/7.2)^.5)*7.2+(HVOL/7.2)*2 :
       :
      REM:ENVELOPE AREA
22040 AHT = EA/.12 :
       'RSI = .12 BETWEEN AIR AND GYPSUM
22050 AHC = (353.6/(T9+TA))* HVOL * 1005 * 2
22060 TOW1=AHC/AHT:
      TOW2=HHC/HTC :
      REM:TIME CONSTANTS
22070 WTSIN=U2A*(TMF-T9)
22072 T91=T9-T1 :
       TAG = T91*(3/30)
22080 IF F$="OFF"
```

```
          THEN 22130
          ELSE 22090
22090  T9N=T9+SEC*(WTSIN-AHT*(T9-TGYP)-.3*HTC*(T9-T1))/AHC
22091  TGYPN=TGYP+SEC*(AHT*(T9-TGYP)-.7*HTC*(TGYP-T1))/HHC
22092  T9=T9N :
        TGYP=TGYPN
22094 REM: LOCATE 10,40 : PRINT USING"###.###  ";T9,TGYP
22100  IF T9>THS
          THEN 22110
          ELSE 22120
22110  RNGTM=0:
       RETURN
22120  RNGTM=RNGTM+SEC:
       RETURN
22130  T9N=T9+SEC*(WTSIN-AHT*(T9-TGYP)-.3*HTC*(T9-T1))/AHC
22131  TGYPN=TGYP+SEC*(AHT*(T9-TGYP)-.7*HTC*(TGYP-T1))/HHC
22132  T9=T9N :
        TGYP=TGYPN
22134 REM: LOCATE 10,40 : PRINT USING"###.###  ";T9,TGYP
22140  IF T9<(THS-TMONOFF)
          THEN 22150
          ELSE 22160
22150  F$="ON":
       FS=SCS:
       RNGTM=0:
       GOSUB 19500:
       RETURN
22160  RNGTM=RNGTM+SEC:
       RETURN
22500 REM===================================================
22510 REM:   KEEPING TRACK OF CONDENSING POINTS IN THE FLUE
22520 REM===================================================
22530 REM
22540  YDEW=0
22545  IF VF(3)<=0
          THEN 22600
22550  FOR Y% = NE% TO 1 STEP -1
22560       BLTEMP=(TF(1,Y%)+TF(2,Y%))/2
22570       IF F$="ON" AND BLTEMP < FLUEDP
               THEN YDEW = Y% :
                     DEW(Y%)=DEW(Y%)+SEC
22580       IF F$="OFF" AND BLTEMP < ROOMDP
               THEN YDEW = Y%:
                     DEW(Y%)=DEW(Y%)+SEC
22582       IF F$="NOT" AND BLTEMP < ROOMDP
               THEN YDEW = Y%:
                     DEW(Y%)=DEW(Y%)+SEC
22590  NEXT
22600  RETURN
23000 REM===================================================
23010 REM:   HOT WATER HEATER BRANCH: BOUNDARY PRESSURES & FLOW RATES
23020 REM===================================================
23030 REM
```

```
23040   IF VF(11) > 0
           THEN SN = 1 :
                 II = 2
           ELSE SN = -1 :
                 II=3
23050   DPDIL= 0 - SN * (473.8 * (( ABS (VF(11)) / ELA(II)) ^ 2) / (TN(11
          ) + TA))
23060   IF VF(4) > 0
           THEN SN = 1
           ELSE SN=-1
23062   IF DHWFPN > NFPSEGS%
           THEN KE4=KE(4)
           ELSE KE4=(.5*NELBOWS*.5)
23063   ELA6M = ARD(5)* ((2.68 / (KE4 + KE(5))) ^ .5)
23070   DPFP= -(SN * (473.8 /(TN(5)+TA)) * (( ABS (VF(5) / ELA6M) ^ 2)))
23072   DPBUO=353.6*GC*DHWFPH*((1/(TDHW+TA)) - (1/(TI(1,1)+TA)))
23080   DPDHW=DPDIL+DPFP+DPBUO
23090   IF DPDHW > 0
           THEN SN = -1
           ELSE SN = 1
23140 REM
23160 REM
23200   QDHW=SN*SQR(ABS(DPDHW)*(TA+TDHW)/473.8)*ELADHW
23210   MDHW=(353.6/(TA+TDHW))*QDHW
23299   RETURN
24000 REM============================================================
24020 REM
24040 REM :  TRANSIENT HEAT TRANSFER MODEL OF THE WATER HEATER FLUEPIPE
24060 REM :  PARAMETERIZED TEMPERATURE ALGORITHMS ARE CALLED IN SUBROUT
          INE 12000
24080 REM
24100 REM ===========================================================
24120 REM
24180 REM UFFP = 0
24200 REM
24220 REM
24240  FOR Y% = 1 TO NDHWFP%
24260      REM :----MASS OF THE FLUE GAS ELEMENT = VOLUME OF ELEMENT
              X  DENSITY AT INITIAL TEMPERATURE-----
24280       GMASSDHW = ((DHWAR * DHWFPLE/NDHWFP%) * (353.6 / (TIDHW(1,Y
              %) + TA)))
24340      REM
24410       UDHW = UI
24415       IF DHWO$="O"
               THEN DHWAC=DHWC
               ELSE DHWAC=DHWSBC
24420       IF Y% = 1 AND MDHW > 0
               THEN TB = T9+(DHWAC*(1-DHWEF))/(MDHW*CPAIR) :
                     GOTO 24480
24460       TB = TIDHW(1,(Y%- 1))
24480       IF MDHW > 0
               THEN  GOTO 24540
24500       IF Y%= NDHWFP%
```

```
                THEN TB = TI(1,DHWFPN):
                      GOTO 24540
24520         TB = TIDHW(1,(Y%+ 1))
24540         INDT% = 1
24580         ITW = GMASSDHW /  ABS (MDHW+.000001)
24590         SADHW=SQR(DHWAR/PIE)*2*PIE*DHWFPLE/NDHWFP%
24600         OTW = (GMASSDHW * HC(1,Y%) / (UDHW * SADHW))
24620         D1TM = TB - TIDHW(1,Y%)
24640         D2TM = TIDHW(1,Y%) - TIDHW(2,Y%)
24660         ITDHW=10000
24680         D3TM=0!
24780         GOSUB 12020
24800         TFDHW(1,Y%)= TIDHW(1,Y%) + DTM
24820         FOR J = 2 TO 4
24840             INDT% = 2
24860             ITW = (M(J,Y%) * HC(J,Y%) / (U(J - 1,Y%) * SADHW))
24880             OTW = (M(J,Y%) * HC(J,Y%) / (U(J,Y%) * SADHW))
24900             D1TM = TIDHW(J - 1,Y%) - TIDHW(J,Y%)
24920             D2TM = TIDHW(J,Y%) - TIDHW(J + 1,Y%)
24940             ITDHW=10000! :
                   D3TM = 0!
24960             GOSUB 12020
24980             TFDHW(J,Y%) = TIDHW(J,Y%) + DTM
25000             IF FPI$="U"
                     THEN GOTO 25020
                     ELSE GOTO 25040
25020             IF J > 2
                     THEN TFDHW(J,Y%) = TN(9)
25040         NEXT J
25060     NEXT Y%
25070      TDHW=0
25080     FOR Y% = 1 TO NDHWFP%
25090         TDHW=TDHW+TFDHW(1,Y%)
25100         FOR J = 1 TO 4
25120             TIDHW(J,Y%) = TFDHW(J,Y%)
25130            REM  LPRINT TIDHW(J,Y%);
25140         NEXT J
25160     NEXT Y%
25170      TDHW=TDHW/NDHWFP%
25180      IF TDHW > 260
              THEN TDHW = 260
25200 REM
25240 REM
25760  RETURN
29000 REM      USER ERROR HANDLING ROUTINES
29110  SCREEN 0:
        COLOR 7
29120  IF ERR=27 OR ERR=24
          THEN LOCATE 20,40:
               PRINT"CHECK PRINTER":
               RESUME
29130  IF ERR=61
          THEN LOCATE 10,40:
```

