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CSDSLE - A FORTRAN PACKAGE FOR THE SOLUTION OF SPARSE

DECOMPOSED SYSTEMS OF LINEAR EQUATIONS

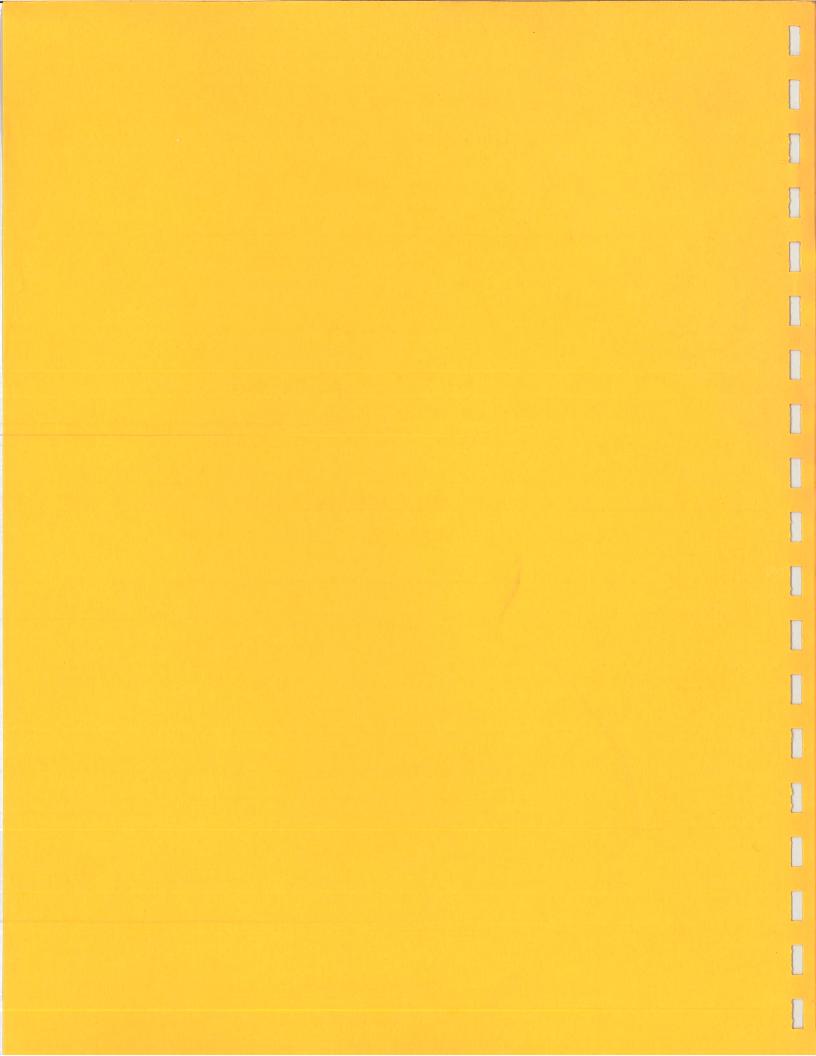
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CSDSLE - A FORTRAN PACKAGE FOR THE SOLUTION OF SPARSE DECOMPOSED SYSTEMS OF LINEAR EQUATIONS

J.A. Starzyk and J.W. Bandler

Abstract

CSDSLE is a package of forty-eight subroutines for solving sparse linear equations for the iterative simulation of very large systems. The equations are assumed to be in decomposed form as required by the Zollenkopf's bi-factorization-type algorithm is used main subroutine. to represent the solution of different submatrices. Different options of the package, when utilized properly, may save a significant amount of computer time and memory compared with the standard sparse-matrix subroutines, including those which utilize simple decomposition or block The package and documentation have been developed for the CDC 170/730 system with the NOS 1.4 level 552 operating system and the Fortran Extended (FTN) Version 4.8 compiler. The report includes 17 illustrative examples, including the use of mass storage, the implementation of changes in the coefficient matrix and changes in the right-Local area changes and their effects on the rest of the hand side. system are discussed. A comparison with the Harwell package MA28 not using decomposition is reported.

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I. INTRODUCTION

The main aim of this package is to serve as an efficient tool in the solution and optimization of extremely large electrical or electronic networks. However, it may be utilized to solve any very large scale problem, which requires the solution of linear equations. method developed to achieve this goal considers two aspects of the problem. Firstly, the size of the problem makes necessary the use of decomposition to fit the requirements to the available computer memory. Secondly, changes in coefficients and/or right hand side values occurring in a local area may cause local effects only, therefore the solution outside this region remains essentially unchanged. ingly, the method operates with a decomposed system of equations, in which changes in the coefficient matrix can be introduced locally and the solution can be obtained for a specified local area. important feature of the method is that, because hierarchical decomposition is employed, the computations can be executed in a parallel processing mode, thus further reducing the time necessary to obtain a solution.

The package is written in Fortran IV for the CDC 170/730 system. At McMaster University it is available in the form of a library of binary relocatable subroutines, which is linked with the user's program by the appropriate call of the main subroutine in the package. The name of the library is CSDSLE. The library is available as a group indirect file under the charge RJWBAND. The sequence of NOS commands to use the package can be as follows:

/GET(CSDSLE/GR) - fetch the library,

/LIBRARY(CSDSLE) - indicate the library to the loader,

/FTN(...,GO) - compile, load and execute the program.

The user should prepare:

- the main program which defines parameters and calls the main subroutine of the package,
- random access file containing the data describing submatrices.

II. GENERAL DESCRIPTION

Flowgraph Representation

Matrix decomposition is based on its Coates signal-flow graph representation [1], in which a square matrix $A = [a_{ij}]_{nxn}$ is represented by a graph with n nodes and k edges, and k is the number of nonzero coefficients in A. A <u>Coates graph</u> edge which goes from node x_j to node x_j has a weight equal to a_{ij} .

Example 1

Coates graph of a coefficient matrix

is shown in Fig. 1.

Graph Decomposition

A signal flow graph is decomposed through its nodes into two sub-graphs (subnetworks). Each of these subgraphs can be decomposed further down to a sufficiently small size. This kind of graph decomposition is called hierarchical decomposition. The structure of hierarchical decomposition can be illustrated by a tree of decomposition. Nodes of

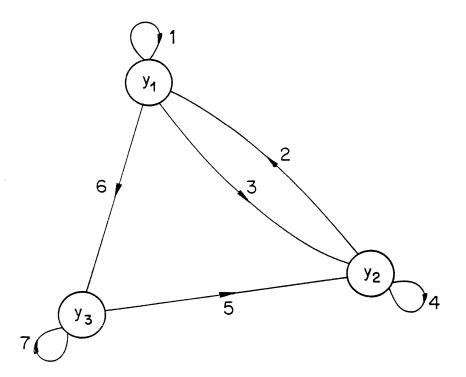


Fig. 1 Coates graph of the matrix $\underset{\sim}{\mathtt{A}}$ of Example 1.

the tree correspond to subgraphs obtained on different <u>levels</u> of decomposition. If a subgraph G_j was obtained during decomposition of subgraph G_i , then there is an edge from the node corresponding to G_i to the node corresponding to G_j . Fig. 3 shows the tree of decomposition corresponding to Fig. 2.

In the decomposition tree we have one <u>initial node</u> - the one which is only the starting point of edges. <u>Terminal nodes</u> are those which are only the end points of edges. All nodes that are not terminal nodes are <u>middle nodes</u>. Subgraphs associated with terminal nodes are called <u>proper blocks</u>. We limit ourselves to bisection as the only graph partition so that every middle node has exactly two descendants. If m is the index of a middle subgraph then two of its descendants have indices 2m and 2m+1, respectively. This way of numbering the graphs makes the analysis of interconnections easier.

Matrix reordering

After all subgraphs have been numbered according to the structure of the decomposition tree, the nodes of a graph are renumbered consecutively in descending order starting from the partition nodes of the graph G_1 , then the partition nodes of graph G_2 and G_3 up to the last partition and then the internal nodes of the proper blocks. After the renumbering, the numbers associated with the graph nodes are called original indices of the nodes. Such renumbering corresponds to reordering the coefficient matrix. An example for the matrix partitioned according to Fig. 2 is shown in Fig. 4.

In Fig. 4, only the shaded areas may contain nonzero coefficients. $\boldsymbol{J}_{\text{i}} \text{ denotes the index set corresponding to the partition nodes of graph}$

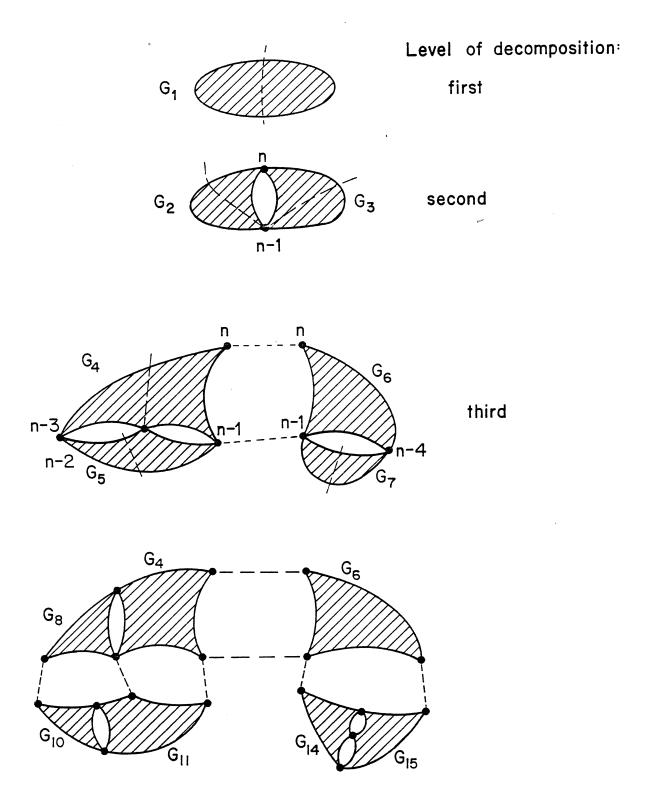


Fig. 2 Three level hierarchical decomposition.

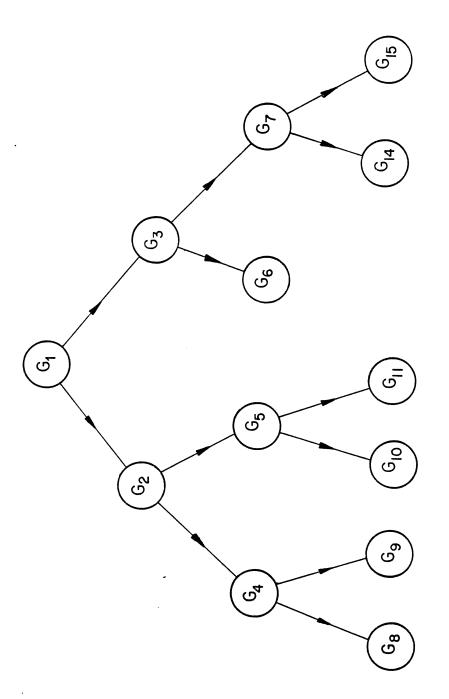


Fig. 3 Tree of decomposition for Fig. 2.

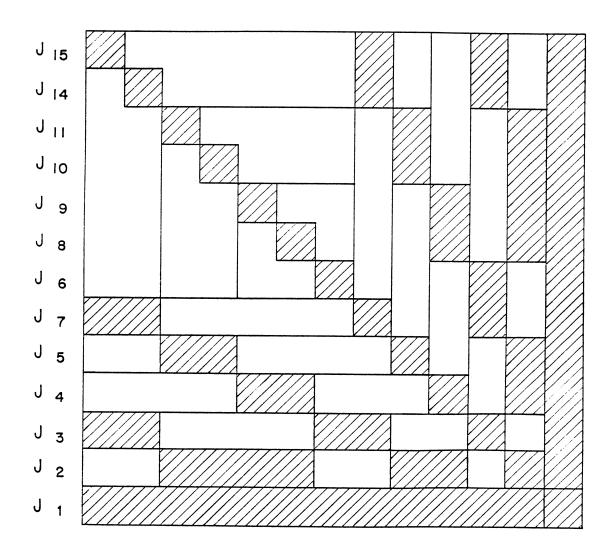


Fig. 4 Nonzero pattern of a reordered coefficient matrix.

 G_{j} (if G_{j} was further partitioned) or the internal nodes for proper blocks.

Obviously, if some nodes were partition nodes of a graph from the higher level they will not be included into J_j . For example, for hierarchical decomposition of Fig. 2, J_2 = {n-2, n-3}, as the node (n-1) is a partition node of G_1 .

There is a strict correspondence between the set of partition nodes of a middle graph and submatrices of the reordered coefficient matrix. These submatrices are called <u>interconnection matrices</u> as they represent interconnection of two subsystems.

Example 2

Consider a system of linear equations

$$\underset{\sim}{\mathbb{A}} \quad \chi = \underset{\sim}{\mathbb{b}}$$

having its coefficient matrix and right-hand side vector equal to

$$A = \begin{bmatrix}
1 & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
2 & 2 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 2 & 3 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 2 & 4 & 2 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 5 & -1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 3 & 6 & 2 & 0 & 0 \\
0 & 0 & 0 & 0 & -1 & 1 & 7 & 2 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 8 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 2 & 9
\end{bmatrix}, b = \begin{bmatrix}
1 \\
1 \\
0 \\
0 \\
0 \\
0 \\
0 \\
2 \\
-1
\end{bmatrix}.$$

Coates graph G_1 of the coefficient matrix is shown in Fig. 5. G_1

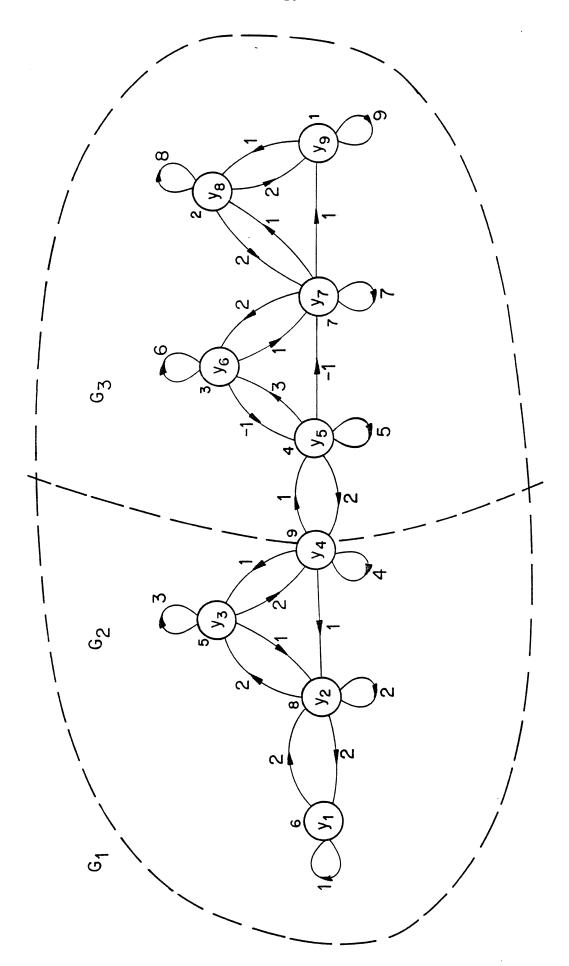


Fig. 5 Partitioned Coates graph \mathbf{G}_1 for Example 2.

has been partitioned into G_2 and G_3 at the node y_4 and this node has been given the index 9, then G_2 has been partitioned into G_4 and G_5 at the node y_2 renumbered to 8 and G_3 has been partitioned into G_6 and G_7 at the node y_7 renumbered to 7. Finally, we obtain proper blocks G_4 , G_5 , G_6 and G_7 , as shown in Fig. 6. In this case, the tree of decomposition is very simple, as shown in Fig. 7. The renumbered coefficient matrix has the nonzero pattern shown in Fig. 8. In fact, the renumbered matrix A is actually more sparse than is shown in Fig. 8, namely

and the renumbered right hand side vector is

$$b = [-1 \ 2 \ 0 \ 1 \ 0 \ 1 \ 9]^{T}$$
.

Sets of indices J according to the partition of signal-flow graph $^{\rm G}$ are as follows:

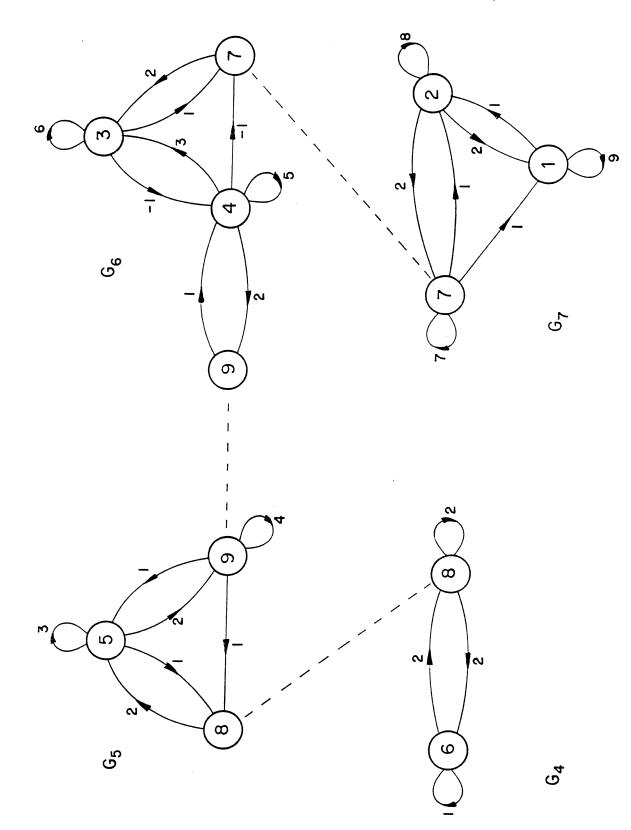


Fig. 6 Proper blocks for Example 2.

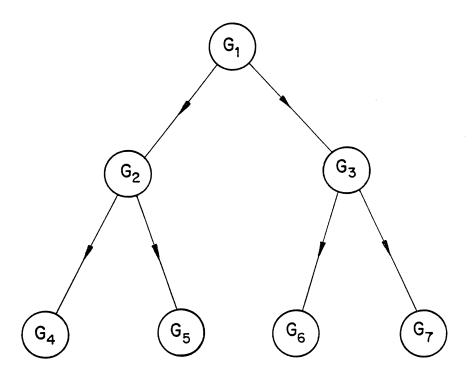


Fig. 7 Tree of decomposition for Example 2.

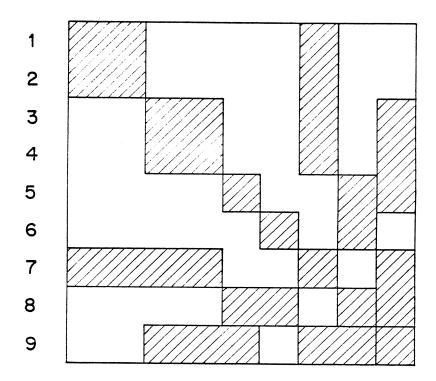


Fig. 8 Nonzero pattern of the coefficient matrix of Example 2.

$$J_1 = \{9\}, \quad J_2 = \{8\}, \quad J_3 = \{7\}, \quad J_4 = \{6\},$$

 $J_5 = \{5\}, \quad J_6 = \{3,4\}, \quad J_7 = \{1,2\}.$

Hierarchical Decomposition in Bi-factorization Approach

The set of n linear equations

can be solved effectively, if A is a sparse matrix, by the use of the bi-factorization method [2]. The inverse of A can be expressed by a multiple product of 2n factor matrices

$$\mathbf{A}^{-1} = \mathbf{R}^{1} \mathbf{R}^{2} \dots \mathbf{R}^{n} \overline{\mathbf{L}}^{n} \dots \overline{\mathbf{L}}^{2} \overline{\mathbf{L}}^{1} , \qquad (2)$$

where the left-hand factor matrices \overline{L}^j are very sparse and differ from the unity matrix only in column j:

$$\overline{L}^{j} = \begin{bmatrix}
1 & & & & & & & \\
& \cdot & & & & & \\
& & & \cdot & & \\
& & & 1 & 0 & & \\
& & & \overline{a}^{j}_{j} & & \\
& & & \overline{a}^{j}_{j+1,j} & 1 & & \\
& & & & \ddots & & \\
& & & \ddots & & \ddots & \\
& & & & \ddots & & \\
& & & & \overline{a}^{j}_{n,j} & & & 1
\end{bmatrix} .$$
(3)

The right-hand factor matrices \mathbb{R}^{j} are also very sparse and differ from the unity matrix only in row j:

The solution of the system (1) can be obtained by multiplying the product form of the inverse (2) by the right-hand side vector

$$y = R^{1}R^{2} \dots R^{n}\overline{L}^{n} \dots \overline{L}^{2}\overline{L}^{1} b.$$
 (5)

After \overline{L}^1 is multiplied by \underline{b} , we obtain the updated vector $\underline{c}^1 = \overline{L}^1 \underline{b}$, then we calculate $\underline{c}^2 = \overline{L}^2 \underline{c}^1$ and after n steps $\underline{c}^n = \overline{L}^n \underline{c}^{n-1}$. Then the right-hand factor matrices are employed to obtain $\underline{c}^{2n-j+1} = \underline{R}^j \underline{c}^{2n-j}$, $j=n,\ n-1,\ \ldots,\ 1$ and finally $\underline{y} = \underline{c}^{2n}$.

Following the technique proposed in [2] we can decompose each left-hand factor matrix \overline{L}^j into a modified matrix \underline{L}^j and a diagonal matrix \underline{D}^i , namely

$$\overline{\underline{L}}^{j} = \underline{L}^{j} \, \underline{\mathbb{D}}^{j} \, , \tag{6}$$

where the modified matrix $\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }{\overset{\ \, }{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}}{\overset{\ \, }}{\overset{\ \, }}{\overset{\$

$$[0...0 \ 1 \ l_{j+1,j}^{j} \ l_{j+2,j}^{j} ... \ l_{nj}^{j}]^{T}$$
,

where

$$\ell_{ij}^{j} = \overline{\ell}_{ij}^{j}/\overline{\ell}_{jj}^{j}$$
, $i = (j+1), ..., n$

and the diagonal matrix $\mathbf{D}^{\mathbf{j}}$ differs from the unity matrix only in the ith diagonal term

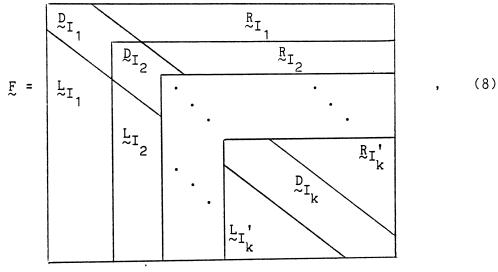
$$d_{jj}^{j} = \overline{\ell}_{jj}^{j} .$$

Let L_j denote a column vector which contains elements of the jth column of L^j starting from $l^j_{j+1,j}$, and let R_j denote a row vector which contains elements of the jth row of R^j starting from $r^j_{j,j+1}$.

A very common way of storing the factor matrices \underline{L}^j and \underline{R}^j is storing vectors \underline{L}_j and \underline{R}_j only together with the diagonal elements d_{jj}^j in the matrix form

	d 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	^R 1				
		d ₂₂	^R 2			
F =			•		•	(7)
	L ₁		•			
		Ľ ₂		e		
				d ⁿ nn		

By grouping together subsets of rows and columns, \mathbf{E} can be expressed in the form



where $I_j = \{m_j, m_j + 1, \dots, \ell_j\}$ and $I'_j = I_j - \{\ell_j\}$.

Such groupings will help when the system is very large and L_{ij} , D_{ij} , C_{ij} can be calculated and stored separately. Then we can execute (5) step

after step, each time taking a group of matrices \underline{L}^j and \underline{D}^j or \underline{R}^j . This will save computer storage and allows us to analyse very large systems. If the system is extremely large, even the updated vectors \underline{c}^j may be too big to be stored as a whole. In this case, we should partition the updated vectors \underline{c}^j and groups of rows of \underline{L}_{I_j} and columns of \underline{R}_{I_j} . This can be done very efficiently while a system is decomposed into blocks according to its topological signal-flow graph representation.

Let matrix F be written in the form

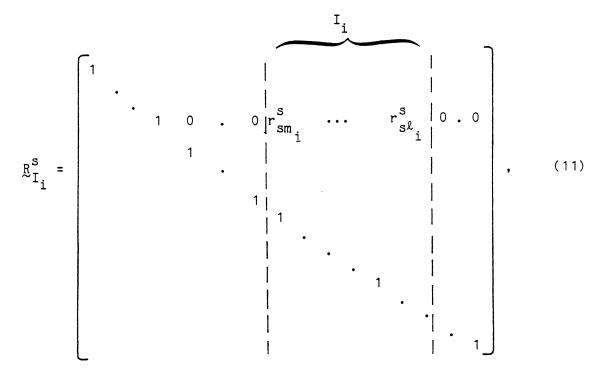
F = €	P _I , R _I , I', I', I', I', I', I', I', I', I', I'	^R I ₁ I ₂		^R I1 ^I k		
	^L I2 ^I 1	P ₁₂ 12	• • •	^R I ₂ I _k	, (9))
	•					
	^L I _k I ₁	^L I I k 2	• • •	EI'I' EI'I' EI'I'		

where $\underset{i}{\mathbb{L}_{i}}_{i}^{I_{i}} \overset{(R}{\approx}_{I_{j}}^{I_{j}}$ denotes a submatrix of $\underset{i}{\mathbb{L}_{i}} \overset{(R}{\approx}_{I_{j}}^{I_{j}}$ which contains elements of rows (columns) I_{i} .

Let column s of L $_{^{\sim}I_{_{1}}I_{_{j}}}$ (s ϵ $_{I_{_{j}}})$ represent a matrix which differs from the unity matrix only in column s:

where $m_i, m_{i+1}, \ldots, l_i \in I_i, m_i > s$.

Let row s of ${R\atop \sim}I_jI_i$ (s ϵ $I_j)$ represent a matrix which differs from the unity matrix only in row s:



where m_i , m_{i+1} , ..., $\ell_i \epsilon I_i$, $m_i > s$. Then, ξ will represent a set of

 $f = [2(I_1k + I_2(k-1) + \ldots + I_k-k)+n] \ \, \text{factor matrices} \ \, \sum_{i=1}^{S}, \ \, \sum_{i=1}^{S},$

Example 3

The renumbered coefficient matrix from Example 2 has its factor matrices represented by matrix \tilde{F} as follows:

$$\begin{bmatrix} \frac{1}{9} & -\frac{2}{9} & & & -\frac{1}{9} \\ -\frac{1}{9} & \frac{9}{70} & & -\frac{8}{70} \\ & \frac{1}{6} & -\frac{1}{2} & -\frac{1}{3} \\ & \frac{1}{6} & \frac{2}{11} & -\frac{2}{33} & -\frac{2}{11} \\ & & \frac{1}{3} & & -\frac{2}{3} & -\frac{1}{3} \\ & & & 1 & -2 \\ & & & -\frac{9}{35} & -\frac{1}{6} & \frac{3}{11} & .15316 & & -.04177 \\ & & & & -\frac{1}{3} & -2 & & -\frac{3}{8} & \frac{1}{4} \\ & & & & -\frac{4}{11} & -\frac{2}{3} & .01856 & -\frac{1}{2} & .3785 \end{bmatrix} \quad \mathbf{I}_{5}$$

It can be seen that the nonzero pattern of $\overline{\xi}$ is the same as that of the coefficient matrix shown in Fig. 8.

According to the partition scheme of matrix \mathcal{E} shown in (9) we have

$$L_{I_1^{\dagger}I_1^{\dagger}} = [-\frac{1}{9}], \qquad L_{I_5^{\dagger}I_1} = [0 - \frac{9}{35}],$$

$$\begin{split} & \mathbb{L}_{\mathbf{I}_{2}^{'}\mathbf{I}_{2}^{'}} = [\frac{1}{6}] \;, \qquad \mathbb{L}_{\mathbf{I}_{5}\mathbf{I}_{2}} = [-\frac{1}{6} \quad \frac{3}{11}] \;, \\ & \mathbb{L}_{\mathbf{I}_{7}\mathbf{I}_{2}} = [0 \quad -\frac{\mu}{11}] \;, \qquad \mathbb{L}_{\mathbf{I}_{6}\mathbf{I}_{3}} = [-\frac{1}{3}] \;, \\ & \mathbb{L}_{\mathbf{I}_{7}\mathbf{I}_{3}} = [-\frac{2}{3}] \;, \qquad \mathbb{L}_{\mathbf{I}_{6}\mathbf{I}_{4}} = [-2] \;, \\ & \mathbb{L}_{\mathbf{I}_{7}\mathbf{I}_{5}} = [.01856] \;, \qquad \mathbb{L}_{\mathbf{I}_{7}\mathbf{I}_{6}} = [-\frac{1}{2}] \;, \\ & \mathbb{D}_{\mathbf{I}_{1}} = \begin{bmatrix} \frac{1}{9} & 0 \\ 0 & \frac{9}{70} \end{bmatrix} \;, \qquad \mathbb{D}_{\mathbf{I}_{2}} = \begin{bmatrix} \frac{1}{6} & 0 \\ 0 & \frac{2}{11} \end{bmatrix} \;, \\ & \mathbb{D}_{\mathbf{I}_{3}} = [\frac{1}{3}] \;, \qquad \mathbb{D}_{\mathbf{I}_{4}} = [11] \;, \qquad \mathbb{D}_{\mathbf{I}_{5}} = [.15316] \;, \\ & \mathbb{D}_{\mathbf{I}_{6}} = [-\frac{3}{8}] \;, \qquad \mathbb{D}_{\mathbf{I}_{7}} = [.3785] \;, \\ & \mathbb{E}_{\mathbf{I}_{1}^{'}\mathbf{I}_{1}^{'}} = [-\frac{2}{3}] \;, \qquad \mathbb{E}_{\mathbf{I}_{1}^{'}\mathbf{I}_{5}} = \begin{bmatrix} -\frac{1}{9} \\ -\frac{8}{70} \end{bmatrix} \;, \qquad \mathbb{E}_{\mathbf{I}_{2}^{'}\mathbf{I}_{2}^{'}} = [-\frac{1}{2}] \;, \\ & \mathbb{E}_{\mathbf{I}_{3}} = [-\frac{1}{3}] \;, \qquad \mathbb{E}_{\mathbf{I}_{2}} = [-\frac{1}{3}] \;, \\ & \mathbb{E}_{\mathbf{I}_{3}} = [-\frac{2}{3}] \;, \qquad \mathbb{E}_{\mathbf{I}_{3}} = [-\frac{1}{3}] \;, \\ & \mathbb{E}_{\mathbf{I}_{4}} = [-2] \;, \qquad \mathbb{E}_{\mathbf{I}_{5}} = [-.04177] \;, \\ & \mathbb{E}_{\mathbf{I}_{6}} = [\frac{1}{4}] \;, \end{aligned}$$

where $I_1 = J_7$, $I_2 = J_6$, $I_3 = J_5$, $I_4 = J_4$, $I_5 = J_3$, $I_6 = J_2$, and $I_7 = J_1$,

where J is as defined in Example 2.

Let us define the multiple products:

$$\xi_{\mathbf{I}_{\mathbf{i}}\mathbf{I}_{\mathbf{j}}} \circ \underset{\sim}{\mathbf{x}} \stackrel{\Delta}{=} \begin{cases} \sum_{j=1}^{l} \sum_{j=1}^{l} \sum_{j=1}^{l} \sum_{j=1}^{l} \dots \sum_{i=1}^{l} \sum_{j=1}^{l} \sum_{j=1}^{l}$$

and let

$$\Phi_{\mathbf{I}_{\mathbf{j}}\mathbf{I}_{\mathbf{i}}} \circ \overset{\mathbf{x}}{\sim} \overset{\Delta}{=} \begin{cases} \begin{pmatrix} \mathbf{m}_{\mathbf{j}} & \mathbf{m}_{\mathbf{j}+1} & & & & \\ \mathbf{R}_{\mathbf{I}_{\mathbf{i}}} & \mathbf{R}_{\mathbf{I}_{\mathbf{i}}} & & & & \\ \mathbf{R}_{\mathbf{I}_{\mathbf{i}}} & \mathbf{R}_{\mathbf{I}_{\mathbf{i}}} & & & & \\ \mathbf{R}_{\mathbf{I}_{\mathbf{i}}} & \mathbf{m}_{\mathbf{j}+1} & & & & \\ \mathbf{R}_{\mathbf{J}} & \mathbf{m}_{\mathbf{j}+1} & & & & & \\ \mathbf{R}_{\mathbf{I}_{\mathbf{i}}} & \overset{\mathbf{R}_{\mathbf{J}}}{\sim} & & & & \\ \mathbf{R}_{\mathbf{J}} & \overset{\mathbf{R}_{\mathbf{J}}}{\sim} & & & \\ \mathbf{R}_{\mathbf{J}} & & & \\ \mathbf{R}_{\mathbf{J}} & & & & \\ \mathbf{R}_{\mathbf{J}} & & & \\ \mathbf{R}_{\mathbf{J}} & & & \\ \mathbf{R}_{\mathbf{J}} & & & & \\ \mathbf{R}_{\mathbf{J}} & & & \\ \mathbf{R}_{\mathbf{J}}$$

In a particular case, if

$$I_{j} = \{m_{j}\}$$

then

$$\xi_{I_j I_j} \circ x = D^{m_j} x,$$

and

$$\Phi_{I_{j}I_{j}} \circ x = x.$$

Lemma 1

The inverse \underline{A}^{-1} (2) can be obtained as a multiple product of factor matrices according to the formula

$$\stackrel{A^{-1}}{\sim} \stackrel{\times}{\sim} = {}^{\Phi}I_{1}I_{1} {}^{\circ} {}^{\Phi}I_{1}I_{2} {}^{\circ} \cdots {}^{\circ} {}^{\Phi}I_{1}I_{k} {}^{\circ}$$

$$\stackrel{\Phi}{\circ} {}^{\Phi}I_{2}I_{2} {}^{\circ} \cdots {}^{\circ} {}^{\Phi}I_{2}I_{k} {}^{\circ} \cdots {}^{\Phi}I_{k}I_{k} {}^{\circ} {}^{\xi}I_{k}I_{k} {}^{\circ}$$

$$\cdots {}^{\circ} {}^{\xi}I_{k}I_{2} {}^{\circ} \cdots {}^{\circ} {}^{\xi}I_{2}I_{2} {}^{\circ} {}^{\xi}I_{k}I_{1} {}^{\circ}$$

$$\cdots {}^{\circ} {}^{\xi}I_{2}I_{1} {}^{\circ} {}^{\xi}I_{1}I_{1} {}^{\circ} \stackrel{\times}{\sim} .$$

$$(14)$$

Lemma 2

Multiple product

$$z = \xi_{I_{k}I_{k}} \circ \cdots \circ \xi_{I_{k}I_{2}} \circ \cdots \circ \xi_{I_{2}I_{2}} \circ$$

$$\circ \xi_{I_{k}I_{1}} \circ \cdots \circ \xi_{I_{2}I_{1}} \circ \xi_{I_{1}I_{1}} \circ z$$

$$(15)$$

can be obtained as a sum of vectors

$$z = \sum_{j=1}^{k} z_{j}, \qquad (16)$$

where

$$\sum_{i=1}^{z} = \xi_{i} \int_{j}^{0} \int_{j}^{\xi_{i}} \int_{1}^{1} \int_{1}^{0} \int_{1}^{z} \int_{1}^{1} \int_{1}^{1} \int_{2}^{0} \int_{1}^{z} \int_{2}^{1} \int_{1}^{1} \int_{1}^{1}$$

where $\begin{bmatrix} x \\ z \end{bmatrix}_j = \begin{bmatrix} 0, \dots 0, x \\ 0 \end{bmatrix}_j^T$, 0, ..., 0]^T. For a particular case

$$z_{I_1} = \xi_{I_1 I_1} \circ [x_{I_1}]$$
 (18)

Example 4

Using LR factorization as in Example 3, and $\frac{x}{2}$ equal to renumbered right-hand side vector $\frac{b}{2}$ as in Example 2, vectors $\frac{z}{2}$ are as follows:

So, on the basis of (16), we have

$$z = \begin{bmatrix} -\frac{1}{9} & \frac{19}{70} & 0 & \frac{2}{11} & 0 & 1 & -0.041374 & 0.375 & 3.4569 \end{bmatrix}^{T}$$
.

Assume that all the multiple products of $\xi_{I_j}I_{\ell}$ o z_{ℓ} (j=1,..,k) in (17) have been previously calculated and stored. If now the coefficients in only one proper block have been altered (for example in G_{14} of Fig. 3) then according to the formula (17) and the nonzero pattern of Fig. 4, we must calculate new values of z_{J_1} , z_{J_7} , z_{J_3} and z_{J_1} , to obtain a new value of z_{J_1} . We have

$$z_{J} = \xi_{J} \quad 0 \quad [x_{J}], \quad (19)$$

$$z_{J_{7}} = \xi_{J_{7}J_{7}} \circ (\xi_{J_{7}J_{15}} \circ z_{J_{15}} + \xi_{J_{7}J_{14}} \circ z_{J_{14}} + [x_{J_{7}J_{15}}]),$$
 (20)

Observe that all the multiple products with variables z_{J_1} , z_{J_1} , z_{J_1} , z_{J_1} , z_{J_2} , z_{J_3} , z_{J_3} , z_{J_4} , z_{J_2} are known and do not have to be recalculated.

In this simple example we have to calculate only 10 multiple products out of 41 to update z. Whenever a certain block has updated coefficients we must repeat the bifactorization for this block and all submatrices representing its interconnections according to the decomposition tree. What is even more important is that the analysis of only one proper block must be repeated, while multiple products corresponding to the substitute subgraphs are not so time-consuming.

Lemma 3

Multiple product

$$y = \Phi_{I_1 I_1} \circ \Phi_{I_1 I_2} \circ \dots \circ \Phi_{I_1 I_k} \circ \cdots \circ \Phi_{I_1 I_k} \circ \cdots \circ \Phi_{I_k I_k} \circ z$$

can be obtained as a sum of vectors

$$y = \sum_{j=1}^{k} y_{j}, \qquad (23)$$

where

$$y_{\mathbf{I}_{j}} = \Phi_{\mathbf{I}_{j}\mathbf{I}_{j}} \circ [z_{\mathbf{I}_{j}}] + \Phi_{\mathbf{I}_{j}\mathbf{I}_{j+1}} \circ y_{\mathbf{I}_{j+1}} + \dots + \Phi_{\mathbf{I}_{j}\mathbf{I}_{k}} \circ y_{\mathbf{I}_{k}}, \quad (24)$$

where $\begin{bmatrix} z_1 \end{bmatrix} = \begin{bmatrix} 0, \dots, 0, z_1 \end{bmatrix}^T$, 0, ..., $0 \end{bmatrix}^T$. For a particular case

$$y_{I_k} = \Phi_{I_k I_k} \circ [z_{I_k}] . \qquad (25)$$

In a very similar way, we can show that if we are interested in the solution for any submatrix then only those multiple products ${}^{\Phi}I_{j}I_{\ell} \circ {}^{\mathbb{Z}}\ell$ must be calculated which correspond to the set of indices J_{j} , J_{ℓ} for submatrices from a given one to the top of the decomposition tree.

The main advantage of this type of partial analysis is a great reduction in computer time, which is proportional to the number of nodes in the subgraph representing the updated submatrix rather than to the number of all nodes, when the coefficient matrix is being partly updated. When our goal is to recalculate the solution in a particular subnetwork only, rather than in the whole network, again the computational time will be proportional to the number of updated unknowns and

not to the total number of variables.

Example 5

On the basis of LR factorization from Example 3 and the vector zobtained in Example 4, we obtain vectors $\mathbf{y}_{\mathbf{I}_{i}}$ as follows:

The final solution is

$$\chi = \begin{bmatrix} -0.1555 & 0.29266 & 0.27966 & -0.43546 & -1.9785 & -1.4785 \\ -0.18577 & 1.2392 & 3.4569 \end{bmatrix}^{T}$$
.

III. STRUCTURE OF THE PACKAGE

There are 2 different entries to the package and two corresponding main subroutines:

subroutine CSDSLE1 - standard entry for analysis of decomposed

systems of linear equations,

2. subroutine CSSLE1 - entry for analysis of systems of linear equations without decomposition [3].

A block diagram of the package is shown in Fig. 9. Checking the input parameters and subdivision of the working areas (defined by the user as variables of indicator vector IN) is performed in CSDSLE1. Subroutine ASDNSR organizes the partial analysis process for updated submatrices. Submatrices to be analyzed have to be stored in random access file No. 2 or in the working area CMPLXWA as described in Section V. ABSUB organizes and stores information about the hierarchical structure, CHEBSUB checks if a subgraph has been previously analyzed. STOREF and READF are used to store and read integer vector IN in and from the mass storage file, respectively. Different submatrices are read with the help of READSB and checked in CHEDEL if all diagonal elements exist in the sub-If certain nodes are common to two or more submatrices, then matrix. diagonal elements must be nonzero at least in one of them. If any diagonal element is not defined then the user is notified by the statement

ALL DIAGONAL ELEMENTS SHOULD BE DEFINED IN THE SUBMATRIX NO. nr and execution of the main subroutine is stopped with IN(3)=1, where nr denotes the index of the corresponding subgraph as numbered at the tree of decomposition.

Subroutine ASUBSR organizes partial analysis of one subgraph and stores the results of partial analysis in the basic record BREC. If the user changes the nonzero pattern of a submatrix such that a new submatrix requires more space in the basic record then the message

MODIFIED SUBGRAPH NO. nr REQUIRES MORE STORAGE THAN THE PREVIOUS ONE REPEAT ANALYSIS FOR ALL SUBGRAPHS

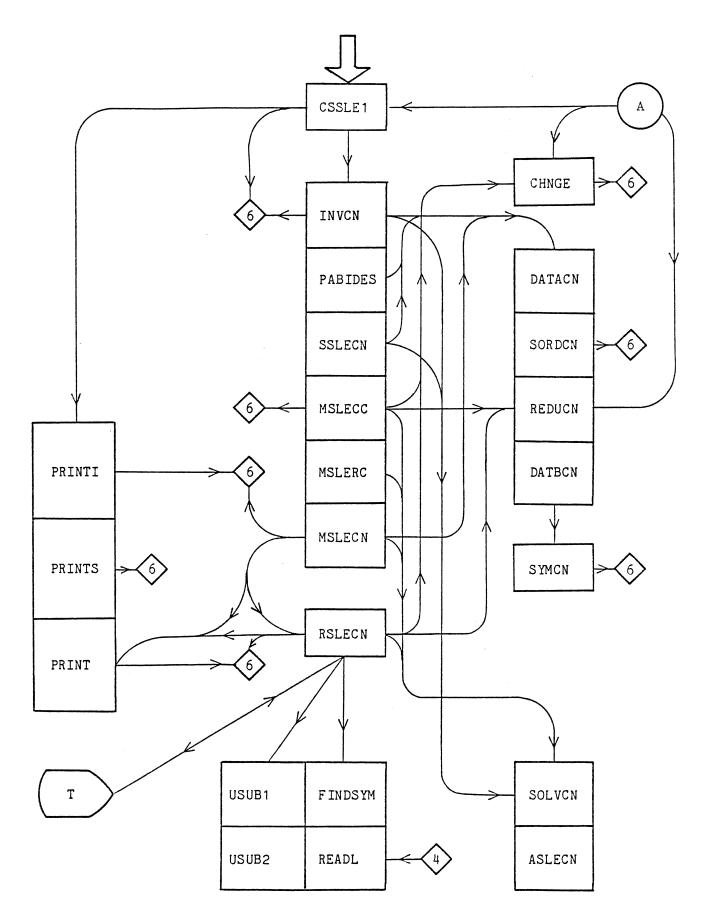


Fig. 9(a) Block diagram of the package.

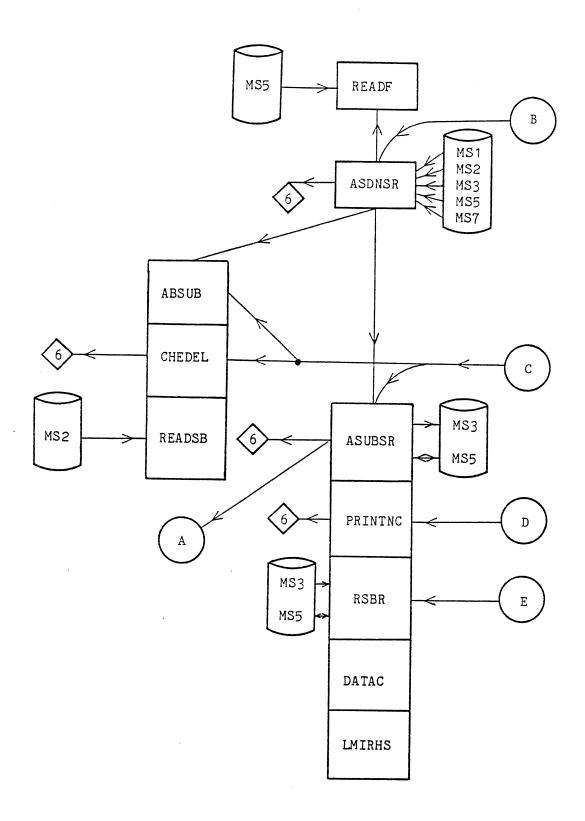


Fig. 9(b)

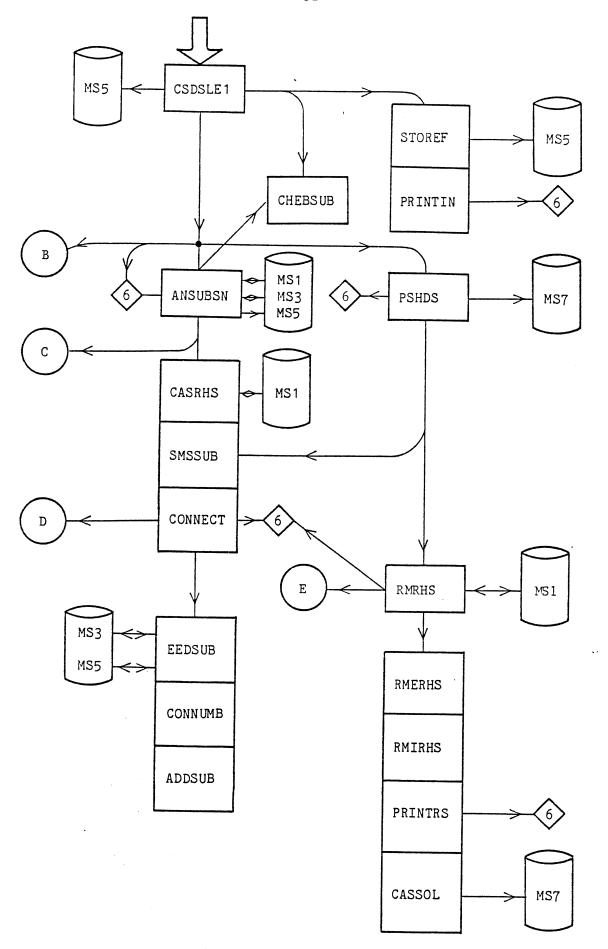


Fig. 9(c)

is printed out and execution of the main subroutine is stopped with IN(3)=1. If the user updates some coefficients in the submatrix with row and column indices outside the nonzero pattern then the message

ELEMENT OUT OF THE MATRIX AREA

is printed out and execution of the main subroutine is stopped with IN(3)=1.

Partial bifactorization of decomposed submatrices for internal nodes of a subgraph is performed in PABIDES called from CSSLE1 with IN(8)=6. For a description of other options with $IN(8)=1, \ldots, 5$, see [3]. DATAC, DATACN and DATBCN are used to prepare the proper form of data for library subroutines. SYMCN checks the structural symmetry and ordering of columns of the coefficient matrix. If the matrix is not symmetrical, new zero coefficients are added to create symmetry. The user is informed by the statement

INITIAL COEFFICIENT MATRIX NONSYMMETRICAL

Each column is checked to see whether the elements are stored according to increasing indices of their row numbers. If not, the program will reorder them and the user will be notified by the statement

REORDERING OF COLUMNS

SORDCN and REDUCN simulate, order and execute Gauss elimination as described in [2]. REDUCN is also used to perform partial bifactorization for the submatrix, corresponding to internal nodes of its subgraph only.

SOLVCN and ASLECN solve the linear equations by a sequence of matrix multiplications (2) for the original and adjoint (transpose) system respectively.

CHNGE changes the value of one element in the coefficient matrix.

If the user tries to update a coefficient which was not previously stored, he will be notified by the statement

ELEMENT FROM ROW rnr AND COLUMN enr WAS NOT STORED IN THE PREVIOUS COEFFICIENT MATRIX

where rnr, cnr denote row and column indices, respectively.

Subroutines PRINTIN, PRINTNC, PRINTRS, PRINT, PRINTI and PRINTS are used to print output information on the file No. 6.

LMIRHS multiplies the left part of the LR factorization by the right-hand side (RHS) vector \mathbf{x} according to the formula

$$z_{j} = \xi_{I_{k}I_{j}} \circ \xi_{I_{k-1}I_{j}} \circ \dots \circ \xi_{I_{j+1}I_{j}} \circ \xi_{I_{j}I_{j}} \circ z, \qquad (26)$$

where j is the index of the subgraph describing a given submatrix and $\xi_{I_iI_j}$ is defined in (12). Subroutine ANSUBSN organizes the partial analysis process for updated submatrices corresponding to the partition nodes of middle graphs, according to the notation described in Section II. These submatrices, called interconnection matrices, have their corresponding graphs called <u>substitute graphs</u>. Only those substitute graphs are analyzed which are necessary for updating the results of a previous solution if the system was previously solved.

A sequence of modified substitute graphs to be reanalyzed is determined in SMSSUB. CONNECT combines the results of analysis of two subgraphs to obtain the description of substitute graph. EEDSUB is used to extract the external description of subgraphs represented at the partition nodes of their ascendant. CONNUMB generates original indices of the nodes for substitute graph. ADDSUB adds two submatrices to obtain the interconnection matrix. CASRHS calculates addresses and stores the RHS vector for the substitute graph. CASSOL calculates addresses and stores the solution vector for a subgraph.

The partial solution at the nodes incident with updated submatrices is calculated in PSHDS. RMRHS organizes multiplication of the right part of the LR factorization by the z vector (15) according to the formula

$$\chi_{j} = \Phi_{I_{j}I_{j}} \circ \Phi_{I_{j}I_{j+1}} \circ \cdots \circ \Phi_{I_{j}I_{k}} \circ z , \qquad (27)$$

where j is the index of the subgraph describing a set of nodes where the solution is calculated ${}^{\Phi}I_{j}I_{i}$ is defined in (13). RMERHS executes a part of (27) for ${}^{\Phi}I_{j}I_{i}$, i ${}^{\varepsilon}$ {j+1,...,k} and RMIRHS executes the last of (27), i.e., the multiple product with ${}^{\Phi}I_{i}I_{i}$.

IV. LIST OF ARGUMENTS

Standard entry (subroutine CSDSLE1)

The subroutine call is

CALL CSDSLE1(IN, INTWA, CMPLXWA, IM, SOLR)

The arguments are as follows:

IN is an integer indicator vector. Its length is at least IN(4) + IN(5) + IN(9)/2 + 26.

Arguments of IN have the following values:

- IN(1) =N, number of unknowns in the current subgraph.
- IN(2) =LES, maximum area predicted for the sparse matrix describing the current subgraph.
- IN(3) =IAR, flag for insufficient area.
- IN(4) number of subgraphs where the solution will be recalculated.
- IN(5) the number of all proper blocks.
- IN(6) =NINT. the number of internal nodes in the current subgraph.
- IN(7) indicator for printing intermediate results

- =0 only part of the intermediate results will be printed,
- =1 results will not be printed,
- =2 all intermediate results will be printed,
- =3 only the solution will be printed.
- IN(8) the indicator for the kind of job
 - =6 the complete bifactorization process is executed for all proper blocks,
 - =7 the solution is calculated for an altered coefficient matrix and/or right-hand side vector (previous use of the main subroutine CSDSLE1 with IN(8)=6 is required),
 - =8 the solution is calculated for an altered right-hand side vector (previous use of the main subroutine CSDSLE1 with IN(8)=6 is required).
- IN(9) =MNS, the highest index of the subgraphs (according to the
 decomposition tree.
- IN(10) =NMS, the number of modified subgraphs, must be less than IN(12)/2.
- IN(11) =LREC, the length of the basic record in double CM words, must
 be greater than 256.
- IN(12) =LADR, the length of the addressing record in CM words, must be
 greater than 2*NMS.
- IN(13) current number of stored basic records.
- IN(14) =NSBR, current number of subgraphs in the basic record.
- IN(15) maximum predicted number of basic and solution records to store the results of analysis of all subgraphs.
- IN(16) maximum number of equations for any subgraph.

