NBSIR 80-2157

A Computer Program for Analysis of Pressurized Stairwells and Pressurized Elevator Shafts

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Sponsored in part by:
The Department of Health and Human Services
Washington, DC 20201

U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, ***Secretary***
Jordan J. Baruch, ***Assistant Secretary for Productivity, Technology, and Innovation***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

PREFACE

This report is an interim product of a joint effort of the Department of Health and Human Services and the National Bureau of Standards (NBS), Center for Fire Research. The program is a multi-year activity initiated in 1975. It consists of projects in the areas of: decision analysis, fire and smoke detection, smoke movement and control, automatic extinguishment, and behavior of institutional populations in fire situations.

This report describes a computer program which analyzes pressurized stairwells and pressurized elevators. The program was initially intended as a research tool to investigate the feasibility of specific systems. However, this program may be of interest to design engineers responsible for pressurized stairwells or pressurized elevators.

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A COMPUTER PROGRAM FOR ANALYSIS OF PRESSURIZED STAIRWELLS AND PRESSURIZED ELEVATOR SHAFTS

John H. Klote

Abstract

Pressurized stairwells and pressurized elevators can be used as a means of providing a smoke free exit route during fire situations. This paper describes a computer program which analyzes systems intended to pressurize stairwells or elevator shafts. The basic assumptions and limitations of the program are also discussed. The appendices contain a program listing and examples.

Key words: Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulation; smoke control; stairwells.

1. INTRODUCTION

Pressurized stairwells are being used as a means of providing smoke free exit routes during fire situations. A discussion of several designs for pressurized stairwell systems is provided by Benjamin and Klote [1][1]. In addition, the concept of pressurized elevator shafts has gained considerable interest as a means of fire escape for the handicapped. The purpose of the program described in this paper is to calculate the pressure differentials produced by such systems. Because a stairwell or an elevator shaft is connected to a building, the program calculates air flows and pressure differentials throughout the building in order to obtain the differential pressures across the stairwell or elevator.

A number of computer programs have been developed which are applicable to smoke control. Some of these programs calculate steady state air flow and pressures throughout a building [2,3]. Other programs go beyond this to calculate smoke concentrations throughout a building that would be produced in the event of a real fire [4-9]. In general, most of these programs are capable of analyzing pressurized stairwells and pressurized elevators. However, the program described in this paper has been specifically written for analysis of pressurized stairwells and elevators. The data input has

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[1] Numbers in brackets refer to the literature references listed at the end of this paper.

been designed to minimize the quantity of required data and still maintain a high level of generality in the model. The output consists of the differential pressures across all of the building shafts in addition to the flows and pressures throughout the building. In addition, the assumptions and limitations of the program discussed in the next section were chosen specifically to allow modeling of pressurized stairwells and pressurized elevators.

This program was intended primarily as a research tool to investigate the feasibility of specific systems and to determine the interaction between these systems and the rest of the building. This program has already been used to analyze pressurized stairwells without vestibules and to evaluate factors which affect the performance of these systems [10]. It is also possible that the program may be used as a design tool directly or to generate quantities of design data. This paper is not intended to be a design guide for either pressurized stairwells or pressurized elevators. The state-of-the-art of these systems is still developing and designers of these systems should seek the most current data available.

2. PROGRAM CONCEPT

In this computer program a building is represented by a network of spaces or nodes each at a specific pressure and temperature. The stairwells and other shafts are modeled by a vertical series of spaces, one for each floor. Air flows through leakage paths from regions of high pressure to regions of low pressure. These leakage paths are doors and windows which may be opened or closed. Leakage can also occur through partitions, floors, exterior walls and roofs. The air flow through a leakage path is a function of the differential pressure across the leakage path.

In this computer model air from outside the building can be introduced by a pressurization system into any level of a shaft or even into other building spaces. This allows simulation of stairwell pressurization, elevator shaft pressurization, stairwell vestibule pressurization and even elevator lobby pressurization. The pressures throughout the building and flow rates through all the flow paths are obtained by solving the air flow network including the driving forces such as the wind, the pressurization system or an inside outside temperature difference.

3. ASSUMPTIONS AND LIMITATIONS

1. Each space is considered to be at one specific pressure and one specific temperature.

2. The flows and leakage paths are assumed to occur at mid-height of each level.

3. The net air supplied by the air handling system or by the pressurization system is assumed to be constant and independent of building pressure.

4. The outside air temperature is assumed to be constant.

5. The barometer pressure at ground level is assumed to be standard atmospheric pressure (101325 P_a). The results of the program are not very sensitive to changes in atmospheric pressure. For altitudes considerably different from sea level the more accurate value can be substituted by changing an assign statement in the subroutine INPUT.

4. EQUATIONS

A. Flow equation

$$F = C(\Delta P)^{\chi} \qquad (3.1)$$

where:

F = mass flow rate

C = flow coefficient

χ = flow exponent

ΔP = differential pressure across flow path

The following equation has been used by Sander and Tamura [3] for corrections for flows not at standard conditions[2].

$$C = C_o \left(\frac{\rho}{\rho_o}\right)^{\chi} \left(\frac{\mu}{\mu_o}\right)^{1-2\chi}$$

where:

C_o = flow coefficient at standard conditions

ρ = density of entering air

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[2] This relationship was originally derived by Tamura and Wilson [11].

ρ_o = density of air at standard conditions

μ = dynamic viscosity of entering air

μ_o = dynamic viscosity of air at standard conditions

This author has observed that the dynamic viscosity is proportional to absolute temperature to the 3/4 power in the range of -40°C to 60°C (-40°F to 140°F) with a maximum error of 1.2 percent. Using this and the fact that density is inversely proportional to absolute temperature the above relation reduces to a function of temperature only.

$$C = C_o \left(\frac{T_o}{T}\right)^{\frac{5\chi}{2} - \frac{3}{4}} \tag{3.2}$$

where:

T = absolute temperature of entry air

T_o = standard absolute temperature

B. Mass Balance Equations

For building compartment[3] i

$$\sum_{j=1}^{N_c} F_{(i,j)} + \sum_{k=1}^{N_o} F_{o(i,k)} + F_{f(i)} = 0 \tag{3.3}$$

and for shafts

$$\sum_{i=N_1}^{N_2} \left[\sum_{j=1}^{N_c} F_{(i,j)} + \sum_{k=1}^{N_o} F_{o(i,k)} + F_{f(i)}\right] = 0 \tag{3.4}$$

where:

$F_{(i,j)}$ = mass flow rate from space j to space i. For building compartments this flow can be either horizontal or vertical, however for shafts this flow can only be horizontal.

$F_{o(i,k)}$ = mass flow rate from direction k outside of the building to space i.

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[3] In this paper the term building compartment refers to a space in a building other than in a shaft.

$F_{f(i)}$ = net mass flow rate of air due to the air handling system or due to a pressurization system.

N_c = number of building spaces connected to space i.

N_o = number of connections to the outside from space i.

N_1 is the space number at bottom level of shaft and the spaces in the shaft are numbered consecutively up to N_2 which is the space number at the top of the shaft.

C. Shaft Pressures

The following relation is used to calculate the gage pressure, $P_{(i)}$, at level i of a shaft in terms of $P_{(i-1)}$ at level i - 1.

$$P_{(i)} = P_{(i-1)} - P_z - P_f \tag{3.5}$$

where:

P_z = hydrostatic pressure difference

P_f = pressure loss due to friction

The following equation is used to calculate the hydrostatic pressure.

$$P_z = \frac{g\bar{P}}{R\bar{T}} \left(h_{(i)} - h_{(i-1)} \right) \tag{3.6}$$

where:

$h_{(i)}$ = height of point i

$h_{(i-1)}$ = height of point i-1

g = gravitational acceleration

R = gas constant

$\bar{T} = \frac{T_{(i)} + T_{(i-1)}}{2}$

$\bar{P} = \frac{P_{(i)} + P_{(i-1)}}{2} + P_b$

P_b is a constant used to convert an average gage pressure to the average absolute pressure $\bar{P}$.

The following equation is used to calculate the pressure loss due to friction.

$$P_f = S \left(\frac{F_u}{C_s} \right)^2 \tag{3.7}$$

where:

F_u = upward flow from i-1 to i in shaft

C_s = shaft flow coefficient

S = sign of F_u

D. Outside Pressures

Outside pressures can either be entered by the user or can be calculated by the following method.

$$P_{o(i)} = P_{h(i)} + C_w P_{v(i)} \tag{3.8}$$

where:

$P_{o(i)}$ = outside gage pressure at height h(i) above absolute pressure at ground level.

$P_{h(i)}$ = hydrostatic pressure difference between h(i) and ground level

$P_{v(i)}$ = velocity pressure due to the wind at height h(i)

C_w = pressure coefficient

Because the outside temperature is constant

$$P_{h(i)} = P_{atm} \exp \left(- \frac{gh(i)}{RT_{out}} \right) - P_b \tag{3.9}$$

where:

P_{atm} = absolute barometric pressure at ground level

T_{out} = outside absolute temperature

When the outside pressures are calculated by the computer the wind velocities are assumed to be described by the power law.

$$V = V_o \left(\frac{h}{h_o}\right)^n$$

where:

V_o = wind velocity at height h_o

n = wind exponent

This relationship has been extensively used to describe the boundary-layer velocity profile of the wind near the surface of the earth. This equation assumes that the terrain surrounding the building is homogeneous. That is, that there are no large obstructions near the building which could produce local wind effects. A value of 0.16 for the wind exponent is appropriate for flat terrain. The wind exponent increases with rougher terrain. For very rough terrain such as urban areas a value of 0.40 would be appropriate.

The equation for the velocity pressure at height h(i) is obtained by substituting the velocity from the power law into the usual relation for velocity pressure ($P_v = \frac{1}{2} \rho V^2$).

$$P_v = \frac{\rho V_o^2}{2} \left(\frac{h_{(i)}}{h_o} \right)^{2n} \tag{3.10}$$

where ρ is the outside air density.

The pressure coefficients are in the range of -0.8 to 0.8 where positive values are for windward walls and negative values are for leeward walls. The pressure coefficient depends upon building geometry and varies locally over the wall surface. Numerical values for C_w and n as well as practical engineering information is available from a number of sources [12-15].

5. PROGRAM DESCRIPTION

This program is written in the computer language FORTRAN V specifically for use on the UNIVAC 1108. A program listing is provided in appendix D. The following is a detailed description of the main program and the major subroutines.

5.1 Main Program

This program was written to handle four different run types as follows:

1. RUN: In this run type subroutine INPUT is used to read data and then the pressures and flows are calculated and printed. After this, the subroutine INPUT2 is used to read modifications to existing data or to determine if execution should be terminated. Under this run type, if modifications were read then the pressures and flows are again calculated and printed. Any number of modified data sets can be determined and solved in this manner.

2. RUN 1: This run type is similar to the one above except that no solutions for pressures and flows are produced for modified data read under the subroutine INPUT2. A solution is obtained for the original data read under subroutine INPUT.

3. TEST: In this run type data are read and tested but no solutions are produced. Run types 2 and 3 can be used to test input data which are to be used later under another run type and under a low cost priority.

4. FIND F: In this run type, the rate of pressurization air necessary to produce a specific pressure differential across a shaft is determined.

Figure 1 is a flow chart for the main program logic under the conditions of a run type RUN.

5.2 INPUT Subroutine

This routine reads the data that are necessary for a flow analysis of the stairwell or elevator, including an analysis of the rest of the building. These data consist of the following:

1. Outside temperature.

2. Temperature throughout the building.

3. Outside pressures. These can be entered or calculated as described earlier.

4. Description of the flow network including flow coefficients and flow exponents for all connections and the net air flows to each space due to the air conditioning system or due to a pressurization system.

The data above can be entered in either SI units or in engineering units. There are two modes for the description of the flow network. The first is a general mode which allows any building geometry and any connections between building spaces that the user chooses to define. The second description mode is simplified in that each floor is represented by one building space and the flow coefficients and exponents are all the same in the vertical direction unless they are defined by exception to be different. This simplified data input greatly reduces the quantity of data required to define a large building. Appendix A contains a detailed description of both of these methods of input.

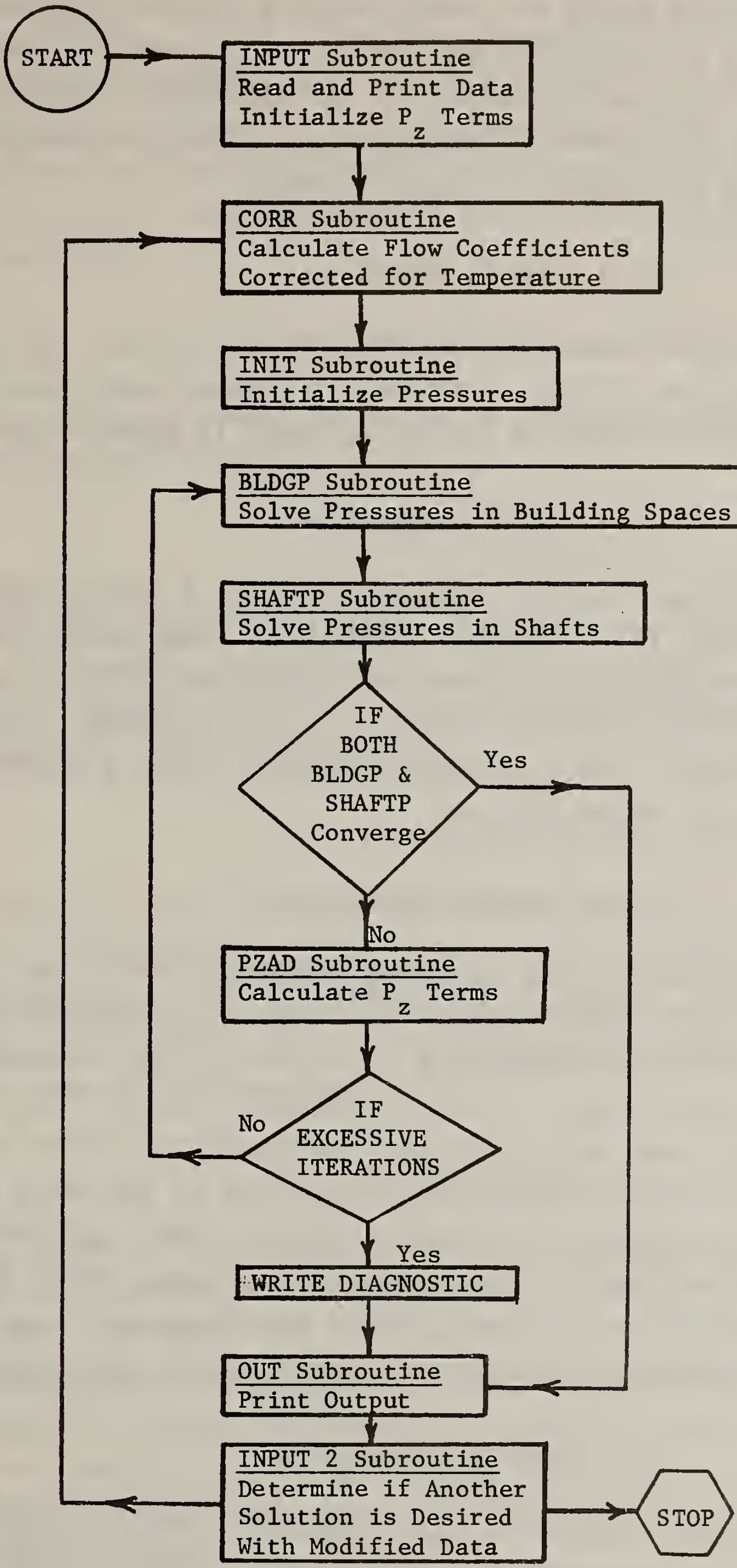

Figure 1. Flow chart for main program logic under a run type RUN.

In addition to reading data, this subroutine provides temperature and pressure data as well as a complete description of the flow network. This routine also calculates initial estimates of the hydrostatic pressure differences. When data is entered in engineering units the subroutine UNITS is called which converts all units to the SI system.

5.3 CORR Subroutine

This routine calculates flow coefficients corrected for the temperature of the entering air using eg. (3.2). Two sets of these corrected coefficients are calculated for each flow path to allow for flow in either direction.

5.4 INIT Subroutine

This routine calculates initial estimates of the building pressures by a technique used by Sander [2]. In this technique, mass flows are considered linear functions of differential pressure and therefore the flow equations can be expressed and solved in matrix form. In this estimate, shaft pressures are considered hydrostatic. The resulting pressures form a starting point for the iterative solution which follows.