```
                PRINT"DISK IS FULL - USE ANOTHER DISKETTE":
                LOCATE 20,1:
                PRINT SPACE$(79):
                PRINT SPACE$(79):
                RESUME 4750
29140   IF ERR=5 AND (ERL=21020 OR ERL=20090)
           THEN GOTO 30000
29999   ON ERROR GOTO 0
30000   BEEP:
        CLS:
         LOCATE 5,5:
        PRINT "You have chosen 'GRAPH' output and the 'INSTALL4.DAT' file
          "
30010   LOCATE 7,5:
        PRINT"indicates that your computer is capable of 640x200"
30015   LOCATE 9,5:
        PRINT"resolution graphics, but this is not the case for"
30017   LOCATE 11,5:
        PRINT"the present configuration"
30020   LOCATE 14,5:
        PRINT"DO YOU WISH TO -"
30030   LOCATE 16,1:
        PRINT"1. RETURN to the main menu to SAVE the current input data,
          then EXIT to DOS "
30040 LOCATE 18,1:PRINT"2. Correct 'INSTALL4.DAT' &  CONTINUE the simulation with a TABULAR output "
30050 LOCATE 22,10:INPUT "Your choice  1 or [2] ";A
30055 IF A=1 THEN GOTO 3671
30060 GOSUB 30100
30070 FL1%=0: GD$="T":RESUME 18326    'SET UP FOR TABLES
30100 CLOSE #1
30110 OPEN "INSTALL4.DAT" FOR INPUT AS #1
30120 LINE INPUT #1, L1$
30130 LINE INPUT #1, L2$
30140 LINE INPUT #1, L3$
30150 LINE INPUT #1, L4$
30160 CLOSE #1
30210 OPEN "INSTALL4.DAT" FOR OUTPUT AS #1
30215 TSCR=2
30220 PRINT #1,TSCR
30230 PRINT #1,L2$
30240 PRINT #1,L3$
30250 PRINT #1,L4$
30260 CLOSE #1
30270 RETURN
```

APPENDIX C

VARIABLE LIST AND LINE NUMBER REFERENCES

LIST OF VARIABLES

AND THEIR DESCRIPTION:

FLUESIM 4.2

(SORTED BY MODULE & TYPE)

VARIABLE LIST FOR PROGRAM: FLUESIM4.BAS DATE: 03-01-1989

THE PROGRAM HAS 1567 LINES OF CODE

NOTE: A NUMBER OF VARIABLES ARE USED AS UTILITY VARIABLES TO TEMPORARILY STORE OR HANDLE INFORMATION MORE EFFICIENTLY. THESE VARIABLES ARE CLASSIFIED AS "UTILITY" IN THE "VARIABLE TYPE" COLUMN.

	VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
1	VV	VERTICAL COMPONENT OF THE WIND VELOCITY (+VE UPWARDS)	(m/s)		BOUNDARY CONDITION	AERODYNAMIC
2	DFO	COEFFICIENT IN THE DAMPER FRICTION LOSS EQUATION			COEFFICIENT	AERODYNAMIC
3	WCOEFV	VERTICAL WIND PRESSURE COEFFICIENT			COEFFICIENT	AERODYNAMIC
4	CONST	COEFFICIENT IN THE DAMPER FRICTION LOSS EQUATION			COEFFICIENT	AERODYNAMIC
5	WCOEFH	HORIZONTAL WIND PRESSURE COEFFICIENT			COEFFICIENT	AERODYNAMIC
6	CPWENV	WIND PRESSURE COEFFICIENT OF THE HOUSE ENVELOPE			COEFFICIENT	AERODYNAMIC
7	PTC	TOTAL WIND PRESSURE COEFFICIENT			COEFFICIENT	AERODYNAMIC
8	VCL	EFFECTIVE ENVELOPE CENTER OF LEAKAGE INCLUDING INTAKE	(m)		DIMENSION	AERODYNAMIC
9	RISE	THE RISE OF EACH SEGMENT IN THE MAIN FLUE PIPE	(m)		DIMENSION	AERODYNAMIC
10	VCLINT	LOCATION OF THE FRESH AIR INTAKE	(m)		DIMENSION	AERODYNAMIC
11	DIA	FLUE PIPE AND FLUE INSIDE DIAMETERS	(m)		DIMENSION	AERODYNAMIC
12	RISET	THE TOTAL RISE OF THE MAIN FLUE PIPE	(m)		DIMENSION	AERODYNAMIC
13	FF	FLUE FRICTION FACTOR			FACTOR	AERODYNAMIC
14	FCAPL	FRICTION LOSS FACTOR OF THE FLUE CAP			FACTOR	AERODYNAMIC
15	COS	TRIG FUNCTION			FUNCTION	AERODYNAMIC
16	MDI$	INDICATOR OF WHETHER OR NOT THERE IS A DRAFT INDUCER		(Y/N)	INDICATOR	AERODYNAMIC
17	LEAKDIST	INDICATOR OF THE ORIENTATION OF ENVELOPE LEAKS			INDICATOR	AERODYNAMIC
18	ELAENV	EQUIVALENT LEAKAGE AREA: OF THE ENVELOPE	(m2)		PARAMETER	AERODYNAMIC
19	ELA	EQUIVALENT LEAKAGE AREA: ARRAY OF ALL ELA'S IN THE SYSTEM	(m2)		PARAMETER	AERODYNAMIC
20	KBD	FRICTION FACTOR FOR THE BAROMETRIC DAMPER			PARAMETER	AERODYNAMIC
21	ELAINT	EQUIVALENT LEAKAGE AREA: OF THE FRECH AIR INTAKE	(m2)		PARAMETER	AERODYNAMIC
22	KE4	FRICTION FACTOR OF THE FLUE PIPE UP TO THE DHW CONNECTION			PARAMETER	AERODYNAMIC
23	KECON	FRICTION FACTOR OF THE DHW CONNECTION TO THE MAIN VENT			PARAMETER	AERODYNAMIC
24	KE	DYNAMIC PRESSURE LOSS FACTORS AT EACH POINT IN THE FLOW NETWORK			PARAMETER	AERODYNAMIC
25	PB	PRESSURE PARAMETERS USED IN THE STEP BY STEP CALCULATION	(PA)		PARAMETER	AERODYNAMIC
26	EXAIR	OIL FURNACE EXESS AIR	(%)		PARAMETER	AERODYNAMIC
27	K1	MINIMUM OVERALL PRESSURE LOSS FACTOR OF FLUE PIPE & CHIMNEY		1.43 + 1.8	PARAMETER	AERODYNAMIC
28	KEINT	FRICTION FACTOR OF THE FRESH AIR INTAKE			PARAMETER	AERODYNAMIC
29	AR	AREA OF OPENINGS AT THE NETWORK POINTS	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
30	ARINT	FRESH AIR INTAKE AREA	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
31	ARDAMP	AREA OF THE BAROMETRIC DAMPER	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
32	ARD	AREA OF FLUE PIPE AND FLUE OPENINGS	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
33	NFPSEGS	NUMBER OF SEGMENTS IN THE MAIN FLUE PIPE			PHYSICAL QUANTITY	AERODYNAMIC
34	NELBOWS	NUMBER OF ELBOWS IN THE MAIN FLUE PIPE			PHYSICAL QUANTITY	AERODYNAMIC
35	NELINT	NUMBER OF ELBOWS IN THE FRESH AIR INTAKE			PHYSICAL QUANTITY	AERODYNAMIC
36	MFIN	UTILITY: MASS FLOW INTO THE FLUE PIPE	(kg/s)		QUANTITY	AERODYNAMIC
37	JUNCTLOSS	EQUIVALENT NUMBER OF ELBOWS DUE TO THE DHW JUNCTION		1	QUANTITY	AERODYNAMIC
38	VWIND	UTILITY: WIND SPEED	(kg/h)		QUANTITY	AERODYNAMIC
39	QDHW	VOLUMETRIC FLOW RATE OF THE HOT WATER BRANCH	(m3/s)		QUANTITY	AERODYNAMIC
40	VWINDH	UTILITY: WIND - HORIZONTAL COMPONENT	(m/s)		QUANTITY	AERODYNAMIC
41	QFLUE	VOLUMETRIC FLOW RATE OF THE FLUE GAS	(m3/s)		QUANTITY	AERODYNAMIC

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
42 VWINDT	WIND SPEED - TOTAL	(m/s)		QUANTITY	AERODYNAMIC
43 QDIL	VOLUMETRIC FLOW RATE OF THE DILUTION FLOW	(m3/s)		QUANTITY	AERODYNAMIC
44 VWINDV	UTILITY: WIND SPEED - VERTICAL COMPONENT	(m/s)		QUANTITY	AERODYNAMIC
45 QFUEL	VOLUMETRIC FLOW RATE OF THE FUEL	(m3/s)		QUANTITY	AERODYNAMIC
46 MTFUEL	TOTAL MASS FLOW OF THE FUEL. MTFUEL = EITHER MTOIL OR MGAS	(kg/s)		QUANTITY	AERODYNAMIC
47 MOIL	MASS FLOW OF THE OIL	(kg/s)		QUANTITY	AERODYNAMIC
48 MTOIL	TOTAL MASS FLOW OF THE OIL & EXCESS AIR	(kg/s)		QUANTITY	AERODYNAMIC
49 QFURN	VOLUMETRIC FLOW RATE OF THE GAS THROUGH THE FURNACE	(m3/s)		QUANTITY	AERODYNAMIC
50 DAMPTCL	UTILITY: EFFECT OF FLUE DAMPER OPENING ON EFFECTIVE FLOW AREA			UTILITY	AERODYNAMIC
51 DAMPACT$	UTILITY: EFFECT OF FLUE DAMPER OPENING ON EFFECTIVE FLOW AREA			UTILITY	AERODYNAMIC
52 DAMPTOP	UTILITY: EFFECT OF FLUE DAMPER OPENING ON EFFECTIVE FLOW AREA			UTILITY	AERODYNAMIC
53 SNFP	UTILITY: KEEPS TRACK OF THE FLOW DIRECTION IN THE FLUE PIPE		(+1 OR -1)	VECTOR	AERODYNAMIC
54 THETAW	ANGLE OF THE WIND @ CHIMNEY TOP	(DEG)		VECTOR	AERODYNAMIC
55 SN	UTILITY: TO KEEP TRACK OF VERTICAL WIND DIR (+VE UP) FOR V2		(+1 OR -1)	VECTOR	AERODYNAMIC
56 QF	VOLUMETRIC FLOW RATE OF THE FANS	(m3/s)		BOUNDARY COND	AERODYNAMIC
57 QGAS	VOLUMETRIC FLOW RATE OF THE FUEL (EG. GAS OR OIL)	(m3/s)		BOUNDARY CONDI	AERODYNAMIC
58 FP	VOLUMETRIC FLOW RATE OF THE FIREPLACE	(l/s)		BOUNDARY CONDI	AERODYNAMIC
59 VH	HORIZONTAL COMPONENT OF THE WIND VELOCITY AT THE CHIMNEY TOP	(m/s)		BOUNDARY CONDI	AERODYNAMIC
60 FANM	MASS FLOW THROUGH THE FANS	(KG/S)		BOUNDARY CONDI	AERODYNAMIC
61 FIRM	MASS FLOW RATE OF THE FIREPLACE	(kg/s)		BOUNDARY CONDI	AERODYNAMIC
62 TN	TEMPERATURE AT EACH NETWORK POINT	(C)		BOUNDARY CONDITION	AERODYNAMIC
63 PVC	PRESSURE COEFFICIENT OF THE VERTICAL COMPONENT OF WIND		(1.)	COEFFICIENT	AERODYNAMIC
64 C	ENVELOPE FLOW COEFFICIENT	m3/(s.Pa^n)		COEFFICIENT	AERODYNAMIC
65 PHC	PRESSURE COEFFICIENT OF THE HORIZONTAL COMPONENT OF WIND		(0.5)	COEFFICIENT	AERODYNAMIC
66 GC	GRAVITATIONAL CONSTANT	(m/s2)	9.8	CONSTANT	AERODYNAMIC
67 RO	DENSITY OF THE GAS AT EACH NETWORK POINT	(kg/m3)		DEPENDENT PROPERTY	AERODYNAMIC
68 TEF	AVERAGE FURNACE GAS TEMPERATURE TO CALCULATE BUOYANCY OF FURNACE	(C)		DEPENDENT PROPERTY	AERODYNAMIC
69 PT	TOTAL PRESSURE	(PA)		DEPENDENT VAR	AERODYNAMIC
70 V	VELOCITY OF FLUE GAS THROUGH EACH ELEMENT OF THE CHIMNEY	(m/s)		DEPENDENT VAR	AERODYNAMIC
71 DI2	CHARACTERISTIC DIAMETER OF OPENINGS AT NETWORK POINTS	(mm)		DIMENSION	AERODYNAMIC
72 LNPP	LOCATION OF THE NEUTRAL PRESSURE PLANE (NO FLUE) REL TO DATUM	(M2)	(-2.8)	DIMENSION	AERODYNAMIC
73 HH	HEIGHT OF THE HEATING APPLIANCE (FROM AIR INTAKE TO DIL DEVICE)	(m)	(1m)	DIMENSION	AERODYNAMIC
74 DI	CHARACTERISTIC DIAMETER OF OPENINGS AT NETWORK POINTS	(mm)		DIMENSION	AERODYNAMIC
75 MU	VISCOSITY OF AIR	(kg/s(m.s))	1.84E-5	FIXED PROPERTY	AERODYNAMIC
76 N	ENVELOPE FLOW COEFFICIENT		(0.5 - 1)	FIXED PROPERTY	AERODYNAMIC
77 L2A	DUMMY VARIABLE USED TO CALCULATE E.L.A. OF OPENINGS	(M2)		PARAMETER	AERODYNAMIC
78 GFF	SUMMATION OF GRAVITATIONAL HEAD UP THE FLUE	(Pa)		PARAMETER	AERODYNAMIC
79 L1A	DUMMY VARIABLE USED TO CALCULATE E.L.A. OF OPENINGS	(M2)		PARAMETER	AERODYNAMIC
80 GF	SUMMATION OF GRAVITATIONAL HEAD UP THE FLUE	(Pa)		PARAMETER	AERODYNAMIC
81 HT	VERTICAL DISTANCE FROM DATUM TO NETWORK POINT	(m)		PHYSICAL DIMEN	AERODYNAMIC
82 ADR	EFFECTIVE AREA OF THE DILUTION DEVICE OPENING WHEN FLOW REVERSED	(m2)		PHYSICAL DIMEN	AERODYNAMIC
83 APRD	LEAKAGE AREA OF THE BAROMETRIC DAMPER WHEN CLOSED	(% OF OPEN)		PHYSICAL DIMENSION	AERODYNAMIC
84 VL	VELOCITY (SCALER) OF GAS/AIR AT EACH NETWORK POINT	(m/s)		PHYSICAL QUANT	AERODYNAMIC
85 VF	VOLUMETRIC FLOW RATE	(m3/s)		PHYSICAL QUANT	AERODYNAMIC
86 Q9	INITIAL & SUBSEQUENT GUESS AT MASS FLOW RATE OF STACK GASES	(kg/s)		PHYSICAL QUANTITY	AERODYNAMIC
87 Q6	INITIAL & UPDATED GUESS AT MASS FLOW RATE THROUGH THE CHIMNEY	(kg/s)		PHYSICAL QUANTITY	AERODYNAMIC
88 MCOMP	SUM OF FAN & FIREPLACE MASS FLOWS	(kg/s)		QUANTITY	AERODYNAMIC
89 NDHWFP	NUMBER OF DWH FLUE PIPE SEGMENTS			QUANTITY	AERODYNAMIC
90 GMASSDHW	MASS OF THE AIR IN THE DHW FLUE PIPE	(kg)		QUANTITY	AERODYNAMIC
91 MFUEL	MASS FLOW OF THE FLUE	(kg/s)		QUANTITY	AERODYNAMIC
92 MF	MASS FLOW RATES AT EACH NETWORK POINT	(kg/s)		QUANTITY	AERODYNAMIC
93 MGAS	MASS FLOW OF THE FUEL (EG. GAS OR OIL)	(kg/s)		BOUNDARY CONDITION	AERODYNAMIC/THERMAL
94 T9	HOUSE TEMPERATURE	(C)	(20)	BOUNDARY CONDITION	AERODYNAMIC/THERMAL
95 T1	OUTDOOR TEMPERATURE	(C)		BOUNDARY CONDITION	AERODYNAMIC/THERMAL
96 HF	HEIGHT OF CHIMNEY FROM DILUTION DEVICE TO TOP	(m)	(8)	DIMENSION	AERODYNAMIC/THERMAL
97 RE	REYNOLDS NUMBER - OF THE FLUE FASES IN THE CHIMNEY			PARAMETER	AERODYNAMIC/THERMAL
98 EH	VERTICAL HEIGHT OF EACH ELEMENT OF FLUE-PIPE & CHIMNEY	(m)	(1)	PHYSICAL DIMEN	AERODYNAMIC/THERMAL

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
99 DF	DIAMETER OF THE CHIMNEY SHAFT OR LINER	(m)	(0.175)	PHYSICAL QUANT	AERODYNAMIC/THERMAL
100 X	UTILITY: LOOP COUNTER FOR THE NUMBER OF NETWORK POINTS			CONTROL	ALL
101 I	UTILITY: LOOP COUNTER			CONTROL	ALL
102 J	LOOP COUNTER FOR THE NUMBER OF CALCULATION PLANE IN-OUT OF CHIMN			CONTROL	ALL
103 II	UTILITY: LOOP COUNTER			CONTROL	ALL
104 SEC	CALCULATION INTERVAL	(S)	(1)	CONTROL	ALL
105 DHF	LENGTH OF EACH SEGMENT OF THE FLUE PIPE	(m)		DIMENSION	ALL
106 ELHT	HEIGHT OF EACH FLUE ELEMENT	(m)		DIMENSION	ALL
107 LEFT$	FUNCTION			FUNCTION	ALL
108 PAR	ARRARY OF KEY PARAMETERS THAT DEFINE THE CASE			PARAMETER	ALL
109 E	SYMBOL TO SIGNIFY "EXPONENT" - NOT A VARIABLE			SYMBOL	ALL
110 ERR	ERROR TRAP INFO: ERROR NUMBER			UTILITY	ALL
111 ERL	ERROR TRAP INFO: ERROR LINE			UTILITY	ALL
112 X2	UTILITY			UTILITY	COMMON
113 PRREG$	UTILITY			UTILITY	COMMON
114 PRUUN	UTILITY			UTILITY	COMMON
115 CHHC	UTILITY			UTILITY	COMMON
116 CHELTL	UTILITY			UTILITY	COMMON
117 TLFLAG	UTILITY			UTILITY	COMMON
118 CHDENL	UTILITY			UTILITY	COMMON
119 PRISE	UTILITY			UTILITY	COMMON
120 CHELTO	UTILITY			UTILITY	COMMON
121 CHDENO	UTILITY			UTILITY	COMMON
122 CHELTS	UTILITY			UTILITY	COMMON
123 CHM$	UTILITY			UTILITY	COMMON
124 ICHTYPE	INDICATOR OF CHIMNEY TYPE (NOT USED IN THE CALC MODULE)			UTILITY	COMMON
125 X1	UTILITY			UTILITY	COMMON
126 GE	UTILITY			UTILITY	COMMON
127 CHTHCL	UTILITY			UTILITY	COMMON
128 TT$	UTILITY			UTILITY	COMMON
129 DB	UTILITY			UTILITY	COMMON
130 ENTRY	UTILITY			UTILITY	COMMON
131 COUNT	UTILITY			UTILITY	COMMON
132 FPDI2	UTILITY			UTILITY	COMMON
133 CHDI2	UTILITY			UTILITY	COMMON
134 CHHK2	UTILITY			UTILITY	COMMON
135 CHTHCO	UTILITY			UTILITY	COMMON
136 CHHK3	UTILITY			UTILITY	COMMON
137 FPAR	UTILITY			UTILITY	COMMON
138 PRCOND$	UTILITY			UTILITY	COMMON
139 CHDENS	UTILITY			UTILITY	COMMON
140 PRFLAG	UTILITY			UTILITY	COMMON
141 CHHK1	UTILITY			UTILITY	COMMON
142 PRFF$	UTILITY			UTILITY	COMMON
143 CHTHCS	UTILITY			UTILITY	COMMON
144 FCAFNO	UTILITY			UTILITY	COMMON
145 MOHE	UTILITY			UTILITY	COMMON
146 PRFLAG2	CONTROL			UTILITY	COMMON
147 TCF2	UTILITY			UTILITY	COMMON
148 PCODE	UTILITY			UTILITY	COMMON
149 LHC	UTILITY			UTILITY	COMMON
150 ROOMDP	ROOM DEW POINT TEMPERATURE	(C)	(6)	REFERENCE QUANTITY	CONDENSATION
151 BLTEMP	BOUNDARY LAYER TEMPERATURE			THERMAL PARAMETER	CONDENSATION
152 DEW	DURATION OVER WHICH CONDENSATION IS EXPERIENCED AT EACH ELEMENT	(s)		TIME PARAMETER	CONDENSATION
153 YDEW	UTILITY: LOCATES THE VERTICAL LOCATION OF THE ONSET OF CONDENSATION			UTILITY	CONDENSATION
154 FLUEDP	DEWPOINT TEMPERATURE IN THE FLUE	(C)	54C	REFERENCE QUANTITIY	CONDENSATION
155 F$	INDICATOR: FURNACE ON, OFF, NOT YET FIRED		(NOT,ON,OFF)	INDICATOR	CONTROL

	VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
156	T9N	UPDATED ROOM TEMPERATURE	(C)		BOUNDARY CONDITION	DYNAMIC ENVELOPE
157	TGYPN	TEMPERATURE OF THE GYPSUM AFTER THE TIME STEP (NEW)	(C)		DEPENDENT PROPERTY	DYNAMIC ENVELOPE
158	TGYP	TEMPERATURE OF THE GYPSUM	(C)		DEPENDENT PROPERTY	DYNAMIC ENVELOPE
159	WTSIN	DELIVERED HEAT TO THE HOUSE FROM THE FURNACE	(W-s)		DEPENDENT VARIABLE	DYNAMIC ENVELOPE
160	HVOL	HOUSE VOLUME	(m3)		DIMENSION	DYNAMIC ENVELOPE
161	HMASS$	HOUSE MASS INDICATOR		(L,M,H)	INDICATOR	DYNAMIC ENVELOPE
162	TOW2	SECOND TIME CONSTANTS OF THE ENVELOPE	(s)		PARAMETER	DYNAMIC ENVELOPE
163	TOW1	FIRST TIME CONSTANTS OF THE ENVELOPE	(s)		PARAMETER	DYNAMIC ENVELOPE
164	T91	INDOOR OUTDOOR TEMPERATURE DIFFERENCE	(C)		PARAMETER	DYNAMIC ENVELOPE
165	TAG	INDOOR TEMPERATURE AMPLITUDE PARAMETER (NOT USED)	(C)		PARAMETER	DYNAMIC ENVELOPE
166	HTC	CONDUCTIVE HEAT TRANSFER COEFFICIENT THROUGH THE ENVELOPE	(W/C)		PARAMETER	DYNAMIC ENVELOPE
167	EA	ENVELOPE AREA	(m2)		PHYSICAL DIMEN	DYNAMIC ENVELOPE
168	TMONOFF	BAND WIDTH OF THE THERMOSTAT	(C)		SETPOINT	DYNAMIC ENVELOPE
169	THS	THERMOSTAT CUT OFF TEMPERATURE	(C)		SETPOINT	DYNAMIC ENVELOPE
170	HHC	HEAT CAPACITY OF THE HOUSE		(W.S/kg K)	THERMAL PARAM	DYNAMIC ENVELOPE
171	AHT	HEAT TRANSFER RATE BETWEEN HOUSE AIR & ENVELOPE	(W/C)		THERMAL PARAMETER	DYNAMIC ENVELOPE
172	AHC	HEAT CAPACITY OF THE MASS OF AIR IN THE HOUSE	(W.s/m3)		THERMAL PARAMETER	DYNAMIC ENVELOPE
173	RNGTM	RECORDS THE DURATION OF FURNACE OPERATION & STANDBY TIME	(s)		UTILITY	DYNAMIC ENVELOPE
174	ERROR	ERROR TRAP INFO: ERROR FUNCTION			UTILITY	ERROR TRAP
175	L1$	UTILITY			UTILITY	ERROR TRAP
176	L3$	UTILITY			UTILITY	ERROR TRAP
177	L2$	UTILITY			UTILITY	ERROR TRAP
178	L4$	UTILITY			UTILITY	ERROR TRAP
179	RESUME	FUNCTION (RESUMES EXECUTION AFTER A TRAPPED ERROR)			RESUME	ERROR TRAPPING
180	TSCR	UTILITY: SPECIFIES TABULAR OUTPUT WHEN SCREEN CAN'T SHOW GRAPHS			UTILITY	ERROR TRAPPING
181	SPACE$	UTILITY: RECORDS THE AVAILABLE SPACE ON THE OUTPUT DISK	(bytes)		UTILITY	ERROR TRAPPING
182	FR4	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
183	FR3	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
184	FR1	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
185	XX	UTILITY: COUNTER			CONTROL	GRAPHICS
186	AXIS	GRAPHICS CONTROL: INDICATOR OF WHETHER AXES HAVE BEEN DRAWN		(0,1)	CONTROL	GRAPHICS
187	FR2	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
188	PUT	FUNCTION			FUNCTION	GRAPHICS
189	LT	FUNCTION			FUNCTION	GRAPHICS
190	T$	UTILITY: TO DISPLAY TITLES ON THE GRAPHS			UTILITY	GRAPHICS
191	YT2	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
192	P4	UTILITY			UTILITY	GRAPHICS
193	P3	UTILITY			UTILITY	GRAPHICS
194	P2	UTILITY			UTILITY	GRAPHICS
195	P1	UTILITY			UTILITY	GRAPHICS
196	YNUMS$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
197	ANDNO	UTILITY			UTILITY	GRAPHICS
198	TTI$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
199	GPOUT	UTILITY: STORING PRESSURE PARAMETERS FOR GRAPHS	(Pa)		UTILITY	GRAPHICS
200	TISET$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
201	ANDFACT	UTILITY			UTILITY	GRAPHICS
202	GFOUT	UTILITY: STORING FLOW RATES FOR GRAPHS	(l/s)		UTILITY	GRAPHICS
203	A$	UTILITY			UTILITY	GRAPHICS
204	GTOUT	UTILITY: STORING TEMPERATURES FOR GRAPHS	(C)		UTILITY	GRAPHICS
205	DIAMND	CONTAINS COORDINATES TO DRAW A DIAMOND ON THE GRAPHS			UTILITY	GRAPHICS
206	Y$	UTILITY: TITLES FOR THE Y-AXIS IN GRAPHS			UTILITY	GRAPHICS
207	IMP2	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
208	YT4	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
209	B	UTILITY			UTILITY	GRAPHICS
210	YT3	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
211	YTEMP$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
212	VAR	UTILITY			UTILITY	GRAPHICS

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
213 PP	UTILITY			UTILITY	GRAPHICS
214 HB800	UTILITY			UTILITY	GRAPHICS
215 YST	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
216 PTI$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
217 XOLD	UTILITY: USED TO LOCATE X-COORDINATES IN PLOTS			UTILITY	GRAPHICS
218 XSCAL	UTILITY: X-AXIS SCALING FACTOR IN GRAPHICS ROUTINE			UTILITY	GRAPHICS
219 YPRS$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
220 PT1	UTILITY: X-AXIS VALUE FOR GRAPHICS			UTILITY	GRAPHICS
221 XNEW	UTILITY: USED TO LOCATE X-COORDINATES IN PLOTS			UTILITY	GRAPHICS
222 B$	UTILITY			UTILITY	GRAPHICS
223 TMP1	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
224 P	UTILITY			UTILITY	GRAPHICS
225 N$	UTILITY: STORES THE SPECS FOR DRAING NUMBERS ON THE GRAPHS			UTILITY	GRAPHICS
226 YY	UTILITY: USED TO THE SCALE THE Y-AXIS			UTILITY	GRAPHICS
227 YFLO$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
228 P$	UTILITY			UTILITY	GRAPHICS
229 TITLE$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
230 YSCAL	UTILITY: USED TO THE SCALE THE Y-AXIS			UTILITY	GRAPHICS
231 CIR	CONTAINS COORDINATES TO DRAW CIRCLES IN THE GRAPHICS ROUTINE			UTILITY	GRAPHICS
232 TRI	CONTAINS COORDINATES TO DRAW A TRIANGLE ON THE GRAPHS			UTILITY	GRAPHICS
233 TIT$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
234 SCAL	UTILITY: SCAL FOR AXIES IN THE GRAPH ROUTINE			UTILITY	GRAPHICS
235 FTI$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
236 TMP3	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
237 PATTRN	UTILITY			UTILITY	GRAPHICS
238 YT1	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
239 YNEW	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
240 BOX	CONTAINS COORDINATE TO DRAW A BOX ON THE GRAPHS			UTILITY	GRAPHICS
241 TMP4	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
242 YOLD	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
243 HFFFF	UTILITY			UTILITY	GRAPHICS
244 NSCAL	UTILITY: SCALE QUANTITY IN HTE GRAPHICS PROGRAM			UTILITY	GRAPHICS
245 SEG	FUNCTION USED IN CONNECTION WITH BSAVING THE SCREEN			FUNCTION	GRAPHICS OUTPUT
246 PRTSC	FUNCTION (FROM ONE OF THE LIBRARIES) PRINTS A GRAPH			FUNCTION	GRAPHICS/OUTPUT
247 LOCDOT	FUNCTION			FUNCTION	INPUT/OUTPUT
248 PIE	GEOMETRIC CONSTANT		(3.131593)	CONSTANT	MAIN
249 X4	UTILITY: VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
250 Q1	VARIABLE USED IN THE ITERATIVE PROCESS	(kg/s)		CONTROL	MAIN
251 JUNK$	CONTROL: STORES USER'S CHOICE OF OPTIONS AT THE END OF A SIMULATION			CONTROL	MAIN
252 C1	VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
253 FT$	FURNACE TYPE INDICATOR		(O/G)	CONTROL	MAIN
254 MASTER	CONTROL TO INDICATE WHETHER THIS IS THE FIRST ACCESS TO FLUESIM			CONTROL	MAIN
255 FS	TIME (IN SECONDS) AT WHICH FURNACE STARTS	(S)		CONTROL	MAIN
256 FL2	CONTROL INDICATOR		(0,1)	CONTROL	MAIN
257 E2	UTILITY VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
258 ITER	CONTROL: ITERATION COUNTER			CONTROL	MAIN
259 Q2	VARIABLE USED IN THE ITERATIVE PROCESS	(kg/s)		CONTROL	MAIN
260 FLUEIN$	UTILITY			CONTROL	MAIN
261 E1	UTILITY VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
262 ZZ	UTILITY: LOOP COUNTER			CONTROL	MAIN
263 C2	VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
264 DRIVE$	INDICATES WHICH DRIVE THE DEFAULT DATA IS LOCATED			CONTROL	MAIN
265 FL1	CONTROL INDICATOR		(0,1)	CONTROL	MAIN
266 X3	UTILITY: VARIABLE USED IN THE ITERATIVE PROCESS	(kg/s)		CONTROL	MAIN
267 GD$	CONTROL: SPECIFIES GRAPHICS OR TABULAR OUTPUT		(G/T)	CONTROL	MAIN
268 S	UTILITY: INTERVAL COUNTER			CONTROL	MAIN
269 ST	NUMBER OF TOTAL CALCULATION STEPS FOR THE RUN			CONTROL	MAIN

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
270 PELHT	UTILITY: TO HELP ESTABLISH WHICH FLUE ELEMENTS ARE INSIDE & OUT	(m)		DIMENSION	MAIN
271 XFT	FRACTION OF THE FLUE HEIGHT USED TO DETERMINE EXT/INT LOCATION	(m)		DIMENSION	MAIN
272 CHBOT	LENGTH OF FLUE FROM TOP TO CHIMNEY BOTTOM	(m)		DIMENSION	MAIN
273 TFPLN	TOTAL FLUE PIPE LENGTH	(m)		DIMENSION	MAIN
274 TFLEN	TOTAL FLUE LENGTH	(m)		DIMENSION	MAIN
275 TIMER	FUNCTION USED TO TIME A PAUSE			FUNCTION	MAIN
276 DEF	FUNCTION: DEF SEG			FUNCTION	MAIN
277 BSAVE	FUNCTION TO STORE THE GRAPHICS SCREEN ON DISK			FUNCTION	MAIN
278 INSTR	FUNCTION TO OBTAIN LENGTH OF STRING VARIABLES			FUNCTION	MAIN
279 SCSFLAG	UTILITY: INDICATOR THAT THE END OF THE SIMULATION HAS BEEN REACHED		(0,1)	INDICATOR	MAIN
280 CHIMT$	CHIMNEY LOCATION INDICATOR		(1/0)	INDICATOR	MAIN
281 AUFF	FURNACE TURN OFF TIME	(s)		TIME PARAMETER	MAIN
282 DOC$	NAME OF THE DEFAULT DATA FILE			UTILITY	MAIN
283 M6LAST	UTILITY: MASS FLOW THROUGH THE CHIMNEY AT THE LAST TIME STEP	(kg/s)		UTILITY	MAIN
284 HD$	UTILITY: OUTPUT HEADING			UTILITY	MAIN
285 T	UTILITY: USED TO TIME A PAUSE			UTILITY	MAIN
286 CHK$	UTILITY			UTILITY	MAIN
287 M9LAST	UTILITY: MASS FLOW THROUGH THE FURNACE AT THE LAST TIME STEP	(kg/s)		UTILITY	MAIN
288 FAULT$	UTILITY			UTILITY	MAIN
289 ONTIME	UTILITY: RECORD THE TOTAL DURATION OF FURNACE OPERATION	(s)		UTILITY	MAIN
290 OFTIM	UTILITY: STORES THE TIME THE FURNACE WAS TURNED OFF	(s)		UTILITY	MAIN
291 ABORT$	UTILITY			UTILITY	MAIN
292 ER4	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
293 ER2	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
294 ER1	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
295 ER3	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
296 BEEP	FUNCTION TO PRODUCE A BEEP SOUND TO INDICATE THE HALTING OF EXECUTION			FUNCTION	MAIN/ERROR TRAP
297 ELA1	EQUIVALENT LEAKAGE AREA: EFFECTIVE ELA OF FLUE PIPE & FLUE	(m2)		PARAMETER	MATH MODULE
298 AREFF	EFFECIVE FLOW AREA OF THE FLUE PIPE AND FLUE COMBINED	(m2)		PHYSICAL DIMENSION	MATH MODULE
299 B8	UTILITY			UTILITY	MATH MODULE
300 B11	UTILITY			UTILITY	MATH MODULE
301 BB	UTILITY			UTILITY	MATH MODULE
302 BA	UTILITY			UTILITY	MATH MODULE
303 B7	UTILITY			UTILITY	MATH MODULE
304 B3	UTILITY			UTILITY	MATH MODULE
305 B5	UTILITY			UTILITY	MATH MODULE
306 CC	UTILITY			UTILITY	MATH MODULE
307 B4	UTILITY			UTILITY	MATH MODULE
308 B2	UTILITY			UTILITY	MATH MODULE
309 Z0	UTILITY: ONE OF THE PARAMETERS IN THE MATH MODULE			UTILITY	MATH MODULE
310 B9	UTILITY			UTILITY	MATH MODULE
311 ZCOR	UTILITY: ONE OF THE PARAMETERS IN THE MATH MODULE			UTILITY	MATH MODULE
312 B12	UTILITY			UTILITY	MATH MODULE
313 B6	UTILITY			UTILITY	MATH MODULE
314 BC	UTILITY			UTILITY	MATH MODULE
315 B10	UTILITY			UTILITY	MATH MODULE
316 B1	UTILITY			UTILITY	MATH MODULE
317 FM	UTILITY: TO PRINT OUT MASS FLOWS	(kg/s)		UTILITY	OUPUT
318 INDIO	PRINT OUT CONTROL: INDIO = 1 CHIMNEY TEMP PROFILE AT EACH STEP		(1,0)	CONTROL	OUTPUT
319 Z1	UTILITY: TIME COUNTERS TO CONTROL EXECUTION OF PRINT OUTS			CONTROL	OUTPUT
320 Z$	UTILITY: CONTROLS THE PRINT OUT OF HEADINGS AND INITIAL CONDITIONS			CONTROL	OUTPUT
321 Z2	UTILITY: TIME COUNTERS TO CONTROL EXECUTION OF PRINT OUTS			CONTROL	OUTPUT
322 X0	UTILITY: COUNTER FOR THE TEMPERATURE PRINT OUT ARRAY			CONTROL	OUTPUT
323 TAB	FUNCTION: CONTROLS LOCATION OF A COLUMN IN THE PRINTOUTS			FUNCTION	OUTPUT
324 OUTPUT	FUNCTION			FUNCTION	OUTPUT
325 D$	UTILITY - NO LONGER USED, LINE 13070 CAN BE DELETED			UTILITY	OUTPUT
326 OO	UTILITY: DUMMY VARIABLE TO OUTPUT FIREPLACE MASS FLOW			UTILITY	OUTPUT

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
327 TT	UTILITY: TO OUTPUT MEAN FLUE GAS TEMPERATURE	(C)		UTILITY	OUTPUT
328 SCS	ELAPSED TIME SINCE FURNACE START-UP	(S)		UTILITY	OUTPUT
329 OU$	UTILITY: CONTAINS THE NAME OF THE OUTPUT (.PRN) FILE			UTILITY	OUTPUT
330 FLENME$	DEFAULT FILE NAME			UTILITY	OUTPUT
331 OP	UTILITY: DUMMY VARIABLE TO OUTPUT FIREPLACE MASS FLOW			UTILITY	OUTPUT