- IN(17) maximum area predicted for sparse matrix analysis of subgraphs, usually 1-2 times the number of nonzero elements in the maximum submatrix.
- IN(18) the number of nonzero elements in the maximum submatrix.
- IN(19) the lowest index over all decomposition nodes.
- IN(20) the number of data records storing the information about modified subgraphs.
- IN(21) current number of RHS records.
- IN(22) the indicator for the RHS updating formula
 - =0 the complete solution will be recalculated,
 - =1 the solution for modified proper blocks only will be recalculated,
 - =2 only the solution for the subgraphs specified by the user will be recalculated if the user specifies substitute subgraphs only then the solution will be recalculated at the partition nodes only.
- IN(23) the indicator for operations on random files
 - =0 random access multi-records files will be created,
 - =1 random access multi-records files will be updated,
 - =2 the program will be executed without creating random access multi-records files,
 - =3 random access multi-records files will be extended.
- IN(24) current number of stored addressing records.
- IN(25) the length of data and RHS records in double CM words, must greater than 2*IN(10).
- IN(26) number of all decomposition modes.
- IN(27)
- -IN(L) store numbers of external nodes for the substitute subgraphs

where L = 26 + IN(9)/2.

If the substitute subgraph is spanned over the partition nodes of the graph number NG, then the number of its external nodes (partition nodes of the ascendant) must be stored in IN(26+NG). Obviously, substitute graph number 1 will always have a number of external nodes equal 0, so IN(27)=0.

IN(L+1)

-IN(M) store the indices of all proper blocks in decreasing order, where M=L+IN(5).

IN(M+1)

- -IN(K) store the indices of subgraphs, where the solution will be calculated, in decreasing order, where K=M+IN(4).
- IM(1) =MS1, mass storage indicator
 =0 mass storage files will not be used,
 =1 mass storage files will be used,
 =2 mass storage file No. 2 (data file) will not be used,
 - =3 mass storage files will be extended.
- IM(2) =NRI, flag denoting a reference to the main subroutine, must be initialized by the user to 0 in conjunction with the first call and must never be subsequently altered.
- IM(3) the size of working area INTWA.
- IM(4) the size of working area CMPLXWA.
- IM(5) the size of the solution record in double CM words. At the output IM(5) contains the number of elements of the solution vector.
- INTWA is an INTEGER working area. Its length is at least 9*In(9)/2 + (In(9)-1)/In(12) + In(9)/50 + 2*In(12) + 2*In(15) + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(20) + (In(26)/In(25)/+1)*2 + 4*In(16) + 2*(In(17) + In(18)) + In(18) + (In(18)/In(18)/In(18)/In(18) + (In(18)/In(1

19.

For small problems of up to 10 submatrices, the user is advised to set standard values IN(9)=20, IN(12)=20, IN(15)=11, IN(20)=10, and use INTWA of length

4*IN(16) + 2*(IN(17) + IN(18)) + 181.

CMPLXWA is a COMPLEX working area. Its length is at least 1 + IN(11) + 3*IN(16) + 4*IN(17) + IN(18) + IN(25).

SOLR solution record. For small problems, it contains the solution vector. In this case, its size must be not less than the total number of variables.

Entry for analysis without decomposition (subroutine CSSLE1)

For a description of subroutine parameters and different job options, see [3].

V. DATA STRUCTURE

There are two different forms of data describing the decomposed system. The first is used principally when initial information about large decomposed systems is needed to obtain the first or nominal solution. In this form, data is assumed to be stored in random access multi-record files in the local file No. 2. Each record contains IN(25) complex numbers. The second is used when the system is not so large or principally when the changes in the coefficient matrix or the right-hand side vector are made in a local area and information about those changes can be stored in one data record. This <u>data record</u> can be stored directly in the working area CMPLXWA from element [IN(11) + 3*IN(16) + 4*IN(17) + 1]. This will save time needed to execute the mass storage

read subroutine. The structure of data file No. 2 is shown in Fig. 10.

1	IN(25)	1	IN(25)	1	IN(25)	
directory						
record 1		record 2		record	3	

Fig. 10. Structure of data file.

The first data record DREC in file No. 2 contains the <u>directory</u> for all the modified subgraphs. The directory is a COMPLEX vector of length 2*IN(10). Information about the NBSth modified subgraph is described by four integer numbers A, B, C, D, stored in the real and imaginary parts of the DREC elements as follows:

DREC(NBS) = CMPLX(A,B)

DREC(NBS + IN(10)) = CMPLX(C,D)

where

- A is the original index of the subgraph,
- B is the index of the record containing information about modifications in the subgraph A,
- C is the length of complex area storing this information,
- D is the address in the record B where this information is stored.

The information about modifications in the subgraphs is stored in the form of COMPLEX matrices CE starting from element 2*IN(10)+1 in record 1 and starting from element 1 in other records.

There are two different forms of information, depending on whether the changes are done in the coefficient matrix or the right-hand side vector.

Data structure for altered coefficient matrix

This structure is also used when the first or nominal solution is calculated. A COMPLEX matrix CE describing the modified subgraph has the structure shown in Fig. 11.

1	2	NEL	NEL	N	(N-1)/2 + 1
N	LES	AK	NROW	V	NON(1), NON(3), NON(5),
NINT	NEL		NCOL		NON(2), NON(4), NON(6),

Fig. 11. Structure of a matrix CE for updated coefficient matrix.

The first two complex elements of CE are as follows:

CE(1) = CMPLX(N, NINT)

CE(2) = CMPLX(LES, NEL)

where

N is the number of nodes in the subgraph describing the altered matrix,

NINT is the number of internal nodes (those which are not partition nodes) in the subgraph,

LES is the length of the area predicted for the sparse matrix operations (2 to 5 times more than NEL),

NEL is the number of updated elements in the submatrix (for the first analysis of a subnetwork NEL is equal to the number of nonzero elements in the submatrix).

Next NEL elements of CE contain the nonzero coefficients of the

submatrix. NEL elements starting from the elements NEL+3 contain row and column indices of consecutive nonzero coefficients, stored in the real and imaginary parts of the CE elements, respectively. Row and column indices must refer to the internal numbering of nodes within each subgraph, i.e., they must be numbered consecutively starting from 1 up to N. A COMPLEX vector V stored in CE starting from the element 2*NEL+3 contains the right-hand side (RHS) vector, and finally, the INTEGER vector NON stored in CE starting from the element 2*NEL+N+3 contains the original indices of the nodes as obtained after graph partition. Elements of NON are stored consecutively in the real and imaginary parts of the CE elements, as illustrated in Fig. 11. While updating the coefficient matrix and RHS vector (with IN(8) = 7), the user may specify as many changes in the coefficient matrix as he wants to by storing NEL updated elements. If a certain element is updated in more than one place, the latest value will replace the old element in the submatrix.

In this case, (IN(8) = 7) the user may not store the vector NON, as these values should not be changed during successive solutions. New values of the whole vector V must be stored even if its value is not updated.

Data structure for altered RHS only

Previous use of the main subroutine with IN(8) = 6 is required before this kind of data can be accepted by the program. When the main subroutine is run with IN(8) = 8, data records are organized as shown in Fig. 10 with the directory in record 1. Each subgraph remains unchanged and only the RHS vector is updated. Complex matrix CE describing the modified subgraph only contains the updated RHS vector as shown in Fig.

12. Again, the entire vectors V must be stored for all those subgraphs for which RHS is updated.

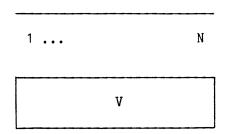


Fig. 12. Structure of a matrix CE for updated RHS only.

Data describing the graph decomposition and the type of job

In the vector IN, the user must assign values to the following variables: IN(4), IN(5), IN(7), IN(8), IN(9), IN(10), IN(11), IN(12), IN(15), IN(16), IN(17), IN(18), IN(19), IN(20), IN(22), IN(23), IN(25), up to IN(K), where

$$K = IN(4) + IN(5) + IN(9)/2 + 26.$$

The user must decide whether or not he will use or create random access multi-record files. These files are necessary when the system is big, so that only part of the information describing it can be stored in central memory. Fig. 13 shows the scheme of memory organization as used by the library subroutines when random files are necessary.

Data records have been described at the beginning of this Section. Each <u>basic record</u> may store information about a partial solution of up to 255 subgraphs. Each subgraph in a basic record has specified its number of nodes N, the number of internal nodes NINT, the length of area predicted for the sparse matrix operations LES, a full description of its bifactorization as generated by the Zollenkopf algorithm [2], the

Addressing MS5 Output File Input File Addressing Partial Solution File Record MS 4 $\langle 9 \text{ SW} \rangle$ Solution File LIBRARY Solution Record Basic MS3 Record MS 7 Data Record RHS Record Data File RHS File **MS2** MS₁

Fig. 13 Memory organization.

vector NON of the original indices of nodes, and the result Z of the multiple product (26) for the subnetwork. The structure of the information describing each subgraph as stored in a basic record is shown in Fig. 14.

1	2	N	N	LES	4*LES	2*N	N
N		(1) – (N+1)	NON	ITAG(1) - ITAG(LES)	CE	DE	Z
NINT	LES		N+2) - 3N+1)	ITAG(LES+1) ITAG(2LES)			

Fig. 14. Structure of the information describing a subgraph in a basic record.

Vectors LCOL, ITAG, CE and DE are as described in [3]. Each basic record has the structure shown in Fig. 15.

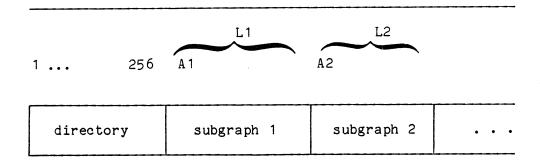


Fig. 15. Structure of a basic record.

The directory in a basic record is a COMPLEX vector of the length 256. Information about the kth subgraph (k = 1, ..., 255) stored in this basic record is described by two integer numbers Ak and Lk stored in the real and imaginary parts of the kth complex element of a basic record,

where Ak denotes the address from where the information describing the kth subgraph starts and Lk is the length of the area storing the kth subgraph. Subgraphs are numbered consecutively as they are stored in a basic record, so k is not the original index of a subgraph according to the decomposition tree.

Original indices of graphs refer to the <u>addressing records</u>. Each addressing record is an INTEGER vector of length LDDR $\stackrel{\Delta}{=}$ 2*LADR = 2*IN(12). If a graph's original index is NSUB, then its address can be found in the addressing record number NR = (NSUB-1)/LADR + 1. Element IADR = NSUB -(NR-1)*LADR of this record contains the index of the basic record storing the information about the subgraph NSUB, while element (IADR+LADR) is the index of the subnetwork in this basic record.

Addressing records are stored in random access file No. 5. The last record in file No. 5 contains information about stored multi-record random access files.

Multirecord random access file No. 1 contains information about the RHS vector at the nodes of substitute subgraphs (external nodes of proper blocks) or the solution vector at these nodes after the analysis is completed. Each RHS record is a COMPLEX vector whose length is IN(25). The first element in the first RHS record corresponds to the RHS at node IN(19). The number of RHS records is equal to IN(26)/IN(25) + 1. The next IN(26)/IN(25) + 1 records in file No. 1 store the z vector (15) for the nodes of the substitute subgraphs and are used when CSDSLE1 is executed with IN(8) = 7 or IN(8) = 8.

The complete solution vector is stored in the multirecord random access file No. 7. The number of components of the calculated solution vector is available in IM(5). Each solution record contains pairs of

complex numbers (A,B). The real part of each complex number A is the original index of a variable and B is the value of the solution for this variable.

VI. GENERAL INFORMATION

Use of COMMON: None.

Workspace: Provided by the user.

Input/output: Input from workspace or random access files. Output as defined by the user; see IN(7).

Subroutines: CSSLE1, DATACN, DATBCN, SYMCN, SORDCN, REDUCN, CHNGE,
PRINT and:

- a) for standard entry: CSDLSE1, ASDNSR, ABSUB, CHEBSUB, STOREF, READF, READSB, CHEDEL, ASUBSR, LMIRHS, ANSUBSN, SMSSUB, CONNECT, EEDSUB, CONNUMB, ADDSUB, CASRHS, PSHDS, RMRHS, RSBR, RMERHS, RMIRHS, CASSOL, PABIDES, DATAC, PRINTIN, PRINTNC, PRINTRS;
- b) for entry for analysis without decomposition: SSLECN, MSLECN, INVCN, MSLECC, MSLERC, SOLVCN, ASLECN, RSLECN, FINDSYM, READL, PRINTI, PRINTS.

Restrictions: $IN(9) \ge IN(5) \ge IN(4) \ge 0$ $IN(5) \ge IN(10) \ge 0$, IN(11) > 20, IN(12) > 2*IN(10) IN(15) > 0, IN(16) > 0, IN(17) > 0, IN(18) > 0, IN(19) > 0, IN(20) > 0, IN(25) > IN(9), $IN(26) \ge 0$

Date: January 1983.

VII. EXAMPLES

Example 6

the system of linear equations of Example 2 has been partitioned into 4 subsystems according to the partition of flow-graph G (see Fig. 6). Proper blocks G_4 , G_5 , G_6 and G_7 are represented as a data record in random access file No. 2. This file has been created by execution of the program DECSYS1 listed on the p. 48. As required by the Record Manager, the size of vector INDEX2 and the value of IREC2 must be not less than the number of data records +1. After file No. 2 (TAPE2) was created the main program EXAMP6 was executed. In this case the sizes of the basic record, the addressing record, and the data record were chosen sufficiently large and only one record of each type was created. All intermediate results are printed and the solution is calculated for all subgraphs. The user's program EXAMP6 and the results are shown on pp. 49-59. For each subgraph, the matrix \mathcal{E} of (7) is presented in the form of 3 matrices:

- (1) Lower triangular part elements of this matrix are equal to $-\bar{\imath}_{ij}^{j}/\bar{\imath}_{jj}^{j}, \ i=(j+1), \ \ldots, \ n \ \text{and have opposite signs to those of}$ $\underline{L}^{j} \ \text{of (6)}.$
- (2) Upper triangular part elements of this matrix are equal to $-r_{ji}^{j}$, $i = (j+1), \ldots, n$ and have opposite signs to those of \mathbb{R}^{j} of (4).
- (3) Diagonal elements equal to d_{jj}^{j} as elements of \mathbb{D}^{j} of (6).

Compare the matrix $\frac{F}{\sim}$ obtained in Example 3 with the one described by the output shown on pp. 51-58.

```
PROGRAM DECSYS1(TAPE2)
                                                                                            000001
\mathbf{C}
                                                                                            000002
            THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION
800000
                                                                                            000004
            ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH
                                                                                            000005
                                                                                            000006
       INTEGER INDEX2(2)
                                                                                            000007
       COMPLEX CE(103)
                                                                                            800000
                                                                                            000009
C
            DIRECTORY
                                                                                            000010
C
                                                                                            000011
       DATA CE/(4.,1.), (5.,1.), (6.,1.), (7.,1.), (13.,9.), (25.,22.),
                                                                                            000012
      +(32.,47.),(25.,79.),
                                                                                            000013
\mathbf{C}
                                                                                            000014
C
            SUBGRAPH G4
                                                                                            000015
C
                                                                                            000016
      +(2.,1.),(2.,4.),(1.,0.),(2.,0.),(2.,0.),(2.,0.),
                                                                                            000017
      +(1.,1.),(2.,1.),(1.,2.),(2.,2.),(1.,0.),(1.,0.),(6.,8.),
                                                                                            000018
\mathbf{C}
                                                                                            000019
Ċ
            SUBGRAPH C5
                                                                                            000020
                                                                                            000021
      +(3.,1.),(6.,9.),(3.,0.),(1.,0.),(2.,0.),(2.,0.),(0.,0.),
                                                                                            000022
      +(0.,0.),(1.,0.),(1.,0.),(4.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),
                                                                                            000023
      +(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(0.,0.),(0.,0.),(9.,0.),
                                                                                            000024
      +(5.,8.),(9.,0.),
                                                                                            000025
C
                                                                                            000026
C
            SUBGRAPH G6
                                                                                            000027
C
                                                                                            000028
      +(4.,2.),(12.,12.),(6.,0.),(-1.,0.),(1.,0.),(3.,0.),(5.,0.)
+,(-1.,0.),(2.,0.),(2.,0.),(0.,0.),(0.,0.),(1.,0.),(0.,0.),(1.,1.),
+(2.,1.),(3.,1.),(1.,2.),(2.,2.),(3.,2.),(4.,2.),(1.,3.),(2.,3.),
                                                                                            000029
                                                                                            000030
                                                                                            000031
      +(3.,3.),(2.,4.),(4.,4.),(0.,0.),(1.,0.),(0.,0.),(0.,0.),(3.,4.),
                                                                                            000032
      +(7.,9.),
                                                                                            000033
\mathbf{C}
                                                                                            000034
\mathbf{C}
            SUBGRAPH G7
                                                                                            000035
                                                                                            000036
      +(3.,2.),(6.,9.),(9.,0.),(1.,0.),(0.,0.),(2.,0.),(8.,0.),
                                                                                            000037
      +(2.,0.),(1.,0.),(1.,0.),(7.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),
+(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(-1.,0.),(2.,0.),(0.,0.),
                                                                                            000038
                                                                                            000039
      +(1.,2.),(7.,0.)/
                                                                                            000040
\mathbf{C}
                                                                                            000041
\mathbf{c}
            IREC2
                      THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE
                                                                                            000042
C
                      NOT LESS THAN IN(20)+1
                                                                                            000043
C
                                                                                            000044
       IREC2=2
                                                                                            000045
       CALL OPENMS (2, INDEX2, IREC2, 0)
                                                                                            000046
\mathbf{C}
                                                                                            000047
C
            STORE INFORMATION ABOUT SUBNETWORKS TO BE ANALYZED
                                                                                            000048
                                                                                            000049
       CALL WRITMS (2, CE, 206, 1)
                                                                                            000050
       STOP
                                                                                            000051
       END
                                                                                            000052
```

C	PROGRAM EXAMP6(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1, 1TAPE2, TAPE3, TAPE5, TAPE7)	000001 000002
CC	THIS IS THE MAIN PROGRAM FOR EXAMPLE 6	000003 000004 000005
	DIMENSION IN(33), IM(5), INTWA(137) COMPLEX CMPLXWA(716),SOLR(20)	000006 000007
	DATA IN/0,0,0,4,4,0,2,6,7,4,540,10,0,0,1,4,12,12,7,1,0,0,0,0,103,3 1,0,1,1,7,6,5,4/ DATA IM/1,0,137,716,10/	000008 000009
C	WRITE (6.10)	000010 000011 000012
	10 FORMAT (1H, /, " EXAMPLE 6", /) CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR)	000013
	STOP END	000015

EXAMPLE 6

HIERARCHICAL ANALYSIS OF LINEAR DECOMPOSED SYSTEMS (CSDSLE PACKAGE)

INPUT DATA

4.	4 .	•4		•	40	Ä			-	-					10	
		•	•	•	•	•	•	•	•	•	•	•	•	•	•	٠
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ZY.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
5	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
¥.	٠	•	•	•	•	•	•	•	•	XII	•	•	•	•	•	•
Ö	٠	•	•	•	•	•	•	•	•	Ę	•	•	•	•	•	•
Z	٠	•	•	•	•	•	•	•	•	S.M.A	•	•	•	•		
WILL BE RECALCULATED	•	•	•	٠	•	•	•	Η̈́	•	IN THE MAXIMUM SUBMATRIX		•			•	
ı	•	ζΩ	•	•	•	•	•	SUBGRAPH	SI C	<u>ب</u>	ES					
1	•	LT	•	•	•	•	•	3GF	LIC	Ď	ĬO.		•	S		
=	•	S	•	•	•	•	•	SUI	A	XII	z			П	Q	
SOLUTION	•	H	•	•	•			[-]	[6]	MA	[0]			<u> </u>	OR	
TI	•	덛	70	•	•			FOR THE	AL(<u>교</u>	II		LA	OM	EC	Ø
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田		2	961	SE		a	00	CO.	T.	_	00		<u>- 1</u>	Z	—	Z
WHERE THE		INDICATOR FOR PRINTING INTERMEDIATE RESULTS	ALL SUBGRAPHS	SUBGRAPHS		ADDRESSING RECORD	BASIC RECORDS	EQUATIONS	MAXIMUM AREA FOR SPARSE MATRIX CALCULATIONS	NUMBER OF NONZERO ELEMENTS	THE LOWEST INDEX OF THE DECOMPOSITION NODES		FOR RHS UPDATING FORMULA	FOR OPERATIONS ON RANDOM FILES	MAXIMUM LENGTH OF DATA AND RHS RECORD	NUMBER OF ALL DECOMPOSITION NODES
Ħ	•	N	د.	GR.		Ë	Ü	T	드	EN	되		TI	SS	۷	11
E	9	E.b	ΨΓ	Œ	BASIC RECORD	=	S	UA	ISS	EM	Ξ	NUMBER OF DATA RECORDS	DA	1.0	T.A	8
×	50	Ň	<u>-</u>	S	00	NG	BA	EG	ΡΛ	E	<u> </u>	ĬO.	UF	LA.	D.	12
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NUMBER OF	NUMBER OF		THE HIGHEST INDEX OF	3		T	M		M	Z	Ę	Z	=	=		
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4	5)	5	6	9	Ξ	37	=)	=======================================	INC 18)	(61)NI	IN(20)	IN(22)	IN(23)	IN(25)	IN(26)
IN(4)	IN(5)	(2)NI	(6)NI	IN(10)	IN(11)	IN(12)	IN(15)	IN(16)	(21)NI	N	N	N	N	Z	IN	Z
_	_	_				_		••								

NUMBERS OF EXTERNAL NODES IN THE SUBSTITUTE SUBGRAPHS

IMAGINARY

					VALUE	REAL IMAGINA	.200000E+01 0. .200000E+01 0.			VALUE	REAL IMAGINARY			VALUE	REAL IMAGINARY			VALUE	REAL IMAGINARY	200000E+01 0.
					COL		01 01													ť,
					ROW		- 01			ROW				ROW				VARIABLE		61
70		SI		SUBGRAPH NO 4	6-3	IMAGINARY	0			5.3	IMAGINARY				IMAGINARY				IMAGINARY	
LOCKS		GRAPI		UBGR/	VALUE			SO		VALUE		.0		VALUE		.0		VALUE		0
INDICES OF ALL PROPER BLOCKS	4,	OF MODIFIED SUBGRAPHS	٠.	COEFFICIENT MATRIX OF S		REAL	. 196060E+01 . 296060E+01	.001 SECONDS	LOVER TRIANGULAR PART		REAL	. 2000000E+01	TRIANGULAR PART		REAL	. 2000000E+01	EMENTS	Λ	REAL	. 100000E+01
OF			9	HENT	COL			: E	RIAN	ROW		c1	RIAN	ROW		ળ	L EL	LE		
INDICES	9 2	INDICES	4	COEFFIC	ROW		- 63	CPU TIME:	LOVER 1	COL		=	UPPER T	T00		-	DIACONAL ELEMENTS	VARIABLE		1

ROW COL		VALUE	ROW	TOO	Λ	VALUE		ROW CO	COL	VALUE	
	REAL	IMAGINARY			REAL	IMAGINARY	RY		REAL		IMAGINARY
-86	.300000E+01 .100000E+01 .200000E+01		- 01 65	ଷଷଷ	.200000E+01 0. 0.			-00	3 .100600E+01 3 .100600E+01 3 .400000E+01	+01 0. +01 0. +01 0.	_
CPU TIME:	. 003 SECONDS	70									
LOWER TRI	LOWER TRIANGULAR PART										
COL ROW		VALUE	ROW		VALUE		ROW		VALUE		
	REAL	IMAGINARY		R	REAL	IMAGINARY	-7	REAL		IMAGINARY	
- 6	. 1000000E+01	0.	ဇာ	.20006	.2000000E+01 0.						
1 ຕ	1333333E+01	0.						المتحاثة			
UPPER TRI	UPPER TRIANGULAR PART										
COL ROW		VALUE	ROW		VALUE		ROW		VALUE		
	REAL	IMAGINARY		R	REAL	IMAGINARY		REAL		IMAGINARY	
- 6	.6666667E+00	0.	တ	. 33333	.333333E+00 0.						
ر. د	.6666667E+00	.0									
DIACONAL ELEMENTS	ELEMENTS										
VARIABLE	VALUE		VARIABLE	ಎ	VALUE	덛	VARIABLE	3LE	VALUE	Æ	
	REAL	IMAGINARY			REAL	IMAGINARY			REAL	IMAGINARY	NARY
-											

COEFFICIENT MATRIX OF SUBGRAPH NO 6

	ARY							- 5	3 -			•							
	IMAGINARY																		
VALUE		9999				ARY						ARY							
VA	REAL	0. 0. .1000000E+01 0.			VALUE	IMAGINARY					VALUE	IMAGINARY							
COL		w w 4 4	-			REAL						REAL							
ROW		0004				•													
	5 4				ROW						ROW								
	IMAGINARY																	RY	
VALUE	IMAG	6999				IMAGINARY						IMAGINARY					<u> </u>	IMAGINARY	0.
Λ		E+01 E+01 E+01 E+01			VALUE		•	0			VALUE		0	0			VALUE		
	REAL	.500000E+01 100000E+01 .200000E+01			VA	REAL	. 1000000E+01	.2000000E+01			VA	REAL	. 3333333E+00	. 1818182E+00				REAL	242424E+00 363636E+00
COL		ପପପଟ					. 100	.200					. 333	. 181			.,		ii
ROW		01 to 4 -			ROW		က	4			ROW		က	4			VARIABLE		භ 4
	IMAGINARY					IMAGINARY						IMAGINARY						IMAGINARY	
VALUE		9999	70		VALUE		0.	0	0.		VALUE		0	0	0		VALUE		00
VA	REAL	.600000E+01 100000E+01 .190000E+01 .300000E+01	.003 SECONDS	LOWER TRIANGULAR PART	ΛV	REAL	1000000E+01	1500000E+01	1212121E+00	UPPER TRIANGULAR PART	/A	REAL	. 5000000E+00	.6060606E-01	.2727273E+00	EMENTS	VAI	REAL	. 166667E+00 . 181818E+00
COL		0	: E	RIAN	ROW		<i>c</i> 1	დ	4.	RIAN	ROW		Ø	ဗ	4	1L EL	3LE		
ROW		-00-	CPU TIME:	LOWER 1	COL		- (. 01 (က	UPPER 1	T00		-	N (n	DIAGONAL ELEMENTS	VARIABLE		- 31

1 1 .96 2 1 .10 3 1 0. U TIME: .00	REAL .900000E+01 0100000E+01 0002 SECONDS LAR PART VALUE	IMAGINARY								
NGU.	+01 +01 ONDS				REAL	IMAGINARY	RY		BFAL	TMACTRABO
U TIME: .000 WER TRIANGULAF	ONDS VALU		- 01 c	01 01 C	.200000E+01 .800000E+01	• • •	- 00	000	. 1000000E+01	
WER TRIANGULAF COL ROW		•	,		1949999	•	7		10+300000.	9
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61	.1000000E+01 0.		3 0		0					
2000 3	.2000000E+01 0.									
UPPER TRIANGULAR PART	R PART									
COL ROW	VALUE		ROW		VALUE		ROW		VALUE	
	REAL	IMAGINARY		REAL	П	IMAGINARY		REAL	IMAGINARY	ıRY
1 2 .222	.222222E+00 0.		က	.1111111E+00	2+00 0.					
က	.1142857E+00 0.									
DIACONAL ELEMENTS	rs									
VARIABLE	VALUE	\mathbf{V}_{ℓ}	VARIABLE		VALUE	£.7	VARIABLE	덛	VALUE	
п	REAL I	IMAGINARY		REAL	ij	IMAGINARY		-	REAL IM	IMACINARY
1111.	.111111E+00 0.		01	. 128571E+00		0.	က	229.	.677143E+01 0.	

SEQUENCE OF SUBSTITUTE SUBGRAPHS TO BE REANALYZED

9 EXTERNAL DESCRIPTION OF THE SUBGRAPH NO NUMBER OF NODES: 2 NUMBER OF ELEMEN

	VALUE	REAL IMAGINARY	121212E+00 0. .272727E+00 0.		
	COL		- 01		
ES: 2 NUFBER OF ELEMENTS: 4	VALUE ROW COL	REAL IMAGINARY	242424E+00 0. 2 363636E+00 0. 1	EXTERNAL DESCRIPTION OF THE SUBGRAPH NO 7 NUMBER OF NODES: 1 NUMBER OF ELEMENTS: 1	VALUE
NUMBER OF NODES: 2	ROW COL		- 0	RNAL DESC ER OF NOI	ROW COL
NUMBER	RO		- 0	EXTE NUMB	RO

က COEFFICIENT MATRIX OF SUBGRAPH NO

.677143E+01

REAL

IMACINARY

		IMAGINARY	0.	
	VALUE	REAL	121212E+00 .272727E+00	
	COL		- 0	
	ROW COL		- 12	
COEFFICIENT MAINIA OF SODOWN II NO S	VALUE	REAL IMAGINARY	.652900E+01 0. 363636E+00 0.	.001 SECONDS
COEFFICIENT	ROW COL		2 - 2 - 2	CPII TIME:

LOWER TRIANGULAR PART

VALUE	IMAGINARY	
	REAL	
ROW		
VALUE	IMAGINARY	0.
VAI	REAL	1212121E+00 0.
ROW		U
COL		

UPPER TRIANGULAR PART

VALUE	IMAGINARY
Ď	REAL
ROW	
VALUE	IMAGINARY
	REAL
ROW	
COL	

.4177165E-01 0.

DIACONAL ELEMENTS

	> -	
	IMAGINAR	•
/ALUE		0
A	REAL	358573E+00 0.
VARIABLE		61
	MAGINARY	
	IMAG	
VALUE		0
VA	REAL	.153163E+00
VARIABLE		-

EXTERNAL DESCRIPTION OF THE SUBGRAPH NO 4 NUMBER OF NODES: 1 NUMBER OF ELEMENTS:

VALUE ROW COL

-. 2000000E+01

REAL

IMAGINARY

		IMAGINARY				IMAGINARY	
	5-3		99		5-3		9 9
	VALUE	REAL	133333E+01 .666667E+00		VALUE	REAL	133333E+01 .66667E+00
	COL		- 01		COL		- 01
ი	ROW COL		c1 —		ROW		c1
EXTERNAL DESCRIPTION OF THE SUBGRAPH NO 5 NUMBER OF NODES: 2 NUMBER OF ELEMENTS: 4	ROW COL VALUE	REAL IMAGINARY	1 1666667E+00 0. 2 2 .33333E+01 0.	COEFFICIENT MATRIX OF SUBGRAPH NO 2	ROW COL VALUE	REAL IMAGINARY	1 1266667E+01 0. 2 2 .333333E+01 0.

IMAGINARY

REAL

IMAGINARY

REAL

VALUE

ROW

VALUE

COL ROW

LOWER TRIANGULAR PART

.002 SECONDS

CPU TIME:

. -. 1333333E+01

UPPER TRIANGULAR PART

VALUE ROW COL

REAL

ROW

VALUE

IMAGINARY

REAL

IMAGINARY

0 -.2500000E+00

DIAGONAL ELEMENTS

VARIABLE

VALUE

IMAGINARY

REAL

VARIABLE

VALUE

9 -.375000E+00

IMAGINARY .300000E+01 REAL

Ø

EXTERNAL DESCRIPTION OF THE SUBGRAPH NO 2 NUMBER OF NODES: 1 NUMBER OF ELEMENTS:

ROW COL

VALUE

IMAGINARY REAL

.300000E+01

EXTERNAL DESCRIPTION OF THE SUBGRAPH NO 3 NUMBER OF NODES: 1 NUMBER OF ELEMENTS:

ROW COL

VALUE

I MAC I NARY 0 -.358573E+00

REAL

COEFFICIENT MATRIX OF SUBGRAPH NO

ROW COL

VALUE

IMAGINARY

REAL

.264143E+01

CPU TIME: .001 SECONDS

DIACONAL ELEMENTS

VARIABLE VALUE

REAL IMAGINARY

.373583E+00 0.

SOLUTION WILL BE RECALCULATED AT THE INTERNAL NODES OF SUBGRAPHS

SOLUTION

-

IN SUBGRAPH NO 1

VARIABLE VALUE

REAL IMAGINARY

.345698E+01 0.

6

IN SUBGRAPH NO 2

VARIABLE

HEAL IMAGINARY

B .123924E+01

IN SUBCRAPH NO 3

VARIABLE VALUE REAL IMAGINARY

-. 185777E+00 0

IN SUBGRAPH NO 4

									IMAGINARY				IMAGINARY		
								VALUE	<u>-</u>	0		VALUE		0	
								VA		00+3		VA		00+3	
									REAL	435464E+00			REAL	. 292660E+00	
										1.43				.29	
								ABLE		4		ABLE		ଷ	6
								VARIABLE				VARIABLE			CTOR
	IARY				IARY				MARY				MARY		N VE
	IMAGINARY				IMAGINARY				IMAGINARY				IMAGINARY		LUTI
VALUE		0		VALUE		0		VALUE	_	0		VALUE	-	0	TIE SC
VA		Z+01		VA		E+01		VA		E+00		VA		E+00	IN T
	REAL	147849E+01	ıo		REAL	197849E+@1	9		REAL	.279658E+00	^		REAL	155505E+00	ABLES
		14	ON H			19	ON H			2.	N H				VARI!
ABLE		9	BGRAP	ABLE		ıo.	BGRAP	ABLE		8	BGRAP	ABLE		9-4	R OF
VARIABLE		•	IN SUBGRAPH NO	VARIABLE			IN SUBGRAPH NO	VARIABLE			IN SUBGRAPH NO	VARIABLE			NUMBER OF VARIABLES IN THE SOLUTION VECTOR

.509 SECONDS

CPU TIME:

Example 7

The system of linear equations of Example 2 has been partitioned and stored in random access file No. 2, as for Example 6. The sizes of the basic record, the addressing record and the data record are the same as for Example 6. Only part of the intermediate results are printed out. The solution is calculated at the partition nodes only, which are internal nodes of the subgraphs 3, 2 and 1. The user's main program EXAMP7 and the corresponding results are shown on pp. 61-65.

C	PROGRAM EXAMP7(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1, 1TAPE2, TAPE3, TAPE5, TAPE7)	0000001 000002
Č	THIS IS THE MAIN PROGRAM FOR EXAMPLE 7	000003 000004
	DIMENSION IN(36), IM(5), INTWA(137) COMPLEX CMPLXWA(716), SOLR(20)	000005 000006 000007
	DATA IN/0,0,0,3,4,0,0,6,7,4,540,10,0,0,1,4,12,12,7,1,0,2,0,0,103,3 1,0,1,1,7,6,5,4,3,2,1/ DATA IM/1,0,137,716,10/	000008 000009
C	WRITE (6,10) 10 FORNAT (1H ,/, " EXAMPLE 7",/)	000010 000011 000012 000013
	CALL CSDSLE1 (IN, INTWA, CMPĹXWA, IM, SOLR) STOP END	000014 000015 000016

EXAMPLE 7

HIERARCHICAL ANALYSIS OF LINEAR DECOMPOSED SYSTEMS (CSDSLE PACKAGE)

INPUT DATA

•••	4.	•	Į	4.	546	Ĩ		4.			Į.			•	103	ψ.
•	•	•	•	•	•	•	•	٠	•	٠	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Ω	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
TE	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
LA	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CO	•	•	. •	•	•	•	•	•	•	•	•	•	•	•	•	•
AL	٠	•	•	•	•	•	•	•	•	×	•	•	•	٠	•	•
E	•	•	•	•	•	•	•	•	•		•	•	•	•	٠	•
E	•	٠	۰	٠	•	•	•	•	•	MA	•	•	•	•	٠	•
BE	•	•	٠	•	•	•	٠	H	•	E C	-	•	•	۰	•	•
ij	•	$\mathbf{\tilde{x}}$	•		•		•	W.	NS.	<u> </u>	E	•	•	۰	٠	•
WILL BE RECALCULATED	•	H	٠		·	•	•	25	LIC	Ď	Ō	·	•	Š	•	
		S						SUBGRAPH	ΓΨ	X			•	Ξ		
<u>[0]</u>		2						ᄕ	[]	MA	[0]			[**	O.B.	
UŢ	:	TE	S	٠	•	•		H	AL(ഥ	II		LA	OM	RECORD	(n)
SOLUTION		ΙV	ЬH			•	Ø	<u>-</u>	Ö	THE MAXIMUM SUBMATRIX	\mathbf{so}		MU	Ñ	=	DE
		INDICATOR FOR PRINTING INTERMEDIATE RESULTS	SUBGRAPHS				MAXIMUM NUMBER OF BASIC RECORDS	FOR THE	MAXIMUM AREA FOR SPARSE MATRIX CALCULATIONS	N	THE DECOMPOSITION NODES		INDICATOR FOR RHS UPDATING FORMULA	OPERATIONS ON RANDOM FILES	MAXIFUM LENCTH OF DATA AND RHS	NUMBER OF ALL DECOMPOSITION NODES
HE		E	BG	HS	•	9	00		TH	_	00		<u></u>	Z	~	Z
_	•	TE	\mathbf{s}	ΙΑΡ	•	E O	E	NO	MA		DE	•	NG	0		01.
SUBGRAPHS WHERE THE			ALL	SUBGRAPHS	_	ADDRESSING RECORD	O	EQUATIONS	띮	NONZERO ELEMENTS	띰		TI	SNS	A 1	LI
H	35	ဋ	ΑI	3UE	H	<u></u>	SI	ZO.	RES	Ę	II	SO	Ωć	LIC	ΥŢ	So
<u> </u>	ŏ	[]	F	3	ည္တ	Ĭ.	B/	ä	3P/	E	F	30.	OF	₩	D/)M
HE	Ħ	Z	→	Ξ	Ξ	<u> </u>)F)ŗ	بہ	2	→	E	3	E	<u>-</u>	C
Æ	ER	PR	SE	E	21	E.	<u>ب</u>	یے	E	ZEI)EX		Ξ) H	
BG	PROPER BLOCKS	=	HIGHEST INDEX OF	MODIFIED	BASIC RECORD	<u> </u>	BE	NUMBER OF	- e	DN.	THE LOWEST INDEX OF	DATA RECORDS	OR	FOR	E.T.	7
50.	PR	<u> </u>	-				M		됟	ž	_		Ξ		EZ	A
		=	ES	NUMBER OF	LENGTH OF	$0^{\mathbf{F}}$	Z	Z	A	OF	3	NUMBER OF	OR	INDICATOR	_	Q.
0	0	To	НЭ	=	Ħ	Ħ	UM	M	UM	<u>~</u>	ΜO	2	AT	AT	UM	2
EH	EH	CA	III	BE	GI	CI	Ξ	E	Ξ	BE	7	BE	2	ī	Ξ	BE
NUMBER OF	NUMBER OF	DI	THE	E C	EN	LENGTH	ΙVΧ	MAXIMUM	IAX	NUMBER	HE	UM	S	S	[AX	MO
N	N	Z	E		-				<u>Σ</u>							
i	ı	ı	ì	1	1	1	1	1		!	I -	1	1	1	1	1
3	10	2	3	IN(10)	(11) NI	INC 12)	INC 15)	1NC 16)	(21)NI	INC 18)	(61)NI	IN(20)	IN(22)	IN(23)	IN(25)	IN(26)
IN(4)	IN(5)	(2)NI	1N(9)) N	2) N	Ę	<u> </u>	<u> </u>		<u></u>	N S) N	N N	3	3)
Ξ	Ξ	Ξ		Π	Π	II	Ι	Ξ	Π	Ξ		Ι	Ξ		Π	_
			•													

NUMBERS OF EXTERNAL NODES IN THE SUBSTITUTE SUBGRAPHS

IMAGINARY

REAL

IMAGINARY

VALUE

COL

ROW

VALUE

999

. 1000000E+01 . 100000E+01 . 400000E+01

က က က

- 01 00

600

IMAGINARY

REAL

IMAGINARY

VALUE

COL

ROW

VALUE

6000

. 1000000E+01

. . .

ಬ ಬ 4 4

01 to 01 4

6666

IFINGINARY

REAL

IMAGINARY

REAL

IMAGINARY

REAL

VALUE

COL

ROW

VALUE

COL

ROW

VALUE

cor

ROW

!~

COEFFICIENT MATRIX OF SUBGRAPH NO

INDICE	S OF 4	INDICES OF ALL PROPER BLOCKS			
~	9	₹			
INDICES	OF	SUBGRAPHS WHERE SOLUTION WILL		BE CALCULATED	red
ဗ	2				
INDICES		OF MODIFIED SUBGRAPHS			
4	9	2			
COEFFI	CIENT	COEFFICIENT MATRIX OF SUBGRAPH NO 4			
ROW	COL	VALUE	ROW	COL	VALUE
		REAL IMAGINARY			REAL
- 6	yest peed	.100000E+01 0. .200000E+01 0.	- 0	ପ୍ରଧ	.200000E+01 .200000E+01
COEFFICIENT	CIENT	MATRIX OF SUBGRAPH NO 5			
ROW	COL	VALUE	ROW	COL	VAL
		REAL IMAGINARY			REAL
- 0 8		.300000E+01 0. .160660E+01 0. .206000E+01 0.	- 60	ପାପପ	.260000E+01 0. 0.
COEFFI	COEFFICIENT	MATRIX OF SUBGRAPH NO 6			
ROW	COL	VALUE	ROW	COL	TVA
		REAL IMAGINARY			REAL
-00-	0	.600000E+01 0. 100000E+01 0. .100000E+01 0. .300000E+01 0.	01 to 4 =	ପପପଟ	.500000E+01 100000E+01 .200000E+01 .200000E+01

9

IMAGINARY

VALUE

9 9

999

1 3 .1000000E+01 2 3 .1000000E+01 3 3 .700000E+01																
 					IMAGINARY	0.0			IMACINARY	0. 0.						
.200000E+01 .80000E+01 .20000E+01				VALUE	REAL	121212E+00 .272727E+00		VALUE	REAL	133333E+01 . 666667E+00					S OF SUBGRAPHS	
ପ୍ରପ୍ର	ZED			COL		- 01		COL		- 01					NODES	
- a c	ANALY			ROW		c1 -		ROW		61 -					INTERNAL NODES	
.900000E+01 0. .100000E+01 0. 0.	SUBSTITUTE SUBGRAPHS TO BE REANALYZED		COEFFICIENT MATRIX OF SUBGRAPH NO 3	VALUE	REAL IMAGINARY	.652900E+01 0. 362636E+00 0.	COEFFICIENT MATRIX OF SUBGRAPH NO 2	VALUE	REAL IMAGINARY	-,266667E÷01 0. ,333333E+01 0.	COEFFICIENT MATRIX OF SUBGRAPH NO 1	VALUE	REAL IMAGINARY	.264143E+01 0.	SOLUTION WILL BE RECALCULATED AT THE INTE	
- 01 62	SEQUENCE OF	3 2 1	COEFFICIENT	ROW COL		7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	COEFFICIENT	ROW COL		2 - 2	COEFFICIENT	ROW COL		1 1	SOLUTION WIL	3 2 1

IMAGINARY

REAL .345698E+01

6

VALUE

IN SUBGRAPH NO 1

SOLUTION

VARIABLE

CJ IN SUBGRAPH NO VARIABLE

VALUE

IMAGINARY REAL

. 123924E+01 IN SUBGRAPH NO ය

VARIABLE

VALUE

IMAGINARY REAL

-.185777E+00 0.

NUMBER OF VARIABLES IN THE SOLUTION VECTOR

.230 SECONDS CPU TIME:

Example 8

The system of linear equations of Example 2 has been partitioned and stored in random access file No. 2 as for Example 6. Smaller basic and addressing records were chosen and, in this example, 2 of each were necessary.

The data record was the same as for Example 6. Only the solution vector is printed out. The user's main program EXAMP8 and the corresponding results are shown on pp. 67-68.

	PROGRAM EXAMP8(INPUT,OUTPUT,RESULT,TAPE4=INPUT,TAPE6=RESULT,TAPE1,1TAPE2,TAPE3,TAPE5,TAPE7)	$000001 \\ 000002$
CCC	THIS IS THE MAIN PROGRAM FOR EXAMPLE 8	000003 000004 000005
u	DIMENSION IN(33), IM(5), INTWA(130) COMPLEX CMPLXWA(586).SOLR(20)	000005 000006 000007
	DATA IN/0,0,0,4,4,0,3,6,7,4,410,5,0,0,2,4,12,12,7,1,0,0,0,0,103,3,10,1.1,7,6.5,4/	000008
C	DATA IM/1,0,130,586,10/	000010 000011
	WRITE (6,10) 10 FORMAT (1H ,/, " EXAMPLE 8",/)	000012 000013
	CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR) STOP	000014 000015
	END	000016

```
EXAMPLE 8
SOLUTION
IN SUBGRAPH NO 1
        VALUE
VARIABLE
         REAL IMAGINARY
       .345698E+01 0.
IN SUBGRAPH NO 2
        VALUE
VARIABLE
         REAL IMAGINARY
   8 .123924E+01 0.
IN SUBGRAPH NO 3
VARIABLE
             VALUE
         REAL IMAGINARY
  7 -.185777E+00 0.
IN SUBGRAPH NO 4
VARIABLE VALUE
       REAL IMAGINARY
  6 -.147849E+01 0.
IN SUBGRAPH NO 5
VARIABLE VALUE
         REAL IMAGINARY
      -.197849E+01 0.
IN SUBGRAPH NO 6
                                  VALUE
VARIABLE
        VALUE VARIABLE
         REAL IMAGINARY
                                  REAL IMAGINARY
   3 .279658E+00 0.
                            4 -.435464E+00 0.
IN SUBGRAPH NO 7
        VALUE
                    VARIABLE
VARIABLE
                                       VALUE
         REAL IMAGINARY
                                  REAL IMAGINARY
```

2 .292660E+00 0.

1 -.155505E+00 0.

CPU TIME: .179 SECONDS

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 9

Example 9

The system of linear equations of Example 2 has been partitioned and stored in complex vector CE. The data record is read directly into the working area CMPLXWA, starting from element 4*IN(7) + 3*IN(16) + IN(11) +1. The main program EXAMP9 is executed without creating or updating any mass storage files. It is possible to read the data record directly into CMPLXWA and to create or update mass storage files. In the latter case, IM(1) must be equal to 2. Only the solution vector is printed out. The user's program EXAMP9 and the corresponding results are shown on pp. 70-71.

```
PROGRAM EXAMP9(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1,
                                                                                               000001
      +TAPE2, TAPE3, TAPE5, TAPE7)
                                                                                               000002
                                                                                               000003
             THIS IS THE MAIN PROGRAM FOR EXAMPLE 9
                                                                                               000004
\bar{\mathbf{C}}
                                                                                               000005
        DIMENSION IN(33), IM(5), INTWA(134)
                                                                                               000006
        COMPLEX CMPLXWA(716), SOLR(20), CE(103)
                                                                                               000007
C
                                                                                               800000
C
             DIRECTORY
                                                                                               റെമെമെ
C
                                                                                               000010
       DATA CE/(4.,1.),(5.,1.),(6.,1.),(7.,1.),(13.,9.),(25.,22.),
                                                                                               000011
      ÷(32.,47.),(25.,79.),
                                                                                               000012
                                                                                               000013
             SUBGRAPH G4
C
                                                                                               000014
С
                                                                                               000015
      \begin{array}{l} + (2.,1.), (2.,4.), (1.,0.), (2.,0.), (2.,0.), (2.,0.), \\ + (1.,1.), (2.,1.), (1.,2.), (2.,2.), (1.,0.), (1.,0.), (6.,8.), \end{array}
                                                                                               000016
                                                                                               000017
\mathbf{C}
                                                                                               000018
\mathbf{C}
             SUBCRAPH C5
                                                                                               000019
C
                                                                                               000020
      +(3.,1.),(6.,9.),(3.,9.),(1.,0.),(2.,0.),(2.,0.),(0.,0.),
                                                                                               000021
      +(0.,0.),(1.,0.),(1.,0.),(4.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),
                                                                                               000022
      +(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(0.,0.),(0.,0.),(9.,0.),
                                                                                               000023
      +(5.,3.),(9.,0.),
                                                                                               000024
\mathbf{c}
                                                                                               000025
C
             SUBGRAPH G6
                                                                                               000026
C
                                                                                               000027
      +(4.,2.),(12.,12.),(6.,0.),(-1.,0.),(1.,0.),(3.,0.),(5.,0.)\\+,(-1.,0.),(2.,0.),(2.,0.),(0.,0.),(0.,0.),(1.,0.),(0.,0.),(1.,1.),\\+(2.,1.),(3.,1.),(1.,2.),(2.,2.),(3.,2.),(4.,2.),(1.,3.),(2.,3.),\\+(3.,3.),(2.,4.),(4.,4.),(0.,0.),(1.,0.),(0.,0.),(0.,0.),(3.,4.),
                                                                                               000028
                                                                                               000029
                                                                                               000030
                                                                                               000031
      +(7.,9.),
                                                                                               000032
                                                                                               000033
             SUBGRAPH G7
                                                                                               000034
                                                                                               000035
      +(3.,2.),(6.,9.),(9.,0.),(1.,0.),(0.,0.),(2.,0.),(3.,0.),
                                                                                               000036
      +(2.,0.),(1.,0.),(1.,0.),(7.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),
                                                                                               000037
      +(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(-1.,0.),(2.,0.),(0.,0.),
                                                                                               000038
      +(1.,2.),(7.,0.)/
                                                                                               000039
       DATA IN/0,0,0,4,4,0,3,6,7,4,540,10,0,0,0,4,12,12,7,0,0,0,2,0,103,3
                                                                                               000040
      +,0,1,1,7,6,5,4/
                                                                                               000041
       DATA IM/0,0,134,716,10/
                                                                                               000042
C
                                                                                               000043
        IA=4*IN(17)+3*IN(16)+IN(11)
                                                                                               000044
       DO 10 I=1,103
                                                                                               000045
    10 CMPLXWA(IA+I) = CE(I)
                                                                                               000046
        WRITE(6,20)
                                                                                               000047
    20 FORMAT(1H ,/, " EXAMPLE 9",/)
                                                                                               000048
       CALL CSDSLEI(IN, INTWA, CMPLXWA, IM, SOLR)
                                                                                               000049
       STOP
                                                                                               000050
       END
                                                                                               000051
```

```
EXAMPLE 9
SOLUTION
IN SUBGRAPH NO 1
VARIABLE
         VALUE
        REAL IMAGINARY
  9 .345698E+01 0.
IN SUBGRAPH NO 2
       VALUE
VARIABLE
        REAL IMAGINARY
  8 .123924E+01 0.
IN SUBGRAPH NO 3
       VALUE
VARIABLE
        REAL IMAGINARY
  7 -.185777E+00 0.
IN SUBGRAPH NO 4
VARIABLE
        VALUE
        REAL IMAGINARY
  6 -.147849E+01 0.
IN SUBGRAPH NO 5
VARIABLE
            VALUE
       REAL IMAGINARY
  5 -.197849E+01 0.
IN SUBGRAPH NO 6
        VALUE VARIABLE VALUE
VARIABLE
        REAL IMAGINARY
                               REAL IMAGINARY
       .279658E+00 0.
                          4 -.435464E+00 0.
IN SUBGRAPH NO 7
        VALUE VARIABLE VALUE
VARIABLE
                                REAL IMAGINARY
        REAL IMAGINARY
                     2 .292660E+00 0.
     -.155505E+00 0.
```

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 9

CPU TIME: .083 SECONDS

The system of linear equations of Example 2 has been partitioned into 4 subsystems according to the partition of flow-graph G (see Fig. 6). Proper blocks ${\bf G_4}$, ${\bf G_5}$ and the directory are stored in the first data record in random access file No. 2, while proper blocks ${\bf G_6}$ and ${\bf G_7}$ are stored in the second data record. File No. 2 has been created by execution of the program DECSYS2 listed on p. 73. After creating file No. 2 the main program EXAMP10 was executed. Smaller basic and addressing records were chosen. Only the solution vector is printed out. The user's program EXAMP10 and the corresponding results are shown on pp. 74-75.

```
PROGRAM DECSYS2(TAPE2)
                                                                                        000001
\mathbf{c}
                                                                                        000002
            THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION
C
                                                                                        000003
Ċ
                                                                                        000004
            ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH
                                                                                        000005
\mathbf{C}
                                                                                        000006
       INTEGER INDEX2(3)
                                                                                        000007
       COMPLEX CE(46), DE(57)
                                                                                        000008
                                                                                        000009
C
            DIRECTORY
                                                                                        000010
C
                                                                                        000011
       DATA CE/(4.,1.),(5.,1.),(6.,2.),(7.,2.),(13.,9.),(25.,22.),
                                                                                        000012
      +(32.,1.),(25.,33.),
                                                                                        000013
                                                                                        000014
            SUBGRAPH G4
                                                                                        000015
C
                                                                                        000016
      +(2.,1.),(2.,4.),(1.,0.),(2.,0.),(2.,0.),(2.,0.),
                                                                                        000017
      +(1.,1.),(2.,1.),(1.,2.),(2.,2.),(1.,0.),(1.,0.),(6.,8.),
                                                                                        000018
                                                                                        000019
C
            SUBGRAPH C5
                                                                                        000020
\mathbf{C}
                                                                                        000021
      +(3.,1.),(6.,9.),(3.,0.),(1.,0.),(2.,0.),(2.,0.),(0.,0.),
                                                                                        000022
      +(0.,0.),(1.,0.),(1.,0.),(4.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),
                                                                                        000023
      +(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(0.,0.),(0.,0.),(9.,0.),
                                                                                        000024
      +(5.,8.),(9.,0.)/
                                                                                        000025
\mathbf{C}
                                                                                        000026
            SUBGRAPH G6
                                                                                        000027
C
                                                                                        000028
       DATA DE/(4.,2.), (12.,12.), (6.,0.), (-1.,0.), (1.,0.), (3.,0.), (5.,0.)
                                                                                        000029
     +,(-1.,0.),(2.,0.),(2.,0.),(0.,0.),(0.,0.),(1.,0.),(0.,0.),(1.,1.),
+(2.,1.),(3.,1.),(1.,2.),(2.,2.),(3.,2.),(4.,2.),(1.,3.),(2.,3.),
                                                                                        000030
                                                                                        000031
      +(3.,3.),(2.,4.),(4.,4.),(0.,0.),(1.,0.),(0.,0.),(0.,0.),(3.,4.),
                                                                                        000032
      +(7.,9.),
                                                                                        000033
                                                                                        000034
           SUBGRAPH G7
                                                                                        000035
                                                                                        000036
     +(3.,2.),(6.,9.),(9.,0.),(1.,0.),(0.,0.),(2.,0.),(8.,0.),
                                                                                        000037
     +(2.,0.),(1.,0.),(1.,0.),(7.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),
+(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(-1.,0.),(2.,0.),(0.,0.),
                                                                                        000038
                                                                                        000039
     +(1.,2.),(7.,0.)/
                                                                                        000040
C
                                                                                        000041
                     THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE NOT LESS THAN IN(20)+1
\mathbf{C}
            IREC2
                                                                                        000042
C
                                                                                        000043
C
                                                                                        000044
       IREC2=3
                                                                                        000045
       CALL OPENMS (2, INDEX2, IREC2,0)
                                                                                        000046
                                                                                        000047
           STORE INFORMATION ABOUT SUBNETWORKS TO BE ANALYZED
                                                                                        000048
                                                                                        000049
       CALL WRITMS (2, CE, 92, 1)
                                                                                        000050
       CALL WRITMS (2, DE, 114, 2)
                                                                                        000051
       STOP
                                                                                        000052
       END
                                                                                        000053
```

C	PROGRAM EXAMP10(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE11, TAPE2, TAPE3, TAPE5, TAPE7)	000001 000002
C	THIS IS THE MAIN PROGRAM FOR EXAMPLE 10	000003 000004 000005
	DIMENSION IN(33), IM(5), INTWA(131) COMPLEX CMPLKVA(540),SOLR(20)	000006 000007
	DATA IN/0,0,0,4,4,0,3,6,7,4,410,5,0,0,2,4,12,12,7,2,0,0,0,0,57,3,0 1,1,1,7,6,5,4/	000008 000009
C	DATA IM/1,0,131,540,10/	000010 000011
	WRITE (6,10) 10 FORNAT (1H ,/, " EXAMPLE 10",/)	000011 000012 000013
	CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR) STOP	000013 000014 000015
	END	000015 000016

```
EXAMPLE 10
SOLUTION
IN SUBGRAPH NO 1
 VARIABLE
         VALUE
         REAL IMAGINARY
   9 .345698E+01 0.
IN SUBGRAPH NO 2
 VARIABLE
            VALUE
        REAL IMAGINARY
  3 .123924E+01 0.
IN SUBGRAPH NO 3
VARIABLE
        VALUE
        REAL IMAGINARY
      -.185777E+00 0.
IN SUBGRAPH NO 4
VARIABLE
        VALUE
         REAL IMAGINARY
   6 -.147349E+01 0.
IN SUBGRAPH NO 5
VARIABLE
         VALUE
        REAL IMAGINARY
   5 -.197849E+01 0.
IN SUBGRAPH NO 6
             VALUE VARIABLE VALUE
VARIABLE
       REAL IMAGINARY
                                  REAL IMAGINARY
  3 .279658E+00 0.
                        4 -.435464E+00 0.
IN SUBGRAPH NO 7
      VALUE VARIABLE VALUE
```

-.155505E+00 0. 2 .292660E+00 0.

