ADDENDUM TO CAD TOOLS WHICH ACCOMMODATE AN EVOLUTIONARY STRATEGY IN CHEMICAL ENGINEERING DESIGN

by

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1 INTRODUCTION

Since the publication of Locke (1981), an optimization capability has been added to the ASCEND-II flowsheeting system. The optimization technique, a variation of the Han-Powell method (Powell, 1977), is described in Locke et a!., (1982). This addendum is intended to describe the changes made to ASCEND-II since September, 1981.

2 BRIEF OVERVIEW OF THE COMMANDS (ADD TO SECTION 2.7)

The following commands have been added to ASCEND-II in order to allow the user to perform optimization calculations:

2.1 GETLO

The *GETLO* command is used to restore the values of variables' lower bounds from a file. The values must first be stored using the *SAVELO* command. .

2.2 GETUP

The *GETUP* command is used to restore the values of variables' upper bounds from a file. The values must first be stored using the *SAVEUP* command.

2.3 LOOKUP

The *LOOKUP* command displays to the user the name of a variable and the variable packet in which it resides when the variable's position in the VAR vector is input. This command was added for debugging purposes.

2.4 LOWBND

The *LOWBND* command is used to input the values of the lower bounds of variables.

2.5 OBJECT

Under the *OBJECT* command, the user names the variable which is to be maximized or minimized.

2.6 OPTMIZ

The *OPTMIZ* command starts the Han-Powell optimization procedure.

2.7 SAVELO

The *SAVELO* command is used to save the values of variables' lower bounds in a file.

2.8 SAVEUP

The *SAVEUP* command is used to save the values of variables' upper bounds in a file.

2.9 UPBND

The *UPBND* command is used to input the values of the upper bounds of variables.

2.10 ViOLAT

The *VIOLAT* command tells the user which variable bounds (upper or lower) have been violated.

3 IMPORTANT STORAGE VECTORS (ADD TO SECTION 4.8)

A Common Area called *OPTMIZ.CMN* contains aH the storage vectors which were added to ASCEND-II to enable optimization calculations to be performed. Each of those vectors is described here.

3.1 STORAGE FOR THE QUADRATIC PROGRAMMING ROUTINE

One of the steps in the Han-Powell algorithm requires the solution of a Quadratic Programming Problem (QPP). Included in ASCEND-II is a group of subroutines called QPSOL, written by Gill et al., (1982). This group of subroutines solves the QPP set up by ASCEND-II. The following arrays are required to set-up and solve the QPP using QPSOL

Matrix CH (DP RE) contains the Hessian Matrix for the current iteration. It is stored as a full matrix. This matrix is called HESS in QPSOL

Vector DELPDU (DP RE) contains the constrained derivative (£$/£u). It is equivalent to vector CVEC in QPSOL, the vector which contains the linear term of the objective function.

Matrix ACN (DP RE) is equivalent to matrix A in QPSOL It contains the general linear constraints. This matrix is calculated by:

$$ACN = -@g/3x^{T}r^{1}\ @g/3u^{T}),$$

where g are the equality constraints describing the flowsheet, x are the pivoted variables, and u are the decision variables. ACN is a very large matrix. It can have as many as 1000 rows and 11 columns.

Vector BLQP (DP RE) is equivalent to BL in QPSOL It contains in its first N locations (N being the number of decision variables) the lower bounds of the allowed changes in the decision variables. The rest of the locations contain the lower bounds of the general linear constraints.

Vector BUQP (DP RE) is equivalent to BU in QPSOL It contains the same information as BLQP, but for upper bounds.

Vector 1STATE (SP IN) is 1:1 with BLQP and BUQP. It gives the status of its corresponding constraint. 1STATE contains a 0 if the constraint is not tight, -1 if the constraint is at its upper bound, and -2 if it is at its lower bound. Other values that ISTATE may take on are described in Gill et al., (1982).

Vector CLAMDA (DP RE) is 1:1 with ISTATE, BLQP, and BUQP. It contains the Lagrange multipliers associated with the tight constraints.

Vector IQWORK (SP IN) is equivalent to IWORK in QPSOL It is used as integer workspace.

Vector QWORK (DP RE) is equivalent to WORK in QPSOL It is used as a workspace.

Vector XQP (DP RE) is equivalent to X in QPSOL It contains the soJution to the QPP.

3.2 ARRAYS NECESSARY FOR THE HESSIAN UPDATE

Several storage arrays are used in the Hessian update routine. Each is described in this subsection.

Vector OLDELP (DP RE) contains the constrained derivative calculated in the previous iteration.

Matrix COLD (DP RE) is a workspace used in updating the Hessian Matrix.

Vector LAMACN (DP RE) is also a work vector for the Hessian update. It is calculated as:

$$LAMACN = (\lambda_{lo} - \lambda_{up}) \cdot ACN,$$

where the λ's are the Kuhn-Tucker multipliers on the linear inequality constraints and are calculated by the QPP.

Vector CHDIAG (DP RE) contains the values of the diagonal elements of the Hessian Matrix.

3.3 REMAINING ARRAYS FOR GENERAL USE

In this subsection the remaining arrays added to perform optimization are described.

Vector DELTA (DP RE) contains the change in the decision variables as calculated by the QPP and scaled by the step size parameter.

Vector BETMIN (DP RE) is 1:1 with DELTA. This vector contains the values of the Kuhn-Tucker multipliers on the corresponding decision variables. If a decision variable is not at its lower bound, the value in BETMIN is 0.

Vector BETMAX (DP RE) is also 1:1 with DELTA. It contains the multipliers on the upper bounds of the decision variables.

Vector LAMLO (DP RE) contains the values of the Kuhn-Tucker multipliers on the tight lower bounds of the pivoted variables. Only the multipliers of the tight constraints are stored. Vector TOLO (SP IN) is 1:1 with LAMLO and contains the position in VAR of the pivoted variable which is at its lower bound. Both LAMLO and TOLO are of length LLO.

Vectors LAMUP (DP RE) and TOUP (SP IN) of length LUP contain the same information as LAMLO and TOLO but for the upper bounds of the pivoted variables.

The partials of the flowsheet equality constraints with respect to the decision variables $0g/du^T$) are stored as a sparse matrix in three vectors. Vector ADEC (DP RE) contains the values of the partial derivatives. Vector IRDEC (SP IN) is 1:1 with ADEC and contains the corresponding row of the Jacobian Matrix. ICDEC (SP IN) is also 1:1 with ADEC and contains the corresponding column of the Jacobian Matrix of that element All three vectors are of length LDEC, and have a maximum length of MDEC.

Vector IDEC (SP IN) contains two pieces of information. The first N locations (where N once again is the number of decision variables) contain the columns of the Jacobian Matrix which Harwell Routine MA28 has chosen to be the decision columns. The next N locations contain the corresponding positions of those variables in vector VAR.

Vector VARMAX (SP RE) is 1:1 with VAR, the vector of variable values. VARMAX contains the maximum value of the corresponding variable.

Vector VARMIN (SP RE) is also 1:1 with VAR. It contains the minimum value of the corresponding variable.

4 ERROR MESSAGES FROM THE NEW ROUTINES (ADD TO SECTION C.2)

4.1 SUBROUTINE SOLV

Called when the SOLVE and OPTMIZ commands are given.

Error #1

The SOLVE command has been given but the Jacobian Matrix is not square.

Error #2

Fatal error in Subroutine MA28AD. The Jacobian Matrix is singular.

Error #3

Error in MA28BD. Must re-pivot.

Error #4

Similar to Error #3

Error #5

While solving, the Right-Hand-Side magnitude increased instead of decreasing.

4.2 SUBROUTINE MULCAL

Errors #1 and #2

These error traps should never be seen by the user. They were included for debugging purposes.

4.3 OTHER ERROR MESSAGES

In addition to the error messages described above, other error messages are include in the new routines. These messages are very descriptive and should be self-explanatory.

5 FORMATS FOR COMMANDS (ADD TO SECTION E)

In this section the formats of the commands added to ASCEND-II are described.

In the formats for the commands, system prompts are italicized. Anything typed by the user is underlined. Comments are in script.

5.1 GETLO

1. Description:

   The GETLO command is used to retrieve stored variable lower bounds from a file. The bounds must be stored using the SAVELO command.

   The user has two options when issuing the GETLO command. The first option is to retrieve all the values of a particular variable packet. (There is no way to retrieve individual lower bounds from a stored variable packet at the present time.) Using the first option, the user names the file from which he is retrieving values, the name under which the variable packet was stored, and the name given the variable packet in this run. Naming two names for the variable packet may not be as convenient as naming one, but it allows the user to retrieve values from one flowsheet to initialize values for another when the name of the variable packet has been changed between runs. The second option available to the user is to retrieve all possible variable packets from a file. A variable packet can be initialized in this way if there is a variable packet in the file which has the same name as it does.

2. Format:

   GETLO

   FORMAT FOR FETCH, GETCF, GETLO, AND GET UP COMMANDS
   FE FILE # SOURCE RECORD VP NAME
   OR
   TO FETCH ALL POSSIBLE VAR PACKS
   FE FILE ALL*
   OR
   FOR END OF FETCH, GETCF, GETLO, OR GETCF COMMANDS
   EN

   FE File # Variable Packet Name
   EN

   The. tuejt can njtfjúzvi individual valuable, packet OK aJUL valûable packet* Atoned with matching name*. He mut give, the EW command to indicate the end o£ thû phase. o{ input.*

5.2 GETUP

1. Description:

The GETUP command is used to retrieve stored variable upper bounds from a file. The values must be stored using the SAVEUP command.