332 VO	UTILITY: USED TO OUTPUT VOLUMETRIC FLOW RATES	(L/s)		UTILITY	OUTPUT
333 FW	FIRING RATE OF THE FURNACE EITHER AT STANDBY OR FULL OPERATION	(W)	F1 OR F2	BOUNDARY CONDITION	THERMAL
334 FU	FIRING RATE OF THE FURNACE EITHER AT STANDBY OR FULL OPERATION	(W)	F1 OR F2	BOUNDARY CONDITION	THERMAL
335 UDHW	FILM HEAT TRANSFER COEFFICIENT IN DHW FLUE PIPE	(W/m2.C)		COEFFICIENT	THERMAL
336 UF	AVERAGE FILM HEAT TRANSFER COEFFICIENT OF GAS UP THE CHIMNEY	(W/C)		COEFFICIENT	THERMAL
337 UTA	OVERALL HEAT TRANSFER COEFFICIENT OF THE FURNACE HEAT EXCHANGER	(W/C)		COEFFICIENT	THERMAL
338 UI	MINIMUM FILM HEAT TRANSFER COEFFICIENT BETWEEN GAS & LINER	(W/m2.C)		COEFFICIENT	THERMAL
339 Y	UTILITY: COUNTER FOR THE NUMBER OF ELEMENTS "NE" UP THE CHIMNEY			CONTROL	THERMAL
340 INOT	CONTROL INDICATOR FOR THE PARAMETERIZED THERMAL MODEL		(1,2,3)	CONTROL	THERMAL
341 D6F	FURNACE GAS TEMPERATURE IN THE HEAT EXCHANGE AREA	(C)		DEPENDENT PROP	THERMAL
342 TIDHW	INITIAL TEMPERATURE OF THE DHW FP ELEMENTS BEFORE THE TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
343 TF	FINAL TEMPERATURE OF THE CHIMNEY LAYERS AT END OF TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
344 TI	INITIAL TEMPERATURE OF THE CHIMNEY ELEMENTS BEFORE THE TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
345 TFDHW	FINAL TEMPERATURE OF THE DHW F.P. LAYERS AT END OF TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
346 TSSGE	STEADY STATE FLUE GAS FURNACE EXIT TEMPERATURE	(C)		DESIGN CONDITION	THERMAL
347 ELTL	CHIMNEY STRUCTURE: ELEMENT THICKNESS LINER	(m)		DIMENSION	THERMAL
348 FPLN	FLUE PIPE LENGTH	(m)		DIMENSION	THERMAL
349 FPELTO	FLUE PIPE CIRCUMFERENCE	(m)		DIMENSION	THERMAL
350 FPELTS	FLUE PIPE CIRCUMFERENCE	(m)		DIMENSION	THERMAL
351 FPELTL	FLUE PIPE CIRCUMFERENCE	(m)		DIMENSION	THERMAL
352 SADHW	SURFACE AREA OF THE DHW FLUE PIPE	(m2)		DIMENSION	THERMAL
353 ELTO	CHIMNEY STRUCTURE: ELEMENT THICKNESS OUTER LAYER	(m)		DIMENSION	THERMAL
354 ELTS	CHIMNEY STRUCTURE: ELEMENT THICKNESS INSULATION LAYER	(m)		DIMENSION	THERMAL
355 FPI$	INDICATOR OF WHETHER OR NOT THE FLUE PIPE IS INSULATED OR UNINSULATED		(I/U)	INDICATOR	THERMAL
356 ITW	AIR CHANGE TIME CONSTANT IN THE FLUE ELEMENTS	(s)		PARAMETER	THERMAL
357 D2TM	UTILITY: TEMPERATURE DIFFERENCE PARAMETER	(C)		PARAMETER	THERMAL
358 D1TM	UTILITY: TEMPERATURE DIFFERENCE PARAMETER	(C)		PARAMETER	THERMAL
359 TZ	TIME CONSTANTS OF ELEMENTS OF THE CHIMNEY (PRINTED OUT)	(s)		PARAMETER	THERMAL
360 D3TM	UTILITY: TEMPERATURE DIFFERENCE PARAMETER	(C)		PARAMETER	THERMAL
361 SSEFF	STEADY STATE EFFICIENCY OF THE FURNACE	(%)		PERFORMANCE PARAM	THERMAL
362 HC	HEAT CAPACITY OF THE MATERIALS IN THE FLUE	(W.s/kg.C)		PROPERTY	THERMAL
363 DENS	DENSITY OF THE INSULATION	(kg/m3)		PROPERTY	THERMAL
364 HCHE	HEAT CAPACITY OF THE HEAT EXCHANGER IN THE FURNACE	(W.s/kg.C)		PROPERTY	THERMAL
365 DTM	CHANGE IN THE TEMPERATURE OF THE HEAT EXCHANGER MASS	(C)		PROPERTY	THERMAL
366 DENL	DENSITY OF THE LINER	(kg/m3)		PROPERTY	THERMAL
367 FPDENO	MATERIAL DENSITY OF THE FLUE PIPE: OUTER JACKET	(kg/m3)		PROPERTY	THERMAL
368 U2AR	UTILITY: U2AR = U2A	(W/C)		PROPERTY	THERMAL
369 FPHC	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
370 FPTHCS	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
371 FPTHCO	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
372 THCS	HEAT TRANSFER COEFFICIENT OF THE CHIMNEY INSULATION OR MID-LAYER	(W/m2.C)		PROPERTY	THERMAL
373 THCL	HEAT TRANSFER COEFFICIENT OF THE CHIMNEY LINER	(W/m2.C)		PROPERTY	THERMAL
374 U	HEAT TRANSFER COEFFICIENT OF THE CHIMNEY LAYERS	(W/C)		PROPERTY	THERMAL
375 FPDENS	MATERIAL DENSITY OF THE FLUE PIPE: INSULATION OR AIR	(kg/m3)		PROPERTY	THERMAL
376 DENO	DENSITY OF THE OUTER CASING OF THE CHIMNEY	(kg/m3)		PROPERTY	THERMAL
377 U1A	HEAT TRANSFER COEFFICIENTS INTO & OUT OF FURNACE HEAT EXCHANGER	(W/C)		PROPERTY	THERMAL
378 FPDENL	MATERIAL DENSITY OF THE FLUE PIPE: LINER	(kg/m3)		PROPERTY	THERMAL
379 FPTHCL	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
380 U2A	HEAT TRANSFER COEFFICIENTS INTO & OUT OF FURNACE HEAT EXCHANGER	(W/C)		PROPERTY	THERMAL
381 THCO	HEAT TRANSFER COEFFICIENT OF THE OUTER PART OF THE CHIMNEY	(W/m2.C)		PROPERTY	THERMAL
382 M	MASS OF EACH ELEMENT AND LAYER OF THE CHIMNEY	(kg)		QUANTITY	THERMAL
383 MFIPOT	MASS OF THE FIRE POT (OIL FURNACE ONLY)	(kg)	(4 kg)	QUANTITY	THERMAL

	VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
384	OTW	UTILITY: TRANSFER A TIME CONSTANT VALUE TO THE THERMAL MODULE	(s)		UTILITY	THERMAL
385	TP	UTILITY: USED TO TRANSFER THE APPROP. TEMP IN CHIMNEY MODEL	(C)		UTILITY	THERMAL
386	A	SURFACE AREA OF CHIMNEY ELEMENTS NORMAL TO LATERAL TO HEAT FLOW	(m2)		PHYSICAL DIMEN	THERMAL
387	FDAMP$	INDICATOR: WHETHER OR NOT THERE IS A FLUE DAMPER		(Y/N)	INDICATOR	THERMAL & AERO
388	F1	FIRING RATE OF THE FURNACE AT STANDBY (PILOT)	(BTU/HR)	(750)	BOUNDARY CONDI	THERMAL & AERO FURN
389	F2	FIRING RATE OF THE FURNACE DURING FULL OPERATION	(BTU/HR)	(100000)	BOUNDARY CONDI	THERMAL & AERO FURN
390	TA	NUMBER OF KELVINS AT 0 DEG C	(K)	273.15	CONSTANT	THERMAL/AERO
391	TDHW	TEMPERATURE OF THE GAS IN THE DHW BRANCH	(C)		DEPENDENT PROPERTY	THERMAL/AERO
392	FICV	FURNACE INTERIOR (COMBUSTION) CHAMBER VOLUME	(m3)		DIMENSION	THERMAL/AERO
393	TTF	MEAN TEMPERATURE OF THE FLUE GAS (CORRESPONDS TO MEAN DENSITY)	(C)		PARAMETER	THERMAL/AERO
394	TTFF	MEAN TEMPERATURE OF THE FLUE PIPE GAS (CORRESPONDS TO MEAN DENS)	(C)		PARAMETER	THERMAL/AERO
395	CPAIR	HEAT CAPACITY OF AIR (SENSIBLE HEAT ONLY)	(W.s/kg.K)		FIXED PROPERTY	THERMAL/ALL
396	TMF	TEMPERATURE OF THE HEAT EXCHANGER SURFACE	(C)		DEPENDENT PROPERTY	THERMAL/CHIMNEY
397	RW	UTILITY: USED TO PASS-ON DENSITY VALUES	(kg/m3)		DUMMY	THERMAL/CHIMNEY
398	TQ	DUMMY VARIABLE TO OUTPUT MEAN FLUE LINER TEMPERATURE	(C)		OUTPUT VARIABLE	THERMAL/CHIMNEY
399	NE	NUMBER OF CALCULATION ELEMENTS UP THE FLUE PIPE & CHIMNEY		(10)	PHYSICAL QUANTITY	THERMAL/CHIMNEY
400	T7F	TEMPERATURE OF THE STACK GASES IN THE UPPER PORTION OF FURNACE	(C)		DEPENDENT PROPERTY	THERMAL/FURNACE
401	T6F	FURNACE GAS TEMPERATURE IN THE AREA OF THE HEAT EXCHANGER	(C)		DEPENDENT PROPERTY	THERMAL/FURNACE
402	M7	MASS OF THE FLUE GAS IN THE UPPER SECTION OF THE FURNACE	(kg)		DEPENDENT QUANTITY	THERMAL/FURNACE
403	M6	MASS OF THE GAS IN THE COMBUSTION SECTION OF THE FURNACE	(kg)		DEPENDENT VAR	THERMAL/FURNACE
404	FE	DERIVED INSTANTANEOUS EFFICIENCY OF THE FURNACE			DEPENDENT VAR	THERMAL/FURNACE
405	M2CP	OVERALL HEAT CAPACITY OF THE FURNACE HEAT EXCHANGER MASS	(W.S)/K	(30600)	FIXED PROPERTY	THERMAL/FURNACE
406	TW	UTILITY: TIME CONSTANTS OF THE CHIMNEY STRUCTURE	(s)		PARAMETER	THERMAL/OUTPUT
407	DHWO$	HOT WATER HEATER: ON/OFF INDICATOR			CONTROL	WATER HEATER
408	DHWAR	HOT WATER HEATER: AREA OF THE FLUE PIPE	(m2)		DIMENSION	WATER HEATER
409	DHWFPH	HOT WATER HEATER: HEIGHT OF THE FLUE PIPE	(m2)		DIMENSION	WATER HEATER
410	DHWFPLE	HOT WATER HEATER: LENGTH OF THE FLUE PIPE	(m2)		DIMENSION	WATER HEATER
411	DHWEF	HOT WATER HEATER: EFFICIENCY	(%)		EFFICIENCY	WATER HEATER
412	DHWTYPE$	HOT WATER HEATER: INDICATOR			INDICATOR	WATER HEATER
413	DHW$	HOT WATER HEATER: INDICATES WHETHER THERE IS A WATER HEATER		(Y/N)	INDICATOR	WATER HEATER
414	DPDIL	FRICTION LOSS THROUGH THE DHW DILUTION PORT	(Pa)		PARAMETER	WATER HEATER
415	DPDHW	NET DRIVING PRESSURE IN THE DHW BRANCH	(Pa)		PARAMETER	WATER HEATER
416	ELA6M	EQUIVALENT LEAKAGE AREA: THE MAIN FLUE PIPE UP TO DHW CONNECTION	(m2)		PARAMETER	WATER HEATER
417	DPFP	FRICTION LOSS THROUGH THE DHW FLUE PIPE	(Pa)		PARAMETER	WATER HEATER
418	ITDHW	AIR CHANGE TIME CONSTANT IN THE FLUE PIPE ELEMENTS	(s)		PARAMETER	WATER HEATER
419	DPBUO	PRESSURE RISE DUE TO BUOYANCY IN THE DHW BRANCH REL TO MAIN	(Pa)		PARAMETER	WATER HEATER
420	ELADHW	EQUIVALENT LEAKAGE AREA: OF THE DHW FLUE PIPE BRANCH	(m2)		PARAMETER	WATER HEATER
421	DHWAC	HOT WATER HEATER: BURNER CAPACITY	(W)		POWER	WATER HEATER
422	DHWC	HOT WATER HEATER: BURNER CAPACITY	(W)		POWER	WATER HEATER
423	DHWSBC	HOT WATER HEATER: STANDBY CAPACITY			QUANTITY	WATER HEATER
424	DHWLAST	HOT WATER HEATER: UTILITY - STORES THE DHW PIPE MASS FLOW RATE	(kg/s)		QUANTITY	WATER HEATER
425	MDHW	MASS FLOW IN THE HOT WATER BRANCH			QUANTITY	WATER HEATER
426	DHWNEL	HOT WATER HEATER: NUMBER OF EQUIVALENT 45 DEG ELBOWS			QUANTITY	WATER HEATER
427	DHWFPN	HOT WATER HEATER: NUMBER OF FLUE PIPE SEGMENTS			QUANTITY	WATER HEATER

LIST OF VARIABLES

AND THEIR DESCRIPTION:

FLUESIM 4.2

(ALPHABETICAL SORT)

VARIABLE LIST FOR PROGRAM: FLUESIM4.BAS   DATE: 03-01-1989

THE PROGRAM HAS 1567 LINES OF CODE

NOTE: A NUMBER OF VARIABLES ARE USED AS UTILITY VARIABLES TO TEMPORARILY STORE OR HANDLE INFORMATION MORE EFFICIENTLY. THESE VARIABLES ARE CLASSIFIED AS "UTILITY" IN THE "VARIABLE TYPE" COLUMN.

	VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
1	A	SURFACE AREA OF CHIMNEY ELEMENTS NORMAL TO LATERAL TO HEAT FLOW	(m2)		PHYSICAL DIMEN	THERMAL
2	A$	UTILITY			UTILITY	GRAPHICS
3	ABORT$	UTILITY			UTILITY	MAIN
4	ADR	EFFECTIVE AREA OF THE DILUTION DEVICE OPENING WHEN FLOW REVERSED	(m2)		PHYSICAL DIMEN	AERODYNAMIC
5	AHC	HEAT CAPACITY OF THE MASS OF AIR IN THE HOUSE	(W.s/m3)		THERMAL PARAMETER	DYNAMIC ENVELOPE
6	AHT	HEAT TRANSFER RATE BETWEEN HOUSE AIR & ENVELOPE	(W/C)		THERMAL PARAMETER	DYNAMIC ENVELOPE
7	ANDFACT	UTILITY			UTILITY	GRAPHICS
8	ANDNO	UTILITY			UTILITY	GRAPHICS
9	APRD	LEAKAGE AREA OF THE BAROMETRIC DAMPER WHEN CLOSED	(% OF OPEN)		PHYSICAL DIMENSION	AERODYNAMIC
10	AR	AREA OF OPENINGS AT THE NETWORK POINTS	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
11	ARD	AREA OF FLUE PIPE AND FLUE OPENINGS	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
12	ARDAMP	AREA OF THE BAROMETRIC DAMPER	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
13	AREFF	EFFECIVE FLOW AREA OF THE FLUE PIPE AND FLUE COMBINED	(m2)		PHYSICAL DIMENSION	MATH MODULE
14	ARINT	FRESH AIR INTAKE AREA	(m2)		PHYSICAL DIMENSION	AERODYNAMIC
15	AUFF	FURNACE TURN OFF TIME	(s)		TIME PARAMETER	MAIN
16	AXIS	GRAPHICS CONTROL: INDICATOR OF WHETHER AXES HAVE BEEN DRAWN		(0,1)	CONTROL	GRAPHICS
17	B	UTILITY			UTILITY	GRAPHICS
18	B$	UTILITY			UTILITY	GRAPHICS
19	B1	UTILITY			UTILITY	MATH MODULE
20	B10	UTILITY			UTILITY	MATH MODULE
21	B11	UTILITY			UTILITY	MATH MODULE
22	B12	UTILITY			UTILITY	MATH MODULE
23	B2	UTILITY			UTILITY	MATH MODULE
24	B3	UTILITY			UTILITY	MATH MODULE
25	B4	UTILITY			UTILITY	MATH MODULE
26	B5	UTILITY			UTILITY	MATH MODULE
27	B6	UTILITY			UTILITY	MATH MODULE
28	B7	UTILITY			UTILITY	MATH MODULE
29	B8	UTILITY			UTILITY	MATH MODULE
30	B9	UTILITY			UTILITY	MATH MODULE
31	BA	UTILITY			UTILITY	MATH MODULE
32	BB	UTILITY			UTILITY	MATH MODULE
33	BC	UTILITY			UTILITY	MATH MODULE
34	BEEP	FUNCTION TO PRODUCE A BEEP SOUND TO INDICATE THE HALTING OF EXECUTION			FUNCTION	MAIN/ERROR TRAP
35	BLTEMP	BOUNDARY LAYER TEMPERATURE			THERMAL PARAMETER	CONDENSATION
36	BOX	CONTAINS COORDINATE TO DRAW A BOX ON THE GRAPHS			UTILITY	GRAPHICS
37	BSAVE	FUNCTION TO STORE THE GRAPHICS SCREEN ON DISK			FUNCTION	MAIN
38	C	ENVELOPE FLOW COEFFICIENT	m3/(s.Pa^n)		COEFFICIENT	AERODYNAMIC
39	C1	VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
40	C2	VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
41	CC	UTILITY			UTILITY	MATH MODULE

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
42 CHBOT	LENGTH OF FLUE FROM TOP TO CHIMNEY BOTTOM	(m)		DIMENSION	MAIN
43 CHDENL	UTILITY			UTILITY	COMMON
44 CHDENO	UTILITY			UTILITY	COMMON
45 CHDENS	UTILITY			UTILITY	COMMON
46 CHDI2	UTILITY			UTILITY	COMMON
47 CHELTL	UTILITY			UTILITY	COMMON
48 CHELTO	UTILITY			UTILITY	COMMON
49 CHELTS	UTILITY			UTILITY	COMMON
50 CHHC	UTILITY			UTILITY	COMMON
51 CHHK1	UTILITY			UTILITY	COMMON
52 CHHK2	UTILITY			UTILITY	COMMON
53 CHHK3	UTILITY			UTILITY	COMMON
54 CHIMT$	CHIMNEY LOCATION INDICATOR		(I/O)	INDICATOR	MAIN
55 CHK$	UTILITY			UTILITY	MAIN
56 CHM$	UTILITY			UTILITY	COMMON
57 CHTHCL	UTILITY			UTILITY	COMMON
58 CHTHCO	UTILITY			UTILITY	COMMON
59 CHTHCS	UTILITY			UTILITY	COMMON
60 CIR	CONTAINS COORDINATES TO DRAW CIRCLES IN THE GRAPHICS ROUTINE			UTILITY	GRAPHICS
61 CONST	COEFFICIENT IN THE DAMPER FRICTION LOSS EQUATION			COEFFICIENT	AERODYNAMIC
62 COS	TRIG FUNCTION			FUNCTION	AERODYNAMIC
63 COUNT	UTILITY			UTILITY	COMMON
64 CPAIR	HEAT CAPACITY OF AIR (SENSIBLE HEAT ONLY)	(W.s/kg.K)		FIXED PROPERTY	THERMAL/ALL
65 CPWENV	WIND PRESSURE COEFFICIENT OF THE HOUSE ENVELOPE			COEFFICIENT	AERODYNAMIC
66 D$	UTILITY - NO LONGER USED, LINE 13070 CAN BE DELETED			UTILITY	OUTPUT
67 D1TM	UTILITY: TEMPERATURE DIFFERENCE PARAMETER	(C)		PARAMETER	THERMAL
68 D2TM	UTILITY: TEMPERATURE DIFFERENCE PARAMETER	(C)		PARAMETER	THERMAL
69 D3TM	UTILITY: TEMPERATURE DIFFERENCE PARAMETER	(C)		PARAMETER	THERMAL
70 D6F	FURNACE GAS TEMPERATURE IN THE HEAT EXCHANGE AREA	(C)		DEPENDENT PROP	THERMAL
71 DAMPACT$	UTILITY: EFFECT OF FLUE DAMPER OPENING ON EFFECTIVE FLOW AREA			UTILITY	AERODYNAMIC
72 DAMPTCL	UTILITY: EFFECT OF FLUE DAMPER OPENING ON EFFECTIVE FLOW AREA			UTILITY	AERODYNAMIC
73 DAMPTOP	UTILITY: EFFECT OF FLUE DAMPER OPENING ON EFFECTIVE FLOW AREA			UTILITY	AERODYNAMIC
74 DB	UTILITY			UTILITY	COMMON
75 DEF	FUNCTION: DEF SEG			FUNCTION	MAIN
76 DENL	DENSITY OF THE LINER	(kg/m3)		PROPERTY	THERMAL
77 DENO	DENSITY OF THE OUTER CASING OF THE CHIMNEY	(kg/m3)		PROPERTY	THERMAL
78 DENS	DENSITY OF THE INSULATION	(kg/m3)		PROPERTY	THERMAL
79 DEW	DURATION OVER WHICH CONDENSATION IS EXPERIENCED AT EACH ELEMENT	(s)		TIME PARAMETER	CONDENSATION
80 DF	DIAMETER OF THE CHIMNEY SHAFT OR LINER	(m)	(0.175)	PHYSICAL QUANT	BOTH/CHIMNEY
81 DHF	LENGTH OF EACH SEGMENT OF THE FLUE PIPE	(m)		DIMENSION	ALL
82 DHW$	HOT WATER HEATER: INDICATES WHETHER THERE IS A WATER HEATER		(Y/N)	INDICATOR	WATER HEATER
83 DHWAC	HOT WATER HEATER: BURNER CAPACITY	(W)		POWER	WATER HEATER
84 DHWAR	HOT WATER HEATER: AREA OF THE FLUE PIPE	(m2)		DIMENSION	WATER HEATER
85 DHWC	HOT WATER HEATER: BURNER CAPACITY	(W)		POWER	WATER HEATER
86 DHWEF	HOT WATER HEATER: EFFICIENCY	(%)		EFFICIENCY	WATER HEATER
87 DHWFPH	HOT WATER HEATER: HEIGHT OF THE FLUE PIPE	(m2)		DIMENSION	WATER HEATER
88 DHWFPLE	HOT WATER HEATER: LENGTH OF THE FLUE PIPE	(m2)		DIMENSION	WATER HEATER
89 DHWFPN	HOT WATER HEATER: NUMBER OF FLUE PIPE SEGMENTS			QUANTITY	WATER HEATER
90 DHWLAST	HOT WATER HEATER: UTILITY - STORES THE DHW PIPE MASS FLOW RATE	(kg/s)		QUANTITY	WATER HEATER
91 DHWNEL	HOT WATER HEATER: NUMBER OF EQUIVALENT 45 DEG ELBOWS			QUANTITY	WATER HEATER
92 DHWO$	HOT WATER HEATER: ON/OFF INDICATOR			CONTROL	WATER HEATER
93 DHWSBC	HOT WATER HEATER: STANDBY CAPACITY			QUANTITY	WATER HEATER
94 DHWTYPE$	HOT WATER HEATER: INDICATOR			INDICATOR	WATER HEATER
95 DI	CHARACTERISTIC DIAMETER OF OPENINGS AT NETWORK POINTS	(mm)		DIMENSION	AERODYNAMIC/ALL
96 DI2	CHARACTERISTIC DIAMETER OF OPENINGS AT NETWORK POINTS	(mm)		DIMENSION	AERODYNAMIC/ALL
97 DIA	FLUE PIPE AND FLUE INSIDE DIAMETERS	(m)		DIMENSION	AERODYNAMIC
98 DIAMND	CONTAINS COORDINATES TO DRAW A DIAMOND ON THE GRAPHS			UTILITY	GRAPHICS

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
99 DOC$	NAME OF THE DEFAULT DATA FILE			UTILITY	MAIN
100 DPO	COEFFICIENT IN THE DAMPER FRICTION LOSS EQUATION			COEFFICIENT	AERODYNAMIC
101 DPBUO	PRESSURE RISE DUE TO BUOYANCY IN THE DHW BRANCH REL TO MAIN	(Pa)		PARAMETER	HOT WATER
102 DPDHW	NET DRIVING PRESSURE IN THE DHW BRANCH	(Pa)		PARAMETER	HOT WATER
103 DPDIL	FRICTION LOSS THROUGH THE DHW DILUTION PORT	(Pa)		PARAMETER	HOT WATER
104 DPFP	FRICTION LOSS THROUGH THE DHW FLUE PIPE	(Pa)		PARAMETER	HOT WATER
105 DRIVE$	INDICATES WHICH DRIVE THE DEFAULT DATA IS LOCATED			CONTROL	MAIN
106 DTM	CHANGE IN THE TEMPERATURE OF THE HEAT EXCHANGER MASS	(C)		PROPERTY	THERMAL
107 E	SYMBOL TO SIGNIFY "EXPONENT" - NOT A VARIABLE			SYMBOL	ALL
108 E1	UTILITY VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
109 E2	UTILITY VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
110 EA	ENVELOPE AREA	(m2)		PHYSICAL DIMEN	DYNAMIC ENVELOPE
111 EH	VERTICAL HEIGHT OF EACH ELEMENT OF FLUE-PIPE & CHIMNEY	(m)	(1)	PHYSICAL DIMEN	BOTH/CHIMNEY
112 ELA	EQUIVALENT LEAKAGE AREA: ARRAY OF ALL ELA'S IN THE SYSTEM	(m2)		PARAMETER	AERODYNAMIC
113 ELA1	EQUIVALENT LEAKAGE AREA: EFFECTIVE ELA OF FLUE PIPE & FLUE	(m2)		PARAMETER	MATH MODULE
114 ELA6M	EQUIVALENT LEAKAGE AREA: THE MAIN FLUE PIPE UP TO DHW CONNECTION	(m2)		PARAMETER	WATER HEATER
115 ELADHW	EQUIVALENT LEAKAGE AREA: OF THE DHW FLUE PIPE BRANCH	(m2)		PARAMETER	WATER HEATER
116 ELAENV	EQUIVALENT LEAKAGE AREA: OF THE ENVELOPE	(m2)		PARAMETER	AERODYNAMIC
117 ELAINT	EQUIVALENT LEAKAGE AREA: OF THE FRECH AIR INTAKE	(m2)		PARAMETER	AERODYNAMIC
118 ELHT	HEIGHT OF EACH FLUE ELEMENT	(m)		DIMENSION	ALL
119 ELTL	CHIMNEY STRUCTURE: ELEMENT THICKNESS LINER	(m)		DIMENSION	THERMAL
120 ELTO	CHIMNEY STRUCTURE: ELEMENT THICKNESS OUTER LAYER	(m)		DIMENSION	THERMAL
121 ELTS	CHIMNEY STRUCTURE: ELEMENT THICKNESS INSULATION LAYER	(m)		DIMENSION	THERMAL
122 ENTRY	UTILITY			UTILITY	COMMON
123 ER1	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
124 ER2	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
125 ER3	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
126 ER4	UTILITY: CHECKS FOR THE ERROR IN MASS FLOW - MAIN ITERATION	(kg/s)		UTILITY	MAIN/AERO
127 ERL	ERROR TRAP INFO: ERROR LINE			UTILITY	ALL
128 ERR	ERROR TRAP INFO: ERROR NUMBER			UTILITY	ALL
129 ERROR	ERROR TRAP INFO: ERROR FUNCTION			UTILITY	ERROR TRAP
130 EXAIR	OIL FURNACE EXESS AIR	(%)		PARAMETER	AERODYNAMIC
131 F$	INDICATOR: FURNACE ON, OFF, NOT YET FIRED		(NOT,ON,OFF)	INDICATOR	CONTROL
132 F1	FIRING RATE OF THE FURNACE AT STANDBY (PILOT)	(BTU/HR)	(750)	BOUNDARY CONDI	THERMAL & AERO FURN
133 F2	FIRING RATE OF THE FURNACE DURING FULL OPERATION	(BTU/HR)	(100000)	BOUNDARY CONDI	THERMAL & AERO FURN
134 FANM	MASS FLOW THROUGH THE FANS	(KG/S)		BOUNDARY CONDI	AERODYNAMIC ENVELOP
135 FAULT$	UTILITY			UTILITY	MAIN
136 FCAPL	FRICTION LOSS FACTOR OF THE FLUE CAP			FACTOR	AERODYNAMIC
137 FCAPNO	UTILITY			UTILITY	COMMON
138 FDAMP$	INDICATOR: WHETHER OR NOT THERE IS A FLUE DAMPER		(Y/N)	INDICATOR	THERMAL & AERO
139 FE	DERIVED INSTANTANEOUS EFFICIENCY OF THE FURNACE			DEPENDENT VAR	THERMAL/FURNACE
140 FF	FLUE FRICTION FACTOR			FACTOR	AERODYNAMIC
141 FICV	FURNACE INTERIOR (COMBUSTION) CHAMBER VOLUME	(m3)		DIMENSION	THERMAL/AERO
142 FIRM	MASS FLOW RATE OF THE FIREPLACE	(kg/s)		BOUNDARY CONDI	AERODYNAMIC ENVELOP
143 FL1	CONTROL INDICATOR		(0,1)	CONTROL	MAIN
144 FL2	CONTROL INDICATOR		(0,1)	CONTROL	MAIN
145 FLENME$	DEFAULT FILE NAME			UTILITY	OUTPUT
146 FLUEDP	DEWPOINT TEMPERATURE IN THE FLUE	(C)	54C	REFERENCE QUANTITITY	CONDENSATION
147 FLUEIN$	UTILITY			CONTROL	MAIN
148 FM	UTILITY: TO PRINT OUT MASS FLOWS	(kg/s)		UTILITY	OUPUT
149 FP	VOLUMETRIC FLOW RATE OF THE FIREPLACE	(l/s)		BOUNDARY CONDI	AERODYNAMIC ENVELOP
150 FPAR	UTILITY			UTILITY	COMMON
151 FPDENL	MATERIAL DENSITY OF THE FLUE PIPE: LINER	(kg/m3)		PROPERTY	THERMAL
152 FPDENO	MATERIAL DENSITY OF THE FLUE PIPE: OUTER JACKET	(kg/m3)		PROPERTY	THERMAL
153 FPDENS	MATERIAL DENSITY OF THE FLUE PIPE: INSULATION OR AIR	(kg/m3)		PROPERTY	THERMAL
154 FPDI2	UTILITY			UTILITY	COMMON
155 FPELTL	FLUE PIPE CIRCUMFERENCE	(m)		DIMENSION	THERMAL

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
156 FPELTO	FLUE PIPE CIRCUMFERENCE	(m)		DIMENSION	THERMAL
157 FPELTS	FLUE PIPE CIRCUMFERENCE	(m)		DIMENSION	THERMAL
158 FPHC	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
159 FPI$	INDICATOR OF WHETHER OR NOT THE FLUE PIPE IS INSULATED OR UNINSULATED		(I/U)	INDICATOR	THERMAL
160 FPLN	FLUE PIPE LENGTH	(m)		DIMENSION	THERMAL
161 FPTHCL	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
162 FPTHCO	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
163 FPTHCS	FLUE PIPE HEAT CAPACITY	(W.s/kg.C)		PROPERTY	THERMAL
164 FR1	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
165 FR2	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
166 FR3	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
167 FR4	UTILITY: CONTROL OF WHICH GRAPH IS TO BE PRESENTED		(1,2,3,4)	CONTROL	GRAPHICS
168 FS	TIME (IN SECONDS) AT WHICH FURNACE STARTS	(S)		CONTROL	MAIN
169 FT$	FURNACE TYPE INDICATOR		(O/G)	CONTROL	MAIN
170 FTI$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
171 FU	FIRING RATE OF THE FURNACE EITHER AT STANDBY OR FULL OPERATION	(W)	F1 OR F2	BOUNDARY CONDITION	THERMAL
172 FW	FIRING RATE OF THE FURNACE EITHER AT STANDBY OR FULL OPERATION	(W)	F1 OR F2	BOUNDARY CONDITION	THERMAL
173 GC	GRAVITATIONAL CONSTANT	(m/s2)	9.8	CONSTANT	AERODYNAMIC/ALL
174 GD$	CONTROL: SPECIFIES GRAPHICS OR TABULAR OUTPUT		(G/T)	CONTROL	MAIN
175 GE	UTILITY			UTILITY	COMMON
176 GF	SUMMATION OF GRAVITATIONAL HEAD UP THE FLUE	(Pa)		PARAMETER	AERODYNAMIC CHIMNEY
177 GFF	SUMMATION OF GRAVITATIONAL HEAD UP THE FLUE	(Pa)		PARAMETER	AERODYNAMIC CHIMNEY
178 GFOUT	UTILITY: STORING FLOW RATES FOR GRAPHS	(l/s)		UTILITY	GRAPHICS
179 GMASSDHW	MASS OF THE AIR IN THE DHW FLUE PIPE	(kg)		QUANTITY	AERODYNAMIC DHW
180 GPOUT	UTILITY: STORING PRESSURE PARAMETERS FOR GRAPHS	(Pa)		UTILITY	GRAPHICS
181 GTOUT	UTILITY: STORING TEMPERATURES FOR GRAPHS	(C)		UTILITY	GRAPHICS
182 HB800	UTILITY			UTILITY	GRAPHICS
183 HC	HEAT CAPACITY OF THE MATERIALS IN THE FLUE	(W.s/kg.C)		PROPERTY	THERMAL
184 HCHE	HEAT CAPACITY OF THE HEAT EXCHANGER IN THE FURNACE	(W.s/kg.C)		PROPERTY	THERMAL
185 HD$	UTILITY: OUTPUT HEADING			UTILITY	MAIN
186 HF	HEIGHT OF CHIMNEY FROM DILUTION DEVICE TO TOP	(m)	(8)	DIMENSION	BOTH/CHIMNEY
187 HFFFF	UTILITY			UTILITY	GRAPHICS
188 HH	HEIGHT OF THE HEATING APPLIANCE (FROM AIR INTAKE TO DIL DEVICE)	(m)	(1m)	DIMENSION	AERODYNAMIC/FURN
189 HHC	HEAT CAPACITY OF THE HOUSE		(W.S/kg K)	THERMAL PARAM	DYNAMIC ENVELOPE
190 HMASS$	HOUSE MASS INDICATOR		(L,M,H)	INDICATOR	DYNAMIC ENVELOPE
191 HT	VERTICAL DISTANCE FROM DATUM TO NETWORK POINT	(m)		PHYSICAL DIMEN	AERODYNAMIC/ALL
192 HTC	CONDUCTIVE HEAT TRANSFER COEFFICIENT THROUGH THE ENVELOPE	(W/C)		PARAMETER	DYNAMIC ENVELOPE
193 HVOL	HOUSE VOLUME	(m3)		DIMENSION	DYNAMIC ENVELOPE
194 I	UTILITY: LOOP COUNTER			CONTROL	ALL
195 ICHTYPE	INDICATOR OF CHIMNEY TYPE (NOT USED IN THE CALC MODULE)			UTILITY	COMMON
196 II	UTILITY: LOOP COUNTER			CONTROL	ALL
197 IND10	PRINT OUT CONTROL: IND10 = 1 CHIMNEY TEMP PROFILE AT EACH STEP		(1,0)	CONTROL	OUTPUT
198 INDT	CONTROL INDICATOR FOR THE PARAMETERIZED THERMAL MODEL		(1,2,3)	CONTROL	DYNAMIC THERMAL
199 INSTR	FUNCTION TO OBTAIN LENGTH OF STRING VARIABLES			FUNCTION	MAIN
200 ITDHW	AIR CHANGE TIME CONSTANT IN THE FLUE PIPE ELEMENTS	(s)		PARAMETER	DYNAMIC THERMAL/DHW
201 ITER	CONTROL: ITERATION COUNTER			CONTROL	MAIN
202 ITW	AIR CHANGE TIME CONSTANT IN THE FLUE ELEMENTS	(s)		PARAMETER	DYNAMIC THERMAL
203 J	LOOP COUNTER FOR THE NUMBER OF CALCULATION PLANE IN-OUT OF CHIMN			CONTROL	ALL
204 JUNCTLOSS	EQUIVALENT NUMBER OF ELBOWS DUE TO THE DHW JUNCTION		1	QUANTITY	AERODYNAMIC
205 JUNK$	CONTROL: STORES USER'S CHOICE OF OPTIONS AT THE END OF A SIMULATION			CONTROL	MAIN
206 K1	MINIMUM OVERALL PRESSURE LOSS FACTOR OF FLUE PIPE & CHIMNEY		1.43 + 1.8	PARAMETER	AERODYNAMIC
207 KBD	FRICTION FACTOR FOR THE BAROMETRIC DAMPER			PARAMETER	AERODYNAMIC
208 KE	DYNAMIC PRESSURE LOSS FACTORS AT EACH POINT IN THE FLOW NETWORK			PARAMETER	AERODYNAMIC
209 KE4	FRICTION FACTOR OF THE FLUE PIPE UP TO THE DHW CONNECTION			PARAMETER	AERODYNAMIC
210 KECON	FRICTION FACTOR OF THE DHW CONNECTION TO THE MAIN VENT			PARAMETER	AERODYNAMIC
211 KEINT	FRICTION FACTOR OF THE FRESH AIR INTAKE			PARAMETER	AERODYNAMIC
212 L1$	UTILITY			UTILITY	ERROR TRAP

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
213 L1A	DUMMY VARIABLE USED TO CALCULATE E.L.A. OF OPENINGS	(M2)		PARAMETER	AERODYNAMIC/ALL
214 L2$	UTILITY			UTILITY	ERROR TRAP
215 L2A	DUMMY VARIABLE USED TO CALCULATE E.L.A. OF OPENINGS	(M2)		PARAMETER	AERODYNAMIC/ALL
216 L3$	UTILITY			UTILITY	ERROR TRAP
217 L4$	UTILITY			UTILITY	ERROR TRAP
218 LEAKDIST	INDICATOR OF THE ORIENTATION OF ENVELOPE LEAKS			INDICATOR	AERODYNAMIC
219 LEFT$	FUNCTION			FUNCTION	ALL
220 LHC	UTILITY			UTILITY	COMMON
221 LNPP	LOCATION OF THE NEUTRAL PRESSURE PLANE (NO FLUE) REL TO DATUM	(M2)	(-2.8)	DIMENSION	AERODYNAMIC/ENVELOPE
222 LOCDOT	FUNCTION			FUNCTION	INPUT/OUTPUT
223 LT	FUNCTION			FUNCTION	GRAPHICS
224 M	MASS OF EACH ELEMENT AND LAYER OF THE CHIMNEY	(kg)		QUANTITY	THERMAL