REAL IMAGINARY

CPU TIME: .192 SECONDS

REAL IMAGINARY

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 9

VARIABLE

The system of linear equations of Example 2 has been partitioned into 4 subsystems according to the partition of flowgraph G_1 (see Fig. 6). Proper blocks G_4 , G_5 and the directory describing these two blocks only, are stored in the first data record in random access file No. 2. File No. 2 has been created by execution of the program DECSYS3 listed on p. 77.

After creating file No. 2, the main program EXAMP11 was executed. In this program, IN(10)=2, which means that two subgraphs will be analyzed. As a result, local files called TAPE1, TAPE3 and TAPE5 have been generated by the program. These files store information about the partial analysis of the proper blocks G_4 and G_5 and they must be preserved by the user to complete analysis after the rest of the network is analyzed.

The remaining part of the system is represented by proper blocks ${\rm G}_6$ and ${\rm G}_7$ stored in file No. 2 after execution of the program DECSYS4 listed on the p. 78.

Next, the program EXAM11A was executed. This program uses information about the system stored in files 1, 2, 3 and 5. Indicators IN(5), IN(9), IN(12), IN(15) up to IN(20), IN(25) and IN(26) must not be changed in EXAM11A as they determine the partitioning of the working areas and indicators evaluated in the previous run. User's programs EXAMP11, EXAMP11A and the corresponding results are shown on pp. 79-82.

```
PROGRAM DECSYS3(TAPE2)
                                                                                             000001
C
                                                                                             000002
            THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION
C
                                                                                             000003
Ċ
                                                                                             000004
            ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH
                                                                                             000005
C
                                                                                             000006
       INTEGER INDEX2(2)
                                                                                             000007
       COMPLEX CE(42)
                                                                                             990998
\mathbf{C}
                                                                                             090009
            DIRECTORY
                                                                                             000010
C
\mathbf{C}
                                                                                             000011
       DATA CE/(4.,1.),(5.,1.),(13.,5.),(25.,18.),
                                                                                             000012
C
                                                                                             000013
\mathbf{C}
            SUBGRAPH G4
                                                                                             000014
\bar{\mathbf{c}}
                                                                                             090015
      +(2.,1.),(2.,4.),(1.,0.),(2.,0.),(2.,0.),(2.,0.),
                                                                                             000016
      +(1.,1.),(2.,1.),(1.,2.),(2.,2.),(1.,0.),(1.,0.),(6.,8.),
                                                                                             999917
                                                                                             000018
\mathbf{C}
            SUBGRAPH G5
                                                                                             000019
                                                                                             000020
      +(3.,1.),(6.,9.),(3.,0.),(1.,0.),(2.,0.),(2.,0.),(0.,0.),\\+(0.,0.),(1.,0.),(1.,0.),(4.,0.),(1.,1.),(2.,1.),(3.,1.),(1.,2.),\\+(2.,2.),(3.,2.),(1.,3.),(2.,3.),(3.,3.),(0.,0.),(0.,0.),(9.,0.),\\
                                                                                             000021
                                                                                             000022
                                                                                             000023
                                                                                             000024
      +(5.,8.),(9.,0.)/
                                                                                              000025
C
                       THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE
                                                                                             000026
CCC
             IREC2
                       NOT LESS THAN IN(20)+1
                                                                                              000027
                                                                                             000028
                                                                                             000029
        IREC2=2
       CALL OPENMS(2, INDEX2, IREC2,0)
                                                                                              000030
                                                                                              000031
Č
             STORE INFORMATION ABOUT SUBNETWORKS TO BE ANALYZED
                                                                                              000032
                                                                                              000033
                                                                                              000034
        CALL WRITMS(2, CE, 100, 1)
       STOP
                                                                                              000035
                                                                                              000036
       END
```

```
PROGRAM DECSYS4(TAPE2)
                                                                                                               000001
C
                                                                                                               000002
C
               THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION
                                                                                                               000003
                                                                                                               000004
Ċ
               ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH
                                                                                                               000005
                                                                                                               000006
         INTEGER INDEX2(2)
                                                                                                               000007
         COMPLEX CE(61)
                                                                                                               000008
C
                                                                                                               000009
               DIRECTORY
\mathbf{C}
                                                                                                               000010
\mathbf{c}
                                                                                                               000011
         DATA CE/(6.,1.),(7.,1.),(32.,5.),(25.,37.),
                                                                                                               000012
\mathbf{C}
                                                                                                               000013
C
                                                                                                               000014
C
                                                                                                               000015
       +(4.,2.),(12.,12.),(6.,0.),(-1.,0.),(1.,0.),(3.,0.),(5.,0.)
                                                                                                               000016
       +,(-1.,0.),(2.,0.),(2.,0.),(0.,0.),(0.,0.),(1.,0.),(0.,0.),(1.,1.),
+(2.,1.),(3.,1.),(1.,2.),(2.,2.),(3.,2.),(4.,2.),(1.,3.),(2.,3.),
+(3.,3.),(2.,4.),(4.,4.),(0.,0.),(1.,0.),(0.,0.),(0.,0.),(3.,4.),
                                                                                                               999917
                                                                                                               000018
                                                                                                               000019
                                                                                                               000020
       +(7.,9.),
                                                                                                               000021
               SUBGRAPH G7
                                                                                                               000022
                                                                                                               000023
       \begin{array}{l} + (3.,2.)\,, (6.,9.)\,, (9.,0.)\,, (1.,0.)\,, (0.,0.)\,, (2.,0.)\,, (8.,0.)\,, \\ + (2.,0.)\,, (1.,0.)\,, (1.,0.)\,, (7.,0.)\,, (1.,1.)\,, (2.,1.)\,, (3.,1.)\,, (1.,2.)\,, \\ + (2.,2.)\,, (3.,2.)\,, (1.,3.)\,, (2.,3.)\,, (3.,3.)\,, (-1.,0.)\,, (2.,0.)\,, (0.,0.)\,, \end{array}
                                                                                                               000024
                                                                                                               000025
                                                                                                               000026
       +(1.,2.),(7.,0.)/
                                                                                                                000027
                                                                                                               000028
\bar{\mathbf{C}}
                           THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE
               IREC2
                                                                                                               000029
                           NOT LESS THAN IN(20)+1
                                                                                                               000030
                                                                                                               000031
         IREC2=2
                                                                                                               000032
         CALL OPENMS(2, INDEX2, IREC2, 0)
                                                                                                                000033
                                                                                                               000034
               STORE INFORMATION ABOUT SUBNETWORKS TO BE ANALYZED
                                                                                                               000035
                                                                                                               000036
         CALL WRITMS(2, CE, 122, 1)
                                                                                                               000037
         STOP
                                                                                                               000038
         END
                                                                                                                000039
```

	PROGRAM EXAMP11(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1	<u>ଡଚ୍ଚଡଡ଼ 1</u>
	1, TAPE2, TAPE3, TAPE5, TAPE7)	00000 2
C		<i>ര</i> ാറെ ാദ
Č	THIS IS THE MAIN PROGRAM FOR EXAMPLE 11	000004
Č		o >>>o 5
_	DIMENSION IN(33), IM(5), INTWA(137)	୭୦୦୦ ୬୫
	CONPLEX CHPLKWA(674), SOLR(20)	ଡ ୍ଡ ୍ଡ ୍ରଟ
	DATA IN/0,0,0,2,4,0, $\dot{3}$,6,7,2,540,10,0,0,1,4,12,12,7,1,0,1,0,0,61,3,	<u>ଡ</u> ୍ଡ୍ରଚ ୍ଚ
	10, 1, 1, 7, 6, 5, 4/	0 330 09
	DATA IN/1,0,137,674,10/	000010
C		000011
	WRITE (6,19)	000012
	10 FORMAT (1H ,/, " EXAMPLE 11",/)	000013
	CALL CSDSLEI (IN, INTVA, CHPLXVA, IN, SOLR)	000014
	STOP	Ø300 15
	END	000016

EXAMPLE 11

HIERARCHICAL STRUCTURE IS NOT COMPLETE SOLUTION CANNOT BE CALCULATED

С	PROGRAM EXAMIIA (INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1+, TAPE2, TAPE3, TAPE5, TAPE7)	000001 000002 000003
CC	THIS IS THE MAIN PROGRAM FOR EXAMPLE 11A	000004 000005
	DIMENSION IN(33), IM(5), INTVA(137)	000006
	COMPLEX CMPLKVA(674), SOLP(20)	000007
	DATA IN/0,0,0,2,4,0,3,6,7,2,540,10,0,0,1,4,12,12,7,1,0,1,3,0,61,3	<u>ଉଚ୍ଚତ୍ର</u>
	+,0,1,1,7,6,5,4/	000009
	DATA IM/S,0,137,674,10/	000010
C		000011
	WRITE(6,100)	000012
	100 FORMAT(1H ,/," EXAMPLE 11A",/)	000013
	CALL CSDSLE1(IN, INTWA, CMPLXWA, IH, SOLR)	000014
	STOP	000015
	END	0000 16

```
EXAMPLE 11A
```

SCLUTION

IN SUBGRAPH NO 1

VARIABLE

VALUE

REAL IMAGINARY

9 .34569**8E+01 0.**

IN SUBGRAPH NO 3

VARIABLE

VALUE

REAL IMAGINARY

7 -.185777E+00 0.

IN SUEGRAPH NO 6

VARIABLE VALUE VARIABLE VALUE

REAL IMAGINARY REAL IMAGINARY

3 .279653E+00 0.

4 -.435464E+00 0.

IN SUBGRAPH NO 7

VARIABLE

VALUE VARIABLE

VALUE

REAL IMAGINARY REAL IMAGINARY 1 -.155505E+00 0. 2 .292660E+00 0.

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 6

CPU TIME: .104 SECONDS

To test networks of different size and different partition types, the program LADDER, listed on pp. 86-89, was used. LADDER generates data for a decomposed system of linear equations which are the nodal equations of a ladder network. As input data for LADDER, the user must supply 3 integer numbers LEVEL, NN and IN25, where LEVEL is the number of decomposition levels, NN is a number of nodes in each proper block, and IN25 is the length of the data record. As a result, LADDER will generate data, which is stored in file No. 2 in the form required by the subroutine CSDSLE1. To prepare data for the user's main program EXAMP12, LADDER was executed with input data as follows: LEVEL = 2, NN = 10, and IN25 = 1500. At the output, LADDER writes the following information:

LENGTH OF WORKING AREA INTWA MUST BE NOT LESS THAN 1A7

LENGTH OF WORKING AREA CMPLXWA MUST BE NOT LESS THAN IB5

NUMBER OF DATA RECORDS + 1 = IREC2

NUMBER OF ALL NODES = NALL

NUMBER OF ALL PROPER BLOCKS = IN5

THE HIGHEST INDEX OF ALL THE SUBGRAPHS = IN9

MAXIMUM AREA FOR SPARSE MATRIX = IN17

NUMBER OF NONZERO ELEMENTS IN MAX SUBMATRIX = IN18

THE LOWEST INDEX OVER ALL DECOMPOSITION NODES = IN19

NUMBER OF ALL DECOMPOSITION NODES = IN26

This information is necessary to run the user's program EXAMP12, where indicator vector IN must be as follows:

IN(5) = IN5, IN(9) = IN9, IN(10) = IN5, IN(16) = NN, IN(17) = IN17, IN(18) = IN18, IN(19) = IN19, IN(20) = IREC2, IN(25) = IN25, IN(26) = IN26.

With LEVEL = 2, NN = 10, and IN25 = 1500, LADDER generated the decomposed graph of a ladder network having 37 nodes, partitioned into 4 proper blocks. Each proper block represents a section of the ladder network having 10 nodes (plus reference), 18 unit resistors and one unit current excitation, as shown in Fig. 16. Such sections are connected in cascade and the nodes are renumbered according to the decomposition tree. User's program EXAMP12 and the corresponding results obtained are shown on pp. 90-92.

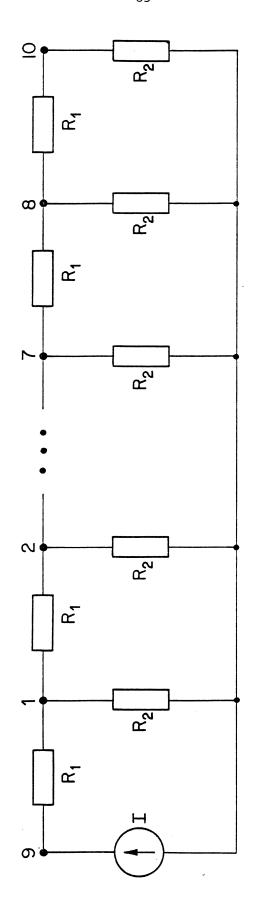


Fig. 16 Proper block for Example 12.

```
PROGRAM LADDER(INPUT, OUTPUT, TAPE4=INPUT, TAPE6=OUTPUT, TAPE2)
                                                                                                 9999991
\mathbf{C}
                                                                                                 000002
C
             THIS PROGRAM GENERATES DATA FOR THE DECOMPOSED SYSTEM
                                                                                                 000003
\mathbf{C}
                                                                                                 000004
             OF LINEAR EQUATIONS WHICH ARE THE NODAL EQUATIONS OF
                                                                                                 000005
C
                                                                                                 000006
             A LADDER NETWORK
                                                                                                 000007
\mathbf{C}
                                                                                                 000008
        INTEGER INTWA(2000)
                                                                                                 000009
        COMPLEX CMPLXWA(10000)
                                                                                                 000010
C
                                                                                                 000011
             READ SIZE OF THE NETWORK
\mathbf{C}
                                                                                                 000012
                                                                                                 000013
        WRITE (6,10)
                                                                                                 000014
    10 FORMAT (1H ,/, " NUMBER OF DECOMPOSITION LEVELS: ", 11X,/, " NUMBER OF
                                                                                                 000015
      1 NODES IN PROPER BLOCK: ",/, " LENGTH OF DATA RECORD: ",/)
                                                                                                 000016
        READ*, LEVEL, NN, IN25
                                                                                                 000017
        CALL SYSTEM (LEVEL, NN, IREC2, NALL, IN5, IN9, IN17, IN18, IN19, IN25, IN26,
                                                                                                 000018
      1 INTWA, CMPLXWA)
                                                                                                 000019
   WRITE (6,20) IREC2, NALL, IN5, IN9, IN17, IN18, IN19, IN26

20 FORMAT (,/, " NUMBER OF DATA RECORDS + 1 = ",16,/, " NUMBER OF ALL NO
1DES = ",16,/, " NUMBER OF ALL PROPER BLOCKS = ",16,/, " THE HIGHEST IN
2DEX OF ALL THE SUBGRAPHS = ",16,/, " MAXIMUM AREA FOR SPARSE MATRIX
3= ",16,/, " NUMBER OF NONZERO ELEMENTS IN MAX SUBMATRIX = ",16,,/, " T
4HE LOWEST INDEX OVER ALL DECOMPOSITION NODES = ",16,,/, " NUMBER OF
                                                                                                 000020
                                                                                                 000021
                                                                                                 000022
                                                                                                 000023
                                                                                                 000024
                                                                                                 000025
      5ALL DECOMPOSITION NODES = ", 14)
                                                                                                 000026
        STOP
                                                                                                 000027
        END
                                                                                                 000028
C
                                                                                                 000029
                                                                                                 000030
       SUBROUTINE SYSTEM (LEVEL, NN, IREC2, NALL, IN5, IN9, IN17, IN18, IN19, IN25
                                                                                                 000031
      1, IN26, INTWA, CMPLXWA)
                                                                                                 000032
        INTEGER INTWA(1)
                                                                                                 000033
        COMPLEX CMPLXWA(1)
                                                                                                 000034
        IN9=2**(LEVEL+1)-1
                                                                                                 000035
        ISBS=IN9/2
                                                                                                 000036
        IN5 = ISBS+1
                                                                                                 000037
        NALL= IN5*NN- ISBS
                                                                                                 000038
        IN18=3*NN-2
                                                                                                 000039
        IN17= IN18
                                                                                                 000040
        IN19=NALL-ISBS+1
                                                                                                 000041
        IN26=ISBS
                                                                                                 000042
        IREC2=(2*IN5+IN5*(2+(3*NN-2)*2+NN+(NN-1)/2+1))/IN25+5
                                                                                                 000043
        IA1 = 1
                                                                                                 000044
        IA2= IA1+2* IN5
                                                                                                 000045
        IA3= IA2+2*IN5
                                                                                                 000046
        IA4= IA3+ IREC2
                                                                                                 000047
        IA5= IA4+ IN18
                                                                                                 000048
        IA6= IA5+ IN18
                                                                                                 000049
        IA7 = IA6 + (NN-1)/2 + 1
                                                                                                 000050
    10 FORMAT (1H ,/, " LENGTH OF WORKING AREA INTWA MUST BE NOT LESS THAN
                                                                                                 000051
      1", [6,/)
                                                                                                 000052
       WRITE (6,10) IA7
                                                                                                 000053
        IB1=1
                                                                                                 000054
        IB2=1+2+2*IN18+NN+(NN-1)/2+1
                                                                                                 000055
        IB3= IB2+ IN25
                                                                                                 000056
        IB4= IB3+ IN18
                                                                                                 000057
        IB5=IB4+NN
                                                                                                 000058
        WRITE (6,20) IB5
                                                                                                 000059
   20 FORMAT (1H ,/, " LENGTH OF WORKING AREA CMPLXWA MUST BE NOT LESS TH
                                                                                                 000060
      1AN", I7/)
                                                                                                 000061
       CALL SYSGEN (INTWA(IA1), INTWA(IA2), INTWA(IA3), CMPLXWA(IB1), CMPLXWA
                                                                                                 000062
      1(IB2), IREC2, CMPLXWA(IB3), INTWA(IA4), INTWA(IA5), CMPLXWA(IB4), INTWA(
                                                                                                 000063
      21A6), NN, IN5, IN9, IN25, ISBS, NALL, IN17)
                                                                                                 000064
       RETURN
                                                                                                 000065
```

```
END
                                                                                    000066
                                                                                    000067
\mathbf{C}
                                                                                    000068
       SUBROUTINE SYSGEN (NSUB, NASUB, INDEX2, CE, DREC, IREC2, AK, NROW, NCOL, V,
                                                                                    000069
      1NON, NN, IN5, IN9, IN25, ISBS, NALL, IN17)
                                                                                    000070
       INTEGER NSUB(1), NASUB(1), INDEX2(1), NROW(1), NCOL(1), NON(1)
                                                                                    000071
       COMPLEX CE(1), DREC(1), AK(1), V(1)
                                                                                    000072
                                                                                    000073
            THIS SUBROUTINE GENERATES A SYSTEM OF LINEAR EQUATIONS
                                                                                    000074
CCC
                                                                                    000075
            AND STORES IT IN THE RANDOM ACCESS MULTI RECORD FILE
                                                                                    000076
                                                                                    000077
C
           NO.2
                                                                                    000078
                                                                                    000079
       CALL OPENMS (2, INDEX2, IREC2,0)
                                                                                   000080
       IND2=1
                                                                                    000081
       LDREC=2*IN25
                                                                                   000082
                                                                                   000083
\mathbf{C}
             WRITE DIRECTORY
                                                                                   000084
\mathbf{C}
                                                                                   000085
       NB= 1
                                                                                   000086
       NC=2+(3*NN-2)*2+NN+(NN-1)/2+1
                                                                                   000087
       ND=2*IN5+1
                                                                                   000088
       DO 20 I=1, IN5
                                                                                   000089
       ND1 = ND + NC
                                                                                   000090
       IF (ND1.LE.IN25) GO TO 10
                                                                                   000091
       NB= NB+ 1
                                                                                   000092
       ND1 = NC + 1
                                                                                   000093
       ND = 1
                                                                                   000094
    10 DREC(I) = CMPLX(FLOAT(I+ISBS), FLOAT(NB))
                                                                                   000095
       DREC(I+IN5) = CMPLX(FLOAT(NC), FLOAT(ND))
                                                                                   000096
       ND=ND1
                                                                                   000097
   20 CONTINUE
                                                                                   000098
       MMNS=2*IN5
                                                                                   000099
       DO 30 I=1, MMNS
                                                                                   000100
       NSUB(I) = INT(REAL(DREC(I)))
                                                                                   000101
       NASUB(I) = INT(AIMAG(DREC(I)))
                                                                                   000102
   30 CONTINUE
                                                                                   000103
       NINT=NN-2
                                                                                   000104
       NEL=3*NN-2
                                                                                   000105
       LES= IN17
                                                                                   000106
       CE(2) = CMPLX(FLOAT(LES), FLOAT(NEL))
                                                                                   000107
       DO 90 NBS=1, IN5
                                                                                   000108
       CALL BLOCK (NBS, NALL, IN9, AK, NROW, NCOL, V, NON, NSUB, NN, LRI)
                                                                                   000109
       IF (LRI.EQ.0) CE(1) = CMPLX(FLOAT(NN), FLOAT(NINT))
                                                                                   000110
         (LRI.EQ.1) CE(1) = CMPLX(FLOAT(NN), FLOAT(NINT+1))
                                                                                   000111
       DO 40 J=1, NEL
                                                                                   000112
       CE(2+J) = AK(J)
                                                                                   000113
       CE(2+NEL+J) = CMPLX(FLOAT(NROW(J)), FLOAT(NCOL(J)))
                                                                                   000114
   40 CONTINUE
                                                                                   000115
       NEL2=2*NEL+2
                                                                                   000116
       DO 50 J=1,NN
                                                                                   000117
       CE(NEL2+J) = V(J)
                                                                                   000118
   50 CONTINUE
                                                                                   000119
       NEL3=NEL2+NN
                                                                                   000120
       NEL4=(NN-1)/2+1
                                                                                   000121
       DO 60 J=1, NEL4
                                                                                   000122
       CE(NEL3+J)=CMPLX(FLOAT(NON(2*J-1)),FLOAT(NON(2*J)))
                                                                                   000123
   60 CONTINUE
                                                                                   000124
                                                                                   000125
C
           STORE A SUBNETWORK IN THE DATA RECORD
                                                                                   000126
č
                                                                                   000127
       IF (NASUB(NBS).EQ. IND2) GO TO 70
                                                                                   000128
       CALL WRITMS (2, DREC, LDREC, IND2)
                                                                                   000129
       IND2=NASUB(NBS)
                                                                                   000130
```

```
70 IAD=NASUB(NBS+IN5)-1
                                                                                    000131
       IC=NSUB(NBS+IN5)
                                                                                    000132
       DO 80 I=1, IG
                                                                                    000133
       DREC(IAD+I)=CE(I)
                                                                                    000134
   80 CONTINUE
                                                                                    000135
   90 CONTINUE
                                                                                    000136
                                                                                    000137
Č
           STORE FINAL RESULTS
                                                                                    000138
                                                                                    000139
       CALL WRITMS (2, DREC, LDREC, IND2)
                                                                                    000140
      RETURN
                                                                                    000141
       END
                                                                                    000142
C
                                                                                    000143
                                                                                    000144
       SUBROUTINE BLOCK(NBS, NALL, IN9, AK, NROW, NCOL, V, NON, NSUB, NN, LRI)
                                                                                    000145
       INTEGER NROW(1), NCOL(1), NON(1), NSUB(1)
                                                                                    000146
       COMPLEX AK(1), V(1)
                                                                                    000147
                                                                                    000148
           THIS SUBROUTINE GENERATES DATA DESCRIBING ONE SUBGRAPH
\mathbf{C}
                                                                                    000149
                                                                                    000150
      LRI=0
                                                                                    000151
      DO 1 I=1, NN
                                                                                    000152
       AK(I) = CMPLX(3.,0.)
                                                                                    000153
      NROW(I) = I
                                                                                    000154
      NCOL(I) = I
                                                                                    000155
      NROW(NN+I) = I+1
                                                                                    000156
      NCOL(NN+I) = I
                                                                                    000157
      AK(NN+I) = CMPLX(-1.,0.)
                                                                                    000158
    1 V(I) = CMPLX(0.,0.)
AK(NN-1) = CMPLX(1.,0.)
                                                                                    000159
                                                                                   000160
       AK(NN) = CMPLX(2.,0.)
                                                                                    000161
      NN2=2*NN-1
                                                                                    000162
      NCOL(NN2) = NN-2
                                                                                    000163
      NCOL(NN2-1)=1
                                                                                   000164
      NN1 = NN - 1
                                                                                   000165
      DO 2 I=1,NN1
                                                                                    000166
      NROW(NN2+I) = I
                                                                                    000167
      NCOL(NN2+1) = I+1
                                                                                   000168
    2 AK(NN2+I) = CMPLX(-1.,0.)
                                                                                    000169
      NN3=NN2+NN-1
                                                                                    000170
      NROW(NN3) = NN-2
                                                                                    000171
      NROW(NN3-1)=1
                                                                                   000172
\mathbf{C}
                                                                                    000173
C
           CALCULATE ORIGINAL INDICES OF THE NODES
                                                                                    000174
                                                                                   000175
      NX0=NSUB(NBS)
                                                                                    000176
      NXR= NX0+1
                                                                                    000177
      NXL=NX0-1
                                                                                   000178
      NX0=NX0/2
                                                                                    000179
      NXR=NXR/2
                                                                                   000180
      NXL=NXL/2
                                                                                   000181
      IF(NXØ.EQ.NXR)GOTO 11
                                                                                   000182
      IF(NXØ.EQ.NXL)GOTO 4
                                                                                   000183
   11 IF(NXL.EQ.0) GOTO5
                                                                                   000184
      NX0=NX0/2
                                                                                   000185
      NXL=NXL/2
                                                                                   000186
      IF(NX0.EQ.NXL) GOTO 3
                                                                                   000187
      GOTO 11
                                                                                   000188
    4 NX0=NX0/2
                                                                                   000189
      NXR=NXR/2
                                                                                   000190
      IF(NXO.NE.NXR) GO TO 4
                                                                                   000191
      IF(NXØ.EQ.0) GOTO 6
                                                                                   000192
    3 NL=NALL-NXL+1
                                                                                   000193
      NR=NALL-NXR+1
                                                                                   000194
      GOTO 7
                                                                                   000195
```

```
000196
\mathbf{c}
                                                                                      000197
           FIRST SECTION
\mathbf{C}
                                                                                      000198
C
                                                                                      000199
    5 NL=1
       NR= NALL-NXR+1
                                                                                      000200
                                                                                      000201
       LRI=1
       GOTO 7
                                                                                      000202
                                                                                      000203
C
                                                                                      000204
           LAST SECTION
                                                                                      000205
    6 NR=NALL-IN9/2
NL=NALL-NXL+1
                                                                                      000206
                                                                                      000207
                                                                                      000208
       LRI=1
       IN1=2+(NSUB(NBS)-IN9/2-1)*(NN-2)
                                                                                      000209
                                                                                      000210
       IN2= IN1+NN-3
                                                                                      000211
       J=0
       DO 8 I=IN1, IN2
                                                                                      000212
                                                                                      000213
       J=J+1
                                                                                      000214
    8 NON(J) = I
                                                                                      000215
       J=J+1
       NON(J) = NL
                                                                                      000216
                                                                                      000217
       V(J) = CMPLX(1., 0.)
                                                                                      000218
       J=J+1
                                                                                      000219
       NON(J) = NR
                                                                                      000220
       J=J+1
       NON(J) = 0
                                                                                      000221
                                                                                      000222
CCC
           RENUMBER LAST TWO NODES
                                                                                      000223
                                                                                      000224
       IF(NL.LT.NR) RETURN
                                                                                      000225
                                                                                      000226
       AK(NN-1) = CMPLX(2.,0.)
                                                                                      000227
       AK(NN) = CMPLX(1.,0.)
       NROW(NN2) = NN-1
                                                                                      000228
                                                                                      000229
       NROW(NN2-1) = NN
       NCOL(NN3-1)=NN
                                                                                      000230
                                                                                      000231
       NCOL(NN3) = NN-1
                                                                                      000232
       NON(J-1) = NL
       NON(J-2) = NR
                                                                                      000233
                                                                                      000234
       V(J-2) = CMPLX(0.,0.)
                                                                                      000235
       V(J-1) = CMPLX(1.,0.)
                                                                                      000236
       RETURN
                                                                                      000237
       END
```

	PROGRAM EXAMP12(INPUT,OUTPUT,RESULT,TAPE4=INPUT,TAPE6=RESULT,TAPE11,TAPE2,TAPE3,TAPE5,TAPE7)	000001 000002 000003
CCC	THIS IS THE MAIN PROGRAM FOR EXAMPLE 12	000004 000005
	DIMENSION IN(33), IM(5), INTWA(229) COMPLEX CMPLXWA(2900), SOLR(200)	000006 000007
	DATA IN/0,0,0,4,4,0,3,6,7,4,1229,10,0,0,1,10,28,28,35,5,0,0,0,0,15 100,3,0,1,1,7,6,5,4/	000008 000009 000010
C	DATA IN/1,0,229,2900,100/ WRITE (6,10)	000010 000011 000012
	10 FORMAT (1H, /, " EXAMPLE 12", /)	000013 000014
	IA3=IN(19)+IN(4)-2 WRITE (6,20) IA3,IN(5),IN(15),IN(12),IA1	000015 000016
	20 FORMAT (1H , /, " LADDER NETWORK WITH", 16, " NODES DECOMPOSED INTO", I 16, " PROPER BLOCKS", /, " NUMBER OF BASIC RECORDS", 16, /, " LENGTH OF A	000017 000018
	2DDRESSING RECORDS", 16,/, "NUMBER OF SOLUTION RECORDS", 16) CALL SECOND (TM1)	000019 000029 000021
	CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR) IF (IN(7).NE.1) STOP CALL SECOND (TM2)	000021 000022 000023
	CPU=TM2-TM1 WRITE (6,30) CPU	000024 000025
	30 FORMAT (1H ,/, "CPU TIME: ",F8.3" SECONDS",/) STOP END	000026 000027 000028
	This	

EXAMPLE 12

4 PROPER BLOCKS LADDER NETWORK WITH 37 NODES DECOMPOSED INTO NUMBER OF BASIC RECORDS 1 LENGTH OF ADDRESSING RECORDS 10 NUMBER OF SOLUTION RECORDS 1

SOLUTION

IN SUBGRAPH NO

VALUE VARIABLE IMAGINARY REAL

.447368E+00 28

Ø N0 IN SUBGRAPH

VARIABLE

VALUE

IMAGINARY

REAL

0 .447571E+00

36

ಣ IN SUBGRAPH NO VALUE VARIABLE IMAGINARY REAL

9 .447291E+00 35

<u>8</u> IN SUBGRAPH

IMAGINARY 000 VALUE .671785E-01 .171583E+00 .161831E+01 REAL VARIABLE 86-IMAGINARY 000 VALUE VALUE .380829E-01 .226784E-01 .299523E-01 REAL VARIABLE VARIABLE 9 6 IMAGINARY 000 VALUE VALUE .618314E+00 .236628E+00 .915704E-01 REAL 10 IN SUBGRAPH NO VARIABLE VARIABLE **01 to 4**

VARIABLE

VALUE

	REAL	IMAGINARY		REAL	IMAGINARY		REAL	IMAGINARY
110	.171130E+00 .658190E-01 .263271E-01	 	13 14 15	.131622E-01 .131595E-01 .263164E-01	• • • •	16 17	.657897E-01	.00
IN SUBGRAPH NO	9 ON H							
VARIABLE	VALUE	UE	VARIABLE	VAI	VALUE	VARIABLE	VALUE	Æ
	REAL	IMAGINARY		REAL	IMAGINARY	_	REAL	IMAGINARY
18 19 20	.171053E+00 .657894E-01 .263156E-01	 	22 23 23	. 131573E-01 . 131562E-01 . 263115E-01	· · · · · · · · · · · · · · · · · · ·	22 24 5	.657782E-01	
IN SUBGRAPH NO	2 ON H							
VARIABLE	VALUE	UE	VARIABLE	VAI	VALUE	VARIABLE	VALUE	Æ
	REAL	IMAGINARY		REAL	IMAGINARY		REAL	IMAGINARY
25 27 28 28	.170850E+00 .652589E-01 .249268E-01		29 30 31	.952138E-02 .363738E-02 .139076E-02	•••	3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	.534909E-03 .213964E-03 .106982E-03	
NUMBER OF V	NUMBER OF VARIABLES IN THE SOLUTION: VECTOR	E SOLUTION: VE	CTOR 37					

CPU TIME: .253 SECONDS

After the first execution of subroutine CSDSLE1 with IN(8) = 6, the user may preserve the results of the LR decomposition of the partitioned system stored in files Nos. 1, 3 and 5 and execute CSDSLE1 with an updated coefficient matrix and RHS vector in one or more proper blocks. Before execution of the user's main program EXAMP13, the program EXAMP6, as described in Example 6, was executed and local files 1, 3 and 5 preserved. Then the data file No. 2 containing information about the updated proper block G_5 was created by execution of the user's program DECSYS5 listed on p. 94. Coefficient (2,1) in G_5 has been assigned the value 3. This corresponds to an equivalent change in the coefficient (8,5) of the matrix from p. 11. The solution of the new system is listed on p. 96.

	PROGRAM DECSYS5(TAPE2)	000001
C	THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION	000002 000003
C C C	ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH	000004 000005
C	INTEGER INDEX2(2)	000006 000007
C	COMPLEX CE(11)	000008 000009
C	DIRECTORY	000010 000011
C	DATA CE/(5.,1.),(9.,3.),	000012 000013
C	SUBGRAPH G5	000014 000015
	+(3.,1.),(9.,1.),(3.,0.),(2.,1.), +(0.,0.),(0.,0.),(9.,0.),	000016 000017
C	+(5.,8.),(9.,0.)/	000018 000019
C	IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE NOT LESS THAN IN(20)+1	000020 000021
Ċ	IREC2=2	000022 000023
C	CALL OPENMS(2, INDEX2, IREC2,0)	000024 000025
C C	STORE INFORMATION ABOUT SUBNETWORKS TO BE ANALYZED	000026 000027
	CALL WRITMS(2,CE,22,1) STOP END	000028 000029 000030
	EII U	บบบบบบ

		000001
	PROGRAM EXAMP13(INPUT,OUTPUT,RESULT,TAPE4=INPUT,TAPE6=RESULT,	00000 t
	1TAPE1.TAPE2.TAPE3.TAPE5.TAPE7)	000002
C	1 22, 25, 20, 20,	000003
CC	THIS IS THE MAIN PROGRAM FOR EXAMPLE 13	000004
ā		000005
_	DIMENSION IN(33), IM(5), INTWA(137)	000006
	COMPLEX CMPLXWA(640), SOLR(20)	000007
	DATA IN/0,0,0,4,4,0,3,7,7,1,540,10,0,0,1,4,12,12,7,1,0,0,1,0,27,3	800000
	1,0,1,1,7,6,5,4/	000009
	DATA IN 1, 0, 137, 640, 10/	000010
C		000011
_	WRITE (6,10)	000012
	10 FORMAT (1H ,/, " EXAMPLE 13",/)	000013
	CALL CSDSLE1 (IN. INTWA. CMPLXWA, IM, SOLR)	000014
	STOP	000015
	END	999916

```
EXAMPLE 13
```

SOLUTION

IN SUBGRAPH NO 1

VARIABLE

VALUE

REAL IMAGINARY

9 .301358E+01 0.

IN SUBGRAPH NO 2

VARIABLE

VALUE

REAL IMAGINARY

.250000E+00 0.

IN SUBGRAPH NO 3

VARIABLE

VALUE

REAL IMAGINARY

-.167256E+00 0.

IN SUBGRAPH NO 4

VARIABLE

VALUE

REAL IMAGINARY

6 .500000E+00 0.

IN SUBGRAPH NO 5

VARIABLE

VALUE

REAL IMAGINARY

5 -.117119E+01 0.

IN SUBGRAPH NO 6

VARIABLE

VALUE

VARIABLE VALUE

REAL IMAGINARY

REAL IMAGINARY

.233737E+00 0.

4 -.355969E+00 0.

IN SUBGRAPH NO 7

VARIABLE

REAL IMAGINARY

VALUE VARIABLE

VALUE

REAL IMAGINARY

1 -.157092E+00 0.

2 .290544E+00 0.

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 9

CPU TIME: . 164 SECONDS

To investigate the savings in computer time, a ladder network of medium size was generated by the program LADDER described in Example 12 with LEVEL = 4, NN = 50 and IN25 = 1500. The only difference was that ungrounded resistors have the values 5.10^{-3} . Generated file No. 2 contains data about the ladder network with 785 nodes decomposed into 16 proper blocks with IREC2 = 15, NALL = 785, IN5 = 16, IN9 = 16, IN17 = 148, IN18 = 148, IN19 = 771 and IN26 = 15 (see Example 12).

This network was analyzed first with the help of the user's main program EXAMP14, listed on p. 99, and local files 1, 3 and 5 were preserved. The results are listed on pp. 102-112. Subsequently, the user's main program EXAM14A was executed.

In EXAM14A, the complex vector CE contains one data record describing the updated coefficient matrix corresponding to the proper block G_{26} , in which the values of coefficients (2,1) and (1,2) have been altered from -2000 to -1. The solution of the altered system is listed on pp. 112-122.

As seen from the results, the change in the solution vector is the largest in subgraph $^{\rm G}_{26}$, where the coefficients have been altered, becoming smaller for the variables associated with nodes far away from the disturbed area. They can be barely detected in subgraphs $^{\rm G}_{22}$ and $^{\rm G}_{30}$ and are not noticed in $^{\rm G}_{16}$ and $^{\rm G}_{21}$ and $^{\rm G}_{31}$, at least for the assumed 6 digits accuracy.

It should be noted that this ladder is very sensitive for changes of elements and excitations because of the very low resistance between the nodes compared with shunt resistances. A change in the solution can also be observed when the solution is calculated for the subgraph ${\rm G}_{26}$

and all its ascendants. To obtain this result the user's main program EXAM14B was executed instead of EXAM14A. In EXAM14B the indicator IN(22)=2, which means that only the solution for the subgraphs specified by the user will be calculated. In this case, G_{26} is altered, therefore IN(58)=26, as required.

By inspecting the results listed on pp. 123-124 we can see how the changes in the subnetwork coefficients affect the solution at partition nodes of all the ascendants of a given subgraph as well as at all internal nodes of this subgraph. This type of analysis is recommended particularly for extremely large networks, because the changes can be localized to a certain area and the updated approximate solution can be obtained much faster than for the whole network.

000	PROGRAM EXAMP14(INPUT,OUTPUT,RESULT,TAPE4=INPUT,TAPE6=RESULT,TAPE11,TAPE2,TAPE3,TAPE5,TAPE7) THIS IS THE MAIN PROGRAM FOR EXAMPLE 14	000001 000002 000003 000004
u	DIMENSION IN(57), IM(5), INTWA(1063)	000005 000006
	COMPLEX CMPLXWA(7000), SOLR(200)	000000
	DATA IN/0,0,0,16,16,0,3,6,31,16,4400,32,0,0,20,50,148,148,771,9,0	000001
	1,0,0,0,1500,15,0,1,1,1,2,2,1,1,2,2,2,2,2,2,1,16*(0)	000000
	DATA IM/1.0.1063,7000.109/	000000
C	2.2.2.2 2,0,2.2.2,2.2.2	000011
	DO 10 I=1.16	000012
	IN(41+I)=32-I	000013
	10 CONTINUE	000014
	WRITE (6,20)	000015
	20 FORMAT (1H ,/, " EXAMPLE 14",/)	000016
	IA1 = (IN(19) + IN(26) - 1) / IM(5) + 1	000017
	IA3 = IN(19) + IN(4) - 2	000018
	WRITE (6,39) IA3, IN(5), IN(15), IN(12), IA1	000019
	30 FORMAT (1H ,/, " LADDER NETWORK WITH", 16, " NODES DECOMPOSED INTO", I	000020
	16, " PROPER BLOCKS", /, " NUMBER OF BASIC RECORDS", 16, /, " LENGTH OF A	
	2DDRESSING RECORDS", 16,/, " NUMBER OF SOLUTION RECORDS", 16)	000022
	CALL SECOND (TM1)	000023
	CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR) IF (IN(7).NE.1) STOP	000024
	CALL SECOND (TM2)	000025
	CPU='IM2-TM1	000026
	WRITE (6,40) CPU	000027 000028
	40 FORMAT (1H ,/, " CPU TIME: ",F8.3" SECONDS",/)	000028
	STOP	000029
	END	000031
		200001

```
PROGRAM EXAM14A(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1
      1, TAPE2, TAPE3, TAPE5, TAPE7)
                                                                                                   000077
C
                                                                                                   000078
C
             THIS IS THE MAIN PROGRAM FOR EXAMPLE 14A
                                                                                                   000079
C
                                                                                                   000080
       DIMENSION IN(57), IM(5), INTWA(1200)
COMPLEX CMPLXWA(7000), SOLR(200), CE(58)
                                                                                                   000081
                                                                                                   000082
       DATA CE/(26.,1.),(56.,3.),(50.,48.),(148.,2.),(-1.,0.),(-1.,0.),(2
                                                                                                   000083
      1.,1.),(1.,2.),50*((0.,0.))/
                                                                                                   000084
      DATA IN/0,0,0,16,16,0,3,7,31,1,4400,32,0,0,20,50,148,148,771,9,0,0 1,1,0,1500,15,0,1,1,1,2,2,1,1,2,2,2,2,2,1,16*(0)/
                                                                                                   000085
                                                                                                   000086
        DATA IM/2,0,1200,7000,100/
                                                                                                   000087
C
                                                                                                   000088
        DO 10 I=1,16
                                                                                                   000089
        IN(41+I)=32-I
                                                                                                   000090
    10 CONTINUE
                                                                                                   000091
        IA=4*IN(17)+3*IN(16)+IN(11)
                                                                                                   000092
        DO 20 I=1,50
                                                                                                   000093
        CE(8+I) = CMPLX(0.,0.)
                                                                                                   000094
   20 CONTINUE
                                                                                                   000095
        CE(57) = CMPLX(1...0.)
                                                                                                   000096
        DO 30 I=1,58
                                                                                                   000097
        CMPLXWA(IA+I) = CE(I)
                                                                                                   000098
   30 CONTINUE
                                                                                                   000099
        WRITE (6,40)
                                                                                                   000100
    40 FORMAT (1H ,/, " EXAMPLE 14A",/)
                                                                                                   000101
        IA1 = (IN(19) + IN(26) - 1) / IM(5) + 1
                                                                                                   000102
        IA3 = IN(19) + IN(4) - 2
                                                                                                   000103
   WRITE (6,50) IA3, IN(5), IN(15), IN(12), IA1

50 FORMAT (1H, /, " LADDER NETWORK WITH", I6, " NODES DECOMPOSED INTO", I
16, " PROPER BLOCKS", /, " NUMBER OF BASIC RECORDS", I6, /, " LENGTH OF A
2DDRESSING RECORDS", I6, /, " NUMBER OF SOLUTION RECORDS", I6)
                                                                                                   000104
                                                                                                   000105
                                                                                                   000106
                                                                                                   000107
        CALL SECOND (TM1)
                                                                                                   000108
        CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR) IF (IN(7).NE.1) STOP
                                                                                                   000109
                                                                                                   000110
        CALL SECOND (TM2)
                                                                                                   000111
        CPU=TM2-TM1
                                                                                                   000112
        WRITE (6,60) CPU
                                                                                                   000113
    60 FORMAT (1H ,/, " CPU TIME: ",F8.3" SECONDS",/)
                                                                                                   000114
        STOP
                                                                                                   000115
        END
                                                                                                   000116
```

```
PROGRAM EXAM14B(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1
                                                                                                  000155
                                                                                                   000156
       1, TAPE2, TAPE3, TAPE5, TAPE7)
                                                                                                   000157
                                                                                                   000158
             THIS IS THE MAIN PROGRAM FOR EXAMPLE 14B
Ċ
                                                                                                   000159
        DIMENSION IN(58), IM(5), INTWA(1200)
COMPLEX CMPLXWA(7000), SOLR(200), CE(58)
                                                                                                   000160
                                                                                                   000161
        DATA CE/(26.,1.),(56.,3.),(50.,48.),(148.,2.),(-1.,0.),(-1.,0.),(2
                                                                                                   000162
                                                                                                   000163
       1.,1.),(1.,2.),50*((0.,0.))/
       DATA IN/0,0,0,1,16,0,3,7,31,1,4400,32,0,0,20,50,148,148,771,9,0,2,11,0,1500,15,0,1,1,1,2,2,1,1,2,2,2,2,2,2,1,17*(0)/
                                                                                                   000164
                                                                                                   000165
                                                                                                   000166
        DATA IM/2,0,1200,7000,100/
                                                                                                   000167
\mathbf{C}
                                                                                                   000168
        DO 10 I=1,16
                                                                                                   000169
        IN(41+I)=32-I
                                                                                                   000170
    10 CONTINUE
                                                                                                   000171
        IN(58) = 26
                                                                                                   000172
        IA=4*IN(17)+3*IN(16)+IN(11)
                                                                                                   000173
        DO 20 I=1,50
                                                                                                   000174
        CE(8+1) = CMPLX(0.,0.)
                                                                                                   000175
    20 CONTINUE
                                                                                                   000176
        CE(57) = CMPLX(1.,0.)
        DO 30 I=1,58
CMPLXWA(IA+I)=CE(I)
                                                                                                   000177
                                                                                                   000178
                                                                                                   000179
    30 CONTINUE
                                                                                                   000180
        WRITE (6,40)
                                                                                                   000181
    40 FORMAT (1H ,/, " EXAMPLE 14B",/)
                                                                                                   000182
         IA1 = (IN(19) + IN(26) - 1) / IM(5) + 1
                                                                                                   000183
         IA3=IN(19)+IN(4)-2
    WRITE (6,50) IA3, IN(5), IN(15), IN(12), IA1

50 FORMAT (1H, /, " LADDER NETWORK WITH", I6, " NODES DECOMPOSED INTO", I

16, " PROPER BLOCKS", /, " NUMBER OF BASIC RECORDS", I6, /, " LENGTH OF A

2DDRESSING RECORDS", I6, /, " NUMBER OF SOLUTION RECORDS", I6)
                                                                                                   000184
                                                                                                   000185
                                                                                                   000186
                                                                                                   000187
                                                                                                   000188
        CALL SECOND (TM1)
         CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR)
                                                                                                   000189
                                                                                                   000190
         IF (IN(7).NE.1) STOP
                                                                                                   000191
         CALL SECOND (TM2)
                                                                                                   000192
         CPU=TM2-TM1
                                                                                                   000193
         WRITE (6,60) CPU
                                                                                                   000194
     60 FORMAT (1H ,/, " CPU TIME: ",F8.3" SECONDS",/)
                                                                                                   000195
         STOP
                                                                                                   000196
```

END

EXAMPLE 14

16 PROPER BLOCKS LADDER NETWORK WITH 785.NODES DECOMPOSED INTO AUNBER OF BASIC RECORDS 20
LENCTH OF ADDRESSING RECORDS 32
NUMBER OF SOLUTION RECORDS 8

32 8

MAXIMUM COMPLEX AREA REQUIRED IS EQUAL TO 6791

SOLUTION

IN SUBGRAPH NO

VALUE VARIABLE

IMAGINARY REAL

.376167E-01

Ø IN SUBCRAPH NO

283

VALUE

VARIABLE

IMAGINARY

REAL

.376167E-01

784

ಣ IN SUBGRAPH NO REAL

VALUE

VARIABLE

IMAGINARY .376166E-01

IN SUBGRAPH NO

783

VALUE VARIABLE

IMAGINARY REAL

.376539E-01 282

C IN SUBGRAPH NO

VALUE VARIABLE

IMAGINARY REAL

.376167E-01

781

9 IN SUEGRAPH NO VALUE

VARIABLE

IMAGINARY REAL

.376167E-01 €82

VALUE ~ IN SUBGRAPH NO

VARIABLE

IMAGINARY REAL

.375820E-01

622

œ IN SUBGRAPH NO VALUE

VARIABLE

IMAGINARY

.388063E-01 REAL

822

IN SUBGRAPH NO

IMAGINARY REAL

VALUE

VARIABLE

.376178E-01 222

IN SUBGRAPH NO 10 VARIABLE

VALUE

IMAGINARY .376167E-01 REAL

922

IN SUBGRAPH NO 11

VALUE VARIABLE

222	.376167E-01	.0						
IN SUBGRAPH	[NO 12							
VARIABLE	VALUE	UE						
	REAL	IMAGINARY						
₹22	.376167E-01	0.						
IN SUBGRAPH	I NO 13							
VARIABLE	VALUE	Œ						
	REAL	IMAGINARY						
822	.376167E-01	.0						
IN SUBCRAPH NO	I NO 14							
VARLABLE	VALUE	UE						
	REAL	IMAGINARY						
222	.376156E-01	.0						
IN SUEGRAPH	I NO 15					aver		
VARIABLE	VALUE	UE						
	REAL	IMAGINARY						
122	.365083E-01	.0						
IN SUBGRAPH	I NO 16							
VARIABLE	VALUE	UE	VARIABLE	. VAI	VALUE	VARIABLE	VALUE	UE
	REAL	IMAGINARY		REAL	IMAGINARY		REAL	IMAGINARY
ରୀ ମ	.706219E-01		19	.249393E-01	00	36	.198292E-01	•
) 4 1	.616539E-01		22	.228075E-01		88	.210611E-01	٠٠,
io v	.576493E-01		01 c	.219151E-01	•	30 6 6	.218334E-01	•
o N	.504780E-01		й С1 5 4	.204552E-01		4. 4. 5. 1	.237098E-01	 • •
. ආ ය	472795E-01		25	1988@3E-@1	.00	4. 4 Ú ú	248233E-01	.00
÷	.4431635-01	· o	07	. 1740475.	•	t O	. Zovo 10E-01	. 0