The user has two options when issuing the GETUP command. The first option is to retrieve all the upper bounds of a particular variable packet. (There is no way to retrieve individual bounds from a stored variable packet at the present time.) Using the first option, the user names the file from which he is retrieving values, the name under which the variable packet was stored, and the name given the variable packet in this run. Naming two names for the variable packet may not be as convenient as naming one, but it allows the user to retrieve values from one flowsheet to initialize values for another when the name of the variable packet has been changed between runs. The second option available to the user is to retrieve all possible variable packets from a file.

2. Format:

GETUP

FORMAT FOR FETCH, GETCF, GETLO, AND GETUP COMMANDS
FE FILE # SOURCE RECORD VP NAME
OR
TO FETCH ALL POSSIBLE VAR PACKS
FE FILE ALL*
OR
FOR END OF FETCH, GETCF, GETLO, OR GETCF COMMANDS
EN

FE File # Variable Packet Name
EN

The, LUZA can JieXtUzve. individual vcuUablt packets OK alt vajúabtz packet vtoJizd with matching now*. He vnuuU givz the EN command to indicate, the end o£ tkJU phcue. o£ input.*

5.3 LOOKUP

1. Description:

Under the LOOKUP command the user gives one or more integer values. These values are the positions in VAR of variables whose names the user would like to know. ASCEND-II returns with the variable names, the names of the packs in which they reside, and their offsets (if any).

2. Format:

LOOKUP

GIVE POSITION(S) OF VARIABLE(S) TO BE LOOKED UP

*Tht tueji H&*pon<U with thz inttgeji poMÅJLotu o£ tkt* **variables.**

ASCEND-II Mi&ponxU with Ju&tntilicaJUon o£ tho&i po&JUiovu.

5.4 LOWBND

1. Description:

Under the LOWBND command, the user can set the lower bound of any variable in the flowsheet. After he gives the command LOWBND, he types the name of the variable packet in which he would like to set lower bounds. He may then specify which variable he wants to set in two ways: The first way is with an integer value in parenthesis. To set the lower bound of the third variable in the packet the user would type (3) and then the value of the lower bound. The second way to specify a variable is by name. To set the lower bound of variable FLOW in a STREAM variable packet, the user would type (FLOW) and then the value of the lower bound. He accesses dimensioned variables by giving the variable name and appropriate offset. To set the lower bound of the third mole fraction in a stream, the user would type: (MF 3) and then the value of the lower bound. If the user does not specify the position of the variable or the variable name, ASCEND-II assumes that he wishes to set the value of the lower bound of the first variable in the packet.

The user may set more than one lower bound value in the same LOWBND statement. After one variable bound is set, the user may set the bound of the next variable in the packet by simply typing the bound value. He is not required to name the second variable. The user may set the bounds of the first two mole fractions in a stream by typing: (MF 1) value of first bound, value of second bound. He may also set the bounds of these variables by naming both of them: (MF 1) value (MF 2) value. He can set lower bounds on the FLOW of the stream and the third mole fraction by typing: (FLOW) value (MF 3) value.

2. Format:

LOWBND

TYPE EN FOR END,

NAME OF PACK TO SET LOWER BOUNDS

Name of Variable Packet

(OPTIONAL START) LOWER BOUNDS

(Name of variable being set) Lower Bound

Tht LUQJI *eX* tht loweji bound oi tht thlnd molt inaction In a *tntam to .01 by typing:

(MF 3 1 ^ 0 1

tit *eX* tht bound* oi tht iltut two molt iJiactlon* to .7 and .3 by typing:

(MF 1 [J. J

Tht tueji *tt& tht loweji bound oi tkt FLcXf to 100. and tht iJuut molt inaction to .5 by typing:

(FLOW) 100. (MF 1] ^5

Aiter tkt value.* in ont vajuablt packtt havt bttn &tt, tht uueji may *tt tht value.* In anothtA vcjuiabtt packtt by typing it* name. A£te* all value.* havt bttn *tt, tht u*eji nztunn* to tht monitoK by typing EN.

5.5 OBJECT

1. Description:

   Under the OBJECT command, the user tells ASCEND-II which variable is to be maximized or minimized in the optimization.

2. Format:

   OBJECT

   MAXIMIZE OR MINIMIZE? (TYPE MAX OR M/NJ

   Tht u*t typt* MAX OK MIN

   TYPE NAME OF VARIABLE PACKET, NAME OF VARIABLE, OFFSET IF ANY

   Tht u*tx Idtntlilt* tht objtct vajujablt

5.6 OPTMIZ

1. Description:

The OPTMIZ command begins the procedure which optimizes the user's flowsheet. After the command is given he must set several parameters. MAXIT is the maximum number of iterations to go. It has no default value as the rest of the parameters do. The other parameters are CNVGD (convergence tolerance), SAMPIV (value Y or N, Y is used if this is the same problem as was run the last time the OPTMIZ command was given), DIAG (a double precision value which can be added to the diagonal of the Hessian Matrix), STPDEC (the maximum step size in the decision variables), FACT (value to which the diagonal of the Hessian Matrix should be initialized), IDEBUG (prints debugging information, the casual user should leave this at 0).

2. Format:

<u>OPTMIZ</u>

GIVE VALUES FOR MAXIT, CNVGD(t.D-6), SAMPIV(N), DIAGfO.O), STPDECf0.5), FACT(LO), IDEBUGfO)

The. tut* give.* value.* &ox the. paJumeXeju. VticuxJU valuer (me. in parenthesis.

5.7 SAVELO

1. Description:

The SAVELO command allows the user to save the lower bounds of variables under the names of the variable packets of his job. They can be retrieved by .using the GETLO command. After the user gives a number for the output file, he has several options by.which to save the variables. The options are described under the SAVECF command.

2. Format:

<u>SAVELO</u>

SPECIFY FILE # FOR WRITING VALUES

<u>File #</u>

Tht uueji &ptcJLiJuu> tkt lilt to utuidt the. value.* will be. wtitt&n.

TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP NAMEfS) FOR SPECIFIC PACKfSJ

PT NAME(S) FOR POINTER STATEMENTS)
UN NAME(S) FOR USER NAMED VARIABLE PACKS
OF SPECIFIC UNIT(S)
A$ FOR ALL VARIABLE PACKS
U$ NAME(S) FOR ALL VARIABLE PACKS OF NAMED UNITfS)

*The. uueji choo*t* one. o£ the. above, option* depending upon which vatuíable. packeX*' IOUXJI bound* he. want* *aved.*

5.8 SAVEUP

1. Description:

The SAVEUP command allows the user to save the upper bounds of variables under the names of the variable packets of his job. They can be retrieved by using the GETUP command. After the user gives a number for the output file, he has several options by which to save the variables. The options are described under the SAVECF command.

2. Format:

SAVEUP

SPECIFY FILE # FOR WRITING VALUES

File #

*The. u*eji 6pe.cJ.ile.* ike. {ite. to ukich the. valuer will be. uvUtten.*

TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP NAMEfS) FOR SPECIFIC PACK(S)
PT NAMEfS) FOR POINTER STATEMENTfS)
UN NAMEfS) FOR USER NAMED VARIABLE PACKS
OF SPECIFIC UNITfS)
A$ FOR ALL VARIABLE PACKS
U$ NAMEfS) FOR ALL VARIABLE PACKS OF NAMED UNITfS)

The. vuejL chooser one. oi the. above, option dtpentting upon which valuíable. pacJkeX*' uppeji bound* he. want* *aved.*

5.9 UPBND

1. Description:

The UPBND command has options exactly like those of the LOWBND command. See the LOWBND command for a description of those options.

2. **Format:**

UPBKD

TYPE EN FOR END,

NAME OF PACK TO SET UPPER BOUNDS

Name of Variable Packet

(OPTIONAL START) UPPER BOUNDS

(Name of variable being set) Upper Bounds
Tht uueji' typt* EN to Ji&tunn to tht moruAox a^teji tkt tcut valuable, tuu* been *6eX.

5.10 VIOLAT

1. Description:

VIOLAT is a one word command without arguments. This command tells the user which variables have values that violate their upper or lower bounds.

2. Format:

VIOLAT

ASCEWP-II ***JieMuou utiXh:***

•••••• *VIOLATED CONSTRAINTS* ••••••

And then eJXhex idzyuUiiz* tht vajúablt* OK type*:

NO CONSTRAINTS VIOLATED

6 TERMINAL SESSION

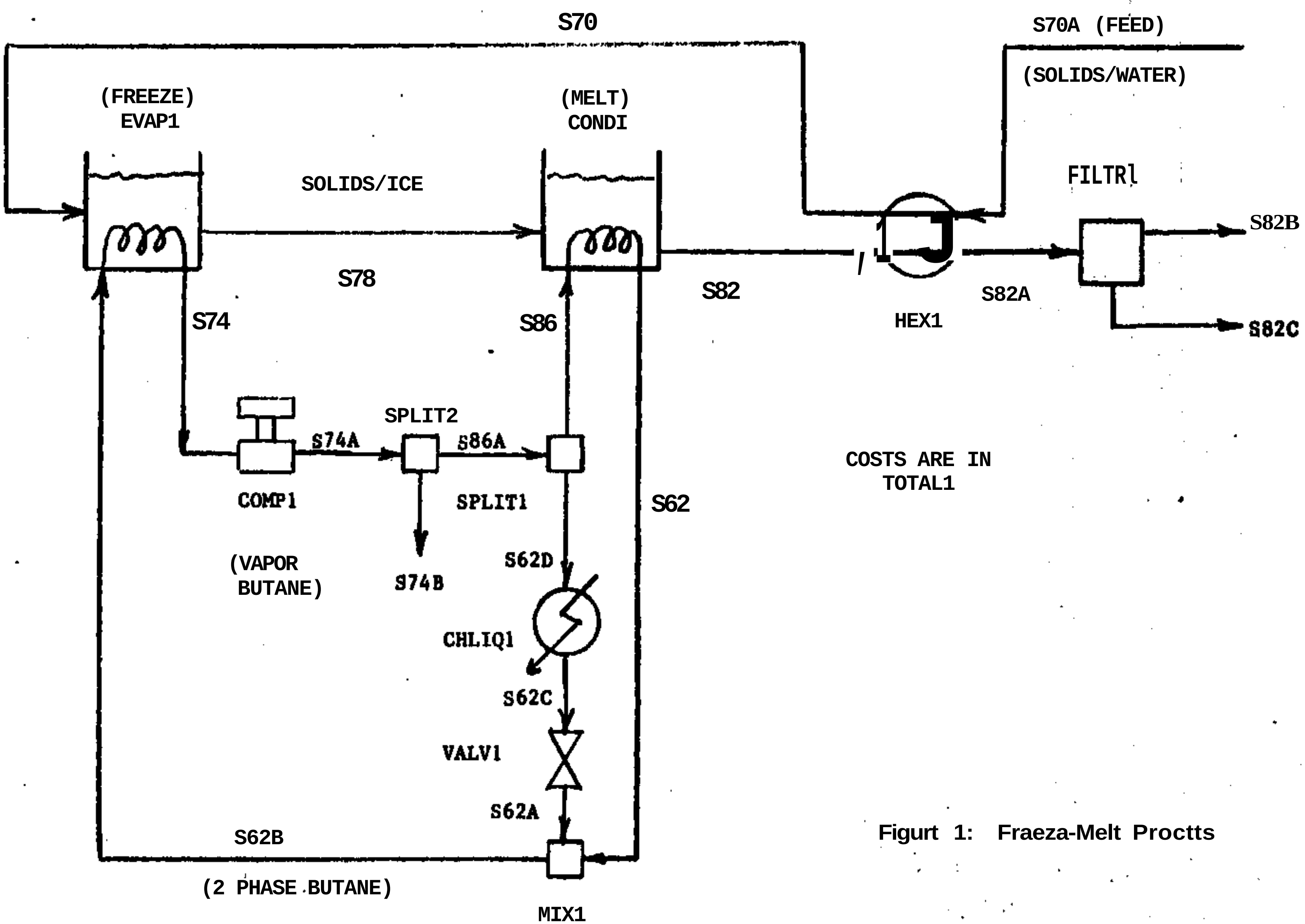
In this terminal session, the user performs several calculations on the flowsheet of Figure . This flowsheet represents a process to separate fine clay particles from water. The particles are so fine that it would take 20 years for them to settle out in settling tanks. It has been found that freezing the clay-water mixture and then melting it will cause the clay particles to coagulate into clumps which then can be filtered out, leaving a relatively pure stream of water.

6.1 DESCRIPTION OF THE FLOWSHEET

Streams containing only butane are represented by solid lines. Those containing clay and water are represented by dashed lines. Incoming clay and water enter the process in stream S70A at a temperature of 302° K (84° F). This stream is cooled down in the heat exchanger through contact with stream S82. Stream S70 then enters the evaporator, actually a direct contact heat exchanger, where liquid butane enters from the bottom (stream S62B). In the evaporator, the butane absorbs its heat of vaporization from the clay-water mixture. As the butane vaporizes, the clay-water stream freezes. An clay-ice mixture enters the condenser as stream S78. The evaporator performs the opposite operation of the evaporator. The ice stream melts while the gaseous butane (stream S86) liquefies through direct contact. Stream S82 contains water and the coagulated clumps of clay at a temperature of 274° K (33° F). This stream enters the heat exchanger cooling incoming stream S70A and then enters the filter where a primarily solid stream (S82B) and a relatively pure water stream (S82C) are produced.

The remainder of the flowsheet is required to pressurize and cool the butane. Gaseous butane leaves the evaporator in stream S74. It is then compressed and enters the first splitter. This splitter is an "imaginary splitter". The flow of stream S74B is 0. The splitter is required because there is a closed butane loop and one too many equations would be written if that splitter were not there (see Locke, 1982, page 79).

The butane stream (still a vapor) is then split into streams S86 and S62D. Stream S86 enters the condenser where it is condensed and leaves as stream S62. Stream S62D runs through the chiller-liquefier, leaving as a liquid in stream S62C. It goes through the valve and mixes with liquid stream S62 to form stream S62B, which enters the evaporator.



Figurt 1: Fraeza-Melt Proctts

Figure 1: Freeze-Melt Process

The cost of this flowsheet is extremely sensitive to the temperature of stream S70. If a great deal of heat is exchanged between S70A and S82, then the temperature of S70 is lowered and less butane is needed, lowering the capital and utility costs in the butane recompression loop. One reaches a tradeoff point, however. At some point the capital cost of the heat exchanger makes further exchange of heat economically unattractive. There is an optimal temperature for S70 which minimizes the flowsheet cost.

6.2 DESCRIPTION OF THE TERMINAL SESSION

In the terminal session which follows, the user performs several calculations, the first calculation is a design calculation. It is not an optimization calculation. There are as many equations as there are calculated variables in the flowsheet. This calculation is done to establish a base case for the optimization.

After solving the first (design) calculation, the user releases five specifications in the flowsheet; the temperatures of streams S62, S62C, S74, S74A and S70. Upper and/or lower bounds are set to prevent temperatures from crossing in the heat exchange devices. At this point the user specifies an objective: Minimize the capital cost of the flowsheet. He is now ready to optimize over those unspecified temperatures. He gives the optimize command and converges the flowsheet in a total of 11 iterations. Four of the temperatures are found to be optimal at their bounds. The optimal point is found to be an internal optimum with respect to the fifth temperature, that of stream S70.

The user may wonder whether the calculated temperature of 276.774° K for stream S70 is actually the optimal temperature to minimize the capital cost of the flowsheet. He can find out very easily using ASCEND-II by fixing all the temperatures so that there are no degrees of freedom, and perturbing the temperature of stream S70 upward and downward and noting the effect on the capital cost. He finds that perturbing upward raises the capital cost of the flowsheet. Perturbing downward also raises the capital cost.

The user now wishes to run a different calculation. The flowsheet will stay the same, but he will try to minimize a different variable, the total cost (combined capital and utility) of the flowsheet. He does this by once again releasing the specifications on those five temperatures and by specifying variable TOTAL in variable packet TOTAL as the variable to be minimized. It takes ASCEND-II 13 iterations to find the optimal solution. Once again the optimum is internal with respect to the temperature of stream S70 (275.233° K), and the user checks that this is the optimum by specifying the five temperatures and raising and lowering the temperature of S70 while calculating the total cost. This experiment verifies that ASCEND-II has found the optimal solution.

In the final calculation performed with this flowsheet, the user once again releases the specifications on the temperatures of those five streams and names an objective variable to be minimized. This time he chooses the total utility cost as the object variable. ASCEND-II converges this problem in 19 iterations. At the solution, all five temperatures are at their upper or lower bounds. The optimal temperature of stream S70 is found to be 275° K, the lower bound. It makes sense for S70 to be at that temperature because at 275° the maximum amount of heat is exchanged between S70 and S82, lowering the cooling requirements in the rest of the flowsheet.

6.3 SAMPLE SESSION

@RUH FRZ

```
GIVE COMMAND
RESET

RESET
GIVE VALUES FOR INPUT AND OUTPUT FILES
DEVICES 20 THROUGH 24 AND 63 DEFAULT TO THE DISK
1

1
```

Tht iiMJi tzAJU ASCENP-II *to xiad ¥Ut 1, the. context fitting {lit. Echo p/uńting Ju̇ ULppjvmed by not naming an output {Hz.*

```
GIVE COMMAND
RESET

RESET
GIVE VALUES FOR INPUT AND OUTPUT FILES
DEVICES 20 THROUGH 24 AND 63 DEFAULT TO THE DISK
38 5

38 5
```