225 M2CP	OVERALL HEAT CAPACITY OF THE FURNACE HEAT EXCHANGER MASS	(W.S)/K	(30600)	FIXED PROPERTY	THERMAL/FURNACE
226 M6	MASS OF THE GAS IN THE COMBUSTION SECTION OF THE FURNACE	(kg)		DEPENDENT VAR	THERMAL/FURNACE
227 M7	MASS OF THE FLUE GAS IN THE UPPER SECTION OF THE FURNACE	(kg)		DEPENDENT QUANTITY	THERMAL/FURNACE
228 MASTER	CONTROL TO INDICATE WHETHER THIS IS THE FIRST ACCESS TO FLUESIM			CONTROL	MAIN
229 MCOMP	SUM OF FAN & FIREPLACE MASS FLOWS	(kg/s)		QUANTITY	AERODYNAMIC ENVELOPE
230 MDHW	MASS FLOW IN THE HOT WATER BRANCH			QUANTITY	HOT WATER
231 MDI$	INDICATOR OF WHETHER OR NOT THERE IS A DRAFT INDUCER		(Y/N)	INDICATOR	AERODYNAMIC
232 MF	MASS FLOW RATES AT EACH NETWORK POINT	(kg/s)		QUANTITY	AERODYNAMIC/ALL
233 MFIN	UTILITY: MASS FLOW INTO THE FLUE PIPE	(kg/s)		QUANTITY	AERODYNAMIC
234 MFIPOT	MASS OF THE FIRE POT (OIL FURNACE ONLY)	(kg)	(4 kg)	QUANTITY	THERMAL
235 MFUEL	MASS FLOW OF THE FLUE	(kg/s)		QUANTITY	AERODYNAMIC/THERMAL
236 MGAS	MASS FLOW OF THE FUEL (EG. GAS OR OIL)	(kg/s)		BOUNDARY CONDITION	BOTH/FURNACE
237 MOHE	UTILITY			UTILITY	COMMON
238 MOIL	MASS FLOW OF THE OIL	(kg/s)		QUANTITY	AERODYNAMIC
239 MTFUEL	TOTAL MASS FLOW OF THE FUEL. MTFUEL = EITHER MTOIL OR MGAS	(kg/s)		QUANTITY	AERODYNAMIC
240 MTOIL	TOTAL MASS FLOW OF THE OIL & EXCESS AIR	(kg/s)		QUANTITY	AERODYNAMIC
241 MU	VISCOSITY OF AIR	(kg/s(m.s))	1.84E-5	FIXED PROPERTY	AERODYNAMIC/ALL
242 N	ENVELOPE FLOW COEFFICIENT		(0.5 - 1)	FIXED PROPERTY	AERODYNAMIC/ENVEL
243 N$	UTILITY: STORES THE SPECS FOR DRAING NUMBERS ON THE GRAPHS			UTILITY	GRAPHICS
244 NDHWFP	NUMBER OF DWH FLUE PIPE SEGMENTS			QUANTITY	AERO/THERMAL
245 NE	NUMBER OF CALCULATION ELEMENTS UP THE FLUE PIPE & CHIMNEY		(10)	PHYSICAL QUANTITY	THERMAL/CHIMNEY
246 NELBOWS	NUMBER OF ELBOWS IN THE MAIN FLUE PIPE			PHYSICAL QUANTITY	AERODYNAMIC
247 NELINT	NUMBER OF ELBOWS IN THE FRESH AIR INTAKE			PHYSICAL QUANTITY	AERODYNAMIC
248 NFPSEGS	NUMBER OF SEGMENTS IN THE MAIN FLUE PIPE			PHYSICAL QUANTITY	AERODYNAMIC
249 NSCAL	UTILITY: SCALE QUANTITY IN HTE GRAPHICS PROGRAM			UTILITY	GRAPHICS
250 OFTIM	UTILITY: STORES THE TIME THE FURNACE WAS TURNED OFF	(s)		UTILITY	MAIN
251 ONTIME	UTILITY: RECORD THE TOTAL DURATION OF FURNACE OPERATION	(s)		UTILITY	MAIN
252 OO	UTILITY: DUMMY VARIABLE TO OUTPUT FIREPLACE MASS FLOW			UTILITY	OUTPUT
253 OP	UTILITY: DUMMY VARIABLE TO OUTPUT FIREPLACE MASS FLOW			UTILITY	OUTPUT
254 OTW	UTILITY: TRANSFER A TIME CONSTANT VALUE TO THE THERMAL MODULE	(s)		UTILITY	THERMAL
255 OU$	UTILITY: CONTAINS THE NAME OF THE OUTPUT (.PRN) FILE			UTILITY	OUTPUT
256 OUTPUT	FUNCTION			FUNCTION	OUTPUT
257 P	UTILITY			UTILITY	GRAPHICS
258 P$	UTILITY			UTILITY	GRAPHICS
259 P1	UTILITY			UTILITY	GRAPHICS
260 P2	UTILITY			UTILITY	GRAPHICS
261 P3	UTILITY			UTILITY	GRAPHICS
262 P4	UTILITY			UTILITY	GRAPHICS
263 PAR	ARRARY OF KEY PARAMETERS THAT DEFINE THE CASE	SEE OUTPUT		PARAMETER	BOTH/ALL
264 PATTRN	UTILITY			UTILITY	GRAPHICS
265 PB	PRESSURE PARAMETERS USED IN THE STEP BY STEP CALCULATION	(PA)		PARAMETER	AERODYNAMIC
266 PCODE	UTILITY			UTILITY	COMMON
267 PELHT	UTILITY: TO HELP ESTABLISH WHICH FLUE ELEMENTS ARE INSIDE & OUT	(m)		DIMENSION	MAIN
268 PHC	PRESSURE COEFFICIENT OF THE HORIZONTAL COMPONENT OF WIND		(0.5)	COEFFICIENT	AERODYNAMIC CHIMNEY
269 PIE	GEOMETRIC CONSTANT		(3.131593)	CONSTANT	MAIN

VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
270 PP	UTILITY			UTILITY	GRAPHICS
271 PRCOND$	UTILITY			UTILITY	COMMON
272 PRFF$	UTILITY			UTILITY	COMMON
273 PRFLAG	UTILITY			UTILITY	COMMON
274 PRFLAG2	CONTROL			UTILITY	COMMON
275 PRISE	UTILITY			UTILITY	COMMON
276 PRREG$	UTILITY			UTILITY	COMMON
277 PRTSC	FUNCTION (FROM ONE OF THE LIBRARIES) PRINTS A GRAPH			FUNCTION	GRAPHICS/OUTPUT
278 PRUUN	UTILITY			UTILITY	COMMON
279 PT	TOTAL PRESSURE	(PA)		DEPENDENT VAR	AERODYNAMIC/ALL
280 PT1	UTILITY: X-AXIS VALUE FOR GRAPHICS			UTILITY	GRAPHICS
281 PTC	TOTAL WIND PRESSURE COEFFICIENT			COEFFICIENT	AERODYNAMIC
282 PT1$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
283 PUT	FUNCTION			FUNCTION	GRAPHICS
284 PVC	PRESSURE COEFFICIENT OF THE VERTICAL COMPONENT OF WIND		(1.)	COEFFICIENT	AERODYNAMIC CHIMNEY
285 Q1	VARIABLE USED IN THE ITERATIVE PROCESS	(kg/s)		CONTROL	MAIN
286 Q2	VARIABLE USED IN THE ITERATIVE PROCESS	(kg/s)		CONTROL	MAIN
287 Q6	INITIAL & UPDATED GUESS AT MASS FLOW RATE THROUGH THE CHIMNEY	(kg/s)		PHYSICAL QUANTITY	AERODYNAMIC CHIMNEY
288 Q6LAST	UTILITY: MASS FLOW THROUGH THE CHIMNEY AT THE LAST TIME STEP	(kg/s)		UTILITY	MAIN
289 Q9	INITIAL & SUBSEQUENT GUESS AT MASS FLOW RATE OF STACK GASES	(kg/s)		PHYSICAL QUANTITY	AERODYNAMIC FURNACE
290 Q9LAST	UTILITY: MASS FLOW THROUGH THE FURNACE AT THE LAST TIME STEP	(kg/s)		UTILITY	MAIN
291 QDHW	VOLUMETRIC FLOW RATE OF THE HOT WATER BRANCH	(m3/s)		QUANTITY	AERODYNAMIC
292 QDIL	VOLUMETRIC FLOW RATE OF THE DILUTION FLOW	(m3/s)		QUANTITY	AERODYNAMIC
293 QF	VOLUMETRIC FLOW RATE OF THE FANS	(m3/s)		BOUNDARY COND	AERODYNAMIC/ENVEL
294 QFLUE	VOLUMETRIC FLOW RATE OF THE FLUE GAS	(m3/s)		QUANTITY	AERODYNAMIC
295 QFUEL	VOLUMETRIC FLOW RATE OF THE FUEL	(m3/s)		QUANTITY	AERODYNAMIC
296 QFURN	VOLUMETRIC FLOW RATE OF THE GAS THROUGH THE FURNACE	(m3/s)		QUANTITY	AERODYNAMIC
297 QGAS	VOLUMETRIC FLOW RATE OF THE FUEL (EG. GAS OR OIL)	(m3/s)		BOUNDARY CONDI	AERODYNAMIC/FURNACE
298 RE	REYNOLDS NUMBER - OF THE FLUE FASES IN THE CHIMNEY			PARAMETER	BOTH/CHIMNEY
299 RESUME	FUNCTION (RESUMES EXECUTION AFTER A TRAPPED ERROR)			RESUME	ERROR TRAPPING
300 RISE	THE RISE OF EACH SEGMENT IN THE MAIN FLUE PIPE	(m)		DIMENSION	AERODYNAMIC
301 RISET	THE TOTAL RISE OF THE MAIN FLUE PIPE	(m)		DIMENSION	AERODYNAMIC
302 RNGTM	RECORDS THE DURATION OF FURNACE OPERATION & STANDBY TIME	(s)		UTILITY	DYNAMIC ENVELOPE
303 RO	DENSITY OF THE GAS AT EACH NETWORK POINT	(kg/m3)		DEPENDENT PROPERTY	AERODYNAMIC/ALL
304 ROOMDP	ROOM DEW POINT TEMPERATURE	(C)	(6)	REFERENCE QUANTITY	CONDENSATION
305 RW	UTILITY: USED TO PASS-ON DENSITY VALUES	(kg/m3)		DUMMY	THERMAL/CHIMNEY
306 S	UTILITY: INTERVAL COUNTER			CONTROL	MAIN
307 SADHW	SURFACE AREA OF THE DHW FLUE PIPE	(m2)		DIMENSION	THERMAL
308 SCAL	UTILITY: SCAL FOR AXIES IN THE GRAPH ROUTINE			UTILITY	GRAPHICS
309 SCS	ELAPSED TIME SINCE FURNACE START-UP	(S)		UTILITY	OUTPUT
310 SCSFLAG	UTILITY: INDICATOR THAT THE END OF THE SIMULATION HAS BEEN REACHED		(0,1)	INDICATOR	MAIN
311 SEC	CALCULATION INTERVAL	(S)	(1)	CONTROL	ALL
312 SEG	FUNCTION USED IN CONNECTION WITH BSAVING THE SCREEN			FUNCTION	GRAPHICS OUTPUT
313 SN	UTILITY: TO KEEP TRACK OF VERTICAL WIND DIR (+VE UP) FOR V2		(+1 OR -1)	VECTOR	AERODYNAMIC
314 SNFP	UTILITY: KEEPS TRACK OF THE FLOW DIRECTION IN THE FLUE PIPE		(+1 OR -1)	VECTOR	AERODYNAMIC
315 SPACE$	UTILITY: RECORDS THE AVAILABLE SPACE ON THE OUTPUT DISK	(bytes)		UTILITY	ERROR TRAPPING
316 SSEFF	STEADY STATE EFFICIENCY OF THE FURNACE	(%)		PERFORMANCE PARAM	THERMAL
317 ST	NUMBER OF TOTAL CALCULATION STEPS FOR THE RUN			CONTROL	MAIN
318 T	UTILITY: USED TO TIME A PAUSE			UTILITY	MAIN
319 T$	UTILITY: TO DISPLAY TITLES ON THE GRAPHS			UTILITY	GRAPHICS
320 T1	OUTDOOR TEMPERATURE	(C)		BOUNDARY CONDITION	BOTH/SURROUNDINGS
321 T6F	FURNACE GAS TEMPERATURE IN THE AREA OF THE HEAT EXCHANGER	(C)		DEPENDENT PROPERTY	THERMAL/FURNACE
322 T7F	TEMPERATURE OF THE STACK GASES IN THE UPPER PORTION OF FURNACE	(C)		DEPENDENT PROPERTY	THERMAL/FURNACE
323 T9	HOUSE TEMPERATURE	(C)	(20)	BOUNDARY CONDITION	BOTH/SURROUNDINGS
324 T91	INDOOR OUTDOOR TEMPERATURE DIFFERENCE	(C)		PARAMETER	DYNAMIC ENVELOPE
325 T9N	UPDATED ROOM TEMPERATURE	(C)		BOUNDARY CONDITION	DYNAMIC ENVELOPE
326 TA	NUMBER OF KELVINS AT 0 DEG C	(K)	273.15	CONSTANT	THERMAL/AERO

	VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
327	TAB	FUNCTION: CONTROLS LOCATION OF A COLUMN IN THE PRINTOUTS			FUNCTION	OUTPUT
328	TAG	INDOOR TEMPERATURE AMPLITUDE PARAMETER (NOT USED)	(C)		PARAMETER	DYNAMIC ENVELOPE
329	TB	UTILITY: USED TO TRANSFER THE APPROP. TEMP IN CHIMNEY MODEL	(C)		UTILITY	THERMAL
330	TCF2	UTILITY			UTILITY	COMMON
331	TDHW	TEMPERATURE OF THE GAS IN THE DHW BRANCH	(C)		DEPENDENT PROPERTY	THERMAL/AERO
332	TEF	AVERAGE FURNACE GAS TEMPERATURE TO CALCULATE BUOYANCY OF FURNACE	(C)		DEPENDENT PROPERTY	AERODYNAMIC FURNACE
333	TF	FINAL TEMPERATURE OF THE CHIMNEY LAYERS AT END OF TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
334	TFDHW	FINAL TEMPERATURE OF THE DHW F.P. LAYERS AT END OF TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
335	TFLEN	TOTAL FLUE LENGTH	(m)		DIMENSION	MAIN
336	TFPLN	TOTAL FLUE PIPE LENGTH	(m)		DIMENSION	MAIN
337	TGYP	TEMPERATURE OF THE GYPSUM	(C)		DEPENDENT PROPERTY	DYNAMIC ENVELOPE
338	TGYPN	TEMPERATURE OF THE GYPSUM AFTER THE TIME STEP (NEW)	(C)		DEPENDENT PROPERTY	DYNAMIC ENVELOPE
339	THCL	HEAT TRANSFER COEFFICIENT OF THE CHIMNEY LINER	(W/m2.C)		PROPERTY	THERMAL
340	THCO	HEAT TRANSFER COEFFICIENT OF THE OUTER PART OF THE CHIMNEY	(W/m2.C)		PROPERTY	THERMAL
341	THCS	HEAT TRANSFER COEFFICIENT OF THE CHIMNEY INSULATION OR MID-LAYER	(W/m2.C)		PROPERTY	THERMAL
342	THETAW	ANGLE OF THE WIND @ CHIMNEY TOP	(DEG)		VECTOR	AERODYNAMIC
343	THS	THERMOSTAT CUT OFF TEMPERATURE	(C)		SETPOINT	DYNAMIC ENVELOPE
344	TI	INITIAL TEMPERATURE OF THE CHIMNEY ELEMENTS BEFORE THE TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
345	TIDHW	INITIAL TEMPERATURE OF THE DHW FP ELEMENTS BEFORE THE TIME STEP	(C)		DEPENDENT PROPERTY	THERMAL
346	TIMER	FUNCTION USED TO TIME A PAUSE			FUNCTION	MAIN
347	TISET$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
348	TIT$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
349	TITLE$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
350	TLFLAG	UTILITY			UTILITY	COMMON
351	TMF	TEMPERATURE OF THE HEAT EXCHANGER SURFACE	(C)		DEPENDENT PROPERTY	THERMAL/CHIMNEY
352	TMONOFF	BAND WIDTH OF THE THERMOSTAT	(C)		SETPOINT	DYNAMIC ENVELOPE
353	TMP1	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
354	TMP2	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
355	TMP3	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
356	TMP4	INDICATOR: SPECIFIES WHICH TEMPERATURES WILL BE PLOTTED			UTILITY	GRAPHICS
357	TN	TEMPERATURE AT EACH NETWORK POINT	(C)		BOUNDARY CONDITION	AERODYNAMIC/ALL
358	TOW1	FIRST TIME CONSTANTS OF THE ENVELOPE	(s)		PARAMETER	DYNAMIC ENVELOPE
359	TOW2	SECOND TIME CONSTANTS OF THE ENVELOPE	(s)		PARAMETER	DYNAMIC ENVELOPE
360	TQ	DUMMY VARIABLE TO OUTPUT MEAN FLUE LINER TEMPERATURE	(C)		OUTPUT VARIABLE	THERMAL/CHIMNEY
361	TRI	CONTAINS COORDINATES TO DRAW A TRIANGLE ON THE GRAPHS			UTILITY	GRAPHICS
362	TSCR	UTILITY: SPECIFIES TABULAR OUTPUT WHEN SCREEN CAN'T SHOW GRAPHS			UTILITY	ERROR TRAPPING
363	TSSGE	STEADY STATE FLUE GAS FURNACE EXIT TEMPERATURE	(C)		DESIGN CONDITION	THERMAL
364	TT	UTILITY: TO OUTPUT MEAN FLUE GAS TEMPERATURE	(C)		UTILITY	OUTPUT
365	TT$	UTILITY			UTILITY	COMMON
366	TTF	MEAN TEMPERATURE OF THE FLUE GAS (CORRESPONDS TO MEAN DENSITY)	(C)		PARAMETER	THERMAL/AERO
367	TTFF	MEAN TEMPERATURE OF THE FLUE PIPE GAS (CORRESPONDS TO MEAN DENS)	(C)		PARAMETER	THERMAL/AERO
368	TTI$	UTILITY: GRAPH TITLE			UTILITY	GRAPHICS
369	TW	UTILITY: TIME CONSTANTS OF THE CHIMNEY STRUCTURE	(s)		PARAMETER	THERMAL/OUTPUT
370	TZ	TIME CONSTANTS OF ELEMENTS OF THE CHIMNEY (PRINTED OUT)	(s)		PARAMETER	THERMAL
371	U	HEAT TRANSFER COEFFICIENT OF THE CHIMNEY LAYERS	(W/C)		PROPERTY	THERMAL
372	U1A	HEAT TRANSFER COEFFICIENTS INTO & OUT OF FURNACE HEAT EXCHANGER	(W/C)		PROPERTY	THERMAL
373	U2A	HEAT TRANSFER COEFFICIENTS INTO & OUT OF FURNACE HEAT EXCHANGER	(W/C)		PROPERTY	THERMAL
374	U2AR	UTILITY: U2AR = U2A	(W/C)		PROPERTY	THERMAL
375	UDHW	FILM HEAT TRANSFER COEFFICIENT IN DHW FLUE PIPE	(W/m2.C)		COEFFICIENT	THERMAL
376	UF	AVERAGE FILM HEAT TRANSFER COEFFICIENT OF GAS UP THE CHIMNEY	(W/C)		COEFFICIENT	THERMAL
377	UI	MINIMUM FILM HEAT TRANSFER COEFFICIENT BETWEEN GAS & LINER	(W/m2.C)		COEFFICIENT	THERMAL
378	UTA	OVERALL HEAT TRANSFER COEFFICIENT OF THE FURNACE HEAT EXCHANGER	(W/C)		COEFFICIENT	THERMAL
379	V	VELOCITY OF FLUE GAS THROUGH EACH ELEMENT OF THE CHIMNEY	(m/s)		DEPENDENT VAR	AERO/THERMAL
380	VAR	UTILITY			UTILITY	GRAPHICS
381	VCL	EFFECTIVE ENVELOPE CENTER OF LEAKAGE INCLUDING INTAKE	(m)		DIMENSION	AERODYNAMIC
382	VCLINT	LOCATION OF THE FRESH AIR INTAKE	(m)		DIMENSION	AERODYNAMIC
383	VF	VOLUMETRIC FLOW RATE	(m3/s)		PHYSICAL QUANT	AERODYNAMIC/ALL

	VARIABLE	DESCRIPTION	UNITS	SET VALUE	TYPE OF VARIABLE	MODULE REFERENCED
384	VH	HORIZONTAL COMPONENT OF THE WIND VELOCITY AT THE CHIMNEY TOP	(m/s)		BOUNDARY CONDI	AERODYNAMIC CHIMNEY
385	VL	VELOCITY (SCALER) OF GAS/AIR AT EACH NETWORK POINT	(m/s)		PHYSICAL QUANT	AERODYNAMIC/ALL
386	VQ	UTILITY: USED TO OUTPUT VOLUMETRIC FLOW RATES	(L/s)		UTILITY	OUTPUT
387	VV	VERTICAL COMPONENT OF THE WIND VELOCITY (+VE UPWARDS)	(m/s)		BOUNDARY CONDI	AREDYNAMIC
388	VWIND	UTILITY: WIND SPEED	(kg/h)		QUANTITY	AERODYNAMIC
389	VWINDH	UTILITY: WIND - HORIZONTAL COMPONENT	(m/s)		QUANTITY	AERODYNAMIC
390	VWINDT	WIND SPEED - TOTAL	(m/s)		QUANTITY	AERODYNAMIC
391	VWINDV	UTILITY: WIND SPEED - VERTICAL COMPONENT	(m/s)		QUANTITY	AERODYNAMIC
392	WCOEFH	HORIZONTAL WIND PRESSURE COEFFICIENT			COEFFICIENT	AERODYNAMIC
393	WCOEFV	VERTICAL WIND PRESSURE COEFFICIENT			COEFFICIENT	AERODYNAMIC
394	WTSIN	DELIVERED HEAT TO THE HOUSE FROM THE FURNACE	(W-s)		DEPENDENT VARIABLE	DYNAMIC ENVELOPE
395	X	UTILITY: LOOP COUNTER FOR THE NUMBER OF NETWORK POINTS			CONTROL	ALL
396	X1	UTILITY			UTILITY	COMMON
397	X2	UTILITY			UTILITY	COMMON
398	X3	UTILITY: VARIABLE USED IN THE ITERATIVE PROCESS	(kg/s)		CONTROL	MAIN
399	X4	UTILITY: VARIABLE USED IN THE ITERATIVE PROCESS			CONTROL	MAIN
400	XD	UTILITY: COUNTER FOR THE TEMPERATURE PRINT OUT ARRAY			CONTROL	OUTPUT
401	XNEW	UTILITY: USED TO LOCATE X-COORDINATES IN PLOTS			UTILITY	GRAPHICS
402	XOLD	UTILITY: USED TO LOCATE X-COORDINATES IN PLOTS			UTILITY	GRAPHICS
403	XPT	FRACTION OF THE FLUE HEIGHT USED TO DETERMINE EXT/INT LOCATION	(m)		DIMENSION	MAIN
404	XSCAL	UTILITY: X-AXIS SCALING FACTOR IN GRAPHICS ROUTINE			UTILITY	GRAPHICS
405	XX	UTILITY: COUNTER			CONTROL	GRAPHICS
406	Y	UTILITY: COUNTER FOR THE NUMBER OF ELEMENTS "NE" UP THE CHIMNEY			CONTROL	THERMAL
407	Y$	UTILITY: TITLES FOR THE Y-AXIS IN GRAPHS			UTILITY	GRAPHICS
408	YDEW	UTILITY: LOCATES THE VERTICAL LOCATION OF THE ONSET OF CONDENSATION			UTILITY	CONDENSATION
409	YFLO$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
410	YNEW	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
411	YNUMS$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
412	YOLD	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
413	YPRS$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
414	YSCAL	UTILITY: USED TO THE SCALE THE Y-AXIS			UTILITY	GRAPHICS
415	YST	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
416	YT1	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
417	YT2	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
418	YT3	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
419	YT4	UTILITY: USED TO PLOT THE Y-COORDINATE			UTILITY	GRAPHICS
420	YTEMP$	UTILITY: USED TO LABEL THE SCALES ON THE Y-AXIS			UTILITY	GRAPHICS
421	YY	UTILITY: USED TO THE SCALE THE Y-AXIS			UTILITY	GRAPHICS
422	Z$	UTILITY: CONTROLS THE PRINT OUT OF HEADINGS AND INITIAL CONDITIONS			CONTROL	OUTPUT
423	Z0	UTILITY: ONE OF THE PARAMETERS IN THE MATH MODULE			UTILITY	MATH MODULE
424	Z1	UTILITY: TIME COUNTERS TO CONTROL EXECUTION OF PRINT OUTS			CONTROL	OUTPUT
425	Z2	UTILITY: TIME COUNTERS TO CONTROL EXECUTION OF PRINT OUTS			CONTROL	OUTPUT
426	ZCOR	UTILITY: ONE OF THE PARAMETERS IN THE MATH MODULE			UTILITY	MATH MODULE
427	ZZ	UTILITY: LOOP COUNTER			CONTROL	MAIN

LIST OF VARIABLES

AND THEIR REFERENCE

LINE NUMBERS:

FLUESIM 4.2

(ALPHABETICAL SORT)

VARIABLE LIST FOR PROGRAM: FLUESIM4.BAS   DATE: 03-09-1989

THE PROGRAM HAS 1567 LINES OF CODE

	VARIABLE	REFERENCED ON LINE No. ...
1	A	30 50 8145 8150 8160 8210 8220 8230 8380 8430 9270 9340 9350 11300 12662 17680 17725 17730 17800 21034 21036 21046 21048 21056 21058 21060 21076 30050 30055
2	A$	21008 21010 21012
3	ABORT$	3660
4	ADR	60 4160 4280 5420 11230
5	AHC	22050 22060 22090 22130
6	AHT	22040 22060 22090 22091 22130 22131
7	ANDFACT	21056 21058 21060 21888
8	ANDNO	27 20184 20186 20188 21206 21888
9	APRD	80 4160
10	AR	20 40 99 330 1646 1647 2095 3185 4160 4270 4290 4300 5390 5400 6355 11170 11180 15240
11	ARD	27 99 4260 4305 5405 6080 6085 9130 9140 9693 9710 9715 9720 9740 9750 9760 10514 11209 23063
12	ARDAMP	94 9710 9715 9720 9740 9760
13	AREFF	10514 10515 11209 11210
14	ARINT	93 443
15	AUFF	90 3560 9710 9715
16	AXIS	20070 21000
17	B	21064 21066 21076 21078
18	B$	21014 21016 21018 21078 21080
19	B1	10550 10625 10680
20	B10	10600 10635 10650 10660 10690
21	B11	10605 10650 10660 10690
22	B12	10610 10635 10650 10660 10690
23	B2	10555 10625 10635 10670 10680
24	B3	10565 10625 10635 10650 10660 10670 10680
25	B4	10570 10590 10660 10670 10675 10680
26	B5	10575 10625 10680
27	B6	10580 10630 10635 10650 10660 10675 10685
28	B7	10585 10630 10635 10650 10660 10675 10685
29	B8	10590 10685
30	B9	10595 10630 10685
31	BA	10625 10650 10660 10670
32	BB	10630 10650 10660 10675
33	BC	10635 10650
34	BEEP	3670 30000
35	BLTEMP	22560 22570 22580 22582
36	BOX	39 106 21199 21903
37	BSAVE	3695
38	C	90 441 17860
39	C1	70 3270 3280 3290 3310 5095

40	C2	70	3390	3400	3410	3420						
41	CC	93	446	6140	10550	10555	11110	11250	17860			
42	CHBOT	80	440	1620								
43	CHDENL	92										
44	CHDENO	92										
45	CHDENS	92										
46	CHDI2	20	40									
47	CHELTL	92										
48	CHELTO	92										
49	CHELTS	92										
50	CHHC	20	40									
51	CHHK1	10680										
52	CHHK2	10685										
53	CHHK3	10690										
54	CHIMT$	80	11490									
55	CHK$	3694										
56	CHM$	30	50									
57	CHTHCL	92										
58	CHTHCO	92										
59	CHTHCS	92										
60	CIR	39	105	21199	21905							
61	CONST	93	6172	11155	11473							
62	COS	1585	1590									
63	COUNT	93										
64	CPAIR	60	370	7060	7100	7200	7310	8190	24420			
65	CPWENV	27	98	6120	10535	11130	17270					
66	D$	13070										
67	D1TM	7110	7150	7210	9280	9360	12170	24620	24900			
68	D2TM	7110	7150	7210	9290	9370	12170	24640	24920			
69	D3TM	7115	7155	7215	9292	9296	9375	12170	24680	24940		
70	D6F	7130	7240									
71	DAMPACT$	94	9730									
72	DAMPTCL	94	9740	9760								
73	DAMPTOP	94	9750	9760								
74	DB	93										
75	DEF	3695										
76	DENL	30	50	8210								
77	DENO	30	50	8230								
78	DENS	30	50	8220								
79	DEW	25	93	428	13610	22570	22580	22582				
80	DF	60										
81	DHF	20	60	1610	1645	8150	9130	12570	12610	12620	12630	12662
82	DHW$	110	3653	5092	9077	9255	9293	17955				
83	DHWAC	24415	24420									
84	DHWAR	94	4306	17980	24280	24590						
85	DHWC	94	110	17960	24415							
86	DHWEF	94	17970	24420								
87	DHWFPH	94	23072									
88	DHWFPLE	94	24280	24590								
89	DHWFPN	94	9077	9255	9293	23062	24500					
90	DHWLAST	3520	5075	5095								
91	DHWNEL	94	4306									
92	DHWO$	94	17958	24415								
93	DHWSBC	94	110	17965	24415							
94	DHWTYPE$	94	111	112	113							
95	DI	30	50									
96	DI2	30	50	1648	8145	8150	8160	12662				
97	DIA	20	93	1646	1647	1648	9693	12590	12600	12662		
98	DIAMND	39	103	21199	21906							
99	DOC$	70	3694									

100.	DPO	93	6172	11155	11473												
101	DPBUO	14510	18380	21523	23072	23080											
102	DPDHW	23080	23090	23200													
103	DPDIL	14510	18380	21522	23050	23080											
104	DPFP	14510	18380	21522	23070	23080											
105	DRIVE$	93	3695														
106.	DTM	7130	7170	7230	9310	9390	12170	24800	24980								
107	E	3280	3400	10070	10100	10110	17320	17330									
108	E1	17320	17340	17370													
109	E2	17330	17340	17390													
110	EA	22030	22040														
111	EH	30	50	4700	4710	9560	9565										
112	ELA	20	40	4260	4270	4280	4290	4300	4305	6080	6085	6170	6280	6290	6355	6360	
		10570	10580	10585	23050												
113	ELA1	10515	10565														
114	ELA6M	23063	23070														
115	ELADHW	94	4306	23200													
116	ELAENV	441	444	445	446												
117	ELAINT	443	444	445													
118	ELHT	30	50	1660	4660	4664											
119	ELTL	30	50	8210													
120	ELTO	30	50	8230													
121	ELTS	30	50	8220													
122	ENTRY	50															
123	ER1	60	2120	3280	3320	3340	3370	3400	3430	10730							
124	ER2	60	3310	3320	3340	3370											
125	ER3	60	2130	3280	3320	3400	3430	3440	3460	10730							
126	ER4	60	3420	3430	3440	3460											
127	ERL	29140															
128	ERR	29120	29130	29140													
129	ERROR	102	29999														
130	EXAIR	93	10100														
131	F$	60	1840	2110	3110	3112	3170	3200	3560	3802	3804	6172	6270	6380	9720	10120	
		22080	22150	22570	22580	22582											
132	F1	80	310	1850	17190	19150											
133	F2	80	8490	11280	17200	19560											
134	FANM	60	1900	1920	17410												
135	FAULT$	3694	3695														
136	FCAPL	94	4120														
137	FCAPNO	94															
138	FDAMP$	94	9695														
139	FE	17210	17220	18280	18290	18300											
140	FF	30	50	12610	12620	12630	12650										
141	FICV	80	7070	7180													
142	FIRM	60	1910	1920	17420												
143	FL1	75	2135	2185	3075	3355	3445	3670	8355	18325	30070						
144	FL2	75	21008	21024	21030	21088	21110	21112	21114	21116	21150	21166	21176	21186	21850	21860	
		21870															
145	FLENME$	25	93														
146	FLUEDP	97	22570														
147	FLUEIN$	93	3671														
148	FM	30	50	17070	17370	17380	17390	17430									
149	FP	90	1910	10625	10680	11110	17420										
150	FPAR	20	40														
151	FPDENL	91															
152	FPDENO	91															
153	FPDENS	91															

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154 FPDI2        20    40
155 FPELTL       91
156 FPELTO       91
157 FPELTS       91
158 FPHC         20    40
159 FPI$       8305  8306  9395 25000
160 FPLN         30    50  1610
161 FPTHCL       91
162 FPTHCO       91
163 FPTHCS       91
164 FR1          75 21187 21870
165 FR2          75 21188 21870
166 FR3          75 21189 21870
167 FR4          75 21190 21870
168 FS           90  3110 22150
169 FT$          70   330  2100  3190  6260  6355  6370  9710  9715 10130 10140 10150 18580 18590
170 FTI$         37 20226 20228 20230 20232 20234 21187 21188 21189 21190
171 FU        10060 10070 10100 10110
172 FW           60  1850  7060 10060 17210 17320 17330 18280 19150 19560
173 GC           60   380  6090  6100  6230  9560  9565  9575  9576 10520 10525 10545 11150 23072
174 GD$          70 30070
175 GE           60
176 GF           60   410  6090  9530  9560  9575 10520
177 GFF        9535  9565  9576
178 GFOUT        37 21526 21527 21528 21529 21530 21870
179 GMASSDHW  24280 24580 24600
180 GPOUT        37 21362 21364 21366 21368 21370 21372 21374 21376 21378 21380 21382 21522 21523 21860
181 GTOUT        37 21348 21350 21352 21354 21356 21358 21360 21361 21850
182 HB800      3695
183 HC           30    50  8190  8305  8306  8380  8430  9270  9340  9350 11300 17700 17725 17730 17800
              24600 24860 24880

184 HCHE         90
185 HD$          27 11350 11360 11370 11380 11390 11400 11410 11420 11430 11440 11450 11460 11470 11476
186 HF           60  1620  1645  1660  4660  4664  4710  6090  6100  8160  9140  9575  9576 10520 10525
              11150 12580 12662

187 HFFFF     20180
188 HH           60  1630  6230 10545
189 HHC          93 22022 22024 22026 22060 22091 22131
190 HMASS$       93 22022 22024 22026
191 HT           20    40   440   448  1630  6100  6230 10525 10545 15180
192 HTC          93 22060 22090 22091 22130 22131
193 HVOL         93 22030 22050
194 I            99  1610
195 ICHTYPE      93
196 II         6340  6350  6360 23040 23050
197 IND10     13350
198 INDT       7090  7140  7190  9250  9330 12070 12075 12080 12090 24540 24840
199 INSTR      3694
200 ITDHW      7115  7155  7215  9291  9295  9375 12075 12170 24660 24940
201 ITER       3180  3260  3300  5075
202 ITW        7100  7140  7200  9260  9340 12070 12080 12170 24580 24860
203 J            19  8140  8145  8150  8160  8170  8370  8380  8390  8400  8420  8430  8440  8450  9320
               9340  9350  9360  9370  9390  9400  9410  9440  9450  9460 17720 17725 17730 17740 17750

204 JUNCTLOSS  9076  9077
205 JUNK$      3677  3678  3679  3680  3681  3693
206 K1           60   340 12620 12630
207 KBD        6355
```