5.5 BLDGP Subroutine

The iterative solution for the building pressures and flows consists of the three subroutines BLDGP, SHAFTP and PZAD. The subroutine BLDGP operates on the building compartments sequentially. The sum of all the mass flows into compartment i is calculated. If the absolute value of this sum is less than a convergence limit then eq. (3.3) is considered satisfied and the computer proceeds to the next compartment or returns to the main program. However, if the absolute value of the sum is greater than the convergence limit, then an improved estimate of the pressure at compartment i is obtained by the regula falsi method [16]. When none of the pressures need to be modified this routine passes a convergence signal to the main program.

5.6 SHAFTP Subroutine

The structure of this routine is very similar to that of BLDGP except that it operates on shafts sequentially. The sum of all the mass flows into shaft i is calculated. If the absolute value of this sum is less than the convergence limit then eq. (3.4) is also considered satisfied and the computer proceeds to the next shaft or returns to the main program. However, if the absolute value of the sum is greater than the convergence limit, then improved estimates of the shaft pressure are calculated. This is done by changing the pressures at the bottom of the shaft and then recalculating the shaft pressure by eq. (3.5). Again the regula falsi method is used, and if none of the shaft pressures need to be modified a convergence signal is passed to the main program. It can be seen from figure 1 that if convergence is achieved in both BLDGP and SHAFTP, then the subroutine OUT will print the solution. Otherwise, the hydrostatic pressure differences are adjusted in the subroutine PZAD.

5.7 PZAD Subroutine

This routine calculates hydrostatic pressure differences by eq. (3.6) using the most recent pressure estimates.

5.8 OUT Subroutine

This routine outputs mass flows and pressures for the flow network as well as the differential pressures across each shaft. If the data input was in engineering units then the subroutine UNITS is called to convert variables to the engineering system before output.

5.9 INPUT2 Subroutine

This routine reads modifications to the flow network. The modifications can consist of changes in the net flow to a stairwell or elevator pressurization system or of changes to flow coefficients between either between building spaces or to the outside. After the modifications are read, a solution to the new flow network is obtained.

6. FUTURE DIRECTION

In the future it is planned to analyze pressurized stairwell systems with pressurized vestibules as has already been done for systems without vestibules [10]. In addition, the use of this program is a part of a large project to study the feasibility of using pressurized elevator shafts for fire evacuation of the handicapped. The further development of this program so that it can easily be used as a design tool is being considered. However, this development would depend upon the determination that a real need exists for such a design tool.

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APPENDIX A. DATA INPUT DESCRIPTION

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Data input consists of the following elements:

1. Initial data
2. Building heights
3. Temperature profiles
4. Outside pressure profiles
5. General flow network input
6. Abbreviated flow network input
7. FIND F data
8. INPUT2 data

Each of these input elements is described in detail in the following sections. Elements 1 through 4 are always required. The flow network can either be defined by a general method of input using element 5 or by an abbreviated method using element 6. The virtue of the abbreviated method is that less data are required. In the abbreviated method each floor is represented by one space and flow coefficients and net flows are all the same vertically. However, the abbreviated flow network input element also allows a number of specific exceptions to this simple model.

Element 7, FIND F data, is used for a FIND F run type. Element 8, INPUT2 data, is used to modify the existing data for another analysis. In the following sections the input required for each of the eight data elements is described in detail. Each block or group of blocks below represent an input card. Unless otherwise stated these cards are unformatted, that is the numbers do not have to be placed in specific columns of the card. However, separate pieces of numerical data must be separated by one or more spaces. Examples of input data are provided in Appendix B.

1. Initial data

run type[1] either RUN, RUN 1, TEST, or FIND F (col. 1-6 must start in col. 1)

project title (col. 1-72)

outside temperature (°C,°F)	unit indication (1 for SI, 2 for Eng)	summary output (0 for none, or file number)[2]

2. Building heights

N_h, no. of building levels	input parameter (either 0 or 1)

If input parameter = 0, then heights for each building level are to be individually inputed as follows:

$h_{(1)}$	$h_{(2)}$	$h_{(3)}$		$h_{(i)}$		$h_{(N_h)}$
			° ° °		° ° °	

where $H_{(i)}$ is the height of the center of level i above the ground (m, ft).

If input parameter = 1, then the following card must be entered.

$h_{(1)}$	distance between floors (m, ft)

3. Temperature profiles

no. of temperature profiles

---

[1] All net flows are inputed at standard conditions of 21°C (70°F) and 1 atmosphere.

[2] The user must assign this file before program execution.

For each temperature profile the following data must be supplied.

no. of temp. points	level no.	temperature (°C, °F)	level no.	temperature (°C, °F)		level no.	temperature (°C, °F)
					∘ ∘		

4. Outside pressure profiles

N_{po} no. of outside pressure profiles	input parameter (either 0 or 1)

If the input parameter = 0, each outside pressure profile is entered as follows:

$P_{o(1)}$	$P_{o(2)}$	$P_{o(3)}$		$P_{o(i)}$		$P_{o(N_h)}$
			∘ ∘ ∘		∘ ∘ ∘	

where $P_{o(i)}$ is the outside pressure at level i.

If the input parameter = 1, the outside pressures are calculated and the following data are required.

V_o wind velocity	h_o height at which velocity is measured	n wind exponent

pressure coefficients for each pressure profile

$C_{W(1)}$	$C_{W(2)}$		$C_{W(Npo)}$
		∘ ∘ ∘ ∘	

5. General flow network input

5.1 General building data

N no. of building compartments	input parameter (0 signals non-abbreviated input)
	0

For each compartment the following data must be supplied.

N_c no. of connections to other spaces	N_o no. of connections to the outside	F_f net flow (ℓ/s, cfm)	temperature profile number	compartment level

For each connection between this compartment and other spaces in the building the following connection data are required.

number of connected space	C_o flow coefficient[3]	χ flow exponent

For each connection to the outside the following connection data are required.

outside pressure profile number	C_o flow coefficient	χ flow exponent

5.2 General shaft data

no of shafts

---

[3] All flow coefficients are entered for standard conditions of 21°C (70°F) and 1 atmosphere. The units for all flow coefficients are $\ell s^{-1}(Pa)^{1-\chi}$ or cfm $("H_2O)^{1-\chi}$.

For each shaft the following data are required.

shaft title (col 1-18)

C_s shaft flow coefficient	bottom level of shaft	top level of shaft	temperature profile number

For each level of this shaft the following data are required.

N_c no. of connections to other spaces	N_o no. of connections to the outside	F_f net mass flow (ℓ/s, cfm)

For each connection between this level of the shaft and other building spaces the following data are required.

no. of other spaces	C_o flow coefficient	χ flow exponent

For each connection between this level of the shaft and the outside the following data are required.

outside pressure profile number	C_o flow coefficient	χ flow exponent

6. Abbreviated flow network input

6.1 Specific building data

N no. of floors in building	input parameter (1 signals abbreviated input)
	1

The following data are entered only once because it is the same for all floors of the building except at locations where specific exceptions are defined.

N_o no. of connections to the outside	no. of the temperature profile	C_o flow coefficient through floors	χ flow exponent through floors	no. of exceptions

For each connection to the outside the following data is required.

outside pressure profile number	C_o flow coefficient	χ flow exponent

For each exception the following data is required.

exception type (1, 2 or 3)	building level for the exception

The next card depends upon the exception type. For exception type = 1, a net flow is defined for this building level.

F_f net flow for building level (ℓ/s, cfm)

For exception type = 2, an exception to an outside connection is defined.

no. of outside pressure profile	C_o flow coefficient	χ flow exponent

For exception type = 3, a new compartment is added at the building level. In this case the following cards are needed to define this new compartment.

C_o flow coefficient between new compartment and rest of the floor	χ flow exponent	N_o no. of connections to the outside

Each of the outside connections is defined as follows.

outside pressure profile number	C_o flow coefficient	χ flow exponent

6.2 Specific shaft data

no. of shafts

For each shaft the following data are required.

shaft title (col 1-18)

C_s shaft flow coefficient	bottom level of shaft	top level of shaft	temperature profile number

The following data are entered only once because it is the same for each level of the shaft except at locations where specific exceptions are defined.

N_o no. of connections to the outside	F_f net mass flow (ℓ/s, cfm)	C_o flow coefficient to building	flow exponent	no. of exceptions

For each outside connection the following data are required.

outside pressure profile number	C_o flow coefficient	χ flow exponent

For each exception the following data are required.

exception type (1, 2 or 3)	level of shaft

The next card depends upon the exception type. For exception type = 1, an exception is defined to the net flow into the level of the shaft.

F_f net mass flow (ℓ/s, cfm)

For exception type = 2, an exception is defined to the outside connection for this shaft.

outside pressure profile number	C_o flow coefficient	χ flow exponent

For exception type = 3, an exception is defined to the flow coefficient between the shaft and the building.

C_o flow coefficient

7. FIND F input.

For a FIND F run type the following data is required.

shaft number	level of shaft	desired differential pressure across shaft	convergence limit

8. INPUT2 data

This routine is used to modify the existing data for a rerun.

N_m no. of modifications

If N_m = 900, program execution is stopped.

For each modification the following data are entered.

modification type	IS Integer	B real number

For modification type = 1, the net flow (F_f = B) at each level of shaft, IS, is changed.

For modification type = 2, the flow coefficient (C_o = B) between each level of shaft IS and the building is modified.

For modification type = 3, the flow coefficient (C_o = B) to the outside is changed for each outside connection from shaft IS. However, if IS = 0, then the flow coefficient for each outside connection from all building compartments is modified.

For modification type = 4, the flow coefficient (C_o = B) between two spaces (IS and JS) is changed. In addition to the modification type, IS and B the second space number is entered on the next line.

JS
second space
number

APPENDIX B. INPUT EXAMPLES

APPENDIX B. INPUT EXAMPLES

1. Example 1

A ten story building with a pressurized stairwell and no vertical leakage within the building is heated to 70°F when the outside temperature is -20°F. The stairwell temperature is 60°F at the tenth floor and 50°F at the bottom floor. The stairwell is pressurized by a net 400 cfm* per floor. The wind is 30 mph at a height of 30 ft and the wind exponent is 0.14. This building has connections to the outside in two directions. The flow coefficients are the same vertically and are listed in table B1 and the flow exponents are expected to be 0.5.

Connection location	C_o, flow coefficients* cfm per $\sqrt{"H_2O}$
Between stairwell & building	900
Between building & outside into the wind	800
Between building & outside away from the wind	800

Table B1. Flow coefficients for example 1.

1.1 General Input

In the general flow network input the building compartments can be located on any floor and there can be any number of compartments per floor. In this case there is only one compartment per floor so the floor levels are chosen to agree with the compartment numbers.

Therefore, space 1 through 10 refer to floors 1 through 10 and spaces 11 through 20 refer to the spaces in the stairshaft. Connections between two spaces only need to be defined for one of the spaces. In this example the connections between the building and the shaft are all defined for the shaft spaces.

---

[*] At standard conditions

```
              RUN
initial       EXAMPLE OF GENERAL FLOW NETWORK INPUT
data          -20   2   0

building       10   1
heights         5  10

temperature     2
profiles        1   1  70
                2   1  60   1   50

outside         2   1
pressure       30  30 .15
profiles      0.7 -0.7

General
building
data             10    0

      1st        0     2     0     1     1
      floor      1   800    .5
                 2   800    .5

      2nd        0     2     0     1     2
      floor      1   800    .5
                 2   800    .5

      3rd        0     2     0     1     3
      floor      1   800    .5
                 2   800    .5

      4th        0     2     0     1     4
      floor      1   800    .5
                 2   800    .5

      5th        0     2     0     1     5
      floor      1   800    .5
                 2   800    .5

      6th        0     2     0     1     6
      floor      1   800    .5
                 2   800    .5

      7th        0     2     0     1     7
      floor      1   800    .5
                 2   800    .5

      8th        0     2     0     1     8
      floor      1   800    .5
                 2   800    .5

      9th        0     2     0     1     9
      floor      1   800    .5
                 2   800    .5

      10th       0     2     0     1     10
      floor      1   800    .5
                 8   800    .5
```

```
General
shaft
data                          1

                              STAIRWELL
                              72000      1     10     2

               1st            1     0   400
               floor          1   900    .5

               2nd            1     0   400
               floor          1   900    .5

               3rd            1     0   400
               floor          1   900    .5

               4th            1     0   400
               floor          1   900    .5

               5th            1     0   400
               floor          1   900    .5

               6th            1     0   400
               floor          1   900    .5

               7th            1     0   400
               floor          1   900    .5

               8th            1     0   400
               floor          1   900    .5

               9th            1     0   400
               floor          1   900    .5

               10th           1     0   400
               floor          1   900    .5

               end            900
               data
```

1.2 Abbreviated Input

This problem can also be solved by use of the abbreviated flow network input. This reduces the quantity of data required and to that extent reduces the chance of input error. The abbreviated data is as follows:

```
               initial    RUN
               data       EXAMPLE OF ABBREVIATED FLOW NETWORK DATA
                          -20     2     0

             building       10     1
             heights         5    10

           temperature       2
           profiles          1     1    70
                             2     1    60     1    50
```

```
outside       {  2     1
pressure      { 30    30   .15
profiles      {0.7  -0.7

abbreviated   { 10     1
building      {  2     1     0    .5     0
data          {  1   800    .5
              {  2   800    .5

abbreviated   {  1
shaft         {  STAIRWELL
data          {  72000     1    10     2
              {  0   400   900    .5     0

end           {  900
data
```

1.3 Example 1 Output

The output for this example is the same for both these forms of input. This example output is given in appendix C.

2. EXAMPLE 2

This is a 30 story building which is 70°F inside. The outside the air temperature is -5°F and there is no wind. This building has a stairwell and an elevator. The flow coefficients which are generally the same vertically are listed in table B2 and the flow exponents are taken to be 0.5.

Connection location	C_o flow coefficient* cfm per $\sqrt{"H_2O}$
Between stairwell & building	900
Between building & outside	1600
Between elevator & building	1600

Table B2. Flow coefficients for example 2.

---

*At standard conditions

In this example a total of four separate cases are analyzed. These cases are:

1. First floor outside door open.
2. First floor outside door closed.
3. First floor door between the elevator and the building open.
4. Stairwell pressurized at a rate of 900 cfm* per floor and all doors closed.

2.1 Example 2 - Input

The last three cases are handled by the use of the INPUT2 routine. The data are as follows:

```
                            RUN
                initial     EXAMPLE INPUT -- 30 STORY BUILDING
                data        -5     2     0

               building     30     1
               heights       5    10

            temperature      1
            profile          1     1    70

                outside      1     1
               pressure      0     1     1
                data         1

           abbreviated      30     1
           building          1     1     0     0     1
           data              1  1600    .5
                             2     1
                             1  25000 .5

                                2
Abbreviated           shaft 1   STAIRWELL
Shaft Data                      72000     1      30     1
                                0     0     900     .5     0

                      shaft 2   ELEVATOR
                                80000     1      30     1
                                0     0    1600     .5     0

                  Case 2:
             modification       1
             type 3             3     0    1600
```

---

*At standard conditions

Case 3: *modification type 4*	1		
	4	1	25000
	31		
Case 4: *modification types 2 and 1*	2		
	2	1	900
	1	1	400
end data	900		

2.2 Example 2 Output

The output for example 2 case 1 (the data above not including modifications for Case 2, 3 and 4) is given in appendix C.