The *IUZA'6 {iw^kteX Ju' nzad i>iom {MJL* 3£ *and zcho-pjuńtzd to* device 5/ *tht tejurúnal.*

```
GIVE COMMAND
FSHEET
C*  THIS IS THE USER INPUT FOR THE SAMPLE OPTIMIZATION PROBLEM.
C*  EACH UNIT BEGINS WITH AN FS STATEMENT.
C*  THERE IS A TOTAL OF 12 UNITS MODELED IN THIS FLOWSHEET:
C*  EVAPORATOR, CONDENSER, TWO SPLITTERS, COMPRESSOR, VALVE,
C*  CHILLER-LIQUEFIER, MIXER, FILTER, HEAT EXCHANGER, ENTHALPY
C*  EVALUATOR, AND TOTAL COST AND UNTILITIES BLOCK.
C*
C*  FLOW IN STREAM S70A OF 1.8672E7 G-MOL/HR, CLAY MOLE FRACTION
C*  OF .00942408 REPRESENTS 50 TON/HR. OF CLAY BEING PROCESSED
C*  AT 12% CONCENTRATION BY WEIGHT.
FS  TOTAL1  TOTAL
V   TOTAL
G   TOTAL
FS  EVAP1   EVAP
V   S70     S78     S62B    S74     EVAPVP  LOGEV   EN62B   EN74
FS  COMP1   COMP
V   S74     S74A    COMPVP
```

```
G   COMP
FS  SPLIT2  SPLIT
V   S74A    S74B    S86A    SPLIT2
G   SPLIT
FS  SPLIT1  SPLIT
V   S86A    S86     S62D    SPLITV
G   SPLIT
FS  CONDI   COND
V   S78     S82     S86     S62     CONDVP  LOGON   EN62    EN86
FS  CHLIQ1  CHLIQ
V   S62D    S62C    CHLIQV
G   CHLIQ
FS  VALV1   VALV
V   S62C    S62A    VALVE
G   VALV
FS  EN62A   LIQEN
V   S62A    EN62A
G   LIQEN
FS  MIX1    MIX
V   S62     S62A    S62B    MIXVP
G   MIX
FS  HEX1    HEX
V   S82     S82A    S70A    S70     HEXVP   LOGHX
G   HEX
FS  FILTR1  FILTR
V   S82A    S82C    S82B    FILTRV  LOGFL
G   FILTR
EN
GIVE COMMAND
VPCONX
C*  VP AND PT STATEMENTS TIE STREAMS TO PHYSICAL
C*  PROPERTIES (BUTANE, WATER, CLAY), ALSO TIE
C*  "UNIT" VARIABLE PACKS TO ENTHALPY VARIABLE
C*  PACKS.  FOR EXAMPLE, VARIABLE PACK MIXVP
C*  POINTS TO LIQUID ENTHALPY VARIABLE PACKS
C*  EN62, EN62A, AND EN62B THROUGH THE WORD
C*  ENMIX.  THE WORDS ON THE TA AND TE LINES
C*  TELL WHAT TYPES OF VARIABLE PACKS ARE
C*  ON THE VP LINES.
VP  ENMIX   EN62    EN62A   EN62B
TE  LIQEN   LIQEN   LIQEN
PT  MIXVP   ENMIX
VP  ENTCON  EN86    EN62
TE  VAPEN   LIQEN
PT  CONDVP  ENTCON
VP  ENEVAP  EN62B   EN74
TE  LIQEN   VAPEN
```

```
PT  EVAPVP  ENEVAP
VP  STRT1   BUTANE
TA  PHYPRP
PT  S62B    STRT1
PT  S74A    STRT1
VP  STRT2   WATER   CLAY
TA  PHYPRP
PT  S70     STRT2
PT  S82     STRT2
VP  UTLPK   CHLIQV  FILTRV  COMPVP
TE  CLHIQV  FILTRV  COMPVP
VP  CAPPK   CHLIQV  FILTRV  COMPVP  HEXVP   EVAPVP  CONDVP
TE  CHLIQV  FILTRV  COMPVP  HEXVP   COVAP   COVAP
PT  TOTAL   UTLPK   CAPPK
EN                  ft
GIVE COMMAND
C*  COMMANDS EXPAND AND PREINT AS IN PREVIOUS PROBLEMS
C*
C*  THE FETCH COMMAND IS USED HERE TO INITIALIZE
C*  PHYSICAL PROPERTY VARIABLE PACKS BUTANE, CLAY.
C*  AND WATER.
EXPAND
GIVE COMMAND
PREINT
GIVE COMMAND
FETCH


FORMAT FOR FETCH, GETCFf GETLO, AND GETUP COMMANDS
FE  FILE #  SOURCE RECORD    VP NAME
OR
TO FETCH ALL POSSIBLE VAR PACKS
FE FILE #  ALL
OR
FOR END OF FETCH, GETCF, GETLO, OR GETUP COMMANDS
EN
FOUND BUTANE


FORMAT FOR FETCH, GETCF, GETLO, AND GETUP COMMANDS
FE  FILE #  SOURCE RECORD    VP NAME
OR
TO FETCH ALL POSSIBLE VAR PACKS
FE FILE #  ALL
OR
FOR END OF FETCH, GETCF, GETLO, OR GETUP COMMANDS
EN
```

```
FOUND CLAY


FORMAT FOR FETCH, GETCF, GETLO, AND GETUP COMMANDS
FE  FILE #  SOURCE RECORD   VP NAME
OR
TO FETCH ALL POSSIBLE VAR PACKS
FE FILE #  ALL
OR
FOR END OF FETCH, GETCF, GETLO, OR GETUP COMMANDS
EN
FOUND WATER


FORMAT FOR FETCH, GETCF, GETLO, AND GETUP COMMANDS
FE  FILE #  SOURCE RECORD   VP NAME
OR
TO FETCH ALL POSSIBLE VAR PACKS
FE FILE #  ALL
OR
FOR END OF FETCH, GETCF, GETLO, OR GETUP COMMANDS
EN
GIVE COMMAND
C*  INITIAL VALUES ARE GIVEN TO THE FOLLOWING VARIABLES
C*  BEFORE THE INITIALIZATION ROUTINES ARE CALLED TO
C*  INITIALIZE THE REST OF THE VARIABLES IN THE FLOW-
C*  SHEET.
INVAL
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2)275.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS.
S74A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (3)124.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
SPLIT2
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
0.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
LOGFL
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
```

```
(1)F T
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S82B
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
(5).0362
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70A
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
(1)F F F F F 1.8672E7,302.,108.,.99057592,.00942408
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
LOGHX
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
T T T T
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
HEXVP
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
   907000.   2.        3.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
SPLITV
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
   .9
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
VALVE
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
   8.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
F F F F F,1.8672E7,279.      108.      .99057592 .00942408
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62B
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
F F F F,   25800000. 275.      109.      1.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN62B
(OPTIONAL START) INIT VALUES  VARIABLE VALUES
   250.
TYPE EN FOR END,
```

```
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN86
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
   250.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
   250.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
   250.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN62A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
   250.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EVAPVP
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
   1.        1.        1.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
CONDVP
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
    .5        .5        .5
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
LOGEV
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
   F,T,F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
LOGCN
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
T T F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN
GIVE COMMAND
UNITIN
GIVE COMMAND
AFTINT
GIVE COMMAND
```

```
RUNVAL
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S82B
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (5) F,   .0362
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2),F,   284.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2)F,F,   275.      117.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S82
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2),F,   274.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS .
S74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2),F,F   276.      96.53
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S78
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2),F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
F,F,F,F,F,   1.8672E7,302.      108.      .99057592 .00942408
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2),F,   279.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62B
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (3),F
TYPE EN FOR END,
```

```
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (2),F,   275.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN
GIVE COMMAND
SETWTS
GIVE COMMAND
PRESOL
GIVE COMMAND
EOF
```

The EOF command Jietuwu contKot to the cue*
at the teJiminal. It lh always the but command
in an input &ile.

```
GIVE COMMAND
SOLVE

SOLVE
```

The uueji Aolvt this pxobltm.*

```
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CMV6D(l.D-6), REUSE(2),
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
20

20
```

It converges in 9 iterations.
ThJu pKobltm JU a simulation, tktnz ajie, no degrees of freedom.

```
CONVERGED IN    9 ITERATIONS
RHS MAGNITUDE     2.208317D-07
MAGNITUDE OF NEWTON STEP      1.143885D-04
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
   3272 MILLISECONDS CPU TIME  153177 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
PRINT

PRINT
```

```
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S70 S62 S62C S74 S74A TOTAL

VP S70 S62 S62C S74 S74A TOTAL
```

```
                          VARIABLE PACK S70

           1.00000D+38                1.00000D+38                1.00000D+38
FLOW  =    1.86720D+07 C  TEMP  =    2.79000D+02 F  PRES  =    1.08000D+02 C
           0.00000D+00                0.00000D+00                0.00000D+00

           1.00000D+38                1.00000D+38
MF    =    9.90576D-01 C  MF    =    9.42408D-03 C
           0.00000D+00                0.00000D+00


                          VARIABLE PACK S62

           1.00000D+38                1.00000D+38                1.00000D+38
FLOW  =    4.89487D+06 C  TEMP  =    2.75000D+02 F  PRES  =    1.09000D+02 C
           0.00000D+00                0.00000D+00                0.00000D+00

           1.00000D+38
MF    =    1.00000D+00 C
           0.00000D+00


                          VARIABLE PACK S62C

           1.00000D+38                1.00000D+38                1.00000D+38
FLOW  =    5.58860D+05 C  TEMP  =    2.75000D+02 F  PRES  =    1.17000D+02 F
           0-00000D+00                0.00000D+00                0.00000D+00

           1.00000D+38
MF    =    1.00000D+00 C
           0.00000D+00
```

```
                         VARIABLE PACK S74

             1.00000D+38                 1.00000D+38                 1.00000D+38
FLOW   =     5.45373D+06 C  TEMP   =     2.76000D+02 F  PRES   =     9.65300D+01 F
             0.00000D+00                 0.00000D+00                 0.00000D+00

             1.00000D+38
MF     =     1.00000D+00 C
             0.00000D+00


                         VARIABLE PACK S74A

             1.00000D+38                 1.00000D+38                 1.00000D+38
FLOW   =     5.45373D+06 C  TEMP   =     2-840000+02 F  PRES   =     1.36443D+02 C
             0.00000D+00                 0.00000D+00                 0.00000D+00

             1.00000D+38
MF     =     1.00000D+00 C
             0.00000D+00


                         VARIABLE PACK TOTAL

             1.00000D+38                 1.00000D+38                 1.00000D+38
TOTUTL=      2.01177D+06 C  TOTCAP=      2.33226D+06 C  TOTAL =      4.34403D+06 C
             0.00000D+00                 0.00000D+00                 0.00000D+00

GIVE COMMAND
RESET

RESET
GIVE VALUES FOR INPUT AND OUTPUT FILES
DEVICES 20 THROUGH 24 AND 63 DEFAULT TO THE DISK
38 5

38 5
```