208	KE	20	40	4090	4120	4125	4260	4270	4280	4290	4300	4305	6080	6085	9070	9075
		9077	10515	10560	11170	11180	11210	11230	12650	15300	18320	23062	23063			
209	KE4	23062	23063													
210	KECON	111	112	113	4306											
211	KEINT	442	443													
212	L1$	30120														
213	L1A	11170	11190	11200	11210	11220	11230	11240	11250	11260						
214	L2$	30130	30230													
215	L2A	11180	11200													
216	L3$	30140	30240													
217	L4$	30150	30250													
218	LEAKDIST	93	6120	10535	11130	17270										
219	LEFT$	3694														
220	LHC	90														
221	LNPP	90	444	17880												
222	LOCDOT	3694														
223	LT	37	20180													
224	M	30	50	8210	8220	8230	8305	8306	8380	8430	9130	9140	9260	9270	9295	9340
		9350	11300	12570	12580	17690	17725	17730	17800	24860	24880					
225	M2CP	90	7140	11290	17600	17620	18090									
226	M6	7070	7100	17630												
227	M7	7180	7200													
228	MASTER	70	101													
229	MCOMP	60	1920	5280												
230	MDHW	94	3520	5075	5092	5095	5110	5280	9294	9295	23210	24420	24480	24580		
231	MOI$	93	6172	11155	11473											
232	MF	30	50	5080	5090	5110	5125	5150	5190	5210	5240	5280	5320	6130	6140	7060
		7100	7200	7300	7310	7320	7330	7340	7370	7390	7400	9220	9255	9610	12570	12580
233	MFIN	9255	9260													
234	MFIPOT	60	320	330	7100											
235	MFUEL	10140														
236	MGAS	10070	10080	10130	10140	17360										
237	MOHE	90														
238	MOIL	10110	10120	10140	10150											
239	MTFUEL	93	5090	5190	5210	10130										
240	MTOIL	10100	10120	10130												
241	MU	60	360	12590												
242	N	90	441	446	6140	11110	11250	17870								
243	N$	37	20102	20104	20106	20108	20110	20112	20114	20116	20118	20120	20122	20124	20126	20128
		20130	20132	20134	20136	20138	20140	20142	21082							
244	NDHWFP	94	9296	24240	24280	24500	24590	25080	25170							
245	NE	90	427	1644	1660	4640	4660	4664	4690	4710	8060	8305	8306	8380	8430	9110
		9230	9430	9490	9540	9630	9693	13180	13250	13310	13380	13440	13500	13600	17510	17545
246	NELBOWS	90	4125	9075	9077	23062										
247	NELINT	93	442													
248	NFPSEGS	90	1610	1645	4650	4700	4710	8150	8280	9077	9130	9140	9400	9565	11300	12570
		12580	12650	12662	13155	17670	17680	17690	17700	17725	17730	17800	23062			
249	NSCAL	21056	21058	21060	21084											
250	OFTIM	3804														
251	ONTIME	93	426	3112	13610											
252	OO	30	50	18080	18090	18100	18110	18120	18130	18140	18150	18160	18170	18250	18260	18270
		18300	18310	18320	18410	18420	21348	21350	21352	21354	21356	21358	21526	21527	21528	21529
253	OP	21872	21880	21882	21884	21886	21888	21909								