APPENDIX C. EXAMPLE OUTPUT

```
AIR FLOW MODEL
EXAMPLE 1 DATA  --  10 STORY BUILDING


                        TEMPERATURE   FIXED                          FLOW        FLOW       FLOW
COMPARTMENT    FLOOR      PROFILE     FLOW    CONNECTION TO     COFFICIENT    EXPONENT     SCFM

     1           1           1          .0    POINT      11       900.0          .5        393.2
                                              OUTSIDE     1       800.0          .5        118.5
                                              OUTSIDE     2       800.0          .5       -511.5
                                                                                              .2 NET

     2           2           1          .0    POINT      12       900.0          .5        374.9
                                              OUTSIDE     1       800.0          .5        211.0
                                              OUTSIDE     2       800.0          .5       -585.7
                                                                                              .2 NET

     3           3           1          .0    POINT      13       900.0          .5        375.6
                                              OUTSIDE     1       800.0          .5        249.9
                                              OUTSIDE     2       800.0          .5       -625.3
                                                                                              .2 NET

     4           4           1          .0    POINT      14       900.0          .5        381.3
                                              OUTSIDE     1       800.0          .5        273.1
                                              OUTSIDE     2       800.0          .5       -654.2
                                                                                              .2 NET

     5           5           1          .0    POINT      15       900.0          .5        389.1
                                              OUTSIDE     1       800.0          .5        288.7
                                              OUTSIDE     2       800.0          .5       -677.6
                                                                                              .2 NET

     6           6           1          .0    POINT      16       900.0          .5        397.9
                                              OUTSIDE     1       800.0          .5        299.8
                                              OUTSIDE     2       800.0          .5       -697.5
                                                                                              .2 NET

     7           7           1          .0    POINT      17       900.0          .5        407.4
                                              OUTSIDE     1       800.0          .5        307.9
                                              OUTSIDE     2       800.0          .5       -715.0
                                                                                              .2 NET

     8           8           1          .0    POINT      18       900.0          .5        417.0
                                              OUTSIDE     1       800.0          .5        313.9
                                              OUTSIDE     2       800.0          .5       -730.8
                                                                                              .2 NET

     9           9           1          .0    POINT      19       900.0          .5        426.9
                                              OUTSIDE     1       800.0          .5        318.4
                                              OUTSIDE     2       800.0          .5       -745.1
                                                                                              .2 NET

    10          10           1          .0    POINT      20       900.0          .5        436.7
                                              OUTSIDE     1       800.0          .5        321.8
                                              OUTSIDE     2       800.0          .5       -758.3
```

```
      STAIRWELL
               FIXED                                 FLOW             FLOW          FLOW
      FLOOR     FLOW      CONNECTED TO          COFFICIENT         EXPONENT         SCFM

        1      400.0      POINT     1              900.0              .5          -393.2
        2      400.0      POINT     2              900.0              .5          -374.9
        3      400.0      POINT     3              900.0              .5          -375.6
        4      400.0      POINT     4              900.0              .5          -381.3
        5      400.0      POINT     5              900.0              .5          -389.1
        6      400.0      POINT     6              900.0              .5          -397.9
        7      400.0      POINT     7              900.0              .5          -407.3
        8      400.0      POINT     8              900.0              .5          -417.0
        9      400.0      POINT     9              900.0              .5          -426.9
       10      400.0      POINT    10              900.0              .5          -436.7
                                                                                      -.0 NET

      FLOWS IN CFM AT 70 DEG F AND 1 ATMOSPHERE


 EXAMPLE 1 DATA   --   10 STORY BUILDING

 DIFFERENTIAL PRESSURE ACROSS SHAFTS (IN H2O)

 FLOOR   STAIRWELL
          INDOOR     OUTDR.


  10       .227       .092
   9       .217       .085
   8       .208       .080
   7       .198       .076
   6       .190       .073
   5       .182       .074
   4       .175       .078
   3       .170       .089
   2       .170       .112
   1       .187       .169


      PRESSURES   (IN H2O)

   I     P          I     P          I     P          I     P          I     P          I     P          I     P          I     P

   1  2.674         2  2.545         3  2.397         4  2.244         5  2.090         6  1.933         7  1.776         8  1.618
   9  1.460        10  1.301
      STAIRWELL
  11  2.862        12  2.715        13  2.567        14  2.419        15  2.271        16  2.123        17  1.975        18  1.826
  19  1.677        20  1.527
```

```
AIR FLOW MODEL
EXAMPLE 2 DATA  --   30 STORY BUILDING


                           TEMPERATURE    FIXED                          FLOW          FLOW        FLOW
COMPARTMENT     FLOOR        PROFILE      FLOW    CONNECTION TO        COFFICIENT    EXPONENT      SCFM

      1           1             1           .0    POINT      31          900.0          .5       -506.0
                                                  POINT      61         1600.0          .5       -915.7
                                                  OUTSIDE     1        25000.0          .5       1421.9
                                                                                                    .2 NET

      2           2             1           .0    POINT      32          900.0          .5       -270.5
                                                  POINT      62         1600.0          .5       -510.4
                                                  OUTSIDE     1         1600.0          .5        781.2
                                                                                                    .3 NET

      3           3             1           .0    POINT      33          900.0          .5       -258.9
                                                  POINT      63         1600.0          .5       -490.6
                                                  OUTSIDE     1         1600.0          .5        749.6
                                                                                                    .1 NET

      4           4             1           .0    POINT      34          900.0          .5       -246.8
                                                  POINT      64         1600.0          .5       -469.9
                                                  OUTSIDE     1         1600.0          .5        716.8
                                                                                                    .1 NET

      5           5             1           .0    POINT      35          900.0          .5       -234.1
                                                  POINT      65         1600.0          .5       -448.2
                                                  OUTSIDE     1         1600.0          .5        682.6
                                                                                                    .2 NET

      6           6             1           .0    POINT      36          900.0          .5       -221.0
                                                  POINT      66         1600.0          .5       -425.3
                                                  OUTSIDE     1         1600.0          .5        646.6
                                                                                                    .2 NET

      7           7             1           .0    POINT      37          900.0          .5       -207.3
                                                  POINT      67         1600.0          .5       -401.0
                                                  OUTSIDE     1         1600.0          .5        608.5
                                                                                                    .3 NET

      8           8             1           .0    POINT      38          900.0          .5       -192.8
                                                  POINT      68         1600.0          .5       -375.1
                                                  OUTSIDE     1         1600.0          .5        568.1
                                                                                                    .3 NET

      9           9             1           .0    POINT      39          900.0          .5       -177.4
                                                  POINT      69         1600.0          .5       -347.1
                                                  OUTSIDE     1         1600.0          .5        524.8
                                                                                                    .3 NET

     10          10             1           .0    POINT      40          900.0          .5       -160.8
                                                  POINT      70         1600.0          .5       -316.5
                                                  OUTSIDE     1         1600.0          .5        477.6
```

```
11     11     1     .0   POINT     41    900.0      .5     -142.7
                         POINT     71   1600.0      .5     -282.6
                         OUTSIDE    1   1600.0      .5      425.4
                                                               .0 NET

12     12     1     .0   POINT     42    900.0      .5     -122.2
                         POINT     72   1600.0      .5     -243.7
                         OUTSIDE    1   1600.0      .5      366.2
                                                               .2 NET

13     13     1     .0   POINT     43    900.0      .5      -97.9
                         POINT     73   1600.0      .5     -197.3
                         OUTSIDE    1   1600.0      .5      295.5
                                                               .3 NET

14     14     1     .0   POINT     44    900.0      .5      -65.8
                         POINT     74   1600.0      .5     -135.6
                         OUTSIDE    1   1600.0      .5      201.5
                                                               .1 NET

15     15     1     .0   POINT     45    900.0      .5       29.1
                         POINT     75   1600.0      .5       44.5
                         OUTSIDE    1   1600.0      .5      -73.2
                                                               .4 NET

16     16     1     .0   POINT     46    900.0      .5       74.1
                         POINT     76   1600.0      .5      143.6
                         OUTSIDE    1   1600.0      .5     -217.3
                                                               .4 NET

17     17     1     .0   POINT     47    900.0      .5      100.9
                         POINT     77   1600.0      .5      198.0
                         OUTSIDE    1   1600.0      .5     -298.5
                                                               .3 NET

18     18     1     .0   POINT     48    900.0      .5      122.1
                         POINT     78   1600.0      .5      240.1
                         OUTSIDE    1   1600.0      .5     -362.0
                                                               .2 NET

19     19     1     .0   POINT     49    900.0      .5      140.5
                         POINT     79   1600.0      .5      275.8
                         OUTSIDE    1   1600.0      .5     -416.0
                                                               .2 NET

20     20     1     .0   POINT     50    900.0      .5      156.9
                         POINT     80   1600.0      .5      307.1
                         OUTSIDE    1   1600.0      .5     -463.9
                                                               .1 NET

21     21     1     .0   POINT     51    900.0      .5      172.0
                         POINT     81   1600.0      .5      335.5
                         OUTSIDE    1   1600.0      .5     -507.2
                                                               .3 NET

22     22     1     .0   POINT     52    900.0      .5      186.1
```

```
                                              POINT     82     1600.0         .5       361.4
                                              OUTSIDE    1     1600.0         .5      -547.2
                                                                                          .3 NET

     23       23        1          .0         POINT     53      900.0         .5       199.4
                                              POINT     83     1600.0         .5       385.5
                                              OUTSIDE    1     1600.0         .5      -584.6
                                                                                          .3 NET

     24       24        1          .0         POINT     54      900.0         .5       212.1
                                              POINT     84     1600.0         .5       408.0
                                              OUTSIDE    1     1600.0         .5      -619.8
                                                                                          .3 NET

     25       25        1          .0         POINT     55      900.0         .5       224.2
                                              POINT     85     1600.0         .5       429.2
                                              OUTSIDE    1     1600.0         .5      -653.1
                                                                                          .2 NET

     26       26        1          .0         POINT     56      900.0         .5       235.8
                                              POINT     86     1600.0         .5       449.3
                                              OUTSIDE    1     1600.0         .5      -684.9
                                                                                          .2 NET

     27       27        1          .0         POINT     57      900.0         .5       246.9
                                              POINT     87     1600.0         .5       468.4
                                              OUTSIDE    1     1600.0         .5      -715.3
                                                                                          .1 NET

     28       28        1          .0         POINT     58      900.0         .5       257.7
                                              POINT     88     1600.0         .5       486.8
                                              OUTSIDE    1     1600.0         .5      -744.4
                                                                                          .1 NET

     29       29        1          .0         POINT     59      900.0         .5       268.2
                                              POINT     89     1600.0         .5       504.5
                                              OUTSIDE    1     1600.0         .5      -772.4
                                                                                          .3 NET

     30       30        1          .0         POINT     60      900.0         .5       278.3
                                              POINT     90     1600.0         .5       521.5
                                              OUTSIDE    1     1600.0         .5      -799.5
                                                                                          .3 NET


   STAIRWELL
               FIXED                          FLOW            FLOW      FLOW
   FLOOR       FLOW     CONNECTED TO      COFFICIENT      EXPONENT      SCFM

     1          .0      POINT     1          900.0           .5        506.0
     2          .0      POINT     2          900.0           .5        270.5
     3          .0      POINT     3          900.0           .5        258.9
     4          .0      POINT     4          900.0           .5        246.8
     5          .0      POINT     5          900.0           .5        234.1
     6          .0      POINT     6          900.0           .5        221.0
     7          .0      POINT     7          900.0           .5        207.3
     8          .0      POINT     8          900.0           .5        192.8
```

```
   9       .0     POINT    9      900.0       .5      177.4
  10       .0     POINT   10      900.0       .5      160.8
  11       .0     POINT   11      900.0       .5      142.7
  12       .0     POINT   12      900.0       .5      122.2
  13       .0     POINT   13      900.0       .5       97.9
  14       .0     PCINT   14      900.0       .5       65.8
  15       .0     POINT   15      900.0       .5      -29.1
  16       .0     POINT   16      900.0       .5      -74.1
  17       .0     POINT   17      900.0       .5     -100.9
  18       .0     POINT   18      900.0       .5     -122.1
  19       .0     POINT   19      900.0       .5     -140.5
  20       .0     POINT   20      900.0       .5     -156.9
  21       .0     POINT   21      900.0       .5     -172.0
  22       .0     POINT   22      900.0       .5     -186.1
  23       .0     POINT   23      900.0       .5     -199.4
  24       .0     POINT   24      900.0       .5     -212.1
  25       .0     POINT   25      900.0       .5     -224.2
  26       .0     POINT   26      900.0       .5     -235.8
  27       .0     POINT   27      900.0       .5     -246.9
  28       .0     POINT   28      900.0       .5     -257.7
  29       .0     POINT   29      900.0       .5     -268.2
  30       .0     POINT   30      900.0       .5     -278.3
                                                          -.0 NET


ELEVATOR
         FIXED                       FLOW        FLOW      FLOW
FLOOR    FLOW     CONNECTED TO    COFFICIENT   EXPONENT    SCFM

   1       .0     POINT    1     1600.0       .5      915.7
   2       .0     POINT    2     1600.0       .5      510.4
   3       .0     POINT    3     1600.0       .5      490.6
   4       .0     POINT    4     1600.0       .5      469.9
   5       .0     POINT    5     1600.0       .5      448.2
   6       .0     PCINT    6     1600.0       .5      425.3
   7       .0     PCINT    7     1600.0       .5      401.0
   8       .0     POINT    8     1600.0       .5      375.1
   9       .0     PCINT    9     1600.0       .5      347.1
  10       .0     POINT   10     1600.0       .5      316.5
  11       .0     POINT   11     1600.0       .5      282.6
  12       .0     PCINT   12     1600.0       .5      243.7
  13       .0     POINT   13     1600.0       .5      197.3
  14       .0     POINT   14     1600.0       .5      135.6
  15       .0     POINT   15     1600.0       .5      -44.5
  16       .0     POINT   16     1600.0       .5     -143.6
  17       .0     POINT   17     1600.0       .5     -198.0
  18       .0     POINT   18     1600.0       .5     -240.1
  19       .0     POINT   19     1600.0       .5     -275.8
  20       .0     POINT   20     1600.0       .5     -307.1
  21       .0     PCINT   21     1600.0       .5     -335.5
  22       .0     PCINT   22     1600.0       .5     -361.4
  23       .0     POINT   23     1600.0       .5     -385.5
  24       .0     POINT   24     1600.0       .5     -408.0
  25       .0     POINT   25     1600.0       .5     -429.2
  26       .0     POINT   26     1600.0       .5     -449.3
  27       .0     POINT   27     1600.0       .5     -468.4
  28       .0     POINT   28     1600.0       .5     -486.8
```

```
      29          .0      POINT   29         1600.0          .5       -504.5
      30          .0      POINT   30         1600.0          .5       -521.5
                                                                          -.1 NET

      FLOWS IN CFM AT 70 DEG F AND 1 ATMOSPHERE


EXAMPLE 2 DATA  --  30 STORY BUILDING


DIFFERENTIAL PRESSURE ACROSS SHAFTS (IN H2O)


FLOOR  STAIRWELL           ELEVATOR
        INDOOR    OUTDR.    INDOOR    OUTDR.


 30      .096      .345      .106      .356
 29      .089      .322      .099      .333
 28      .082      .299      .093      .309
 27      .075      .275      .086      .286
 26      .069      .252      .079      .262
 25      .062      .229      .072      .239
 24      .056      .206      .065      .215
 23      .049      .183      .058      .192
 22      .043      .160      .051      .168
 21      .037      .137      .044      .145
 20      .030      .114      .037      .121
 19      .024      .092      .030      .097
 18      .018      .070      .023      .074
 17      .013      .047      .015      .050
 16      .007      .025      .008      .027
 15      .001      .003      .001      .003
 14     -.005     -.019     -.007     -.021
 13     -.012     -.041     -.015     -.044
 12     -.018     -.063     -.023     -.068
 11     -.025     -.086     -.031     -.092
 10     -.032     -.108     -.039     -.116
  9     -.039     -.131     -.047     -.139
  8     -.046     -.154     -.055     -.163
  7     -.053     -.177     -.063     -.187
  6     -.060     -.201     -.071     -.211
  5     -.068     -.224     -.078     -.235
  4     -.075     -.248     -.086     -.259
  3     -.083     -.271     -.094     -.283
  2     -.090     -.295     -.102     -.306
  1     -.316     -.319     -.328     -.330


      PRESSURES  (IN H2O)

  I    P         I    P         I    P         I    P         I    P         I    P         I    P         I    P

  1  5.242       2  4.872       3  4.720       4  4.568       5  4.417       6  4.265       7  4.114       8  3.962
  9  3.810      10  3.659      11  3.507      12  3.356      13  3.204      14  3.053      15  2.902      16  2.751
```

```
17  2.600    18  2.450    19  2.300    20  2.149    21  1.999    22  1.849    23  1.699    24  1.549
25  1.399    26  1.250    27  1.100    28   .951    29   .801    30   .652
     STAIRWELL
31  4.926    32  4.781    33  4.637    34  4.493    35  4.349    36  4.205    37  4.061    38  3.916
39  3.772    40  3.627    41  3.482    42  3.337    43  3.193    44  3.048    45  2.903    46  2.758
47  2.613    48  2.468    49  2.324    50  2.180    51  2.036    52  1.892    53  1.748    54  1.605
55  1.461    56  1.318    57  1.175    58  1.033    59   .890    60   .747
     ELEVATOR
61  4.914    62  4.770    63  4.626    64  4.482    65  4.338    66  4.195    67  4.051    68  3.907
69  3.763    70  3.620    71  3.476    72  3.333    73  3.189    74  3.046    75  2.902    76  2.759
77  2.616    78  2.472    79  2.329    80  2.186    81  2.043    82  1.900    83  1.757    84  1.614
85  1.471    86  1.329    87  1.186    88  1.043    89   .901    90   .758
```