IMAGINARY

		IMAGINARY		IMAGINARY	
	VALUE		VALUE		9999999999
.274289E-01 .289340E-01 .305838E-01 .323865E-01 .343511E-01 .364875E-01	VAI	REAL	.154230E-01 .160358E-01 .167287E-01 .175053E-01 .19354E-01 .203780E-01 .215325E-01 .227946E-01 .227946E-01 .227946E-01 .290548E-01 .27930E-01 .27930E-01 .390518E-01	REAL	$\begin{array}{c} .153112E-01\\ .159317E-01\\ .166317E-01\\ .174149E-01\\ .182852E-01\\ .92469E-01\\ .203048E-01\\ .214643E-01\\ .227311E-01\\ .241116E-01\\ .256126E-01\\ .256126E-01\\ \end{array}$
44444 4505-891	VARIABLE		82 83 84 85 86 87 88 89 90 91 95 97		130 131 132 133 134 135 136 138 138 140
000000000	UE	IMAGINARY	99999999999999999999999999999999999999	IMAGINARY	
. 190264E-01 . 187431E-01 . 185536E-01 . 184567E-01 . 184522E-01 . 187294E-01 . 189944E-01	VALUE	REAL	. 151211E-01 . 146264E-01 . 142049E-01 . 138543E-01 . 135731E-01 0 . 132130E-01 0 . 1313256E-01 0 . 13146E-01 0 . 131662E-01 0 . 131632E-01 0 . 134678E-01 0 . 144261E-01 0 . 144261E-01 0 . 148874E-01 0 . 148874E-01	REAL	147747E-01 143036E-01 139041E-01 135741E-01 133119E-01 131164E-01 129364E-01 129213E-01 129258E-01 129850E-01
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	VARIABLE		66 67 68 69 70 71 73 74 75 76 77 78 78 79 80 81		114 115 116 119 120 122 123 123
••••••••••••••••••••••••••••••••••••••	ᇤ	IMAGINARY	••••••••••••••••	IMAGINARY	
	VALUE		ALU		
.415770E-0 .390444E-0 .367071E-0 .345533E-0 .325722E-0 .296896E-0 .275706E-0		REAL	.363191E-0 .340136E-0 .318781E-0 .299020E-0 .263892E-0 .248349E-0 .234048E-0 .220917E-0 .197910E-0 .170707E-0 .170707E-0 .156915E-0	REAL	.352454E-01 .330131E-01 .309459E-01 .290335E-01 .272661E-01 .256353E-01 .241324E-01 .227562E-01 .214813E-01 .203203E-01
10 11 12 13 14 15 16 17 17 18	VARIABLE		50 51 52 53 54 55 55 57 57 58 50 61 62 63 64 63 64 85		9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9

· · · · ·		IMAGINARY													IMAGINARY														
6666	VALUE		99	99	9	9	© e	S	9	S	S S	6	•	VALUE		•	S	• •	· c	S	9	9	0	S	s c	9	9	6	0
.272417E-01 .290069E-01 .309173E-01 .329822E-01 .352120E-01	VA	REAL	.153077E-01 .159284E-01	.166286E-01 .174121E-01	. 182825E-01	. 203026E-01	.214622E-01	.241097E-01	.256109E-01	.272400E-01	. 296634E-01	.329809E-01		VA	REAL		193070E-01	16-35551	.174120E-01	. 182825E-01	.192444E-01	.203025E-01	.214621E-01	. ZZ(Z91E-01	. 256 108F-01	.272400E-01	.290054E-01	.309158E-01	.329808E-01
1441 1444 1443 1443	VARIABLE	-	621 178	189 181	182 183	184	185	187	188	189 100	198 191	192		VARIABLE		0	997	866	223	230	231	232	233	# 10 C	236	237	238	239	240 0
3000	ᄕ	IMAGINARY		 9 0	06			0.	.0	•				F-3	IMAGINARY				0.	0.	0.	0.							
	VALUE		55.	3	<i>S S</i>		<i>5</i>	. .	9	5 0	9	90		VALUE		•		· ©	9	9	0	S	3 c	9 6	9	9	0	0	S
. 133086E-01 . 135698E-01 . 138938E-01 . 142974E-01	Λ	REAL	. 147633E-01	・1359年7日-01 ・135653E-01	. 133038E-01	. 129793E-01	. 129 147E-01	. 129792E-01	. 131087E-01	135637E-01	. 138945E-01	. 142933E-01		Α	REAL	14765771	142932E-01	. 138944E-01	. 135650E-01	. 133035E-01	. 131035E-01	. 129790E-01	129145E-01	199799R-01	. 131085E-01	.133035E-01	. 135650E-01	. 138944E-01	. 142932E-01
125 126 127 128 129	VARIABLE		162	165	166 167	168	021 120	121	172	174	175	176 176		VARIABLE		910	212	212	213	214	215	5 16	217	618	220	221	222	223	224
		IMAGINARY													IMAGINARY														
00000	VALUE		999	900	S S	6	9 0	0	© C	· •	0			VALUE		•	6	0	0	9	©	9 c	S	9	0	0	0	9	9
.182984E-01 .174268E-01 .166424E-01 .159411E-01 .153196E-01	VA	REAL	.352118E-01 .329818E-01	. 290063E-01	.27240BE-01 .256116E-01		.214627E-01	. 203031E-01	. 192449E-01	. 174124E-01	. 166290E-01	. 159287E-01 . 153080E-01	NO 20	VAJ	REAL	352108E-01	.329808E-01	.309153E-01	.290054E-01	.272460E-01	.25610BE-01	10-3760147.	.214621F-01	.203025E-01	.192444E-01	. 182825E-01	.174120E-01	. 166286E-01	. 159283E-01
109 110 111 112 113 IN SUBGRAPH	VARIABLE		146 741	041	151		- TO	155	156	153	150	160 161	IN SUEGRAPH	VARIABLE		19.4	195	196	197	193	190 0	2 C	203	263	204	200	200	2.00 2.00 2.00 2.00 2.00 2.00 2.00 2.00	n 9 17

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.352107E-01			REAL	. 153076E-0	159283E-0	.166285E-0	.174120E-0	. 182825E-0	.192444E-0	.203025E-0	.214621E-0	.227291E-0	.241097E-01	. 25610BE-0	.272400E-01	.290054E-01	.30915BE-01	.329808E-01	.352107E-01			REAL	0-0270031	150283E-0	166285E-0	.174120E-0	.182825E-0	.192444E-01	.203025E-01	.214621E-01	. 22729 IE-01	.241097E-01	. 256 108E-0	. 272400E-01	.290054E-0	.309158E-01	.329808E-0	.352107E-0]
241		VARIABLE		274	275	276	222	278	526	280	281	282	283	204	285	286	282	288	289		VARIABLE	_	ccc	0 0 0 0 0 0 0 0	8.00 40.00 40.00	325	326	327	328	329	330	331	332	333	334	335	336	332
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.147635E-01		Λ	REAL	147635E-01	142932F-01	. 138944E-01	. 135650E-01	. 133035E-01	.131085E-01	.129790E-01	. 129145E-01	. 129145E-01	.129790E-01	. 131035E-01	. 133035E-01	. 135650E-01	. 138944E-01	.142932E-01	.147635E-01		>	REAL	717	147053E-01	138944F-01	135650E-01	. 133035E-01	. 131085E-01	. 129790E-01	. 129145E-01	. 129145E-01	. 129790E-01	. 131065E-01	. 133635E-01	. 135650E-01	. 138944E-01	. 142932E-01	. 147635E-01
225		VARIABLE		258	950	260	261	262	263	264	265	266	292	268	269	270	27.1	272	273		VARIABLE			300	300	300	310	311	312	313	314	315	316	317	318	319	320	321
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20%	IN SUEGRAPH NO	VARIABLE		0,70	1 6	04.0	24.6	0 v2 4 4 1 6	1 C1	25.5	249	250	251	252	253	254	255	256	257	IN SUBGRAPH	VARIABLE		ć ć	962 67	162	4 60 C	400	295	296	262	298	568	360	301	302	303	304	305

IN SUFGRAPH NO 23

**.	IMAGINARY	,	IMAGINARY	
VALUE		VALUE	VALUE	
V	REAL	.153076E-01 .159283E-01 .165285E-01 .174120E-01 .192444E-01 .203025E-01 .214621E-01 .227291E-01 .256108E-01 .256108E-01 .299054E-01 .329808E-01	REAL 153076E-01 159283E-01 166285E-01 1724120E-01 1922444E-01 203025E-01 214621E-01 227291E-01 227291E-01 227290E-01 239908E-01 3399898E-01 3399898E-01 352167E-01	
VARIABLE	•	370 371 372 373 374 375 376 377 378 380 381 381 382 383 383 383	418 419 420 420 422 423 425 426 427 427 428 430 431 433 433	
EJ.	IMACINARY	•••••••••••••••••••••••••••••••••••••	IMAGINARY 0	
VALUE		ALU	ALL	
	REAL	.147635E-01 .138944E-01 .138650E-01 .133035E-01 .131035E-01 .129145E-01 .129145E-01 .129145E-01 .139135E-01 .131035E-01 .135550E-01 .135550E-01	REAL 147635E-01 142932E-01 138944E-01 131035E-01 129790E-01 129790E-01 129790E-01 131035E-01 133035E-01 133635E-01 135650E-01 135650E-01 142932E-01	
VARIABLE		354 355 355 356 359 360 361 362 363 364 365 365 366 367	402 403 403 405 405 406 411 4111 4112 413 415 416 417	
	IMAGINARY	•••••	IMAGINARY	
VALUE		1 0 0	VALUE	
•	REAL	.352107E-0 .329808E-0 .309158E-0 .290054E-0 .272400E-0 .227291E-0 .214621E-0 .19244E-0 .182825E-0 .174120E-0 .159283E-0	REAL 52107E-0 25805E-0 69158E-0 69158E-0 724008E-0 41097E-0 41097E-0 63025E-0 63025E-0 74120E-0 65285E-0 53076E-0 53076E-0	
VARIABLE		338 339 340 341 342 343 345 345 346 346 347 346 349 350 351 351 353 IN SUBGRAPH	385 387 389 389 399 391 392 393 394 395 395 396 11 396 11 399 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 11 400 10 10 10 10 10 10 10 10 10 10 10 10 1	

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. 153076E-01 . 159283E-01 . 166285E-01 . 174120E-01 . 192444E-01 . 203025E-01 . 214621E-01 . 257291E-01 . 256108E-01 . 256108E-01 . 256108E-01 . 329808E-01 . 329808E-01	VALUE REAL 153076E-01 165285E-01 174120E-01 182825E-01 0.203025E-01 22444E-01 22406E-01 22406E-01 22406E-01 2399158E-01 3399158E-01 3399158E-01 3399158E-01	VALUE REAL .153076E-01 0 .159282E-01 0 .16285E-01 0
44444444444444444444444444444444444444	VARIABLE 514 515 516 516 519 520 523 525 525 526	VARIABLE 562 563 564 565
	UE IMAGINARY 0.00.00.00.00.00.00.00.00.00.00.00.00.0	UE IMACINARY 0. 0. 0. 0.
147635E-01 138944E-01 138944E-01 135656E-01 131085E-01 129790E-01 129145E-01 129145E-01 129145E-01 129730E-01 1397308E-01 131085E-01 135656E-01 135659E-01 142932E-01	NALUE REAL .147635E-01 .142932E-01 .135650E-01 .135650E-01 .139035E-01 .129790E-01 .129796E-01 .129730E-01 .131085E-01 .129730E-01 .131085E-01 .139730E-01 .131085E-01 .137636E-01	VALUE REAL .147635E-01 0 .142932E-01 0 .138944E-01 0
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.352107E-01 .329808E-01 .309158E-01 .272400E-01 .256108E-01 .2561097E-01 .227291E-01 .227291E-01 .203025E-01 .192444E-01 .152285E-01	26 REAL 52107E-0 29808E-0 99054E-0 90054E-0 72400E-0 56108E-0 72400E-0 741097E-0 93925E-0 74120E-0 74120E-0	NO 27 REAL .352107E-0 .329803E-0 .309158E-0
44444444444444444444444444444444444444	VARIABLE VARIABLE 483 484 485 485 485 485 489 491 494 494 494 495 496 11 496	IN SUBGRAPH VARIABLE 530 531 532 533

C	IMAGINARY		IMAGINARY
99999999999		0000000000000000	
$\begin{array}{c} .182824E-01\\ .192443E-01\\ .203025E-01\\ .214621E-01\\ .227290E-01\\ .241096E-01\\ .256108E-01\\ .272400E-01\\ .290054E-01\\ .309158E-01\\ .329808E-01\\ .329808E-01$	VALUE REAL	. 153073E-01 . 159279E-01 . 166281E-01 . 182520E-01 . 203020E-01 . 214615E-01 . 227285E-01 . 2561090E-01 . 2561090E-01 . 256046E-01 . 3290046E-01 . 3290046E-01	VALUE REAL .152964E-01 0 .159162E-01 0 .15916E-01 0 .173981E-01 0 .192284E-01 0 .192284E-01 0 .202854E-01 0
566 568 572 572 573 573 573	VARIABLE	66666666666666666666666666666666666666	VARIABLE 658 659 661 662 663 665 665 665 665
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55 55 55 55 55 55 55 55 55 55 55 55 55	VARIABLE	00000000000000000000000000000000000000	VARIABLE 642 643 644 645 646 646 647 649
• • • • • • • • • • • • • •	UE IMAGINARY	6666666666666	UE IMAGINARY 0. 0. 0. 0. 0. 0. 0. 0. 0.
. 272400E-01 . 256108E-01 . 241097E-01 . 227291E-01 . 214621E-01 . 19244E-01 . 1724126E-01 . 174126E-01 . 16285E-01 . 159282E-01	NO 28 VALUE REAL	.352107E-01 .329803E-01 .309153E-01 .296053E-01 .272399E-01 .241096E-01 .227290E-01 .214621E-01 .19243E-01 .19243E-01 .16523E-01 .16523E-01 .16523E-01	NALUE REAL .352096E-01 0 .329796E-01 0 .309145E-01 0 .290045E-01 0 .272385E-01 0 .256091E-01 0 .255091E-01 0
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.227094E-01 .2408B5E-01 .255B81E-01 .272156E-01 .289792E-01 .398B77E-01 .329567E-01			REAL	. 149500E-01	. 162166E-01	. 16969BE-01	. 178079E-01	. 187351E-01	19/35991.	. 2007 00 00 00 00 00 00 00 00 00 00 00 00	234339F-01	. 248856E-01	.264616E-01	.281700E-01	.300192E-01	.320185E-0	.341780E-0			REAL	.346719E-02	.312222E-02	.297356E-02	.283977E-02	. 272017E-02	. 261418E-02	. 232120E-02	. 237284E-02	. 231659E-02	.227193E-02	
666 668 668 669 670 672 673		VARIABLE	•	902	208	602	210	711	212	613	÷ 1 - 1	716	212	218	612	220	721		VARIABLE		257 255	758	229	092	761	1 62	763	7.04 7.04	992	292	
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. 129081E-01 . 129722E-01 . 131012E-01 . 132956E-01 . 13586E-01 . 142835E-01		VA	REAL	. 146481E-01	. 141694E-01	. 134224E-01	.131504E-01	. 129442E-01	. 128027E-01	. 127252E-01	127113E-01	127010E-01	1305231-01	132955E-01	. 136051E-01	. 139827E-01	.144303E-01		Λ Λ	REAL	. 103363E-01	0.004100E	. 841186E-02	.785845E-02	.734439E-02	. 686705E-02	. 642405E-02	.601317E-02	527978F-02	.495344E-02	
650 651 652 653 654 655 655		VARIABLE		069	69.1 692	693	694	695	969	269	869	669	202	202	203	704	202		VARIABLE		739	0 T V	4.7 2.4.7	743	744	745	246	747	748	092	
• • •		-	IMAGINARY																	IMAGINARY								•	•		
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. 214601E-01 . 203003E-01 . 192420E-01 . 182799E-01 . 174092E-01 . 166256E-01 . 159251E-01	NO 30	VA	REAL	.351735E-01	. 329468E-01	289594E-01	.271906E-01	.255578E-01	.240528E-01	.226680E-01	.213966E-01	.202321E-01	. 191689E-01	1820148-01	1653525-61	158281E-01	.152001E-01	I NO 31	\mathbf{V}_{L}	REAL	.340211E-01	317041E-01	. 295453E-01	. 256616E-01	. 239168E-01	. 222916E-01	.207778E-01	.193679E-01	. 180548E-01	. 168321E-01 . 156934E-01	
6834 6835 6837 6839 649	IN SUBGRAPH NO	VARIABLE		674	929	670	\$29	629	689	681	682	683	1 89	683	000	683	689	IN SUBGRAPH	VARIABLE		223	723	ተ u 21 C 1	7 (R)	727	723	429	730	731	732 733	

999	
$egin{array}{l} .223862E-02 \\ .221651E-02 \\ .220549E-02 \end{array}$	
022 692 892	
9000	
.465195E-02 .437373E-02 .411737E-02 .388159E-02	
751 752 753 754	
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00000	,
. 146333E-01 . 136463E-01 . 127276E-01 . 118725E-01	
734 735 736 737 738	

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 785

2.740 SECONDS CPU TIME:

EXAMPLE 14A

16 PROPER BLOCKS LADDER NETWORK WITH 785 NODES DECOMPOSED INTO NUMBER OF BASIC RECORDS 20 LENGTH OF ADDRESSING RECORDS 32 NUMBER OF SOLUTION RECORDS 8

HAXIMUM INTEGER AREA NEQUIRED IS EQUAL TO 1063

MAXIMUM COMPLEX AREA REQUIRED IS EQUAL TO 6791

SOLUTION

IN SUEGRAPH NO

VARIABLE

VALUE

IMAGINARY REAL

.375801E-01 **78**5

C) IN SULGRAPH NO

IMAGINARY VALUE REAL

VARIABLE

.376167E-01 784

IN SUBGRAPH NO VARIABLE

VALUE

IMAGINARY REAL

6 .386843E-01 283

IN SUBGRAPH NO

VARIABLE

VALUE

IMAGINARY REAL

782

D

IN SUBGRAPH NO

VARIABLE

.376539E-01

VALUE

IMAGINARY REAL

.376166E-01

9 IN SUBGRAPH NO 182

VALUE VARIABLE IMAGINARY

REAL

.282707E-03 082

VALUE 2 IN SUBGRAPH NO VARIABLE IMAGINARY

.375830E-01 REAL

œ IN SUBGRAPH NO

622

VALUE VARIABLE IMAGINARY REAL

.388063E-01 822

IN SUBGRAPH NO

VARIABLE

IMAGINARY VALUE REAL

.376178E-01 222

IN SUBGRAPH NO 10

VALUE

VALUE VARIABLE

IMAGINARY REAL

.376167E-01 922

IN SUBGRAPH NO 11

VARIABLE

VALUE

IMAGINARY REAL

922

.376155E-01

VALUE VARIABLE

IN SUBGRAPH NO 12

IMAGINARY REAL

.364481E-01

IN SUBCRAPH NO 13 422

VALUE VARIABLE

IMAGINARY REAL

.717272E-01

273

IN SUBGRAPH NO 14

VALUE VARIABLE

IMAGINARY REAL

.376490E-01 222

IN SUBGRAPH NO 15

VALUE VARIABLE

REAL

IMAGINARY

.365083E-01 122

IN SUBGRAPH NO 16

VARIABLE

IMAGINARY	9999999999999		IMAGINARY		IMAGINARY
REAL	.198292E-01 .203942E-01 .210611E-01 .218334E-01 .227148E-01 .23709BE-01 .248233E-01 .274289E-01 .269610E-01 .269340E-01 .305838E-01 .305838E-01 .305831-01 .305831-01 .305831-01 .305831-01 .323865E-01 .323865E-01 .323865E-01	VALUE	REAL	154230E-01 16035BE-01 1672BTE-01 175053E-01 183694E-01 0.193254E-01 203780E-01 2215325E-01 0.22750E-01 0.227930E-01 0.272930E-01 0.272930E-01 0.330237E-01 0.330237E-01 0.330237E-01 0.330237E-01 0.330237E-01 0.330237E-01 0.330237E-01	REAL
	888884444444444 97899188459789-	VARIABLE		62 63 63 64 65 66 68 69 90 91 92 94 95 96	
IMAGINARY		·	IMAGINARY		IMAGINARY
REAL.	.249393E-01 .238139E-01 .228075E-01 .219151E-01 .204552E-01 .194049E-01 .196264E-01 .185536E-01 .184567E-01 .185399E-01 .185399E-01	VALUE	REAL	E-01 E-01 E-01 E-01 E-01 E-01 E-01 E-01	REAL
	1 3 3 3 3 3 3 5 5 6 5 8 5 6 5 6 6 6 6 6 6 6 6 6 6 6 6	VARIABLE		66 67 69 69 71 72 73 75 76 76 77 78 79 80 80 81	
IMAGINARY		e)	IMAGINARY		IMAGINANI
REAL	. 706219E-01 . 659750E-01 . 576493E-01 . 539288E-01 . 504780E-01 . 472795E-01 . 443175E-01 . 413776E-01 . 390444E-01 . 345533E-01 . 345533E-01 . 325722E-01 . 325722E-01 . 251895E-01	VALUE	REAL	.363191E-01 .340136E-01 .318781E-01 .299620E-01 .263892E-01 .263892E-01 .24349E-01 .226917E-01 .208917E-01 .17886E-01 .17886E-01 .17886E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01 .176918E-01	neau
	2 3 4 4 4 6 6 9 9 10 11 12 13 13 14 15 16 17 17 18	VARIABLE		50 51 52 53 53 54 55 56 57 59 60 61 61 62 63 64 65 IN SUBGRAPH	

	I MAG I NARY	IMAGINARY
	VALUE 60.00.00.00.00.00.00.00.00.00.00.00.00.0	· · · ·
.153112E-01 .159316E-01 .166317E-01 .174149E-01 .182852E-01 .203048E-01 .227311E-01 .241116E-01 .256126E-01 .272417E-01 .290069E-01	NA REAL .153077E-01 .159284E-01 .166286E-01 .174121E-01 .182825E-01 .203026E-01 .203026E-01 .214622E-01 .227291E-01 .227290E-01 .272400E-01 .272400E-01 .32980954E-01	VAI REAL .153076E-01 .159283E-01 .166285E-01
0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	VARIABLE 178 179 180 181 181 182 183 184 195 190 191	VARIABLE 226 227 228 229
0000000000000000	UE IMAGINARY 0.00.00.00.00.00.00.00.00.00.00.00.00.0	UE IMAGINARY 0. 0. 0.
. 147747E-01 . 143036E-01 . 139041E-01 . 135141E-01 . 131164E-01 . 129864E-01 . 129236E-01 . 129856E-01 . 13986E-01 . 13140E-01 . 135698E-01 . 135698E-01	VALUE REAL .147638E-01 0 .138947E-01 0 .135653E-01 0 .135038E-01 0 .1373038E-01 0 .129793E-01 0 .129792E-01 0 .129792E-01 0 .131087E-01 0 .135652E-01 0 .135652E-01 0 .135652E-01 0 .135652E-01 0 .135652E-01 0 .135652E-01 0 .137652E-01 0 .137652E-01 0 .137652E-01 0 .137652E-01 0	VALUE REAL .147635E-01 0 .142932E-01 0 .138944E-01 0
41111111111111111111111111111111111111	VARIABLE 162 163 164 165 166 167 168 170 172 173 173 175	VARIABLE 210 211 212 213
699999999999999	IMAGINARY	IMAGINARY
	VALUE 1 0 0 1 0 0 1 0 0 0 1 1 0 0 0 0 1 1 0 0 0 0 1 0	VALUE 1 0. 1 0. 1 0. 1 0.
.352454E-01 .3304131E-01 .300459E-01 .200335E-01 .256352E-01 .241324E-01 .227502E-01 .227502E-01 .227502E-01 .192615E-01 .192615E-01 .154268E-01 .166424E-01	REAL REAL 52118E-0 529818E-0 500168E-0 50168E-0 5016E-0 56116E-0 14627E-0 14627E-0 14627E-0 14627E-0 52408E-0 52408E-0 52597E-0 52597E-0 52596E-0 56296E-0 56296E-0	NO 20 REAL .352108E-0 .329808E-0 .309158E-0
998 1000 1000 1000 1000 1111 1310	VARIABLE 146 147 148 149 150 150 151 152 153 154 155 155 155 156 156 160 160	IN SUBGRAPH VARIABLE 194 195 196 197

	JE IMAG INARY		UE IMAGINARY 0. 0. 0. 0. 0. 0. 0. 0.
. 182825E-01 . 19244E-01 . 214621E-01 . 227291E-01 . 241097E-01 . 256108E-01 . 290654E-01 . 399158E-01 . 399158E-01	VALUE REAL	.153076E-01 .159283E-01 .166285E-01 .174120E-01 .182824E-01 .192443E-01 .203025E-01 .214621E-01 .227290E-01 .272400E-01 .256108E-01 .272400E-01 .372400E-01	VALUE REAL .153072E-01 0 .159279E-01 0 .174115E-01 0 .182820E-01 0 .19243BE-01 0 .203019E-01 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	VARIABLE	22222222222222222222222222222222222222	VARIABLE 322 323 324 325 326 327 328
	VALUE IMAGINARY		VALUE IMAGINARY 1 0. 1 0. 1 0. 1 0. 1 0. 1 0. 1 0.
. 133035E-01 . 131085E-01 . 129790E-01 . 129145E-01 . 129790E-01 . 131085E-01 . 133035E-01 . 138944E-01 . 142932E-01	VAI	. 147635E-01 . 142932E-01 . 138944E-01 . 135055E-01 . 131085E-01 . 129746E-01 . 129746E-01 . 129790E-01 . 13965E-01 . 131085E-01 . 135650E-01 . 135650E-01	VAI REAL . 147634E-01 . 142931E-01 . 138942E-01 . 135649E-01 . 135633E-01 . 13033E-01 . 129733E-01
214 215 216 217 229 220 222 223 224 225	VARIABLE	22222222222222222222222222222222222222	VARIABLE 306 307 309 310 311 312 313
••••••••••••••••••••••••••••••••••••••	JE IMAGINARY		UE IMAGINARY 0.00.00.00.00.00.00.00.00.00.00.00.00.0
.272400E-01 .256108E-01 .241097E-01 .214621E-01 .203025E-01 .19244E-01 .174120E-01 .159283E-01	I NO 21 VALUE REAL	000000040100087000 000000010100087000	NO 23 VALUE REAL .352167E-01 0 .329808E-01 0 .290053E-01 0 .272399E-01 0 .2541096E-01 0
198 199 199 199 199 199 199 199 199 199	IN SUBGRAPH VARIABLE		VARIABLE 3 290 3 291 3 292 3 293 2 294 2 295 2 295 2 295 2

		IMAGINARY										IMAGINARY	
•••••	VALUE	11	999	666			9 9				VALUE	II	000000000000
.227284E-01 .241090E-01 .256101E-01 .272392E-01 .290045E-01 .309149E-01 .352097E-01	VAI	REAL	.152958E-01 .159156E-01 .166149E-01	. 173974E-01 . 182668E-01	.202844E-01 .214428E-01	.227083E-01 .240374E-01	.255869E-01	.289778E-01	.329491E-01 .351766E-01		VAI	REAL	. 149305E-01 . 155236E-01 . 161942E-01 . 16945BE-01 . 177822E-01 . 187074E-01 . 197262E-01 . 208436E-01 . 220653E-01 . 233972E-01 . 248462E-01
933 933 933 935 935 935 935 935 935	VARIABLE		370 371 372	373 374 375	376 376 377	828 379	ය සිය 1	383 383 883 883 883	334 385		VARIABLE		44 44 44 44 44 44 44 44 44 44 44 44 44
	e	IMAGINARY	0	•••							딤	IMAGINARY	
	VALUE										VALUE		
. 129142E-01 . 12978BE-01 . 131083E-01 . 133032E-01 . 13564BE-01 . 142929E-01		REAL	. 147597E-01 . 142891E-01 . 138960E-01	. 135603E-01 . 132965E-01 . 131031E-01	. 129732E-01	. 129077E-01 . 129718E-01	. 13100BE-0	135561E-0	.142830E-01			REAL	. 146418E-01 . 141626E-01 . 137542E-01 . 134146E-01 . 131421E-01 . 129352E-01 . 127931E-01 . 127931E-01 . 127491E-01 . 127491E-01
314 316 316 318 318 320 320	VARIABLE		355 355 355 355	357 358 359	360 361	362 363	364 365	366 367	368 369		VARIABLE		4 4 4 4 4 4 6 0 0 0 0 0 0 0 0 0 0 0 0 0
		IMAGINARY										IMAGINARY	
9999999	VALUE		000	999	99		- -	99			VALUE		000000000000
.214621E-0 .203024E-0 .192443E-0 .182824E-0 .166284E-0 .159281E-0 .153075E-0		REAL.	.352095E-01 .329795E-01 .309144E-01	$\begin{array}{c} .296039E-0] \\ .272384E-0] \\ .256091E-0] \end{array}$.241078E-01	.214600E-01	. 192419E-01 . 182798E-01	. 174091E-01	. 159249E-01 . 153041E-01	I NO 24		REAL	.351715E-01 .329387E-01 .308766E-01 .289569E-01 .271879E-01 .255549E-01 .256647E-01 .213930E-01 .202283E-01
298 299 300 301 302 303 504 305 IN SUBGRAPH	VARIABLE		338 339 340	4. 4. 4. - ci ci	88 84 44 44 65	346 347	348 849	350 551	352 353	IN SUBGRAPH	VARIABLE		286 287 389 391 391 391 395 395 395 395

		IMAGINARY	I MAG I NARY	
9999	UE	IM		99999
.281246E-01 .299705E-01 .319663E-01 .341219E-01	VALUE	REAL	.326118E-02 .275255E-02 .251949E-02 .229904E-02 .229904E-02 .170251E-02 .170251E-02 .152197E-02 .134904E-02 .102258E-02 .102258E-02 .102258E-03 .716603E-03 .716603E-03 .7464973E-01 .229190E-01 .264711E-01 .264711E-01 .36449E-01 .378526E-01 .378526E-01 .36449E-01 .36449E-01 .36449E-01	.540131E-01 .579851E-01 .622469E-01
430 431 433	VARIABLE		VARIABLE VARIABLE VASCA VARIABLE VASCA VARIABLE VARIABLE VARIABLE VARIABLE VARIABLE VARIABLE VARIABLE	0000 0000 0000 0000 0000
0000	ഥ	IMAGINARY	00.00.00.00.00.00.00.00.00.00.00.00.00.	
.132808E-01 .135894E-01 .139659E-01 .144122E-01	VALUE	REAL	108765E-01 101215E-01 0.941706E-02 0.875972E-02 0.757338E-02 0.653858E-02 0.653858E-02 0.653858E-02 0.653858E-02 0.452491E-02 0.452491E-02 0.353493E-02 0.452491E-02 0.353496E-02 0.353936E-02 0.353936E-02 0.353936E-02 0.353936E-02 0.3539312E-02 0.729886E-02 0.729886E-01 0.100998E-01 0.100998E-01 0.107388E-01 0.127195E-01 0.127195E-01 0.137138E-01 0.137138E-01 0.137138E-01	. 171298E-01 . 171298E-01 . 184318E-01 . 198259E-01
444 415 416 71	VARIABLE		VAR A 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	000 0110 0111 0111
	UE	IMAGINARY	0	
.173203E-01 .165301E-01 .158226E-01 .151942E-01		REAL	.339565E-01 .316347E-01 .29471E-01 .274549E-01 .255759E-01 .238248E-01 .192542E-01 .192542E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .179328E-01 .17466E-01 .17466E-02 .174166E-02 .174166E-02 .174166E-02 .174166E-02 .278667E-02 .278667E-02 .278667E-02 .278667E-02 .278667E-02 .278667E-02 .278667E-02 .278667E-02	.414201E-02 .460224E-02 .508548E-02 .559415E-02
398 399 400 401 1N SHRCBAPH	< €		4334 4335 4336 4336 444 444 44433 1N SUBGRAPH VARIABLE 4833 4833 4836 4836 4836 4836 4836 4836	4 4 4 4 4 4 4 4 4 4 4 4 6 6 6 6 6 6 6 6

IMAGINARY IMAGINARY VALUE VALUE VALUE .215680E-01 .224676E-01 .234794E-01 .330184E-01 .352456E-01 .215247E-01 .154108E-01 .290489E-01 . 190114E-01 200386E-01 .207764E-0 .246087E-01 .272426E-01 .304220E-0 322357E-0 .342106E-01 .160244E-01 . 174953E-01. 183601E-01 .193166E-01 .203697E-0 . 256612E-01 .272868E-0 . 186166E-0 .258610E-0 .241638E-0 VARIABLE VARIABLE VARIABLE 611 612 613 614 615 616 6229 6221 6223 6223 623 624 633 IMAGINARY IMAGINARY VALUE VALUE VALUE .250166E-01 .238483E-01 .227973E-01 .218603E-01 210326E-01 . 180155E-01 . 183149E-01 .145922E-01 .134507E-01 . 196890E-01 . 184067E-01 .179554E-01 . 179851E-01 . 181047E-01 .150844E-01 .138245E-01 .135453E-01 .131839E-01 . 131100E-01 .130966E-01 . 137022E-01 .140221E-01 .144122E-01 . 203100E-01 . 191665E-01 . 187397E-01 .181657E-01 33337E-01 .131487E-01 . 132666E-01 REAL VARIABLE VARIABLE VARIABLE IMAGINARY IMAGINARY VALUE VALUE VALUE . 625938E-01 . 585076E-01 . 547139E-01 .449051E-01 .421051E-01 .395157E-01 .339077E-01 669930E-01 .511938E-01 .479296E-01 371238E-01 310186E-01 277409E-01 263139E-01 362055E-01 279897E-01 263094E-01 349175E-01 247605E-01 .162979E-01 298101E-0 . 233355E-0 .208289E-0 .187395E-0 156520E-0 328859E-0 293065E-0 .220272E-0 .197349E-0 .170253E-0 24 28 29 IN SUBGRAPH NO IN SUBGRAPH NO IN SUBGRAPH NO VARIABLE VARIABLE VARIABLE

REAL	IMAGINARY		REAL	IMAGINARY		REAL	IMAGINARY
.352407E-01 .330086E-01 .300415E-01 .290291E-01 .272619E-01 .256310E-01 .227461E-01 .21473E-01 .21473E-01 .192574E-01 .192574E-01 .1525E-01 .15336E-01	6000000000000000	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	. 147699E-01 . 138989E-01 . 135687E-01 . 133063E-01 . 131104E-01 . 129147E-01 . 12913BE-01 . 129775E-01 . 131061E-01 . 135609E-01 . 135609E-01 . 135609E-01	••••••••••••••••••••••••••••••••••••••	658 659 665 665 665 665 665 670 670 672 673	. 152997E-01 . 159193E-01 . 166185E-01 . 174008E-01 . 182700E-01 . 292875E-01 . 227112E-01 . 240902E-01 . 255897E-01 . 255897E-01 . 272171E-01 . 308890E-01 . 329519E-01	
VALUE REAL	UE IMAGINARY	VARIABLE	VA	VALUE IMAGINARY	VARIABLE	VAI	VALUE
.351745E-01 .329418E-01 .308738E-01 .289661E-01 .271913E-01 .255585E-01 .255585E-01 .213971E-01 .20336E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01 .213971E-01		6696 6991 6993 7700 7700 7700 7700 7700 7700 7700 7	$\begin{array}{c} .146484E-01\\ .141696E-01\\ .137617E-01\\ .134226E-01\\ .139444E-01\\ .129444E-01\\ .127254E-01\\ .127115E-01\\ .127115E-01\\ .12713E-01\\ .139526E-01\\ .139826E-01\\ .139826E-01\\ .139826E-01\\ .139826E-01\\ .139826E-01\\ .139826E-01\\ .144304E-01\\ .144404E-01\\ .144404E-01\\$		7066 7097 7098 7100 7112 7113 7115 7115 7117 7119	. 149501E-01 . 155445E-01 . 162167E-01 . 169699E-01 . 178080E-01 . 197559E-01 . 220995E-01 . 234340E-01 . 248856E-01 . 2481760E-01 . 281700E-01 . 320186E-01	000000000000000
VALUE REAL .340211E-01 0	UE IMAGINARY 0.	VARIABLE	VAI REAL .103363E-01	VALUE IMAGINARY 1 0.	VARIABLE 756	VALUE REAL .346719E-02 0	JUE IMAGINARY 0.

9	0	9	\$	9	0	\$	\$	\$	0	0	\$	\$	9			
.328649E-02	.312222E-02	.297356E-02	.283977E-02	.272018E-02	.261418E-02	.252126E-02	.244095E-02	.237284E-02	.231659E-02	.227193E-02	.223863E-02	. 221652E-02	. 226549E-02			
292	892	692	092	192	292	892	764	292	992	292	892	692	022			
.0	0.	.0	.0	0.	0.	.0	0.	.0	.0	0		.0	.0	0		
.964766E-02	.900722E-02	.841181E-02	.785845E-02	.734439E-02	.686706E-02	.642405E-02	.601317E-02	.563236E-02	.527970E-02	. 495345E-02	.465196E-02	.437373E-02	.411737E-02	.388160E-02	.366523E-02	
740	741	742	743	744	745	246	242	748	749	250	751	752	753	754	222	
•			•	•	•		•	•	٠.	0.			•	•		
9	9	9	9									\$				
.317041E-01	.295456E-01	.275348E-01	.256616E-01	.239168E-01	. 2229 16E-01	.207778E-01	.193679E-01	. 180549E-01	. 168321E-01	.156935E-01	. 146333E-01	.136463E-01	. 127276E-01	.118725E-01	.110767E-01	
723	724	725	726	252	728	672	082	182	282	233	\$82	735	982	282	238	

CPU TIME: 1.480 SECONDS

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 785

EXAMPLE 14B

16 PROPER BLOCKS LADDEA NETWORK WITH 770 NODES DECOMPOSED INTO NUMBER OF BASIC RECORDS 20 LENGTA OF ADDRESSING RECORDS 32 NUMBER OF SOLUTION RECORDS 8

32 8

MAXIMUM INTEGER AREA REQUIRED IS EQUAL TO 1063

MAXIMUM COMPLEX AREA REQUIRED IS EQUAL TO 6791

SOLUTION

IN SUBGRAPH NO

VARIABLE

VALUE

IMAGINARY REAL

.375801E-01

IN SUBCRAPH NO 263

VALUE က VARIABLE IMAGINARY REAL

.386843E-01

783

9 IN SUBGRAPH NO VALUE

VARIABLE

IMAGINARY REAL

.282707E-03 **682** VALUE VARIABLE

IN SUBGRAPH NO 13

IMAGINARY REAL

.717272E-01 223

IMAGINARY VALUE .328183E-01 .352473E-01 .378526E-01 .579851E-01 .622469E-01 .246335E-01 .264711E-01 .284411E-01 229190E-0 .406472E-0] .436449E-0 .503113E-01 .668200E-0 .468609E-0 VARIABLE IMAGINARY VALUE .729886E-02 .793614E-02 .861310E-02 .933312E-02 . 109170E-01 . 117888E-01 . 127195E-01 . 137138E-01 . 147767E-01 .66980BE-02 .100998E-01 .171298E-01 213192E-01 .198259E-01 REAL VARIABLE 510 511 512 513 499 500 501 IMAGINARY VALUE . 665059E-03 . 103151E-02 . 138313E-02 . 174166E-02 . 24866FE-02 . 287689E-02 . 328149E-02 . 376249E-02 . 414201E-02 . 508548E-02 . 5085415E-02 .141854E-03 342029E-03 REAL 26 IN SUBGRAPH NO VARIABLE

CPU TIME: .340 SECONDS

NUMBER OF VARIABLES IN THE SOLUTION VECTOR

52

Example 15

The user's main program EXAMP15 illustrates how to obtain a new solution for an updated RHS. After execution of program EXAMP6, as described in Example 6 files, Nos. 1, 3 and 5 were preserved. Then data file No. 2, containing information about the updated RHS vector in proper block \mathbf{G}_5 , was created by execution of the user's program DECSYS6 listed on p. 126. After that, the user's program EXAMP15 was executed. EXAMP15 and the corresponding results are listed on pp. 127-129.

PROGRAM DECSYS6(TAPE2) C THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION C ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH C ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH O00215 C INTEGER INDEX2(2) C OMPLEX CE(5) C DIRECTORY C DIRECTORY C DATA CE/(5.,1.),(3.,3.), C SUBGRAPH G5 C SUBGRAPH G5 C F(0.,0.),(0.,0.),(9.,0.)/ C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE O00221
THIS PROGRAM CREATES THE RANDOM FILE CONTAINING INFORMATION C ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH C ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH C INTEGER INDEX2(2) C COMPLEX CE(5) C DIRECTORY C DIRECTORY C DATA CE/(5.,1.),(3.,3.), C SUBGRAPH G5 C SUBGRAPH G5 C F(0.,0.),(0.,0.),(9.,0.)/ C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 6002218 600223 600224 600225 600227
C ABOUT THE SUBGRAPHS OF THE DECOMPOSED GRAPH C INTEGER INDEX2(2) COMPLEX CE(5) C DIRECTORY C DATA CE/(5.,1.),(3.,3.), C SUBGRAPH G5 C SUBGRAPH G5 C SUBGRAPH G5 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
INTEGER INDEX2(2) COMPLEX CE(5) DIRECTORY DATA CE/(5.,1.),(3.,3.), CSUBGRAPH G5
INTEGER INDEX2(2) COMPLEX CE(5) DIRECTORY DATA CE/(5.,1.),(3.,3.), CSUBGRAPH G5
INTEGER INDEX2(2) COMPLEX CE(5) DIRECTORY DATA CE/(5.,1.),(3.,3.), CSUBGRAPH G5
COMPLEX CE(5) DATA CE(5) DATA CE(5.,1.),(3.,3.), COMPLEX CE(5) DATA CE(5.,1.),(3.,3.), COMPLEX CE(5) DATA CE(5.,1.),(3.,3.), COMPLEX CE(5) DATA CE(5.,1.),(3.,3.), DATA CE(5.,1.),(3.,3.), COMPLEX CE(5) DATA CE(5.,1.),(3.,3.), DATA CE(5.,1.),(3.,
C DIRECTORY 000219 C DATA CE/(5.,1.),(3.,3.), 000221 DATA CE/(5.,1.),(3.,3.), 000222 C SUBGRAPH G5 000224 C +(0.,0.),(0.,0.),(9.,0.)/ 000225 +(0.,0.),(0.,0.),(9.,0.)/ 000227 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C DIRECTORY 600220 C DATA CE/(5.,1.),(3.,3.), 000221 DATA CE/(5.,1.),(3.,3.), 000222 C SUBGRAPH G5 600224 C +(0.,0.),(0.,0.),(9.,0.)/ 000225 +(0.,0.),(0.,0.),(9.,0.)/ 000227 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C DATA CE/(5.,1.),(3.,3.), 000221 C SUBGRAPH G5 000224 C +(0.,0.),(0.,0.),(9.,0.)/ 000225 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C DATA CE/(5.,1.),(3.,3.), 000221 C SUBGRAPH G5 000224 C +(0.,0.),(0.,0.),(9.,0.)/ 000225 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
DATA CE/(5.,1.),(3.,3.), C 900223 C SUBGRAPH G5 000224 C +(0.,0.),(0.,0.),(9.,0.)/ C 1REC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C SUBGRAPH G5 000223 C SUBGRAPH G5 000224 C +(0.,0.),(0.,0.),(9.,0.)/ 000225 C 1REC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C SUBGRAPH G5 000224 C +(0.,0.),(0.,0.),(9.,0.)/ 000225 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C
+(0.,0.),(0.,0.),(9.,0.)/ 000226 C 000227 C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C 1REC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
C IREC2 THE NUMBER OF RECORDS IN RANDOM FILE NO.2. HAVE TO BE 000228
The state of the s
C NOT LESS THAN IN(20)+1 000229
C 000230
IREC2=2 000231
CALL OPENMS(2, INDEX2, IREC2, 0) 900232
C 090233
C STORE INFORMATION ABOUT SUBNETWORKS TO BE ANALYZED 000234
C 900235
CALL WRITMS(2,CE,22,1) 900236
STOP 900237
END 900237

	PROGRAM EXAMP15(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE11, TAPE2, TAPE3, TAPE5, TAPE7)	000197 000198 000199
C C	THIS IS THE MAIN PROGRAM FOR EXAMPLE 15	000200 000201
•	DIMENSION IN(33), IM(5), INTWA(137)	000202
	COMPLEX CMPLXWA(716), SOLR(20)	000203 000204
	DATA IN/0,0,0,4,4,0,3,8,7,1,540,10,0,0,1,4,12,12,7,1,0,0,1,0,27,3,	000205
	10,1,1,7,6,5,4/ DATA IM/1,0,137,716,10/	000206
C	BMM 112 1,0,120,120,120	000207
	WRITE (6,10)	000208
	10 FORMAT (1H ,/, " EXAMPLE 15",/)	000209
	CALL CSDSLEI (IN, INTWA, CMPLXWA, IM, SOLR)	000210
	STOP	000211
	END	000212

```
EXAMPLE 15
```

MAXIMUM COMPLEX AREA REQUIRED IS EQUAL TO 640

SOLUTION

IN SUBGRAPH NO 1

VARIABLE VALUE

REAL IMAGINARY

9 .345698E+01 0.

IN SUBGRAPH NO 2

VARIABLE VALUE

REAL IMAGINARY

8 .123924E+01 0.

IN SUBGRAPH NO 3

VARIABLE VALUE

REAL IMAGINARY

7 -.185777E+00 0.

IN SUBGRAPH NO 4

VARIABLE VALUE

REAL IMAGINARY

6 -.147849E+01 0.

IN SUBGRAPH NO 5

VARIABLE VALUE

REAL IMAGINARY

5 -.197849E+01 0.

IN SUBGRAPH NO 6

VARIABLE VALUE VARIABLE VALUE

REAL IMAGINARY REAL IMAGINARY

3 .279658E+90 0. 4 -.435464E+00 0.

IN SUBGRAPH NO 7

VARIABLE VALUE VARIABLE VALUE

REAL IMAGINARY REAL IMAGINARY

1 -.155505E+00 0. 2 .292660E+00 0.

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 9

CPU TIME: . 146 SECONDS

Example 16

The ladder network of Example 14 is used to demonstrate the effect of a change in the RHS vector in a subgraph of a bigger network. After execution of the user's main program EXAMP14, as described in Example 14 files Nos. 1, 3 and 5 were preserved and user's program EXAM16A was executed. In this program, the current excitation in the proper block G_{26} was given the value 20 instead of 1. The results obtained are listed on pp. 133-143. Again, it can be seen that the changes in the solution vector vanish with increasing distance from the new excitation and they cannot be observed for the assumed 6 digit accuracy in subgraphs $G_{16}-G_{21}$ (compare with the results of Example 14).