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254  OTW          7100   7140   7200   9270   9350  12090  12170  24600  24880
255  OU$            93    107
256  OUTPUT        107  30210
257  P           21118  21122  21126  21136  21140  21144
258  P$             70  18330  18620
259  P1             75  21178  21860
260  P2             75  21180  21860
261  P3             75  21182  21860
262  P4             75  21184  21860
263  PAR            20     40  11110  11130  11140  11150  11160  11200  11220  11240  11260  11270  11280  11290  11300
             11476

264  PATTRN         27  20182  20184  20186  20188  21882
265  PB             20     40   3270   3390   6100   6120   6140   6170   6172   6180   6230   6280   6290   6300   6360
              6390   6400  10525  10535  10545  10575  10595  11155  11160  14490  17440  18140  18360  21362  21364

266  PCODE          50
267  PELHT          60   1620   1660
268  PHC            60   1585   6120  10535  11130  17270
269  PIE            60    390   1585   1590   1600   1646   1647   1648   9693  12662  24590
270  PP          21118  21124  21128  21134  21142  21146
271  PRCOND$        90
272  PRFF$          90
273  PRFLAG         70
274  PRFLAG2        70    120    122
275  PRISE          20
276  PRREG$         90
277  PRTSC        3693
278  PRUUN          20
279  PT            103  21887  21900  21901
280  PT1         21877  21882  21884  21887  21900  21903  21904  21905  21906
281  PTC            90   1585
282  PTI$           37  20190  20192  20194  20196  20198  20200  20202  20204  20206  20208  20209  20210  20211  2117
             21180  21182  21184

283  PUT         21199  21903  21904  21905  21906
284  PVC            60   1580   1585   6120  10535  11130  17280
285  Q1           2120   3280   3320   3340   3370   3400   3430
286  Q2             70   3310   3340   3370
287  Q6             60   2080   2095   2097   3280   3310   3320   3340   3400   3430   3520   5075   5080  10715
288  Q6LAST       2097   3520   5075
289  Q9             70   2090   2095   2097   2110   3200   3280   3320   3400   3420   3430   3440   3520   5075   509
             10716

290  Q9LAST       2097   3520   5075
291  QDHW        18425  21530  23200  23210
292  QDIL        10665  10670  10675  10680  10685  10690  10710
293  QF             90   1900  10625  10680  11110  17410
294  QFLUE       10670  10680  10690  10700  10715
295  QFUEL       10150  10630  10635  10675  10685  17360
296  QFURN       10675  10685  10690  10705  10716
297  QGAS        10080  10090  10150
298  RE          12590  12600  12610
299  RESUME      29120  29130  30070
300  RISE           30     50   4700
301  RISET          93    440   6090   6100   9575  10520  10525
302  RNGTM        3804  22110  22120  22150  22160
303  RO             20     40   1900   1910   4765   4770   5320   6120   6140   7180   9680  10080  10535  11130  1125
             14230
```

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304 ROOMDP      97 22580 22582
305 RW        9550  9560  9565
306 S         3060  3065  3110  3185  3560  3662  3804 18327
307 SADHW    24590 24600 24860 24880
308 SCAL     21056 21058 21060 21064
309 SCS         90  2140  3070  3090  3110  3550  3560  3676  3804  9710  9715 13110 18080 18090 18326
             18340 19580 21305 21346 21888 21930 21940 22150

310 SCSFLAG     50  3670  4662
311 SEC         90  2135  2140  3070  3090  3112 12070 12075 12080 12090 12170 21942 22090 22091 22120
             22130 22131 22160 22570 22580 22582

312 SEG       3695
313 SN        1583  1585  6110  6120  6130  6140  6160  6170  6240  6250  6280  6290  6340  6350  6360
             10530 10535 11120 11130 23040 23050 23060 23070 23090 23200

314 SNFP      6150  6170
315 SPACE$   29130
316 SSEFF       80  8490
317 ST          90  2135  3550  3676 18326 21014 21056 21058 21060
318 T          190  8455
319 T$       21088 21100 21150 21162
320 T1          90    97   441   446  4650 17160 22072 22090 22091 22130 22131
321 T6F         90  7070  7110  7130  7150  7210  7240
322 T7F         90  7230  7250
323 T9          90    97  2145  2146  3802  4650  4660  5092  7060  7150  7380  8490 17170 17210 18280
             21360 21945 22050 22070 22072 22090 22091 22092 22100 22130 22131 22132 22140 24420

324 T91      22072
325 T9N      22090 22092 22130 22132
326 TA          60   400   441   446  4765  4770  6090  6100  6170  6220  6230  6280  6290  6360  7070
              7310  7320  7330  7340  7350  9130  9140  9550  9575  9576  9680 10520 10525 10540 10545

327 TAB      13140 13240 13300 13370 13430 13490 13590 14080 14150 14210 14270 14330 14390 15100 15160
             15220 15280 16060

328 TAG      22072
329 TB        9190  9210  9230  9240  9280 24420 24460 24500 24520 24620
330 TCF2        80
331 TDHW        94  5092 18428 21361 23072 23200 23210 25070 25090 25170 25180
332 TEF       6220  6230 10540 10545 10580 10585 10600 10705
333 TF          20    40  9310  9390  9400  9450 22560
334 TFDHW       38 24800 24980 25020 25090 25120
335 TFLEN     1605  1610  1645
336 TFPLN       90
337 TGYP        97 22090 22091 22092 22130 22131 22132
338 TGYPN    22091 22092 22131 22132
339 THCL        30    50  8080
340 THCO        30    50  8100
341 THCS        30    50  8090
342 THETAW      90  1580  1583  1585  1590  1600
343 THS         75  2145  2146  3802 22100 22140
344 TI          20    40  4650  4660  4670  9130  9140  9210  9240  9280  9290  9296  9310  9360  9370
              9390  9450  9550  9600  9630  9740  9750  9760 12590 12620 13260 13320 13390 13450 13510

345 TIDHW       38    94  9296 24280 24460 24520 24620 24640 24800 24900 24920 24980 25120
346 TIMER      190  8455
347 TISET$      37 21168 21170 21172 21174 21178 21180 21182 21184 21187 21188 21189 21190 21196
348 TIT$        37 21002 21004 21006 21008
349 TITLE$      90  3690 18600
```

350	TLFLAG	50														
351	TMF	90	3160	3170	7110	7150	7170	17210	18150	18280	22070					
352	TMONOFF	75	2145	2146	3552	11060	19055	19590	21941	21945	22140					
353	TMP1	75	21168	21850												
354	TMP2	75	21170	21850												
355	TMP3	75	21172	21850												
356	TMP4	75	21174	21850												
357	TN	20	40	4770	6100	6170	6220	6230	6280	6290	6360	7060	7080	7110	7210	7230
		7250	7260	7310	7320	7330	7340	7350	7360	7370	7380	7390	7400	9190	9230	9400
358	TOW1	22060														
359	TOW2	22060														
360	TQ	17500	17530	17545	17560	18180	18210	18240	18270							
361	TRI	39	104	21199	21904											
362	TSCR	30215	30220													
363	TSSGE	80	8490													
364	TT	4765	6090	6100	6170	9575	10520	10525	10555	10565	10610	10700	11150	17500	17520	17545
		17550	18180	18200	18230	18250										
365	TT$	70														
366	TTF	10560	10565													
367	TTFF	9576	9620													
368	TTI$	37	20212	20214	20216	20218	20220	20222	20224	20225	21168	21170	21172	21174		
369	TW	30	50	17725	17730	17740	17800	17810								
370	TZ	8380	8390	8430	8440											
371	U	30	50	8070	8080	8090	8100	8305	8306	8380	8430	9270	9340	9350	11300	12600
		12640	12660	17670	17730	17800	24860	24880								
372	U1A	70	7100	7140	8500	8510	11290	17610	17620	18090						
373	U2A	70	3150	3160	3170	7140	8510	8520	17210	18280	22070					
374	U2AR	60	3150	3160	3170	8520										
375	UDHW	24410	24600													
376	UF	80	350	9080	9490	12660	17670	17725	18310							
377	UI	60	350	8070	12640	24410										
378	UTA	8490	8500	8510												
379	V	12570	12580	12590												
380	VAR	21072	21082	21084												
381	VCL	93	444	448	6100	10525	11150	17880								
382	VCLINT	93	444													
383	VF	30	50	5320	5400	5405	5420	6150	6160	6170	6172	6250	6280	6290	6350	6355
		6360	11155	11473	14350	17090	18100	18110	18120	18130	22545	23040	23050	23060	23070	
384	VH	60	1590	6120	10535	11130	17270									
385	VL	30	50	5390	5400	5405	5420	7110	7210	11510	11520	14410				
386	VQ	20	40	17090	17370	17380	17390	17430								
387	VV	60	1600	6110	6120	10530	10535	11120	11130	17280						
388	VWIND	90														
389	VWINDH	90														
390	VWINDT	90	1590	1600												
391	VWINDV	90														
392	WCOEFH	38	94													
393	WCOEFV	38	94													
394	WTSIN	22070	22090	22130												
395	X	4080	4090	4100	4640	4650	4660	4664	4670	4680	4690	4700	4710	4720	4760	4765
		4770	5100	5110	5140	5150	5180	5190	5230	5240	5270	5280	5310	5320	5380	5390
396	X1	60														
397	X2	60														
398	X3	60	2130	3280	3320	3400	3430	3440	3460							
399	X4	60	3420	3440	3460											

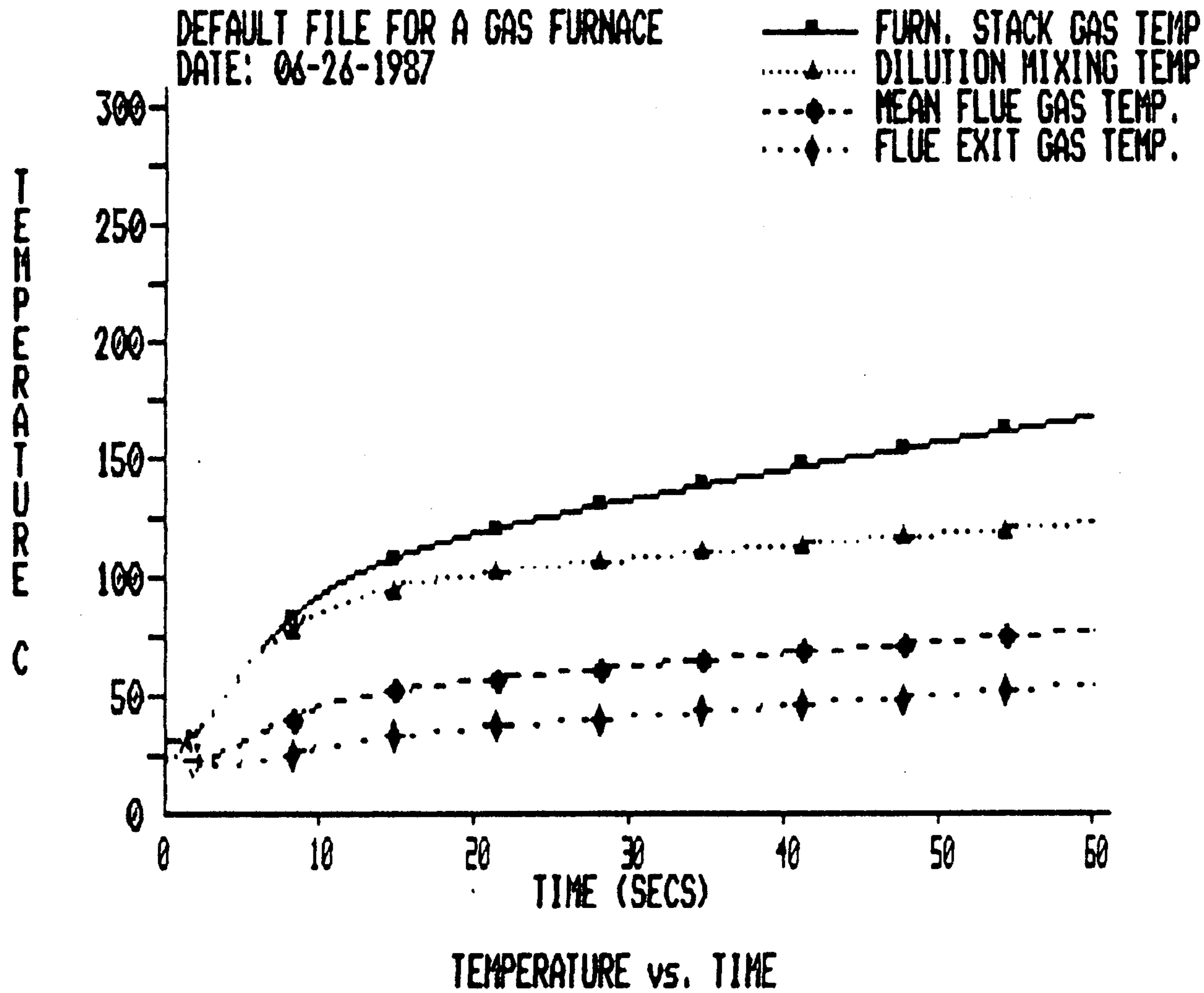
400	XD	60	420													
401	XNEW	21305	21872	21875	21877	21882	21920	21930								
402	XOLD	21872	21882	21884	21888	21920										
403	XPT	80	4660	4664												
404	XSCAL	21056	21058	21060	21875	21877	21882	21884	21888							
405	XX	21204	21206	21208												
406	Y	427	428	1644	1645	1646	1647	1648	8060	8070	8080	8090	8100	8145	8150	8160
		8190	8210	8220	8230	8240	8280	8305	8306	8320	9110	9130	9140	9190	9200	9210
407	Y$	37	21088	21090	21092	21094	21150	21152	21154	21156						
408	YDEW	421	18440	22540	22570	22580	22582									
409	YFLO$	21106	21114													
410	YNEW	37	21850	21860	21870	21872	21875	21882	21884	21902	21909					
411	YNUMS$	21110	21112	21114	21124	21142										
412	YOLD	37	21872	21882	21884	21888	21909									
413	YPRS$	21108	21112													
414	YSCAL	21110	21112	21114	21875	21882	21884	21888	21902							
415	YST	21850	21860	21870	21875	21882	21884	21888	21902							
416	YT1	21902	21903													
417	YT2	21902	21904													
418	YT3	21902	21905													
419	YT4	21902	21906													
420	YTEMP$	21104	21110													
421	YY	21056	21058	21060	21074											
422	Z$	70	1740	2160												
423	Z0	10650	10665													
424	Z1	60	2150	3100	3110	3560	3804	18327	18328							
425	Z2	60	2150	18327												
426	ZCOR	10660	10665													
427	ZZ	1660														

LIST OF COMMANDS, FUNCTIONS AND RESERVED WORDS

N A M E	# OF REFS
ABS	60
AND	44
AS	3
CALL	1
CHAIN	1
CHR$	4
CLOSE	4
CLS	9
COLOR	6
COMMON	11
DATE$	2
DEFINT	1
DIM	7
DRAW	6
ELSE	45
END	1
EXP	1
FOR	75
GOSUB	49
GOTO	102
IF	213
INKEY$	2
INPUT	6
INT	31
KEY	1
LEN	2
LINE	8
LOCATE	33
MID$	4
NEXT	73
OFF	1
ON	2
OPEN	3
OR	14
PRESET	1
PRINT	313
PSET	8
READ	1
RETURN	33
SCREEN	3
SIN	2
SQR	11
STEP	1
STR$	1
THEN	213
TO	73
USING	75
WEND	2
WHILE	2
WIDTH	2

APPENDIX D

SAMPLE OUTPUT


DEFAULT FILE FOR A GAS FURNACE
DATE: 06-26-1987
FURN. STACK GAS TEMP.
DILUTION MIXING TEMP.
MEAN FLUE GAS TEMP.
FLUE EXIT GAS TEMP.
TEMPERATURE C
300
250
200
150
100
50
0
0
10
20
30
40
50
60
TIME (SECS)
TEMPERATURE vs. TIME

MODEL OF THE TRANSIENT PERFORMANCE OF FURNACE & FLUE IN NON-DESIGN FLOW CONDITIONS

PROGRAM DEVELOPED BY: SCANADA CONSULTANTS LIMITED
FOR: CANADA MORTGAGE AND HOUSING CORPORATION
DATE: 1984 - 1987

C A S E: GAS FURNACE - DEFAULT VALUE IS DEFAULT FILE FOR A GAS FURNACE WITH AN EXTERIOR B-VENT DATE: 06-29-1987

TIME (s)	TIME(IN # FURN. T-C)	FURNACE FLOW(L/s)	DILUTION FLOW(L/s)	HOT WATER BRANCH(L/s)	CHIMNEY FLOW(L/s)	INC. ENVEL FLOW(L/s)	ENVELOPE PRES DROP	FURNACE HT-EX TEMP	FURNACE EXIT TEMP	MIXING TEMP(C)	DHW BRANCH TEMP (C)	MEAN FLUE GAS TEMP	GAS EXIT TEMP (C)	MEAN FLUE LINER TEMP	INSTANT. EFFICIENCY	FLUE FILM LOSS COEFF	FLUE FRICTION	CONDENSATION AT ELEMENT
0.0	0.000	8.0	14.2	0.0	22.3	20.4	-0.4	32.0	32.0	26.0	20.0	25.0	25.0	24.0	100.0	9.0	3.9	----
0.0	0.000	8.0	14.2	0.0	22.3	20.4	-0.4	32.0	32.0	26.0	20.0	25.0	25.0	24.0	100.0	9.0	3.9	----
0.5	0.010	8.5	11.1	0.0	19.6	17.9	-0.4	32.0	32.0	24.2	20.0	24.8	25.0	24.0	100.0	13.3	3.5	----
0.9	0.020	8.4	11.2	0.0	19.5	17.9	-0.4	31.9	32.0	25.1	20.0	24.6	25.0	23.9	100.0	14.3	3.5	----
1.4	0.030	8.4	11.1	0.0	19.4	17.8	-0.4	31.9	32.0	25.0	20.0	24.5	25.0	23.9	100.0	14.3	3.5	----
1.8	0.039	8.4	11.0	0.0	19.4	17.8	-0.4	31.9	32.0	25.1	20.0	24.4	24.9	23.8	100.0	14.2	3.5	----
2.3	0.049	8.3	11.0	0.0	19.3	17.7	-0.4	31.9	32.0	25.1	20.0	24.3	24.9	23.8	100.0	14.2	3.5	----
2.7	0.058	8.3	11.0	0.0	19.3	17.7	-0.4	31.9	32.0	25.1	20.0	24.2	24.9	23.8	100.0	14.2	3.5	----
3.2	0.068	8.3	10.9	0.0	19.2	17.7	-0.4	31.8	32.0	25.1	20.0	24.1	24.8	23.7	100.0	14.2	3.5	----
3.6	0.078	8.3	10.9	0.0	19.2	17.6	-0.4	31.8	32.0	25.1	20.0	24.1	24.8	23.7	100.0	14.1	3.5	----
4.1	0.087	8.3	10.9	0.0	19.2	17.6	-0.4	31.8	32.0	25.1	20.0	24.0	24.5	23.6	100.0	14.1	3.5	----
4.5	0.097	8.3	10.9	0.0	19.2	17.6	-0.4	31.8	32.0	25.1	20.0	24.0	24.0	23.6	100.0	14.1	3.5	----

******* FURNACE WILL BE TURNED ON AT 10.32 SECONDS *******

S Y S T E M   P A R A M E T E R S

ENVELOPE ADVERSE PRESS.(FANS & FIREPLACE)	(Pa):	0.0
WIND INDUCED DRIVING PRESSURE	(Pa):	2.9
NET BOUNDARY DRIVING PRESSURE	(Pa):	2.9
CHIMNEY/HOUSE BUOYANCY PRESSURE AT STANDBY	(Pa):	4.3
NET DRIVING PRESSURE PARAMETER (AT STANDBY)	(Pa):	7.2
FURNACE EQUIVALENT LEAKAGE AREA OF FLOW	(m2):	0.010
CHIMNEY EQUIVALENT LEAKAGE AREA OF FLOW	(m2):	0.009
E.L.A. OF REVERSE FLOW OF DILUTION PORT	(m2):	0.033
ENVELOPE EQUIVALENT LEAKAGE AREA AT 10 PA	(m2):	0.080
DILUTION PORT/CHIMNEY E.L.A. RATIO	(--):	3.7
FURNACE HEAT FLOW DENSITY PARAMETER	(kW/m2):	2930.0
FURNACE HEAT TRANSFER TIME CONSTANT	(s):	47.0
CHIMNEY LINER HEAT TRANSFER TIME CONSTANT	(s):	57.9

FLUE LOCATION: EXTERIOR
CHIMNEY FLOW DIRECTION AT STANDBY: UPWARD (1.84 m/s)

C A S E: GAS FURNACE - DEFAULT VALUE IS DEFAULT FILE FOR A GAS FURNACE WITH AN EXTERIOR B-VENT DATE: 06-29-1987

TIME (s)	TIME(IN # FURN. T-C)	FURNACE FLOW(L/s)	DILUTION FLOW(L/s)	HOT WATER BRANCH(L/s)	CHIMNEY FLOW(L/s)	INC. ENVEL FLOW(L/s)	ENVELOPE PRES DROP	FURNACE HT-EX TEMP	FURNACE EXIT TEMP	MIXING TEMP(C)	DHW BRANCH TEMP (C)	MEAN FLUE GAS TEMP	GAS EXIT TEMP (C)	MEAN FLUE LINER TEMP	INSTANT. EFFICIENCY	FLUE FILM LOSS COEFF	FLUE FRICTION	CONDENSATION AT ELEMENT
10.3	0.222	8.4	10.8	0.0	19.1	16.8	-0.3	31.6	32.0	25.1	20.0	23.8	23.9	23.1	2.9	14.1	3.5	----
10.8	0.231	22.1	-2.2	0.0	19.3	17.0	-0.3	31.5	32.0	25.1	20.0	23.7	23.8	23.0	2.9	14.1	3.5	1 AND UP
11.2	0.241	20.7	-0.4	0.0	19.6	17.2	-0.4	31.7	33.7	33.7	20.0	24.4	23.8	23.0	2.9	14.2	3.5	1 AND UP
11.7	0.251	21.0	-0.9	0.0	19.2	16.9	-0.3	32.0	36.4	36.4	20.0	25.2	23.8	23.0	3.0	14.4	3.7	1 AND UP
12.1	0.260	21.2	-0.6	0.0	19.6	17.2	-0.3	32.4	39.9	39.9	20.0	26.2	23.7	22.9	3.1	14.1	3.7	1 AND UP
12.6	0.270	21.4	-0.7	0.0	19.4	17.0	-0.3	32.8	43.9	43.9	20.0	27.4	23.7	22.9	3.2	14.3	4.0	1 AND UP
13.0	0.279	21.7	-0.3	0.0	19.9	17.4	-0.4	33.4	48.0	48.0	20.0	28.7	23.6	22.9	3.3	14.2	4.0	1 AND UP
13.4	0.288	21.9	0.2	0.0	20.4	17.8	-0.4	33.9	52.2	52.2	20.0	30.1	23.6	22.9	3.5	14.5	3.9	1 AND UP
13.8	0.297	22.1	0.3	0.0	20.5	17.8	-0.4	34.5	56.3	56.3	20.0	31.7	23.6	22.9	3.6	14.7	4.1	1 AND UP
14.3	0.306	22.4	0.8	0.0	21.1	18.3	-0.4	35.1	60.2	59.6	20.0	33.2	23.5	22.9	3.7	14.7	4.1	1 AND UP
14.7	0.315	22.6	0.8	0.0	21.2	18.3	-0.4	35.6	63.9	62.3	20.0	34.8	23.5	22.9	3.9	15.0	4.3	1 AND UP
23.7	0.508	25.1	3.1	0.0	24.4	20.1	-0.4	48.4	108.0	96.3	20.0	53.8	35.0	25.0	7.0	16.1	5.3	1 AND UP
31.8	0.683	25.9	4.5	0.0	26.3	21.3	-0.5	59.4	122.7	103.6	20.0	59.5	39.2	28.0	9.8	16.9	5.1	2 AND UP
39.5	0.848	26.5	5.4	0.0	27.6	22.1	-0.5	69.4	133.1	108.4	20.0	63.8	42.4	31.1	12.3	17.4	5.0	4 AND UP
46.8	1.006	27.1	6.1	0.0	28.7	22.7	-0.5	78.6	142.2	112.6	20.0	67.6	45.5	34.1	14.5	17.8	4.9	5 AND UP
53.9	1.158	27.5	6.8	0.0	29.8	23.3	-0.5	87.1	150.5	116.3	20.0	71.1	48.5	37.0	16.6	18.1	4.8	6 AND UP
60.7	1.305	28.0	7.4	0.0	30.7	23.8	-0.6	95.0	158.3	119.6	20.0	74.4	51.4	39.9	18.6	18.4	4.8	7 AND UP
67.4	1.448	28.4	7.9	0.0	31.5	24.3	-0.6	102.5	165.6	122.7	20.0	77.5	54.2	42.7	20.5	18.7	4.7	7 AND UP
73.9	1.587	28.8	8.4	0.0	32.3	24.7	-0.6	109.5	172.5	125.6	20.0	80.5	56.9	45.4	22.2	18.9	4.7	8 AND UP
80.2	1.723	29.1	8.9	0.0	33.1	25.1	-0.6	116.1	179.0	128.3	20.0	83.3	59.5	48.0	23.9	19.2	4.6	9 AND UP
86.4	1.856	29.4	9.3	0.0	33.8	25.4	-0.6	121.8	185.1	130.7	20.0	85.9	62.0	50.6	43.5	19.4	4.6	10 AND UP
92.5	1.987	29.7	9.6	0.0	34.3	25.7	-0.6	125.9	189.8	132.5	20.0	88.2	64.4	53.0	45.3	19.5	4.6	10 AND UP
98.5	2.116	29.9	9.9	0.0	34.9	25.9	-0.6	129.8	193.8	133.9	20.0	90.3	66.6	55.4	47.0	19.7	4.6	----
104.4	2.242	30.1	10.1	0.0	35.4	26.2	-0.6	133.5	197.4	135.2	20.0	92.2	68.7	57.6	48.6	19.8	4.5	----
110.2	2.368	30.3	10.4	0.0	35.8	26.4	-0.6	137.0	200.9	136.4	20.0	94.0	70.6	59.8	50.0	19.9	4.5	----
116.0	2.492	30.5	10.6	0.0	36.3	26.5	-0.6	140.2	204.1	137.6	20.0	95.7	72.5	61.8	51.4	20.0	4.5	----
121.7	2.614	30.6	10.8	0.0	36.7	26.7	-0.6	143.3	207.1	138.6	20.0	97.4	74.3	63.8	52.7	20.1	4.5	----
127.3	2.736	30.8	11.0	0.0	37.0	26.9	-0.7	146.2	210.0	139.7	20.0	98.9	76.1	65.6	54.0	20.2	4.5	----
132.9	2.856	30.9	11.2	0.0	37.4	27.0	-0.7	149.0	212.7	140.6	20.0	100.4	77.7	67.4	55.2	20.3	4.5	----
138.5	2.975	31.1	11.3	0.0	37.7	27.2	-0.7	151.6	215.3	141.5	20.0	101.8	79.3	69.1	56.3	20.4	4.4	----
144.0	3.094	31.2	11.5	0.0	38.0	27.3	-0.7	154.0	217.7	142.4	20.0	103.1	80.8	70.8	57.3	20.5	4.4	----
149.5	3.211	31.3	11.6	0.0	38.3	27.4	-0.7	156.4	220.0	143.2	20.0	104.4	82.3	72.3	58.3	20.6	4.4	----
154.9	3.328	31.4	11.8	0.0	38.6	27.5	-0.7	158.6	222.2	143.9	20.0	105.6	83.7	73.8	59.3	20.6	4.4	----
160.3	3.444	31.6	11.9	0.0	38.9	27.6	-0.7	160.8	224.3	144.7	20.0	106.7	85.0	75.3	60.2	20.7	4.4	----
165.6	3.559	31.7	12.0	0.0	39.2	27.7	-0.7	162.8	226.3	145.3	20.0	107.8	86.3	76.7	61.1	20.7	4.4	----
171.0	3.674	31.8	12.1	0.0	39.4	27.8	-0.7	164.7	228.2	146.0	20.0	108.9	87.5	78.0	61.9	20.8	4.4	----
176.3	3.787	31.9	12.2	0.0	39.6	27.9	-0.7	166.5	230.0	146.6	20.0	109.9	88.7	79.3	62.7	20.8	4.4	----
181.5	3.901	31.9	12.3	0.0	39.8	28.0	-0.7	168.3	231.7	147.2	20.0	110.8	89.8	80.5	63.4	20.9	4.4	----
186.8	4.013	32.0	12.4	0.0	40.1	28.1	-0.7	169.9	233.3	147.8	20.0	111.8	90.9	81.7	64.1	20.9	4.4	----
192.0	4.126	32.1	12.5	0.0	40.3	28.1	-0.7	171.5	234.9	148.3	20.0	112.6	92.0	82.8	64.8	21.0	4.4	----
197.2	4.237	32.2	12.6	0.0	40.5	28.2	-0.7	173.0	236.4	148.8	20.0	113.5	93.0	83.9	65.5	21.0	4.4	----
202.4	4.349	32.3	12.7	0.0	40.6	28.3	-0.7	174.5	237.8	149.3	20.0	114.3	94.0	84.9	66.1	21.1	4.3	----
207.5	4.459	32.3	12.7	0.0	40.8	28.3	-0.7	175.8	239.1	149.8	20.0	115.1	94.9	85.9	66.7	21.1	4.3	----
212.7	4.570	32.4	12.8	0.0	41.0	28.4	-0.7	177.2	240.4	150.2	20.0	115.8	95.8	86.9	67.2	21.1	4.3	----
217.8	4.680	32.5	12.9	0.0	41.1	28.5	-0.7	178.4	241.7	150.7	20.0	116.5	96.7	87.8	67.8	21.2	4.3	----
222.9	4.789	32.5	12.9	0.0	41.3	28.5	-0.7	179.6	242.9	151.1	20.0	117.2	97.5	88.7	68.3	21.2	4.3	----
228.0	4.899	32.6	13.0	0.0	41.4	28.6	-0.7	180.8	244.0	151.4	20.0	117.9	98.3	89.6	68.8	21.2	4.3	----
233.1	5.008	32.6	13.1	0.0	41.6	28.6	-0.7	181.9	245.1	151.8	20.0	118.5	99.1	90.4	69.3	21.3	4.3	----
238.1	5.116	32.7	13.1	0.0	41.7	28.7	-0.7	182.9	246.1	152.2	20.0	119.1	99.8	91.2	69.7	21.3	4.3	----

***** THE FURNACE IS ABOUT TO BE TURNED OFF. THE STATE OF ALL FLOW SYSTEMS IS AS FOLLOWS:

TIME = 240.1 SECONDS

TEMPERATURES OF THE FLUE GAS, LINER, AND STRUCTURE

	FP 1	FP 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10
FLUE GAS TEMP (C)	143.0	134.2	129.6	125.1	120.7	116.4	112.2	108.1	104.0	100.1
INNER LINER (C)	95.3	88.9	104.7	100.7	96.8	93.0	89.3	85.7	82.2	78.8
INSUL OR STRUCT (C)	20.0	20.0	40.3	38.5	36.8	35.2	33.7	32.2	30.8	29.5
OUTER STRUCTURE(C)	20.0	20.0	5.1	5.1	5.1	5.1	5.0	5.0	5.0	5.0
SURROUNDING (DEG C)	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONDENSING TIME (%)	5.8	10.3	10.4	13.8	17.3	21.1	24.8	28.7	32.6	36.7