APPENDIX D. PROGRAM LISTING

APPENDIX D. PROGRAM LISTING

* MAIN PROGRAM

```
@NBS*PLIB$.SHOW     A.MAIN
C
C     COMPUTER PROGRAM FOR AIR FLOW ANALYSIS IN BUILDINGS
C      SPECIFICALLY FOR ANALYSIS OF PRESSURIZED STAIRWELLS
C       AND PRESSURIZED ELEVATORS
C
C
C     PROGRAM VARIABLES
C     C       FLOW COEFFICIENT BETWEEN BUILDING POINTS
C     CO      FLOW COEFFICIENT TO OUTSIDE
C     CS      FLOW COEFFICIENT OF SHAFT
C     E       LIMIT WITHIN WHICH CONVERGENCE IS ACCEPTABLE
C     F       NET FLOW INTO POINT I
C     FC      FLOW BETWEEN INTERNAL POINTS
C     FF      FIXED FLOW INTO POINT I
C     FO      FLOW TO OUTSIDE
C     FSS     NET FLOW INTO SHAFT IS
C     H       HEIGHT FROM GROUND TO MIDPOINT OF FLOOR
C     IBUG    OUTPUT VARIABLE
C     ICONV   INTEGER USED IN SUBROUTINES BLDGP AND SHAFTP
C             IF ICONV = 0 THEN  THE PRESSURES WERE UNCHANGED
C     IFLOOR FLOOR LEVEL WHERE POINT IS LOCATED
C     IT      POINTER TO TEMP PROFILE FOR POINT I
C     ITS     POINTER TO TEMPERATURE PROFILE OF SHAFT
C     JC      POINT NO. CONNECTED TO POINT I
C     JOC     DIRECTION OF OUTSIDE CONNECTION
C     N       NO. OF BUILDING COMPARTMENTS
C     NC      NO. OF INTERNAL POINTS CONNECTED TO POINT I
C     NCO     NO. OF OUTSIDE CONNECTIONS
C     NFS1    BOTTOM FLOOR OF SHAFT
C     NFS2    TOP FLOOR OF SHAFT
C     NH      NO. OF FLOORS
C     NPO     NO. OF OUTSIDE PRESSURE PROFILES
C     NS      NO. OF SHAFTS
C     NS1     I VALUE FOR START OF SHAFT
C     NS2     I VALUE FOR END OF SHAFT
C     NT      TOTAL NO. OF POINTS (BLDG AND SHAFT)
C     NTP     NO. OF TEMPERATURE PROFILES
C     P       PRESSURE AT POINT I
C     PFO     OUTSIDE PRESSURE PROFILES
C     PO      OUTSIDE PRESSURE
C     PS      PRESSURE PROFILE OF SHAFT - WORKSPACE
C     PZ      PRESSURE DUE TO ELEVATION DIFFERENCE
C     T       TEMPERATURE PROFILE ARRAY
C     TITLE   PROJECT TITLE
C     TITSH   SHAFT TITLE
C     X       FLOW EXPONENT TO INTERIOR POINTS
C     XO      FLOW EXPONENT TO OUTSIDE
C
C
C     PROGRAM PARAMETERS
C     MB      MAX NO. OF BUILDING COMPARTMENTS
C     MM      MAX NO. OF POINTS
C     MS      MAX NO. OF SHAFTS
C     MC      MAX NO. OF CONNECTIONS FOR ANY POINT
C     MPO     MAX NO. OF OUTSIDE PRESSURE PROFILES
C     MTP     MAX NO. OF TEMPERATURE PROFILES
```

```
*                           MAIN PROGRAM

C     MFL    MAX NO. OF FLOORS
C
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON NT,   P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      COMMON /RUN/IRUN
      DATA MRUN/6HRUN   /
      DATA MRUN1/6HRUN1  /
      DATA NTEST/6HTEST  /
      DATA NFINDF/6HFIND F/
C
C
C       READ ITEST TO DETERMINE RUN TYPE
C       ITEST = RUN  FOR NORMAL RUN
C       ITEST = RUN1 FOR A NORMAL RUN OF 1ST DATA AND
C              A TEST OF ALL OTHER DATA
C       ITEST =TEST FOR A TEST RUN OF ALL DATA
C       ITEST = FIND F  TO FIND FIXED FLOW ,FF, FOR A SET PRESSURE
C              ACROSS A FLOOR OF A SHAFT
C
      READ(5,804)ITEST
      NITER=500
      IRUN=1
C
C       CALL INPUT TO READ DATA
C
      CALL INPUT
C
C       SET UP FOR FIND F RUN TYPE
C       IS = SHAFT NO.
C       IF = FLOOR NO,
C       DPS = SET PRESSURE ACROSS SHAFT IS AT FLOOR IF
C       EDP = ALLOWABLE CONVERGENCE LIMIT
C
      IF(ITEST .NE. NFINDF)GO TO 10
      READ(5,700)IS,IF,DPS,EDP
      IDP=NS1(IS)+IF-1
      JDF=JC(IDP,1)
      IQ=0
      N1=NS1(IS)
      N2=NS2(IS)
      WRITE(6,807)IS,IF,DPS,EDP
10    E=0.2
20    ICS=1
      IF(ITEST .EQ. NTEST)GO TO 41
      IF(IRUN .GT. 1 .AND. ITEST .EQ. MRUN1)GO TO 41
C
C       TEMPERATURE CORRECTION
C
      CALL CORR
C
C       CALL INIT TO INITIALIZE PRESSURE ARRAY , P
```

```
*                                 MAIN PROGRAM
C
22    CALL INIT
C
C
C       DO LOOP TO 30 IS ITERATIVE SOLUTION TO PRESSURE ARRAY
C
24    DO 30 ITER=1,NITER
C
C       CALL BLDGP TO SOLVE FOR BUILDING PRESSURES
C
      CALL BLDGP
      ICB=ICONV
      IF(ICB .EQ. 0 .AND. ICS .EQ. 0)GO TO 40
C
C       CALL SHAFTP TO SOLVE FOR SHAFT PRESSURES
C
      CALL SHAFTP
      ICS=ICONV
      IF(ICB .EQ. 0 .AND. ICS .EQ. 0)GO TO 40
C
C       CALL PZAD TO CALCULATE PZ TERMS
C
      CALL PZAD
30    CONTINUE
C
C       IF ROUTINE FAILS TO CONVERGE IN NITER
C       ITERATIONS PRINT ERROR MESSAGE
C
      WRITE(6,800)
40    CONTINUE
      WRITE(6,801)ITER
C
C       GC TO 50 FOR FIND F RUN TYPE
C
      IF(ITEST .EQ. NFINDF)GO TO 50
C
C
C       CALL OUT TO OUTPUT SOLUTION
C
42    CALL OUT
      IF(ITEST .EQ. NFINDF)WRITE(6,806)IS,FM
41    IF(ITEST .EQ. MRUN)WRITE(6,805)
C
C       CALL INPUT2 TO CHECK IF ANOTHER RUN IS REQUIRED
C       WITH MODIFIED DATA
C
      CALL INPUT2
      IF(ITEST .NE. NFINDF)GO TO 20
C
C       ZERO FF FOR SHAFT IS FOR 1ST ITERATION OF A NEW FIND F RUN TYPE
C
      DO 44 I=N1,N2
      FF(I)=0.
44    CONTINUE
      IQ=0
      GO TO 20
C
C
```

```
C         SELECTION OF NEW FIXED FLOW , FM , FOR FIND F RUN TYPE
C
50      DPM=P(IDP)-P(JDP)-DPS
        IQ=IQ+1
        IF(IQ .GT. 30)GO TO 42
        IF(IBUG .EQ. 0)GO TO 52
        WRITE(6,901)DPM,DP1,DP2,F1,F2,IDP,JDP
C
C         CHECK CONVERGENCE OF DIFFERENTIAL PRESSURE , DPM
C
52      IF(ABS(DPM) .LT. EDP)GO TO 42
        IF(IQ .NE. 1)GO TO 51
        DP1=DPM
        F1=0.
        FM=500.
        GO TO 58
51      IF(IQ .NE. 2)GO TO 53
        IF(DPM .LT. 0.)GO TO 42
        GO TO 54
53      IF(DPM*DP1 .GT. 0.)GO TO 56
54      DP2=DPM
        F2=FM
        FM=SQRT((F1*F1)-DP1*(F2*F2-F1*F1)/(DP2-DP1))
        GO TO 58
56      DP1=DPM
        F1=FM
        FM=SQRT((F1*F1)-DP1*(F2*F2-F1*F1)/(DP2-DP1))
C
C         ASSIGN FM TO FF FOR SHAFT IS
C
58      DO 59 I=N1,N2
59      FF(I)=FM
        IF(IBUG .EQ. 0)GO TO 60
        WRITE(6,900)FM
60      ICS=1
        IF(IQ .GT. 3)GO TO 24
        GO TO 22
C
C         END OF SELECTION OF NEW FF FOR FIND F RUN TYPE
C
C
C        FORMAT STATEMENTS
C
700     FORMAT( )
800     FORMAT(/////5X,35(1H1)//5X,
       +35HFAILURE OF MAIN PROGRAM TO CONVERGE  //5X,35(1H1)//)
801     FORMAT(    10X,I5,5X,11HITERATIONS    )
804     FORMAT(A6)
805     FORMAT(1H1)
806      FORMAT(10X,20HFIXED FLOW IN SHAFT  ,I2,3H IS,F8.2/1H1)
807     FORMAT(10(/),10X,28HRUN TO DETERMINE FIXED FLOW  ,
       1 18HPER FLOOR IN SHAFT  ,I2/10X,
       2 41HSO THAT THE PRESSURE DIFFERENCE AT FLOOR  ,I3,
       3 3H IS,F8.2,7H PASCAL/10X,28HWITH A CONVERGENCE LIMIT OF  ,
       4 F8.5,7H PASCAL,10(/))
808     FORMAT(10X,10HNET FLOWS   //8(6X,1HI,4X,3HNF )/)
809     FORMAT(/10X,15HNET FLOW SHAFT   ,I3,3H IS,F6.1)
900     FORMAT(10X,4HFM =,F10.2)
```

```
*                                        MAIN PROGRAM

901    FORMAT(//10X,5HDPM =,E12.4,2X,5HDP1 =,E12.4,2X,5HDP2 =,E12.4
     + /10X,4HF1 =,E12.4,2X,4HF2 =,E12.4,2X,5HIDP =,I4,2X,5HJDP =,I4)
       END

@HDG,P *                                          SUBROUTINE INPUT     .L,1
```