Again, the user may restrict the solution to be calculated for certain subgraphs and their ascendants, to estimate the changes. The user's program EXAM16B, listed on p. 132, was used instead of EXAM16A to obtain the results listed on pp. 144-145.

```
PROGRAM EXAM16A(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1
                                                                                                   000213
       1, TAPE2, TAPE3, TAPE5, TAPE7)
                                                                                                   000214
                                                                                                   000215
             THIS IS THE MAIN PROGRAM FOR EXAMPLE 16
                                                                                                   000216
C
                                                                                                   000217
        DIMENSION IN(57), IM(5), INTWA(1200)
COMPLEX CMPLXWA(7000), SOLR(200), CE(52)
                                                                                                   000218
                                                                                                   000219
        DATA CE/(26.,1.),(50.,3.),50*((0.,0.))/
                                                                                                   000220
       DATA IN/0,0,0,16,16,0,1,8,31,1,4400,32,0,0,20,50,148,148,771,9,0,0 1,1,0,1500,15,0,1,1,1,2,2,1,1,2,2,2,2,2,1,16*(0)/
                                                                                                   000221
                                                                                                   000222
                                                                                                   000223
        DATA IM/2,0,1200,7000,100/
                                                                                                   000224
C
        DO 10 I=1,16
                                                                                                   000225
        IN(41+I)=32-I
                                                                                                   000226
                                                                                                   000227
    10 CONTINUE
        IA=4*IN(17)+3*IN(16)+IN(11)
                                                                                                   000228
        DO 20 I=1,50
                                                                                                   000229
        CE(2+1) = CMPLX(0.,0.)
                                                                                                   000230
    20 CONTINUE
                                                                                                   000231
        CE(51) = CMPLX(20.,0.)
                                                                                                   000232
        DO 30 I=1,52
                                                                                                   000233
        CMPLXWA(IA+I)=CE(I)
                                                                                                   000234
                                                                                                   000235
    30 CONTINUE
        WRITE (6,40)
                                                                                                   000236
    40 FORMAT (1H ,/, " EXAMPLE 16",/)
                                                                                                   000237
        IA1 = (IN(19) + IN(26) - 1) / IM(5) + 1
                                                                                                   000238
        IA3 = IN(19) + IN(4) - 2
                                                                                                   000239
    WRITE (6,50) IA3, IN(5), IN(15), IN(12), IA1

50 FORMAT (1H, /, " LADDER NETWORK WITH", I6, " NODES DECOMPOSED INTO", I
16, " PROPER BLOCKS", /, " NUMBER OF BASIC RECORDS", I6, /, " LENGTH OF A
2DDRESSING RECORDS", I6, /, " NUMBER OF SOLUTION RECORDS", I6)
                                                                                                   000240
                                                                                                   000241
                                                                                                   000242
                                                                                                   000243
        CALL SECOND (TM1)
                                                                                                   000244
        CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR)
                                                                                                   000245
        IF (IN(7).NE.1) STOP
                                                                                                   000246
        CALL SECOND (TM2)
                                                                                                   000247
        CPU=TM2-TM1
                                                                                                   000248
        WRITE (6,60) CPU
                                                                                                   000249
    60 FORMAT (1H ,/, " CPU TIME: ",F8.3" SECONDS",/)
                                                                                                   000250
        STOP
                                                                                                   000251
                                                                                                   000252
```

```
PROGRAM EXAM16B(INPUT, OUTPUT, RESULT, TAPE4=INPUT, TAPE6=RESULT, TAPE1
                                                                                                      000253
                                                                                                       000254
       1, TAPE2, TAPE3, TAPE5, TAPE7)
                                                                                                       000255
                                                                                                       000256
              THIS IS THE MAIN PROGRAM FOR EXAMPLE 16B
\mathbf{C}
Ĉ
                                                                                                       000257
        DIMENSION IN(58), IM(5), INTWA(1200)
COMPLEX CMPLXWA(7000), SOLR(200), CE(52)
                                                                                                       000258
                                                                                                       000259
        DATA CE/(26.,1.),(50.,3.),50*((0.,0.))/
                                                                                                       000260
       DATA IN/0,0,0,1,16,0,3,8,31,1,4400,32,0,0,20,50,148,148,771,9,0,2,11,0,1500,15,0,1,1,1,2,2,1,1,2,2,2,2,2,2,1,17*(0)/
                                                                                                       000261
                                                                                                       000262
        DATA IM/2,0,1200,7000,100/
                                                                                                       000263
                                                                                                       000264
\mathbf{C}
        DO 10 I=1,16
                                                                                                       000265
        IN(41+I)=32-I
                                                                                                       000266
                                                                                                       000267
    10 CONTINUE
        IN(58) = 26
                                                                                                       000268
        IA=4*IN(17)+3*IN(16)+IN(11)
                                                                                                       000269
                                                                                                       000270
        DO 20 I=1,50
        CE(2+1) = CMPLX(0.,0.)
                                                                                                       000271
                                                                                                       000272
    20 CONTINUE
                                                                                                       000273
        CE(51) = CMPLX(20.,0.)
        DO 30 I=1,52
                                                                                                       000274
                                                                                                       000275
        CMPLXWA(IA+I) = CE(I)
    30 CONTINUE
                                                                                                       000276
                                                                                                       000277
        WRITE (6,40)
    40 FORMAT (1H ,/," EXAMPLE 16B",/)
IA1=(IN(19)+IN(26)-1)/IM(5)+1
                                                                                                       000278
                                                                                                       000279
                                                                                                       000280
        IA3 = IN(19) + IN(4) - 2
    WRITE (6,50) IA3, IN(5), IN(15), IN(12), IA1
50 FORMAT (1H, /, " LADDER NETWORK WITH", I6, " NODES DECOMPOSED INTO", I
16, " PROPER BLOCKS", /, " NUMBER OF BASIC RECORDS", I6, /, " LENGTH OF A
2DDRESSING RECORDS", I6, /, " NUMBER OF SOLUTION RECORDS", I6)
                                                                                                       000281
                                                                                                       000282
                                                                                                       000283
                                                                                                       000284
        CALL SECOND (TM1)
                                                                                                       000285
        CALL CSDSLE1 (IN, INTWA, CMPLXWA, IM, SOLR)
                                                                                                       000286
        IF (IN(7).NE.1) STOP
                                                                                                       000287
        CALL SECOND (TM2)
                                                                                                       000288
                                                                                                       000289
        CPU=TM2-TM1
                                                                                                       000290
         WRITE (6,60) CPU
    60 FORMAT (1H ,/, " CPU TIME: ",F8.3" SECONDS ",/)
                                                                                                       000291
                                                                                                       000292
         STOP
                                                                                                       000293
        END
```

EXAMPLE 16

16 PROPER BLOCKS LADDER NETWORK WITH 785 NODES DECOMPOSED INTO NUMBER OF BASIC RECORDS 20
LENGTH OF ADDRESSING RECORDS 32
NUMBER OF SOLUTION RECORDS 8

MAXIMUM INTEGER AREA REQUIRED IS EQUAL TO 1063

MAXIMUM COMPLEX AREA REQUIRED IS EQUAL TO 6791

SOLUTION

IN SUSCRAPH NO

VALUE

VARIABLE

IMAGINARY REAL

.376037E-01

282

IN SUSCRAPH NO

IMAGINARY REAL

VALUE

VARISBLE

.376167E-01

784

IN SUBGRAPH NO

VALUE

VARIABLE

IMAGINARY REAL

. 597014E-01 283

IN SUSGRAPH NO

VALUE REAL VARIABLE

IMAGINARY

282

.376539E-01

IN SUBGRAPH NO

VARIABLE

VALUE

IMAGINARY

REAL

.376167E-01

781

VALUE IN SUBGRAPH NO

VARIABLE

IMAGINARY REAL

.244028E-01 280

VALUE IN SUBGRAPH NO

VARLABLE

IMAGINARY REAL

.376036E-01

622

IN SUBCRAPH NO

VALUE VARIABLE

IMAGINARY REAL

.388063E-01

IN SUBGRAPH NO

822

VALUE VARIABLE IMAGINARY REAL

.376178E-01 222

IN SUBGRAPH NO 10

IMAGINARY VALUE REAL VARIABLE

.376167E-01 922

IN SUBCRAPH NO 11

IMAGINARY

																				VALUE	. 1	2E-01 0. 2E-01 0. 1E-01 0.
																					REAL	. 198292E-01 . 203942E-01 . 210611E-01
																				VARIABLE		90000
																					IMAGINARY	
																				VALUE	-	9999
																					REAL	. 249393E-01 . 238139E-01 . 228075E-01
																				VARIABLE		19 20 21
	I MAG I NARY				IMAGINARY				IMAGINARY													
VALUE		0		VALUE		0		VALUE		60		VALUE		6		VALUE		0		VALUE		888
;~	REAL	.376163E-01	IN SUBGRAPH NO 12	-	REAL	.372031E-01	IN SUBCRAPH NO 13		REAL	.743176E+00	IN SUBGRAPH NO 14		REAL	.383069E-01	IN SUEGRAPH NO 15		REAL	.3650B9E-01	SUEGRAPH NO 16		REAL	.706219E-01 .659759E-01 .616539E-01
							=				Ы				ΡH				H			

		IMAGINARY		IMAC I NARY
\$\$\$\$\$\$\$\$\$\$\$	VALUE		VALUE	0000000
.237098E-01 .248233E-01 .260610E-01 .274289E-01 .289340E-01 .305338E-01 .323865E-01 .343511E-01 .364875E-01	VA	REAL	.154230E-01 .167287E-01 .175053E-01 .175053E-01 .193254E-01 .215325E-01 .241707E-01 .241707E-01 .272930E-01 .272930E-01 .272930E-01 .256677E-01 .256677E-01 .256677E-01	REAL .153112E-01 .159316E-01 .164149E-01 .174149E-01 .182852E-01 .192469E-01 .203948E-01
444444444 -064666	VARIABLE		032 032 033 030 030 030 030 040 040 040 040 040	130 131 132 133 134 136 136 136
		IMAGINARY		IMAGINARY
	VALIIE		VALUE	6666666
.204552E-01 .198803E-01 .194049E-01 .196264E-01 .18733E-01 .184567E-01 .184567E-01 .1845622E-01 .185399E-01	70	REAL	.151211E-01 .142049E-01 .135543E-01 .135731E-01 .135731E-01 .131356E-01 .131355E-01 .13146E-01 .132849E-01 .132849E-01 .134678E-01 .134678E-01 .140370E-01	REAL . 147747E-01 . 143036E-01 . 139041E-01 . 135741E-01 . 131164E-01 . 129864E-01
4 10 4 4 4 10 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	VARIARIE	VAINTABLE	66 67 69 70 71 71 73 75 76 76 79 81	1144 1155 1166 1177 1199 120
	,	IMAGINARY		IMAGINARY
	VALITE	307	VALUE	60000000
.504780E-01 .443175E-01 .415770E-01 .396444E-01 .34553E-01 .325722E-01 .307540E-01 .290896E-01	NO 17	REAL	.363191E-0 .340136E-0 .318781E-0 .299020E-0 .263892E-0 .234046E-0 .203891E-0 .203891E-0 .197910E-0 .178855E-0 .176855E-0 .176855E-0	REAL .352454E-01 .350131E-01 .296355E-01 .272661E-01 .256352E-01 .241324E-01
- 8 0011111111111111111111111111111111111	IN SUBGRAPH	VARLEBLE	50 52 53 53 55 56 50 60 62 62 63 63 IN SUGRAPH	993 100 102 103 103

	÷	IMAGINARY		IMACINARY	
6666666	VALUE	I			99999999999
.227311E-01 .241116E-01 .256126E-01 .272417E-01 .29669E-01 .369173E-01 .352126E-01	VAI	REAL	.153077E-01 .159284E-01 .166286E-01 .174121E-01 .192844E-01 .203026E-01 .214622E-01 .241097E-01 .254006E-01 .25400E-01 .359159E-01 .359159E-01	VALUE REAL	.153076E-01 .159283E-01 .16285E-01 .174120E-01 .182825E-01 .203025E-01 .214621E-01 .227291E-01 .241097E-01
00000000000000000000000000000000000000	VARIABLE		1788 1896 1832 1832 1836 1836 1990 1991 1936 1937 1938	VARIABLE	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
00000000	1	IMAGINARY	••••••••••••••••••••••••••••••••••••••	IMAGINARY	••••••
	VALUE				00000000000
. 129208E-01 . 129850E-01 . 131140E-01 . 133085E-01 . 135698E-01 . 142974E-01		REAL	.147638E-01 .142935E-01 .138653E-01 .135638E-01 .131087E-01 .129147E-01 .129147E-01 .129792E-01 .131087E-01 .133037E-01 .135652E-01 .135652E-01	REAL	. 147635E-01 . 142932E-01 . 138944E-01 . 135650E-01 . 131035E-01 . 129790E-01 . 129790E-01 . 129790E-01 . 129790E-01
1222 1223 1234 1244 127 129	VARIABLE		162 163 164 165 165 167 170 171 172 173 175 175		0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
		IMAGINARY		IMAGINARY	
	E-I	IMAG		IMAG	000000000000
	VALUE		ALU		
.214818E-01 .203208E-01 .192615E-01 .182964E-01 .166424E-01 .159411E-01		REAL	.352118E-01 .329618E-01 .309168E-01 .299963E-01 .272408E-01 .241164E-01 .227297E-01 .214627E-01 .192449E-01 .16299E-01 .174124E-01 .153630E-01 .153630E-01	REAL	.352108E-01 .329808E-01 .399153E-01 .290054E-01 .272400E-01 .256103E-01 .241097E-01 .227291E-01 .21621E-01 .205025E-01
106 107 108 108 110 111 112 113 IN SUGRAPH	VARIABLE		1465 3 1467 3 1468 3 1469 3 1569 2 1574 2 1574 2 1575 2 1576 1 1576 1 1576 1 1576 1 1577 2 1576 1 1576 1 1577 2 1577 2 1577 2 1578 1 1578 1 1578 1 1579 1 1570 1		11 19 19 19 19 19 19 19 19 19 19 19 19 1

	٠.	IMAGINARY		IMAGINARY	•
\$ \$ \$ \$	35		VALUE	IM	6999999999999999
.290054E-01 .309158E-01 .329808E-01 .352107E-01	VALUE	REAL	. 153076E-01 . 15925E-01 . 166255E-01 . 174129E-01 . 192825E-01 . 192825E-01 . 203025E-01 . 227291E-01 . 241097E-01 . 256108E-01 . 256108E-01 . 25606E-01 . 309158E-01 . 352107E-01	REAL	. 153975E-01 . 159281E-01 . 166284E-01 . 174118E-01 . 19242E-01 . 203023E-01 . 214619E-01 . 227288E-01 . 241094E-01 . 256165E-01 . 256165E-01 . 272397E-01 . 272397E-01 . 399155E-01
238 259 240 241	VABIABLE		274 275 276 277 278 289 283 285 288 288 288 288 288 288		0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
		IMAGINARY		IMAGINARY	
• • • • • • • • •	VALITE		VALUE		
. 135650E-01 . 138944E-01 . 142932E-01 . 147635E-01	Λ	REAL	147635E-01 138944E-01 138944E-01 135650E-01 131085E-01 129790E-01 129145E-01 129790E-01 129790E-01 129736E-01 129736E-01 139035E-01 13655E-01	REAL	. 147635E-01 . 138943E-01 . 138943E-01 . 135650E-01 . 139034E-01 . 129144E-01 . 129144E-01 . 129144E-01 . 139144E-01 . 139144E-01 . 139144E-01 . 139034E-01 . 135649E-01 . 135649E-01
222 223 224 225	VABIABIE	VARLABLE	258 259 260 261 261 263 264 265 265 270 271 272 273		3006 3007 3009 3009 3110 3113 3114 3219 3219 3219
		IMAGINARY		IMAGINARY	
0000	VALTE		00.00.00.00.00.00.00.00.00.00.00.00.00.		
.174120E-01 .166286E-01 .159283E-01 .153076E-01	NO 21	REAL	.352107E-0 .329808E-0 .309158E-0 .299053E-0 .272400E-0 .256108E-0 .227291E-0 .214507E-0 .19244E-0 .19244E-0 .15262E-0 .154123E-0 .15926E-0 .15926E-0	REAL	.352107E-01 .329803E-01 .290954E-01 .290954E-01 .272400E-01 .256108E-01 .24621E-01 .214621E-01 .203952E-01 .192443E-01 .16235E-01 .16235E-01
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	IN SUEGRAPH	VAKLABLE	242 243 244 245 245 245 253 253 254 255 255 255 255 255 257 278 287 287 287 287		0 - 21 - 25 - 25 - 25 - 25 - 25 - 25 - 25

	IMAGINARY		IMAG I NARY
VALUE	_	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	AALUE
VAI	REAL	.153034E-01 .15923BE-01 .166237E-01 .17406BE-01 .1923B4E-01 .202961E-01 .214553E-01 .24101BE-01 .24101BE-01 .242095E-01 .272095E-01 .309053E-01 .329696E-01	REAL 157850E-01 157850E-01 172470E-01 172470E-01 190543E-01 2009985E-01 224941E-01 224941E-01 238575E-01 253402E-01 269494E-01 33653E-01 33653E-01 346253E-01
VARIABLE		370 371 372 373 374 375 376 377 378 378 379 381 381 382 383 383 383	418 419 420 422 422 423 425 427 428 430 431 432 433 433 433 432 433
r.1	IMAGINARY		IMAGINARY 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
VALUE		ALU	ALU
	REAL	147622E-01 138928E-01 135634E-01 133017E-01 139121E-01 129770E-01 129770E-01 129770E-01 129765E-01 131058E-01 13306E-01 135619E-01 135619E-01	REAL 147204E-01 142470E-01 138448E-01 132464E-01 129132E-01 12838E-01 128977E-01 132098E-01 134644E-01 137864E-01
VARIABLE		354 355 355 356 358 369 363 364 365 365 366 367	402 403 404 405 406 406 411 411 4113 4115 4115 4116 4117
e e	IMAGINARY	••••••••••••••••••••••••••••••••••••••	IMAGINARY 00. 00. 00. 00. 00. 00. 00. 00.
VALUE		ALU	ALU
	REAL	252163E-0 69153E-0 90049E-0 72394E-0 72394E-0 741090E-0 74109E-0 74110E-0 74110E-0 74110E-0 74110E-0 74110E-0 74110E-0	REAL 3296598E-0 329659E-0 289899E-0 289899E-0 287865E-0 224377E-0 292765E-0 192162E-0 173795E-0 175379E-0 1558999E-0
VARIEE		338 339 340 341 341 344 344 345 346 346 347 348 348 348 348 348 351 351 351 351 351 351 351 351 351 351	385 387 387 383 394 394 395 395 395 397 393 397 393 401 IN SUGGAPH

IN SUBGRAPH NO 23

IMAGINARY		IMAGINARY	IMAGINARY
	VALUE	699999999999999	VALUE
REAL	.110439E-01 .113522E-01 .117173E-01 .121410E-01 .126253E-01 .137862E-01 .152231E-01 .160538E-01 .160538E-01 .160538E-01 .160538E-01 .179604E-01 .179601 .202272E-01 .202272E-01	REAL 239 597 E+00 255 7455 E+00 275 50 1 E+00 318237 E+00 341537 E+00 393387 E+00 422195 E+00 453113 E+00 550139 E+00 560139 E+00 601166 E+00	VA) REAL .837522E-01
	466 467 468 469 470 471 473 474 477 477 476 478 479 480 481	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	VARIABLE 562
IMAGINARY	•••••••••••••••••••••••••••••••••••••	IMAGINARY 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	IMACINARY
	ALU		VALUE 0 0
REAL	. 133878E-01 . 128167E-01 . 123097E-01 . 118643E-01 . 11494E-01 . 106778E-01 . 106778E-01 . 103797E-01 . 103797E-01 . 103094E-01 . 103094E-01 . 103094E-01 . 103917E-01	REAL .777 144E-01 .83358BE-01 .894200E-01 .959283E-01 .10419E+00 .118473E+00 .127120E+00 .146367E+00 .157064E-00 .168546E+00 .1680870E+00 .194099E+00 .208298E+00	V REAL . 226835E+00
2.7	450 451 452 453 454 455 455 460 460 461 463 463 463	4 4 4 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	VARIABLE 546
IMAGINARY		IMAGINARY	IMAGINARY
	00000000000000000000000000000000000000		VALUE
REAL	.347668E-0 .325044E-0 .304045E-0 .284566E-0 .266510E-0 .234312E-0 .20609E-0 .194636E-0 .194636E-0 .173164E-0 .173164E-0 .155157E-0 .147339E-0 .147339E-0	REAL .260269E-01 .277851E-01 .296802E-01 .317238E-01 .362977E-01 .415985E-01 .47534E-01 .477323E-01 .511492E-01 .527687E-01 .527687E-01 .527687E-01	REAL 692612E+0
	4334 4335 4335 44337 4444 4444 4445 1N SU-CRAPH	44444444444444444444444444444444444444	S 1:

		IMAGINARY	IMAGINARY	
99999999999999	VALUE		VALUE	୍ର୍ଚ୍ଚ
.797011E-01 .7260486E-01 .727763E-01 .696679E-01 .673089E-01 .631893E-01 .616081E-01 .69336E-01 .593636E-01 .584197E-01 .584197E-01	IV	REAL .174496E-01 .179246E-01 .191445E-01 .191445E-01 .198967E-01 .207483E-01 .217637E-01 .239454E-01 .239454E-01 .256566E-01 .266566E-01 .265236E-01 .265236E-01 .26556E-01 .26556E-01 .26556E-01 .26556E-01 .26556E-01	VA REAL	.153635E-01 .159787E-01 .166739E-01 .174524E-01
666 666 666 666 666 666 666 666 666 66	VARIABLE	6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	VARIABLE	658 658 661 661 661
	Æ	IMAGINARY 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	JE I MAG I NARY	
.211936E+00 .19804BE+00 .185149E+00 .173176E+00 .151772E+00 .151772E+00 .133407E+00 .133407E+00 .117714E+00 .110770E+00 .110770E+00 .110770E+00 .104379E+00	VALUE	REAL .214030E-01 .204795E-01 .196535E-01 .189357E-01 .177710E-01 .177710E-01 .16953E-01 .16953E-01 .16953E-01 .16635E-01 .164930E-01 .164073E-01 .165426E-01 .165627E-01	VALUE REAL	. 149677E-01 . 144830E-01 . 140706E-01 . 137237E-01 . 134553E-01
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	VARIABLE	00000000000000000000000000000000000000	VARIABLE	642 643 644 645 646
		IMAGINARY	IMAGINARY	
	VALUE		VALUE	99999
.645511E+00 .60163EE+00 .506773E+00 .452712E+00 .454255E+00 .454253E+00 .454253E+00 .394891E+00 .36243E+00 .36347E+00 .278565E+00 .260266E+00	NO 28	REAL .557381E-01 .521537E-01 .4876503E-01 .427456E-01 .400610E-01 .375736E-01 .352740E-01 .311933E-01 .293918E-01 .277373E-01 .262215E-01 .248367E-01	VA REAL	.355556E-01 .335797E-01 .314736E-01 .295250E-01
B B B B B B B B B B B B B B B B B B B	IN SUNGRAPH VARI (ELE	578 578 589 581 582 583 583 583 598 598 598 598 10 SUGGRAPH	VARIABLE	\$25 \$25 \$25 \$35 \$45 \$5 \$5 \$5 \$5 \$5 \$5 \$5 \$5 \$5 \$5 \$5 \$5 \$5

	IMAGINARY		IMAGINARY	
999999999		666666666666666666666666666666666666666		909999999
.192755E-01 .203293E-01 .214846E-01 .227475E-01 .241240E-01 .256212E-01 .272464E-01 .29080E-01 .309145E-01 .329756E-01	VALUE REAL	. 149521E-01 . 155464E-01 . 162184E-01 . 169715E-01 . 187365E-01 . 208766E-01 . 221606E-01 . 234356E-01 . 24386E-01 . 224386E-01 . 224366E-01 . 24456E-01 . 341787E-01	VALUE REAL	.346725E-02 .328655E-02 .312227E-02 .297361E-02 .283983E-02 .272022E-02 .261423E-02 .252131E-02
6663 6663 6663 6663 672 672 673	VARIABLE	7066 7007 7009 7100 7117 7118 717 718 720	VARIABLE	755 755 755 769 769 165 165 49
•••••••	IMAGINARY		IMAGINARY	
	VALUE		VALUE	
.132493E-01 .131095E-01 .130352E-01 .130825E-01 .132037E-01 .135456E-01 .136456E-01 .136456E-01	NEAL	146546E-01 141754E-01 137671E-01 131553E-01 129487E-01 127291E-01 127591E-01 127548E-01 127644E-01 130553E-01 130953E-01 136677E-01	V REAL	. 103365E-01 . 964783E-02 . 900737E-02 . 841195E-02 . 734452E-02 . 686718E-02 . 642417E-02
647 6448 650 651 651 655 655	VARIABLE	6990 6990 6990 6996 7700 7700 7700 7700	VARIABLE	739 7441 7441 7443 7444 746
	E IMAGINARY		E IMAGINARY	
•	VALUE	******	VALUE	
.260615E-01 .245293E-01 .2318259E-01 .206412E-01 .19559E-01 .176850E-01 .168825E-01	ИО 30 REAL		NO 31 REAL	.346217E-01 .317047E-01 .295461E-01 .275352E-01 .256521E-01 .239172E-01 .225920E-01 .207732E-01
66666666666666666666666666666666666666	IN SUBCRAPH VARIABLE		IN SUBGRAPH VARIABLE	722 7223 7224 7224 7226 7229 729

9	6	9	S	5	S	•		
.237288E-62	.231663E-02	. 227 197E-02	.223867E-02	221656E-02	220553E-02			
265	992	292	268	692	022	! •		
٠.						٠.		
0	0	0	٥	9	0	9	9	
.563246E-02	. 527980E-02	.495353E-02	.465294E-02	.437381E-02	.411744E-02	.388167E-02	.366530E-02	
748	749	022	751	752	753	754	222	
.0	•	0.	•	· •	.0	.0	.0	
. 180552E-01	. 168324E-01	. 156937E-01	. 146335至-01	. 136466E-01	. 127278E-01	.118727E-01	.110769E-01	
731	₹82	733	73∜	733	23ର	282	233	

CPU TIME: 1.423 SECONDS

NUMBER OF VARIABLES IN THE SOLUTION VECTOR 785

EXAMPLE 16B

16 PROPER BLOCKS LADDER NETWORK WITH 770: NODES DECOMPOSED INTO NUMBER OF BASIC RECORDS 20 LENGTH OF ADDRESSING RECORDS 32 NUMBER OF SOLUTION RECORDS 8

MAXIMUM INTEGER AREA REQUIRED IS EQUAL TO 1063

MAXIMUM CONPLEX AREA REQUIRED IS EQUAL TO 6791

SOLUTION

IN SUBGRAPH NO

VARIABLE

IMAGINARY

REAL

.376037E-01

282

ಛ IN SUBGRAPH NO

IMAGINARY

VALUE

VARIABLE

.597014E-01

283

IN SUBGRAPH NO

VALUE VARIABLE IMAGINARY REAL

.244028E-01 682

IN SUECRAPH NO 13

VALUE VARIABLE IMAGINARY REAL

.743176E+00 273

IN SUBGRAPH NO 26

	IMAGINARY		•	•	•	•	•	•	•	•	•	•	•					
VALUE		9		S		S		S					S				0	
-	REAL	239897E+00	257455E+00	276301E+00	296527E+06	318237E+06	341537E+00	366546F+00	3933A7E+00	422195E+06	453113E+00	486298E+00	.521914E+00	.560139E+00	.601166E+00	.645198E+00	.692456E+00	
VARIABLE	-	41.6	100	516	212	51.8	519	520	521	522	523	525	525	526	527	528	529	
뇓	IMAGINARY	0.	.0	. 0	.0	0.	0	0	. 0	. 0			0.	0.	0.	0.	0.	
VALUE		-01	0.1	0.1	.01	00	_	_	_	_	_	_		_	_	_	00	
	REAL	.777144E-0	.833588E-0	.894200E-0	.959283E-0	. 102916E+00	. 110419E+06	.118473E+00	. 127120E+00	. 136403E+00	. 146367E+00	.157064E+00	.168546E+00	. 180870E+00	.194099E+00	.208298E+00	. 223539E+00	
VARIABLE		498	499	500	501	502	503	504	505	506	202	508	509	510	511	512	513	370R 52
	IMAGINARY																	OLUTION: VEC
VALUE		0	0	0	0	0	0	9	0	0	9	0	9	9	9	0	0	THE S
Ď	REAL	.260289E-01	.277851E-01	.296802E-01	.317238E-01	.339259E-01	.362977E-01	.383510E-01	.415985E-01	.445540E-01	.477323E-01	.511492E-01	.548219E-01	.587687E-01	.633894E-01	.675651E-01	.724586E-01	NUMBER OF VARIABLES IN THE SOLUTION VECTOR
VARIABLE		482	483	484	485	486	487	483	489	490	491	49.2	493	404	496	496	264	NUMBER OF V

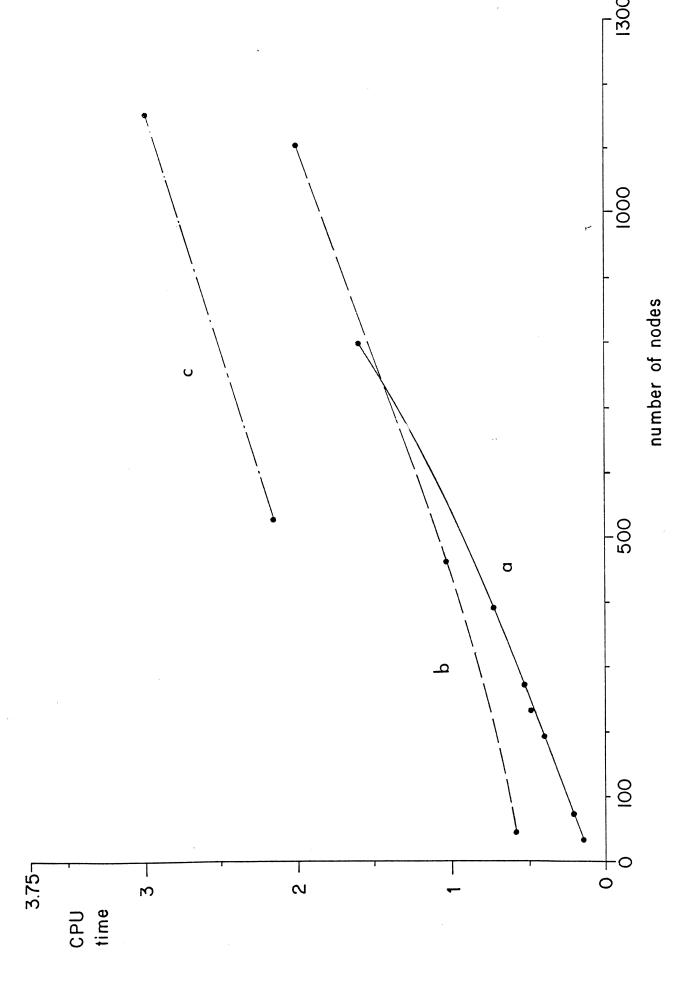
CPU TIME:

.290 SECONDS

Example 17

Ladder networks of different size were analyzed using data generated by the program LADDER listed on pp. 86-89. Figs. 16 and 17 show the dependence of the analysis time for the first execution versus number of network nodes. The larger the number of proper blocks the greater the time needed for mass storage operation. This is the reason that, for relatively small networks, the number of blocks should be small. From the tests performed for ladder networks, it can be seen that networks having less than 100 nodes need not be decomposed, but decomposition is necessary for networks having 1000 nodes or more. For large networks, both the computer memory required and time of analysis will be greater when the network is analyzed without decomposition. All subsequent analyses of the decomposed network will be much more efficient than those of the network analyzed without decomposition.

In Fig. 17 the curve a shows the dependence for partitioning into 4 proper blocks, curve b the case for 16 proper blocks and curve c the case for 128 proper blocks. In Fig. 18 curves b and c show the dependence for partitioning into 16 and 128 proper blocks, respectively, while curve a shows the estimated time for analysis without decomposition using the Harwell package [4-6].



Computation time for different sized blocks (see text on page 146). Fig. 17

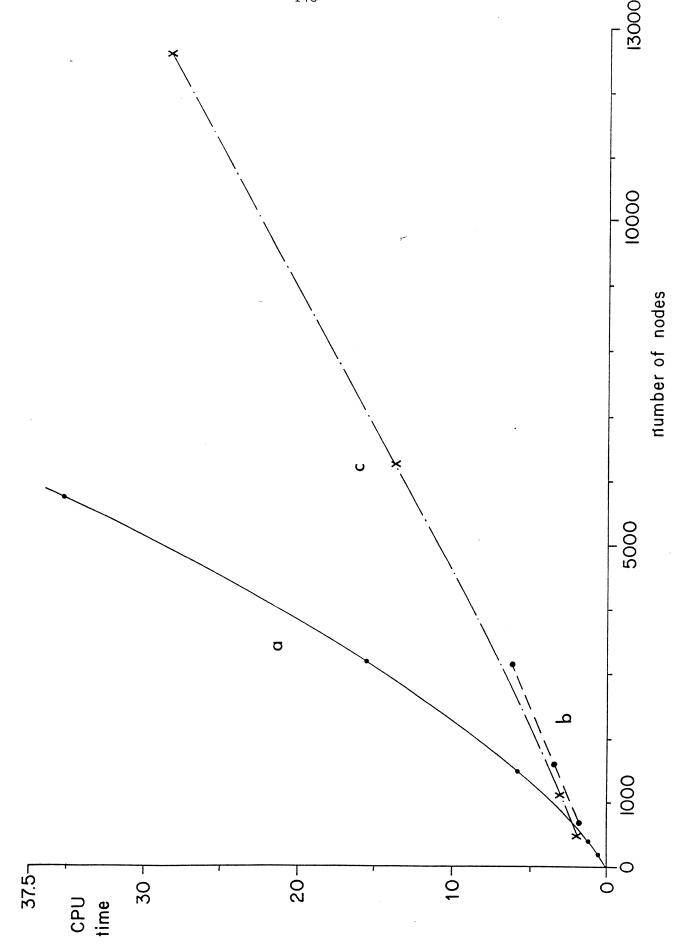


Fig. 18 Computation time for different approaches (see text on page 146).

REFERENCES

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- [2] K. Zollenkopf, "Bifactorization basic computational algorithm and programming techniques", in <u>Large Sparse Sets of Linear Equations</u>, J.K. Reid, Ed. New York: Academic Press, 1971, pp. 75-96.
- [3] "Document SOC-D20, CSSLE, sparse matrix techniques", Group on Simulation, Optimization and Control, Faculty of Engineering, McMaster University, Hamilton, Canada, September 1982.
- [4] I.S. Duff, "MA28 a set of Fortran subroutines for sparse unsymmetric linear equations", Computer Science and Systems Division, AERE Harwell, Oxfordshire, England, Report R.8730, November 1980.
- [5] MA28A/B/C subroutine specification; Harwell Subroutine Library, AERE, Harwell, Oxfordshire, England, July 1980.
- [6] "Document SOC-D1, MA28, sparse matrix techniques", Group on Simulation, Optimization and Control, Faculty of Engineering, McMaster University, Hamilton, Canada, December 1981. Origin of the package: Harwell Subroutine Library, AERE, Harwell, Oxfordshire, England.

APPENDIX
LISTING OF THE CSDSLE PACKAGE

Subroutine	Number of Lines	Number of Words	Listing from Page
	(source text)	(compiled code)	
CSDSLE1	357	1267	152
ASDNSR	216	1141	157
ABSUB	14	30	160
CHEBSUB	14	31	161 •
STOREF	10	41	161
R EA DF	10	14	161
READSB	17	73	161
CHEDEL	22	101	162
ASUBSR	263	1566	162
LM IRHS	39	410	166
ANSUBN	145	1250	166
SMSSUB	73	122	169
CONNECT	48	374	170
EE DS UB	111	443	171
CONNUMB	87	130	172
ADDSUB	88	337	174
CASRHS	79	227	175
PSHDS	75	361	176
RM RHS	104	615	178
RSBR	78	340	179
RM ER HS	54	140	180
RM IR HS	30	103	181
CASSOL	70	244	182
CSSLE1	178	1157	183
SSLECN	75	267	186
MSLECN	136	637	187
INVCN	118	416	189
MSLECC	73	365	191

Subroutine	Number of Lines (source text)	Number of Words (compiled code)	Listing from Page
MSLERC	28	127	192
PABIDES	33	245	192
DATAC	77	127	193
DATACN	29	72	194
DATBCN	47	155	195
SYMCN	97	231	195
SORDON	129	276	197
REDUCN	76	232	199
SOLVCN	55	152	200
ASLECN	42	150	201
RSLECN	234	1444	202
FINDSYM	16	35	205
REA DL	16	41	206
CHNGE	49 .	132	206
PRINTIN	77	642	207
PRINTNC	42	314	208
PRINTRS	40	314	209
PRINT	41	316	209
PRINTI	48	330	210
PRINTS	60	372	211

C

SUBROUTINE CSDSLE1(IN, INTWA, CMPLXWA, IM, SOLR) 000001 000002 THIS SUBROUTINE CALCULATES ADDRESSES FOR SUBMATRICES STORED 000003 000004 WITHIN WORKING AREAS INTWA AND CMPLXWA, AND CALLS THE 000005 000006 SUBROUTINES: ASDNSR WHICH ANALYSES THE SUBMATRICES OF THE 000007 80000 DECOMPOSED MATRIX, ANSUBSN WHICH ANALYSES THE SUBSTITUTE 000009 000010 SUBGRAPHS, AND PSHDS WHICH PERFORMS PARTIAL SOLUTION FOR 000011 000012 THE HIERARCHICALLY DECOMPOSED SYSTEM. 000013 000014 AUTHOR - JANUSZ STARZYK, MC MASTER UNIVERSITY, JANUARY 1983 000015 000016 DIMENSION IN(1), INTVA(1), IM(1) 000017 COMPLEX CMPLXWA(1), SOLR(1) 000018 000019 IN THE MAIN PROGRAM THE USER MUST DETERMINE VALUES ONLY OF THE 000020 000021 FOLLOWING VARIABLES: IN(4), IN(5), IN(7), IN(8), IN(9), IN(10), 000022 000023 IN(11), IN(12), IN(15), IN(16), IN(17), IN(18), IN(19), IN(20), 000024 000025 IN(22), IN(23), IN(25) UP TO THE LAST ELEMENT OF VECTOR IN, 000026 000027 IM(1), IM(2), IM(3), IM(4), IM(5).000028 000029 IN(1) NUMBER OF UNKNOWNS IN THE CURRENT SUBGRAPH 000030 000031 IN(2) MAXIMUM AREA PREDICTED FOR THE SPARSE MATRIX 🚟 000032 DESCRIBING THE CURRENT SUBGRAPH 000033 000034 IN(3) FLAG FOR INSUFFICIENT AREA 000035 000036 IN(4) NUMBER OF SUBGRAPHS WHERE THE SOLUTION WILL 000037 BE RECALCULATED 000038 000039 NUMBER OF ALL PROPER BLOCKS IN(5) 000040 000041 IN(6) NUMBER OF INTERNAL NODES IN THE CURRENT SUBGRAPH 000042 000043 INDICATOR FOR PRINTING INTERMEDIATE RESULTS IN(7) 000044 =0 ONLY PART OF INTERMEDIATE RESULTS WILL BE PRINTED =1 RESULTS WILL NOT BE PRINTED =2 ALL INTERMEDIATE RESULTS WILL BE PRINTED 000045 000046 000047 =3 ONLY THE SOLUTION WILL BE PRINTED 000048 000049 IN(8) INDICATOR FOR KIND OF JOB 000050 THE COMPLETE BIFACTORIZATION PROCESS IS EXECUTED FOR ALL PROPER BLOCKS 000051 000052 THE SOLUTION IS CALCULATED FOR AN ALTERED 000053 COEFFICIENT MATRIX AND/OR RIGHT-HAND SIDE VECTOR 000054 (PREVIOUS USE OF THE MAIN: SUBROUTINE CSDSLE1 WITH 000055 IN(8)=6 IS REQUIRED) 000056 THE SOLUTION IS CALCUTATED FOR AN ALTERED 000057 RIGHT-HAND SIDE VECTOR (PREVIOUS USE OF THE MAIN 000058 SUBROUTINE CSDSLE1 WITH IN(8)=6 IS REQUIRED) 000059 000060 THE HIGHEST INDEX OF THE SUBGRAPHS IN(9) 000061 000062 IN(10) NUMBER OF MODIFIED SUBGRAPHS, MUST BE LESS THAN 000063 IN(12)/2 000064