THE MASSFLOW SYSTEM PARAMETERS

<--------F L U E--------> <----E N V E L O P E----><--DRAFT HOOD INLET-> <--------F U R N A C E-------->

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
TEMPERATURE (DEG C)	0.0	100.1	114.3	143.0	152.3	152.3	0.0	0.0	20.0	20.0	20.0	152.3	20.0	20.0	20.0	1291.7	246.5	246.5	152.3
DENSITY (KG/M3)	1.29	0.95	0.91	0.85	0.83	0.83	1.29	1.29	1.21	1.21	1.21	0.83	1.21	1.21	1.21	0.23	0.68	0.68	0.83
MASS FLOW (KG/S)	0.038	0.038	0.038	0.038	0.038	0.038	0.037	0.037	0.037	0.016	0.016	0.016	0.021	0.021	0.021	0.022	0.022	0.022	0.022
VOLUME FLOW (M3/S)	0.029	0.040	0.042	0.045	0.046	0.046	0.029	0.029	0.031	0.013	0.013	0.019	0.018	0.018	0.018	0.099	0.033	0.033	0.027
FLOW VELOCITY (M/S)	0.00	3.88	4.02	4.32	4.42	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.44	0.10	0.03	2.97	0.00

PRESSURE PARAMETERS OF THE FLOW SYSTEMS

NET BUOYANCY	WIND EFFECT	ENVELOPE LOSS	FRICTION LOSS	NET DRIVING	FURN BUOYANCY	INLET DROP	OUTLET DROP	NET FURNACE	DILUTION PORT	DRAFT INDUCER	DHW INDUCED	DHW BUOYANCY
30.493	2.913	-0.712	-32.434	0.261	6.109	-0.351	-6.019	-0.261	-0.261	0.000	0.000	0.000

S U M M A R Y   T A B L E

OUTDOOR TEMPERATURE = 0 C
INDOOR TEMPERATURE = 20 C

STANDBY FIRING RATE = 220 W
FULL FIRING RATE = 29300 W
INSTANT. EFFICIENCY = 69.9 %

WIND SPEED & PRESSURE COEFFICIENTS:	SPEED (M/S)	PRESSURE COEFFICIENTS CHIM TOP	INSIDE HOUSE
HORIZONTAL COMPONENT	3.0	0.50	0.00
VERT. COMPONENT (+VE UP)	0.0	1.00	

FLOW RATES:	L/S	KG/S
FUEL FLOW	1.400	0.001
FURNACE OUTLET FLOW	32.7	0.022 (126 % EXCESS AIR)
DILUTION FLOW INTO HOOD	13.1	0.016
FLUE INLET FLOW	45.8	0.038 (294 % EXCESS AIR)
FAN FLOW	0.0	0.000
FIREPLACE FLOW	0.0	0.000
INCREMENTAL ENVELOPE FLOW	28.6	0.037 (AT OUTDOOR TEMPERATURE)

INDUCED PRESSURE DROP ACROSS THE ENVELOPE = -0.7 Pa

TEMPERATURES:

FURNACE FLAME TEMPERATURE = 1292. C
FURNACE EXIT TEMPERATURE = 246.5 C
FLUE GAS T. AFTER DILUTION = 152.3 C
MEAN FLUE GAS TEMPERATURE = 119.3 C
MEAN FLUE LINER TEMPERATURE= 91.5 C

THERMAL PROPERTIES OF FURNACE & CHIMNEY

HEAT CAPACITY OF FURNACE HEAT EXCHANGER = 17500. W.S/C
DESIGN HEAT TRANSFER RATE FROM GAS TO FURN HEAT-EXCH= 376. W/C
FURNACE HEAT TRANSFER TIME CONSTANT = 47. SECS
FURNACE HEAT TRANSPORT TIME CONSTANT (FINAL CONDIT) = 18.2 SECS

AT THE BASE OF THE CHIMNEY:	FLUE GAS	LINER	SLEEVE	STRUCTURE
HEAT TRANSFER COEFF. 'U' (W/(M2.C))	21.288	5.850	5.280	7.230
ELEMENTAL SURFACE AREA 'A' (M2)	0.339	0.374	0.428	0.863
ELEMENTAL MASS 'M' (KG)	0.009	0.307	1.004	16.353
HEAT CAPACITY OF MATERIALS 'CP' (W.S/KG.C)	1035.0	896.0	500.0	1080.0
HEAT TRANSFER TIME CONSTANTS-OUT (S)	1.2	125.9	222.4	2832.2
HEAT TRANSFER TIME CONSTANTS-IN (S)		38.2	229.5	7824.4

ENVELOPE CHARACTERISTICS:	WITHOUT AIR INTAKE	WITH AIR INTAKE (IF ANY)
FLOW COEFFICIENT (M3/(S.PA^N) =	0.0305	0.0366
FLOW EXPONENT (--) =	0.720	0.720
LOCATION OF VCL BELOW CHIM TOP=	2.80	3.64(m)

HOT WATER HEATER SPECS. FOR A SHARED FLUE ARRANGEMENT

----- NONE -----

***** FURNACE WAS JUST TURNED OFF ******

C A S E: GAS FURNACE - DEFAULT VALUE IS DEFAULT FILE FOR A GAS FURNACE WITH AN EXTERIOR B-VENT DATE: 06-29-1987

TIME (s)	TIME(IN # FURN. T-C)	FURNACE FLOW(L/s)	DILUTION FLOW(L/s)	HOT WATER BRANCH(L/s)	CHIMNEY FLOW(L/s)	INC. ENVEL FLOW(L/s)	ENVELOPE PRES DROP	FURNACE HT-EX TEMP	FURNACE EXIT TEMP	MIXING TEMP(C)	DHW BRANCH TEMP (C)	MEAN FLUE GAS TEMP	GAS EXIT TEMP (C)	MEAN FLUE LINER TEMP	INSTANT. EFFICIENCY	FLUE FILM LOSS COEFF	FLUE FRICTION	CONDENSATIO AT ELEMENT
240.3	5.164	20.1	20.1	0.0	41.5	29.3	-0.7	183.4	246.5	152.3	20.0	119.4	100.1	91.6	100.0	21.3	4.3	----
240.5	5.168	21.3	19.5	0.0	41.6	29.3	-0.7	183.4	246.0	101.7	20.0	115.0	100.2	91.6	100.0	21.2	4.3	----
240.7	5.173	21.1	19.5	0.0	41.6	29.3	-0.7	183.3	245.1	105.9	20.0	111.7	100.2	91.6	100.0	21.2	4.2	----
240.9	5.177	21.1	19.6	0.0	41.2	29.4	-0.7	183.2	243.9	105.0	20.0	108.8	100.2	91.6	100.0	21.2	4.1	----
241.1	5.181	21.0	19.4	0.0	40.7	29.2	-0.7	183.1	242.4	104.4	20.0	106.3	100.2	91.6	100.0	21.3	4.1	----
241.3	5.186	21.0	19.5	0.0	40.6	29.3	-0.7	182.9	240.8	104.1	20.0	104.3	100.3	91.6	100.0	21.2	4.1	----
241.5	5.190	20.9	19.7	0.0	40.6	29.5	-0.7	182.8	239.1	103.2	20.0	102.5	100.3	91.6	100.0	21.2	4.0	----
241.7	5.194	20.9	19.9	0.0	40.7	29.7	-0.7	182.6	237.3	102.2	20.0	100.9	100.3	91.6	100.0	21.3	3.9	----
242.0	5.199	20.9	20.1	0.0	40.8	29.9	-0.8	182.4	235.5	101.2	20.0	99.5	100.4	91.5	100.0	21.4	3.8	----
242.2	5.203	20.9	20.3	0.0	41.0	30.2	-0.8	182.2	233.7	100.1	20.0	98.2	100.4	91.5	100.0	21.6	3.7	----
247.2	5.311	19.5	20.6	0.0	40.6	30.5	-0.8	176.2	197.8	86.0	20.0	90.0	88.0	89.8	100.0	21.9	3.5	----
252.2	5.420	18.7	20.2	0.0	39.6	30.0	-0.8	170.3	180.3	80.0	20.0	85.8	85.1	87.7	100.0	21.6	3.5	----
257.3	5.528	18.1	19.9	0.0	38.9	29.7	-0.7	164.5	170.3	76.5	20.0	82.9	82.8	85.6	100.0	21.5	3.5	----
262.3	5.636	17.8	19.7	0.0	38.2	29.5	-0.7	159.0	163.1	74.0	20.0	80.5	80.8	83.6	100.0	21.3	3.5	----
267.4	5.745	17.4	19.5	0.0	37.7	29.2	-0.7	153.7	157.2	72.0	20.0	78.4	79.0	81.6	100.0	21.2	3.5	----
272.4	5.853	17.1	19.3	0.0	37.2	29.0	-0.7	148.7	151.8	70.1	20.0	76.4	77.2	79.6	100.0	21.0	3.5	----
277.4	5.961	16.9	19.1	0.0	36.7	28.8	-0.7	143.8	146.9	68.4	20.0	74.5	75.4	77.8	100.0	20.9	3.5	----
282.5	6.070	16.6	18.9	0.0	36.2	28.5	-0.7	139.1	142.2	66.7	20.0	72.8	73.8	76.0	100.0	20.8	3.5	----
287.5	6.178	16.3	18.7	0.0	35.7	28.3	-0.7	134.6	137.7	65.1	20.0	71.0	72.2	74.3	100.0	20.6	3.5	----
292.6	6.286	16.1	18.5	0.0	35.3	28.1	-0.7	130.2	133.3	63.6	20.0	69.4	70.6	72.6	100.0	20.5	3.5	----
297.6	6.395	15.8	18.4	0.0	34.8	27.9	-0.7	126.1	129.2	62.1	20.0	67.8	69.1	71.1	100.0	20.4	3.5	----
302.7	6.503	15.6	18.2	0.0	34.4	27.6	-0.7	123.2	125.3	60.7	20.0	66.3	67.6	69.5	100.0	20.2	3.5	----
307.7	6.611	15.4	18.0	0.0	34.0	27.4	-0.7	120.8	122.2	59.6	20.0	64.9	66.3	68.1	100.0	20.1	3.5	----
312.7	6.720	15.2	17.9	0.0	33.7	27.2	-0.7	118.4	119.5	58.7	20.0	63.7	65.0	66.7	100.0	20.0	3.5	----
317.8	6.828	15.1	17.7	0.0	33.3	27.1	-0.7	116.1	117.1	57.8	20.0	62.5	63.8	65.3	100.0	19.9	3.5	----
322.8	6.937	14.9	17.6	0.0	33.0	26.9	-0.7	113.9	114.8	57.0	20.0	61.4	62.6	64.0	100.0	19.8	3.5	----
327.9	7.045	14.8	17.5	0.0	32.7	26.7	-0.6	111.7	112.6	56.2	20.0	60.4	61.5	62.8	100.0	19.7	3.5	----
332.9	7.153	14.6	17.3	0.0	32.4	26.6	-0.6	109.6	110.5	55.5	20.0	59.4	60.4	61.6	100.0	19.6	3.5	----
338.0	7.262	14.5	17.2	0.0	32.1	26.4	-0.6	107.5	108.5	54.7	20.0	58.4	59.4	60.5	100.0	19.5	3.5	----
343.0	7.370	14.3	17.1	0.0	31.8	26.2	-0.6	105.5	106.5	54.0	20.0	57.5	58.4	59.5	100.0	19.4	3.5	----
348.0	7.478	14.2	17.0	0.0	31.5	26.1	-0.6	103.5	104.5	53.3	20.0	56.6	57.4	58.4	100.0	19.3	3.5	----
353.1	7.587	14.1	16.8	0.0	31.3	25.9	-0.6	101.6	102.6	52.6	20.0	55.7	56.5	57.4	100.0	19.2	3.5	----
358.1	7.695	14.0	16.7	0.0	31.0	25.8	-0.6	99.7	100.8	51.9	20.0	54.8	55.6	56.5	100.0	19.1	3.5	----
363.2	7.803	13.8	16.6	0.0	30.7	25.6	-0.6	97.9	98.9	51.3	20.0	54.0	54.8	55.6	100.0	19.1	3.5	----
368.2	7.912	13.7	16.5	0.0	30.5	25.5	-0.6	96.1	97.2	50.6	20.0	53.2	53.9	54.7	100.0	19.0	3.5	----
373.3	8.020	13.6	16.4	0.0	30.2	25.3	-0.6	94.4	95.5	50.0	20.0	52.5	53.1	53.8	100.0	18.9	3.5	----
378.3	8.128	13.5	16.3	0.0	30.0	25.2	-0.6	92.7	93.8	49.4	20.0	51.7	52.3	53.0	100.0	18.8	3.5	----
383.3	8.237	13.3	16.2	0.0	29.8	25.1	-0.6	91.0	92.1	48.7	20.0	51.0	51.6	52.2	100.0	18.7	3.5	----
388.4	8.345	13.2	16.1	0.0	29.5	24.9	-0.6	89.4	90.5	48.1	20.0	50.3	50.8	51.4	100.0	18.6	3.5	----
393.4	8.453	13.1	16.0	0.0	29.3	24.8	-0.6	87.8	89.0	47.6	20.0	49.6	50.1	50.7	100.0	18.5	3.5	----
398.5	8.562	13.0	15.9	0.0	29.1	24.6	-0.6	86.3	87.4	47.0	20.0	48.9	49.4	49.9	100.0	18.5	3.5	----
400.1	8.596	13.0	15.8	0.0	29.0	24.6	-0.6	85.8	87.0	46.8	20.0	48.7	49.2	49.7	100.0	18.4	3.5	----

PHYSICAL CHARACTERISTICS OF THE SYSTEM

	FLUE 1	2	3	4	5	6	ENVELOPE 7	8	9	10	DRAFT HOOD INLET 11	12	FURNACE 13	14	15	16	17	18	19
DISTANCE->DATUM (M)	0.00	0.00	0.00	8.92	8.92	9.18	0.00	3.64	3.64	9.18	9.18	9.18	9.18	9.90	9.90	9.90	8.97	8.97	9.18
AREA OF OPENING (M2)	0.000	0.013	0.013	0.013	0.013	0.000	0.000	0.000	0.000	0.000	0.040	0.000	0.000	0.000	0.040	1.000	1.000	0.011	0.000
K FACTOR NORMAL	0.0	1.0	0.8	1.2	0.5	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	3.0	0.0	0.0	2.0	0.0

TIME = 400.1 SECONDS

TEMPERATURES OF THE FLUE GAS, LINER, AND STRUCTURE

	FP 1	FP 2	F 3	F 4	F 5	F 6	F 7	F 8	F 9	F 10
FLUE GAS TEMP (C)	47.5	48.1	48.3	48.6	48.8	49.0	49.1	49.2	49.2	49.2
INNER LINER (C)	50.9	50.7	49.5	49.6	49.6	49.6	49.5	49.4	49.2	48.9
INSUL OR STRUCT (C)	20.0	20.0	35.5	34.9	34.4	33.8	33.2	32.6	32.0	31.4
OUTER STRUCTURE(C)	20.0	20.0	5.5	5.5	5.5	5.4	5.4	5.3	5.3	5.2
SURROUNDING (DEG C)	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONDENSING TIME (%)	5.8	10.3	10.4	13.8	17.3	21.1	24.8	28.7	32.6	36.7

THE MASSFLOW SYSTEM PARAMETERS

	FLUE 1	2	3	4	5	6	ENVELOPE 7	8	9	10	DRAFT HOOD INLET 11	12	FURNACE 13	14	15	16	17	18	19
TEMPERATURE (DEG C)	0.0	49.2	48.9	47.5	46.8	46.8	0.0	0.0	20.0	20.0	20.0	46.8	20.0	20.0	20.0	36.7	87.0	87.0	46.8
DENSITY (KG/M3)	1.29	1.10	1.10	1.10	1.11	1.11	1.29	1.29	1.21	1.21	1.21	1.11	1.21	1.21	1.21	1.14	0.98	0.98	1.11
MASS FLOW (KG/S)	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.019	0.019	0.019	0.013	0.013	0.013	0.013	0.013	0.013	0.013
VOLUME FLOW (M3/S)	0.025	0.029	0.029	0.029	0.029	0.029	0.025	0.025	0.026	0.016	0.016	0.017	0.011	0.011	0.011	0.011	0.013	0.013	0.012
FLOW VELOCITY (M/S)	0.00	2.80	2.79	2.78	2.78	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.26	0.01	0.01	1.18	0.00

PRESSURE PARAMETERS OF THE FLOW SYSTEMS

NET BUOYANCY	WIND EFFECT	ENVELOPE LOSS	FRICTION LOSS	NET DRIVING	FURN BUOYANCY	INLET DROP	OUTLET DROP	NET FURNACE	DILUTION PORT	DRAFT INDUCER	DHW INDUCED	DHW BUOYANCY
12.814	2.913	-0.575	-14.774	0.378	1.115	-0.126	-1.367	-0.378	-0.378	0.000	0.000	0.000

SUMMARY TABLE

OUTDOOR TEMPERATURE	=	0 C
INDOOR TEMPERATURE	=	20 C
STANDBY FIRING RATE	=	220 W
FULL FIRING RATE	=	29300 W
INSTANT. EFFICIENCY	=	100.0 %

WIND SPEED & PRESSURE COEFFICIENTS:	SPEED (M/S)	PRESSURE COEFFICIENTS CHIM TOP	INSIDE HOUSE
HORIZONTAL COMPONENT	3.0	0.50	0.00
VERT. COMPONENT (+VE UP)	0.0	1.00	

FLOW RATES:	L/S	KG/S	
FUEL FLOW	0.000	0.000	
FURNACE OUTLET FLOW	12.9	0.013	(0 % EXCESS AIR)
DILUTION FLOW INTO HOOD	15.8	0.019	
FLUE INLET FLOW	28.8	0.032	(0 % EXCESS AIR)
FAN FLOW	0.0	0.000	
FIREPLACE FLOW	0.0	0.000	
INCREMENTAL ENVELOPE FLOW	24.5	0.032	(AT OUTDOOR TEMPERATURE)

INDUCED PRESSURE DROP ACROSS THE ENVELOPE = -0.6 Pa

TEMPERATURES:

FURNACE FLAME TEMPERATURE	=	37. C
FURNACE EXIT TEMPERATURE	=	87.0 C
FLUE GAS T. AFTER DILUTION	=	46.8 C
MEAN FLUE GAS TEMPERATURE	=	48.7 C
MEAN FLUE LINER TEMPERATURE	=	49.7 C

THERMAL PROPERTIES OF FURNACE & CHIMNEY

HEAT CAPACITY OF FURNACE HEAT EXCHANGER	= 17500.	W.S/C
DESIGN HEAT TRANSFER RATE FROM GAS TO FURN HEAT-EXCH	= 376.	W/C
FURNACE HEAT TRANSFER TIME CONSTANT	= 47.	SECS
FURNACE HEAT TRANSPORT TIME CONSTANT (FINAL CONDIT)	= 46.1	SECS