Tfie *tueji nzaxU monz conmandU £jiom {UUL 3&. Uúng thm commands, the. tueji &£*> tkt tzmpejatfwm o£ Mwuuiu* S10, S14, S74A, S6Z, and S62C to* 6e *calcjuJLa&d. ThzAt tejaqpejuUuAjt* wUUL* be rfegAee^ *o{ {h&zdom Jin the. optimization calculation. The. tueji aJUo MJU upptA and lovoeji bound* uohejiz appAopJuate..*

```
GIVE COMMAND
```

```
RUNVAL
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN
GIVE  COMMAND
PRESOL
GIVE  COMMAND
LOVBND
TYPE EN FOR END,
NAME OF PACK TO SET LOWER BOUNDS
S70
 (OPTIONAL START)  LOWER BOUNDS
 (TEMP) 274.5
TYPE EN FOR END,
NAME OF PACK TO SET LOWER BOUNDS
S74A
 (OPTIONAL START)  LOWER BOUNDS
 (TEMP) 284.
TYPE EN FOR END,
NAME OF PACK TO SET LOWER BOUNDS
S74
 (OPTIONAL START)  LOWER BOUNDS
```

```
(TEMP) 270.
TYPE EN FOR END,
NAME OF PACK TO SET LOWER BOUNDS
S62
(OPTIONAL START) LOVER BOUNDS
(TEMP) 275.
TYPE EN FOR END,
NAME OF PACK TO SET LOWER BOUNDS
EN
GIVE COMMAND
UPBND
TYPE EN FOR END,
NAME OF PACK TO SET UPPER BOUNDS
S70
(OPTIONAL START) UPPER BOUNDS
(TEMP) 282.
TYPE EN FOR END,
NAME OF PACK TO SET UPPER BOUNDS
S62C
(OPTIONAL START) UPPER BOUNDS
(TEMP)  275.
TYPE EN FOR END,
NAME OF PACK TO SET UPPER BOUNDS
S74A
(OPTIONAL START) UPPER BOUNDS
(TEMP) 290.
TYPE EN FOR END,
NAME OF PACK TO SET UPPER BOUNDS
S74
(OPTIONAL START) UPPER BOUNDS
(TEMP) 275.
TYPE EN FOR END,
NAME OF PACK TO SET UPPER BOUNDS
EN
GIVE COMMAND
OBJECT
```

Undeji tht OBJECT command tht tueji teJUU ASCEWP-II *that vajuablt TOTCAP in vcuuuibJU packeX TOTAL U to be. rrujumizzd.*

```
MAXIMIZE OR MINIMIZE?
(TYPE MAX OR MIN)
MIN
TYPE NAME OF VARIABLE PACKET, NAME OF VARIABLE, OFFSET  IF ANY
TOTAL TOTCAP
GIVE COMMAND
SETWTS
```

Re^cole *the, vajuablt* and tquuation*.*

```
GIVE COMMAND
```

```
EOF
```
Return control to the user.
```
GIVE COMMAND
OPTMIZ

OPTMIZ
```
Start the optimization.
```
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(1.D-6), SAMPIV(N),
DIAG(0.0), STPDEC(0.5), FACT(1.0), IDEBUG(0)
3

3
%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 531743

DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     3.963033D-02
MAGNITUDE OF NEWTON STEP      1.091950D-01
VALUE OF ALPHA       1.000000D+00
VALUE OF TAU      1.000000D+00
```
ALPHA and TAU are step size parameters.
```
VALUE OF NU       1.045812D+00
MAGNITUDE OF STEP IN DECISIONS      1.066865D-01
VALUE OF THE OBJECTIVE VARIABLE      2.318769D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTCAP IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
```
Harwell routine MA28 has chosen these variables to be decision variables.
```
VARIABLE FLOW   IN PACKET S62D
```

```
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   4137 MILLISECONDS CPU TIME  217111 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
1 Y

1 Y
```

Tht "Y" indicate that tht samt pivot sequence
and Ht&Mån UaXxix should bt tutd cu in tht pimvlotu

OFTMIZ command.

```
%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow  "   PC= 533134

DID NOT CONVERGE IN    1 ITERATIONS
RHS MAGNITUDE     5.504399D-03
MAGNITUDE OF NEWTON STEP      3.807231D-02
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      5.2996700-01
MAGNITUDE OF STEP IN DECISIONS      2.661225D-02
VALUE OF THE OBJECTIVE VARIABLE      2.347448D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTCAP IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4
THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
```

```
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
  * 1262 MILLISECONDS CPU TIME   31131 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
VIOLAT

VIOLAT
```

VIOLAT *command causes violated constraints to* be *reported.*

```
**********  VIOLATED CONSTRAINTS ********
     NO CONSTRAINTS VIOLATED
```

At this point, none have been violated.

```
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
3 Y

3 Y

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     2.237737D-05
MAGNITUDE OF NEWTON STEP      2.Q04419D-05
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      9.087786D-01
MAGNITUDE OF STEP IN DECISIONS      2.272388D-03
VALUE OF THE OBJECTIVE VARIABLE      2.348716D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTCAP IN PACKET TOTAL
```

```
NUMBER OF TIGHT CONSTRAINTS      4

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   3724 MILLISECONDS CPU TIME  151505 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l-D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
3 Y

3 Y

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 531743

DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     5.943835D-09
MAGNITUDE OF NEWTON STEP      1.041970D-08
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      1.000082D+00
MAGNITUDE OF STEP IN DECISIONS      3.742476D-05
```

```
VALUE OF THE OBJECTIVE VARIABLE      2.348734D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTCAP IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   3721 MILLISECONDS CPU TIME  156847 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
3 Y

3 Y
%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

CONVERGED IN    1 ITERATIONS
```

Tfie pAoblzm kcu convzjigtd bi a total o£ 11 Jtixjuitloiu.

```
RHS MAGNITUDE      1.806291D-16
MAGNITUDE OF NEWTON STEP      6.610749D-09
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      1.000263D+00
MAGNITUDE OF STEP IN DECISIONS      4.330504D-09
VALUE OF THE OBJECTIVE VARIABLE      2.348734D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTCAP IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4
```

4 coYuJjiaJjuU aAe tight at thi solution.

```
THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOVER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EK62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   1176 MILLISECONDS CPU TIME   15160 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S62 S62C S74 S74A S70 TOTAL

VP S62 S62C S74 S74A S70 TOTAL


                           VARIABLE PACK S62

             1.00000D+38                1.00000D+38                1.00000D+38
 FLOW   »    4.88732D+06 C  TEMP   =    2.75000D+02 C  PRES   =    1.09000D+02 C
             0.00000D+00                2.75000D+02 •              0.00000D+00

             1.00000D+38
 MF     =    1-00000D+00 C
             O.00OOOD+OO


                           VARIABLE PACK S62C

             1.00000D+38                2.75000D+02                1.00000D+38
```

```
FLOW   =     4.48475D+05 C  TEMP   =     2.75000D+02 C  PRES   =     1.17000D+02 F
             0.00000D+00                 0.00000D+00                 0.00000D+00

             1.00000D+38
MF     =     1.00000D+00 C
             0.00000D+00
```

VARIABLE PACK S74

```
             1.00000D+38                 2.75000D+02 *               1.00000D+38
FLOW   =     5.33579D+06 C  TEMP   =     2,750000+02 C  PRES   =     9.65300D+01 F
             0.00000D+00                 2.70000D+02                 0.00000D+00

             l.00000D+38
MF     =     1.00000D+00 C
             0.00000D+00
```

VARIABLE PACK S74A

```
             l.00000D+38                 2.90000D+02                 l.00000D+38
FLOW   =     5.33579D+06 C  TEMP   =     2.84000D+02 C  PRES   =     1.42575D+02 C
             0.00000D+00                 2.84000D+02                 0.00000D+00

             l.00000D+38
MF     =     1.00000D+00 C
             0.00000D+00
```

VARIABLE PACK S70

```
             l.00000D+38                 2.82000D+02                 l.00000D+38
FLOW   =     1.86720D+07 C  TEMP   =     2.76774D+02 C  PRES   =     1.08000D+02 C
             0.00000D+00                 2.74500D+02                 0.00000D+00

             l.00000D+38                 l.00000D+38
MF     =     9.90576D-01 C  MF     =     9.42408D-03 C
             0.00000D+00                 0.00000D+00
```

VARIABLE PACK TOTAL

```
           T.00000D+38                 1.00000D+38                 1.00000D+38
TOTUTL=    1.76798D+06 C  TOTCAP=      2.34873D+06 C  TOTAL =      4.11671D+06 C
           0.00000D+00                 0.00000D+00                 0.00000D+OO
```

Tfte *tempejiatuKt* o£ vUitam* S61,* S62C, *S74 and S74A o)tz at bound*. The. optimum i& inttnnal with HZApexA to tht tempejtaJwie. o£ 6tAtam S70. A tempejurfUHZ in S10 o£* 276.774° *K give.* a total capital covt o£ $2.34S73E6.*

The tueji now £ixt the. live. tzwpejiatuHZ* and vastier the. tempejuituHt ol S10 up and down to vejU£y that thi& Ju the. optimum.*

```
GIVE COMMAND
RUNVAL

RUNVAL
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62

S62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C

S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74

S74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74A
```

```
S74A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70

S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F 275.

 (TEMP) F 275.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN

EN
GIVE COMMAND
PRESOL

PRESOL
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2),
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
3

3
 ERROR IN SOLV    NO.    5   SPECS    1         9.840035D-02
 ERROR IN SOLV    NO.    5   SPECS    1         9.840035D-02
DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     3.057110D-02
MAGNITUDE OF NEWTON STEP      1.330357D-01
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
   1236 MILLISECONDS CPU TIME    8611 MILLISECONDS CONNECT TIME
```

```
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR HAXIT, CNVGD(l.D-6), REUSE(2),
                  STPMAX(0.3),SAMPIV(N),IDEBUG(O)
3 Y

3 Y

CONVERGED IN    3 ITERATIONS
RHS MAGNITUDE     2.229930D-10
MAGNITUDE OF NEWTON STEP      1.072744D-06
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
   1150 MILLISECONDS CPU TIME   54091 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S70 TOTAL

VP S70 TOTAL



                         VARIABLE PACK S70

           1.00000D+38              2.82000D+02              1.00000D+38
 FLOW  =   1.86720D+07 C  TEMP  =   2.75000D+02 F  PRES  =   1.08000D+02 C
           0.00000D+00              2.74500D+02              0.00000D+00
```

```
            1.00000D+38                1.00000D+38
 MF    =    9.90576D-01 C  MF    =     9.42408D-03 C
            0.OOOOOD+OO                0.00000D+00
```

```
                        VARIABLE PACK TOTAL

            1.00000D+38                1.00000D+38                1.00000D+38
 TOTUTL=    1.45406D+06 C  TOTCAP=     2.48920D+06 C  TOTAL =     3.94326D+06 C
            0.00000D+00                0.00000D+00                0.00000D+00
```