000065

IN(11)		LENGTH OF BASIC RECORD IN DOUBLE CM WORDS MUST BE GREATER THAN 256	000066 000067 000068
IN(12)		LENGTH OF ADDRESSING RECORD IN CM WORDS	000069
IN(13)		CURRENT NUMBER OF STORED BASIC RECORDS	000070 000071
			000072
IN(14)		CURRENT NUMBER OF SUBGRAPHS IN THE BASIC RECORD	000073 000074
IN(15)		MAXIMUM PREDICTED NUMBER OF BASIC AND SOLUTION RECORDS - TO STORE THE RESULTS OF ANALYSIS OF ALL SUBGRAPHS	00007 6 000077
: IN(16)		MAXIMUM NUMBER OF EQUATIONS FOR ANY SUBGRAPH	000078 000079
IN(17)		MAXIMUM AREA PREDICTED FOR SPARSE MATRIX ANALYSIS	000080 000081
13		OF SUBGRAPHS; MUST BE GREATER THAN IN(18)-IN(16)	000082
		USUALLY 1-2 TIMES THE NUMBER OF NONZERO ELEMENTS	000083 000084
IN(18)		NUMBER OF NONZERO ELEMENTS IN THE MAXIMUM SUBMATRIX	000085 .K
IN(19)		THE LOWEST INDEX OVER ALLADECOMPOSITION NODEST	000086 000087
inclay			000088
IN(20)		NUMBER OF DATA RECORDS STORING INFORMATION ABOUT MODIFIED SUBGRAPHS	00008 9 000090
*		ADUUT MUDIFIED SUDGRAFIAS S.	000091
IN(21)		CURRENT NUMBER OF RHS RECORDS	000092
IN(22)		INDICATOR FOR RHS UPDATING FORMULA	000093 000094
	= Ø	COMPLETE SOLUTION VECTOR WILL BE RECALCULATED	000095
	= 1	THE SOLUTION FOR MODIFIED SUBGRAPHS ONLY WILL BE	000096 000097
() ()	=2	RECALCULATED ONLY THE SOLUTION FOR THE SUBGRAPHS SPECIFIED BY THE	000098
f.		USER WILL BE RECALCULATED - IF THE USER SPECIFIES	000099
O C		SUBSTITUTE SUBGRAPHS ONLY THEN THE SOLUTION WILL BE RECALCUTATED AT THE PARTITION NODES ONLY	000100 000101
			000102
IN(23)	- 0	INDICATOR FOR OPERATIONS ON RANDOM FILES RANDOM ACCESS MULTI-RECORDS FILES WILL BE CREATED	000103 000104
	= 0 = 1	RANDOM ACCESS MULTI-RECORDS FILES WILL BE UPDATED	000105
		THE PROGRAM WILL BE EXECUTED WITHOUT CREATING:	000106
C 2	=3	RANDOM ACCESS MULTI-RECORDS FILES RANDOM ACCESS MULTI-RECORDS FILES WILL BE EXTENDED	000107 000108
•	-0		000109
IN(24)		CURRENT NUMBER OF STORED ADDRESSING RECORDS	000110 000111
IN(25)		LENGTH OF DATA AND RHS RECORDS IN DOUBLE CM WORDS,	000112
5		MUST BE GREATER THAN 2*IN(10)	000113 000114
IN(26)		NUMBER OF ALL DECOMPOSITION NODES (2)	000115
1			000116
IN(27) -	111(L) STORE NUMBERS OF EXTERNAL NODES FOR THE SUBSTITUTE SUBGRAPHS, WHERE L=26+IN(9)/2	000117 000118
()			00011 9
	– I N	N(M) STORE THE INDICES OF ALL PROPERABLOCKS IN DECREASING ORDER, WHERE M=L+IN(5)	000120 000121
41 11			000122
IN(M+1)	– I N	I(K) STORE THE INDICES OF SUBGRAPHS WHERE THE	000123
1.		SOLUTION WILL BE RECALCULATED, WHERE K=M+IN(4)	000124
TM(1)		MASS STORAGE INDICATOR	000126
	=0	MASS STORAGE FILES WILL NOT BE USED	000127 000128
t. 13	= 1 = 2	MASS STORAGE FILES WILL BE USED MASS STORAGE FILE NO. 2 (DATA FILE) WILL NOT	
()	_	BE USED	000130

```
=3 MASS STORAGE FILES WILL BE EXTENDED
                                                                                                  000131
                                                                                                  000132
                          FLAG DENOTING A REFERENCE TO THE MAIN SUBROUTINE MUST BE INITIALIZED BY THE USER TO 0 IN CONJUNCTION WITH THE FIRST CALL AND MUST NEVER BE SUBSEQUENTLY
             IM(2)
000000
                                                                                                  000133
                                                                                                  000134
                                                                                                  000135
                          ALTERED
                                                                                                  000136
                                                                                                  000137
                          THE SIZE OF WORKING AREA INTWA
             IM(3)
                                                                                                  000138
CCCCC
                                                                                                  000139
             IM(4)
                          THE SIZE OF WORKING AREA CMPLXWA
                                                                                                  000140
                                                                                                  000141
                          NUMBER OF VARIABLES IN THE SOLUTION RECORD AT THE OUTPUT IM(5) CONTAINS THE NUMBER OF VARIABLES
             IM(5)
                                                                                                  000142
                                                                                                  000143
CCCCC
                           IN THE SOLUTION VECTOR
                                                                                                  000144
                                                                                                  000145
             SOLR
                          SOLUTION RECORD
                                                                                                  000146
                          FOR SMALL PROBLEMS IT CONTAINS SOLUTION VECTOR AND
                                                                                                  000147
                          INDICES OF ITS VARIABLES
IN SUCH CASE ITS SIZE MUST BE NOT LESS THAN THE
                                                                                                  000148
0000000
                                                                                                  000149
                          DOUBLE THE NUMBER OF ALL VARIABLES W
                                                                                                  000150
                                                                                                  000151
             IF THE USER DOES NOT EMPLOY MASS STORAGE FILES FOR INPUT DATA HE MUST PREPARE AND STORE THE DATA IN THE WORKING AREA CMPLXWA STARTING FROM ELEMENT 4*IN(17)+1+3*IN(16)+IN(11)
                                                                                                  000152
                                                                                                  000153
                                                                                                  000154
             THIS CORRESPONDS TO THE USE OF ONE DATA RECORD
                                                                                                  000155
                                                                                                  000156
             THE SIZE OF THE WORKING AREA INTWA MUST NOT BE LESS THAN 3*IN(16)+2+2*IN(17)+2*IN(12)+2*IN(9)+IN(20)+1+IN(15)+1++++(IN(9)-1)/IN(12)+3+IN(18)+IN(18)+7+IN(16)+IN(9)/2+
                                                                                                  000157
                                                                                                  000158
                                                                                                  000159
             +(IN(26)/IN(25))*2+3+2*IN(9)+IN(15)+1+IN(9)/50+1=
                                                                                                  000160
             = 19+9*IN(9)/2+2*IN(12)+2*IN(15)+4*IN(16)+2*(IN(17)+IN(18))+
                                                                                                  000161
             +IN(20)+(IN(9)-1)/IN(12)+IN(9)/50+(IN(26)/IN(25))*2
                                                                                                  000162
                                                                                                  000163
             THE SIZE OF WORKING AREA CMPLXWA MUST NOT BE LESS THAN
                                                                                                  000164
             IN(11)+3*IN(16)+4*IN(17)+IN(18)+IN(25)+1
                                                                                                  000165
                                                                                                  000166
             FOR SMALL PROBLEMS OF UP TO 10 SUBGRAPHS THE USER IS ADVISED
                                                                                                  000167
             TO SET STANDARD VALUES IN(9)=20, IN(12)=20, IN(15)=11, IN(20)=10, AND USE INTWA OF SIZE 181+4*IN(16)+2(IN(17)+IN(18))
                                                                                                  000168
                                                                                                  000169
                                                                                                  000170
       CALL SECOND(TM1)
                                                                                                  000171
       MSI = IM(1)
                                                                                                  000172
        NRI= IM(2)
                                                                                                  000173
                                                                                                  000174
             CHECK INPUT INFORMATION Com
\mathbf{C}
                                                                                                  000175
                                                                                                  000176
        IF(IN(7).EQ.1.OR.IN(7).EQ.3) GOTO 3
                                                                                                  000177
        CALL PRINTING IN)
                                                                                                  000178
                                                                                                  000179
       CONTINUE
        IF(IN(9).GE.IN(5).AND.IN(5).GE.IN(10)) GOTO 1
                                                                                                  000180
        WRITE(6, 100)
                                                                                                  900181
       RETURN
                                                                                                  000182
  100 FORMAT(1H, //, "THE NUMBER OF MODIFIED SUBGRAPHS SHOULD BE LESS THA +N OR EQUAL TO ", /, "THE NUMBER OF PROPER SUBGRAPHS AND THE HIGHEST
                                                                                                  00018345
                                                                                                  000 184
      + INDEX OF THE SUBGRAPHS", /, " CHECK IN(5); IN(9) AND IN(10)", /)
                                                                                                  000185
     1 CONTINUE
                                                                                                  000186
        IF(IN(15).LE.IN(9)) GOTO 2
                                                                                                  000187
  WRITE(6,110)
110 FORMAT(1H,/," THE NUMBER OF BASIC RECORDS NEED NOT TO BE GREATER
                                                                                                  000188
                                                                                                  000189<sup>11</sup>
      +THAN THE HIGHEST INDEX OF THE SUBGRAPHS ", /, " CHECK IN(15) ", /)
                                                                                                  000190
       RETURN
                                                                                                  000191
     2 CONTINUE
                                                                                                  000192
        IF(IN(4).LE.IN(5).AND.(IN(5)*2-1).LE.IN(9)) GOTO 49
                                                                                                  000193
        WRITE(6, 120)
                                                                                                  000194
  120 FORMAT(1H, /, " IN(4) SHOULD NOT BE GREATER THAN IN(5) AND (IN(5)*2
                                                                                                  000195
```

```
+-1) < = IN(9)")
                                                                                       000196
        RETURN
                                                                                       000197
       IF(IN(27).EQ.0) GOTO 5
                                                                                       000198
   WRITE(6,130)
130 FORMAT(1H,/," THE NUMBER OF EXTERNAL NODES FOR SUBSTITUTE SUBGRAP
                                                                                       000199
                                                                                       000200
       +H NO.1 MUST BE ZERO",/," CHECK IN(27)",/)
                                                                                       000201
        RETURN
                                                                                       000202
     5 CONTINUE
                                                                                       000203
   IF(IN(8).GT.6.AND.MSI.EQ.0.AND.NRI.EQ.0) WRITE(6,140)
140 FORMAT(1H, /, "WARNING!!! - DATA IS TAKEN TO BE IN BIFACTORIZED FO
                                                                                       000204
                                                                                       000205
       +RM")
                                                                                       000206
        IF(IN(11).GT.256) GOTO 10
                                                                                       000207
        WRITE(6,220)
                                                                                       000208
   220 FORMAT(1H ,/, " LENGTH OF BASIC RECORD MUST BE GREATER THAN 256"
                                                                                       995999
                                                                                       000210
    10 CONTINUE
                                                                                       000211
        IF(IM(1).EQ.3)IN(23)=3
                                                                                       000212
        IF(IN(23).EQ.3)IM(1)=3
                                                                                       000213
        IF(IN(23).NE.1.AND.IN(23).NE.3.OR.IM(1).NE.0)GOTO.14
                                                                                       000214
       WRITE(6,230)
                                                                                       000215
  230 FORMAT(1H, /, " WITH IN(23) EQUAL TO 1 OR 3 MASS STORAGE FILES MUST + BE USED", /, " CHECK. IM(1)", /)
                                                                                       000216
                                                                                       000217
       RETURN
                                                                                       000218
    14 CONTINUE
                                                                                       000219
        IF(IN(17).LT.(IN(18)-IN(16))) WRITE(6,240)
                                                                                       000220
   240 FORMAT(1H ,/, " WARNING!!! - IN(17) MAY BE TOO SMALL",/)
                                                                                       000221
       N= IN( 16)
                                                                                       000222
       LES= IN( 17)
                                                                                      000223
       LADR= IN( 12)
                                                                                      000224
       MNS= IN(9)
                                                                                      000225
        IA1=3*N+2
                                                                                      000226
        IA2= IA1+2*LES [1]
                                                                                      000227
        IA3= IA2+2*LADR
                                                                                      000228
       IA4= IA3+2*MNS + -
                                                                                      000229
       IA5= IA4+ IN(20)+1
                                                                                      000230
       IA6= IA5+ IN( 15)+1
                                                                                      000231
       IA7=IA6+(IN(9)-1)/LADR+3
                                                                                      000232
       IA8= IA7+ IN( 18)
                                                                                      000233
       IA9= IA8+ IN( 18)
                                                                                      000234
       IA10= IA9+7
                                                                                      000235
       IA11= IA10+N
                                                                                      000236
       IA12= IA11+MNS/2
                                                                                      000237
       IA13= IA12+(IN(26) / IN(25)+1)*2±1
                                                                                      000238
       IA14= IA13+2* IN(9)
                                                                                      000239
       IA15=IA14+IN(15)+1 :
                                                                                      000240
C
                                                                                      000241
            CHECK THE SIZE OF WORKING AREA INTWA
C
                                                                                      000242
\mathbf{C}
                                                                                      000243
       IA16=IA15+IN(9)/50+1
                                                                                      999244
       IF(IM(3).LT. IA16) GOTO 6 11
                                                                                      000245
       IF(IM(3).GT. IA16) WRITE(6, 180) IA16
                                                                                      000246
       IB1=4*LES+1
                                                                                      000247
       IB2= IB1+2*N
                                                                                      000248
       IB3= IB2+N
                                                                                      000249
       IB4= IB3+ IN(11)
                                                                                      000250
       IB5= IB4+ IN(25):11
                                                                                      000251
                                                                                      000252
           CHECK THE SIZE OF WORKING AREA CMPLXWA
                                                                                      000253
\mathbf{C}
                                                                                      000254
       IB6= IB5+ IN( 18)
                                                                                      000255
       IF(IM(4).LT.IB6) GOTO 7
IF(IM(4).GT.IB6) WRITE(6,170)IB6
                                                                                      000256
                                                                                      000257
\mathbf{c}
                                                                                      000258
\mathbf{C}
           THE ADDRESSES CALCULATED IN THIS SUBROUTINE ARE NEEDED FOR
                                                                                      000259
                                                                                      000260
```

```
PARTINIONING THE WORKING AREAS INTO ARRAYS TO BECOME THE
 C C C
                                                                                      000261
                                                                                      000262
             PARAMETERS OF SUBROUTINE ASDNSR. IN SUBROUTINE ASDNSR THE
                                                                                      000263
                                                                                      000264
 C
             ARRAYS HAVE THE FOLLOWING DIMENSIONS
                                                                                      000265
 \mathbf{C}
                                                                                      000266
 C C C
             IN(26+IN(9)/2+IN(5)+IN(4)).
                                                                                      999267
                                                                                      000268
            LCOL(3*N+1), ITAG(2*LES), CE(4*LES), DE(2*N), V(N), IADREC(2*LADR)
                                                                                      000269
                                                                                      000270
 C
            BREC(LREC), DREC(IN(25)), NSUB(2*MNS), INDEX2(IN(20)+1)
                                                                                      000271
                                                                                      000272
 C
            INDEX3(IN(15)+1), INDEX5((MNS-1)/LADR+3), AK(NEL), NCOL(NEL),
                                                                                      000273
 00000000000000
                                                                                      000274
            NROW(NEL), INDX(7), NON(N), INDEX1(IN(26)/IN(25)+2), NASUB(MNS*2)
                                                                                      000275)
                                                                                      000276
            INDEX7(IN(15)+1), IT(IN(9) >50+1)
                                                                                      000277
                                                                                      000278
            WHERE MNS=IN(9), NMS=IN(10), LREC=IN(11), LADR=IN(12), N=IN(16)
                                                                                      000279
                                                                                      000280
            LES= IN(17), NEL= IN(18)
                                                                                      000281
                                                                                      000282
            SUBROUTINE ASDNSR PERFORMS AN ANALYSIS OF EACH SUBGRAPH OF
                                                                                      000283
                                                                                      000284
            THE DECOMPOSED GRAPH AND STORES THE RESULTS
                                                                                      000285
                                                                                      000286
       CALL ASDNSR(IN, INTWA(1), INTWA(IA1), CMPLXWA(1), CMPLXWA(IB1)
                                                                                      000287
      +, CMPLXWA(IB2), INTWA(IA2), CMPLXWA(IB3), CMPLXWA(IB4), INTWA(IA3), +INTWA(IA4), INTWA(IA5), INTWA(IA6), CMPLXWA(IB5), INTWA(IA7),
                                                                                      000288
                                                                                      000289
      + INTWA( IA8), INTWA( IA9), INTWA( IA10), INTWA( IA12), INTWA( IA13),
                                                                                      000290
      +INTWA(IA14), NRI, MSI, INTWA(IA15), IA6, IA16)
                                                                                      000291
       IF(IN(3).EQ.1) RETURN
                                                                                      000292
        IM(2) = NRI
                                                                                      000293
                                                                                      000294
CCC
            IN ANSUBSN WE HAVE AN ADDITIONAL MATRIX
                                                                                     000295
                                                                                      000296
            NEXTN(MNS/2)
                                                                                     000297
                                                                                     000298
            SUBROUTINE ANSUBSN PERFORMS ANALYSIS OF SUBSTITUTE GRAPHS
                                                                                     000299
                                                                                     000300
       CALL ANSUBSN(IN, INTWA(1), INTWA(IA1), CMPLXWA(1), CMPLXWA(IB1)
                                                                                     000301
      +, CMPLXWA(IB2), INTWA(IA2), CMPLXWA(IB3), INTWA(IA3), INTWA(IA5), INTWA(IA6), CMPLXWA(IB5), INTWA(IA7),
                                                                                     000302
                                                                                     000303
      + INTWA(IA8), INTWA(IA9), INTWA(IA10), INTWA(IA11),
                                                                                     000304
      +CMPLXWA(IB4), INTWA(IA12), INTWA(IA15))
                                                                                     000305
       IF(IN(3).EQ. 1) RETURN
                                                                                     000306
CCC
                                                                                     000307
            CHECK WHETHER ALL SUBSTITUTE SUBGRAPHS HAVE BEEN ANALYZED
                                                                                     000308
                                                                                     000309
       CALL CHEBSUB(1, INTWA(1A15), IR).
                                                                                     000310
       IF(IR.EQ. 1) GOTO 12
                                                                                     000311
       WRITE(6,210)
                                                                                     000312
       GOTO 13
                                                                                     000313
  210 FORMAT(1H
                   ,/, " HIERARCHICAL STRUCTURE IS NOT COMPLETE",/, " SOLUTIO
                                                                                     00031416
      +N CANNOT BE CALCULATED",/)
                                                                                     000315
                                                                                     000316
           SUBROUTINE PSHDS PERFORMS A PARTIAL SOLUTION FOR THE
CCCC
                                                                                     000317
                                                                                     000318
           HIERARCHICALLY DECOMPOSED SYSTEM
                                                                                     000319
                                                                                     000320
   12 CALL PSHDS(IN, INTWA(1), INTWA(IA1), CMPLXWA(1), CMPLXWA(IB1)
                                                                                     000321
     +, CMPLXWA( IB2), INTWA( IA2), CMPLXWA( IB3), INTWA( IA3),
     + INTWA(IA5), INTWA(IA6), INTWA(IA9), INTWA(IA10), INTWA(IA12),
                                                                                     000322
                                                                                     000323
     +INTWA(IA14), CMPLXWA(IB4), SOLR, IM)
                                                                                     000324
       IF(IN(3).EQ. 1) RETURN
                                                                                     000325
```

```
CALL SECOND(TM2)
                                                                                     000326
       CPU=TM2-TM1
                                                                                     000327
       IF(IN(7).NE.1) WRITE(6,190) CPU(5
                                                                                     000328
   190 FORMAT(1H ,/, " CPU TIME: ", F8.3, " SECONDS",/)
                                                                                     000329
       IF(IN(23).EQ.2) RETURN
                                                                                     000330
C
                                                                                     000331
\mathbf{c}
            STORE MASS STORAGE FILES INFORMATION
                                                                                     000332
                                                                                     000333
    13 LI=26+IN(9)/2+IN(5)+IN(4)
                                        1 1
                                                                                     000334
       IF(LI.GE. IA4) GOTO 9:
                                                                                     000335
       DO 8 I=1,LI
                                                                                     000336
       INTWA(I) = IN(I)
                                                                                     000337
       IND=(IN(9)-1)/IN(12)+2
                                                                                     000338
       CALL STOREF(5, INTWA, IA16, IND, INTWA(IA6))
                                                                                     000339
       RETURN
                                                                                     000340
       WRITE(6,200)
                                                                                     000341
  200 FORMAT(1H,/," MASS STORAGE INFORMATION CANNOT BE STORED",/," INCR +EASE IN(12), IN(16) OR IN(17)",/)
                                                                                     000342
                                                                                     000343
       RETURN
                                                                                     000344
       WRITE(6, 150)
                                                                                     000345
       IN(3)=3
                                                                                     000346
       RETURN
                                                                                     000347
       WRITE(6, 160)
                                                                                     000348
       IN(3) = 4
                                                                                     000349
       RETURN
                                                                                     000350
   150 FORMAT(1H ,/, " INTEGER WORKING AREA INTWA TOO SMALL - CHECKLIM(3)"
                                                                                    000351)
                                                                                     000352
   160 FORMAT(1H ,/, " COMPLEX WORKING AREA CMPLXWA TOO SMALL - CHECK IM(4
                                                                                    000353
                                                                                    000354
   170 FORMAT(1H ,/, " MAXIMUM COMPLEX AREA REQUIRED IS EQUAL TO", 15,/)
                                                                                    000355
   180 FORMAT(1H ,/, " MAXIMUM INTEGER AREA REQUIRED IS EQUAL TO", 15,/)
                                                                                    000356
                                                                                    000357
C
                                                                                    000358
                                                                                     000359
       SUBROUTINE ASDNSR(IN, LCOL, ITAG, CE, DE, V, IADREC, BREC, DREC, NSUB, INDEX
                                                                                    000360 A
      +2, INDEX3, INDEX5, AK, NCOL, NROW, INDX, NON, INDEX1, NASUB, INDEX7, NRI, MSI,
                                                                                    0003611
                                                                                    000362
                                                                                    000363
C
           THIS SUBROUTINE PERFORMS ANALYSIS OF SUBGRAPHS OF A
                                                                                    000364
0000000
                                                                                    000365
           DECOMPOSED GRAPH AND STORES THE RESULTS IN RANDOM FILE
                                                                                    000366
                                                                                    000367
           NO.3, WHILE ADDRESSES FOR THESE RESULTS ARE STORED IN
                                                                                    000368
                                                                                    000369
           RANDOM FILE NO.5. SUBGRAPHS TO BE ANALYZED HAVE TO BE
                                                                                    000370
                                                                                    000371
C
           STORED IN RANDOM FILE NO.2 OR IN THE WORKING AREA CMPLXWA
                                                                                    000372
                                                                                    000373
      DIMENSION IN(1), LCOL(1), ITAG(1), IADREC(1), NSUB(1), INDEX1(1), +, INDEX2(1), INDEX3(1), INDEX5(1), NCOL(1), NROW(1), INDX(1), NON(1)
                                                                                    000374
                                                                                    000375
      +, NASUB(1); INDEX7(1), IT(1)
                                                                                    000376
       COMPLEX CE(1), DE(1), V(1), BREC(1), AK(1), DREC(1)
                                                                                    000377
                                                                                    000378
C
           LTHR
                           LENGTH OF SPACE FOR CURRENT BLOCK IN THE BASIC
                                                                                    000379
CCC
                           RECORD
                                                                                    000380
                                                                                    000381
           BREC
                           BASIC RECORD
                                                                                    000382
C
                                                                                    000383
C
           IADREC
                           ADDRESSING RECORD
                                                                                    000384
C
                                                                                    000385
C
           NON
                           ORIGINAL INDICES OF THE NODES
                                                                                    000386
                                                                                    000387
C
           CURRENT INFORMATION ABOUT RANDOM FILES IS STORED IN THE ARRAY
                                                                                    000388
                                                                                    000389
           INDX. WHERE
                                                                                    000390
```

```
0000000000
                                                                                      000391
            INDX(2)
                            CURRENT INDEX OF DATA RECORD IN RANDOM FILE
                                                                                      000392
                            NO. 2
                                                                                      000393
                                                                                      000394
            INDX(3)
                            CURRENT INDEX OF A BASIC RECORD IN RANDOM FILE
                                                                                      000395
                            NO. 3
                                                                                      000396
                                                                                      000397
                            CURRENT INDEX OF THE RHS RECORDEIN
            INDX(4)
                                                                                      000398
                            RANDOM FILE NO. 1
                                                                                      000399
00000
                                                                                      000400
                            CURRENT INDEX OF THE ADDRESSING RECORD IN
            INDX(5)
                                                                                      000401
                            RANDOM FILE NO. 5
                                                                                      000402
                                                                                      000403
            INDX(7)
                            CURRENT INDEX OF THE SOLUTION RECORD IN
                                                                                      000404
\bar{\mathbf{c}}
                            RANDOM FILE NO. 7
                                                                                      000405
                                                                                      000406
       MNS= IN(9)
                                                                                      000407
       LREC= IN(11)
                                                                                      000408
       LADR= IN( 12)
                                                                                      000409
       LDREC=2*LREC
                                                                                      000410
       LLDR=LADR*2
                                                                                      000411
       NMS= IN( 10)
                                                                                      000412
       IF(IN(23).EQ.3) GOTO 10
                                                                                      000413
       IAX= IN(9)/50+1
                                                                                      000414
   DO 11 I=1, IAX
11 IT(I)=0
                                                                                      000415
                                                                                      000416
       BREC(1) = CMPLX(514...0.)
                                                                                      000417
       INDX(2) = 1
                                                                                      000418
       INDX(3) = 1
                                                                                      000419
       INDX(4) = 1
                                                                                      000420
       INDX(5) = 1
                                                                                      000421
       INDX(7) = 1
                                                                                      000422
       IN( 13) = 0
                                                                                      000423
       IN(14) = 0
                                                                                      000424
       IN(21) = 1
                                                                                      000425
       IN(24) = 0
                                                                                      000426
   10 MMNS=2*MNS
                                                                                      000427
       IF(NRI.GT.0) GOTO 21"
                                                                                      000428
                                                                                      000429
       IF(MSI.EQ.0) GOTO 7.
                                                                                      000430
CCC
                                                                                      000431
           OPEN RANDOM FILES
                                        . ...
                                                                                      000432
                                                                                      000433
       IREC1 = (IN(26) / IN(25) + 1) *2 + 1
                                        ) :
                                                                                      000434
       IREC2 = IN(20) + 1
                                                                                      000435
       IREC3= IN( 15) +1
                                                                                      000436
       IREC5=(MNS-1)/LADR+3
                                                                                      000437
       CALL OPENMS(5, INDEX5, IREC5, 0) b,
                                                                                      000438
CCC
                                                                                      000439
           READ STORED MASS STORAGE FILES INFORMATION
                                                                                      000440
                                                               111
                                                                                      000441
       IF(IN(23).NE.1.AND.IN(23).NE.3)GOTO 15
                                                                                      000442
       IND=(IN(9)-1)/IN(12)+2
                                                                                      000443
       CALL READF(5, LCOL, IA16, IND, LCOL(IA6))
IN(5)=LCOL(5)
                                                                                      000444
                                                                                      000445
       IN(9) = LCOL(9)
                                                                                      000446
       IN(13) = INDX(3) - 1
                                                                                      000447
       IN(14) = LCOL(14)
                                                                                      000448
       IN(19)=LCOL(19)
                                                                                      000449
       IN(21) = LCOL(21)
                                                                                      000450
       IN(24) = LCOL(24)
                                                                                      000451
       IN(26) = LCOL(26)
                                                                                      000452
       IF(MSI.EQ.2)INDX(2)=1
                                                                                      000453
   15 CONTINUE
                                                                                      000454
       CALL OPENMS(1, INDEX1, IREC1, 0) 1.
                                                                                      000455
```

```
IF(MSI.NE.2) CALL OPENMS(2, INDEX2, IREC2:0)
                                                                                    000456
       CALL OPENMS(3, INDEX3, IREC3,0) & CALL OPENMS(7, INDEX7, IREC3,0)
                                                                                    000457
                                                                                    000458
    21 IF(IN(23).EQ.0.OR.IN(23).EQ.2) GOTO 5
                                                                                    000459
                                                                                    000460
\mathbf{C}
            READ THE INFORMATION STORED IN THE RANDOM FILES
                                                                                    000461
\mathbf{C}
                                                                                    000462
       CALL READMS(5, IADREC, LLDR, INDX(5))
                                                                                    000463
       CALL READMS(3, BREC, LDREC, INDX(3))
                                                                                    000464
       IF(MSI.NE.1.AND.MSI.NE.3) GOTO 7
                                                                                    000465
                                                                                    000466
\mathbf{C}
            READ THE FIRST DATA RECORD FROM RANDOM FILE NO.2.
                                                                                    000467
00000000
                                                                                    000468
            INDICES OF MODIFIED SUBGRAPHS ARE STORED IN THE FIRST NMS
                                                                                    000469
                                                                                    000470
            ELEMENTS OF MATRIX NSUB STORED IN THE FIRST RECORD OF
                                                                                    000471
                                                                                    000472
            RANDOM FILE NO.2 AT THE BEGINNING OF THE INFORMATION ON
                                                                                    000473
                                                                                    000474
           SUBGRAPHS. ELEMENT NMS+K, 11<=K<=NMS OF MATRIX NSUB STORES THE
                                                                                    000475
Ċ
                                                                                    000476
Č
           LENGTH OF THE RECORD ASSOCIATED WITH THE KTH SUBGRAPH
                                                                                    000477
                                                                                    000478
       LDDX= IN(25) *2.
                                                                                    000479
       CALL READMS(2, DREC, LDDX, 1)
                                                                                    000480
       CONTINUE
                                                                                    000481
       NSBR= IN( 14)
                                                                                    000482
       NMS2=2*NMS
                                                                                    000483
       DO 6 I=1, NMS2
                                                                                    000484
       NSUB(I) = INT(REAL(DREC(I)))
                                             )
                                                                                    000485
      NASUB(I) = INT(AIMAG(DREC(I))) | | | | |
                                                                                    000486
       DO 14 I=1, NMS
                                                                                    000487
       CALL ABSUB(NSUB(I), IT)
                                                                                    000488
       IF(IN(7).EQ.1.OR.IN(7).EQ.3) GOTO: 1
                                                                                    000489
       WRITE(6, 123) (NSUB(I), I=1, NMS)).
                                                                                    000490
     1 CONTINUE
                                                                                    000491
123
       FORMAT(1H, //, "INDICES OF MODIFIED SUBGRAPHS", //, (2014))
                                                                         ( )
                                                                                    000492
       DO 2 NBS=1.NMS
                                                                                    000493
\mathbf{C}
                                                                                    000494
\mathbf{c}
           READ THE MODIFIED SUBGRAPH HAVING INDEX NSUB(NBS)
                                                                                    000495
C
                                                                                    000496
       IF(IN(8).LT.8) CALL READSB(CE, NSUB, NASUB, NBS, DREC, INDX, LDDX, NMS)
                                                                                    000497
       IF(IN(8).EQ.8) CALL READSB(V, NSUB, NASUB, NBS, DREC, INDX, LDDX, NMS)
                                                                                    000498
       IF(IN(8).EQ.8) GOTO 8
                                                                                    000499
C
                                                                                    000500
С
           FOR AN UPDATED COEFFICIENT MATRIX AND RHS VECTOR
                                                                                    000501
C
                                                                                    000502
C
           INFORMATION ABOUT THE SUBGRAPH IS STORED IN THE REAL AND
                                                                                    000503
č
                                                                                    000504
           IMAGINARY PARTS OF COMPLEX MATRIX CE IN THE SEQUENCE
                                                                                    000505
C
                                                                                    000506
           (N, NINT), (LES, NEL), AK, (NROW, NCOL), V, NON
                                                                                    000507
C
                                                                                    000508
C
           WHEN ONLY THE RHS IS UPDATED THE VECTOR V CONTAINS THIS RHS
                                                                                    000509
                                                                                    000510
       IN(1) = INT(REAL(CE(1)))
                                                                                    000511
       NEL=INT(AIMAG(CE(2)))
                                       1 ;
                                                                                    000512
       N= IN(1)
                                                                                    000513
       IN(2) = INT(REAL(CE(2)))
                                       3.3
                                                                                    000514
       IN(3)=2
                                                                                    000515
       IN(6) = INT(AIMAG(CE(1))) (3)
                                       1.3
                                                                                    000516
C
                                                                                    000517
С
           CHECK INPUT DATA DESCRIBING NBS-TH SUBNETWORKS
                                                                                    000518
\mathbf{C}
                                                                                    000519
       IF(N.GT. IN(16)) GOTO 12.
                                                                                    000520
```

```
000521
       IF(IN(6).GT.N) GOTO 16
       IF(IN(2).GT.IN(17)) GOTO 17
IF(NEL.GT.IN(18))GOTO 18
                                                                                        000522
                                                                                         000523
                                                                                         000524
       DO 3 I=1, NEL
                                                                                         000525
       AK(I) = CE(I+2)
                                                                                         000526
       NROW( I) = INT( REAL( CE( I+NEL+2) ))
                                                                                         000527
    3 NCOL(I) = INT(AIMAG(CE(I+NEL+2)).)
                                                                                         000528
       IX=2*NEL+2
                                                                                         000529
       DO4 I=1,N
                                                                                         000530
       V(I) = CE(I + IX)
       IF(IN(8).EQ.7) GOTO 8
                                                                                         000531
                                                                                         000532
       IX=IX+N
                                                                                         000533
       IY=(N-1)/2
       DO 13 I=1, IY
NON(2*I) = INT(AIMAG(CE(IX+I)))
                                                                                         000534
                                                                                         000535
   13 NON(2*1-1) = INT(REAL(CE(IX+I)))
                                                                                         000536
                                                                                         000537
       IY= IY+1
                                                                                         000538
       NON(2*IY-1) = INT(REAL(CE(IX+IY)))
                                                                                         000539
       IF((2*IY).EQ.N) NON(2*IY) = INT(AIMAG(CE(IX+IY)))
                                                                                         000540
CCC
                                                                                         000541
            CHECK DIAGONAL ELEMENTS OF THE SUBMATRIX:
                                                                                         000542
                                                                                         000543
       CALL CHEDEL(IN(6), NEL, NCOL, NROW, NSUB, NBS, LCOL, IN(3))
                                                                                         000544
       IF(IN(3).EQ. 1) RETURN
                                                                                         000545
C
            ANALYSE THE SUBGRAPH AND STORE THE RESULTS IN THE BASIC
                                                                                         000546
CCC
                                                                                         000547
            RECORD
                                                                                         000548
                                                                                         000549
    8 IN3=2
       CALL ASUBSR(IN, LCOL, ITAG, CE, DE, V, IADREC, BREC, NSUB, INDEX3
                                                                                         000550
      + INDEX5, AK, NCOL, NROW, INDX, NON, N, NEL, NBS, NSBR, LREC, LADR, IN3)
                                                                                         000551
                                                                                         000552
       IF(IN(3).EQ.1) RETURN
                                                                                         000553
    2 CONTINUE
                                                                                         000554
       RETURN
    12 WRITE(6, 130) NSUB(NBS)
                                                                                         000555
                                                                                         000556
       IN(3) = 1
                                                                                         000557
       RETURN
  130 FORMAT(1H, /, " NUMBER OF UNKNOWNS IN THE SUBGRAPH", 14, " IS GREATER + THAN IN(16)",/)
                                                                                         000558
                                                                                         000559
                                                                                         000560
    16 WRITE(6, 140) NSUB(NBS)
                                                                                         000561
       IN(3)=1
                                                                                         000562
       RETURN
  140 FORMAT(1H, /, "NUMBER OF INTERNAL NODES IN THE SUBGRAPH", 14; " IS G +REATER THAN THE NUMBER OF UNKNOWNS IN THIS SUBGRAPH", /)
                                                                                         000563 :
                                                                                         000564
                                                                                         000565
    17 WRITE(6, 150) NSUB(NBS)
       IN(3) = 1
                                                                                         000566
                                                                                         000567
       RETURN
  150 FORMAT(1H, /, " LENGTH OF THE AREA PREDICTED FOR SPARSE MATRIX OPER +ATIONS IN THE SUBGRAPH", 14, " IS GREATER THAN IN(17)",/)
                                                                                         000568
                                                                                         000569
                                                                                         000570
    18 WRITE(6, 160) NSUB(NBS)
                                                                                         000571
       IN(3) = 1
                                                                                         000572
       RETURN
  160 FORMAT(1H ,/, " NUMBER OF NONZERO ELEMENTS IN THE SUBGRAPH", 14, " IS
                                                                                         000573 :::
                                                                                         000574
        GREATER THAN IN(18) ",/)
                                                                                         000575
                                                                                         000576
                                                                                         000577
C
                                                                                         000578
       SUBROUTINE ABSUB(N, IT)
                                                                                         000579
            THIS SUBROUTINE ADDS BINARY CODE OF A SUBNETWORK NO. N TO THE
                                                                                         000580
\mathbf{c}
                                                                                         000581
č
                                                                                         000582
            VECTOR IT
                                                                                         000583
                                                                                         000584
       DIMENSION IT(1)
                                                                                         000585
       IB= 1
```

	IA=(N-1)/50+1 :- IC=N-(IA-1)*50-1	00058 6 00058 7
	ID=SHIFT(IR.IC)	000588
	IT(IA) = OR(IT(IA), ID)	000589 000590
	RETURN END	000591
C		000592
C	SUBROUTINE CHEBSUB(N, IT, IR)	000593 000594
C		000595
C	THIS SUBROUTINE CHECKS BINARY CODE OF A SUBNETWORK NO. N	000596 000597
C	IN THE VECTOR IT	000598
Ċ	PARTYCLON IN(1)	000599 000600
	DIMENSION IT(1) IB=1	000601
	IA=(N-1)/50+1	000602
	IC=N-(IA-1)*50-1 ID=SHIFT(IB, IC)	000603 000604
	IR=AND(IT(IA), ID)	000605
	RETURN	000606 000607
C	END	000608
Ğ		000609
C	SUBROUTINE STOREF(NR, INTWA, LGTH, IND, INDEX5)	000610 000611
C C	THIS SUBROUTINE STORES INTEGER VECTOR TO MASS STORAGE FILE	000612
C C	NO. NR	000613 000614
C		000615
	INTEGER INTWA(1), INDEX5(1)	000616 000617
	CALL WRITMS(NR, INTWA, LGTH, IND). RETURN	000618
	END	000619 000620
C		000621
u	SUBROUTINE READF(NR, INTWA, LGTH, IND, INDEX5)	000622
C	THIS SUBROUTINEUREADS INTEGER VECTOR FROM MASS STORAGE FILE	000623 000624
C	THIS SUBROUTINE READS THIESER VEGTOR TRUIT INDES STORAGE TIES	000625
C	NO. NR	000626 000627
C	INTEGER INTWA(1), INDEX5(1) CALL READMS(NR, INTWA, LGTH, IND)	000628
		00062 9 000630
	RETURN END	000631
C		000632
C	SUBROUTINE READSB(CE, NSUB, NASUB, NBS, DREC, INDX, LDREC, NMS)	000633 000634
C		000635
C	THIS SUBROUTINE READS INPUT DATA FOR THE SUBGRAPH	000636 000637
C C	WHOSE INDEX IS NBS OR THE STATE OF THE STATE	000638
C		000639 000640
	INTEGER NSUB(1), NASUB(1), INDX(1) COMPLEX CE(1), DREC(1)	000641
	IF(NASUB(NBS), EQ. INDX(2)) GOTO 1	000642 000643
	CALL READMS(2, DREC, LDREC, NASUB(NBS)) INDX(2) = NASUB(NBS)	000644
	1 IAD=NASUB(NMS+NBS)-1	000645
	IC=NSUB(NMS+NBS)	000646 000647
	DO 2 I=1, IG 2 CE(I)=DREC(IAD+I)	000648
	RETURN	000649 000650
	END	969999

```
000651
                                                                                      000652
       SUBROUTINE CHEDEL(NINT, NEL, NCOL, NROW, NSUB, NBS, L, NN)
                                                                                      000653
                                                                                      000654
C
           THIS SUBROUTINE CHECKS WHETHER ALL DIAGONAL ELEMENTS ARE
                                                                                      000655
C
                                                                                      000656
           DEFINED IN THE SUBGRAPH NSUB(NBS)
                                                                                      000657
\mathbf{c}
                                                                                      000658
       INTEGER NCOL(1), NROW(1), NSUB(1), L(1)
                                                                                      000659
                                                                                      000660
       NN = 0
       DO 1 I=1, NINT
                                                                                      000661
    1 L(I)=0
                                                                                      000662
                                                                                      000663
       DO 2 I=1, NEL
       IF(NCOL(I).EQ.NROW(I)) L(NCOL(I))=1
                                                                                      000664
                                                                                      000665
       DO 3. I=1, NINT
                                                                                      000666
      IL=IL+L(I)
                                                                                      000667
       IF (IL. EQ. NINT) RETURN
                                                                                      000668
  WRITE(6,100) NSUB(NBS)

100 FORMAT(1H ,/, " ALL DIAGONAL ELEMENTS SHOULD BE DEFINED IN THE SUBM +ATRIX NO. ", 15)
                                                                                      000669
                                                                                      000670 ::.
                                                                                      000671
                                                                                      000672
       NN=1
                                                                                      000673
       RETURN
                                                                                      000674
       END
\mathbf{C}
                                                                                      000675
\mathbf{C}
                                                                                      000676
       SUBROUTINE ASUBSR(IN, LCOL, ITAG, CE, DE, V, IADREC, BREC, NSUB, INDEX3,
                                                                                      000677
     + INDEX5, AK, NCOL, NROW, INDX, NON, N, NEL, NBS, NSBR, LREC, LADR, IN3)
                                                                                      000678
                                                                                      000679
\mathbf{C}
           THIS SUBROUTINE ANALYSES THE SUBGRAPH AND STORES THE RESULTS
                                                                                      000680
C
                                                                                      000681
C
           OF ANALYSIS IN THE BASIC RECORD BREC
                                                                                      000682
CCCCCC
                                                                                      000683
           THE REAL PARTS OF THE FIRST 256 ELEMENTS OF EACH BASIC RECORD
                                                                                      000684
                                                                                      000685
           CONTAIN THE ADDRESSES OF THE RESULTS FOR DIFFERENT SUBGRAPHS.
                                                                                      000686.
                                                                                      000687
Ċ
           RESULTS ARE STORED IN THE COMPLEX VECTOR BREC IN THE SEQUENCE:
                                                                                      000688
                                                                                      000689
Č
           (N,NINT),(LES,LTHR),(LCOL(1),LCOL(N+2)),(LCOL(N+1),LCOL(2N+2))
                                                                                      000690+>
                                                                                      000691
           (ITAG(1),(ITAG(LES+1)),CE,DE,V
                                                                                      000692
\mathbf{C}
                                                                                      000693
C
     DIMENSION IN(1), LCOL(1), ITAG(1), IADREC(1), NSUB(1), INDEX3(1), +INDEX5(1), NCOL(1), NROW(1), INDX(1), NON(1)
                                                                                      000694
                                                                                      000695
       COMPLEX CE(1), DE(1), V(1), BREC(1), AK(1), COEFF
                                                                                      000696
                                                                                      000697
\mathbf{C}
       LLDR=LADR*2
                                                                                      000698
                                                                                      000699
       LDREC=2*LREC
                                                                                      999799
       LES= IN(2)
                                                                                      000701
       LTHR=(2+5*N+5*LES)*2
       NMS= IN( 10)
                                                                                      000702
                                                                                      000703
           PRINT THE COEFFICIENT MATRIX
                                                                                      000704
C
                                                                                      000705
                                                                                      000706
       IF(IN(7).EQ.1.OR.IN(7).EQ.3) GOTO 15
                                                                                      000707
       IF(IN(8).EQ.8) GOTO 28
       WRITE(6,20) NSUB(NBS)
                                                                                      000708
                                                                                      000709
       CALL PRINTNC(NEL, NROW, NCOL, AK)
                                                    )
       WRITE(6,49)
                                                                                      000710
       CALL PRINT(N, V)
                                                                                      000711
       FORMAT(1H ,/, " RHS VECTOR ",/)
49
                                                                                      000712
       CONTINUE
                                                                                      000713
15
       IF(IN(8).EQ.7) GOTO 21
                                                                                      000714
                                                                                      000715
       IF(IN(8).EQ.8) GOTO 19
```

```
000716
                                                                                      000717
           THIS PART IS EXECUTED WHEN THE SUBGRAPH IS ANALYSED FOR THE
\mathbf{C}
                                                                                      000718
\mathbf{C}
           FIRST TIME
                                                                                      000719
\bar{\mathbf{C}}
       CALL DATAC(N, NEL, AK, NCOL, NROW, LCOL, ITAG, CE, DE, IN(2), IN(3))
                                                                                      000720
      IF(IN(3).EQ.1) RETURN
FORMAT(1H, /, " COEFFICIENT MATRIX OF SUBGRAPH NO", I3, /)
                                                                                      000721
                                                                                      000722
                                                                                      000723
       IN(3) = 2
       IF(IN3.EQ.0) IN(3) = 0.
                                                                                      000724
                                                                                      000725
C
           PERFORM PARTIAL BIFACTORIZATION OF THE SUBGRAPH MATRIX
Č
                                                                                      000726
                                                                                      000727
       CALL CSSLE1(IN, LCOL, ITAG, CE, DE, V, EPS)
                                                                                      000728
                                                                                      000729
       IF(IN(3).EQ.1) RETURN
                                                                                      000730
       LES= IN(2)
                                                                                      999731
       NINT=IN(6)
                                                                                      000732
C
           MULTIPLY LEFT PART OF LR FACTORIZATION BY THEIRES VECTOR FOR:
                                                                                      000733
CCC
                                                                                      000734
           THE NBS SUBGRAPH
                                                                                      000735
       CALL LMIRHS(NINT, LCOL, LCOL(2*N+2), ITAG, ITAG(LES+1), CE, DE, V)),
                                                                                      000736
                                                                                      000737
C
                                                                                      000738
       LTHR=(2+5*N+5*LES)*2
       IF(IN(23).NE.1) GOTO 1
                                                                                      000739
                                                                                      000740
\mathbf{C}
           READ THE ADDRESS FOR THE SUBGRAPH NSUB(NBS) AND THE INDEX
                                                                                      000741
\mathbf{C}
           OF THE BASIC RECORD
                                                                                      000742
\mathbf{C}
                                                                                      000743
                                                                                      000744
       NADR=(NSUB(NBS)-1)/LADR+1
       IADR=NSUB(NBS)-(NADR-1)*LADR
                                                                                      000745
                                                                                      000746
       IF(INDX(5).EQ.NADR): GOTO 2
       CALL WRITMS(5, IADREC, LLDR, INDX(5),1,1)
                                                                                      000747
       CALL READMS(5, IADREC, LLDR, NADR)
                                                                                      000748
       INDX(5) = NADR
                                                                                      000749
                                                                                      000750
           READ BASIC RECORD
                                         11:
                                                                                      000751
_{\mathbf{C}}^{\mathbf{C}}
                                                                                      000752
                                                                                      000753
    2 NRBR= IADREC( IADR)
       NSBR=IADREC(IADR+LADR)
                                                                                      000754
       IF(INDX(3).EQ.NRBR)/GOTO 3
                                                                                      000755
       IF(INDX(3).GT.IN(15)) GOTO 14))
                                                                                      000756
       CALL WRITMS(3, BREC, LDREC, INDX(3), 1, 1)
CALL READMS(3, BREC, LDREC, NRBR)
                                                                                      000757
                                                                                      000758
                                                                                      000759
       INDX(3)=NRBR
       сото з
                                                                                      000760
     1 NSBR=NSBR+1
                                                                                      000761
                                                                                      000762
       IN(14) = IN(14) + 1
       IF(INDX(3).GT.IN(13)) GOTO 17)
                                                                                      000763
                                                                                      000764
       INDX(3) = IN(13) + 1
       CALL READMS(3, BREC, LDREC, INDX(3))
                                                                                      000765
                                                                                      000766
C
Č
            IF NSBR 255 OPEN NEW BASIC RECORD
                                                                                      000767
                                                                                      000768
   17 IF(NSBR.GT.255) GOTO 13
                                                                                      000769
       IADR1=INT(REAL(BREC(NSBR)))
                                                                                      000770
                                                                                      000771
       IADR= IADR1+LTHR
                                                                                      000772
                                                                                      000773 S.
            IF IADR> 2*LREC THEN STORE THE BASIC RECORD AND OPEN A NEW ONE.
000000
                                                                                      000774
           BASIC RECORDS ARE STORED IN THE RANDOM FILE NO.3, EACH HAVING
                                                                                      000775
                                                                                      000776
                                                                                      000777
           LREC COMPLEX ELEMENTS
                                                                                      000778
                                                                                      000779
       IF (IADR.LE:LDREC) GOTO 10
                                                                                      000780
   13 IN(13) = IN(13)+1
```

```
000781
       INDX(3) = IN(13) + 1
       IF(IN(23).NE.1) GOTO.4
                                                                                       000782
       WRITE(6, 130) NSUB(NBS)
                                                                                       000783
  130 FORMAT(1H,/," MODIFIED SUBGRAPH NO.",14," REQUIRES MORE STORAGE T +HAN THE PREVIOUS ONE",/," REPEAT ANALYSIS FOR ALL SUBGRAPHS",/)
                                                                                       000784
                                                                                       000785
       IN(3) = 1
                                                                                       000786
                                                                                       000787
       RETURN
      IF(IN(13).GT.IN(15)) GOTO 14 CALL WRITMS(3, BREC, LDREC, IN(13)) DO 9 I=2,256
                                                                                       000788
                                                                                       000789
                                                                                       000790
      BREC(I) = CMPLX(0.,0.)
                                                                                       999791
                                                                                       000792
       NSBR= 1
                                                                                       000793
       IN(14) = 1
       IADR1=514
                                                                                       000794
       IADR=514+LTHR
                                                                                       000795
       IF(IADR.GT.LDREC) GOTO12::
                                                                                       000796
\mathbf{C}
                                                                                       000797
\mathbf{C}
           STORE THE SUBGRAPH WHOSE INDEX: IS NSBR
                                                                                       000798
                                                                                       000799
   10 BREC(NSBR+1) = CMPLX(FLOAT(IADR), 0.)
                                                                                       ดดดลดด
       BREC(NSBR) = CMPLX(REAL(BREC(NSBR)), FLOAT(LTHR))
                                                                                       000801
       IAD= IADR1/2
                                                                                       000802
       BREC(IAD) = CMPLX(FLOAT(N), FLOAT(NINT))
                                                                                       000803
       BREC(IAD+1) = CMPLX(FLOAT(LCOL(1)), FLOAT(LES))
                                                                                       000804
                                                                                       000805
       N1=N+1
                                                                                       000806
       DO 5 I=2,N1
    5 BREC(IAD+I) = CMPLX(FLOAT(LCOL(I)), FLOAT(LCOL(I+N)))
                                                                                       000807
       N2= IAD+ 1+N
                                                                                       000808
       N3=2*N+1
                                                                                       000809
       DO 6 I=1.N
                                                                                       000810
    6 BREC(N2+1)=CMPLX(FLOAT(NON(I)),FLOAT(LCOL(N3+I)))
                                                                                       000811
                                                                                       000812
       N2= IAD+1+2*N
                                                                                       000813
       DO 7 I=1,LES
      BREC(N2+I) = CMPLX(FLOAT(ITAG(I)), FLOAT(ITAG(I+LES)))
                                                                             1)
                                                                                       000814
   26 N3=N2+LES
                                                                                       000815
       LES4=LES*4
                                                                                       000816
       DO 25 I=1, LES4
                                                                                       000817
   25 BREC(N3+I) = CE(I)
                                                                                       000818
                                                                                       000819
       NN=2*N
       N2=N3+LES4
                                                                                       000820
       N3=N2+NN
                                                                                       000821
       DO 8 I=1,NN
                                                                                       000822
    8 BREC(N2+1) = DE(1)
                                                                                       000823
                                                                                       000824
   30 DO 31
               I = 1. N
   31 BREC(N3+I)=V(I)
                                                                                       000825
                                                                                       000826
           STORE ADDRESS FOR THE SUBGRAPH NSUBCRBS): IN THE RECORD 485. WHOSE INDEX IS NADR :
C
                                                                                       000827
                                                                                       000828
                                                                                       000829
       NADR=(NSUB(NBS)-1)/LADR+1
                                                                                       900830
       IADR=NSUB(NBS)-(NADR-1)*LADR R
                                                                                       000831
       IF(INDX(5).EQ.NADR) GOTO 11
IF(IN(23).EQ.2) RETURN
                                                                                       000832
                                                                                       000833
       IF(NADR.GT.((IN(9)-1)/IN(12)+1)) GOTO 16)
                                                                                       000834
                                                                                       000835
            ADDRESSES FOR SUBGRAPHS ARE STORED IN RECORD NO. NADR IN
                                                                                       000836
0000000000
                                                                                       000837
           RANDOM FILE NO.5. THE INDEX OF THE BASIC RECORD WHICH STORES
                                                                                       000838
                                                                                       000839
           THE RESULT OF THE ANALYSIS OF THE SUBGRAPH IS STORED IN THE
                                                                                       000840
                                                                                       000841
           POSITION IADR, WHILE THE INDEX OF THE SUBGRAPH IN THE BASIC
                                                                                       000842
                                                                                       000843
           RECORD IS STORED IN THE POSITION IADR+LADR
                                                                                       000844
                                                                                       000845
```

```
IF(IN(23).NE.1) CALL WRITMS(5, IADREC, LLDR, INDX(5))
                                                                                   000846
                                                                                   000847
       IF(IN(23).EQ.1) CALL WRITMS(5, IADREC, LLDR, INDX(5), 1, 1)
                                                                                   000848
       IF(INDX(5).GT.IN(24)) IN(24) = INDX(5)
       IF(NADR.GT. IN(24)) GOTO 18
                                                                                   000849
   CALL READMS(5, IADREC, LLDR, NADR)
18 INDX(5) = NADR
                                                                                   000850
                                                                                   000851
   11 IADREC(IADR) = INDX(3)
                                                                                   000852
       IADREC(IADR+LADR) = NSBR
                                                                                   000853
                                                                                   000854
       RETURN
                                                                                   000855
\mathbf{C}
           THIS PART IS EXECUTED AFTER UPDATING THE COEFFICIENT MATRIX
                                                                                   000856
000000
                                                                                   000857
           WITHIN THE SAME PATTERN OF NONZERO ELEMENTS. 200
                                                                                   000858
                                                                                   000859
           READ SUBGRAPH NSUB(NSB) FROM THE BASIC RECORDS
                                                                                   000860
                                                                                   000861
   21 CALL RSBR(NSUB(NBS), LADR, INDX, IADREC, BREC, LREC, LCOL, NON, DE, V, ITAG,
                                                                                   000862
                                                                                   000863
     +CE, INDEX3; INDEX5, N, NINT, LES, IAA, IN, IAD, NSBR)
                                                                                   000864
      LES2=LES*2
                                                                                   000865
      DO 27 I=1, LES2
                                                                                   000866
      CE(I) = CE(LES2+I)
                                                                                   000867
       DO 34 I=1,N
                                                                                   000868
   34 DE(I) = DE(N+I) ->
                                                                                   000869
č
                                                                                   900870
           UPDATE THE COEFFICIENT MATRIX
                                                                                   000871
                                                                                   000872
      DO 22 I=1, NEL
                                                                                   000873
       NRW= NROW( I)
                                                                                   000874
       NCL=NCOL(1)
                                                                                   000875
       COEFF=AK( I)
       IF(NRW.GT.N.OR.NRW.LE.O.OR.NCL.GT.N.OR.NCL.LE.O) GOTO 23
                                                                                   000876
       CALL CHNGE(IEX, NRW, NCL, COEFF, LCOL, ITAG, ITAG(LES+1), CE, CE(LES+1), DE
                                                                                   000877
                                                                                   000878
                                                                                   000879
   22 IF( IEX. EQ. 1) GOTO 23
                                                                                   000880
\mathbf{c}
           STORE UPPER AND LOWER PARTS
                                                                                   000881
C
                                                                                   000882
\mathbf{C}
                                                                                   000883
       DO 32 I=1,LES2
                                                                                   000884
   32 CE(LES2+I) = CE(I)
                                                                                   000885
C
                                                                                   000886
\mathbf{C}
           STORE DIAGONAL ELEMENTS
                                                                                   000887
\mathbf{C}
                                                                                   000888
      DO 33 I=1,N
                                                                                   000889
   33 DE(N+I) = DE(I)
                                                                                   000890
C
                                                                                   000891
           PERFORM PARTIAL BIFACTORIZATION
                                                                                   000892
C
      CALL REDUCN(N, LCOL, LCOL(2*N+2), ITAG, ITAG(LES+1), CE, CE(LES+1), DE, NI
                                                                                   000893
                                                                                   000894
                                                                                   000895
C
           MULTIPLY LEFT PART OF LR BIFACTORIZATION BY THE RHS VECTOR
                                                                                   000896
\mathbf{C}
                                                                                   000897
\mathbf{C}
       CALL LMIRHS(NINT, LCOL, LCOL(2*N+2), ITAG, ITAG(LES+1), CE, DE, V)).
                                                                                    000898
                                                                                   000899
       N2= IAD+1+2*N
                                                                                   99999
       GOTO 26
                                                                                   000901
   12 WRITE(6, 100)
  100 FORMAT(1H ,/, " BASIC RECORD TOO SMALL TO STORE RESULTS",/,
                                                                                   99992
                                                                                   000903
     +" INCREASE IN(11)",/)
                                                                                   000904
       IN(3) = 1
                                                                                   000905
       RETURN
                                                                                   000906
CCC
           THIS PART IS EXECUTED AFER UPDATING:RHS ONLY
                                                                                   99997
                                                                                   000908
                                                                                   000909
   28 N=NSUB(NMS+NBS)
                                                                                   000910
       WRITE(6,29) NSUB(NBS)
```

```
29 FORMAT(1H ./, " UPDATED RIGHT HAND SIDE VECTOR OF THE SUBGRAPH NO
                                                                                    000911
                                                                                   000912
     +", I3/)
      CALL PRINT(N, V)
                                                                                   000913
                                                                                   000914
           READ SUBGRAPH NSUB(NBS) FROM THE BASIC RECORD
                                                                                    000915
C
                                                                                   000916
\mathbf{C}
   19 CALL RSBR(NSUB(NBS), LADR, INDX, IADREC, BREC, LREC, LCOL, NON, DE, V, ITAG,
                                                                                   000917
                                                                                   999918
     +CE, INDEX3; INDEX5, N, NINT, LES, IAA, IN, IAD, NSBR)
                                                                                   000919
C
           MULTIPLY LEFT PART OF LR BIFACTORIZATION BY THE RHS VECTOR
                                                                                    000920
\mathbf{C}
                                                                                    000921
      CALL LMIRHS(NINT, LCOL, LCOL(2*N+2), ITAG, ITAG(LES+1), CE, DE, V));
                                                                                   000922
                                                                                   000923
      N3 = IAD + 1 + N*4 + LES*5
                                                                                   000924
      GOTO 30
   14 WRITE(6, 110)
                                                                                   000925
  110 FORMAT(1H,/, " NUMBER OF PREDICTED BASIC RECORDS TOO SMALL",/, +" INCREASE IN(15)",/)
                                                                                    000926
                                                                                   000927
                                                                                   000928
      IN(3) = 1
      RETURN
                                                                                   000929
                                                                                   000930
   16 WRITE(6, 120)
  120 FORMAT(1H ,/, " NUMBER OF ADDRESSING RECORDS TOO SMALL",/,
                                                                                   000931
      " CHECK INDICES OF MODIFIED SUBGRAPHS AT THE RANDOM FILE NO 2",/)
                                                                                    000932
      IN(3) = 1
                                                                                   000933
                                                                                   000934
      RETURN
                                                                                   000935
   23 WRITE(6,24)
   24 FORMAT(1H , " ELEMENT OUT OF THE MATRIX AREA",/)
                                                                                   000936
                                                                                   000937
       IN(3) = 1
      RETURN
                                                                                   000938
                                                                                    000939
      END
                                                                                    000940
C
                                                                                   000941
\mathbf{C}
      SUBROUTINE LMIRHS(NINT, LCOL, NSEQ, ITAG, LNXT, CE, DE, V)
                                                                                   000942
\mathbf{C}
                                                                                   000943
C
           THIS SUBROUTINE MULTIPLIES THE LEFT PART OF LR FACTORIZATION
                                                                                   000944
                                                                                   000945
C
           BY THE RHS VECTOR FOR INTERNAL NODES OF A SUBGRAPH.
                                                                                   000946
                                                                                   000947
CCCCC
           THE LEFT-HAND FACTOR MATRIX IS ASSUMED TO HAVE DIAGONAL
                                                                                   000948
                                                                                   000949
           ELEMENTS EQUAL TO 1.
                                                                                   000950
                                                                                   000951
       INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1)
                                                                                   000952
      COMPLEX CE(1), DE(1), V(1). CF
                                                                                    000953
                                                                                   000954
C
          NINT - NUMBER OF INTERNAL! NODES
                                                                                   000955
C
                                                                                   000956
       IF(NINT.LE.0) RETURN
                                                                                   000957
      DO 20 J=1,NINT
                                                                                   000958
      K=NSEQ(J)
                                                                                   000959
      CF=DE(K)*V(K)
                                                                                   000960
                                                                                   000961
      V(K) = CF
      L=LCOL(K)
                                                                                   000962
   10 IF(L.LE.0) GOTO 20 )
                                                                                   000963
       I = ITAG(L)
                                                                                   000964
                                                                                   000965
       V(I) = V(I) - CE(L) * CF
                                                                                   000966
      L=LNXT(L)
   GOTO 10
20 CONTINUE
                                                                                   000967
                                                                                   000968
      RETURN
                                                                                   000969
                                                                                   000970
      END
                                                                                   000971
C
                                                                                   000972
\mathbf{C}
      SUBROUTINE ANSUBSN(IN,LCOL, ITAG, CE, DE, V, IADREC, BREC, NSUB, INDEX3, IN
                                                                                   000973 U
                                                                                   000974
     +DEX5, AK, NCOL, NROW, INDX, NON, NEXTN, RHSR, INDEX1, IT)
                                                                                   000975
C
```

```
THIS SUBROUTINE PERFORMS ANALYSIS OF SUBSTITUTE GRAPHS. 15.
                                                                                  000976
                                                                                  000977
\mathbf{C}
           ONLY SUBSTITUTE GRAPHS WHICH ARE NECESSARY FOR UPDATING THE
                                                                                  000978
C
C
                                                                                  000979
           RESULTS OF THE PREVIOUS SOLUTION WILL BE ANALYSED
                                                                                  000980
\mathbf{C}
                                                                                  000981
      DIMENSION IN(1), LCOL(1), ITAG(1), IADREC(1), NSUB(1), INDEX1(1),
                                                                                  000982
     +INDEX3(1); INDEX5(1), NCOL(1), NROW(1), INDX(1), NON(1), NEXTN(1), IT(1)
                                                                                  000983
                                                                                  000984
      COMPLEX CE(1), DE(1), V(1), BREC(1), AK(1), RHSR(1)
                                                                                  000985
C
                    CONTAINS NUMBERS OF EXTERNAL NODES FOR EACH SUBSTITUTE
                                                                                  000986 ::
C
           NEXTN
                                                                                  000987
C
                                                                                  000988
                    SUBGRAPH. SUBSTITUTE SUBGRAPH NO.1 MUST HAVE ZERO
C
                                                                                  000989
C
                                                                                  000990
C
                    EXTERNAL NODES
                                                                                  000991
CCC
                                                                                  000992
           CALCULATE THE ADDRESSES FOR WORKING AREAS
                                                                                  000993
                                                                                  000994
      IA1= IN(16)+1
       IA2= IN( 17) /2+1
                                                                                  000995
                                                                                  000996
       IA3= IN( 17)+1
                                                                                  000997
       IA4= IN( 17) + IA2
                                                                                  000998
       IA5=IN(26)/IN(25)+11/
                                                                                  000999
       IB1= IN( 16)/2+1
                                                                                  001000
      LADR= IN(12)
                                                                                  001001
      NSBR= IN( 14)
                                                                                  001002
      LREC=IN(11)
                                                                                  001003
      LDRR=2*IN(25)
                                                                                  001004
      LDREC=2*LREC
                                                                                  001005
      LLDR=2*LADR
                                                                                  001006
       IF(IN(23).EQ.0.OR.IN(23).EQ.2) GOTO 8
                                                                                  001007
                                                                                  001008
Č
           READ STORED PARTIAL SOLUTION
                                                                                  001009
                                                                                  001010
       IF(IN(23).EQ.3)GOTO.12
                                                                                  001011
      DO 11 I=1, IA5
                                                                                  001012
      CALL READMS(1, RHSR, LDRR, IA5+I)
                                                                                  001013
   11 CALL WRITMS(1,RHSR,LDRR,I,1,1)
                                                                                  001014
   12 CONTINUE
                                                                                  001015
       IF(IA5.NE.INDX(4)) CALL READMS(1,RHSR,LDRR,INDX(4))
                                                                                  001016
    8 CONTINUE
                                                                                  001017
\mathbf{C}
           READ NUMBERS OF EXTERNAL NODES FOR THE SUBSTITUTE SUBGRAPHS
                                                                                  901018
\mathbf{c}
                                                                                  001019
C
                                                                                  001020
      ME= IN(9)/2
                                                                                  001021
      DO 9 I=1, ME
                                                                                  001022
    9 NEXTN(I)=IN(26+I)
                                                                                  001023
C
                                                                                  001024
           FIND A SEQUENCE OF MODIFIED SUBSTITUTE SUBGRAPHS
\mathbf{c}
                                                                                  001025
C
                                                                                  001026
      NMS= IN( 10)
                                                                                  001027
       IORD=0
                                                                                  001028
       CALL SMSSUB(NMS, NSUB, NCHS, IORD)
                                                  22.2
                                                                                  001029
\mathbf{C}
                                                                                  001030
           ANALYSE THE MODIFIED SUBSTITUTE SUBGRAPHS
C
                                                                                  001031
C
                                                                                  001032
      NS=NMS+1
                                                                                  001033
       IF(IN(7).EQ.1.OR.IN(7).EQ.3) GOTO 2
                                                  0::
       WRITE(6, 100) (NSUB(1), I=NS, NCHS)
                                                                                  001034
  100 FORMAT(1H ,/, " SEQUENCE OF SUBSTITUTE SUBGRAPHS TO BE REANALYZED"
                                                                                  001035."
                                                                                  001036
       ,//(2014))
                                                                                  001037
    2 CONTINUE
                                                                                  001038
CCC
           MODIFIED SUBSTITUTE SUBGRAPHS HAVE INDICES PLACED IN NSUB
                                                                                  001039
                                                                                  001040
```

```
IN ADDRESSES FROM NS+1 TO NCHS. THE HIGHER ADDRESS
\mathbf{C}
                                                                                          001041
С
                                                                                          001042
\mathbf{C}
            THE LOWER THE INDEX OF THE CORRESPONDING SUBSTITUTE SUBGRAPH.
                                                                                          001043
                                                                                          001044
       DO 1 I=NS, NCHS
                                                                                          001045
       NSB=NSUB(I)
                                                                                          001046
       NSB1=2*NSB
                                                                                          001047
       NSB2=NSB1+1
                                                                                          001048
       CALL CHEBSUB(NSB1, IT, IR1)
                                                                                          001049
       CALL CHEBSUB(NSB2, IT, IR2)
                                                                                          001050
       IF(IR1.EQ.0.OR.IR2.EQ.0) GOTO-1
                                                                                          001051
       CALL ABSUB(NSB, IT)
CALL CONNECT(NSB1, NSB2, N, NEL, LCOL(1), LCOL(1A1), ITAG(1), ITAG(1A2)
                                                                                          001052
                                                                                          001053
      +, ITAG(IA3), ITAG(IA4), CE(I), CE(IA3), DE(I), DE(IBI), NON, NROW, NCOL, AK, +V, BREC, INDX, IADREC, LADR, IN, LREC, INDEX3, INDEX5)
                                                                                          001054
                                                                                          001055
       IF(IN(3).EQ.1) RETURN
                                                                                          001056
       IN(1) = N
                                                                                          001057
       IN(2) = NEL
                                                                                          001058
       IN(3)=2
                                                                                          001059
       IN(6)=N-NEXTN(NSB)
                                                                                          001060
                                                                                          001061
\bar{\mathbf{C}}
            CHECK DIAGONAL ELEMENTS IN THE SUBMATRIX :
                                                                                          001062
                                                                                          001063
       CALL CHEDEL(IN(6), NEL, NCOL, NROW, NSUB, NSB, LCOL, IN(3))
                                                                                          001064
       IF(IN(3).EQ. 1) RETURN
                                                                                          001065
       IF(IN(6).GT.0) GOTO 3
                                                                                          001066
       WRITE(6,110)
                                                                                          001067
  110 FORMAT(1H, /, " SUBSTITUTE MATRIX OF ZERO DIMENSION", /, "CHECK DA +DESCRIBING INDICES OF EXTERNAL NODES FOR SUBSTITUTE SUBGRAPHS")
                      , " SUBSTITUTE MATRIX OF ZERO DIMENSION", /, "CHECK DATA
                                                                                          001068
                                                                                          001069
                                                                                          001070
       IN(3)=1
       RETURN
                                                                                          001071
    3 IN3=0
                                                                                          001072
       CALL ASUBSR(IN, LCOL, ITAG, CE, DE, V, IADREC, BREC, NSUB, INDEX3,
                                                                                          001073
      + INDEX5, AK; NCOL, NROW, INDX, NON, N, NEL, I, NSBR, LREC, LADR, IN3)
                                                                                          001074
                                                                                          001075
            CALCULATE THE ADDRESS AND STORE RHS VECTOR
C
                                                                                          001076
                                                                                          001077
       CALL CASRHS(IN, RHSR, NSB, INDX, INDEX1, N, NEXTN, NSUB, V, NON)
                                                                                          001078
       IF(IN(3).EQ.1)RETURN
                                                                                          001079
     1 CONTINUE
                                                                                          001080
       IF(IN(23).EQ.2) RETURN
                                                                                          001081
                                                                                          001082
C
            STORE FINAL RESULTS (NOT NECESSARY WHEN THE PROGRAM IS 🕾
                                                                                          001083
C
            EXECUTED WITHOUT CREATING PERMANENT FILES)
                                                                                          001084
C
                                                                                          001085
       LLD1=LADR*2
                                                                                          001086
       IN(13) = IN(13) + 1
                                                                                          001087
       IF(IN(23).EQ.1) IN(13) = INDX(3)
                                                                                          001088
       INDX(3) = IN(13)
                                                                                          001089
       IF(IN(13).GT.IN(15)) GOTO 5
                                                                                          001090
       IF(INDX(5).GT.((IN(9)-1)/LADR+1)) GOTO
                                                                                          001091
       IF(IN(23).EQ.0.OR.IN(23).EQ.3) GOTO 4
                                                                                          001092
       CALL WRITMS(1,RHSR,LDRR,IN(21),1,1)
CALL WRITMS(3,BREC,LDREC,IN(13),1,1)
                                                                                          001093
                                                             1
                                                                                          001094
       CALL WRITMS(5, IADREC, LLDR, INDX(5), 1, 1)
                                                                                          001095
            I=1, IA5
       DO 6
                                                                                          001096
       CALL READMS(1, RHSR, LDRR, I)
                                                                                          001097
            WRITMS(1,RHSR,LDRR,IA5+I,1,1)
      CALL
                                                                                          001098
                                                       - 1
       RETURN
                                                                                          001099
      CALL WRITMS(1, RHSR, LDRR, IN(21))
CALL WRITMS(3, BREC, LDREC, IN(13))
                                                       13
                                                                                          001100
                                                      :33
                                                                                          001101
       CALL WRITMS(5, IADREC, LLDR, INDX(5))
                                                      1.
                                                                                          001102
       DO 10 I=1, IA5
                                                                                          001103
       CALL READMS(1,RHSR,LDRR,I)
                                                                                          001104
   10 CALL WRITMS(1, RHSR, LDRR, IA5+I)
                                                                                          001105
```

```
001106
      RETURN
                                                                                    001107
  120 FORMAT(1H ,/, " NUMBER OF PREDICTED BASIC RECORDS TOO SMALL",/, + " INCREASE IN(15) ",/)
    5 WRITE(6,120)
                                                                                    001108
                                                                                    001109
                                                                                    001110
       IN(3)=1
                                                                                    001111
      RETURN
                                                                                    001112
      WRITE(6, 140)
  140 FORMAT(1H, /, " NUMBER OF ADDRESSING RECORDS TOO SMALL ",/, " CHECK + INDICES OF MODIFIED SUBGRAPHS AT THE RANDOM FILE NO 2",/)
                                                                                    001113%
                                                                                    001114
                                                                                    001115
       IN(3)=1
                                                                                    001116
       RETURN
                                                                                    001117
       END
                                                                                    001118
\mathbf{c}
                                                                                    001119
C
                                                                                    001120
       SUBROUTINE SMSSUB(NMS, NSUB, NCHS, 10RD)
                                                                                    001121
C
           THIS SUBROUTINE DETERMINES A SEQUENCE OF MODIFIED SUBSTITUTE
                                                                                    001122
CC
                                                                                     001123
                                                                                     001124
           SUBGRAPHS TO BE REANALYZED. NCHS IS THE TOTAL NUMBER OF
                                                                                     001125
C
           SUBGRAPHS WHICH ARE MODIFIED DURING THE HIERARCHICAL
                                                                                     001126
C
                                                                                     001127
CCCC
           ANALYSIS. INDICES OF SUBSTITUTE SUBGRAPHS MODIFIED
                                                                                     001128
                                                                                     001129
                                                                                     001130
           DURING THE ANALYSIS ARE STORED IN THE MATRIX NSUB IN
                                                                                     001131
                                                                                     001132
           ADDRESSES FROM NMS+1 TO NCHS
Č
                                                                                     001133
C
                                                                                     001134
       INTEGER NSUB(1)
                                                                                     001135
C
           ORDER MODIFIED SUBGRAPHS IN DECREASING SEQUENCE
                                                                          CHI
                                                                                     001136
C
                                                                                     001137
                                                                                     001138
       IF(NMS.LE.1) GOTO 2.
                                                                                     001139
       DO 1 I=2,NMS
                                                                                     001140
       J= I
                                                                                     001141
       IF(NSUB(J).LT.NSUB(J-1)) GOTOJ1
                                                                                     001142
       IA=NSUB(J)
                                                                                     001143
       NSUB(J) = NSUB(J-1)
                                                                                     001144
       NSUB(J-1) = IA
                                                                                     001145
       J=J-1
                                                                                     001146
       IF(J.LE.1) GOTO 1
                                                                                     001147
       GOTO 3
                                                                                     001148
       CONTINUE
                                                                                     001149
    2 CONTINUE
                                                                                     001150
            PREVIOUS PART OF NSUB CONTAINING LENGTHS OF RECORDS
                                                                                     001151
CCC
            STORING INFORMATION ABOUT BLOCKS WILL BE CHANGED
                                                                                     001152
                                                                                     001153
                                                                                     001154
       I = 1
                                                                                     001155
       J=NMS
                                                                                     001156
       IA=NSUB(I)
                                                                                     001157
       IB= IA/2
                                                                                     001158
       IF(IB.EQ.0) GOTO 4
                                                                                     001159
       IF(I.GT.NMS) GOTO 9
                                                                                     001160
       T = T + 1
       IF( IA.EQ. IB*2) GOTO 111
                                                                                     001161
                                                                                     001162
       IC=NSUB(I)/2
                                                                                     001163
       IF(IB.NE.IC) GOTO 11
                                                                                     001164
       T = T + 1
                                                                                     001165
       GOTO 11
                                                                                     001166
       J = J + 1
                                                                                     001167
       NSUB(J) = IB
                                                                                     001168
       GOTO 6
                                                                                     001169
       I = I + 1
                                                                                     001170
    11 IF(I.GT.J)GOTO 7
```

```
001171
       DO 10 IX=I,J
       IF(IB.NE.NSUB(IX)) GOTO 10
                                                                                            001172
       GOTO 6
                                                                                            001173
                                                                                            001174
   10 CONTINUE
                                                                                            001175
       GOTO 7
     4 NCHS=J
                                                                                            001176
                                                                                            001177
            ORDER MODIFIED SUBGRAPHS IN DECREASING SEQUENCE
                                                                                            001178
\mathbf{c}
                                                                                            001179
       IF(NCHS.LE.1) RETURN
                                                                                            001180
                                                                                            001181
       DO 14 I=2,NCHS
       J= I
                                                                                            001182
   13 IF(NSUB(J).LT.NSUB(J-1)) GOTO 14
                                                                                            001183
       IA=NSUB(J)
                                                                                            001184
       NSUB(J) = NSUB(J-1)
                                                                                            001185
       NSUB(J-1) = IA
                                                                                            001186
                                                                                            001187
       J=J-1
                                                                                            001188
       IF(J.LE.1) GOTO 14 +
       GOTO 13
                                                                                            001189
   14 CONTINUE
                                                                                            001190
                                                                                            001191
       RETURN
                                                                                            001192
       END
                                                                                            001193
                                                                                            001194
       SUBROUTINE CONNECT(NSB1,NSB2,N,NEL,NON1,NON2,NROW1,NROW2,NCOL1,NCO
                                                                                            001195
      +L2, AK1, AK2, V1, V2, NON, NROW, NCOL, AK, V, BREC, INDX, IADREC, LADR, IN, LREC
                                                                                            001196
      +, INDEX3, INDEX5)
                                                                                            001197
                                                                                            001198
            THIS SUBROUTINE COMBINES THE RESULTS OF ANALYSIS OF TWO
                                                                                            001199
\mathbf{C}
                                                                                            001200
\mathbf{C}
            SUBGRAPHS NSUB1 AND NSUB2 INTO THE DESCRIPTION OF A PROPER
                                                                                            001201
                                                                                            001202
            SUBGRAPH SPANNED OVER THEIR EXTERNAL NODES
                                                                                            001203
C
                                                                                            001204
C
      DIMENSION NON1(1), NON2(1), NROW1(1), NROW2(1), NCOL1(1), NCOL2(1), NON(+1), NROW(1), NCOL(1), INDX(1), IADREC(1), IN(1), INDEX3(1), INDEX5(1)

COMPLEX AK1(1), AK2(1), V1(1), V2(1), AK(1), V(1), BREC(1)
                                                                                            001205
                                                                                            991296
                                                                                            001207
                                                                                            001208
Ċ
                       IS THE NUMBER OF NODES IN THE SUBSTITUTE SUBGRAPH
                                                                                            001209
            N
                                                                                            001210
                        IS THE NUMBER OF NONZERO ELEMENTS IN THE SUBMATRIX
                                                                                            001211
C
            NEL
                       REPRESENTING THE SUBSTITUTE SUBGRAPH
C
                                                                                            001212
C
                                                                                            001213
C
            NROW, NCOL DESCRIBE ROW AND COLUMN INDICES OF ELEMENTS IN THE
                                                                                            001214
                        RESULTING SUBGRAPH
                                                                                            001215
CCCCC
                                                                                            001216
            AK
                       COEFFICIENT MATRIX OF DIMENSION NOT LESS THAN 1886
                                                                                            001217
                       NEL1+NEL2
                                                                                            001218
                                                                                            001219
                       RHS VECTOR OF DIMENSION NOT LESS THAN N
            v
                                                                                            001220
                                                                                            001221
       CALL EEDSUB(NSB1, N1, NEL1, NROW1, NCOL1, NON1, BREC, AK1, V1, INDX, IADREC,
                                                                                            001222
      +LADR, LREC; INDEX3, INDEX5, IN)
                                                                                            001223
       IF(IN(3).EQ.1) RETURN
IF(IN(7).NE.2)GOTO 1
                                                                                            001224
                                                                                            001225
       WRITE(6, 100) NSB1, N1, NEL1
                                                                                            001226
       CALL PRINTNC(NEL1, NROW1, NCOL1, AK1)
                                                                                            001227
  100 FORMAT(1H, /, "EXTERNAL DESCRIPTION OF THE SUBGRAPH NO", 13, / +, "NUMBER OF NODES: ", 13, 4x, "NUMBER OF ELEMENTS: ", 13, /,)
                                                                                            001228
                                                                                            001229
     1 CONTINUE
                                                                                            001230
      CALL EEDSUB(NSB2, N2, NEL2, NROW2, NCOL2, NON2, BREC, AK2, V2, INDX, IADREC, +LADR, LREC, INDEX3, INDEX5, IN)
                                                                                            001231
                                                                                            001232
       IF(IN(3).EQ.1) RETURN
IF(IN(7).NE.2) GOTO 2
                                                                                            001233
                                                                                            001234
       WRITE(6, 100) NSB2, N2, NEL2:
                                                                                            001235
```

```
CALL PRINTNC(NEL2, NROW2, NCOL2, AK2)
                                                                                     001236
    2 CONTINUE
                                                                                     001237
       CALL CONNUMB(NON1, NON2, NON, N1, N2, N)
                                                                                     001238
       CALL ADDSUB(N1, N2, N, NEL1, NEL2, NEL, NROW1, NROW2, NROW, NCOL1, NCOL2,
                                                                                     001239
                                                                                     001240
      +NCOL, NON1, NON2, AK1, AK2, AK, V1, V2, V)
                                                                                     001241
       RETURN
                                                                                     001242
                                                                                     001243
                                                                                     001244
C
       SUBROUTINE EEDSUB(NSUB, NEX, NEL, NROW, NCOL, NON, BREC, AK, V, INDX,
                                                                                     001245
                                                                                     001246
      + IADREC, LADR, LREC, INDEX3, INDEX5, IN)
                                                                                     001247
           THIS SUBROUTINE EXTRACTS EXTERNAL DESCRIPTION OF THE SUB-
                                                                                     001248
C
C
                                                                                     001249
           GRAPH WHOSE INDEX IS NSUBEFROM THE DESCRIPTION OF THE SUBGRAPH
                                                                                     001250
C
                                                                                     001251
\mathbf{C}
                                                                                     001252
C
           AT THE LOWER LEVEL.
                                                                                     001253
C
           AT THE OUTPUT THE SUBGRAPH: IS DESCRIBED BY THE COEFFICIENT
                                                                                     001254
                                                                                     001255
           MATRIX AK, ITS ROWS AND COLUMNS BY MATRICES NROW & NCOL,
                                                                                     001256
C
                                                                                     001257
                                                                                     001258
           RESPECTIVELY. ROW AND COLUMN INDICES ARE WITHIN THE RANGE
\mathbf{C}
                                                                                     001259
C
           1 TO NEX. NEX IS THE NUMBER OF NODES.
                                                                                     001260
C
                                                                                     001261
C
           NEL IS THE NUMBER OF NONZERO ELEMENTS
                                                                                     001262
                                                                                     001263
\mathbf{C}
       INTEGER NON(1), NROW(1), NCOL(1), INDX(1), IADREC(1), INDEX3(1), INDEX3(
                                                                                     0012645C
                                                                                     001265
      +1), IN(1)
       COMPLEX AK(1), BREC(1), V(1), REE:
                                                                                     001266
                                                                                     001267
           FIND THE ADDRESS FOR THE SUBGRAPH NSUB
                                                                                     001268
C
                                                                                     001269
                                                                                     001270
       LDREC=2*LREC
                                                                                     001271
       LLDR=LADR*2
       NADR=(NSUB-1)/LADR+1
                                                                                     001272
                                                                                     001273
       IADR=NSUB-(NADR-1)*LADR
       IF(INDX(5).EQ.NADR) GOTO 4
                                                                                     001274
                                                                                     001275
       IF(NADR.GT.((IN(9)-1)/IN(12)+1)) GOTO 611
                                                                                     001276
\mathbf{C}
           STORE OLD ADDRESSING RECORD
                                                                                     001277
                                                                                     001278
       IF(IN(23).NE.1) CALL WRITMS(5, IADREC, LLDR, INDX(5))
IF(IN(23).EQ.1) CALL WRITMS(5, IADREC, LLDR, INDX(5), 1, 1)
                                                                                     001279
                                                                                     661286
       IF(INDX(5).GT.IN(24)) IN(24) = INDX(5)
                                                                                     001281
       CALL READMS(5, IADREC, LLDR, NADR)
                                                                                     001282
                                                                                     001283
       INDX(5) = NADR
      NRBR= IADREC( IADR)
                                                                                     001284
       NSBR=IADREC(IADR+LADR) :
                                                                                     001285
                                                                                     001286
           READ THE DESCRIPTION OF THE SUBGRAPH
                                                                                     001287
C
                                                                                     001288
       IF(INDX(3).EQ.NRBR) GOTO 5
                                                                                     001289
                                                                                     001290
       IF(INDX(3).GT.IN(15)) GOTO 7 ))
                                                                                     001291
                                                                                     001292
           STORE OLD BASIC RECORD
C
                                                                                     001293
       IF(IN(23).NE.1) CALL WRITMS(3, BREC, LDREC, INDX(3)) IF(IN(23).EQ.1) CALL WRITMS(3, BREC, LDREC, INDX(3), 1, 1)
                                                                                     001294
                                                                                     001295
       CALL READMS(3, BREC, LDREC, NRBR)
                                                                                     001296
       INDX(3) = NRBR
                                                                                     001297
                                                                                     001298
      IADR=REAL(BREC(NSBR))
                                                                                     001299
       LTHR= AIMAG(BREC(NSBR))
                                                                                     001300
       IAD= IADR/2
```

```
001301
      N=REAL(BREC(IAD))
                                                                                        001302
       NINT=AIMAG(BREC(IAD))
                                                                                        001303
       LES=AIMAG(BREC(IAD+1))
                                                                                        001304
                                                                                        001305
           CALCULATE MATRICES AK, V, NROW, NCOL, NON
                                                                                        001306
                                                                                        001307
       IA= IAD+NINT
                                                                                        001308
       IA1= IA+N+1
                                                                                        001309
       IA4=IA1+5*LES+N
                                                                                        001310
       IA5= IA4+2*N
                                                                                        001311
       NEX=N-NINT
DO 1 I=1, NEX
                                                                                        001312
                                                                                        001313
       AK( I) = BREC( IA4+ I)
                                                                                        001314
       V( I) = BREC( IA5+ I)
                                                                                        001315
       NROW(I) = I
                                                                                        001316
       NCOL(I) = I
                                                                                        001317
     1 NON(I) = REAL(BREC(IA1+I))
                                                                                        001318
\mathbf{C}
                                                                                        001319
            CALCULATE MATRICES AK, NROW, NCOL
C
                                                                                        001320
                                                                                        001321
       IA1= IAD+2*N+1
                                                                                        001322
       IA2=IA1+LES
                                                                                        001323
       IA3=IA2+LES
                                                                                        001324
       J=NEX
                                                                                        001325
       DO 2 I=1, NEX
                                                                                        001326
       IS=REAL(BREC(IA+I))
                                                                                        001327
       IF(IS.LE.0) GOTO 2
                                                                                        001328
       J=J+1
                                                                                        001329
       AK(J)=BREC(IA2+IS)
                                                                                         001330
       IRR=REAL(BREC(IA1+IS))-NINT (5)
                                                                                         001331
       NROW(J) = IRR
                                                                                         001332
       NCOL(J) = I
                                                                                         001333
       J = J + 1
                                                                                         001334
       AK(J)=BREC(IA3+IS)
                                                                                         001335
       NROW(J) = I
                                                                                         001336
       NCOL(J) = IRR
                                                                                         001337
C
                                                                                         001338
            ADDRESS FOR THE NEXT ELEMENT
                                                                                         001339
                                                                                         001340
       IS=AIMAG(BREC(IA1+IS))
                                                                                         001341
       сото з
                                                                                         001342
       CONTINUE
                                                                                         001343
       NEL=J
                                                                                         001344
       RETURN
                                                                                         001345
       WRITE(6, 120)
   120 FORMAT(1H, /, " NUMBER OF ADDRESSING RECORDS TOO SMALL", /, " CHECK N +UMBERS OF MODIFIED SUBGRAPHS IN THE RANDOM FILE NO 2", /)
                                                                                         001346
                                                                                         001347
                                                                                         001348
        IN(3)=1
                                                                                         001349
       RETURN
                                                                                         001350
       WRITE(6,130)
   130 FORMAT(1H, /, " NUMBER OF PREDICTED BASIC RECORDS TOO SMALL",/, + " INCREASE IN(15)",/)
                                                                                         001351
                                                                                         001352
                                                                                         001353
        IN(3) = 1
                                                                                         001354
        RETURN
                                                                                         001355
        END
                                                                                         001356
\mathbf{c}
                                                                                         001357
\mathbf{C}
                                                                                         001358
        SUBROUTINE CONNUMB(NON1, NON2, NON, N1, N2, N)
                                                                                         001359
\mathbf{C}
             THIS SUBROUTINE ASSIGNS ORIGINAL INDICES OF THE NODES TO THE
                                                                                         001360
                                                                                         001361
 C
                                                                                         001362
             NODES OF CONNECTED SUBGRAPHS. INPUT INFORMATION ABOUT THE
                                                                                         001363
 \mathbf{c}
             ORIGINAL INDICES OF SUBGRAPH NODES IS PLACED IN NON1 AND NON2.
                                                                                         001364
 \mathbf{C}
                                                                                         001365
```