AT THE BASE OF THE CHIMNEY:	FLUE GAS	LINER	SLEEVE	STRUCTURE
HEAT TRANSFER COEFF. 'U' (W/(M2.C))	18.437	5.850	5.280	7.230
ELEMENTAL SURFACE AREA 'A' (M2)	0.339	0.374	0.428	0.863
ELEMENTAL MASS 'M' (KG)	0.011	0.307	1.004	16.353
HEAT CAPACITY OF MATERIALS 'CP' (W.S/KG.C)	1035.0	896.0	500.0	1080.0
HEAT TRANSFER TIME CONSTANTS-OUT (S)	1.8	125.9	222.4	2832.2
HEAT TRANSFER TIME CONSTANTS-IN (S)		44.1	229.5	7824.4

```
ENVELOPE CHARACTERISTICS:         WITHOUT     WITH
-------------------------         AIR INTAKE  AIR INTAKE (IF ANY)
                                  ----------  ----------
FLOW COEFFICIENT (M3/(S.PA^N) = 0.0305      0.0366
FLOW EXPONENT    (--)         = 0.720       0.720
LOCATION OF VCL BELOW CHIM TOP= 2.80        3.64(m)


HOT WATER HEATER SPECS. FOR A SHARED FLUE ARRANGEMENT
-----------------------------------------------------

-----  NONE  -----
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MODEL OF THE TRANSIENT PERFORMANCE OF FURNACE & FLUE IN NON-DESIGN FLOW CONDITIONS

PROGRAM DEVELOPED BY: SCANADA CONSULTANTS LIMITED
FOR: CANADA MORTGAGE AND HOUSING CORPORATION
DATE: 1984 - 1987

C A S E: GAS FURNACE - DEFAULT VALUE IS DEFAULT FILE FOR A GAS FURNACE WITH AN EXTERIOR B-VENT   DATE: 06-29-1987

TIME	NET BUOYANCY	WIND EFFECT	ENVELOPE LOSS	FRICTION LOSS	NET DRIVING	FURN BUOYANCY	INLET DROP	OUTLET DROP	NET FURNACE	DILUTION PORT	DRAFT INDUCER	DHW INDUCED	DHW BUOYANCY
0.0	4.977	2.913	-0.445	-7.141	0.304	0.384	-0.068	-0.620	-0.304	-0.304	0.000	0.000	0.000
0.5	4.896	2.913	-0.371	-7.253	0.186	0.578	-0.075	-0.689	-0.186	-0.186	0.000	0.000	0.000
0.9	4.856	2.913	-0.369	-7.212	0.188	0.553	-0.073	-0.668	-0.188	-0.188	0.000	0.000	0.000

******* FURNACE WILL BE TURNED ON AT 1.37 SECONDS *******

S Y S T E M   P A R A M E T E R S

ENVELOPE ADVERSE PRESS.(FANS & FIREPLACE) (Pa): 0.0
WIND INDUCED DRIVING PRESSURE (Pa): 2.9
NET BOUNDARY DRIVING PRESSURE (Pa): 2.9
CHIMNEY/HOUSE BUOYANCY PRESSURE AT STANDBY (Pa): 4.5
NET DRIVING PRESSURE PARAMETER (AT STANDBY)(Pa): 7.4

FURNACE EQUIVALENT LEAKAGE AREA OF FLOW (m2): 0.010
CHIMNEY EQUIVALENT LEAKAGE AREA OF FLOW (m2): 0.009
E.L.A. OF REVERSE FLOW OF DILUTION PORT (m2): 0.033
ENVELOPE EQUIVALENT LEAKAGE AREA AT 10 PA (m2): 0.080
DILUTION PORT/CHIMNEY E.L.A. RATIO (--): 3.7
FURNACE HEAT FLOW DENSITY PARAMETER (kW/m2): 2930.0
FURNACE HEAT TRANSFER TIME CONSTANT (s): 47.0
CHIMNEY LINER HEAT TRANSFER TIME CONSTANT (s): 57.0

FLUE LOCATION: EXTERIOR
CHIMNEY FLOW DIRECTION AT STANDBY: UPWARD (1.88 m/s)

APPENDIX E

DEFINITION OF OUTPUT HEADINGS

DETAILED SUMMARY

Time (s)

- the simulation time expressed in seconds

Time expressed in furnace time constants (non-dimensional)

- the time divided by the time constant of the furnace. The time constant of the furnace is the mass of the heat exchanger divided by the overall heat transfer coefficient of that heat exchanger.

Furnace flow (L/s)

- the volumetric flow rate of air and combustion gases through the furnace

Dilution flow (L/s)

- the volumetric flow of air through the dilution device. Under normal operating conditions it is positive, but under spillage conditions the dilution flow is negative.

Chimney flow (L/s)

- the volumetric flow of combustion gases and dilution air up the chimney. When that quantity is positive, the flue gases are flowing upwards. When it is negative, backdrafting is indicated.

Incremental envelope flow (L/s)

- the total volumetric flow of air leakage through the envelope

Envelope pressure drop (Pa)

- the resulting house depressurization due to the incremental envelope flow

Furnace heat exchange temperature (°C)

- the mean temperature of the heat exchanger material within the furnace

Furnace exit temperature (°C)

- the temperature of the exhausting combustion gas (i.e. stack gas temperature)

Mixing temperature (°C)

- the temperature of the flue gas after mixing with the dilution air from the dilution port. When there is spillage occurring and positive flue flow, the mixing temperature is the same as the furnace exit temperature. When there is no spillage, then the mixing temperature is generally lower than the furnace exit temperature.

Mean flue gas temperature (°C)

- the temperature of the flue gas that would result in the same total gas column weight as the sum of the actual column weights of all the vertical elements of flue gas (i.e. the mean flue gas temperature corresponds to the true mean density of the flue gas)

Gas exit temperatures (°C)

- the temperature of the flue gas in the last element at the top of the flue

Mean flue liner temperature (°C)

- the arithmetic mean of the liner temperatures all the way up the flue (including flue pipe or vent connector elements)

Instantaneous efficiency (%)

- the quantity of heat transferred from the furnace heat exchanger to the house circulation air divided by the heat generated by the burner. When the furnace is off, this quantity is automatically set to 100%.

Flue film heat loss coefficient ($W/m^2 °C$)

- the heat loss coefficient through the boundary layer separating the main stream of the flue gas and the liner surface of the flue. It is the average of all the heat transfer coefficients from the base of the chimney to the top.

Flue pipe and flue friction factor (non-dimensional)

- the sum of all friction factors including entrance losses, elbows, length friction losses and exit losses at the chimney top

Condensation indicator

- indicates the lowest element of the flue that has it boundary layer temperature below the dew point of the flue gas

SYSTEM PARAMETERS AT FURNACE TURN-ON

Envelope adverse pressure (fans and fireplace) (Pa)

- the total induced pressure drop across the envelope of the house due to exhaust fan and fireplace operation

Wind induced driving pressure (Pa)

- the net driving pressure resulting from all wind effects including vertical and horizontal wind components acting at the chimney top and the horizontal wind component acting on the envelope of the house

Net boundary driving pressure (Pa)

- the summation of the envelope adverse pressure and the wind induced driving pressure

Chimney house buoyancy pressure at standby (Pa)

- the net buoyancy in the chimney minus the net buoyancy of the house air at standby. (The net buoyancy of the house air is the buoyancy of the column of house air measured from the dilution device to the envelope's vertical centre of leakag- e.)

Driving pressure of the draft inducer (Pa)

- the net increase in pressure across the operating draft inducer within the venting device

Net driving pressure parameter (Pa)

- the summation of all driving and resisting pressures in the flue/house/outdoor chimney loop

Furnace equivalent leakage area of flow (m^2)

- the effective sharp-edged orifice area of the flow paths in the furnace including the entrance and exit openings of the furnace.

Chimney equivalent leakage area of flow (m^2)

- the effective sharp-edged orifice area of the flow paths in the chimney and flue pipe, including all elbows, entrance and exit losses

ELA of reverse flow of the dilution port (m)

- the effective sharp-edged orifice area of the dilution port when the flow is reversing through it. This is used in the calculation of spillage flow rates when the flow is spilling or backdrafting.

Envelope equivalent leakage area at 10 Pa

- the ELA of the house as determined by a CGSB standard test in accordance with CAN/CGSB - 149.10-M, "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method".

Dilution port chimney ELA ratio (non-dimensional)

- the ratio of the ELA of the dilution port to that of the chimney

Furnace heat flow density parameter (kW/m^2)

- the heating capacity of the burner divided by the ELA of the furnace

Furnace heat transfer time constant (s)

- the mass of the heat exchanger divided by the overall heat transfer coefficient across the heat exchanger

Chimney liner heat transfer time constant (s)

- the mass of the chimney liner divided by the coefficient of heat transfer into that chimney liner from the flue gas

PRESSURE PARAMETERS OF THE FLOW SYSTEMS

Net buoyancy (Pa)

- the net buoyancy of the chimney minus the net buoyancy of the air inside the house envelope. (The net buoyancy of the house air is the buoyancy of the column of house air measured from the dilution device to the envelope's vertical centre of leakage.)

Wind effect (Pa)

- the summation of all driving and retarding wind effects in the system

Envelope loss (Pa)

- the friction loss of the air being drawn through the envelope. This is the house depressurization at the vertical centre of leakage.

Friction loss (Pa)

- the friction loss in the flue pipe and chimney. It is the pressure drop at all the elements going up the chimney including entrance, elbow, length and exit losses.

Net driving pressure (Pa)

- the net increase in pressure across the operating draft inducer within the venting device

Furnace buoyancy (Pa)

- the total buoyancy of the column of gas in the furnace

Inlet drop (Pa)

- the friction pressure drop at the inlet opening of the furnace

Outlet drop (Pa)

- the friction pressure drop at the exhaust port of the furnace. This is the controlling opening on furnace flow in the furnace. Most of the furnace loss is in the outlet drop.

Net furnace pressure (Pa)

- the summation of furnace buoyancy rise minus the inlet and outlet drops. This number should be negative for proper operation of the system. If the resulting net furnace pressure is positive then this means that the furnace is a better chimney than the chimney itself and this will result in spilled gases.

Pressure across the dilution port (Pa)

- same as the net driving pressure in the furnace and also of opposing sign to the net driving pressure of the chimney. These differing signs are simply due to sign conventions used in the model, but these three numbers are the same magnitude. The pressure across the dilution port determines, along with the ELA of the dilution port, the flow rate through the dilution port.

Draft inducer (Pa)

- the net increase in pressure across the operating draft inducer within the venting device

PHYSICAL CHARACTERISTICS OF THE SYSTEM

Note: The physical characteristics of the systems are specified for 19 points in the flue, envelope, draft hood and furnace flow systems. These 19 points are shown in Figures 1 and 2 of the accompanying diagrams.

Distance (datum) (m)

- distance between each calculation point and the top of the flue or chimney

Area of opening (m^2)

- the actual area of the various openings in the flow system

K factor (normal)

- friction factor for normal flow in each element of the mass flow system. Elements 3 and 4 in the mass flow network are the flue and flue pipe. The friction factors shown for points 3 and 4 are the values calculated on the final time step of the run.

TEMPERATURES OF THE FLUE GAS, LINER AND STRUCTURE

(Note: There are 10 or more elements up the flue pipe and flue depending on the number of flue pipe segments chosen. The flue pipe segments are indicated by "FP" and the flue segments are indicated by "F" in the table.)

Flue gas temperature (°C)

- the temperature of the centre core of the flue gas in each element of the flue

Inner liner temperature (°C)

- the temperature of the inner-most mass element of the chimney assembly

Insulation or structure temperature (°C)

- the temperature of the next mass element in the chimney assembly

Outer structure temperature (°C)

- the temperature of the outer-most mass element in the chimney assembly

Surrounding temperature (°C)

- the temperature of the interior or exterior air surrounding the flue pipe or chimney elements

Condensing time (%)

- the total amount of time that a flue pipe or chimney elements' boundary layer temperature is below the dew point of the flue gas expressed as a percentage of the overall operating time of the furnace

MASS FLOW SYSTEMS PARAMETERS

(Note: The properties and mass flow results in the mass flow pressure parameter model are reported in this category for all 19 calculation points in the mass flow network - see Figure 1.)

Temperature (°C)

- the temperature of the air or the combustion gas for each calculation point

Density (kg/m^3)

- the density of the air or the combustion gas at each calculation point

Mass flow (kg/s)

- the mass flow rate through the openings at each calculation point

Volume flow (m^3/s)

- the volumetric flow rate that corresponds to the mass flow rate at each point. It is calculated by dividing the mass flow by the density

Flow velocity (m/s)

- the air or gas velocity at each point. It is calculated by dividing the volumetric flow by the effective cross sectional area of the opening. The quantity is reported to be zero in areas where the opening is a plenum; i.e. for outdoor elements or points within the house.

SUMMARY TABLE

Outdoor temperature (°C)

- the temperature of outdoors. A ventilated attic is assumed to be at the outdoor temperature.

Indoor temperature (°C)

- the mean temperature in the house including all upstairs rooms and the basement

Standby firing rate (W)

- the heat generating capacity of the pilot light for a gas furnace. For an oil furnace it is zero.

Full firing rate (W)

- the burner capacity at steady state operation

Instantaneous efficiency (%)

- the quantity of heat transferred from the furnace heat exchanger to the house circulation air divided by the heat generated by the burner. When the furnace is off, this quantity is automatically set to 100%.

Wind speed and pressure coefficients

- The wind speed horizontal and vertical components (m/s) as reported. Also reported are the wind pressure coefficients (non-dimensional) used with the respective wind speeds to determine the driving and/or reversing pressures due to wind.

Flow rates

- These are presented in volumetric (L/s) and mass flow (kg/s) quantities. They are:
  - The fuel flow, which is the simple flow rate of the gas or the oil, as the case may be.
  - The furnace outlet flow is the flow rate of combustion products and excess air at the exit of the furnace heat exchanger.
  - The excess air is the volumetric excess air calculated in accordance with methods published by CCRL. 100% excess air is stoichiometric air.
  - The dilution flow into the hood is the flow rate into the draft hood or barometric damper.
  - The flue inlet flow is the summation of the furnace outlet flow and the dilution flow.
  - The fan flow is the summation of all exhaust fan flow rates (specified by the user).
  - Fireplace flow is the net flow rate of the fireplace or wood stove at steady state operation. These are kept constant for a run of the program.
  - The incremental envelope flow is the increase in air flow through the envelope due to the flue flow, the exhaust fan flow and the fireplace flow. The outdoor temperature is used to normalize the numbers.
  - The induced pressure drop across the envelope is the pressure drop due to friction losses which result from the incremental envelope flow.

Temperatures (°C)

- The furnace flame temperature is the predicted temperature rise over the flame in the burner system. This is an approximate number that is derived from the mass flow rate of air and fuel through the system and the specified heat release rate of the burner. No chemical equations have been solved to derive this number.

- The furnace exit temperature is the temperature of the flue gas at the top of the furnace.
- The flue gas temperature after dilution is the temperature after mixing of the furnace stack gas and the dilution air.

- The mean flue gas temperature is the temperature of the flue gas that would result in the same total gas column weight as the sum of the actual column weights of all the vertical elements of flue gas (i.e. the mean flue gas temperature corresponds to the true mean density of the flue gas).

- The mean flue liner temperature is the arithmetic mean of the liner temperatures all the way up the flue (including flue pipe or vent connector elements)

- The heat capacity of the furnace heat exchanger (s/c) is the product of the mass of the heat exchanger times the specific heat of the material in the heat exchanger.

- The design heat transfer rate (W/C) is the heat transfer rate from the combusted fuel and excess air in the furnace to the heat exchanger surface.

- The furnace heat transfer time constant (s) is the heat capacity of the heat exchanger divided by the design heat transfer rate from the combusted fuel and excessive air to the furnace.

- The furnace heat transport time constant (s) - final condition - is the overall dilution time constant of the air flowing through the furnace.

THERMAL CHARACTERISTICS OF THE CHIMNEY

This data specifies the various properties of the structure of the flue and chimney. These are modelled as a series of cylindrical elements joined end-to-end. Each element is further subdivided, for the purpose of modelling outward heat flow, into a series of concentric cylindrical elements. The properties described below are related to each of these concentric cylindrical elements and the radial heat flow into each from the next inward element and out of each to the next outward element.

Elemental surface area (m^2)

- the surface area normal to the radial heat flow

Elemental mass (kg)

- the mass of each element

Heat capacity of the material (J/kg. C)

- the specific heat of the material of which each element is composed

Heat transfer time constant (OUT) (s)

- the mass of an element divided by the coefficient of heat transfer to the next outward element multiplied by the area through which heat transfer occurs (normally equal to the elemental surface area)

Heat transfer time constant (IN) (s)

- the mass of an element divided by the coefficient of heat transfer from the next inward element multiplied by the area through which heat transfer occurs (normally equal to the elemental surface area)

ENVELOPE CHARACTERISTICS

Three envelope characteristics are given:

Flow coefficient ($m^3/s\ Pa^n$) and **Flow exponent**

- These characteristics of the envelope are determined by a CGSB Airtightness Test. These numbers are shown for the envelope both without an air intake and with an air intake, if any.

Location of the vertical centre of leakage

- below the chimney top is also given with respect to the envelope without an air intake and with an air intake. The overall effect of the air intake in terms of increased ELA and lowering of the vertical centre of leakage can be observed in this tabular output. (See the Glossary of Terms for definition of vertical centre of leakage.)

HOT WATER HEATER SPECS

The final output is the hot water heater specifications for a shared flue arrangement.

Burner capacity

- taken to be zero if the hot water heater has been shut down for a long time. A small capacity - say 200 to 500 watts - can be specified for the effect of pilot light and heat loss from the hot water. The full firing rate can be specified for hot water heater operation.

Hot water heater efficiency (%)

- the steady-state efficiency of the water heater

Cross-sectional area of the domestic hot water flue pipe branch (m^2)

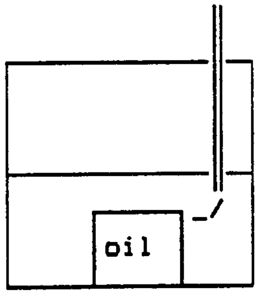
- the actual area of the vent connector or flue pipe of the hot water heater that is connected to the main branch.

APPENDIX F

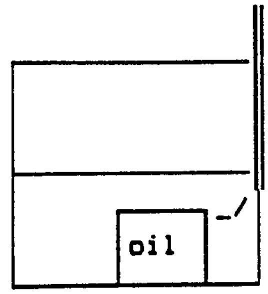
INPUT DATA FORMS

FUEL TYPE AND CHIMNEY LOCATION SELECTION

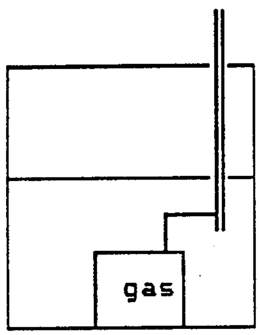
#1-Oil Furnace With
Interior Chimney



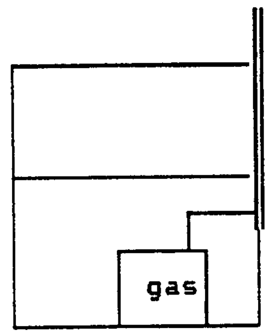
#2-Oil Furnace With
Exterior Chimney



#3-Gas Furnace With
Interior Chimney



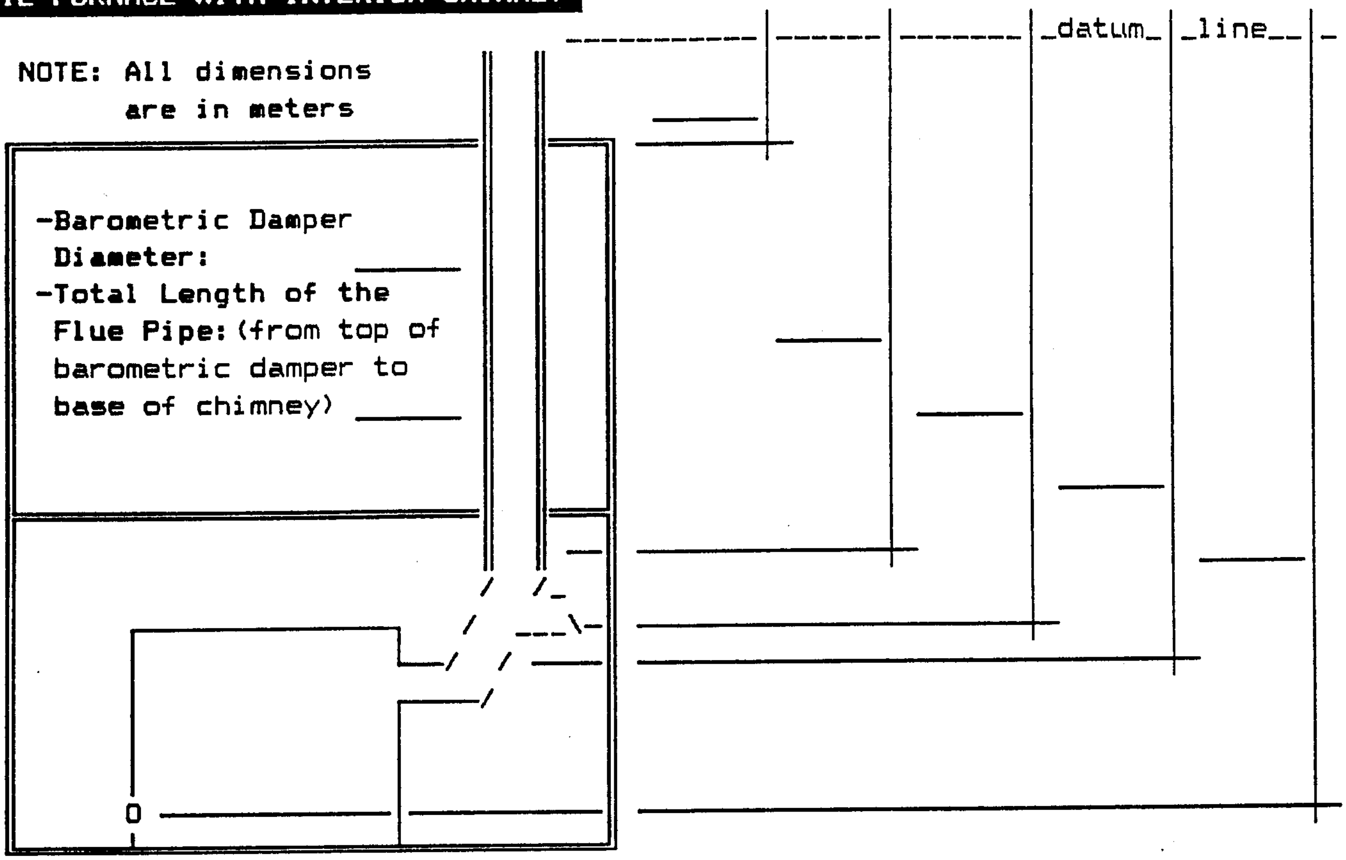
#4-Gas Furnace With
Exterior Chimney



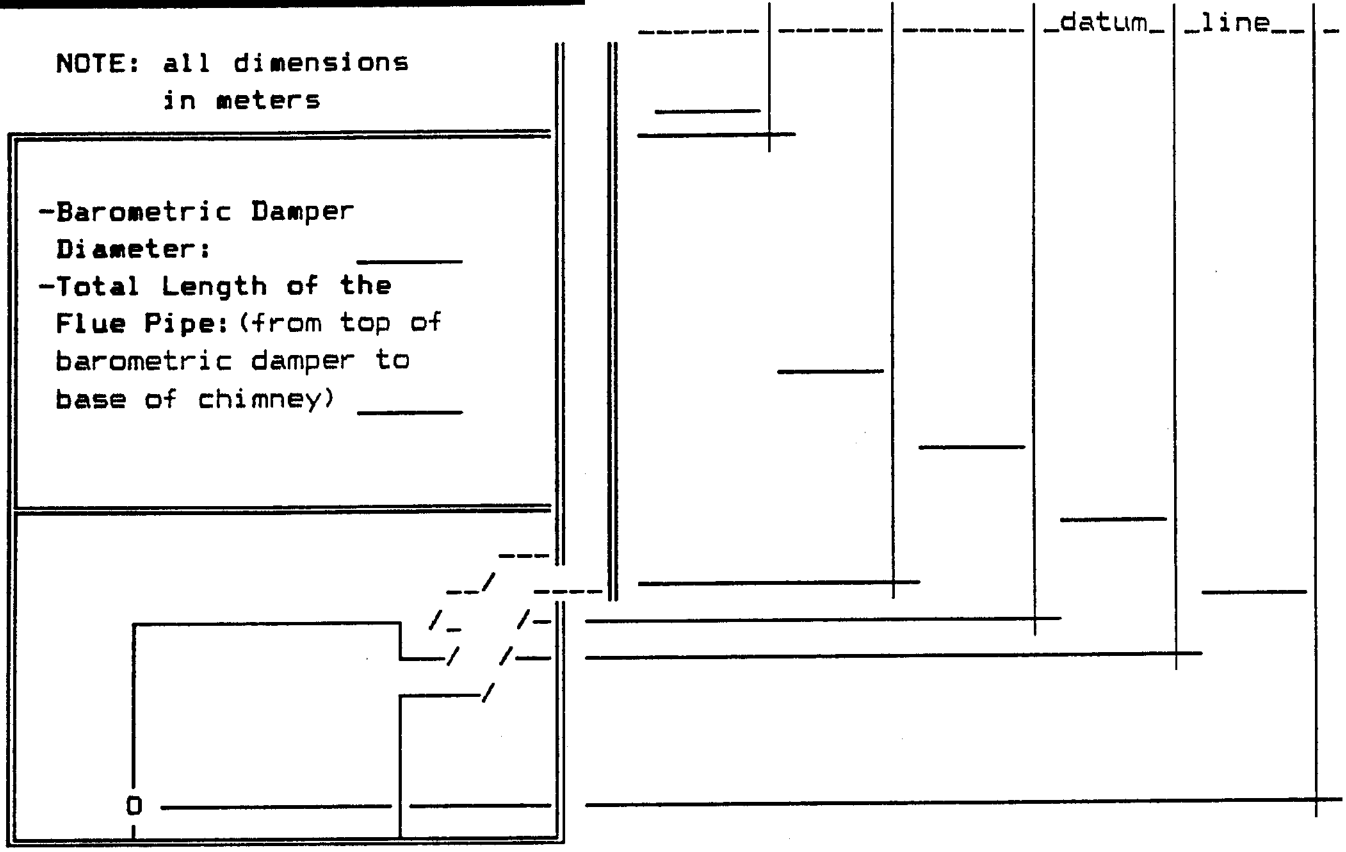
ENTER YOUR SELECTION #(1,2,3 or 4): _

OIL FURNACE WITH INTERIOR CHIMNEY

NOTE: All dimensions are in meters

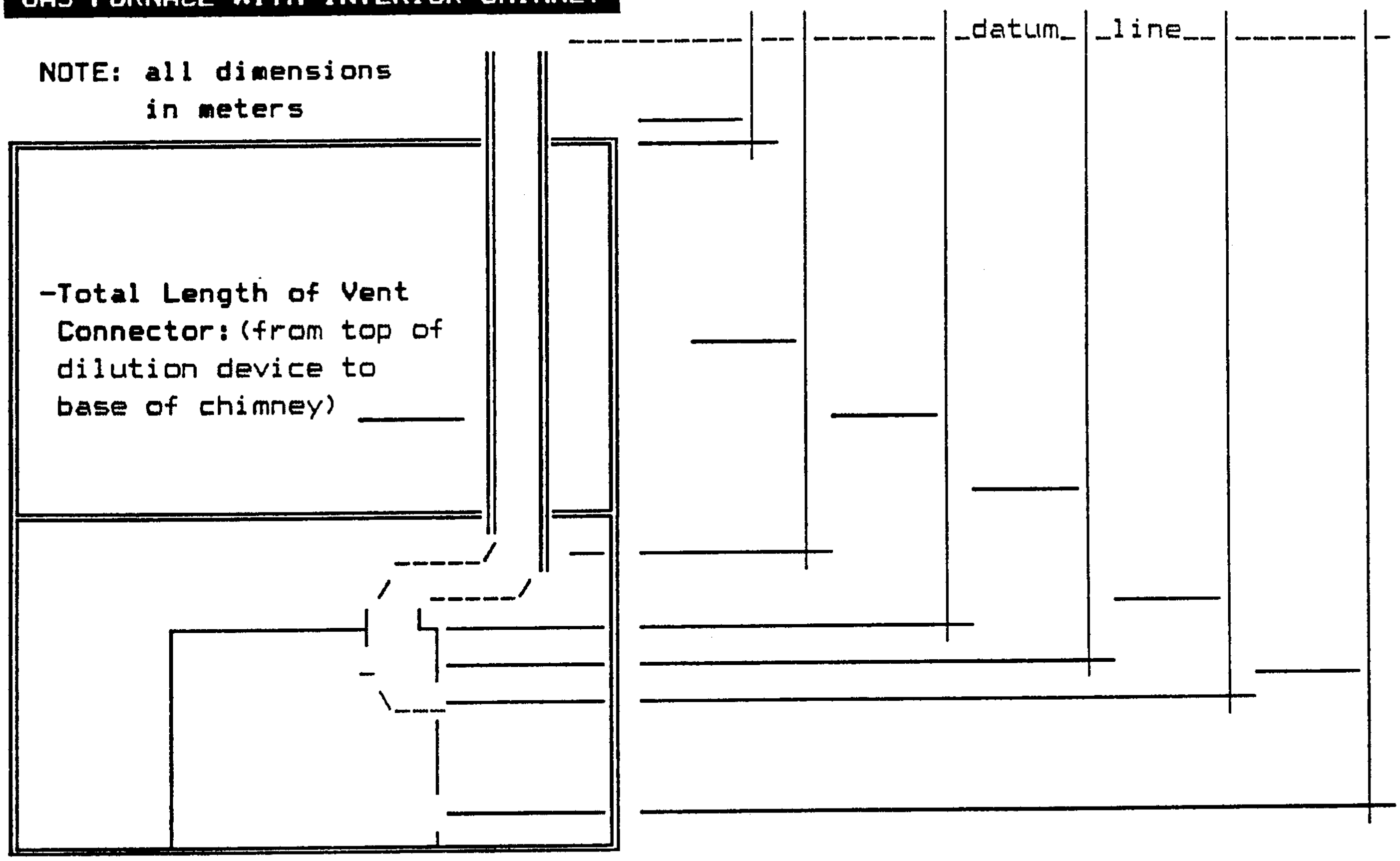


OIL FURNACE WITH EXTERIOR CHIMNEY

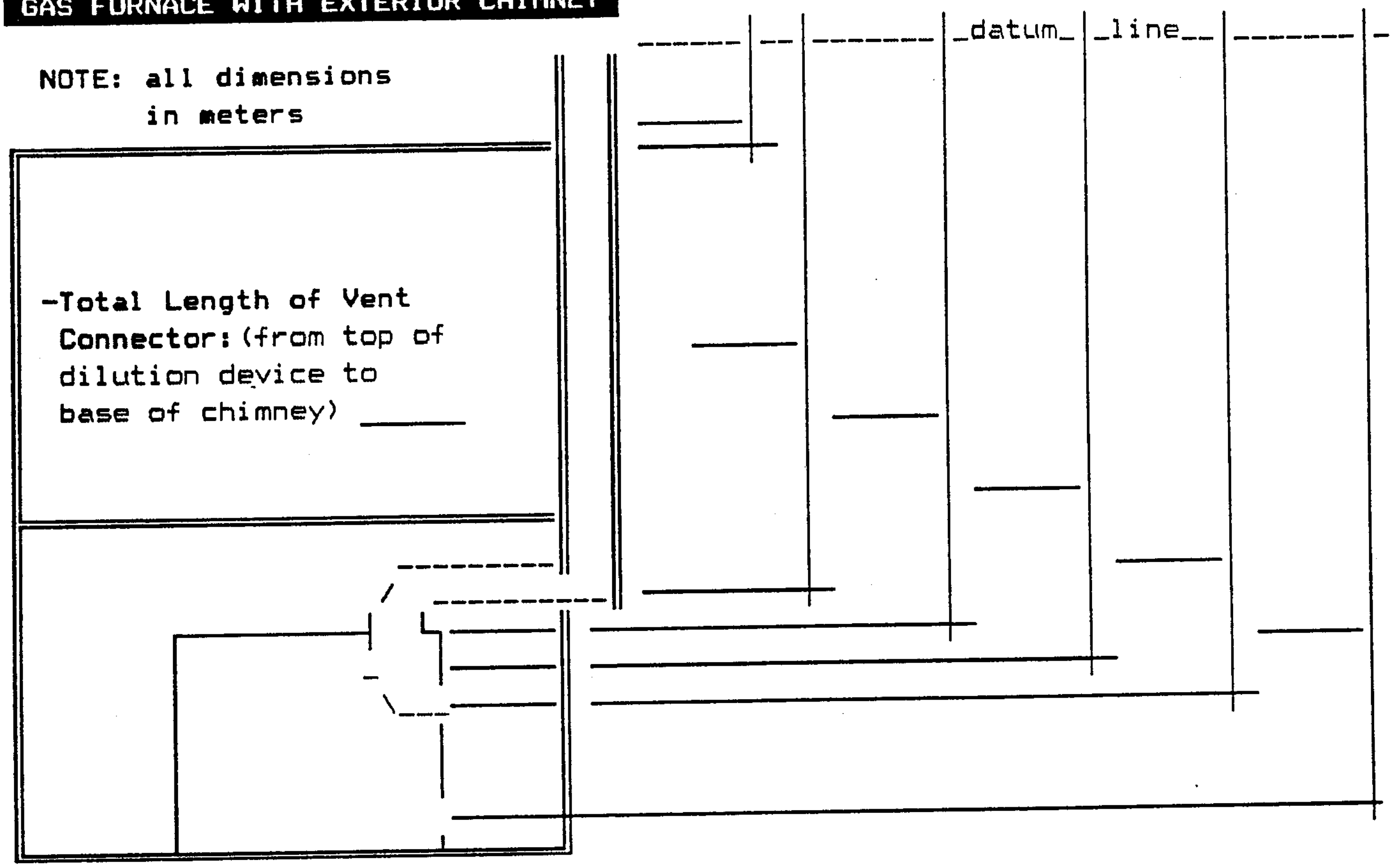


GAS FURNACE WITH INTERIOR CHIMNEY

NOTE: all dimensions in meters

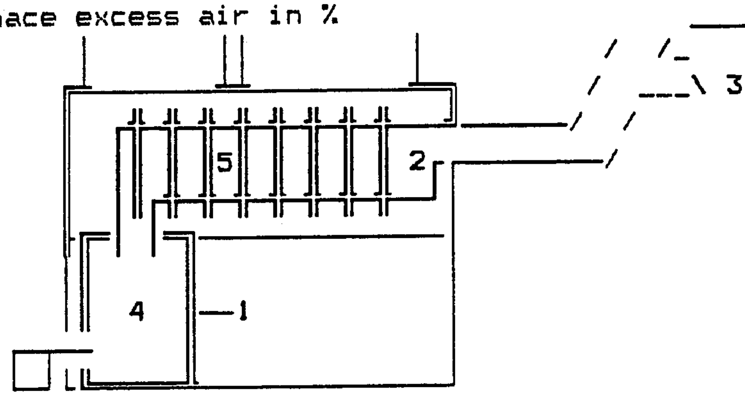


GAS FURNACE WITH EXTERIOR CHIMNEY



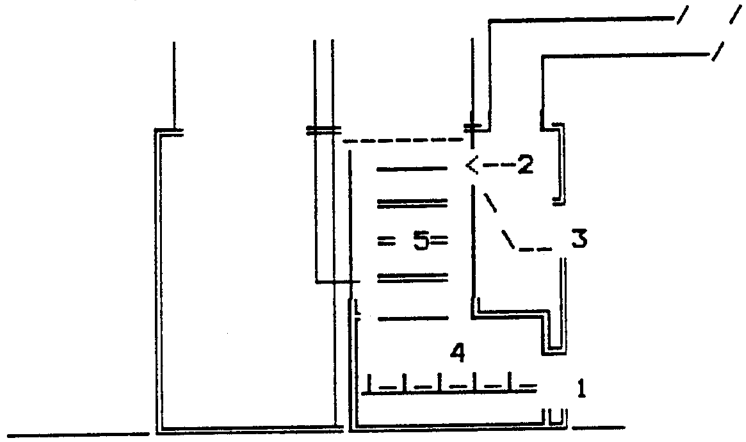
OIL FURNACE CHARACTERISTICS

OPENING AREAS:	-1-firebox leakage area	________	(m2)
	-2-outlet (breech)	________	(m2)
	-3-damper-full open area	________	(m2)
	-% of above when closed (5-100%)	________	(%)
OTHER DATA:	-4-interior chamber volume	________	(m3)
	-5-heat exchanger's:-mass	________	(kg)
	-heat capacity	________	(W.s/kg.C)
	-firing rates-full on	________	(W)
	-standby(heat source)	________	(W)
	-steady state efficiency	________	(%)
	-steady state stack gas exhaust temperature	________	(C)
	-furnace excess air in %	________	(%)

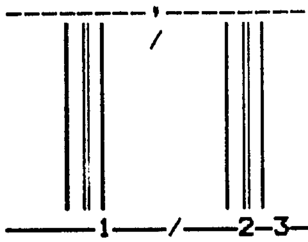


GAS FURNACE CHARACTERISTICS

OPENING AREAS:	-1-combustion air inlet	________	(m2)
	-2-outlet (total of all exhaust ports)	________	(m2)
	-3-draft hood opening area	________	(m2)
OTHER DATA:	-4-interior chamber volume	________	(m3)
	-5-heat exchanger's:-mass	________	(kg)
	-heat capacity	________	(W.s/kg.C)
	-firing rates-full on	________	(W)
	-standby(pilot light)	________	(W)
	-steady state efficiency	________	(%)
	-steady state stack gas exhaust temp.	________	(C)

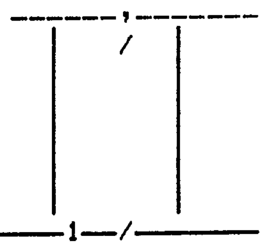


FLUE PIPE / VENT CONNECTOR



Insulated Flue Pipe

NODAL POINTS*
>1-inner metal liner <
2-insulation/air <
3-outer metal casing <



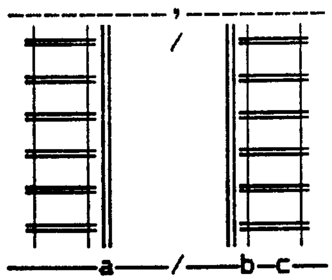
Single walled Flue Pipe*

Open Area of the Flue Pipe	________	(m2)
Circumference or Perimeter		
1-inner metal liner	________	(m)
2-insulation	________	(m)
3-outer metal casing	________	(m)
Element Thickness		
1-inner metal liner	________	(m)
2-insulation	________	(m)
3-outer metal casing	________	(m)
Densities		
1-inner metal liner	________	(kg/m3)
2-insulation	________	(kg/m3)
3-outer metal casing	________	(kg/m3)
Heat Capacities		
1-inner metal liner	________	(W.s/kg.C)
2-insulation	________	(W.s/kg.C)
3-outer metal casing	________	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	________	(W/m2.C)
-points 2 and 3	________	(W/m2.C)
-points 3 and surrounding	________	(W/m2.C)

*For single walled flue pipe enter "0" for all entries of nodal points 2 & 3.

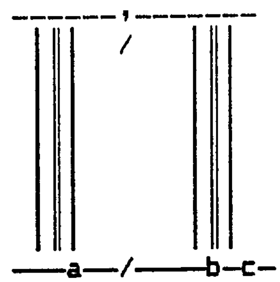
CHIMNEY TYPES

STUDY THE FOUR CHIMNEY SECTIONS BELOW AND SELECT THE TYPE THAT BEST DESCRIBES THE CHIMNEY YOU WANT TO MODEL



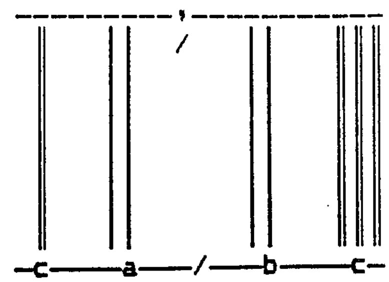
#1 MASONRY

a-clay flue liner
b-air space
c-masonry enclosure



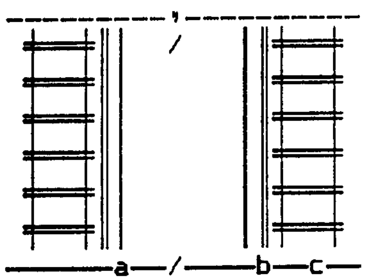
#2 A-VENT

a-inner metal liner
b-insulated cavity
c-outer metal casing



#3 B-VENT

a-inner metal liner
b-outer metal casing
c-enclosing structure

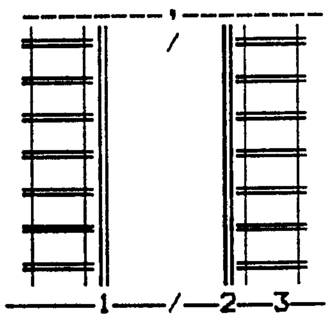


4 MASONRY WITH METAL FLUE LINER

a-metal flue liner
b-clay flue liner
c-masonry enclosure

ENTER YOUR SELECTED CHIMNEY TYPE #_

MASONRY CHIMNEY CHARACTERISTICS

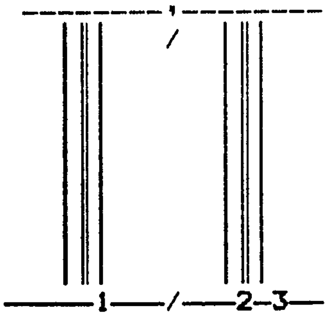


NODAL POINTS

1-inner half of clay liner
2-outer half of clay liner
3-masonry enclosure
(brick or other
masonry products)

Open Area of the Flue	________	(m2)
Circumference or Perimeter		
1-inner half of liner	________	(m)
2-outer half of liner	________	(m)
3-masonry enclosure	________	(m)
Element Thickness		
1-inner half of liner	________	(m)
2-outer half of liner	________	(m)
3-masonry enclosure	________	(m)
Densities		
1-inner half of liner	________	(kg/m3)
2-outer half of liner	________	(kg/m3)
3-masonry enclosure	________	(kg/m3)
Heat Capacities		
1-inner half of liner	________	(W.s/kg.C)
2-outer half of liner	________	(W.s/kg.C)
3-masonry enclosure	________	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	________	(W/m2.C)
-points 2 and 3	________	(W/m2.C)
-points 3 and surrounding	________	(W/m2.C)

A-VENT CHIMNEY CHARACTERISTICS

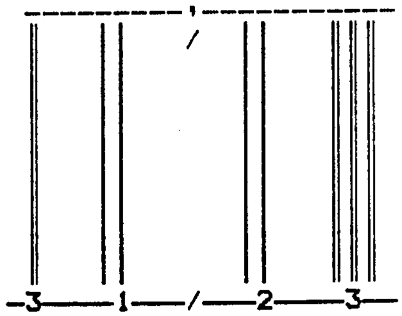


NODAL POINTS

1-inner metal liner
2-insulation
3-outer metal casing

Open Area of the Flue	________	(m2)
Circumference or Perimeter		
1-inner metal liner	________	(m)
2-insulation	________	(m)
3-outer metal casing	________	(m)
Element Thickness		
1-inner metal liner	________	(m)
2-insulation	________	(m)
3-outer metal casing	________	(m)
Densities		
1-inner metal liner	________	(kg/m3)
2-insulation	________	(kg/m3)
3-outer metal casing	________	(kg/m3)
Heat Capacities		
1-inner metal liner	________	(W.s/kg.C)
2-insulation	________	(W.s/kg.C)
3-outer metal casing	________	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	________	(W/m2.C)
-points 2 and 3	________	(W/m2.C)
-points 3 and surrounding	________	(W/m2.C)

B-VENT CHIMNEY CHARACTERISTICS

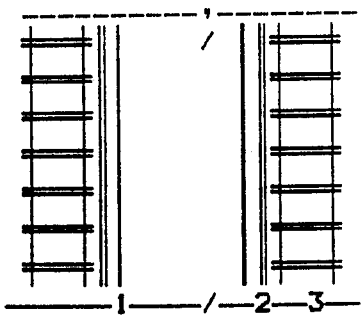


NODAL POINTS

1-inner metal liner
2-outer metal casing
3-enclosing structure
(i.e. gypsum board)

Open Area of the Flue	________ (m2)
Circumference or Perimeter	
1-inner metal liner	________ (m)
2-outer metal casing	________ (m)
3-enclosing structure	________ (m)
Element Thickness	
1-inner metal liner	________ (m)
2-outer metal casing	________ (m)
3-enclosing structure	________ (m)
Densities	
1-inner metal liner	________ (kg/m3)
2-outer metal casing	________ (kg/m3)
3-enclosing structure	________ (kg/m3)
Heat Capacities	
1-inner metal liner	________ (W.s/kg.C)
2-outer metal casing	________ (W.s/kg.C)
3-enclosing stucture	________ (W.s/kg.C)
Heat Loss Factors Between:	
-points 1 and 2	________ (W/m2.C)
-points 2 and 3	________ (W/m2.C)
-points 3 and surrounding	________ (W/m2.C)

MASONRY CHIMNEY WITH METAL FLUE LINER CHARACTERISTICS



NODAL POINTS

1-metal flue liner
2-clay flue liner
3-masonry enclosure
(brick or other
masonry products)

Open Area of the Flue	________	(m2)
Circumference or Perimeter		
1-metal flue liner	________	(m)
2-clay flue liner	________	(m)
3-masonry enclosure	________	(m)
Element Thickness		
1-metal flue liner	________	(m)
2-clay flue liner	________	(m)
3-masonry enclosure	________	(m)
Densities		
1-metal flue liner	________	(kg/m3)
2-clay flue liner	________	(kg/m3)
3-masonry enclosure	________	(kg/m3)
Heat Capacities		
1-metal flue liner	________	(W.s/kg.C)
2-clay flue liner	________	(W.s/kg.C)
3-masonry enclosure	________	(W.s/kg.C)
Heat Loss Factors Between:		
-points 1 and 2	________	(W/m2.C)
-points 2 and 3	________	(W/m2.C)
-points 3 and surrounding	________	(W/m2.C)

ENVELOPE

Airtightness Characteristics: -ELA (equiv. leakage area) ________ (m2)
(as defined by standard -flow exponent: n ________
CAN/CGSB-149.10-M) (non dimensional)
Maximum Exhaust Fan Flow Rate: ________ (L/s)
Maximum Fireplace Flow Rate: ________ (L/s)

AMBIENT TEMPERATURE AND WIND SPEED

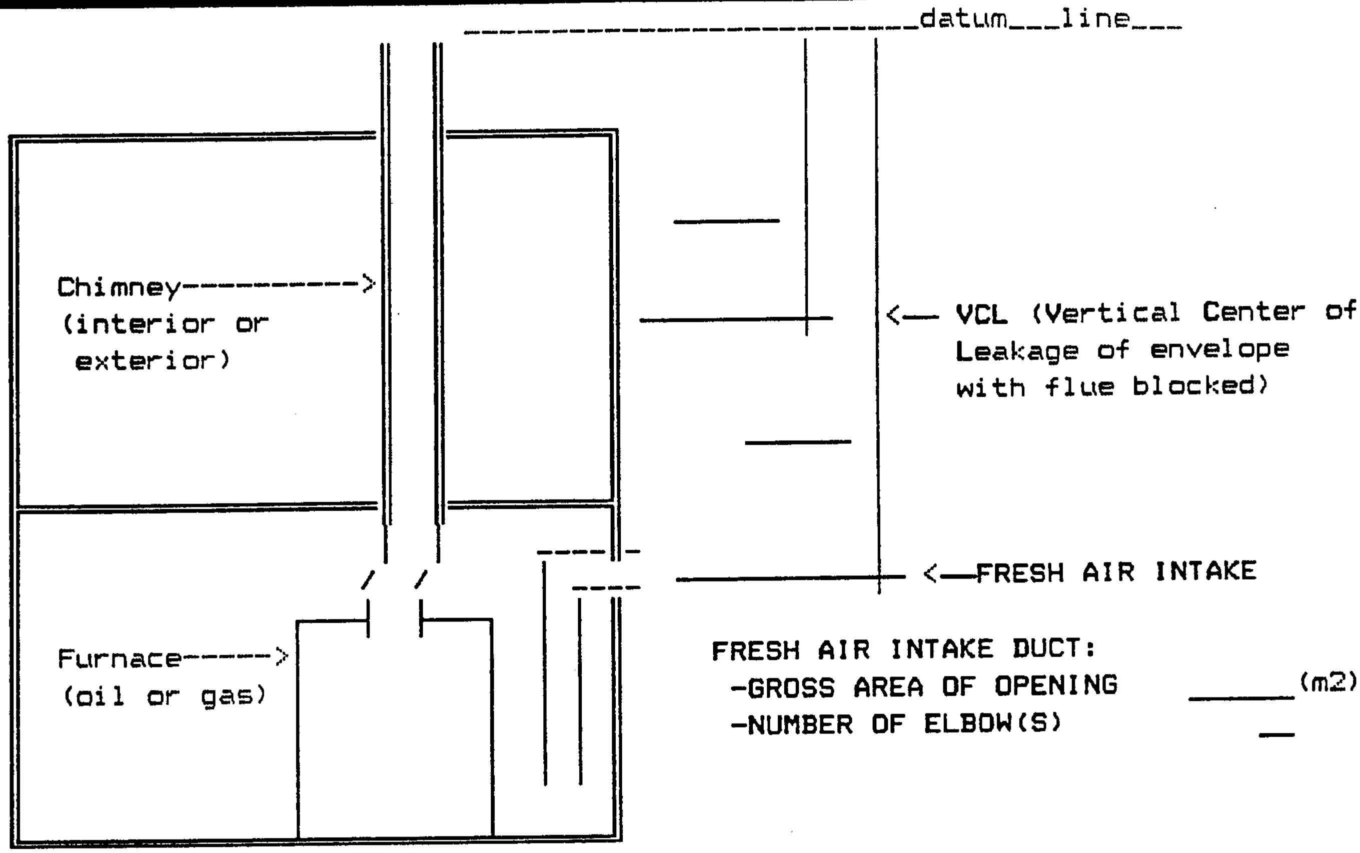
Outdoor Temperature 10.0 (C) Wind Speeds: -horizontal ________ (m/s)
Indoor Temperature 20.0 (C) -vertical ________ (m/s)
(up is +)

INITIAL TEMPERATURES OF ELEMENTS

Initial Flue Temperatures: -flue gas ________ (C)
-nodal point #1 ________ (C)
-nodal point #2 ________ (C)
-nodal point #3 ________ (C)

Initial furnace temperatures: -heat exchanger surface ________ (C)
-stack gas ________ (C)

VCL & FRESH AIR INTAKE LOCATION & CHARACTERISTICS



FRESH AIR INTAKE DUCT:

-GROSS AREA OF OPENING ______ (m2)

-NUMBER OF ELBOW(S) __

DOMESTIC HOT WATER HEATER CHARACTERISTICS

-SHARED FLUE WITH FURNACE? (Y,N) _

-water heater "on" or "standby" (O,S) _

-burner capacity ________ (W)

-standby capacity (pilot light & losses) ________ (W)

-steady state efficiency ________ (%)

-cross-sectional area of vent connector ________ (m2)

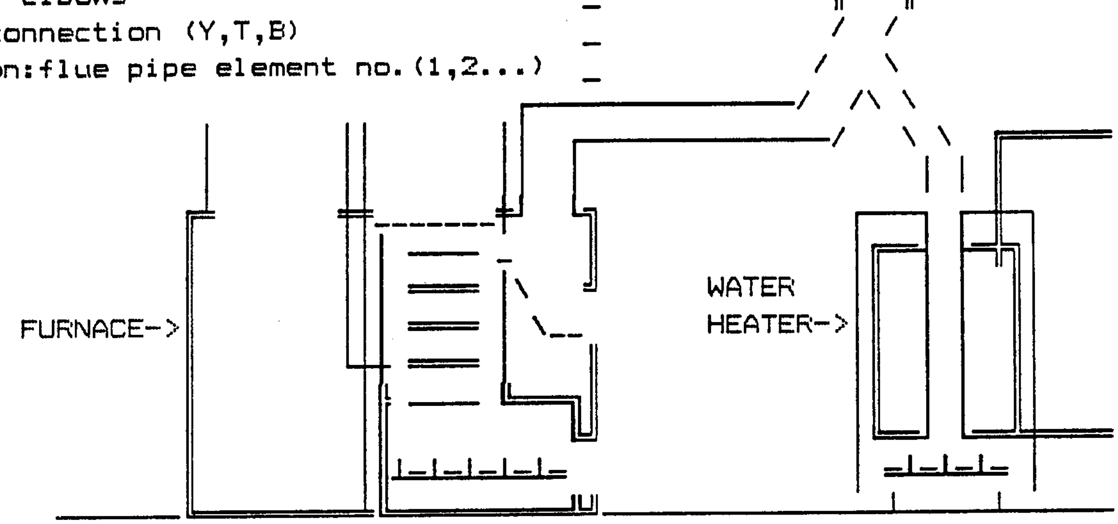
-flue pipe length ________ (m)

-flue pipe height ________ (m)

-number of elbows _

-type of connection (Y,T,B) _

-connection:flue pipe element no.(1,2...) _



FLUE DAMPER AND FLUE CAP

FLUE DAMPER:

-Is there a flue damper? (Y,N) _

-Damper activation: thermal or electric? (T,E) _

-Thermal activation temperature:-fully open ____ (°C)

-fully closed ____ (°C)

-Leakage area around flue damper when closed ________ (m2)

FLUE CAP:

-Horizontal wind pressure coefficient ________

(horizontal wind pressure coefficient is needed even if 'Actual wind angle' below is not 0°)

-Actual wind angle ________ (°)

(measured from horizontal: + up, - down)

-Wind pressure coefficient at that angle ________

-Wind speed at that angle ________ (m/s)

-Flue cap friction factor ________

OPTIONAL SPECIFICATIONS

Furnace Thermostat Setting:

-thermostat setpoint ______ (°C)

-furnace thermostat band* ______ (°C)

House Thermal Characteristics:

-heated house volume ________ (m3)

-thermal conductivity of the house envelope ________ (W/°C)

-thermal mass of the house structure (L,M,or H)** _

Mechanical Draft Inducer:

-Do you wish to include a draft inducer in the vent connector? (Y/N) _

---

* -enter "0" if you want to specify the furnace ON & OFF times in TIME CONTROLS
-enter the number of degrees for the thermostat band to simulate the dynamic performance of the envelope/furnace/thermostat system, e.g."4.0"(C)

** enter "L" for ordinary wood frame structure, "M" for a wood frame house with interior mass e.g. brick, & "H" for a conc. block or solid masonry structure

TIME CONTROLS

Simulation Start Time	________ (sec)
Initial Time Step	________ (sec)
Furnace On	________ (sec)
Furnace Off	________ (sec)
Simulation Stop Time	________ (sec)

APPENDIX G

STANDARD DIMENSIONS OF VARIOUS TYPES OF CHIMNEYS

STANDARD B-VENT DIMENSIONS

NOMINAL SIZE	INNER LINER	OUTER CASING	AREA OF OPENING	(CIRCUMFERENCE) INNER LINER	(CIRCUMFERENCE) OUTER CASING
3"	3" 76.2 mm	4" 101.6 mm	7.1 in^2 0.0046 m^2	9.4" 0.239m	12.6" 0.319 m
4"	4" 101.6 mm	5" 127.0 mm	12.6 in^2 0.0081 m^2	12.6 0.319 m	15.7" 0.399 m
5"	5" 127.0 mm	6" 152.4 mm	19.6 in^2 0.0127 m^2	15.7" 0.399 m	18.8" 0.479 m
6"	6" 152.4 mm	7" 177.8 mm	28.3 in^2 0.0182 m^2	18.8" 0.479 m	22.0" 0.559 m
7"	7" 177.8 mm	8" 203.2 mm	38.5 in^2 0.0248 m^2	22.0" 0.559 m	25.1" 0.638 m
8"	8" 203.2 mm	9" 228.6 mm	50.3 in^2 0.0324 m^2	25.1" 0.638 m	28.3" .718 m
10"	10" 254.0mm	12" 305.0 mm	78.5 in^2 0.0507 m^2	31.4" 0.798 m	37.7" 0.958 m
12"	12" 305.0 mm	13" 330.4 mm	113.in^2 0.0731 m^2	37.7" 0.958 m	40.8" 1.038 m

STANDARD A-VENT DIMENSIONS

NOMINAL SIZE	INNER LINER ACTUAL SIZE DIAM.	MID POINT THRU INSUL. DIAM.	OUTER JACKET DIAM.	AREA OF OPENING	CIRCUMFERENCES INNER LINER	INSULATION THRU CENTRE	OUTER JACKET
6"	6" 152.4 mm	7" 177.8 mm	8" 203.2 mm	28.3 in^2 0.0182 m^2	18.8" 0.479 m	22" 0.559 m	25.1" 0.638 m
7"	7" 177.8 mm	8" 203.2 mm	9" 228.6 mm	38.5 in^2 0.0248 m^2	22" 0.559 m	25.1" 0.638 m	28.3" 0.718 m
8"	8" 203.2 mm	9" 228.6 mm	10" 254.0 mm	50.3 in^2 0.0324 m^2	25.1" 0.638 m	28.3" 0.718 m	31.4" 0.798 m
10"	10" 254.0 mm	11" 279.4 mm	12" 305 mm	78.5 in^2 0.0507 m^2	31.4" .798 m	34.6" 0.878 m	37.7" 0.958 m

STANDARD CLAY TILE LINER DIMENSIONS

NOMINAL SIZE (inches) (mm)	INSIDE DIMENSIONS (inches) (mm)	OUTSIDE DIMENSIONS (inches) (mm)	AVG. WALL THICKNESS (inches) (mm)	INSIDE AREA (in2) (m2)	INSIDE PERIMETER (inches) (m)	OUTSIDE PERIMETER (inches) (m)
7 x 7 178 x 178	5 1/8 x 5 1/8 130 x 130	6 7/8 x 6 7/8 174 x 174	7/8 22	26.3 0.0170	20.5 0.521	27.5 0.699
7 x 8 177 x 203	5 1/8 x 6 1/8 130 x 156	6 7/8 x 7 7/8 175 x 200	7/8 22	31.4 0.0200	22.5 0.572	29.5 0.749
8 x 8 203 x 203	6 1/4 x 6 1/4 159 x 159	7 3/4 x 7 9/16 197 x 192	11/16 18	38.7 0.0249	23.8 0.605	28.4 0.722
8 x 12 203 x 305	6 1/4 x 10 3/16 159 x 259	7 7/8 x 11 3/4 200 x 299	13/16 20	63.7 0.0411	31.2 0.792	36.0 0.915
12 x 12 305 x 305	9 7/8 x 9 15/16 251 x 253	11 5/8 x 11 3/4 295 x 299	7/8 23	97.1 0.0627	36.8 0.935	42.4 1.078
12 x 16 305 x 406	10 1/4 x 13 3/4 260 x 349	12 5/16 x 15 13/16 313 x 402	1 26	139 0.0899	44.8 1.137	51.2 1.301
16 x 16 406 x 406	13 1/2 x 13 3/8 343 x 340	15 3/4 x 15 1/2 400 x 394	1 1/8 28	176 0.1133	48.3 1.226	55.8 1.418

THE TWO SMALLER LINERS ARE NOT CURRENTLY AVAILABLE IN CANADA,
THE DIMENSIONS FOR THOSE LINERS WERE EXTRACTED FROM CATALOGUES
ALL OTHER MEASUREMENTS WERE TAKEN FROM SAMPLE CLAY TILE LINERS.

APPENDIX H

TEST DATA ON FLUE CAPS

AERODYNAMIC AND FLOW CHARACTERISTICS OF FIVE FLUE CAPS*

MEASURED WIND PRESSURE COEFFICIENTS FOR A BLOCKED FLUE

WIND ANGLE	A-VENT	B-VENT	3 FINNED CAP	OPEN MASONRY	MASONRY CAP&GRILL
-45°	0.662	0.432	0.461	0.242	0.629
-30°	0.731	0.446	0.621	0.989	1.078
0°	0.728	0.503	0.580	1.626	0.958
30°	0.536	0.439	0.241	0.873	0.777
45°	0.556	0.646	0.136	0.812	0.731

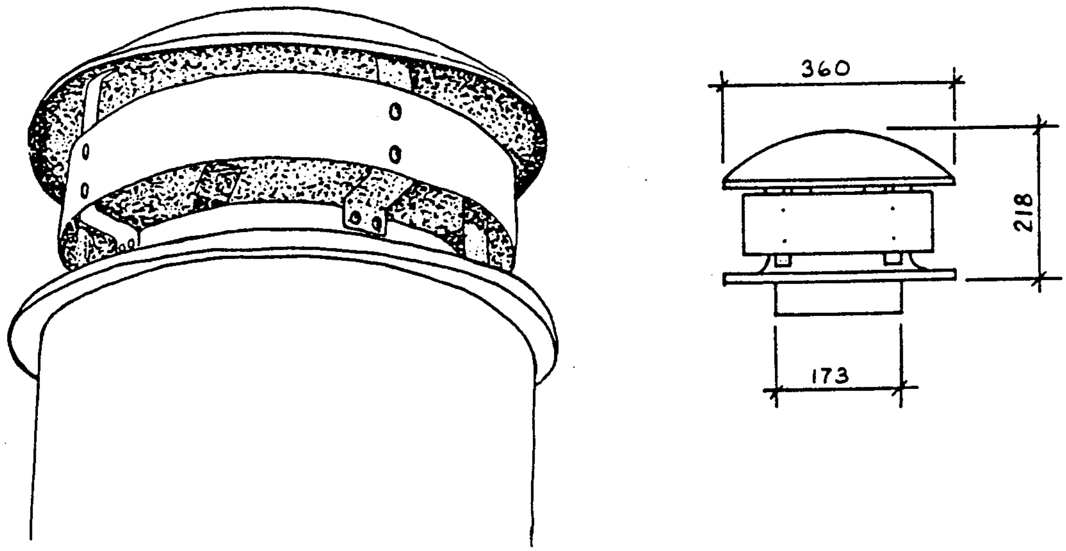
MEASURED WIND PRESSURE COEFFICIENTS FOR AN UNBLOCKED FLUE

WIND ANGLE	A-VENT	B-VENT	3 FINNED CAP	OPEN MASONRY	MASONRY CAP&GRILL
-45°	0.470	0.274	0.239	0.263	0.583
-30°	0.531	0.248	0.235	0.755	0.753
0°	0.500	0.269	0.229	1.094	0.669
30°	0.395	0.218	0.166	0.837	0.759
45°	0.433	0.331	0.099	0.787	0.694

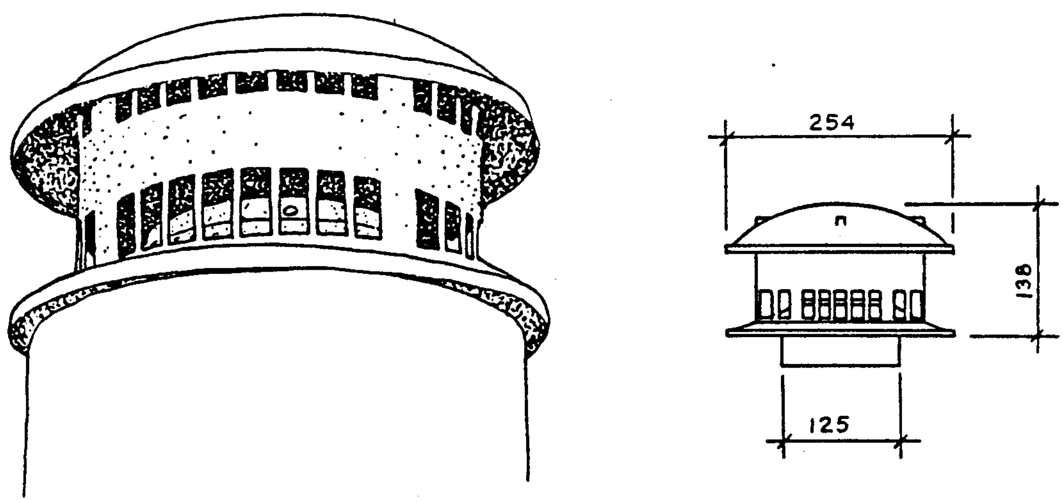
FLOW CHARACTERISTICS

WIND ANGLE	A-VENT	B-VENT	3 FINNED CAP	OPEN MASONRY	MASONRY CAP&GRILL
FRICTION FACTOR (K)	1.1	1.4	3.6	0.7	1.0
RATIO OF CAP ELA TO CHIMNEY AREA (ELA/A)	1.6	1.4	0.9	1.9	1.6

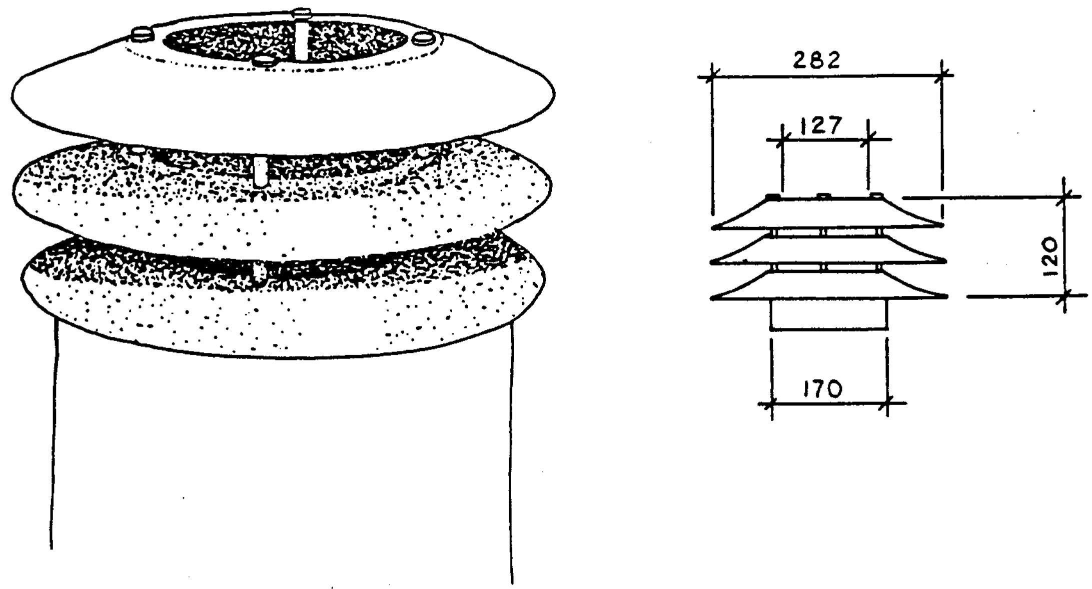
* The Influence of Termination Configuratiion on the Flow Performance of Flues
Scanada Sheltair Consortium Inc. for
Canada Mortgage and Housing Corporation
June 11, 1987



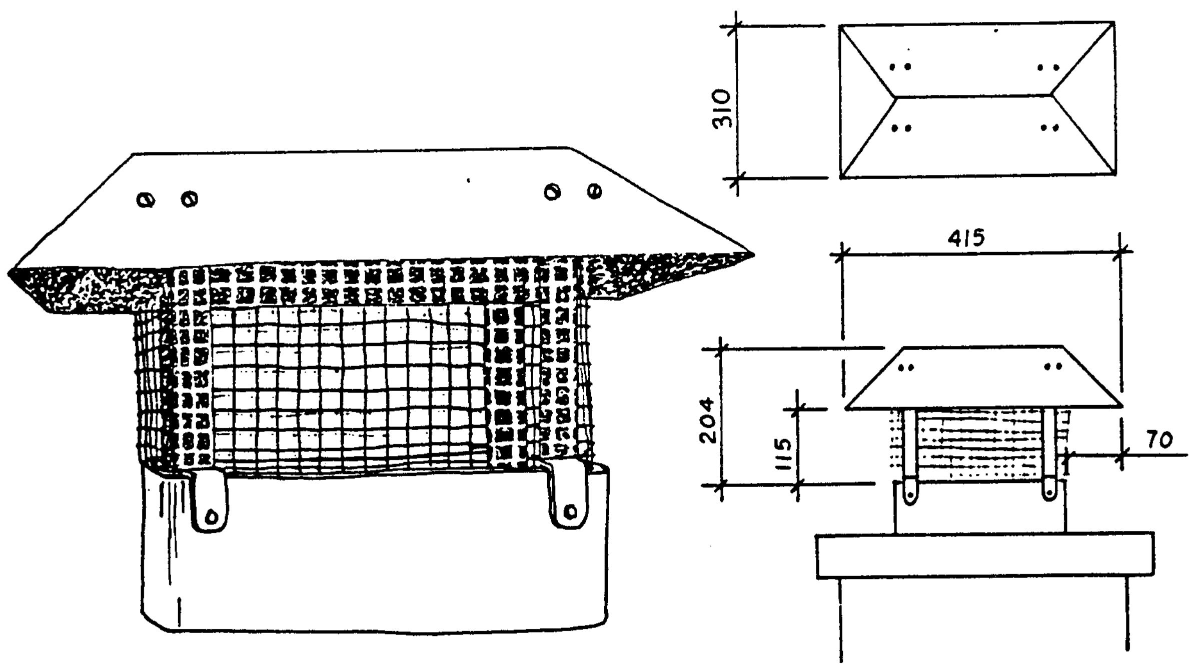
A-VENT CAP



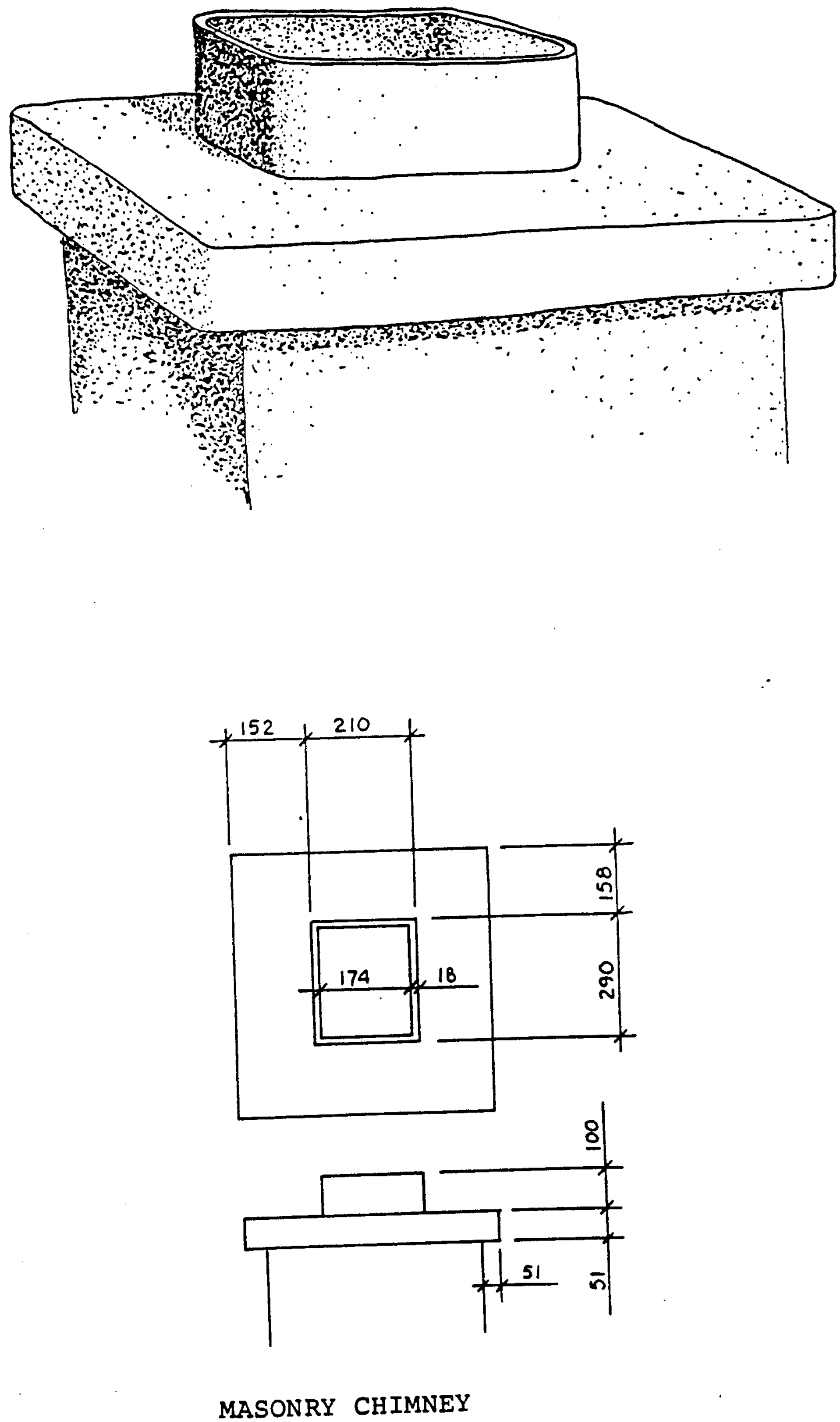
B-VENT CAP



THREE-FINNED CAP



CAP & GRILL FOR A MASONRY CHIMNEY



MASONRY CHIMNEY

APPENDIX I

LIST OF BACKGROUND RESEARCH PAPERS

The Thermal and Flow Performance of Furnace Flues in Houses, Volumes I and II, Scanada Consultants Limited, March 1985.

Critical Levels of House Depressurization: Differences and Similarities Between Sheltair's Maximum Allowable Depressurization Limits, University of Toronto's Vent Establishment Pressures, and Scanada's Net Driving Pressure Parameter, Scanada Consultants Limited, March 1985.

Thermal and Aerodynamic Performance of Chimney Flues- Armstrong Field Testing Phase 1 and 2, Scanada Consultants Limited, July 1985.

Validation and Refinement of the Transient Furnace Flue Model, Scanada Consultants Limited, February, 1986.

Residential Combustion Venting Failure - A Systems Approach, Modification and Refinement to the FLUE SIMULATOR Model, Scanada Consultants Limited, May 1987.

1st Quarter Modifications to FLUE SIMULATOR (Differences Between Versions 3.0 and 4.0), Scanada Consultants Limited, May 1987.