*   SUBROUTINE INPUT

```
@NBS*PLIB$.SHOW     A.INPUT
      SUBROUTINE INPUT
C
C       THIS ROUTINE READS AND PRINTS DATA
C         AND INITIALIZES PZ ARRAY
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON /PZZ/ PGZ
      COMMON  /IO/TITLE(12),IOUT,IUNIT,NCOMP(MFL),SNCOMP(MFL)
      COMMON NT,   P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      DIMENSION II(MFL),TT(MFL),PAR(7),CW(MPO),PH(MFL),NZZ(MM)
      DATA  PAR/3H MM,3H MS,3H MC,3HMPO,3HMTP,3HMFL,3H MB/
      DATA   IBUG/0/
C
C         READ AND WRITE PROJECT TITLE
C
      READ(5,600)(TITLE(I),I=1,12)
      WRITE(6,601)(TITLE(I),I=1,12)
C
C
C         READ GENERAL DATA
C
C
C         TOUT = OUTSIDE TEMPERATURE
C         IUNIT = 1 FOR SI UNITS
C               = 2 FOR ENG UNITS
C         IOUT = 0 FOR NO SUMMARY OUTPUT
C         OTHERWISE IOUT IS FILE NO. TO
C         WHICH SUMMARY OUTPUT IS WRITTEN
C
      READ(5,700)TOUT,IUNIT,IOUT
      WRITE(6,411)TOUT,IUNIT,IOUT
      IF(IUNIT .GT. 2 .OR. IUNIT .LT. 1)GO TO 105
C
C         READ HEIGHTS
C         NN=0 FOR INPUT OF ALL HEIGHTS
C         NN=1 FOR CALCULATION OF HEIGHTS
C
      READ(5,700)NH,NN
      WRITE(6,412)NH,NN
      IF(NH .LE. MFL)GO TO 89
      IPAR=6
      GO TO 110
89    IF(NN .EQ. 1)GO TO 97
      READ(5,700)(H(I),I=1,NH)
      WRITE(6,413)(H(I),I=1,NH)
      GO TO 99
97    READ(5,700)H(1),DH
      WRITE(6,414)H(1),DH
      DO 98 I=2,NH
      IM=I-1
```

```
98    H(I)=H(IM)+DH
C
C       READ TEMPERATURE PROFILES
C
99    READ(5,700)NTP
      WRITE(6,415)NTP
      IF(NTP .LE. MTP)GO TO 90
      IPAR=5
      GO TO 110
90    DO 3 IP=1,NTP
      READ(5,700)NNN,(II(J),TT(J),J=1,NNN)
      WRITE(6,416)NNN,(II(J),TT(J),J=1,NNN)
      IF(NNN .GT. 1)GO TO 2
      DO 1 IFF=1,NH
1     T(IP,IFF)=TT(1)
      GO TO 3
2     J=1
      JP1=2
      DO 4 IFF=1,NH
      T(IP,IFF)=TT(J)+(TT(JP1)-TT(J))*(IFF-II(J))/(II(JP1)-II(J))
      IF(IFF .NE. II(JP1))GO TO 4
      IF(JP1 .EQ. NNN)GO TO 4
      J=JP1
      JP1=J+1
4     CONTINUE
3     CONTINUE
C
C
C       READ OUTSIDE PRESSURE PROFILES
C       NN=0 FOR INPUT OF ALL PRESSURES
C       NN=1 FOR CALCULATION BY POWER LAW
C
      READ(5,700)NPO,NN
      WRITE(6,417)NPO,NN
      IF(NPO .LE. MPO)GO TO 91
      IPAR=4
      GO TO 110
91    IF(NN .EQ. 1)GO TO 81
C
C       READ ALL OUTSIDE PRESSURES
C
      DO 6 I=1,NPO
6     READ(5,700) PGZ,(PFO(J,I),J=1,NH)
      WRITE(6,418)PGZ,(PFO(J,I),J=1,NH)
      GO TO 85
C
C       CALCULATE OUTSIDE PRESSURES
C       PATMOS IS ATMOSPHERIC PRESSURE (PA)
C
81    READ(5,700)VW,HW,XW,(CW(I),I=1,NPO)
      WRITE(6,419)VW,HW,XW,(CW(I),I=1,NPO)
      IF(IUNIT .EQ. 1)VW=VW*0.2778
      IF(IUNIT .EQ. 2)VW=VW*0.4470
      PATMOS=101325.
      TOO=TOUT+273.
      IF(IUNIT .EQ. 2)TOC=(TOUT+460.)/1.8
      PVA=176.4*VW*VW/TOO
      Z=-0.03417/TOO
```

```
      IF(IUNIT .EQ. 2)Z=0.3048*Z
      CWM=CW(1)
      IF(NPO .EQ. 1)GO TO 212
      DO 211 I=1,NPO
      IF(CW(I) .LT. CWM)CWM=CW(I)
211   CONTINUE
212   PGZ=PATMOS*EXP(H(NH)*Z)+CWM*PVA*((H(NH)/HW)**(2.*XW))-100.
      DO 210 I=1,NH
      PH(I)=PATMOS*EXP(H(I)*Z)
210   CONTINUE
      DO 82 I=1,NPO
      DO 82 J=1,NH
      PFO(J,I)=PH(J)+CW(I)*PVA*((H(J)/HW)**(2.*XW))-PGZ
82    CONTINUE
C
C
C         BUILDING DATA INPUT
C       NFLS = NO. OF FLOORS IN BUILDING
C       IF1 = LOWER FLOOR IN SERIES OF SIMILAR FLOORS
C       IF2 = UPPER FLOOR IN SERIES OF SIMILAR FLOORS
C       NOC = NO. OF COMPARTMENTS PER FLOOR
C       NZ = NO. OF CONNECTIONS TO COMPARTMENTS ON SAME FLOOR
C       NA = NO. OF CONNECTIONS TO COMPARTMENTS ON FLOOR ABOVE
C
85    I=0
      SNCOMP(1)=0.
      READ(5,700)NFLS
      WRITE(6,420)NFLS
      IF(NFLS .GT. NH)GO TO 106
7     READ(5,700)IF1,IF2,NOC
      WRITE(6,400)IF1,IF2,NOC
      IF(IF1 .GT. IF2)GO TO 107
      NCOMP(IF1)=NOC
      IFP=IF1+1
      SNCOMP(IFP)=SNCOMP(IF1)+NOC
      DO 10 IZ=1,NOC
      I=I+1
      READ(5,700)NZ,NA,NNO,FF(I),IT(I)
      WRITE(6,401)NZ,NA,NNO,FF(I),IT(I)
      NZZ(I)=NZ
      NN=NZ+NA
      IFLOOR(I)=IF1
      IF(NN .LE. MC)GO TO 111
      IPAR=3
      GO TO 110
111   IF(NNO .LE. MPO)GO TO 112
      IPAR=4
      GO TO 110
112   IF(IT(I) .GT. NTP .OR. IT(I) .LT. 1)GO TO 102
      NC(I)=NN
      IF(NZ .EQ. 0)GO TO 63
C
C       INPUT CONNECTIONS TO COMPARTMENTS ON SAME FLOOR
C
      READ(5,700)(JC(I,J),C(I,J),X(I,J),J=1,NZ)
      WRITE(6,402)
      WRITE(6,403)(JC(I,J),C(I,J),X(I,J),J=1,NZ)
      DO 62 J=1,NZ
```

```
62    JC(I,J)=JC(I,J)+SNCOMP(IF1)
63    IF(NA .EQ. 0)GO TO 8
C
C       INPUT CONNECTIONS TO COMPARTMENTS ON FLOOR ABOVE
C
      NP=NZ+1
      READ(5,700)(JC(I,J),C(I,J),X(I,J),J=NP,NA)
      WRITE(6,404)
      WRITE(6,403)(JC(I,J),C(I,J),X(I,J),J=NP,NA)
      DO 66 J=NP,NA
66    JC(I,J)=JC(I,J)+NCOMP(IF1)+SNCOMP(IF1)
8     NCO(I)=NNO
      IF(NNO .EQ. 0)GO TO 10
C
C       INPUT CONNECTION TO OUTSIDE
C
      READ(5,700)(JOC(I,JJ),CO(I,JJ),XO(I,JJ),JJ=1,NNO)
      WRITE(6,405)
      WRITE(6,403)(JOC(I,JJ),CO(I,JJ),XO(I,JJ),JJ=1,NNO)
      DO 9 JJ=1,NNO
      J=JOC(I,JJ)
9     PO(I,JJ)=PFO(IF1,J)
10    CONTINUE
      IF(IF1 .NE. IF2)GO TO 11
      IF(IF1 .EQ. NFLS)GO TO 20
      GO TO 19
C
C       ASIGN DATA FOR FLOORS SIMILAR TO FLOOR IF1
C
11    IFP=IF1+1
      DO 17 IFF=IFP,IF2
      NCOMP(IFF)=NOC
      IFFP=IFF+1
      SNCOMP(IFFP)=SNCOMP(IFF)+NOC
      DO 16 IZ=1,NOC
      I=I+1
      I1=IZ+SNCOMP(IF1)
      IFLOOR(I)=IFF
      FF(I)=FF(I1)
      IT(I)=IT(I1)
      NN=NC(I1)
      NNO=NCO(I1)
      NC(I)=NN
      NCO(I)=NNO
      IF(IFF .NE. NFLS)GO TO 23
      NN=NZZ(I1)
      NC(I)=NN
23    IF(NN .EQ. 0)GO TO 14
      DO 12 J=1,NN
      C(I,J)=C(I1,J)
      X(I,J)=X(I1,J)
      JC(I,J)=JC(I1,J)+SNCOMP(IFF)-SNCOMP(IF1)
12    CONTINUE
14    IF(NNO .EQ. 0)GO TO 16
      DO 15 JJ=1,NNO
      JOC(I,JJ)=JOC(I1,JJ)
      J=JOC(I,JJ)
      CO(I,JJ)=CO(I1,JJ)
```

```
      XO(I,JJ)=XO(I1,JJ)
15    PO(I,JJ)=PFO(IFF,J)
16    CONTINUE
17    CONTINUE
18    IF(IF2 .EQ. NFLS)GO TO 20
19    CONTINUE
      GO TO 7
20    N=I
      N2=N
      IF(N .LE. MB)GO TO 114
      IPAR=7
      GO TO 110
C
C        SHAFT DATA INPUT
C
114   READ(5,700)NS
      IF(NS .LE. MS)GO TO 113
      IPAR=2
      GO TO 110
113   DO 100 IS=1,NS
      READ(5,603)(TITSH(IS,I),I=1,3)
      WRITE(6,406)(TITSH(IS,I),I=1,3)
      READ(5,700)CS(IS),NFS1(IS),NFS2(IS),ITS(IS)
      WRITE(6,407)CS(IS),NFS1(IS),NFS2(IS),ITS(IS)
      N1=N2+1
      N2=N1+NFS2(IS)-NFS1(IS)
      NS1(IS)=N1
      NS2(IS)=N2
      IFF=NFS1(IS)-1
      READ(5,700)NNO,FFF,JCP,CC,XX,NNN
      WRITE(6,408)NNO,FFF,JCP,CC,XX,NNN
      IF(NNO .EQ. 0)GO TO 21
      READ(5,700)(JOC(N1,J),CO(N1,J),XO(N1,J),J=1,NNO)
      WRITE(6,403)(JOC(N1,J),CO(N1,J),XO(N1,J),J=1,NNO)
21    DO 24 I=N1,N2
      NC(I)=1
      NCO(I)=NNO
      IFF=IFF+1
      IFLOOR(I)=IFF
      JC(I,1)=JCP+SNCOMP(IFF)
      C(I,1)=CC
      X(I,1)=XX
      FF(I)=FFF
      IF(NNO .EQ. 0)GO TO 24
      DO 22 J=1,NNO
      JJ=JOC(N1,J)
      PO(I,J)=PFO(IFF,JJ)
      JOC(I,J)=JJ
      CO(I,J)=CO(N1,J)
22    XO(I,J)=XO(N1,J)
24    CONTINUE
C
C         EXCEPTIONS TO GENERAL SHAFT INPUT
C         NNN = NO. OF EXCEPTIONS
C         KE = 1 FOR FF EXCEPTION
C         KE = 2 FOR OUTSIDE CONNECTION
C         KE = 3 FOR INTERNAL CONNECTION
C
```

```
      IF(NNN .EQ. 0)GO TO 100
      DO 69 IK=1,NNN
      READ(5,700)KE,IFF
      WRITE(6,409)KE,IFF
      I=NS1(IS)+IFF-NFS1(IS)
      IF(KE .EQ. 1)GO TO 41
      IF(KE .EQ. 2)GO TO 42
      IF(KE .EQ. 3)GO TO 51
      GO TO 104
41    READ(5,700)FF(I)
      WRITE(6,410)FF(I)
      GO TO 69
42    READ(5,700)J,CCO,XXO
      WRITE(6,405)
      WRITE(6,403)J,CCO,XXO
      NNC=NCO(I)
      IF(NNC .EQ. 0)GO TO 44
      DO 43 K=1,NNC
      IF(JOC(I,K) .EQ. J)GO TO 46
43    CONTINUE
44    NJO=NNC+1
      NCO(I)=NJO
47    PO(I,NJO)=PFO(IFF,J)
      JOC(I,NJO)=J
      CO(I,NJO)=CCO
      XO(I,NJO)=XXO
      GO TO 69
46    NJO =K
      KK=K+1
      IF(CCO .NE. 0)GO TO 47
      NJO=NNC-1
      NCO(I)=NJO
      IF(NJO .EQ. 0)GO TO 69
      DO 49 K=KK,NNC
      KM=K-1
      PO(I,KM)=PO(I,K)
      JOC(I,KM)=JOC(I,K)
      CO(I,KM)=CO(I,K)
49    XO(I,KM)=XO(I,K)
      GO TO 69
51    READ(5,700)JCP,CC,XX
      WRITE(6,402)
      WRITE(6,403)JCP,CC,XX
      J=JCP+SNCOMP(IFF)
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 53
      DO 52 K=1,NNC
      IF(JC(I,K) .EQ. J)GO TO 55
52    CONTINUE
      IF(CC .NE. 0.)GO TO 53
      WRITE(6,520)IS,KE,IFF
      GO TO 69
53    NJ=NN+1
      NC(I)=NJ
54    JC(I,NJ)=J
      C(I,NJ)=CC
      X(I,NJ)=XX
      GO TO 69
```

```
55    NJ=K
      KK=K+1
      IF(CC .NE. 0.)GO TO 54
      NJ=NN-1
      NC(I)=NJ
      IF(NJ .EQ. 0)GO TO 69
      DO 61 K=KK,NN
      KM=K-1
      JC(I,KM)=JC(I,K)
      C(I,KM)=C(I,K)
61    X(I,KM)=X(I,K)
69    CONTINUE
100   CONTINUE
      NT=N2
      IF(NT .LE. MM)GO TO 160
      IPAR=1
      GO TO 110
C
C        PRINT OUTSIDE TEMPERATURE
C
160   WRITE(6,601)(TITLE(I),I=1,12)
      IF(IUNIT .EQ. 1)WRITE(6,800)TOUT
      IF(IUNIT .EQ. 2)WRITE(6,500)TOUT
      IF(IUNIT .EQ. 2)TOUT=(TOUT-32.)/1.8
      TOUT=TOUT+273.
C
C        PRINT HEIGHT AND TEMPERATURE PROFILES
C
      IF(IUNIT .EQ. 1)WRITE(6,811)(IP,IP=1,NTP)
      IF(IUNIT .EQ. 2)WRITE(6,511)(IP,IP=1,NTP)
      WRITE(6,813)
      DO 30 IFF=1,NH
30    WRITE(6,812)H(IFF),(T(IP,IFF),IP=1,NTP)
C
C        CONVERT TEMPERATURES TO DEG K
C
      DO 33 IFF=1,NH
      DO 33 IP=1,NTP
      IF(IUNIT .EQ. 2)T(IP,IFF)=(T(IP,IFF)-32.)/1.8
33    T(IP,IFF)=T(IP,IFF)+273.
C
C        PRINT OUTSIDE PRESSURE PROFILES
C
      IF(IUNIT .EQ. 1)GO TO 79
      WRITE(6,514)(IP,IP=1,NPO)
      WRITE(6,813)
      DO 76 IFF=1,NH
      DO 77 J=1,NPO
77    PFO(IFF,J)=PFO(IFF,J)/248.8
      WRITE(6,515)H(IFF),(PFO(IFF,J),J=1,NPO)
      DO 78 J=1,NPO
78    PFO(IFF,J)=PFO(IFF,J)*248.8
76    CONTINUE
      GO TO 83
79    WRITE(6,814)(IP,IP=1,NPO)
      WRITE(6,813)
      DO 31 IFF=1,NH
      WRITE(6,815)H(IFF),(PFO(IFF,J),J=1,NPO)
```

```
31    CONTINUE
C
C       CORRECT FOR CONNECTIONS ONLY INPUTED ONCE
C
83    DO 60 I=1,NT
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 60
      DO 58 JJ=1,NN
      J=JC(I,JJ)
      IF(J .EQ. 0)GO TO 58
      NNJ=NC(J)
      IF(NNJ .EQ. 0)GO TO 57
      DO 56 IA=1,NNJ
      IF(JC(J,IA) .EQ. I)GO TO 58
56    CONTINUE
57    NNJ=NNJ+1
      IF(NNJ .LE. MC)GO TO 59
      IPAR=3
      GO TO 110
59    NC(J)=NNJ
      JC(J,NNJ)=I
      C(J,NNJ)=C(I,JJ)
      X(J,NNJ)=X(I,JJ)
      IF(J .GT. N .OR. I .GT. N)GO TO 58
      PZ(J,NNJ)=-PZ(I,JJ)
58    CONTINUE
60    CONTINUE
C
C       CORRECT UNITS
C
      IF(IUNIT .EQ. 2)CALL UNITS
C
C       INITIALIZE PZ FOR BUILD COMPARTMENTS
C
87    DO 40 I=1,N
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 40
      IA=IT(I)
      IFI=IFLOOR(I)
      DO 38 JJ=1,NN
      J=JC(I,JJ)
      IFJ=IFLOOR(J)
      IF(IFI .EQ. IFJ)GO TO 38
      IB=IT(J)
      TEMPA=0.5*(T(IA,IFI)+T(IB,IFJ))
      PZ(I,JJ)=3462.*(H(IFJ)-H(IFI))/TEMPA
38    CONTINUE
40    CONTINUE
C
C       INITIALIZE PZ FOR SHAFTS
C
      DO 50 IS=1,NS
      N1=NS1(IS)
      N2=NS2(IS)-1
      ITT=ITS(IS)
      DO 45 I=N1,N2
      IFI=IFLOOR(I)
      IFJ=IFI+1
```

```
      TEMPA=0.5*(T(ITT,IFI)+T(ITT,IFJ))
      PZ(I,1)=3462.*(H(IFJ)-H(IFI))/TEMPA
45    CONTINUE
50    CONTINUE
C
C        CHECK SHAFT CONNECTIONS
C
      DO 240 IS=1,NS
      N1=NS1(IS)
      N2=NS2(IS)
      DO 239 I=N1,N2
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 239
      DO 236 J=1,NN
      JJ=JC(I,J)
      IF(IFLOOR(I) .NE. IFLOOR(JJ))GO TO 103
236   CONTINUE
239   CONTINUE
240   CONTINUE
      RETURN
C
C
C        DIAGNOSTIC OUTPUT
C
102   WRITE(6,902)I,IT(I)
      GO TO 109
103   WRITE(6,903)
      GO TO 109
104   WRITE(6,904)
      GO TO 109
105   WRITE(6,905)
      GO TO 109
106   WRITE(6,906)
      GO TO 109
107   WRITE(6,907)
      GO TO 109
110   WRITE(6,910)PAR(IPAR)
C
C        PRINT CORRECTED BUILDING DATA
C
109   WRITE(6,940)
      DO 70 I=1,N
      NN=NC(I)
      IF(NN .GT. 0)GO TO 180
      WRITE(6,941)I,IFLOOR(I),IT(I),FF(I)
      GO TO 182
180   WRITE(6,942)I,IFLOOR(I),IT(I),FF(I),JC(I,1),C(I,1),X(I,1)
      IF(NN .EQ. 1)GO TO 182
      WRITE(6,943)(JC(I,J),C(I,J),X(I,J),J=2,NN)
182   NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 70
      WRITE(6,944)(JOC(I,J),CO(I,J),XO(I,J),J=1,NNO)
70    CONTINUE
C
C        PRINT CORRECTED SHAFT INPUT DATA
C
      DO 80 IS=1,NS
      WRITE(6,816)(TITSH(IS,I),I=1,3)
```

```
      WRITE(6,806)IS,CS(IS),ITS(IS)
      N1=NS1(IS)
      N2=NS2(IS)
      WRITE(6,807)
      DO 75 I=N1,N2
      NN=NC(I)
      IF(NN .GT. 0)GO TO 72
      WRITE(6,801)IFLOOR(I),FF(I)
      GO TO 74
72    WRITE(6,808)IFLOOR(I),FF(I),JC(I,1),C(I,1),X(I,1)
      IF(NN .EQ. 1)GO TO 74
      WRITE(6,809)(JC(I,J),C(I,J),X(I,J),J=2,NN)
74    NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 75
      WRITE(6,810)(JOC(I,J),CO(I,J),XO(I,J),J=1,NNO)
75    CONTINUE
80    CONTINUE
      STOP
C
C        FORMAT STATEMENTS
C
400   FORMAT(5X,5HIF1 =,I3,7H, IF2 =,I3,7H, NOC =,I3)
401   FORMAT(5X,4HNZ =,I3,6H NA = ,I3,7H, NNO = ,I3,6H, FF =,F8.1,
     + 7H,  IT =,I3)
402   FORMAT(5X,25HCONNECTION ON SAME FLOOR    )
403   FORMAT(5X,3HJ =,I3,5H, C =,F8.1,5H, X =,F5.2)
404   FORMAT(5X,26HCONNECTION TO FLOOR ABOVE    )
405   FORMAT(5X,22HCONNECTION TO OUTSIDE     )
406   FORMAT(5X,3A6)
407   FORMAT(5X,4HCS =,F9.1,8H, NFS1 =,I3,8H, NFS2 =,I3,7H, ITS =,I3)
408   FORMAT(5X,5HNNO =,I3,7H, FFF =,F8.1,5H, J =,I3,5H, C =, F8.1,
     + 5H, X =,F5.2,7H, NNN = ,I3)
409   FORMAT(5X,4HKE =,I3, 7H, IFF =,I3)
410   FORMAT(5X,4HFF =,F8.1)
411   FORMAT(5X,6HTOUT =,F6.0,9H, IUNIT =,I3,8H, IOUT =,I3)
412   FORMAT(5X,4HNH =,I3,6H, NN =,I3)
413   FORMAT(5X,7HHEIGHTS /(10F8.2))
414   FORMAT(5X,6HH(1) =,F8.2,6H, DH =,F8.2)
415   FORMAT(6X,5HNTP =,I3)
416   FORMAT(5X,20HTEMPERATURE PROFILE  /I5,(10(I4,F7.1)))
417   FORMAT(5X,5HNPO =,I3,6H, NN =,I3)
418   FORMAT(5X,5HPGZ =,F12.1/17HPRESSURE PROFILE  /(10F12.1))
419   FORMAT(5X,4HVW =,F6.1,6H, HW =,F6.1,6H, XW =,F4.2,6H, CW =,
     + (10F4.2))
420   FORMAT(/5X,6HNFLS =,I3)
500   FORMAT(//10X,20HOUTSIDE TEMPERATURE   ,F6.1,2H F)
511   FORMAT(    ///5X,6HHEIGHT,5X,29HTEMPERATURE PROFILES (DEG F)    /
     + 7X,2HFT,3X,19I6)
514   FORMAT(////5X,6HHEIGHT ,5X,26HOUTSIDE PRESSURE PROFILES
     1 11H (IN H2O)    /7X,2HFT,3X,8I10)
515   FORMAT(F11.2,3X,8F10.3)
520   FORMAT(///5X,15HERROR IN SHAFT  ,I2,15HEXCEPTION KE =  ,I2,
     + 2X,5HFLOOR ,I3//)
600   FORMAT(12A6)
601   FORMAT(1H1///10X,12A6///)
603   FORMAT(3A6,I2)
700   FORMAT( )
800   FORMAT(//10X,20HOUTSIDE TEMPERATURE   ,F6.1,2H C)
```

```
801   FORMAT(I13,F11.1)
806   FORMAT(    10X,12HSHAFT NUMBER ,I4/10X,17HSHAFT COEFFICIENT ,F10.1/
     1 10X,20HTEMPERATURE PROFILE  ,I4)
807   FORMAT(/21X,5HFIXED,25X,4HFLOW,12X,4HFLOW/10X,5HFLOOR,6X,
     1 4HFLOW,5X,12HCONNECTED TO  ,6X,11HCOEFFICIENT ,6X,8HEXPONENT
     2  /)
808   FORMAT(I13,F11.1,6X,5HPOINT,I5,F16.1,F12.2)
809   FORMAT(30X,5HPOINT,I5,F16.1,F12.2)
810   FORMAT(30X,7HOUTSIDE ,I3,F16.1,F12.2)
811   FORMAT(    ///5X,6HHEIGHT,5X,29HTEMPERATURE PROFILES (DEG C)    /
     + 7X,2HM ,3X,19I6)
812   FORMAT(F11.2,3X,19F6.1)
813   FORMAT(/)
814   FORMAT(////5X,6HHEIGHT ,5X,26HOUTSIDE PRESSURE PROFILES
     1 11H (PASCALS)   /7X,2HM ,3X,8I10)
815   FORMAT(F11.2,3X,8F10.1)
816   FORMAT(///10X,3A6)
817   FORMAT(10X,45HFLOW COEFFICIENTS CORRECTED FOR TEMPREATURE     )
902   FORMAT(10(/),10X,11HCOMPARTMENT  ,I4/
     1 10X,20HTEMPERATURE PROFILE  ,I4,17H  DOES NOT EXIST  /
     + 10X,16HPROGRAM STOPPED  ,10(/))
903   FORMAT(10(/),5X,23HSHAFT CONNECTION ERROR     ,
     1 /10X,16HPROGRAM STOPPED  ,10(/))
904   FORMAT(10(/),10X,40HINPUT ERROR IN EXCEPTIONS TO SHAFT DATA
     1 /10X,16HPROGRAM STOPPED  ,10(/))
905   FORMAT(10(/),10X,37HINPUT ERROR IN UNIT TYPE DESIGNATION    /
     1   10X,16HPROGRAM STOPPED    ,10(/))
906   FORMAT(10(/),10X,37HINPUT ERROR NO. OF FLOORS EXCEEDS NH   /
     1 10X,16HPROGRAM STOPPED  ,10(/))
907    FORMAT(10(/),10X,25HINPUT ERROR IF1 .GT. IF2    /
     1 10X,16HPROGRAM STOPPED  ,10(/))
910   FORMAT(10(/),10X,36HINPUT EXCEEDS DIMENSION PARAMETER  ,A3/
     + 10X,16HPROGRAM STOPPED  ,10(/))
930   FORMAT(10X,3A6)
935   FORMAT(// 10X,26HFLOW COEFFICIENTS AS READ  )
940   FORMAT(10X,15HBUILDING  DATA  //34X,11HTEMPERATURE  ,4X,5HFIXED,
     1 12X,2(11X,4HFLOW)/10X,11HCOMPARTMENT ,4X,5HFLOOR,6X,7HPROFILE,
     2 6X,4HFLOW,5X,13HCONNECTION TO ,4X,11HCOEFFICIENT ,4X,
     3 8HEXPONENT )
941   FORMAT(/4X,3I12,F14.1)
942   FORMAT(/4X,3I12,F14.1,4X,5HPOINT,I7,F11.1,F13.1)
943   FORMAT(58X,5HPOINT,I7,F11.1,F13.1)
944   FORMAT(58X,9HOUTSIDE   ,I3,F11.1,F13.1)
      END

@HDG,P *                            SUBROUTINE CORR     .L,1
```