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```
ON OUTPUT NON1 AND NON2 CONTAIN CURRENT INDICES OF
                                                                             001366
                                                                             001367
      SUBGRAPHS NODES IN THE RESULTING SUBSTITUTE GRAPH.
                                                                             001368
                                                                             001369
                                                                             001370
  INTEGER NON1(1), NON2(1), NON(1)
                                                                             001371
      ASSIGN INDICES TO THE NODES OF THE SUBSTITUTE GRAPH.
                                                                             001372
                                                                             001373
      N IS THE NUMBER OF NODES IN THE SUBSTITUTE SUBGRAPH
                                                                             001374
                                                                             001375
      NON ARE ORIGINAL INDICES OF THE NODES IN THE SUBSTITUTES:
                                                                             001376
                                                                             ·001377
      SUBCRAPH
                                                                             001378
                                                                             001379
                                                                             001380
  I1=1
                                                                             001381
  12=1
                                                                             001382
  I = 0
  LN1=NON1(I1)
                                                                             001383
  LN2=NON2( I2)
                                                                             001384
                                                                             001385
4 IF(LN1-LN2)1,2,3
                                                                             001386
  T = T + 1
                                                                             001387
  NON(I) = LN1
                                                                             001388
  I1=I1+1
  IF(I1.GT.N1) GOTO 5
                                                                             001389
  LN1=NON1(I1)
                                                                             001390
                                                                             001391
  GOTO 4
                                                                             001392
2 I=I+1
  NON(I) = LN1
                                                                             001393
                                                                             001394
  I 1 = I 1 + 1
                                                                             001395
  12 = 12 + 1
                                                                             001396
  LN1=NON1(I1)
  LN2=NON2(12)
                                                                             001397
  IF(I1.GT.N1)
                GOTO 5
                                                                             001398
  IF(12.GT.N2) GOTO 6 No.
                                                                             001399
  COTO 4
                                                                             001400
                                                                             001401
3 I=I+1
  NON(I) = LN2
                                                                             001402
                                                                             001403
  12 = 12 + 1
  IF(12.GT.N2) GOTO 6
                                                                             001404
  LN2=NON2(12)
                                                                             001405
  GOTO 4
                                                                             001406
  IF(12.GT.N2) GOTO 7
                                                                             001407
  I = I + 1
                                                                             001408
  NON(I)=LN2
                                                                             001409
                                                                             001410
  12 = 12 + 1
  LN2=NON2(12)
                                                                             001411
  GOTO 5
                                                                             001412
 IF(I1.GT.N1) GOTO 7
                                                                             001413
                                                                             001414
  I = I + 1
                                                                             001415
  NON(I) = LN1
                                                                             001416
  T1=T1+1
  LN1=NON1( I1)
                                                                             001417
                                                                             001418
  GOTO 6
7 CONTINUE
                                                                             001419
                                                                             001420
                                                                             001421
      RENUMBER THE EXTERNAL NODES OF CONNECTED SUBGRAPHS
                                                                             001422
                                                                             001423
                                                                             001424
  J= 1
  DO 8 I=1,N1
                                                                             001425
  NL=NON1(I)
                                                                             001426
 IF(NON(J).LT.NL) GOTO 9 (1)
                                                                             001427
  NON1(I)=J
                                                                             001428
                                                                             001429
  T = .T + 1
8 CONTINUE
                                                                             001430
```

```
GOTO 14
                                                                                       001431
       J=J+1
                                                                                       001432
       GOTO 10
                                                                                       001433
      J= 1
                                                                                       001434
       DO 11 I=1, N2
                                                                                       001435
       NL=NON2(I)
                                                                                       001436
    13 IF(NON(J).LT.NL) GOTO 12
                                                                                       001437
       NON2(I)=J
                                                                                       001438
       J=J+1
                                                                                       001439
    11 CONTINUE
                                                                                       001440
       RETURN
                                                                                       001441
    12 J=J+1
                                                                                       001442
       GOTO 13
                                                                                       001443
       END
                                                                                       001444
\mathbf{C}
                                                                                       001445
\mathbf{C}
                                                                                       001446
       SUBROUTINE ADDSUB(N1, N2, N, NEL1, NEL2, NEL, NROW1, NROW2, NROW, NCOL1, NCO
                                                                                       001447
      +L2, NCOL, NON1, NON2, AK1, AK2, AK, V1, V2, V)
                                                                                       001448
C
                                                                                       001449
C
            THIS SUBROUTINE ADDS TWO SUBMATRICES DESCRIBING SUBSTITUTE
                                                                                       001450
                                                                                       001451
\mathbf{C}
           SUBGRAPHS TO OBTAIN A MATRIX DESCRIBING THEIR INTERCONNECTION
                                                                                       001452
Č
                                                                                       001453
       INTEGER NROW1(1), NROW2(1), NROW(1), NCOL1(1), NCOL2(1), NCOL(1), NON1(1
                                                                                       001454
      +),NON2(1):
                                                                                       001455
       COMPLEX AK1(1), AK2(1), AK(1), V1(1), V2(1), V(1)
                                                                                       001456
                                                                                       001457
                      IS THE NUMBER OF NODES IN THE SUBSTITUTE SUBGRAPH
cccccccccc
                                                                                       001458
                                                                                       001459
           NEL1, NEL2, NEL ARE THE INDICES OF NONZERO ELEMENTS IN
                                                                                       001460
                      SUBMATRICES TO BE ADDED AND IN THE RESULTING SUBMATRIX, RESPECTIVELY
                                                                                       001461
                                                                                       001462
                                                                                       001463
           NROW, NCOL DESCRIBE ROW AND COLUMN INDICES OF ELEMENTS IN
                                                                                       001464
                       RESULTING SUBMATRIX
                                                                                       001465
                                                                                       001466
           AK
                       THE COEFFICIENT MATRIX
                                                                                       001467
                                                                                       001468
           v
                       RHS VECTOR
                                                                                       001469
                                                                                       001470
       NX=NEL1+NEL2
                                                                                       001471
       DO 1 I=1,NX
                                                                                       001472
    1 AK(I) = CMPLX(0.,0.)
                                                                                       001473
       DO 2 I=1, N
                                                                                       001474
    2 V(I)=CMPLX(0.,0.)
                                                                                       001475
                                                                                       001476
C
           CALCULATE DIAGONAL ELEMENTS AND RHS 1:1
                                                                                       001477
                                                                                       001478
       I 1= 1
                                                                                       001479
       12=1
                                                                                       001480
       DO 3 I=1,N
                                                                                       001481
       L1=NON1(11)
                                                                                       001482
       L2=NON2(I2)
                                                                                       001483
       IF(L1.EQ. I) GOTO 4
                                                                                       001484
      IF( 12.GT.N2) GOTO 3
AK( 1) = AK2( 12) + AK( 1)
                                                                                       001485
                                                                                       001486
       V(I) = V(I) + V2(I2)
                                                                                       001487
       NROW(I) = I
                                                                                       001488
       NCOL(I) = I
                                                                                       001489
       12=12+1
                                                                                       001490
       COTO 3
                                                                                      001491
       IF(I1.GT.N1) GOTO 5 (1) AK(I) = AK(I) + AK1(I1)
                                                                                       001492
                                                                                       001493
       V(I) = V(I) + V1(I1)
                                                                                       001494
       NROW(I) = I
                                                                                       001495
```

```
001496
      NCOL(I) = I
                                                                                    001497
       I1=I1+1
                                                                                    001498
       IF(L2.EQ. I) GOTO 5
                                                                                    001499
    3 CONTINUE
                                                                                    001500
           CALCULATE THE REMAINING PART OF THE COEFFICIENT MATRIX TO
                                                                                    001501
Č
                                                                                    001502
                                                                                    001503
       I = N + 1
                                                                                    001504
      NS1= I1
                                                                                    001505
      NS2= I2
                                                                                    001506
             JJ=NS1, NEL1
      DO 6
                                                                                    001507
       IR1=NON1(NROW1(JJ))
                                                                                    001508
       IC1=NON1(NCOL1(JJ))
                                                                                    001509
       <u>AK( I) = AK( I) + AK1( JJ) 🖹</u>
                                                                                    001510
       NROW(I) = IR1
                                                                                    001511
       NCOL(I) = IC1
                                                                                    001512
       DO 7 J3=NS2, NEL2
                                                                                    001513
       IR2=NON2(NROW2(J3))
                                                                                    001514
       IC2=NON2(NCOL2(J3))
                                                                                    001515
       IF(IR1.EQ. IR2.AND. IC1.EQ. IC2) AK(I) = AK(I) + AK2(J3) ) :
                                                                                    001516
    7 CONTINUE
                                                                                    001517
       I = I + 1
                                                                                    001518
    6 CONTINUE
                                                                                    001519
       DO 8 J3=NS2, NEL2
                                                                                    001520
       IR2=NON2(NROW2(J3))
                                                                                    001521
       IC2=NON2(NCOL2(J3))
                                                                                    001522
       DO 9 JJ=NS1, NEL1
                                                                                    001523
       IR1=NON1(NROW1(JJ))
                                                                                    001524
       IC1=NON1(NCOL1(JJ))
                                                                                    001525
       IF(IR1.EQ. IR2.AND. IC1.EQ. IC2) GOTO 8
                                                   Charles
                                                                                    001526
       CONTINUE
                                                                                    001527
       AK( 1) = AK( 1) + AK2( J3) 🕒
                                                                                    001528
       NROW(I) = IR2
                                                                                    001529
       NCOL(I) = IC2
                                                                                    001530
       I = I + 1
                                                                                    001531
       CONTINUE
                                                                                    001532
       NEL= I-1
    14
                                                                                    001533
       RETURN
                                                                                    001534
       END
                                                                                    001535
\mathbf{C}
                                                                                    001536
\mathbf{C}
       SUBROUTINE CASRHS(IN, RHSR, NSB, INDX, INDEX1, N, NEXTN, NSUB, V, NON)
                                                                                    001537
                                                                                    001538
\mathbf{C}
           THIS SUBROUTINE CALCULATES ADDRESSES AND STORES THE RHS VECTOR
                                                                                    001539
C
                                                                                    001540
\mathbf{C}
                                                                                    001541
           FOR THE SUBSTITUTE SUBGRAPH NSB
\mathbf{C}
                                                                                    001542
C
                                                                                    001543
       INTEGER IN(1), INDX(1), INDEX1(1), NEXTN(1), NSUB(1), NON(1)
                                                                                    001544
       COMPLEX RHSR(1), V(1)
                                                                                    001545
C
                                                                                    001546
                       RICHT HAND SIDE RECORD
           RHSR
C
                                                                                    001547
                       INDEX OF RIGHT HAND SIDE RECORD
                                                                                    001548
           NRHSR
C
                                                                                    001549
C
                       ADDRESS IN THE RIGHT HAND SIDE RECORD, WHERE THE
                                                                                    001550
            IAD1
C
                       INFORMATION ABOUT GIVEN SUBSTITUTE SUBGRAPH BEGINS
                                                                                    001551
C
                                                                                     001552
C
                       NUMBERS OF EXTERNAL NODES FOR THE SUBSTITUTE
                                                                                    001553
            NEXTN
C
                       SUBGRAPHS. SUBSTITUTE SUBGRAPH NO. 1 HAS ZERO
                                                                                     001554
C
                                                                                     001555
                       EXTERNAL NODES AND
                                                                                     001556
C
                                                                                     001557
                       CURRENT INDEX OF THE RHS RECORD
Č
            INDX(4)
                                                                                     001558
C
                                                                                     001559
                       LENGTH OF RHS RECORD
            LRHSR
\mathbf{c}
                                                                                     001560
```

```
IN25= IN(25)
                                                                                    001561
       LADR= IN(12)
                                                                                    001562
       LLD1=LADR*2
                                                                                    001563
       LRHS=2*IN25
                                                                                    001564
                                                                                    001565
C
            FIND THE SMALLEST EXTERNAL NODE IN NSB
                                                                                    001566
                                                                                    001567
       NSEN=NON(1)-IN(19)+1
                                                                                    001568
       NRHSR=NSEN/IN25+1
                                                                                    001569
C
                                                                                    001570
\mathbf{C}
            STORE OLD RHS RECORD
                                                                                    001571
                                                                                    001572
       IF(NRHSR.EQ.INDX(4)) GOTO 9
IF(IN(23).NE.1) CALL WRITMS(1,RHSR,LRHS,IN(21))
                                                                                    001573
                                                                                    001574
       IF(IN(23).EQ. 1) CALL WRITMS(1, RHSR, LRHS, IN(21), 1, 1)
                                                                                   001575
       CALL READMS(1, RHSR, LRHS, NRHSR).
                                                                                    001576
       INDX(4) = NRHSR.
                                                                                   001577
       IN(21)=NRHSR
                                                                                   001578
      IAD1=NSEN-(NRHSR-1)*IN25:
                                                                                   001579
C
                                                                                   001580
           CALCULATE THE ADDRESS IN THE RHS RECORD
                                                                                   001581
                                                                                   001582
       IAD=IAD1+N-NEXTN(NSB)-1
                                                                                   001583
       IF(IAD.LT.IAD1) RETURN
                                                                                   001584
       I J = 0
                                                                                   001585
       IF(IAD.LE.IN25) GOTO 8
                                                                                   001586
      DO 10 I=IAD1, IN25
                                                                                   001587
       IJ = IJ + 1
                                                                                   001588
    10 RHSR(I)=V(IJ)
                                                                                   001589
C
                                                                                   001590
           STORE THE RHS RECORD
                                                                                   001591
                                                                                   001592
       IF(IN(23).NE.1) CALL WRITMS(1, RHSR, LRHS, IN(21))
                                                                                   001593
       IF(IN(23).EQ. 1) CALL WRITMS(1, RHSR, LRHS, IN(21), 1, 1)
                                                                         1)
                                                                                   001594
       IN(21) = IN(21) + 1
                                                                                   001595
       INDX(4) = IN(21)
                                                                                   001596
       IAD1=1
                                                                                   001597
       IAD= IAD- IN25
                                                                                   001598
       IF(IAD.GT.IN25) GOTO 6
                                                                                   001599
000000000000
                                                                                   001600
           WRITE THE RHS VECTOR ASSOCIATED WITH THE SUBGRAPH.
                                                                                   001601
                                                                                   001602
           THE ELEMENT RHSR(IAA), WHERE IAA=NSEN-(NRHSR-1)*IN(25), ()
                                                                                   001603
                                                                                   001604
           STORES THE RHS ELEMENT CORRESPONDING TO NON(1), WHILE THE RHS
                                                                                   001605
                                                                                   001606
           ELEMENT FOR THE NODE NON(I) WILL BEIAT THE ADDRESS
                                                                                   001607
                                                                                   001608
           NON(I) - NON(I) + IAA
                                                                                   001609
                                                                                   001610
    8 DO 11 I=IAD1, IAD
                                                                                   001611
       IJ= IJ+1
                                                                                   001612
   11 RHSR(I) = V(IJ)
                                                                                   001613
      RETURN
                                                                                   001614
      END
                                                                                   001615
\mathbf{C}
                                                                                   001616
C
                                                                                   001617
      SUBROUTINE PSHDS(IN, LCOL, ITAG, CE, DE, V, IADREC, BREC, NSUB, INDEX3, INDE
                                                                                   001618
     +X5, INDX, NON, INDEX1, INDEX7, RHSR, SOLR, IMD R
                                                                                   001619
C
                                                                                   001620
C
           THIS SUBROUTINE CALCULATES A PARTIAL SOLUTION FOR THE
                                                                                   001621
C
                                                                                   001622
           HIERARCHICALLY DECOMPOSED SYSTEM OF LINEAR EQUATIONS
C
                                                                                   001623
                                                                                   001624
      INTEGER NSUB(1), NON(1), INDX(1), IADREC(1), LCOL(1), ITAG(1), INDEX3(1)
                                                                                  001625
```

```
+, INDEX1(1), INDEX5(1), INDEX7(1), IN(1), IM(1)
                                                                                  001626
      COMPLEX BREC(1), V(1), DE(1), CE(1), RHSR(1), SOLR(1)
                                                                                  001627
                                                                                  001628
C
                                                                                  001629
      LREC= IN(11)
                                                                                  001630
      NMS= IN( 10)
                                                                                  001631
      IRHSUF=IN(22)
                                                                                  001632
      LL=0
                                                                                  001633
C
                                                                                  001634
                      INDICATOR FOR RHS UPDATING FORMULA
           IRHSUF
CCCCC
                   =0 COMPLETE RHS VECTOR WILL BE RECALCULATED
                                                                                  001635
                   = 1 ONLY THE RHS FOR THE MODIFIED SUBGRAPHS WILL BE
                                                                                  001636
                                                                                  001637
                      RECALCULATED
                   =2 ONLY THE RHS FOR THE SUBGRAPHS SPECIFIED BY THE USER
                                                                                  001638
                                                                                  001639
Č
                      WILL BE RECALCULATED
                                                                                  001640
                   =3 COMPLETE RHS WILL BE RECALCULATED
                                                                                  001641
C
      IF(IRHSUF.EQ.1) GOTO 9
                                                                                  001642
                                                                                  001643
       IF(IRHSUF.EQ.2) GOTO 2
                                1
                                                                                  001644
C
                                                                                  001645
           COMPLETE RHS WILL BE RECALCULATED
C
                                                                                  001646
č
                                                                                  001647
      NMS=IN(5)
                                                                                  001648
      NREC=26+IN(9)/2
                                                                                  001649
       GOTO 3
                                                                                  001650
C
           RHS WILL BE RECALCULATED FOR THE SUBGRAPHS SPECIFIED
                                                                                  001651
CCC
                                                                                  001652
           BY THE USER
                                                                                  001653
                                                                                  001654
    2 NMS=IN(4)
      NREC=26+IN(9)/2+IN(5)
                                                                                  001655
                                                                                  001656
      DO 4 I=1.NMS
    4 NSUB(I) = IN(NREC+I)
                                                                                  001657
                                                                                  001658
       IORD= 1
                                                                                  001659
    9 CALL SMSSUB(NMS, NSUB, NCHS, IORD)
                                                                                  001660
       IF(IN(7).EQ.1.OR.IN(7).EQ.3) GOTO 1
  WRITE(6, 100) (NSUB(I), I=1, NCHS)
100 FORMAT(1H, /, " SOLUTION WILL BE RECALCULATED AT THE INTERNAL NODES
                                                                                  001661
                                                                                  001662
      + OF SUBGRAPHS ", //(2014))
                                                                                  001663
                                                                                  001664
     1 CONTINUE
                                                                                  001665
           MULTIPLY RIGHT PART OF LR! FACTORIZATION BY THE RHS VECTOR
                                                                                  001666
C
                                                                                  001667
                                                                                  001668
       IF(IN(7).EQ.1) GOTO: 7
                                                                                  901669
       WRITE(6,110)
      FORMAT(1H ,/, " SOLUTION",/,1H:"_____",/)
                                                                                  001670
                                                                                  001671
     7 CONTINUE
                                                                                  001672
       DO 5 IJ=1, NCHS
                                                                                  001673
       NRS=NCHS-IJ+1
       CALL RMRHS(NRS, NMS, NSUB, IN, INDX, IADREC, BREC, LREC, LCOL, NON, DE, V, ITA
                                                                                  001674
      +G, CE, INDEX3, INDEX5, RHSR, IM, LL, SOLR, INDEX7, INDEX1)
                                                                                  001675
                                                                                  001676
       IF(IN(3).EQ.1) RETURN
                                                                                  001677
    5 CONTINUE
                                                                                  001678
           STORE FINAL RESULTS
                                                                                  001679
C
                                                                                  001680
                                                                                  001681
       IM5 = IM(5)
                                                                                  001682
       IM(5) = LL
  IF(IN(7).NE.1) WRITE(6,120) LL (6) 120 FORMAT(1H, /, "NUMBER OF VARIABLES IN THE SOLUTION VECTOR", 14)
                                                                                  001683
                                                                                  001684
                                                                                  001685
       IF(IN(23).EQ.2) RETURN
                                                                                  001686
       LSOL=4*IM5
                                                                                  001687
       IF(IN(23).EQ.0.OR.IN(23).EQ.3) GOTO 6
                                                                                  001688
       CALL WRITMS(7, SOLR, LSOL, INDX(7), 1, 1)
                                                  40
                                                                                  001689
       RETURN
    6 CALL WRITMS(7, SOLR, LSOL, INDX(7))
                                                                                  001690
```

```
RETURN
                                                                                         001691
       END
                                                                                         001692
C
                                                                                         001693
                                                                                         001694
       SUBROUTINE RMRHS(NRS, NMS, NSUB, IN, INDX, IADREC, BREC, LREC, LCOL, NON,
                                                                                         001695
      +DE, V, ITAG, CE, INDEX3, INDEX5, RHSR, IM, LL, SOLR, INDEX7, INDEX1)
                                                                                         001696
                                                                                         001697
            THIS SUBROUTINE MULTIPLIES THE RIGHT PART OF THE LR
                                                                                         001698
00000
                                                                                         001699
            FACTORIZATION BY THE RHS VECTOR FOR (NRS) TH SUBGRAPH. THE RHS
                                                                                         001700::
                                                                                         001701
            IS NOT UPDATED FOR PROPER BLOCKS
                                                                                         001702
                                                                                         001703
      INTEGER NSUB(1), NON(1), INDX(1), IADREC(1), LCOL(1), ITAG(1), INDEX3(1)
+, INDEX1(1), INDEX5(1), IN(1), IARRHS(1), IM(1), INDEX7(1)
                                                                                         001704
                                                                                         001705
       COMPLEX BREC(1), V(1), DE(1), CE(1), RHSR(1), SOLR(1)
                                                                                         001706
                                                                                         001707
CCCCC
                    IS THE INDEX OF THE SUBGRAPH FOR WHICH THE RHS IS
            NSB<sub>1</sub>
                                                                                         001708
                    CALCULATED FOR INTERNAL NODES ONLY
                                                                                         001709
                                                                                         001710
            NSB
                    IS THE INDEX OF THE SUBSTITUTE SUBGRAPH FOR WHICH THE
                                                                                         001711
                    RHS VECTOR IS CALCULATED
                                                                                         001712
                                                                                         001713
       NSB1=NSUB(NRS)
                                                                                         001714
       IN25= IN(25)
                                                                                         001715
       LADR= IN(12)
                                                                                         001716
       LLD1=2*LADR
                                                                                         001717
       LRHS=2*IN(25)
                                                                                         001718
       INSS=0
                                                                                         001719
\mathbf{C}
                                                                                         001720
            READ SUBGRAPH NSB1
C
                                                                                         001721
C
                                                                                         001722
       CALL RSBR(NSB1, LADR, INDX, IADREC, BREC, LREC, LCOL, NON, DE, V, ITAG, CE, IN
                                                                                         001723
      +DEX3, INDEX5, N, NINT, LES, IA4, IN, IAD, NSBR)
                                                                                         001724
       DO 12 I=1,N
V(I)=BREC(IA4+I)
                                                                                         001725
12
                                                                                         001726
       N1 = NON(NINT+1)
                                                                                         001727
       NSEN=NON(1)-IN(19)+1
                                                                                         001728
       NRHSR=NSEN/IN25+1
                                                                                         001729
       IF(NRHSR.LT.1) NRHSR=1
                                                                                         001730
    2 NSB=NSB1/2
                                                                                         001731
       IF(NSB.EQ.0) GOTO 8.
                                                                                         001732
C
                                                                                         001733
C
            STORE OLD RHS RECORD
                                                                                         001734
                                                                                         001735
       IF(NRHSR.EQ.INDX(4)) GOTO 9
                                                                                         001736
       IF(NRHSR.GT.(IN(26)/IN(25)+2)) GOTO 14 )
                                                                                        001737
       IF(IN(23).NE.1) CALL WRITMS(1, RHSR, LRHS, IN(21))
IF(IN(23).EQ.1) CALL WRITMS(1, RHSR, LRHS, IN(21), 1, 1)
                                                                                        001738
                                                                                        001739
       CALL READMS(1, RHSR, LRHS, NRHSR)
                                                                                        001740
       INDX(4)=NRHSR
                                                                                        001741
       IN(21)=NRHSR
                                                                                        001742
      IAD1=NSEN-(NRHSR-1)*IN25
                                                                                        001743
      N1=(NRHSR-1)*IN25+IN(19)
                                                                                        001744
                                                                                        001745
           MULTIPLY THE RIGHT PART OF THE LR FACTORIZATION BY THE RHS VECTOR FOR EXTERNAL NODES
                                                                                        001746
                                                                                        001747
                                                                                        001748
      CALL RMERHS(NINT, NON, LCOL, LCOL(2*N+2), ITAG, ITAG(LES+1),
                                                                                        001749
     +CE(LES+1), V, RHSR, INSS, N1, IN25)
IF(INSS.EQ. 0) GO TO 8
                                                                                        001750
                                                                                        001751
    3 NSB1=NSB
                                                                                        001752
      NRHSR= NRHSR+ 1
                                                                                        001753
      GOTO 2
                                                                                        001754
    8 NSB1=NSUB(NRS)
                                                                                        001755
```

```
IF(NRS.LE.NMS) GOTO 1
                                                                                  001756
    5 NSEN=NON(1)-IN(19)+1
                                                                                  001757
      NRHSR=NSEN/IN25+1
                                                                                  001758
       IF(NRHSR.LT.1) NRHSR=1
                                                                                  001759
                                                                                  001760
\mathbf{C}
           STORE OLD RHS RECORD :-
                                                                                  001761
Ċ
                                                                                  001762
       IF(NRHSR.EQ. INDX(4)) GOTO 6
                                                                                  001763
       IF(NRHSR.GT.(IN(26)/IN(25)+2)) GOTO 14)
                                                                                  001764
       IF(IN(23).NE.1) CALL WRITMS(1, RHSR, LRHS, IN(21))
                                                                                  001765
       IF(IN(23).EQ. 1) CALL WRITMS(1, RHSR, LRHS, IN(21), 1, 1)
                                                                        13
                                                                                  001766
       CALL READMS(1, RHSR, LRHS, NRHSR)
                                                                                  001767
       INDX(4)=NRHSR
                                                                                  001768
       IN(21)=NRHSR
                                                                                  001769
    6 IAD1=NSEN-(NRHSR-1)*IN25
                                                                                  001770
\mathbf{C}
                                                                                  001771
           MULTIPLY THE RIGHT PART OF THE LR FACTORIZATION BY THE RHS
                                                                                  001772
C
           VECTOR FOR INTERNAL NODES 2011
                                                                                  001773
C
                                                                                  001774
    1 CALL RMIRHS(NINT, LCOL, LCOL(2*N+2), ITAG, ITAG(LES+1), CE(LES+1), V)
                                                                                  001775
       IF(NRS.LE.NMS) GOTO 10
                                                                                  001776
                                                                                  001777
           STORE RHS VECTOR
                                                                                  001778
                                                                                  001779
      DO 11 IJ=1, NINT
                                                                                  001780
   11 RHSR(IAD1+IJ-1)=V(IJ)
                                                                                  001781
   10 CONTINUE
                                                                                  001782
                                                                                  001783
           CALCULATE THE ADDRESS AND STORE SOLUTION VECTOR
                                                                                  001784
                                                                                  001785
      CALL CASSOL(IN, IM, LL, SOLR, NINT, INDX, V, NON, INDEX7)
                                                                                  001786
      IF(IN(3).EQ. 1) RETURN
                                                                                  001787
      IF(IN(7).EQ.1) RETURN
                                                                                  001788
      WRITE(6, 140) NSUB(NRS)
                                                                                  001789
  140 FORMAT(1H ,/, " IN SUBGRAPH NO., 14,/)
                                                                                  001790
      CALL PRINTRS(NINT, V, NON)
                                                                                  001791
      RETURN
                                                                                  001792
   14 WRITE(6, 100)
                                                                                  001793
  100 FORMAT(1H ,/, " NUMBER OF RHS RECORDS TOO SMALL ",/, " INCREASE IN(19
                                                                                  00179415
                                                                                  001795
      IN(3) = 1
                                                                                  001796
      RETURN
                                                                                  001797
      END
                                                                                  001798
\mathbf{C}
                                                                                  001799
C
                                                                                  001800
      SUBROUTINE RSBR(NSUB, LADR, INDX, IADREC, BREC, LREC, LCOL, NON, DE, V, ITAG
                                                                                  001801
     +, CE, INDEX3, INDEX5, N, NINT, LES, IAA, IN, IAD, NSBR)
                                                                                  001802
                                                                                  001803
C
           THIS SUBROUTINE READS SUBGRAPH WHOSE INDEX IS NSUB FROM
                                                                                  001804
                                                                                  001805
\mathbf{C}
           THE BASIC RECORD
C
                                                                                  001806
C
                                                                                  001807
      INTEGER NON(1), INDX(1), IADREC(1), LCOL(1), ITAG(1), INDEX3(1), INDEX5(
                                                                                  00180850
     +1), IN(1)
                                                                                  001809
      COMPLEX BREC(1), V(1), DE(1), CE(1)
                                                                                  001810
                                                                                  001811
           FIND THE ADDRESS FOR SUBGRAPH NSUB RE-
                                                                                  001812
                                                                                  001813
      LDREC=2*LREC
                                                                                  001814
      LLDR=LADR*2
                                                                                  001815
      NADR=(NSUB-1)/LADR+1
                                                                                  001816
      IADR=NSUB-(NADR-1)*LADR ::
                                                                                  001817
      IF(INDX(5).EQ.NADR) GOTO 4
                                                                                  001818
      CALL WRITMS(5, IADREC, LLDR, INDX(5), 1, 1)
                                                                                  001819
      CALL READMS(5, IADREC, LLDR, NADR)
                                                                                  001820
```

```
INDX(5) = NADR
                                                                                     001821
      CONTINUE
                                                                                     001822
       INDX(5)=NADR
                                                                                     001823
       NRBR=IADREC(IADR)
                                                                                     001824
       NSBR=IADREC(IADR+LADR)
                                                                                     001825
                                                                                     001826
C
           READ THE DESCRIPTION OF THE SUBGRAPH
C
                                                                                     001827
\mathbf{C}
                                                                                     001828
       IF(INDX(3).EQ.NRBR) GOTO 3
                                                                                     001829
                                                                                     001830
Ċ
           STORE THE UPDATED BASIC RECORD
                                                                                     001831
Č
                                                                                     001832
       IF(IN(23).NE.1) CALL WRITMS(3) BREC, LDREC, INDX(3)) 0.
                                                                                     001833
       IF(IN(23).EQ.1) CALL WRITMS(3, BREC, LDREC, INDX(3), 1, 1)
                                                                                     001834
       CALL READMS(3, BREC, LDREC, NRBR).
                                                                                     001835
       INDX(3) = NRBR
                                                                                     001836
    3 IADR=REAL(BREC(NSBR))
                                                                                     001837
      LTHR=AIMAG(BREC(NSBR))
                                                                                     001838
       IAD= IADR/2
                                                                                     001839
      N=REAL(BREC(IAD))
                                                                                     001840
      NINT=AIMAG(BREC(IAD))
                                                                                     001841
      LES=AIMAG(BREC(IAD+1))
                                                                                     001842
CCC
                                                                                     001843
           READ MATRICES LCOL, NON, DE, V
                                                                                     001844
                                                                                     001845
      LCOL(1) = REAL(BREC(IAD+1))
                                                                                     001846
                                                                                     001847
       IA1 = IAD + 1
       IA2= IA1+N
                                                                                     001848
       IA3= IA2+N+5*LES
                                                                                     001849
       IA4=IA3+2*N
                                                                                     001850
       IAA= IA4
                                                                                     001851
      NDB=2*N+1
                                                                                     001852
      DO 1 I=1, N
                                                                                     001853
       LCOL(I+1) = INT(REAL(BREC(IA1+I)))
                                                                                     001854
      LCOL(N+1+I) = INT(AIMAG(BREC(IA1+I)))
                                                                                     001855
      LCOL(NDB+1) = INT(AIMAG(BREC(IA2+I)))
NON(I) = INT(REAL(BREC(IA2+I)))
                                                                                     001856
                                                                                     001857
      DE( I) = BREC( IA3+ I)
                                                                                     001858
      DE(N+I) = BREC(IA3+N+I)
                                                                                     001859
      CONTINUE
                                                                                     001860
       IF(IN(8).GT.6) GOTO:6
                                                                                     001861
       DO 7 I=1,N
                                                                                     001862
      V(I) = BREC(IA4+I)
                                                                                     001863
      CONTINUE
                                                                                     001864
\mathbf{C}
                                                                                     001865
Č
           READ MATRICES ITAG, CE
                                                                                     001866
                                                                                     001867
       143=142+N
                                                                                     001868
       IA4= IA3+LES
                                                                                     001869
      DO 2 I=1, LES
                                                                                     001870
       ITAG(I) = INT(REAL(BREC(IA3+I)))
                                                                                     001871
      ITAG(LES+I) = INT(AIMAG(BREC(IA3+I)))
                                                                                     001872
      LES4=LES*4
                                                                                     001873
      DO 5 I=1,LES4
                                                                                     001874
      CE(I) = BREC(IA4+I)
                                                                                     001875
      RETURN
                                                                                     001876
      END
                                                                                     001877
                                                                                     001878
\mathbf{C}
\mathbf{C}
                                                                                     001879
      SUBROUTINE RMERHS(NINT, NON, LCOL, NSEQ, ITAG, LNXT, REAV, RHSR, INSS
                                                                                     001880
                                                                                     001881
     +, N1, LRHSR)
                                                                                     001882
C
           THIS SUBROUTINE MULTIPLIES THE RIGHT PART OF THE LR
                                                                                     001883
\mathbf{C}
                                                                                     001884
           FACTORIZATION BY THE RHS VECTOR FOR EXTERNAL NODES OF A
                                                                                     001885
```