A tewptJiatuJie. o£ 275° K ACLUZA tkt total capital co6t to $Z.4S92E6.

```
GIVE COMMAND
RUNVAL

RUNVAL
TYPE EM FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70

S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP)  277.5

 (TEMP)  277.5
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN

EN
GIVE COMMAND
PRESOL

PRESOL
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2),
```

```
                  STPMAX(0.3), SAMPIV(N), IDEBUG(0)
2

2
DID NOT CONVERGE IN    2 ITERATIONS
RHS MAGNITUDE     5.684856EH05
MAGNITUDE OF NEWTON STEP      3.030009D-04
VALUE OF ALPHA      1.0000000+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
    756 MILLISECONDS CPU TIME    4769 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
VIOLAT

VIOLAT

**********  VIOLATED CONSTRAINTS ********
    UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2)f
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
3 Y

3 Y
CONVERGED IN    1 ITERATIONS
RHS MAGNITUDE     5.848690D-09
MAGNITUDE OF NEWTON STEP      2.170864D-05
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
    508 MILLISECONDS CPU TIME    2950 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
VIOLAT

VIOLAT
```

```
**********  VIOLATED CONSTRAINTS ********
    UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S74 S70 TOTAL

VP S74 S70 TOTAL


                              VARIABLE PACK S74

           1.00000D+38                2.75000D+02 *              1.00000D+38
 FLOW  =   5.33225D+06 C  TEMP  =     2.75000D+02 F  PRES  =     9.65300D+01 F
           0.00000D+00                2.70000D+02                0.00000D+00

           1.00000D+38
 MF    =   1.00000D+00 C
           0.00000D+00


                              VARIABLE PACK S70

           I.00000D+38                2.82000D+02                1.00000D+38
 FLOW  =   1.86720D+07 C  TEMP  =     2.77500D+02 F  PRES  =     1.08000D+02 C
           0.00000D+00                2.74500D+02                0.00000D+00

           1.00000D+38                1.00000D+38
 MF    =   9.90576D-01 C  MF    =     9.42408D-03 C
           0.00000D+00                0.00000D+00


                              VARIABLE PACK TOTAL

           1.00000D+38                1.00000D+38                1.00000D+38
 TOTUTL=   1.89653D+06 C  TOTCAP=     2.35641D+06 C  TOTAL =     4.25294D+06 C
           0.00000D+00                0.00000D+00                0.00000D+00
```

Raiuńg tht ttrnptnatiiJit o£ SJO to 277.5° *K JUMLHZGLMJ* tht total capital coU to $2.35641E6, aJUo higher than tht optimum calculated by ASCENV-JI.*

```
GIVE COMMAND
RUNVAL

RUNVAL
```

Tht uutJi no Att tht tvnptMJwit* o& tht iivt 6tJvtam6 to bt* cfl/cw/fl-fttfT

```
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70

S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62

S62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C

S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAttE OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74

S74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
```

```
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74A

S74A
 (OPTIONAL START)"INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN

EN
GIVE COMMAND
PRESOL

PRESOL
GIVE COMMAND
OBJECT

OBJECT
```

He MXJ> *the. objictivt to minimize, vajuxiblt TCfTAL in vajuablz packeX TCfTAL. ThJU vajuabli* i& the. Mim o£ alt capital and utility co&U.*

```
MAXIMIZE OR MINIMIZE?
 (TYPE MAX OR MIN)
MIN

MIN
TYPE NAME OF VARIABLE PACKET, NAME OF VARIABLE, OFFSET  IF ANY
TOTAL TOTAL

TOTAL TOTAL
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
3

3
%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 531204
```

```
%FRSAPR Floating underflow       PO 533144

%FRSAPR Floating underflow      PC= 531743

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     1.670897D-01
MAGNITUDE OF NEWTON STEP      5.828885D-01
VALUE OF ALPHA      5.228612D-01
VALUE OF TAU      1.000000D+00
VALUE OF NU      3.193678D-01
MAGNITUDE OF STEP IN DECISIONS      3.645845D-02
VALUE OF THE OBJECTIVE VARIABLE      3.807182D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTAL  IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   3848 MILLISECONDS CPU TIME   61115 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
4 Y

4 Y
%FRSAPR Floating underflow      PC= 533144
```

```
%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow   .  PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

DID NOT CONVERGE IN    4 ITERATIONS
RHS MAGNITUDE     5.678692D-03
MAGNITUDE OF NEWTON STEP      3.507210D-02
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      3.552950D+00
MAGNITUDE OF STEP IN DECISIONS      5-287903D-03
VALUE OF THE OBJECTIVE VARIABLE      3.931284D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTAL  IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4

THE TIGHT CONSTRAINTS
   LOVER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   5339 MILLISECONDS CPU TIME  105954 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l-D-6), SAMPIV(N),
```

```
DIAG(0.0), STPDEC(0.5), FACT(l.0), IDEBUG(0)
4 Y

4 Y

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 533134

%FRSAPR Floating underflow      PC= 533144

DID NOT CONVERGE IN    4 ITERATIONS
RHS MAGNITUDE     3.537908D-09
MAGNITUDE OF NEWTON STEP      1.649673D-07
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      1.440249D+00
MAGNITUDE OF STEP IN DECISIONS      8.857473D-06
VALUE OF THE OBJECTIVE VARIABLE      3.932645D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTAL  IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      4
THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW   IN PACKET S62D
VARIABLE FLOW   IN PACKET S86
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED * 156 EQUATIONS     5 DEGREES OF FREEDOM
   4943 MILLISECONDS CPU TIME   90220 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS  ' 117
```

GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
5 Y

5 Y

%FRSAPR Floating underflow PC= 533134

%FRSAPR Floating underflow PC= 533144

%FRSAPR Floating underflow PC= 533134

%FRSAPR Floating underflow PC= 533144

CONVERGED IN 2 ITERATIONS
TkU pKoblzm converge. in 13 ittAcutioru. Once, agointernal*
iouK cofUtMubnJU OJUL tight, udvile. the. mJbujnxm Ju
u&Uh xuptcA to the. tzmpejiatujie. o£ tthzam S70.
RHS MAGNITUDE 6.855309D-16
MAGNITUDE OF NEWTON STEP 3.623683D-10
VALUE OF ALPHA 1.000000D+00
VALUE OF TAU 1.000000D+00
VALUE OF NU 9.996357D-01
MAGNITUDE OF STEP IN DECISIONS 3.870119D-09
VALUE OF THE OBJECTIVE VARIABLE 3.932645D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTAL IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS 4
THE TIGHT CONSTRAINTS
LOWER BOUND OF VARIABLE TEMP IN PACKET S74A
UPPER BOUND OF VARIABLE TEMP IN PACKET S74
LOWER BOUND OF VARIABLE TEMP IN PACKET S62
UPPER BOUND OF VARIABLE TEMP IN PACKET S62C

THE DECISION VARIABLES ARE
VARIABLE FLOW IN PACKET S62D
VARIABLE FLOW IN PACKET S86
VARIABLE DELP IN PACKET CHLIQV
VARIABLE Q IN PACKET EN62A
VARIABLE Q IN PACKET EN62
TOTAL OF 237 VARIABLES
76 FIXED 161 CALCULATED 156 EQUATIONS 5 DEGREES OF FREEDOM
2323 MILLISECONDS CPU TIME 51861 MILLISECONDS CONNECT TIME

```
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
VIOLAT

VIOLAT

**********  VIOLATED CONSTRAINTS ********
    LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S62 S62C S74 S74A S70 TOTAL

VP S62 S62C S74 S74A S70 TOTAL


                            VARIABLE PACK S62

            1.00000D+38                 1.00000D+38                 1.00000D+38
 FLOW  =    4.88732D+06 C  TEMP  =      2.75000D+02 C  PRES  =      1.09000D+02 C
            0.00000D+00                 2.75000D+02 *               0.00000D+00

            1.00000D+38
 MF    =    1.00000D+00 C
            0.00000D+00


                            VARIABLE PACK S62C

            1.00000D+38                 2.75000D+02                 1.00000D+38
 FLOW  =    3.49945D+05 C  TEMP  =      2.75000D+02 C  PRES  =      1.17000D+02 F
            0.00000D+00                 0.00000D+00                 0.00000D+00

            1.00000D+38
 MF    =    1.00000D+00 C
            0.00000D+00
```

VARIABLE PACK S74

		1.00000D+38				2.75000D+02				1.00000D+38	
FLOW	=	5.23726D+06	C	TEMP	=	2.75000D+02	C	PRES	=	9.65300D+01	F
		0.00000D+00				2.70000D+02				0.00000D+00	
		1.00000D+38									
MF	=	1.00000D+00	C								
		0.00000D+00									

VARIABLE PACK S74A

		1.00000D+38				2.90000D+02				1.00000D+38	
FLOW	=	5.23726D+06	C	TEMP	=	2.84000D+02	C	PRES	=	1.42575D+02	C
		0.00000D+00				2,84000D+02	*			0.00000D+00	
		1.00000D+38									
MF	=	1.00000D+00	C								
		0.00000D+00									

VARIABLE PACK S70

		1.00000D+38				2.82000D+02				1.00000D+38	
FLOW	=	1.86720D+07	C	TEMP	=	2.75233D+02	C	PRES	=	1.08000D+02	C
		0-00000D+00				2-74500D+02				0.00000D+00	
		1.00000D+38				1.00000D+38					
MF	=	9.90576D-01	C	MF	=	9.42408D-03	C				
		0.00000D+00				0.00000D+00					

VARIABLE PACK TOTAL

	1.00000D+38			1.00000D+38				1.00000D+38	
TOTUTL=	1.49531D+06	C	TOTCAP^	2.43734D+06	C	TOTAL	=	3.93264D+06	C
	0.00000D+00			0.00000D+00				0.00000D+00	

A temperature in S70 of 275.233° K gives a total cost of $3.93Z64E6.