*   SUBROUTINE CORR

```
@NBS*PLIB$.SHOW     A.CORR
      SUBROUTINE CORR
C
C        THIS ROUTINE CALCULATES FLOW COEFFICIENTS
C        WHICH ARE CORRECTED FOR TEMPERATURE
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      DO 12 I=1,NT
C
C        CORRECT C
C
      NN=NC(I)
      IF(I .GT. N)GO TO 1
      IP=IT(I)
      GO TO 4
1     DO 2 IS=1,NS
      IF(I .LE. NS2(IS) .AND. I .GE. NS1(IS))GO TO 3
2     CONTINUE
      WRITE(6,700)
      STOP
3     IP=ITS(IS)
4     IFF=IFLOOR(I)
      T1=T(IP,IFF)
      IF(NN .EQ. 0)GO TO 10
      DO 9 J=1,NN
      JJ=JC(I,J)
      C1(I,J)=C(I,J)*((294./T1)**(2.5*X(I,J)-0.75))
      IF(JJ .GT. N)GO TO 5
      IP=IT(JJ)
      GO TO 8
5     DO 6 IS=1,NS
      IF(JJ .LE. NS2(IS) .AND. JJ .GE. NS1(IS))GO TO 7
6     CONTINUE
      WRITE(6,700)
      STOP
7     IP=ITS(IS)
8     IFF=IFLOOR(JJ)
      T2=T(IP,IFF)
      C2(I,J)=C(I,J)*((294./T2)**(2.5*X(I,J)-0.75))
9     CONTINUE
C
C        CORRECT CO
C
10    NNC=NCO(I)
      IF(NNC .EQ. 0)GO TO 12
      DO 11 J=1,NNC
      CO1(I,J)=CO(I,J)*((294./T1)**(2.5*XO(I,J)-0.75))
      CO2(I,J)=CO(I,J)*((294./TOUT)**(2.5*XO(I,J)-0.75))
11    CONTINUE
```

```
*                                         SUBROUTINE CORR

12     CONTINUE
       RETURN
700    FORMAT(///10X,36HPROGRAM STOPPED IN SUBROUTINE CORR    //)
       END

@HDG,P *                                         SUBROUTINE INIT       .L,1
```

```
*                                SUBROUTINE INIT

@NBS*PLIB$.SHOW     A.INIT
      SUBROUTINE  INIT
C
C
C      THIS ROUTINE INITIALIZES THE PRESSURE ARRAY
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      PARAMETER  MBP=MB+1
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      DIMENSION SC(MS),SCO(MS)
      COMMON /MAT/A(MB,MBP),XX(MB),NNN
      DOUBLE PRECISION A,XX
      NNN=N
C
C        CALCULATE AVERAGE OUTSIDE PRESSURE
C
      SUM=0.
      DO 10 J=1,NPO
      DO 10 I=1,NH
10    SUM=SUM+PFO(I,J)
      PA=SUM/(NPO*NH)
C
C
C
C        THE DO LOOP TO STATEMENT 30 ESTIMATES
C          SHAFT PRESSURES
C
      DO 30 IS=1,NS
C
C        CALCULATE SHAFT PRESSURE DIFFERENCE , DP
C
      SUM=0.
      SUMN=0.
      SUMX=0.
      NX=0
      N1=NS1(IS)
      N2=NS2(IS)
      DO 18 I=N1,N2
      SUM=SUM+FF(I)
      NN=NC(I)
      IF(NN .EQ. 0.)GO TO 16
      DO 15 J=1,NN
      SUMX=SUMX+X(I,J)
      NX=NX+1
      SUMN=SUMN+C(I,J)
15    CONTINUE
      SC(IS)=SUMN
16    NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 18
      DO 17 J=1,NNO
      SUMX=SUMX+XO(I,J)
```

```
      NX=NX+1
      SUMN=SUMN+CO(I,J)
17    CONTINUE
      SCO(IS)=SUMN-SC(IS)
18    CONTINUE
      AX=NX/SUMX
      DP2=SUM/SUMN
      SIGN=1.
      IF(DP2 .LT. 0.)SIGN=-1.
      DP=SIGN*(DP2**AX)
C
C       CALCULATE AVERAGE TEMP OF SHAFT
C
      SUM=0.
      IP=ITS(IS)
      DO 20 I=N1,N2
      IFF=IFLOOR(I)
20    SUM=SUM+T(IP,IFF)
      TA=SUM/(N2-N1+1)
C
C       ESTIMATE PRESSURE AT BOTTOM OF SHAFT , PBOT
C
      HH=0.5*(H(NH)-H(1))+H(1)
      NF1=NFS1(IS)
      PBOT=PA+DP+3462.*(HH-H(NF1))/TA
C
C       ESTIMATE OTHER SHAFT PRESSURES
C
      P(N1)=PBOT
      NM=N2-1
      DO 24 I=N1,NM
      IP1=I+1
24    P(IP1)=P(I)-PZ(I,1)
30    CONTINUE
C
C       END OF SHAFT PRESSURE ESTIMATES
C
C       SET UP MATRIX FOR BUILDING COMPARTMENTS
C
      NP1=N+1
      DO 50 I=1,N
      NN=NC(I)
      SUMII=0.
      SUMNP=0.
      IF(NN .EQ. 0.)GO TO 42
      DO 40 JJ=1,NN
      J=JC(I,JJ)
      IF(J .GT. N)GO TO 34
      A(I,J)=C(I,JJ)
      SUMII=SUMII-C(I,JJ)
      SUMNP=SUMNP-C(I,JJ)*PZ(I,JJ)
      GO TO 40
34    SUMII=SUMII-C(I,JJ)
      SUMNP=SUMNP-C(I,JJ)*P(J)
40    CONTINUE
42    NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 46
      DO 45 K=1,NNO
```

```
      SUMII=SUMII-CO(I,K)
45    SUMNP=SUMNP-CO(I,K)*PO(I,K)
46    A(I,I)=SUMII
      A(I,NP1)=SUMNP-FF(I)
50    CONTINUE
C
C       WRITE MATRIX
C
      IF(IBUG .EQ. 0)GO TO 84
      WRITE(6,802)
      DO 52 I=1,N
52    WRITE(6,803)(A(I,J),J=1,NP1)
C
C
C       CALL ROUTINE TO SOLVE FOR INITIAL BUILDING PRESSURES
C
84    CALL SIMEQ
C
C       OUTPUT INITIAL PRESSURES
C
      IF(IBUG .EQ. 0)GO TO 89
      WRITE(6,800)
      WRITE(6,801)(I,XX(I),I=1,N)
      NN=NS1(1)
      WRITE(6,801)(I,P(I),I=NN,NT)
C
C
C      ASSIGN BUILDING PRESSURES
C
89    DO 90 I=1,N
90    P(I)=XX(I)
      RETURN
800   FORMAT(///8(6X,1HI,4X,3HP   )/)
801   FORMAT(8(I7,F7.1))
802    FORMAT(///10X,20HMATRIX COEFFICIENTS   /)
803   FORMAT(10X,11F11.1)
      END

@HDG,P *                                   SUBROUTINE BLDGP       .L,1
```

*   SUBROUTINE BLDGP

```
@NBS*PLIB$.SHOW    A.BLDGP
      SUBROUTINE  BLDGP
C
C
C      THIS ROUTINE CALCULATES STEADY STATE PRESSURES
C          FOR BUILDING COMPARTMENTS
C
C
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON NT,   P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS,PI
      IF(IBUG .GT. 0)WRITE(6,806)
      ITM=20
      ICONV=0
      DO 15 I=1,N
C
C     CALCULATE NET FLOW ,FI, INTO POINT I
      FI=PFLOW(I,P(I))
C
C     CHECK MAGNITUDE OF FI
      IF(ABS(FI) .LT. E)GO TO 15
      ICONV=ICONV+1
C
C     SET UP PARAMETERS FOR ITERATION
      DP=1.0
      IPHASE=1
      DPI=0.
      EE=0.2*ABS(FI)
      IF(EE .LT. E)EE=E
      SIGN=1
      IF(FI .LT. 0.)SIGN=-1
      IK=0
      IF(IBUG .GT. 0)WRITE(6,802)
C
C     ITERATION TO REDUICE MAGNITUDE OF FN
2     IK=IK+1
C
C     NEW ESTIMATE OF PRESSURE ,PI, AT POINT I
      PI=P(I)+SIGN*DP
C
C     CALCULATE NET FLOW ,FN, INTO POINT I USING PI
      FN=PFLOW(I,PI)
      IF(IBUG.GT.0)WRITE(6,804)I,IK,FI,FN,FP,DPI,DP,DPP,PI,IPHASE
C
C     CHECK MAGNITUDE OF FN
      IF(ABS(FN) .LT. EE)GO TO 10
C
C     CHECK NUMBER OF ITERATIONS
      IF(IK .GT. ITM)GO TO 25
C
C     CHECK PHASE
```

```
*                                 SUBROUTINE BLDGP
      IF(IPHASE .EQ. 2)GO TO 6
C
C     CHECK FOR TRANSITION FROM PHASE 1 TO PHASE 2
      IF(FI*FN .LT. 0.)GO TO 4
C
C     PHASE 1
      DPI=DP
      DP=5.0*DP
      FI=FN
      GO TO 2
C
C     PHASE 2
4     IPHASE=2
      GO TO 9
6     IF(FI*FN .GT. 0.)GO TO 8
C
C     NEW DP BETWEEN DPI AND DP
9     DPP=DP
      FP=FN
      DP=DPI+(DPP-DPI)*FI/(FI-FN)
      GO TO 2
C
C     NEW DP BETWEEN DP AND DPP
8     FI=FN
      DPI=DP
      DP=DPI+(DPP-DPI)*FN/(FN-FP)
      GO TO 2
10    P(I)=PI
15    CONTINUE
C
      RETURN
25    WRITE(6,800)
      STOP
C
C      FORMAT STATEMENTS
C
800   FORMAT(///10X,20(1H*)///10X,22HEXCESSIVE ITERATIONS    /
     + 10X,8HIN BLDGP ///10X,20(1H*)//////)
802   FORMAT(//11X,1HI,2X,2HIT,12X,2HFI,13X,2HFN,13X,2HFP,12X,3HDPI,
     +13X,2HDP,12X,3HDPP,13X,2HPI,3X,5HPHASE /)
804   FORMAT(8X,2I4,3E15.4,4F15.6,I5)
806   FORMAT(    ///10X,6HBLDGP   )
      END

@HDG,P *                               SUBROUTINE SHAFTP      .L,1
```

```
@NBS*PLIB$.SHOW     A.SHAFTP
      SUBROUTINE  SHAFTP
C
C
C      THIS ROUTINE CALCULATES STEADY STATE PRESSURES
C          FOR SHAFTS
C
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMCN NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS,PI
      IF(IBUG .GT. 0)WRITE(6,806)
      ITM=20
      ICONV=0
      DO 15 I=1,NS
C
C     CALCULATE NET FLOW ,FI, INTO POINT I
      N1=NS1(I)
      FI=SFLOW(I,P(N1))
C
C     CHECK MAGNITUDE OF FI
      IF(ABS(FI) .LT. E)GO TO 15
      ICCNV=ICONV+1
C
C     SET UP PARAMETERS FOR ITERATION
      DP=1.0
      IPHASE=1
      DPI=0.
      EE=0.2*ABS(FI)
      IF(EE .LT. E)EE=E
      SIGN=1
      IF(FI .LT. 0.)SIGN=-1
      IK=0
      IF(IBUG .GT. 0)WRITE(6,802)
C
C     ITERATION TO REDUICE MAGNITUDE OF FN
2     IK=IK+1
C
C     NEW ESTIMATE OF PRESSURE ,PI, AT BOTTOM OF SHAFT I
      PI=P(N1)+SIGN*DP
C
C      CALCULATE NET FLOW ,FN, INTO SHAFT I USING PI
      FN=SFLOW(I,PI)
      IF( IBUG.GT.0)WRITE(6,804)I,IK,FI,FN,FP,DPI,DP,DPP,PI,IPHASE
C
C     CHECK MAGNITUDE OF FN
      IF(ABS(FN) .LT. EE)GO TO 10
C
C     CHECK NUMBER OF ITERATIONS
      IF(IK .GT. ITM)GO TO 25
C
C     CHECK PHASE
```

```
      IF( IPHASE .EQ. 2)GO TO 6
C
C     CHECK FOR TRANSITICN FROM PHASE 1 TO PHASE 2
      IF(FI*FN .LT. 0.)GO TO 4
C
C     PHASE 1
      DPI=DP
      DP=5.0*DP
      FI=FN
      GO TO 2
C
C     PHASE 2
4     IPHASE=2
      GO TO 9
6     IF(FI*FN .GT. 0.)GC TO 8
C
C     NEW DP BETWEEN DPI AND DP
9     DPP=DP
      FP=FN
      DP=DPI+(DPP-DPI)*FI/(FI-FN)
      GO TO 2
C
C     NEW DP BETWEEN DP AND DPP
8     FI=FN
      DPI=DP
      DP=DPI+(DPP-DPI)*FN/(FN-FP)
      GO TO 2
10    N2=NS2(I)
      DO 11 IF=N1,N2
      II=IF+1-N1
11    P(IF)=PS(II)
15    CONTINUE
C
      RETURN
25    WRITE(6,800)
      STOP
C
C      FORMAT STATEMENTS
C
800   FORMAT(///10X,20(1H*)///10X,22HEXCESSIVE ITERATIONS   /
     + 10X,9HIN SHAFTP  ///10X,20(1H*)//////)
802   FOFMAT(//11X,1HI,2X,2HIT,12X,2HFI,13X,2HFN,13X,2HFP,12X,3HDPI,
     +13X,2HDP,12X,3HDPP,13X,2HPI,3X,5HPHASE /)
804   FORMAT(8X,2I4,3E15.4,4F15.6,I5)
806   FORMAT(   ///10X,6HSHAFTP)
      END

@HDG,P *                            SUBROUTINE PZAD       .L,1
```

* SUBROUTINE PZAD

```
@NBS*PLIB$.SHOW    A.PZAD
      SUBROUTINE  PZAD
C
C       THIS POUTINE CORRECTS PZ TERMS FOR PRESSURE
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      COMMON /PZZ/ PGZ
      DOUBLE PRECISION P,PO,PS
      IF(IBUG .GT. -2)GO TO 1
      WRITE(6,800)
      DO 2 I=1,N
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 2
      WRITE(6,801)(I,J,PZ(I,J),J=1,NN)
2     CONTINUE
      NP1=N+1
      WRITE(6,802)(IL,PZ(IL,1),IL=NP1,NT)
1     DO 10 I=1,N
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 10
      IA=IT(I)
      IFI=IFLOOR(I)
      DO 8 JJ=1,NN
      J=JC(I,JJ)
      IFJ=IFLOOR(J)
      IF(IFI .EQ. IFJ)GO TO 8
      IB=IT(J)
      TEMPA=0.5*(T(IA,IFI)+T(IB,IFJ))
      PAVE=0.5*(P(I)+P(J))+PGZ
      PZ(I,JJ)=(0.03416*PAVE/TEMPA)*(H(IFJ)-H(IFI))
8     CONTINUE
10    CONTINUE
      DO 20 IS=1,NS
      N1=NS1(IS)
      N2=NS2(IS)-1
      ITT=ITS(IS)
      DO 15 I=N1,N2
      IFI=IFLOOR(I)
      IFJ=IFI+1
      TEMPA=0.5*(T(ITT,IFI)+T(ITT,IFJ))
      J=I+1
      PA=0.5*(P(I)+P(J))+PGZ
15    PZ(I,1)=(0.03416*PA/TEMPA)*(H(IFJ)-H(IFI))
20    CONTINUE
      RETURN
800   FORMAT(/10X,10HINITIAL PZ /)
801   FORMAT(10X,3HPZ(,I2,1H,I2,4H) =   ,F12.4)
802   FORMAT(10X,3HPZ(,I2,6H,1) '   ,F12.4)
803   FORMAT(/10X,11HADJUSTED PZ  /)
      END
```

* SUBROUTINE OUT

```
@NBS*PLIB$.SHOW     A.OUT
      SUBROUTINE OUT
C
C
C         THIS ROUTINE OUTPUTS FLOWSAND DIFFERENTIAL PRESSURES
C         FOR ALL SHAFTS AND BUILDING COMPARTMENTS
C
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
      COMMON  /IO/TITLE(12),IOUT,IUNIT,NCOMP(MFL),SNCOMP(MFL)
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      INTEGER  COM
C
C         IUNIT = 1 FOR SI UNITS
C         IUNIT = 2 FOR ENG UNITS
C         WHEN IUNIT = 2 GO TO 100
      IF(IUNIT .EQ. 2)GO TO 100
C
C         BUILDING COMPARTMENT OUTPUT
C
1     I=0
      IL=0
      WRITE(6,800)(TITLE(I),I=1,12)
      DO 30 IFF=1,NH
      NNN=NCOMP(IFF)
      IF(NNN .EQ. 0)GO TO 30
      DO 29 IC=1,NNN
      I=I+1
      NN=NC(I)
      NNO=NCO(I)
      IL=IL+NN+NNO+2
      IF(IL .LT. 51)GO TO 2
      WRITE(6,800)(TITLE(I),I=1,12)
      IL=NN+NNO+2
2     IF(NN .GT. 0)GO TO 3
      WRITE(6,801)IFF,IC,P(I),IT(I),FF(I)
      GO TO 21
3     DO 20 J=1,NN
      JJ=JC(I,J)
      DP=P(JJ)-P(I)+PZ(I,J)
      CC=C2(I,J)
      IF(DP .LT. 0.)CC=C1(I,J)
      IF(JJ .LE. N)GO TO 10
      DO 5 IS=1,NS
      IF(JJ .GE. NS1(IS) .AND. JJ .LE. NS2(IS))GO TO 6
5     CONTINUE
6     IF(J .GT. 1)GO TO 7
      WRITE(6,802)IFF,IC,P(I),IT(I),FF(I),(TITSH(IS,K),K=1,3)
     + ,DP,CC,X(I,1),FC(I,1)
      GO TO 20
```

```
7       WRITE(6,803)(TITSH(IS,K),K=1,3),DP,CC,X(I,J),FC(I,J)
        GO TO 20
10      IFJ=IFLOOR(JJ)
        COM=JJ-SNCOMP(IFJ)
        IF(J .GT. 1)GO TO 12
        WRITE(6,804)IFF,IC,P(I),IT(I),FF(I),IFJ,COM,DP,CC,X(I,1),FC(I,1)
        GO TO 20
12      WRITE(6,805)IFJ,COM,DP,CC,X(I,J),FC(I,J)
20      CONTINUE
21      IF(NNO .EQ. 0)GO TO 29
        DO 23 J=1,NNO
        JJ=JCC(I,J)
        DP=PO(I,J)-P(I)
        CC=CO2(I,J)
        IF(DP .LT. 0.)CC=CO1(I,J)
23      WRITE(6,806)JJ,DP,CC,XO(I,J),FO(I,J)
29      WRITE(6,807)F(I)
30      CONTINUE
C
C         SHAFT OUTPUT
C
        IL=IL+6
        DO 60 IS=1,NS
        N1=NS1(IS)
        N2=NS2(IS)
        IL=IL+N2+18-N1
        IF( IL .LT. 56)GO TO 32
        WRITE(6,814)
        IL=N2+18-N1
32      WRITE(6,808)(TITSH(IS,K),K=1,3),ITS(IS),CS(IS)
        DO 50 I=N1,N2
        NN=NC(I)
        IF(NN .GT. 0)GO TO 35
        WRITE(6,809)IFLOOR(I),P(I),FF(I)
        GO TO 41
35      DO 40 J=1,NN
        JJ=JC(I,J)
        DP=P(JJ)-P(I)
        CC=C2(I,J)
        IF(DP .LT. 0.)CC=C1(I,J)
        IFJ=IFLOOR(JJ)
        COM=JJ-SNCOMP(IFJ)
        IF(J .GT. 1)GO TO 36
        WRITE(6,810)IFLOOR(I),P(I),FF(I),IFJ,COM,DP,CC, X(I,1),FC(I,1)
        GO TO 40
36      WRITE(6,811)IFJ,COM,DP,CC, X(I,J),FC(I,J)
40      CONTINUE
41      NNO=NCO(I)
        IF(NNO .EQ. 0)GO TO 50
        DO 46 J=1,NNO
        JJ=JCC(I,J)
        DP=PO(I,J)-P(I)
        CC=CO2(I,J)
        IF(DP .LT. 0.)CC=CO1(I,J)
46      WRITE(6,812)JJ,DP,CC,XO(I,J),FO(I,J)
50      CONTINUE
        WRITE(6,813)FSS(IS)
60      CONTINUE
```

```
      GO TO 165
C
C       BUILDING DATA OUTPUT  FOR IUNIT = 2
C
100   I=0
      IL=0
      WRITE(6,800)(TITLE(I),I=1,12)
      DO 130 IFF=1,NH
      NNN=NCOMP(IFF)
      IF(NNN .EQ. 0)GO TO 130
      DO 129 IC=1,NNN
      I=I+1
      FFI=F(I)/0.4719
      PIII=P(I)/248.8
      FFF=FF(I)/0.4719
      NN=NC(I)
      NNO=NCO(I)
      IL=IL+NN+NNO+2
      IF(IL .LT. 51)GO TO 102
      WRITE(6,800)(TITLE(I),I=1,12)
      IL=NN+NNO+2
102   IF(NN .GT. 0)GO TO 103
      WRITE(6,601)IFF,IC,PIII,IT(I),FFF
      GO TO 121
103   DO 120 J=1,NN
      FCCC=FC(I,J)/0.4719
      JJ=JC(I,J)
      DP=(P(JJ)-P(I)+PZ(I,J))/248.8
      CC=C2(I,J)
      IF(DP .LT. 0.)CC=C1(I,J)
      CC=CC*2.119/(0.004019**X(I,J))
      IF(JJ .LE. N)GO TO 110
      DO 105 IS=1,NS
      IF(JJ .GE. NS1(IS) .AND. JJ .LE. NS2(IS))GO TO 106
105   CONTINUE
106   IF(J .GT. 1)GO TO 107
      WRITE(6,602)IFF,IC,PIII,IT(I),FFF   ,(TITSH(IS,K),K=1,3)
     + ,DP,CC,X(I,1),FCCC
      GO TO 120
107   WRITE(6,603)(TITSH(IS,K),K=1,3),DP,CC,X(I,J),FCCC
      GO TO 120
110   IFJ=IFLOOR(JJ)
      COM=JJ-SNCOMP(IFJ)
      IF(J .GT. 1)GO TO 112
      WRITE(6,604)IFF,IC,PIII,IT(I),FFF   ,IFJ,COM,DP,CC,X(I,1),FCCC
      GO TO 120
112   WRITE(6,605)IFJ,COM,DP,CC,X(I,J),FCCC
120   CONTINUE
121   IF(NNO .EQ. 0)GO TO 129
      DO 123 J=1,NNO
      FOO=FO(I,J)/0.4719
      JJ=JCC(I,J)
      DP=(PO(I,J)-P(I))/248.8
      CC=CO2(I,J)
      IF(DP .LT. 0.)CC=CO1(I,J)
      CC=CC*2.119/(0.004019**XO(I,J))
123   WRITE(6,606)JJ,DP,CC,XO(I,J),FOO
129   WRITE(6,807)FFI
```

```
130   CONTINUE
C
C       SHAFT OUTPUT FOR IUNIT = 2
C
      IL=IL+6
      DO 160 IS=1,NS
      CSS=CS(IS)/0.02992
      FFI=FSS(IS)/0.4719
      N1=NS1(IS)
      N2=NS2(IS)
      IL=IL+N2+18-N1
      IF(IL .LT. 56)GO TO 132
      WRITE(6,814)
      IL=N2+18-N1
132   WRITE(6,808)(TITSH(IS,K),K=1,3),ITS(IS),CSS
      DO 150 I=N1,N2
      FFF=FF(I)/0.4719
      PIII=P(I)/248.8
      NN=NC(I)
      IF(NN .GT. 0)GO TO 135
      WRITE(6,609)IFLOOR(I),PIII,FFF
      GO TO 141
135   DO 140 J=1,NN
      FCCC=FC(I,J)/0.4719
      JJ=JC(I,J)
      DP=(P(JJ)-P(I))/248.8
      CC=C2(I,J)
      IF(DP .LT. 0.)CC=C1(I,J)
      CC=CC*2.119/(0.004019**X(I,J))
      IFJ=IFLOOR(JJ)
      COM=JJ-SNCOMP(IFJ)
      IF(J .GT. 1)GO TO 136
      WRITE(6,610)IFLOOR(I),PIII,FFF   ,IFJ,COM,DP,CC, X(I,1),FCCC
      GO TO 140
136   WRITE(6,611)IFJ,COM,DP,CC, X(I,J),FCCC
140   CONTINUE
141   NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 150
      DO 146 J=1,NNO
      FOO=FO(I,J)/0.4719
      JJ=JOC(I,J)
      DP=(PO(I,J)-P(I))/248.8
      CC=CO2(I,J)
      IF(DP .LT. 0.)CC=CO1(I,J)
      CC=CC*2.119/(0.004019**XO(I,J))
146   WRITE(6,612)JJ,DP,CC,XO(I,J),FOO
150   CONTINUE
      WRITE(6,813)FFI
160   CONTINUE
C
C       SUMMARY OUTPUT
C       USER INSERTS WRITE STATEMENTS TO FILE IOUT
C
165   CONTINUE
      RETURN
C
C
C       FORMAT STATEMENTS
```

```
C
601   FORMAT(/4X,I3,I10,F13.3,I8,F12.0)
602   FORMAT(/4X,I3,I10,F13.3,I8,F12.0,3X,3A6,F16.3,F15.0,F10.2,F11.1)
603   FORMAT(53X,3A6,F16.3,F15.0,F10.2,F11.1)
604   FORMAT(/4X,I3,I10,F13.3,I8,F12.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,
     1 F11.3,F15.0,F10.2,F11.1)
605   FORMAT(53X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.3,F15.0,F10.2,F11.1)
606   FORMAT(53X,17HOUTSIDE DIRECTION,I3,F14.3,F15.0,F10.2,F11.1)
609   FORMAT(4X,I3,F10.3,F11.0)
610   FORMAT(4X,I3,F10.3,F11.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.3,
     1 F15.0,F10.2,F11.1)
611   FORMAT(31X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.3,F15.0,F10.2,F11.1)
612   FORMAT(31X,17HOUTSIDE DIRECTION ,I3,F14.3,F15.0,F10.2,F11.1)
800   FORMAT(1H1,20X,12A6//94X,8HADJUSTED/35X,4HTEMP,7X,5HFIXED,28X,
     1 12HDIFFERENTIAL,5X,4HFLOW,8X,4HFLOW/4X,5HFLOOR,2X,11HCOMPARTMENT
     2 ,2X,8HPRESSURE,2X,7HPROFILE,5X,4HFLOW,3X,16HCONNECTION    TO ,
     3 12X,8HPRESSURE,4X,11HCOEFFICIENT,2X,8HEXPONENT,5X,4HFLOW /)
801   FORMAT(/4X,I3,I10,F13.1,I8,F12.0)
802   FORMAT(/4X,I3,I10,F13.1,I8,F12.0,3X,3A6,F16.1,F15.1,F10.2,F11.1)
803   FORMAT(53X,3A6,F16.1,F15.1,F10.2,F11.1)
804   FORMAT(/4X,I3,I10,F13.1,I8,F12.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,
     1 F11.1,F15.1,F10.2,F11.1)
805   FORMAT(53X,5HFLOOR,I3,12H COMPARTMENT, I3,F11.1,F15.1,F10.2,F11.1)
806   FORMAT(53X,17HOUTSIDE DIRECTION,I3,F14.1,F15.1,F10.2,F11.1)
807   FORMAT(115X,F8.1,4H NET)
808   FORMAT(////20X,3A6//20X,20HTEMPERATURE PROFILE,I3/20X,
     1 23HSHAFT FLOW COEFFICIENT,F10.0//72X,8HADJUSTED/24X,5HFIXED,
     2 28X,12HDIFFERENTIAL,5X,4HFLOW,8X,4HFLOW/4X,5HFLOOR,2X,8HPRESSURE,
     3 5X,4HFLOW,3X,16HCCNNECTION    TO,12X,8HPRESSURE,4X,11HCOEFFICIENT
     4,2X,8HEXPONENT,5X,4HFLOW/)
809   FORMAT(4X,I3,F10.1,F11.0)
810   FORMAT(4X,I3,F10.1,F11.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.1,
     1 F15.1,F10.2,F11.1)
811   FORMAT(31X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.1,F15.1,F10.2,F11.1)
812   FORMAT(31X,17HOUTSIDE DIRECTION ,I3,F14.1,F15.1,F10.2,F11.1)
813   FORMAT(93X,F8.1,4H NET)
814   FORMAT(1H1)
      END

@HDG,P *                              SUBROUTINE INPUT2
```

```
@NBS*PLIB$.SHOW      A.INPUT2
      SUBROUTINE INPUT2
C
C        THIS ROUTINE DETERMINES IF THE PROGRAM IS TO BE STOPPED
C        OR IF ANOTHER RUN IS REQUIRED WITH MODIFIED DATA
C        NNN NO. OF CHANGES
C        KC = 1 FOR FF
C        KC = 2 FOR C
C        KC = 3 FOR CO
C        KC = 4 FOR C BETWEEN 2 POINTS ONLY
C
      PARAMETER MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON NT,  P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      COMMON  /IO/TITLE(12),IOUT,IUNIT,NCOMP(MFL),SNCOMP(MFL)
      COMMCN /RUN/IRUN
      IRUN=IRUN+1
      IBUG=0
5     READ(5,700)NNN
      IF(NNN .GT. 9)STOP
      WRITE(6,600)(TITLE(I),I=1,12),IRUN
      DO 100 IA=1,NNN
      READ(5,700)KC,IS,B
      IF(KC .LT. 1 .OR. KC .GT. 4)GO TO 200
      BB=B
      IF(KC .EQ. 1)GO TO 10
      IF(KC .EQ. 2)GO TO 20
      IF(KC .EQ. 3)GO TO 30
      IF(KC .EQ. 4)GO TO 50
      STOP
C
C        CHANGE IN FF IN SHAFT IS
C
10    N1=NS1(IS)
      N2=NS2(IS)
      IF(IUNIT .EQ. 2)BB=BB*0.4719
      DO 15 I=N1,N2
      FF(I)=BB
15    CONTINUE
      WRITE(6,800)IS,B
      GO TO 100
C
C        CHANGE IN C FOR SHAFT IS
C
20    N1=NS1(IS)
      N2=NS2(IS)
      DO 28 I=N1,N2
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 28
      DO 24 J=1,NN
      IF(IUNIT .EQ. 2)BB=B*0.4719/(248.8**X(I,1))
      C(I,J)=BB
```

```
      JJ=JC(I,J)
      NM=NC(JJ)
      DO 22 K=1,NM
      IF(JC(JJ,K) .EQ. I)GO TO 23
22    CONTINUE
23    C(JJ,K)=BB
24    CONTINUE
28    CONTINUE
      WRITE(6,801)IS,B
      GO TO 100
C
C       CHANGE CO IN BUILDING
C
30    IF(IS .GT. 0)GO TO 40
      DO 38 I=1,N
      NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 38
      DO 34 J=1,NNO
      IF(IUNIT .EQ. 2)BB=B*0.4719/(248.8**XO(I,J))
      CO(I,J)=BB
34    CONTINUE
38    CONTINUE
      WRITE(6,802)B
      GO TO 100
C
C       CHANGE CO IN SHAFT IS
C
40    N1=NS1(IS)
      N2=NS2(IS)
      DO 48 I=N1,N2
      NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 48
      DO 44 J=1,NNO
      IF(IUNIT .EQ. 2)BB=B*0.4719/(248.8**XO(I,J))
      CO(I,J)=BB
44    CONTINUE
48    CONTINUE
      WRITE(6,803)IS,B
      GO TO 100
C
C       NEW C BETWEEN POINTS IS AND JS
C
50    READ(5,700)JS
      NN=NC(IS)
      DO 51 J=1,NN
      IF(JC(IS,J) .EQ. JS)GO TO 52
51    CONTINUE
      GO TO 200
52    IF(IUNIT .EQ. 2)BB=B*0.4719/(248.8**X(IS,J))
      C(IS,J)=BB
      NN=NC(JS)
      DO 53 J=1,NN
      IF(JC(JS,J) .EQ. IS)GO TO 54
53    CONTINUE
      GO TO 200
54    C(JS,J)=BB
      WRITE(6,805)IS,JS,B
100   CONTINUE
```

```
      RETURN
200   WRITE(6,804)
      STOP
600   FORMAT(///10X,12A6//10X,3HRUN,I4///)
700   FORMAT( )
800   FORMAT(10X,25HNEW FIXED FLOW FOR SHAFT    ,I2,4H  IS,F8.1/)
801   FORMAT(10X,16HNEW C FOR SHAFT  ,I2,4H  IS,F8.1//)
802   FORMAT(10X,23HNEW CO FOR BUILDING IS  ,F8.1//)
803   FORMAT(10X,17HNEW CO FOR SHAFT  ,I2,4H  IS,F8.1//)
804   FORMAT(//10X,21HERROR IN INPUT2 DATA  /)
805   FORMAT(10X,14HNEW C BTTWEEN  ,I3,4H AND,I3,3H IS ,F8.1//)
      END

@HDG,P *                              SUBROUTINE UNITS  ,L,1
```