GIVE COMMAND
RUNVAL

RUNVAL

Once *agcin thz* cue *KWJU to* 6e *MUit that tkJU i* thi optimum.* He *puitunb* the. temptnatujit o£ Witam S70 ^tightly hlghzji and tJUghtly IOUKJL.*

```
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62

S62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C

S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74

S74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74A

S74A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) F

 (TEMP) F
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70

S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
```

```
 (TEMP) F 275.

 (TEMP) F 275.
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS / VALUES, OR BOUNDS
EN

EN
GIVE COMMAND
PRESOL

PRESOL
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2),
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
3

3
 ERROR IN SOLV    NO.    5   SPECS    1         1.458551D-02
 ERROR IN SOLV    NO.    5   SPECS    1         1.458551D-02
DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     5.381058D-06
MAGNITUDE OF NEWTON STEP      3.373613D-03
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
   1276 MILLISECONDS CPU TIME    6931 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 •.• C/R FOR ALL UNITS



SOLVING
```

```
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2),
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
3 Y

3 Y
CONVERGED IN    1 ITERATIONS
RHS MAGNITUDE     3.947056D-11
MAGNITUDE OF NEWTON STEP      6.987953D-07
VALUE OF ALPHA      l.OOOOOOD+OO
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
    490 MILLISECONDS CPU TIME    3283 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
VIOLAT

VIOLAT

**********  VIOLATED CONSTRAINTS ********
    LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$   FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S74A S70 TOTAL

VP S74A S70 TOTAL



                            VARIABLE PACK S74A

            1.00000D+38                2.90000D+02                1.00000D+38
 FLOW  =    5.22236D+06 C  TEMP  =     2.84000D+02 F  PRES  =     1.42575D+02 C
            O.OOOOOD+00                2.84000D+02 *              O.OOOOOD+00

            1.00000D+38
 MF    =    l.OOOOOD+00 C
            O.OOOOOD+00
```

```
                    VARIABLE PACK S70

          1.00000D+38             2.82000D+02               1.00000D+38
FLOW   =  1.86720D+07 C  TEMP  =  2.75000D+02 F  PRES   =   1.08000D+02 C
          0.00000D+00             2.74500D+02               O.OOOOGD+00

          1.00000D+38             1.00000D+38
MF     =  9.90576D-01 C  MF    =  9.42408D-03 C
          0.00000D+00             0.00000D+00


                    VARIABLE PACK TOTAL

          1.00000D+38             1.00000D+38               1.00000D+38
TOTUTL=   1.45406D+06 C  TOTCAP=  2.48920D+06 C  TOTAL  =   3.94326D+06 C
          0.00000D+00             0.00000D+00               0.00000D+00
```

Lowejúng the. **temperature** *o{ S10* **to** 275.° **K** *JÚUMA* **the. total**
<LOU to S3.94326E6.

```
GIVE COMMAND
RUNVAL

RUNVAL
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70

S70
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP)  275.5

 (TEMP)  275.5
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN

EN
GIVE COMMAND
PRESOL

PRESOL
GIVE COMMAND
SOLVE

SOLVE
```

```
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2),
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
3 Y

3 Y
 ERROR IN SOLV    NO.    5   SPECS    1         8.123370D-02
 ERROR IN SOLV    NO.    5   SPECS    1         8.123370D-02
DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     4.167432D-04
MAGNITUDE OF NEWTON STEP      4.146642D-02
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
   1126 MILLISECONDS CPU TIME    6916 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
SOLVE

SOLVE
GIVE NAME OF UNIT(S) TO SOLVE
UN NAME1 NAME2 ... C/R FOR ALL UNITS



SOLVING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), REUSE(2),
                  STPMAX(0.3), SAMPIV(N), IDEBUG(O)
3 Y

3 Y
CONVERGED IN    1 ITERATIONS
RHS MAGNITUDE     4.906400D-07
MAGNITUDE OF NEWTON STEP      1.317807D-04
VALUE OF ALPHA      1.000000D+00
TOTAL OF  237 VARIABLES
   81 FIXED   156 CALCULATED   156 EQUATIONS     0 DEGREES OF FREEDOM
    521 MILLISECONDS CPU TIME    5485 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    136
GIVE COMMAND
VIOLAT
```

```
VIOLAT

**********  VIOLATED CONSTRAINTS ********
    LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP S74A S70 TOTAL

VP S74A S70 TOTAL


                              VARIABLE PACK S74A

           1.00000D+38                 2.90000D+02                 1.00000D+38
 FLOW  =   5.25434D+06 C  TEMP  =      2.84000D+02 F  PRES  =      1.42575D+02 C
           0.00000D+00                 2.84000D+02 *               0.00000D+00

           1.00000D+38
 MF    =   1.00000D+00 C
           0.00000D+00


                              VARIABLE PACK S70

           1.00000D+38                 2.82000D+02                 1.00000D+38
 FLOW  =   1.86720D+07 C  TEMP  =      2.75500D+02 F  PRES  =      1.08000D+02 C
           0.00000D+00                 2.74500D+02                 0.00000D+00

           1.00000D+38                 1.00000D+38
 MF    =   9.90576D-01 C  MF    =      9.42408D-03 C
           0.00000D+00                 0.00000D+00


                              VARIABLE PACK TOTAL

           1.00000D+38                 1.00000D+38                 1.00000D+38
```

```
TOTUTL=     1.54255D+06 C  TOTCAP=     2.39981D+06 C  TOTAL =     3.94236D+06 C
            O.OOOOOD+OO                0.00000D+00                0.OOOOOD+OO
```

Raluńq the- tunpejartuAe. to 275.5° *K aJUo JuncMJUi* ikt total cost.*

```
GIVE COMMAND
RUNVAL

RUNVAL
```

Tfte *uueji now JieJLexut* the.* £cve *tzmpejuvtujvi* specifications *and* AOIVZA *a diHejiznt pAoblzm.*

```
TYPE EH FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62

S62
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOH END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S62C

S62C
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74

S74
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S74A

S74A
 (OPTIONAL START)  INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
```

```
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
S70

S70
 (OPTIONAL START) INIT VALUES  VARIABLE VALUES
 (TEMP) C

 (TEMP) C
TYPE EN FOR END,
NAME OF PACK TO SET FLAGS, VALUES, OR BOUNDS
EN

EN
GIVE COMMAND
PRESOL

PRESOL
GIVE COMMAND
```

Undejt tkt OBJECT command **fie** *tztU* **ASCB/P-II** *to trioUmizt the. total utMtfiiA.*

```
OBJECT

OBJECT
MAXIMIZE OR MINIMIZE?
 (TYPE MAX OR MIN)
MIN

MIN
TYPE NAME OF VARIABLE PACKET, NAME OF VARIABLE, OFFSET  IF ANY
TOTAL TOTUTL

TOTAL TOTUTL
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
3

3
%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204
```

```
%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE     7.750054D-03
MAGNITUDE OF NEWTON STEP      3.741913D-02
VALUE OF ALPHA      1-000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      8.918913D-01
MAGNITUDE OF STEP IN DECISIONS      2.306593D-01     I
VALUE OF THE OBJECTIVE VARIABLE      1.445954D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTUTL IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      5

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE AREA   IN PACKET HEXVP
   LOWER BOUND OF VARIABLE Q      IN PACKET EN62A

THE DECISION VARIABLES ARE
VARIABLE AREA   IN PACKET HEXVP
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE FLOW   IN PACKET S74A
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   5593 MILLISECONDS CPU TIME   95921 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
5 Y

5 Y
%FRSAPR Floating underflow      PC= 531204
```

```
%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 5^31204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 533144

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow       PO 474632

%FRSAPR Floating underflow      PC= 474666

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

DID NOT CONVERGE IN    5  ITERATIONS
RHS MAGNITUDE     2.513287D-03
MAGNITUDE OF NEWTON STEP      2.647448D-04
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      8.809121D-01
MAGNITUDE OF STEP IN DECISIONS      2.236069D-01
VALUE OF THE OBJECTIVE VARIABLE      1.380288D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTUTL IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      5

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE AREA   IN PACKET HEXVP
   LOWER BOUND OF VARIABLE Q      IN PACKET EN62A

THE DECISION VARIABLES ARE
VARIABLE AREA   IN PACKET HEXVP
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE FLOW   IN PACKET S74A
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
```

```
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   5494 MILLISECONDS CPU TIME  240947 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O-O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
5 Y

5 Y

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 474747

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 474523
DID NOT CONVERGE IN    5 ITERATIONS
RHS MAGNITUDE     1.988932D-03
MAGNITUDE OF NEWTON STEP      1.408310D-04
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      9.128868D-01
MAGNITUDE OF STEP IN DECISIONS      2.236068D-01
```

```
VALUE OF THE OBJECTIVE VARIABLE      1.346975D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTUTL IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      5

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE AREA   IN PACKET HEXVP
   LOWER BOUND OF VARIABLE Q      IN PACKET EN62A

THE DECISION VARIABLES ARE
VARIABLE AREA   IN PACKET HEXVP
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE FLOW   IN PACKET S74A
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   5916 MILLISECONDS CPU TIME  186349 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N),
DIAG(O.O), STPDEC(0.5), FACT(l.O), IDEBUG(O)
3 Y

3 Y
%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 474523

DID NOT CONVERGE IN    3 ITERATIONS
RHS MAGNITUDE      1.779622D-03
MAGNITUDE OF NEWTON STEP     1.079014D-04
VALUE OF ALPHA      1.000000D+00
```

```
VALUE OF TAU      1.000000D+00
VALUE OF NU      9.250184D-01
MAGNITUDE OF STEP IN DECISIONS      2.236068D-01
VALUE OF THE OBJECTIVE VARIABLE      1.333835D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTUTL IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      5

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   UPPER BOUND OF VARIABLE AREA   IN PACKET HEXVP
```