*   SUBROUTINE UNITS

```
@NBS*PLIB$.SHOW    A.UNITS
      SUBROUTINE UNITS
C
C        THIS ROUTINE CONVERTS VARIABLES H,FF,C,CO,CS TO SI UNITS
C
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS
      DIMENSION B(4)
      DATA B/0.3048,248.8,0.4719,0.02992/
      DO 10 I=1,NH
10    H(I)=H(I)*B(1)
      DO 20 I=1,NT
      FF(I)=FF(I)*B(3)
      DO 16 J=1,MC
      IF(X(I,J) .EQ. 0)GO TO 16
      BB=B(3)/(B(2)**X(I,J))
      C(I,J)=C(I,J)*BB
16    CONTINUE
      DO 18 J=1,MPO
      IF(XO(I,J) .EQ. 0)GO TO 18
      BB=B(3)/(B(2)**XO(I,J))
      CO(I,J)=CO(I,J)*BB
18    CONTINUE
20    CONTINUE
      DO 22 IS=1,NS
22    CS(IS)=CS(IS)*B(4)
      RETURN
      END

@HDG,P *                             SUBROUTINE SIMEQ       .L,1
```

*   SUBROUTINE SIMEQ

```
@NBS*PLIB$.SHOW     A.SIMEQ
      SUBROUTINE SIMEQ
C
C         CHOLESKY'S METHOD OF SOLUTION OF
C        SIMULTANEOUS LINEAR ALGEBRIC EQUATIONS
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      PARAMETER  MBP=MB+1
      DOUBLE PRECISION A,X
      COMMON /MAT/ A(MB,MBP),X(MB),N
      NP1=N+1
      ZERO=1.0E-35
      K=0
C
C
C         SEE IF A(1,1) IS ZERO
C     IF SO ADD ANOTHER ROW TO ROW 1
      IF(ABS(A(1,1)) .GT. ZERO)GO TO 40
      DO 31 I=1,N
      IF(A(I,1) .NE. 0.)GO TO 32
   31 CONTINUE
   12 WRITE(6,804)K
      STOP
   32 DO 33 J=1,NP1
   33 A(1,J)=A(1,J)+A(I,J)
C
C     CALCULATE UPPER AND LOWER
C     TRIANGULAR MATRICES OVER ORIG
C     MATRIX A
   40 AA=A(1,1)
      DO 2 J=2,NP1
    2 A(1,J)=A(1,J)/AA
      DO 10 I=2,N
      K=0
C
C     STORE A(I,1) ... A(I,I) IN X ARRAY
C     IN CASE NEW A(I,I) IS ZERO
C     ROW I CAN BE RECALCULATED
    4 DO 5 J=1,I
    5 X(J)=A(I,J)
      K=K+1
      DO 10 J=2,NP1
      IF(J .GT. I)GO TO 8
      JM1=J-1
      AA=0.
      DO 3 IR=1,JM1
    3 AA=AA+A(I,IR)*A(IR,J)
      A(I,J)=A(I,J)-AA
C
C     CHECK IF A(I,I) IS ZERO
C     IF SO MULTIPLY OLD ROW I BY 2.
C
      IF(I .NE. J)GO TO 10
      IF(ABS(A(I,I)) .GT. ZERO)GO TO 10
      DO 6 JJ=1,I
    6 A(I,JJ)=X(JJ)
      DO 7 JJ=1,NP1
```

```
    7 A(I,J)=2.*A(I,J)
      IF(K .GT. 3)GO TO 12
      GO TO 4
    8 IM1=I-1
      AA=0.
      DO 9 IR=1,IM1
    9 AA=AA+A(I,IR)*A(IR,J)
      A(I,J)=(A(I,J)-AA)/A(I,I)
   10 CONTINUE
C     END OF CALCULATION OF TRIANGULAR MATRICES
C
C
C     BACKWARD SUBSTITUTION
C
      X(N)=A(N,NP1)
      DO 20 II=2,N
      AA=0.
      I=NP1-II
      IP1=I+1
      DO 15 J=IP1,N
   15 AA=AA+A(I,J)*X(J)
   20 X(I)=A(I,NP1)-AA
C
  804 FORMAT(//////10X,16HPROGRAM FAILURE   ,I3/////)
      END

@HDG,P *                                 FUNCTION FLOW  ,L,1
```

```
*                                 FUNCTION FLOW


@NBS*PLIB$.SHOW    A.FLOW
      FUNCTION FLOW(PI,PJ,PZ,C,X)
      DOUELE PRECISION PI,PJ
C
C     THIS FUNCTION CALCULATES FLOWS BETWEEN TWO POINTS
C
      IF(ABS(C) .LT. 0.001)GO TO 10
      DP=PJ-PI+PZ
      SIGN=1.0
      IF(DP .LT. .0)SIGN=-1.
      IF(X .NE. .5)GO TO 11
      FLOW=SIGN*C*SQRT(SIGN*DP)
      RETURN
10    FLOW=0.0
      RETURN
11    FLOW=SIGN*C*((SIGN*DP)**X)
      RETURN
      END

@HDG,P *                               FUNCTION PFLOW          .L,1
```

```
*                                          FUNCTION PFLOW


@NBS*PLIB$.SHOW     A.PFLOW
      FUNCTION PFLOW(I,PI)
C
C
C     THIS FUNCTION CALCULATES NET FLOWS INTO POINT I
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO),TOUT
      DOUBLE PRECISION P,PO,PS,PI
      NN=NC(I)
      SUM=0.
      IF(NN .EQ. 0)GO TO 3
      DO 1 JJ=1,NN
      J=JC(I,JJ)
      CC=C1(I,JJ)
      IF(PI .LT. P(J))CC=C2(I,JJ)
      PZZ=PZ(I,JJ)
      IF(I .GT. N)PZZ=0.
      FC(I,JJ)=FLOW(PI,P(J),PZZ,CC,X(I,JJ))
1     SUM=SUM+FC(I,JJ)
3     NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 4
      DO 2 K=1,NNO
      CC=CO1(I,K)
      IF(PI .LT. PO(I,K))CC=CO2(I,K)
      FO(I,K)=FLOW(PI,PO(I,K),0,CC,XO(I,K))
2     SUM=SUM+FO(I,K)
4     PFLOW=SUM+FF(I)
      IF(I .LE. N)F(I)=SUM+FF(I)
      RETURN
      END

@HDG,P *                                        FUNCTION PSFLOW     .L,1
```

* FUNCTION PSFLOW

```
@NBS*PLIB$.SHOW     A.PSFLOW
      FUNCTION PSFLOW(I,PI)
C
C
C     THIS FUNCTION CALCULATES NET HORIZONTAL FLOWS
C       INTO A FLOOR OF A SHAFT
C
      PARAMETER  MM=220,MS=2,MC=4,MPO=2,MTP=2,MFL=105,MB=105
      COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
      COMMON NT,    P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
     1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
     2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
     3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,X(MM,MC),XO(MM,MPO),TITSH(MS,3),
     4 NH,H(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
     5 ,NCO(MM),JOC(MM,MPO)
      DOUBLE PRECISION P,PO,PS,PI
      NN=NC(I)
      SUM=0.
      IF(NN .EQ. 0)GO TO 3
      DO 1 JJ=1,NN
      J=JC(I,JJ)
      CC=C1(I,JJ)
      IF(PI .LT. P(J))CC=C2(I,JJ)
1     SUM=SUM+FLOW(PI,P(J),0,CC,X(I,JJ))
3     NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 4
      DO 2 K=1,NNO
      CC=CO1(I,K)
      IF(PI .LT. PO(I,K))CC=CO2(I,K)
2     SUM=SUM+FLOW(PI,PO(I,K),0,CC,XO(I,K))
4     PSFLOW=SUM+FF(I)
      RETURN
      END

@BRKPT    PRINT$
```

FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

01. Summary date
Yr. Mo. Day

02. Summary prepared by (*Name and Phone*)
John Klote 921-3387

03. Summary action
New ☒ Replacement ☐ Deletion ☐
Previous internal Software ID

04. Software date
Yr. 80 Mo. 05 Day 27

05. Software title
A Computer Program for Analysis of Pressurized Stairwells and Pressurized Elevator Shafts

06. Short title

07. Internal Software ID

08. Software type
☐ Automated Data System
☒ Computer Program
☐ Subroutine/Module

09. Processing mode
☐ Interactive
☒ Batch
☐ Combination

10. Application area

General
☐ Computer Systems Support/Utility
☒ Scientific/Engineering
☐ Bibliographic/Textual
☐ Management/ Business
☐ Process Control
☐ Other

Specific
Smoke control in buildings

11. Submitting organization and address
Fire Protection Systems Research
Center for Fire Research
National Bureau of Standards
Washington, D.C. 20234

12. Technical contact(s) and phone
John Klote
921-3387

13. Narrative

Pressurized stairwells and pressurized elevators can be used as a means of providing a smoke free exit route during fire situations. This computer program analyzes systems intended to pressurize stairwells and elevator shafts.

14. Keywords
Air movement; computer programs; egress; elevator shafts; escape means; pressurization; smoke control; stairwells

15. Computer manuf'r and model Univac 1108	16. Computer operating system	17. Programing language(s) Fortran V	18. Number of source program statements 1900
19. Computer memory requirements	20. Tape drives	21. Disk/Drum units	22. Terminals

23. Other operational requirements

24. Software availability
Available ☒ Limited ☐ In-house only ☐

25. Documentation availability
Available ☒ Inadequate ☐ In-house only ☐

26. FOR SUBMITTING ORGANIZATION USE

185–101

Standard Form 185
1974 July
U.S. Dept. of Commerce—NBS
(FIPS. Pub. 30)

NBS-114A (REV. 9-78)

U.S. DEPT. OF COMM.
BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION OR REPORT NO.
NBSIR 80-2157

2. Gov't. Accession No.

3. Recipient's Accession No.

4. TITLE AND SUBTITLE

A COMPUTER PROGRAM FOR ANALYSIS OF PRESSURIZED STAIRWELLS AND PRESSURIZED ELEVATOR SHAFTS

5. Publication Date
January 1981

6. Performing Organization Code

7. AUTHOR(S)
John H. Klote

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, DC 20234

10. Project/Task/Work Unit No.
7528558

11. Contract/Grant No.

12. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

13. Type of Report & Period Covered

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Pressurized stairwells and pressurized elevators can be used as a means of providing a smoke free exit route during fire situations. This paper describes a computer program which analyzes systems intended to pressurize stairwells or elevator shafts. The basic assumptions and limitations of the program are also discussed. The appendices contain a program listing and examples.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Air movement; computer programs; egress; elevator shafts; escape means; pressurization; smoke control; stairwells.

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☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

19. SECURITY CLASS (THIS REPORT)
UNCLASSIFIED

20. SECURITY CLASS (THIS PAGE)
UNCLASSIFIED

21. NO. OF PRINTED PAGES
85

22. Price
$8.00