The. tyvtem think* that vcuUablz AREA in HEXVP lt> at JUU uppeji bound. ThJU valuable. JU a dtcJUlon vcuiablz. The. AtjAtzm muut bt takUng the. maximum allowed stzp in HUM dtcJulon valuable, bicaiui thz OKtai AJ> iaji faom it* uppeji bound.

```
   LOWER BOUND OF VARIABLE Q      IN PACKET EN62A

THE DECISION VARIABLES ARE
VARIABLE AREA   IN PACKET HEXVP
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE FLOW   IN PACKET S74A
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED   161 CALCULATED   156 EQUATIONS     5 DEGREES OF FREEDOM
   3349 MILLISECONDS CPU TIME  127372 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS    117
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP HEXVP

VP HEXVP


                          VARIABLE PACK HEXVP
```

```
           1-00000D+38                1.00000D+38                1.00000D+38
COEF   =   9.07000D+05 F  DTCOL =     5.24211D-01 C  DTHOT =     5.24211D-01 C
           0.00000D+00                5.00000D-01                5.00000D-01

           1.00000D+38                1.0000QD+38                1.00000D+38
TAVC   =   2.87738D+02 C  TAVH  =     2.88262D+02 C  CPC   =     1.80000D+01 C
           0.00000D+00                0.00000D+00                0.00000D+00

           1.00000D+38                1.00000D+38                1.00000D+38
CPC    =   5.78000D+01 C  CPH   =     1.80000D+01 C  CPH   =     5.78000D+01 C
           0.00000D+00                0.00000D+00                0.00000D+00

           1.00000D+38                1.00000D+38                1.00000D+38
Q      =   9.42693D+09 C  XLOG  =     2.00000D+00 F  DTLM  =     5.24211D-01 C
           0.00000D+00               -1.00000D+38                0.00000D+00

           1.00000D+38                1.00000D+38                1.00000D+38
AREA   =   1.97879D+04 C  CAP80 =     7.95432D+05 C  LNAR  =     9.89381D+00 C
           0.00000D+00                0.00000D+00               -1.00000D+38

GIVE COMMAND
OPTMIZ

OPTMIZ
OPTIMIZING
GIVE VALUES FOR MAXIT, CNVGD(l.D-6), SAMPIV(N)#
DIAG(O.O), STPDEC(0.5), FACT(1.0), IDEBUG(O)
3 l.D-6 Y 0- 2.

3 1.EH6 Y 0. 2.
```

Allow tkz dtcJLM.on vcuUablz to takz a larger 6tcp than the. dz£aatt.*

```
%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 474523

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 531204

%FRSAPR Floating underflow      PC= 474523
```

This problem converges in 19 iterations.

```
CONVERGED IN    3 ITERATIONS
RHS MAGNITUDE     2.072687D-13
MAGNITUDE OF NEWTON STEP      2.428529D-07
VALUE OF ALPHA      1.000000D+00
VALUE OF TAU      1.000000D+00
VALUE OF NU      4.000549D-07
MAGNITUDE OF STEP IN DECISIONS      4.033654D-11
VALUE OF THE OBJECTIVE VARIABLE      1.329733D+06
THE OBJECTIVE IS TO MINIMIZE VARIABLE TOTUTL IN PACKET TOTAL
NUMBER OF TIGHT CONSTRAINTS      5

THE TIGHT CONSTRAINTS
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S74A
   LOWER BOUND OF VARIABLE DTHOT  IN PACKET HEXVP
   UPPER BOUND OF VARIABLE TEMP   IN PACKET S74
   LOWER BOUND OF VARIABLE TEMP   IN PACKET S62
   LOWER BOUND OF VARIABLE Q      IN PACKET EN62A

THE DECISION VARIABLES ARE
VARIABLE AREA   IN PACKET HEXVP
VARIABLE DELP   IN PACKET CHLIQV
VARIABLE FLOW   IN PACKET S74A
VARIABLE Q      IN PACKET EN62A
VARIABLE Q      IN PACKET EN62
TOTAL OF  237 VARIABLES
   76 FIXED    161 CALCULATED    156 EQUATIONS     5 DEGREES OF FREEDOM
   3849 MILLISECONDS CPU TIME  118834 MILLISECONDS CONNECT TIME
NUMBER OF PARTIALS UNDER FIXED COLUMNS IS     117
GIVE COMMAND
PRINT

PRINT
TYPE AL FOR ALL USER NAMED VARIABLE PACKS
VP  NAME(S)  FOR SPECIFIC PACK(S)
PT  NAME(S)  FOR POINTER STATEMENT(S)
UN  NAME(S) FOR USER NAMED VARIABLE PACKS OF SPECIFIC UNIT(S)
A$  FOR ALL VARIABLE PACKS
U$  NAME(S)  FOR ALL VARIABLE PACKS OF NAMED UNIT(S)
VP HEXVP EN62A S62 S62C S74 S74A S70 TOTAL

VP HEXVP EN62A S62 S62C S74 S74A S70 TOTAL
```

All five temperatures are at their bounds. At the same time that these temeratures reach their bounds, variables Q in EN62A and DTHOT in HEXVP also reach their bounds.

VARIABLE PACK HEXVP

		1.00000D+38				1.00000D+38				1.00000D+38	
COEF	=	9.07000D+05	F	DTCOL	=	5.00000D-01	C	DTHOT	=	5.00000D-01	C
		0.00000D+00				5.00000D-01				5.00000D-01	*
		1.00000D+38				1.00000D+38				1.00000D+38	
TAVC	=	2.87750D+02	C	TAVH	=	2.88250D+02	C	CPC	=	1.800000+01	C
		0.00000D+00				0-00000D+00				0-00000D+00	
		1.00000D+38				1.00000D+38				1.00000D+38	
CPC	=	5.78000D+01	C	CPH	=	1.80000D+01	C	CPH	=	5.78000D+01	C
		0.00000D+00				0.00000D+00				0.00000D+00	
		1.00000D+38				1.00000D+38				1-00000D+38	
Q	=	9.43524D+09	C	XLOG	=	2.00000D+00	F	DTLM	=	5.00000D-01	C
		0.00000D+00				-1.00000D+38				0.00000D+00	
		1.00000D+38				1.00000D+38				1.00000D+38	
AREA	=	2.08054D+04	C	CAP80	=	8.21592D+05	C	LNAR	=	9.94297D+00	C
		0.00000D+00				0.00000D+00				-1.00000D+38	

VARIABLE PACK EN62A

		1.00000D+38				1.00000D+38				1.00000D+38	
TREF	=	2.50000D+02	F	TAVG	=	2.50000D+02	C	CP	=	3.18500D+01	C
		0.00000D+00				0.00000D+00				0.00000D+00	
		1.00000D+38									
Q	=	--3-98694D-36	C								
		0.00000D+00	*								

VARIABLE PACK S62

		1.00000D+38				1.00000D+38				1.00000D+38	
FLOW	=	4.88732D+06	C	TEMP	=	2.75000D+02	C	PRES	=	1.09000D+02	C
		0.00000D+00				2.75000D+02	*			0-00000D+00	
		1.00000D+38									

```
MF     =    1.00000D+00 C
            0.00000D+00
```

VARIABLE PACK S62C

```
            1.00000D+38                2.75000D+02                1.00000D+38
FLOW   »    2.63894D+05 C  TEMP   =    2.50000D+02 C  PRES   =    1.17000D+02 F
            0.00000D+00                0.00000D+00                0.00000D+00

            1.00000D+38
MF     =    1.00000D+00 C
            0.00000D+00
```

VARIABLE PACK S74

```
            1.00000D+38                2.75000D+02 *              1.00000D+38
FLOW   =    5.15121D+06 C  TEMP   =    2.75000D+02 C  PRES   =    9.65300D+01 F
            0.00000D+00                2.70000D+02                0.00000D+00

            1.00000D+38
MF     =    1.00000D+00 C
            0.00000D+00
```

VARIABLE PACK S74A

```
            1.00000D+38                2.90C00D+02                1.00000D+38
FLOW   =    5.15121D+06 C  TEMP   =    2-84000D+02 C  PRES   =    1.42575D+02 C
            0.00000D+00                2.84000D+02 *              0.00000D+00

            1.00000D+38
MF     =    1.00000D+00 C
            0.00000D+00
```

VARIABLE PACK S70

```
            1.00000D+38                2.82000D+02                1.00000D+38
FLOW   =    1.86720D+07 C  TEMP   =    2.74500D+02 C  PRES   =    1.08000D+02 C
            0.00000D+00                2;74500D+02 *              0.00000D+00
```

```
          1.00000D+38                 1.00000D+38
 MF    =  9-90576D-01 C  MF    =      9.42408D-03 C
          0.OOOOOD+00                 0.OOOOOD+00


                        VARIABLE PACK TOTAL

          1.OOOOOD+38                 1.00000D+38                 1.00000D+38
 TOTUTL=  1.32973D+06 C  TOTCAP=      3.37715D+06 C  TOTAL =      4.70688D+06 C
          0.OOOOOD+00                 0.OOOOOD+00                 0.OOOOOD+00

GIVE COMMAND
STOP

STOP
STOP

END OF EXECUTION
CPU TIME: 2:26.84       ELAPSED TIME: 59:52.93
EXIT
```

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