```
001886
\mathbf{C}
           SUBCRAPH
                                                                                  001887
C
                                                                                  001888
       INTEGER NON(1), LCOL(1), NSEQ(1), ITAG(1), LNXT(1)
                                                                                  001889
       COMPLEX RE(1), V(1), RHSR(1), SUM
                                                                                  001890
C
                                                                                  001891
                     NUMBER OF INTERNAL NODES
C
           NINT
                                                                                  001892
C
                                                                                  001893
           IAD1
                     ADDRESS IN RHSR WHERE THE INFORMATION ABOUT THE
CCCC
                                                                                  001894
                     SUBSTITUTE SUBGRAPH BEGINSA.
                                                                                  001895
                                                                                  001896
           LRHSR
                     ADDRESS IN RHSR WHERE THE INFORMATION ABOUT THE
                                                                                  001897
C
                     RHS VECTOR STOPS
                                                                                  001898
                                                                                  001899
Č
           INSS
                     INDICATOR FOR INSUFFICIENT SPACE IN RHSR. WHEN BY
                                                                                  001900
                     INSS=1 THE RHS VECTOR FROM ANOTHER RECORD MUST BE
                                                                                  001901
Ċ
                     CONSIDERED
                                                                                  001902
                                                                                  001903
       INSS=0
                                                                                  001904
      N3=1-N1
                                                                                  001905
      N2=LRHSR-N3
                                                                                  001906
C
                                                                                  601907
C
           N1 AND N2 ARE THE LOWEST AND THE HIGHEST INDICES, RESPECTIVELY
                                                                                  001908
\mathbf{c}
                                                                                  001909
C
           OF NODES FOR WHICH INFORMATION ABOUT THE RHS VECTOR IS STORED
                                                                                  001910
                                                                                  001911
C
           IN A GIVEN RHS RECORD.
                                                                                  001912
                                                                                  001913
      DO 50 JJ=1,NINT
                                                                                  001914
       J=NINT-JJ+1
                                                                                  001915
      K=NSEQ(J)
                                                                                  001916
      SUM=V(K)
                                                                                  001917
      L=LCOL(K)
                                                                                  001918
      IF(L.LE.0) GOTO 40
                                                                                  001919
       I = ITAG(L)
                                                                                  001920
      IF(I.LE.NINT) GOTO 69
                                                                                  001921
       I=NON(I)
                                                                                  001922
      IF(I.LT.N1) GOTO 60
                                                                                  001923
       IF(I.LE.N2) GOTO 80%
                                                                                  001924
       INSS=1
                                                                                  001925
      GOTO 60
                                                                                  001926
      SUM=SUM-RE(L) *RHSR(N3+I)
   80
                                                                                  001927
      L=LNXT(L)
   60
                                                                                 001928
      GOTO 30
                                                                                  001929
      V(K)=SUM
                                                                                  001930
      CONTINUE
                                                                                 001931
      RETURN
                                                                                 001932
      END
                                                                                 001933
C
                                                                                 001934
С
                                                                                 001935
      SUBROUTINE RMIRHS(NINT, LCOL, NSEQ, ITAG, LNXT, RE, V)
                                                                                 001936
C
                                                                                 001937
C
           THIS SUBROUTINE MULTIPLIES THE RIGHT PART OF THE LR
                                                                                 001938
C
                                                                                 001939
           FACTORIZATION BY THE RHS VECTOR FOR INTERNAL NODES OF A
\mathbf{C}
                                                                                 001940
\mathbf{c}
                                                                                 001941
           SUBGRAPH
C
                                                                                 001942
                                                                                 001943
      INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1)
                                                                                 001944
      COMPLEX RE(1), V(1), SUM
                                                                                 001945
C
                                                                                 001946
                     NUMBER OF INTERNAL NODES 244
\mathbf{C}
           NINT
                                                                                 001947
                                                                                 001948
      IF(NINT.LE.1) RETURN
                                                                                 001949
      N1=NINT-1
                                                                                 001950
```

```
001951
       DO 50 JJ=1,N1
                                                                                       001952
       J=NINT-JJ
                                                                                       001953
       K=NSEQ(J)
                                                                                       001954
       SUM= V(K)
                                                                                       001955
       L=LCOL(K)
                                                                                       001956
      IF(L.LE.0) GOTO 40
                                                                                       001957
       I = ITAG(L)
                                                                                       001958
       IF(I.GT.NINT) GOTO 60
                                                                                       001959
       SUM=SUM-RE(L) *V(I)
                                                                                       001960
      L=LNXT(L)
                                                                                       001961
       GOTO 30
                                                                                       001962
   40 V(K)=SUM
                                                                                       001963
   50
       CONTINUE
                                                                                       001964
       RETURN
                                                                                       001965
       END
                                                                                       001966
C
                                                                                       001967
       SUBROUTINE CASSOL(IN, IM, LL, SOLR, NINT, INDX, V, NON, INDEX7)
                                                                                       001968
                                                                                       001969
\mathbf{c}
            THIS SUBROUTINE CALCULATES ADDRESSES AND STORES THE SOLUTION
                                                                                        001970
C
                                                                                        001971
C
                                                                                        001972
            VECTOR FOR THE INTERNAL NODES OF A SUBGRAPH (13)
\mathbf{C}
                                                                                       001973
č
       INTEGER IN(1), INDX(1), NON(1), IM(1), INDEX7(1), COMPLEX SOLR(1), V(1)
                                                                                       001974
                                                                                        001975
                                                                                       001976
C
                                                                                        001977
                       SOLUTION RECORDIA
C
            SOLR
                                                                                        001978
C
C
C
C
                                                                                        001979
                        INDEX OF SOLUTION RECORD OF
            NSOLR
                                                                                       001980
                        ADDRESS IN THE SOLUTION RECORD, WHERE THE
                                                                                       001981
            IAD1
                        INFORMATION ABOUT GIVEN SUBGRAPH BEGINS
                                                                                        001982
Ċ
                                                                                        001983
                        NUMBER OF EXTERNAL NODES FOR THE SUBGRAPH
                                                                                        001984
            NINT
C
                                                                                        001985
                        CURRENT INDEX OF THE SOLUTION RECORD
                                                                                        001986
            INDX(7)
                                                                                        001987
                       LENGTH OF SOLUTION RECORDIN
                                                                                        001988
            LSOL
\mathbf{C}
                                                                                        001989
                                                                                        001990
       IM5= IM(5)
                                                                                        001991
       LSOL=4*IM5
                                                                                        001992
       NSEN=LL+1
       NSOLR=NSEN/IM5+1
                                                                                        001993
                                                                                        001994
                                                                                        001995
C
            STORE OLD SOLUTION RECORDING
                                                                                        001996
                                                                                        001997
       IF(NSOLR.EQ.INDX(7)) GOTO 9
       IF(NSOLR.GT.IN(15)) GOTO 1

IF(IN(23).NE.1) CALL WRITMS(7,SOLR,LSOL,INDX(7))

IF(IN(23).EQ.1) CALL WRITMS(7,SOLR,LSOL,INDX(7),1,1)
                                                                                        001998
                                                                                        001999
                                                                                        002000
                                                                                        002001
        INDX(7) = NSOLR
                                                                                        002002
       IAD1=NSEN-(NSOLR-1)*IM5
                                                                                        002003
CCC
            CALCULATE THE ADDRESS IN THE SOLUTION RECORD See
                                                                                        002004
                                                                                        002005
                                                                                        002006
       IAD=IAD1+NINT-1
                                                                                        002007
                                          tr.
       IF(IAD.LT.IAD1) RETURN
                                                                                        002008
        IJ=0
                                                                                        002009
        IF(IAD.LE.IM5) GOTO 8
     6 DO 10 I=IAD1, IM5
IJ=IJ+1
                                                                                        002010
                                                                                        002011
       SOLR(2*I-1) = CMPLX(FLOAT(NON(IJ)), 0.)
                                                                                        002012
                                                                                        002013
    10 SOLR(2*I)=V(IJ)
                                                                                        002014
\mathbf{C}
                                                                                        002015
            STORE THE SOLUTION RECORDING
Ċ
```

```
002016
C
       IF(IN(23).NE.1) CALL WRITMS(7,SOLR,LSOL,INDX(7))
IF(IN(23).EQ.1) CALL WRITMS(7,SOLR,LSOL,INDX(7),1,1)
                                                                                          002017
                                                                                          002018
       INDX(7) = INDX(7) + 1
                                                                                          002019
                                                                                          002020
       IAD1=1
                                                                                          002021
       IAD= IAD- IM5
       IF(IAD.GT.IM5) GOTO 6
                                                                                          002022
                                                                                          002023
\mathbf{C}
            WRITE THE SOLUTION VECTOR ASSOCIATED WITH THE SUBGRAPH
                                                                                          002024
                                                                                          002025
     8 DO 11 I=IAD1, IAD
                                                                                          002026
       IJ = IJ + 1
                                                                                          002027
       SOLR(2*I-1) = CMPLX(FLOAT(NON(IJ)),0.)
                                                                                          002028
   11 SOLR(2*I) = V(IJ)
                                                                                          002029
       LL=LL+NINT
                                                                                          002030
       RETURN
                                                                                          002031
       WRITE(6,2)
                                                                                          002032
     2 FORMAT(1H ,/, " NUMBER OF SOLUTION RECORDS TOO SMALL",/," INCREASE
                                                                                          002033 ::
      +IN(15)",/)
                                                                                          002034
       IN(3)=1
                                                                                          002035
                                                                                          002036
       RETURN
       END
                                                                                          002037
\mathbf{c}
                                                                                          002038
                                                                                          002039
C
       SUBROUTINE CSSLE1 (IN, LCOL, ITAG, CE, DE, V, EPS)
                                                                                          002040
C
                                                                                          002041
             THIS SUBROUTINE CALLS SIX MAIN SUBROUTINES FOR THE SOLUTION:
C
                                                                                          002042
                                                                                          002043
C
             OF A LINEAR SYSTEM OF EQUATIONS DEPENDING ON THE PARTICULAR
                                                                                          002044
C
                                                                                          002045
             JOB
                                                                                          002046
C
                                                                                          002047
C
       DIMENSION IN(8), LCOL(1); ITAG(1)
                                                                                          002048
       COMPLEX CE(1), DE(1), V(1)
                                                                                          002049
                                                                                          002050
                        NUMBER OF UNKNOWNS
C
            IN(1) = N
                                                                                          002051
Č
                                                                                          002052
            IN(2)=LES : MAXIMUM AREA PREDICTED FOR THE SPARSE MATRIX
\mathbf{C}
                                                                                          002053
C
                                                                                          002054
            IN(3) = IAR INDICATOR FOR CHECKING STRUCTURAL SYMMETRY AND COLUMN ORDERING OF THE COEFFICIENT MATRIX AND FLAGFOR INSUFFICIENT AREA
C
                                                                                          002055
\mathbf{C}
                                                                                          002056
C
                                                                                          002057
C
                                                                                          002058
            IN(4) = IAF FLAG FOR INTERACTIVE SOLUTION
C
                                                                                          002059
č
                          IF IAF=1 FOR SINGLE SOLUTION OR INVERSION OF THE GIVEN MATRIX THEN RESULTS WILL NOT BE PRINTED OUT
                                                                                          002060
                                                                                          0020617
C
                                                                                          002062
            IN(5) = ISUB1 INDICATOR FOR USER SUBROUTINE; NUMBER OF CHANGES
\mathbf{C}
                                                                                          002063
C
                           IN THE COEFFICIENT MATRIX
                                                                                          002064
                                                                                          002065
CCCC
            IN(6) = ISUB2 INDICATOR FOR USER SUBROUTINE: NUMBER OF INTERNAL
                                                                                          002066
                          NODES
                                                                                          002067
                                                                                          002068
C
            IN(7)=NINV@PREDICTED NUMBER OF NONZERO ELEMENTS IN THEMO
                                                                                          002069
                           INVERSE MATRIX
                                                                                          002070
                           IF NINV=1 FOR MULTIPLE NONINTERACTIVE SOLUTION
                                                                                          002071
CCCCC
                          OR FOR PARTIAL BIFACTORIZATION OF DECOMPPOSED GRAPH THEN RESULTS WILL NOT BE PRINTED OUT
                                                                                          002072
                                                                                          002073
                                                                                          002074
                           INDICATOR FOR KIND OF JOB
            IN(8)
                                                                                          002075
C
                   = 1
                          THE SINGLE SOLUTION SUBROUTINE IS EXECUTED
                                                                                          002076
C
                   =2
                          THE MULTIPLE SOLUTION SUBROUTINE IS EXECUTED:
                                                                                          002077
                   =3
                          THE INVERSION SUBROUTINE IS EXECUTED
\mathbf{c}
                                                                                          002078
                          THE SOLUTION IS CALCULATED FOR AN ALTERED COEFFI-
                                                                                          002079
                   =4
С
                          CIENT MATRIX AND/OR RIGHT HAND SIDE VECTOR (24)
\mathbf{C}
                                                                                          002080
```

```
THE SOLUTION IS CALCULATED FOR AN ALTERED RIGHT
                                                                                                     002081
                     =5
                              HAND SIDE VECTOR ONLY
BIFACTORIZATION IS PERFORMED FOR INTERNAL
                                                                                                     002082
                                                                                                     002083
                     =6
                                                                                                     002084
C
                              NODES ONLY
                                                                                                     002085
C
C
C
             FOR IN(8)=4 THE USER STORES THE NEW COEFFICIENTS IN THE...
WORKING AREA CE FROM ELEMENT LES*2+1, WHILE ROW AND COLUMN
INDICES OF THE NEW COEFFICIENTS ARE STORED IN THE WORKING AREA
                                                                                                     002086
                                                                                                     002087
                                                                                                     002088
\mathbf{c}
             ITAG FROM ELEMENT 2*LES+1 AND 3*LES+1, RESPECTIVELY. IN(5) STORES THE NUMBER OF NEW COEFFICIENTS.
                                                                                                     002089
                                                                                                     002090
                                                                                                     002091
Č
             FOR IN(8)=4 AND/OR IN(8)=5 THE USER STORES THE NEW RIGHT
                                                                                                     002092
CCC
             HAND SIDE ELEMENTS IN THE WORKING AREA V FROM ELEMENT N+1
                                                                                                     002093
                                                                                                     002094
             DIMENSION OF MATRIX LCOL MUST BE EQUAL TO 4*N+1 FOR INVERSION
                                                                                                     002095
C
                                                                                                     002096
             AND 3*N+1 FOR THE OTHER CASES
\mathbf{C}
                                                                                                     002097
CCC
             DIMENSION OF MATRIX ITAG MUST BE EQUAL TO 2*LES+NINV FOR
                                                                                                     002098
             IN(8) = 1, 2, 3, 5, 6 AND 4*LES FOR IN(8) = 4
                                                                                                     002099
                                                                                                     002100
C
             DIMENSION OF MATRIX CE MUST BE EQUAL TO 2*LESI+NINV FOR
                                                                                                     002101
CCCCCCC
                                                                                                     002102
              IN(8) = 1.3.5.6 AND 4*LES FOR IN(8) = 2.4
                                                                                                     002103
             DIMENSION OF MATRIX DE MUST BE EQUAL TO 2*N FOR IN(8)=2,4
                                                                                                     002104
             AND N FOR THE OTHER CASES
                                                                                                     002105
                                                                                                     002106
             DIMENSION OF MATRIX V MUST BE EQUALITO 2*N FOR IN(8)=2,4,5
                                                                                                     002107
                                                                                                     002108
č
             AND N FOR THE OTHER CASES
                                                                                                     002109
                                                                                                     002110
        N = IN(1)
                                                                                                     002111
        LES= IN(2)
                                                                                                     002112
        N1 = N+1
                                                                                                     002113
        N2 = N + 2
                                                                                                     002114
        N3=N2+N
                                                                                                     002115
        N4=N3+N
                                                                                                     002116
        LES1=LES+1
                                                                                                     002117
        LES2=LES1+LES
                                                                                                     002118
        LES3=LES2+LES
                                                                                                     002119
        CALL SECOND (TM1)
        IF(IN(8).EQ.6) GO TO 70
IF(IN(8).EQ.5) GO TO 60
                                                                                                     002120
                                                                                                     002121
        IF (IN(8) .EQ. 4) GO TO 50
IF (IN(8) .EQ. 3) GO TO 20)
IF (IN(8) .EQ. 2) GO TO 10)
                                                                                                      002122
                                                                                                      002123
                                                                                                      002124
                                                                                                     002125
                                                                                                      002126
Č
              THE SINGLE SOLUTION SUBROUTINE IS EXECUTED
                                                                                                     992127
       CALL SSLECN (IN(1), LCOL(1), LCOL(N2), LCOL(N3), ITAG(1), ITAG(LES1), CE 1(1), CE(LES1), DE(1), V(1), LF, IN(2), IN(3)) ( IF (IN(3).EQ.1) RETURN IF (IN(4).EQ.1) RETURN
                                                                                                     002128:::
                                                                                                      002129
                                                                                                      002130
                                                                                                      002131
                                                                                                      002132
        CALL SECOND (TM2)
        CPU=TM2-TM1
                                                                                                      002133
        WRITE (6,30) CPU
IF(IN(4).NE.1) WRITE(6,120)
FORMAT(1H,/, SOLUTION",/)
                                                                                                      002134
                                                                                                      002135
                                                                                                      002136
120
                                                                                                      002137
        IF (IN(4).NE.1) CALL PRINT (IN(1), V)
                                                                                                      002138
                                                                                                      002139
C
              THE MULTIPLE SOLUTION SUBROUTINE ISSEXECUTED
                                                                                                      002140
                                                                                                      002141
\mathbf{C}
       CALL MSLECN (IN(1),LCOL(1),LCOL(N2),LCOL(N3),ITAG(1),ITAG(LES1),CE 1(1),CE(LES1),DE(1),V(1),LF,IN(2),IN(3),IN(4),V(N1),CE(LES2),CE(LES 23),DE(N1),IN(5),IN(6),IN(7))
                                                                                                      002142
10
                                                                                                      002143
                                                                                                      002144
        IF(IN(7).EQ. 1) RETURN
                                                                                                      002145
```

```
CALL SECOND (TM2)
                                                                                              002146
        CPU=TM2-TM1
                                                                                              002147
        WRITE (6,30) CPU
                                                                                              002148
        RETURN
                                                                                              002149
\overline{\mathbf{C}}
                                                                                              002150
             THE INVERSION SUBROUTINE IS EXECUTED:
                                                                                              002151
\mathbf{C}
                                                                                              002152
       CALL INVCN (IN(1), LCOL(1), LCOL(N2), LCOL(N3), ITAG(1), ITAG(LES1), CE(11), CE(LES1), DE(1), V(1), LF, IN(2), IN(3), EPS, LCOL(N4), ITAG(LES2), CE(L
20
                                                                                              002153
                                                                                              002154
       2ES2), IN(7))
                                                                                              002155
        IF (IN(3).EQ.1) RETURN
                                                                                              002156
        IF(IN(4).EQ.1) RETURN
                                                                                              002157
        CALL SECOND (TM2)
CPU=TM2-TM1
                                                                                              002158
                                                                                              002159
        WRITE (6,30) CPU
                                                                                              002160
        IF (IN(4).NE.1) WRITE (6,40) : (IN(4).NE.1) CALL PRINTI (IN(1),CE(LES2),LCOL(N4),ITAG(LES2))
                                                                                              002161
                                                                                              002162
        RETURN
                                                                                              002163
C
                                                                                              002164
             THE SOLUTION IS CALCULATED FOR AN ALTERED COEFFICIENT (1)
\mathbf{C}
                                                                                              002165
C
             MATRIX AND/OR RIGHT HAND SIDE VECTOR:
                                                                                              002166
                                                                                              002167
С
      CALL MSLECC (IN(1), LCOL(1), LCOL(N3), ITAG(1), ITAG(LES1), CE(1), 1CE(LES1), DE(1), V(1), LF, IN(2), IN(3), IN(4), V(N1), CE(LES2), CE(LES 23), DE(N1), IN(5), ITAG(LES2), ITAG(LES3))

IF (IN(3).EQ.1) RETURN
50
                                                                                              002168
                                                                                              002169
                                                                                              002170
                                                                                              002171
        IF(IN(7).EQ. 1) RETURN
                                                                                              002172
        CALL SECOND (TM2)
                                                                                              002173
       CPU=TM2-TM1
                                                                                              002174
        WRITE (6,30) CPU
                                                                                              002175
        IF(IN(7).NE.1) WRITE(6,120)
                                                                                              002176
        IF (IN(7).NE.1) CALL PRINT (IN(1), V)
                                                                                              002177
                                                                                              002178
       RETURN
C
                                                                                              002179
C
             THE SOLUTION IS CALCULATED FOR AN ALTERED RIGHT HAND SIDE
                                                                                              002180
ā
             VECTOR ONLY
                                                                                              002181
\mathbf{C}
                                                                                              002182
       CALL MSLERC (IN(1), LCOL(1), LCOL(N3), ITAG(1), ITAG(LES1), CE(1)
60
                                                                                              002183
      1, CE(LES1), DE(1), V(1), IN(4), V(N1))
                                                                                              002184
        IF (IN(3).EQ.1) RETURN
                                                                                              002185
        IF(IN(7).EQ.1) RETURN
                                                                                              002186
       CALL SECOND (TM2)
                                                                                              002187
       CPU=TM2-TM1
                                                                                              002188
       WRITE (6,30) CPU
                                                                                              002189
       IF(IN(7).NE.1) WRITE(6,120)
                                                                                              002190
        IF (IN(7).NE.1) CALL PRINT (IN(1), V)
                                                                                              002191
                                                                                              002192
\mathbf{C}
                                                                                              002193
\mathbf{C}
                                                                                              002194
\mathbf{c}
            BIFACTORIZATION: IS PERFORMED FOR INTERNAL NODES ONLY
                                                                                              002195
\mathbf{C}
                                                                                              002196
70
       CALL PABIDES(IN(1), LCOL(1), LCOL(N2), LCOL(N3), ITAG(1), ITAG(LES1),
                                                                                              002197
      1CE(1), CE(LES1), DE(1), LF, IN(2), IN(3), IN(6))
IF(IN(3).EQ. 1) RETURN
                                                                                              002198
                                                                                              002199
       IF(IN(7).NE.2) RETURN
                                                                                              002200
       CALL SECOND(TM2)
                                                                                              002201
       CPU=TM2-TM1
                                                                                              002202
       WRITE(6,30)CPU
                                                                                              002203
       IF(IN(1).EQ.1.AND.LCOL(1).EQ.0) GOTO 900)
                                                                                              002204
       WRITE(6,110)
                                                                                              002205
       CALL PRINTS (IN(1), CE(1), LCOL(1), ITAG(1), ITAG(LES1))
                                                                                              002206
                                                                                  ( )
       WRITE(6, 100)
                                                                                              002207
                                                                                              002208
       CALL PRINTS(IN(1), CE(LES1), LCOL(1), ITAG(1), ITAG(LES1))
       WRITE(6, 130)
                                                                                              002209
       CALL PRINT(IN(1), DE)
                                                                                              002210
```

```
FORMAT(1H, /, " DIAGONAL ELEMENTS", /)
FORMAT(1H, /, " UPPER TRIANGULAR PART ", /)
FORMAT(1H, /, " LOWER TRIANGULAR PART ", /)
 130
                                                                                            002211
 100
                                                                                            002212
110
                                                                                            002213
80
        RETURN
                                                                                            002214
        FORMAT (1H ,/, " CPU TIME: ",F8.3, " SECONDS",/)
FORMAT (1H ,/, " INVERSE MATRIX",/)
30
                                                                                            002215
40
                                                                                            002216
        END
                                                                                            002217
\mathbf{C}
                                                                                            002218
C
                                                                                            002219
        SUBROUTINE SSLECN (N,LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, DE, V, LF, LES, IA
                                                                                            002220
       1R)
                                                                                            002221
C
                                                                                            002222
000000000000000
             THIS SUBROUTINE SOLVES A SYSTEM OF SPARSE LINEAR EQUATIONS
                                                                                            002223
                                                                                            002224
             WHOSE COEFFICIENT MATRIX IS SPARSE AND NONSYMMETRICAL
                                                                                            002225
                                                                                            002226
             BASED UPON THE ZOLLENKOPF ALGORITHM PRESENTED IN
                                                                                            002227
                                                                                            002228
             " LARGE SPARSE SETS OF LINEAR EQUATIONS "
                                                                     1.11
                                                                                            002229
                                                                                            002230
             - PROCEEDINGS OF THE OXFORD CONFERENCE OF THE INSTITUTE OF
                                                                                            002231:
                                                                                            002232
            MATHEMATICS AND ITS APPLICATIONS, HELD IN APRIL 1970-
                                                                                            002233
                                                                                            002234
            J.K.REID, EDITOR, ACADEMIC PRESS, 1971, PP.75-96
                                                                                            002235
                                                                                            002236
        INTEGER ITAG(1), LCOL(1), LNXT(1), NOZE(1); NSEQ(1)
                                                                                            002237
       COMPLEX CE(1), V(1), RE(1), DE(1)
                                                                                            002238
002239
                   IS THE NUMBER OF UNKNOWNS, ORDER OF THE MATRIX
                                                                                 4.3
                                                                                            002240
                                                                                            002241
            LCOL STARTING POSITION OF COLUMNS

N+1-ST ELEMENT OF LCOL INDICATES THE FIRST VACANT POSITION. DIMENSION IS EQUAL TO N+1
                                                                                            002242
                                                                                            002243
                                                                                            002244
                                                                                            002245
            NOZE NUMBER OF NONZERO TERMS
CALCULATED BY THE DATBCN SUBROUTINE
                                                                                            002246
                                                                                            002247
                   DIMENSION IS EQUAL TO N
                                                                                            002248
                                                                                            002249
            NSEQ SEQUENCE OF PIVOTAL INDICES CALCULATED BY THE DATACN SUBROUTINE
                                                                                            002250
                                                                                            002251
                   DIMENSION IS EQUAL TO N
                                                                                            002252
                                                                                            002253
            ITAG ROW INDEX OF ELEMENTS STORED IN CE
DIMENSION IS NOT SMALLER THAN THE NUMBER: OF NONZERO
                                                                                            002254
                                                                                            002255
                   ELEMENTS
                                                                                            002256
                                                                                            002257
            LNXT LOCATION OF THE NEXT TERM IN EACH COLUMN AT
                                                                                            002258
                   DIMENSION IS NOT SMALLER THAN THE NUMBER OF NONZERO
                                                                                            002259
                   ELEMENTS
                                                                                            002260
                   CALCULATED BY THE DATACN SUBROUTINE
                                                                                            002261
                                                                                            002262
            CE
                   IS THE MATRIX OF COMPLEX COEFFICIENTS OF A GIVEN EQUATION
                                                                                            002263
                                                                                            002264
            RE
                   AN ARRAY HAVING ROWWISE STORED! TERMS OF THE COEFFICIENT
                                                                                            002265
                  MATRIX. CALCULATED BY THE DATA SUBROUTINE
                                                                                            992266
                                                                                            002267
                  AN ARRAY OF DIMENSION N STORING DIAGONAL TERMS OF CO-
EFFICIENT MATRIX. DATA REQUIRED FROM THE USER
            DE
                                                                                            002268
                                                                                            002269
                                                                                            002270
            v
                       ARRAY OF DIMENSION N STORING THE RIGHT HAND
                                                                                            002271:
                  SIDE VECTOR
                                                                                            002272
                  AT THE OUTPUT V CONTAINS THE SOLUTION VECTOR
                                                                                            002273
                                                                                            002274
            LF
                   INDICATOR FOR THE NEXT VACANT LOCATION
                                                                                            002275
```

LES NUMBER OF ELEMENTS IN MATRICES ITAG, LNXT, RE & CE	0022 0022
IAR INDICATOR FOR CHECKING STRUCTURAL SYMMETRY AND COLUMN ORDERING OF COEFFICIENT MATRIX AND FLAG FOR INSUFFIC	0022 0022
ORDERING OF COEFFICIENT MATRIX AND FLAG FOR INSUFFIC	
	0022 0022
CALL DATACN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES)	
CALL DATBCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES, IAR)	0022 0022
IAR=0 NINT=N	0022
CALL SORDCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, IAR, NINT)	0022 0022
IF (IAR.EQ.1) RETURN CALL REDUCN (N,LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, NINT)	8829
IF (IAR.EQ.1) RETURN	0029
CALL SOLVCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V) RETURN	
END	0022 0022
	0022
SUBROUTINE MSLECN (N.LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, DE, V, LF, LE	0022 S.IA 0022
1R, IAF, VV, CCE, RRE, DDE, ISUB1, ISUB2, NINV)	0022
THIS SUBROUTINE OBTAINS MULTIPLE SOLUTIONS OF A SYSTEM OF	0022 0023
LINEAR EQUATIONS WHOSE COEFFICIENT MATRIX IS SPARSE AND	9922
DIMERIC EQUATIONS WHOSE COEFFICIENT MAIRIX IS SPARSE ANDS	0023 0023
NONSYMMETRICAL	0023
AN INTERACTIVE OR NONINTERACTIVE VERSION CAN BE USED TO HA	0023 NDLE 0023
DIFFERENT CHANGES IN BOTH COEFFICIENT MATRIX AND RIGHT HAN	0023
	D □ 0023 0023
SIDE VECTOR	0023 0023
INTEGER ITAG(1), LCOL(1), LNXT(1), NOZE(1), NSEQ(1) COMPLEX CE(1), V(1), RE(1), DE(1), VV(1), CCE(1), RRE(1), DDE(1)	0023
CONFLEX GE(1), V(1), RE(1), DE(1), VV(1), GGE(1), RRE(1), DDE(1)	0023 0023
N IS THE NUMBER OF UNKNOWNS, ORDER OF THE MATRIX	0023
LCOL STARTING POSITION OF COLUMNS	0023 0023
N+1-ST ELEMENT OF LCOL INDICATES THE FIRST VACANT POSITION	0023
DIMENSION IS EQUAL TO N+1 NOZE NUMBER OF NONZERO TERMS CALCULATED BY THE DATBCN SUBROUTINE DIMENSION IS EQUAL TO N	0023 0023
NOZE NUMBER OF NONZERO TERMS	0023
CALCULATED BY THE DATBON SUBROUTINE	0023 0023
DIMENSION IS EQUAL TO N	0023
NSEQ SEQUENCE OF PIVOTAL INDICES	0023 0023
CALCULATED BY THE DATACN SUBROUTINE DIMENSION IS EQUAL TO N	0023
	0023 0023
ITAG ROW INDEX OF ELEMENTS STORED IN CE DIMENSION IS NOT SMALLER THAN THE NUMBER OF NONZERO	0023
ELEMENTS	0023 0023
LNXT LOCATION OF THE NEXT TERM IN EACH COLUMNA	0023
DIMENSION IS NOT SMALLER THAN THE NUMBER OF NONZERO	0023 0023
ELEMENTS CALCULATED BY THE DATACN SUBROUTINE	0023
	0023: 0023:
CE IS THE MATRIX OF COMPLEX COEFFICIENTS OF A GIVEN EQUA	TION 0023: 0023
	いいつりん

```
AN ARRAY HAVING ROWWISE STORED TERMS OF THE COEFFICIENT
                                                                                        002341
           RE
                  MATRIX CALCULATED BY THE DATA SUBROUTINE
                                                                                        002342
                                                                                        002343
AN ARRAY OF DIMENSION N STORING DIAGONAL TERMS OF CO-
                                                                                        002344
           DE
                  EFFICIENT MATRIX - DATA REQUIRED FROM THE USER
                                                                                        002345
                                                                                        002346
                      ARRAY OF DIMENSION N STORING THE RIGHT HAND
                                                                                        002347
            v
                  SIDE VECTOR
                                                                                        002348
                  AT THE OUTPUT V CONTAINS THE SOLUTION VECTOR
                                                                                        002349
                                                                                        002350
                  INDICATOR FOR THE NEXT VACANT LOCATION
                                                                                        002351
           LF
                                                                                        002352
                 NUMBER OF ELEMENTS IN MATRICES ITAG, LNXT, RE & CE
                                                                                        002353
           LES
                                                                                        002354
                  INDICATOR FOR CHECKING STRUCTURAL SYMMETRY AND COLUMN
                                                                                        002355
            IAR
                  ORDERING OF THE COEFFICIENT MATRIX AND FLAG FOR INSUFFI-
                                                                                        002356
                  CIENT AREA
                                                                                        002357
                                                                                        002358
            IAF
                 FLAG FOR INTERACTIVE SOLUTION. FOR IAF ODD THE SOLUTION
                                                                                        002359
                 IS OBTAINED DURING AN INTERACTIVE SESSION, WHILE FOR IAF EVEN THE SOLUTION IS GENERATED ON THE BASIS OF DATA STORED BY THE USER
                                                                                        002360
                                                                                        002361
                                                                                        002362
                  FOR IAF EQUAL:
                                                                                        002363
                                                                                        002364
                  0 OR 1 ONLY THE SOLUTION OF THE GIVEN SYSTEM IS
                                                                                        002365
                          CALCULATED
                                                                                        002366
                          THE SOLUTION OF THE GIVEN AND ADJOINT SYSTEM MAY
                                                                                        002367
                  2 OB 3
                                                                                        002368
                          BE CALCULATED
                  4 OR 5 ONLY THE SOLUTION OF THE ADJOINT SYSTEM IS CALCULA
                                                                                        002369
                                                                                        002370
                  TED
                                                                                        002371
            VV, CCE, RRE, DDE -ADDITONAL MATRICES STORING INTERMEDIATE 11
                                                                                        002372
                  RESULTS FOR THE INTERACTIVE SOLUTION
                                                                                        002373
                                                                                        002374
            ISUB1, ISUB2 - INDICATORS FOR USER SUBROUTINES USUB1, USUB2.

IF EQUAL 1 USER SUBROUTINES WILL BE CALLED BEFORE

ALTERING THE COEFFICIENT MATRIX AND/OR RIGHT HAND
                                                                                        002375
                                                                                        002376
                                                                                        002377
                  SIDE VECTOR
                                                                                        002378
                                                                                        002379
           FILE NO 6 IS NECESSARY FOR PRINTING THE RESULTS
                                                                                        002380
                                                                                        002381
C
       DO 10 I=1, N
                                                                                        002382
       VV( I) = V( I)
                                                                                        002383
       CONTINUE
                                                                                        002384
10
                                                                                        002385
       CALL DATACN (N.LCOL.NOZE.NSEQ.ITAG.LNXT.CE,RE,LF,LES)
                                                                                        002386
C
       CALL DATBCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES, IAR)
                                                                                        002387
                                                                             1.3
                                                                                        002388
       IAR=0
       NINT=N
                                                                                        002389
       CALL SORDCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, IAR, NINT)
                                                                                        002390
       IF (IAR. EQ. 1) RETURN
                                                                                        002391
       DO 20 I=1,LES
CCE(I)=CE(I)
                                                                                        002392
                                                                                        002393
       RRE( I ) = RE( I )
                                                                                        002394
20
       CONTINUE
                                                                                        002395
                                                                                        002396
       DO 30 I=1,N
                                                                                        002397
       DDE(I)=DE(I)
       CONTINUE
                                                                                        002398
30
       CALL REDUCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, NINT)
                                                                                        002399
       IF (IAR.EQ.1) RETURN
IF (IAF.GT.3) GO TO:50
                                                                                        002400
                                                                                        002401
       CALL SOLVCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                        002402
       WRITE (6.70)
                                                                                        002403
       IF(NINV.NE.1) WRITE(6,100) FORMAT(1H, /, "SOLUTION", /)
                                                                                        002404
100
                                         111
                                                                                        002405
```

```
IF(NINV.NE.1) CALL PRINT(N.V)
                                                                                              002406
         DO 40 I=1,N
                                                                                              002407
         V( I) = VV( I)
                                                                                              002408
         CONTINUE
 40
                                                                                              002409
         IF (IAF.LT.2) GO TO 60
 50
                                                                                              002410
         CALL ASLECN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                              002411
         WRITE (6,80)
                                                                                              002412
         IF(NINV.NE.1) WRITE(6,100)
                                                                                              002413
         IF(NINV.NE. 1) CALL PRINT(N, V) Par
                                                                                              002414
 60
         CONTINUE
                                                                                              002415
         IF( IAF. EQ. 0. OR. IAF. EQ. 2. OR. IAF. EQ. 4) GO TO 90
                                                                                              002416
        CALL RSLECN (N, IAF, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, DE, V, VV, LF, LES, I
                                                                                             002417
       1AR, CCE, RRE, DDE, ISUB1, ISUB2)
                                                                                              002418
                                                                                              002419
        DO 310 I=1,LES
CE(I)=CCE(I)
 90
                                                                                              002420
                                                                                             002421
        RE(I) = RRE(I)
                                                                                             002422
 310
        CONTINUE
                                                                                             002423
        DO 320 I=1.N
                                                                                             002424
        DE( 1) = DDE( 1)
                                                                                             002425
 320
        CONTINUE
                                                                                             002426
        RETURN
                                                                                             002427
 \mathbf{C}
                                                                                             002428
 C
                                                                                             002429
 70
        FORMAT (1H ,/, " END OF FIRST SOLUTION")
FORMAT (1H ,/, " SOLUTION OF ADJOINT SYSTEM")
                                                                                             002430
 80
                                                                                             002431
                                                                                             002432
\mathbf{C}
                                                                                             002433
\mathbf{C}
                                                                                             002434
        SUBROUTINE INVCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, DE, V, LF, LES, IAR
                                                                                             002435
       1, EPS, LCLI, ITGI, INV, NINV)
                                                                                             002436
C
                                                                                             002437
CCC
             THIS SUBROUTINE CALCULATES THE INVERSION OF THE GIVEN SPARSE
                                                                                             002438
                                                                                             002439
             MATRIX. IF AN ELEMENT OF THE INVERSE MATRIX HAS AN ABSOLUTE
                                                                                             002440
\mathbf{C}
                                                                                             002441
C
             VALUE SMALLER THAN EPS THEN A ZERO VALUE IS ASSUMED. THE FINAL
                                                                                             002442 M.
\mathbf{C}
                                                                                             002443
Č
             INVERTED MATRIX IS STORED IN SPARSE FORM SIMILAR TO THE INPUT
                                                                                             002444
                                                                                             002445
\mathbf{C}
             DATA
                                                                                             002446
                                                                                             002447
        INTEGER ITAG(1), LCOL(1), LNXT(1), NOZE(1), NSEQ(1)
INTEGER LCLI(1), ITGI(1)
                                                                                             002448
                                                                                             002449
        COMPLEX CE(1), V(1), RE(1), DE(1)::
                                                                                             002450
        COMPLEX INV(1)
                                                                                             002451
\mathbf{C}
                                                                                             002452
                   IS THE NUMBER OF UNKNOWNS, ORDER OF THE MATRIX
C
                                                                                             002453
0000000000000000
                                                                                            002454
            LCOL STARTING POSITION OF COLUMNS
N+1-ST ELEMENT OF LCOL INDICATES THE FIRST VACANT
                                                                                            002455
                                                                                            002456
                   POSITION.
                                                                                            002457
                   DIMENSION IS EQUAL TO N+1
                                                                                            002458
                                                                                            002459
            NOZE NUMBER OF NONZERO TERMS
CALCULATED BY THE DATBCN SUBROUTINE
                                                                                            002460
                                                                                            002461
                   DIMENSION IS EQUAL TO N
                                                                                            002462
                                                                                            002463
            NSEQ SEQUENCE OF PIVOTAL INDICES
CALCULATED BY THE DATACN SUBROUTINE
DIMENSION IS EQUAL TO N
                                                                                            002464
                                                                                            002465
                                                                                            002466
                                                                                            002467
            ITAG ROW INDEX OF ELEMENTS STORED IN CE
                                                                                            002468
C
                  DIMENSION IS NOT SMALLER THAN THE NUMBER OF NONZERO
                                                                                            002469
                   ELEMENTS
                                                                                            002470
```

•			
C	INUT	LOCATION OF THE NEXT TERM IN EACH COLUMNA	002471
Ğ	LIMI	DIMENSION IS NOT SMALLER THAN THE NUMBER OF NONZERO	002472 002473
č		ELEMENTS	002474
C C		CALCULATED BY THE DATACN SUBROUTINE	002475
č			002476
C C	CE	IS THE MATRIX OF COMPLEX COEFFICIENTS OF A GIVEN EQUATION	
C			002478
C	RE	AN ARRAY HAVING ROWWISE STORED! TERMS OF THE COEFFICIENT	002479
Č C		MATRIX. CALCULATED BY THE DATA SUBROUTINE	002480
C			002481
C ·	DE	AN ARRAY OF DIMENSION N STORING DIAGONAL TERMS OF CO-	002482
Č C		EFFICIENT MATRIX. DATA REQUIRED FROM THE USER	002483
C	v	AN ARRAY OF DIMENSION N STORING THE RIGHT HAND	002484
Č		SIDE VECTOR	002485 002486
Č		AT THE OUTPUT V CONTAINS THE SOLUTION VECTOR	002487
č		AT THE COTTOT V CONTAINS THE ECHOTTON VEGTOR	002488
Č	LF	INDICATOR FOR THE NEXT VACANT LOCATION	002489
C	•		002490
C	LES	NUMBER OF ELEMENTS IN MATRICES ITAG, LNXT, RE & CE	002491
C			002492
C	IAR	INDICATOR FOR CHECKING STRUCTURAL SYMMETRY AND COLUMN	002493
C		ORDERING OF COEFFICIENT MATRIX AND FLAG FOR INSUFFICIENT	002494T
C	<u> </u>	AREA	002495
C			002496
C	EPS	ALL ELEMENTS OF THE INVERSE MATRIX HAVING ABSOLUTE VALUE	
C		LESS THAN EPS WILL BE ASSUMED ZERO VALUE AND WILL NOT	
C		BE STORED	002499
C	T CT T	CHARMAN DOCUMEN OF COLUMNS INCHES INVESTOR MARRIES	002500
C	LCLI	STARTING POSITON OF COLUMNS IN THE INVERSE MATRIX	002501
C C	· .	N+1-ST ELEMENT OF LCLI INDICATES THE FIRST VACANT POSITON DIMENSION IS EQUAL TO N+1	
Č			002503
č	TTCT	ROW INDEX OF ELEMENTS STORED IN INV	002504 002505
Č	1101	DIMENSION IS NOT LESS THAN NINV	002506
č		DIMENSION IS NOT ELES THAN NINV	002507
č	INV	COLUMNWISE STORED INVERSE MATRIX	002508
Ċ		ROW INDEX OF ELEMENTS STORED IN INV DIMENSION IS NOT LESS THAN NINV COLUMNWISE STORED INVERSE MATRIX DIMENSION IS NOT LESS THAN NINV	002509
C			002510
C	NINV	NUMBER OF NONZERO ELEMENTS IN INV	002511
C			002512
	CALL DAT	ACN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES)	002513
C			002514
		BCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES, IAR)	002515
	IAR=0		002516
	NINT=N	DCN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, IAR, NINT)	002517
		EQ. 1) RETURN	002518 002519
		UCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, NINT)	002519
	IF (IAR.	EQ. 1) RETURN	002521
C			002522
C	PREP	ARE THE RIGHT HAND SIDE VECTOR DE-	002523
C			002524
	LICZ=0		002525
	LCLI(1)=		002526
	DO 30 I=		002527
	DO 10 J=	1,N LX(0.,0.)	002528
1.0	CONTINUE	LACTO, U.,	002529
10		LX(1.,0.)	002530
		VCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)	002531 00253 2
	DO 20 J=		00253 <u>2</u>
		(V(J)).LE.EPS) GO TO 20	002534
	LICZ=LIC		002535
			

C C	NUMBER OF ELEMENTS IN THENINVERSE IS GREATER THAN DECLARED	002536 002537
Ċ	IF (LICZ.GT.NINV) GO TO 40 ITGI(LICZ)=J	002538 002539 002540
20	INV(LICZ) = V(J) CONTINUE	002541 002542
30	LCLI(I+1)=LICZ+1 CONTINUE	002543 002544
40	RETURN NINV=0	002545 002546
	WRITE (6,50) RETURN	002547 002548
C 50	FORMAT (" NUMBER OF ELEMENTS IN THE INVERSE IS GREATER THAN DECLA 1RED")	002551
C	END	002552 002553
C	SUBROUTINE MSLECC(N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V, LF, LES,	002554 002555
C	+ IAR, IAF, VV, CCE, RRE, DDE, NCHM, IRN, ICN)	002556 002557
C C	THIS SUBROUTINE REPEATS THE SOLUTION OF THE LINEAR SPARSE	002558 002559
Č C	SYSTEM FOR ALTERED COEFFICIENTS AND/OR RIGHT HAND SIDE VECTOR	002560∺ 002561
C C	IAF INTERACTIVE VECTOR SHOULD BE EQUAL 0,2 OR 4 DEPENDING ON	002562 002563
C C	THE DESIRED TYPE OF ANALYSIS	002564 002565
c	INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1), IRN(1), ICN(1) COMPLEX COEFF, CE(1), RE(1), DE(1), V(1), VV(1), CCE(1), RRE(1), DDE(1)	002566 002567 002568
G G	NEW COEFFICIENT SHOULD BE PLACED IN CCE AND ITS ROW AND	002569 002570
C	COLUMN NUMBERS IN IRN AND LICH RESPECTIVELY. NCHM IS THESE	002571 002572
С С С	NUMBER OF NEW COEFFICIENTS. NEW RIGHT HAND SIDE ELEMENTS	002573 002574
C	SHOULD BE PLACED IN VV.	002575 002576
· ·	IF (NCHM.EQ.0) GO TO 360 DO 330 I=1,NCHM	002577 002578
	NROW= IRN(I)	002579 002580
	NCOL=ICN(I) COEFF=CCE(I) IF(NROW.GT.N.OR.NROW.LE.0.OR.NCOL.GT.N.OR.NCOL.LE.0) GO TO 100	002581 002582
C	THE NEW ELEMENT MUST BE ENTERED INTO CE OR REDEPENDING ON	002583 002584
C C	WHICH OF THESE MATRICES IS TO STORE THE VALUE OF THIS ELEMENT AFTER THE SIMULATION AND ORDERING PROCESS	002585 002586 002587
C 3 30	CALL CHNGE (IAR, NROW, NCOL, COEFF, LCOL, ITAG, LNXT, CE, RE, DE) IF(IAR.EQ. 1) RETURN. CONTINUE	002588 002589 002590
C C	REPEAT BIFACTORIZATION 22	002591 002592
C	IAR=0	002593 002594
C C C	STORE THE NEW VALUES OF THE ELEMENTS OF THE COEFFICIENTS	002595 002596 002597
C	DO 340 I=1, LES CCE(I)=CE(I)	002598 002599 002600

```
002601
      RRE(I) = RE(I)
                                                                                    002602
340
       CONTINUE
                                                                                    002603
      DO 350 I=1,N
                                                                                    002604
      DDE(I) = DE(I)
350
       CONTINUE
                                                                                    002605
                                                                                    002606
      NINT=N
      CALL REDUCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, NINT) 8,
                                                                                    002607
                                                                                    002608
\mathbf{C}
           SOLUTION WITH NEW RIGHT HAND SIDE VECTOR
                                                                                    002609
\mathbf{C}
                                                                                    002610
C
                                                                                    002611
  360 CONTINUE
      DO 380 J=1,N
V(J)=VV(J)
                                                                                    002612
                                                                                    002613
                                                                                    002614
       CONTINUE
380
       IF (IAF.EQ.0) GO TO 420
                                                                                    002615
                                                                                    002616
       CALL ASLECN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                               10.
                                                                                    992617
       DO 410 J=1,N
       V(J) = VV(J)
                                                                                    002618
       CONTINUE
                                                                                    002619
410
       IF (IAF.EQ.4) GO TO:430
                                                                                    002620
420
                                                                                    002621
       CALL SOLVCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                    002622
430
       CONTINUE
                                                                                    002623
       RETURN
      WRITE (6,490)
FORMAT(1H, " ELEMENT OUT OF THE MATRIX AREA",/)
                                                                                    002624
  100
                                                                                    002625
 490
                                                                                    002626
       RETURN
                                                                                    002627
       END
                                                                                    002628
                                                                                    002629
C
       SUBROUTINE MSLERC(N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V, IAF, VV)
                                                                                    002630
                                                                                    002631
C
           THIS SUBROUTINE REPEATS THE SOLUTION OF THE LINEAR SPARSE
                                                                                    002632
CCCCCC
                                                                                    002633
           SYSTEM FOR ALTERED RIGHT HAND SIDE VECTOR
                                                                                     002634
                                                                                     002635
           IAF INTERACTIVE VECTOR SHOULD BE EQUAL 0,2 OR 4 DEPENDING ON
                                                                                     002636
                                                                                     002637
                                                                                     002638
C
           THE DESIRED TYPE OF ANALYSIS
                                                                                     002639
Ċ
                                                                                     002640
       INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1)
       COMPLEX CE(1), RE(1), DE(1), V(1), VV(1)
                                                                                     002641
                                                                                     002642
C
           NEW RIGHT HAND SIDE ELEMENTS SHOULD BE PLACED IN VV
                                                                                     002643
C
                                                                                     002644
C
                                                                                     002645
       DO 380 J=1,N
       V(J) = VV(J)
                                                                                     002646
       CONTINUE
                                                                                     002647
380
       IF (IAF.EQ.0) GO TO 420
                                                                                     002648
       CALL ASLECN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                     002649
                                                                                     002650
       DO 410 J=1, N
V(J)=VV(J)
                                                                                     002651
                                                                                     002652
       CONTINUE
410
                                                                                     002653
       IF (IAF.EQ.4) GO TO 430
420
       CALL SOLVCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                     002654
                                                                                     002655
       CONTINUE
430
                                                                                     002656
       RETURN
                                                                                     002657
       END
                                                                                     002658
C
                                                                                     002659
       SUBROUTINE PABIDES (IN, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, DE, LF, LES, IA
                                                                                     002660
                                                                                     002661
     +R, NINT)
                                                                                     002662
\mathbf{C}
           THIS SUBROUTINE PERFORMS PARTIAL BIFACTORIZATION OF A
                                                                                     002663
CCC
                                                                                     002664
                                                                                     002665
           DECOMPOSED SYSTEM OF LINEAR EQUATIONS
```

C

CCC

C C C

C C 2 C

I N'	TEGER	ITAG(1), LCOL(1), LNXT(1), NOZE(1), NSEQ(1), IN(1)	14	00266 00266
CO	MPLEX (CE(1), RE(1), DE(1)		00266
	NINT	IS THE NUMBER OF INTERNAL NODES		00266 00267
37.				00267
CAI	LL DAT	ACN(N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES) BCN(IN, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES, IAR)	144 144	00267 00267 00267
CA	R=0 LL SORI (IAR.E	OCN(N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, IAR, NINT) Q. 1) RETURN	AD:	00267 00267 00267
	STOR	E UPPER AND LOWER PARTS		00267 00267
T.ES	S2=LES:	\$2		00268 00268
DO	1 I=1	LES2		00268
1 CE	(LES2+	I)=CE(I)		00268 00268
	STOR	E DIAGONAL ELEMENTS 200		00268 00268
	2 I=1 (N+I)=	, N DE(I) :		00268 00268
RE'	TURN	UCN(N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, NINT)		00268 00269 00269
EN	D			00269 00269
SU	BROUTI	NE DATAC (N, NEL, AK, NCOL, NROW, LCOL, ITAG, CE, DE, LES, I	AR)	00269 00269 00269
	THIS	ROUTINE CHANGES THE DATA STORED IN THE COEFFICIEN	TOMATRIX	00269
	AK TO	THE FORM DESIRED BY THE SUBROUTINES SOLVING THE	SPARSE	00269 00269
	avam.	awa :		00270
		EMS.		00270 00270
	COLUI	IN NUMBERS OF SUCCESSIVE ELEMENTS FROM AK! ARE STOR	ED IN	00276 00276
•	MATR	IX NCOL, WHILE ROW NUMBERS IN NROW. 18 18 18 18 18 18 18 18 18 18 18 18 18		00270
	THE I	PROGRAM GENERATES MATRICES LCOL, ITAG, CE, DE, WHE	RE	00276 00276 00276
	N	NUMBER OF EQUATIONS W		00276
	NET	NUMBER OF ELEMENTS IN AK		00271 00271
				00271
	LCOL	STARTING POSITIONS OF COLUMNS N+1-ST ELEMENT OF LCOL INDICATES THE FIRST VACANT	POSITON	00271 00271
	: .	DIMENSION IS EQUALTO N+1		00271
	ITAG	ROW INDEX FOR ELEMENTS STORED IN CE		00271 00271
		DIMENSION IS NOT SMALLER THAN THE NUMBER OF NONZE	RO :	00271 00271
	\$.	CALCULATED BY THE DATACN SUBROUTINE (1)		00272
	CE	COLUMNWISE STORED MATRIX OF NONZERO COEFFICIENTS	1/1	00272 00272
	CE.	OF A GIVEN EQUATION	a I	00272
	DE	AN ARRAY OF DIMENSION N STORING DIAGONAL TERMS OF	THE:	00272 00272
	1784	COEFFICIENT MATRIX		00272
	LES	PREDICTED MAXIMUM AREA USED BY MATRIX CE		00272 00272
	-			00272
	I AR	FLAG FOR INSUFFICIENT AREA		00273

```
002731
C
                                                                                       002732
       COMPLEX AK(1), CE(1), DE(1)
                                                                                       002733
       INTEGER NCOL(1), NROW(1), LCOL(1), ITAG(1) |)
                                                                                       002734
       N1 = N + 1
                                                                                       002735
       DO 10 I=1,N1
       LCOL(I)=0
                                                                                       002736
                                                                                       002737
       CONTINUE
10
                                                                                       002738
       LCOL(1) = 1
                                                                                       002739
       DO 20 I=1, NEL
       IF (NCOL(I).EQ.NROW(I)) GO TO 20
                                                                                       002740
                                                                                       002741
       LCOL(NCOL(I)+1)=LCOL(NCOL(I)+1)+1
                                                                                       002742
20
       CONTINUE
                                                                                       002743
       DO 40 I=1,N
                                                                                       002744
       LCOL(I+1)=LCOL(I)+LCOL(I+1)
                                                                                       002745
40
       CONTINUE
                                                                                       002746
C
                                                                                       002747
            CALCULATE MATRICES DE, CE, ITAG
C
                                                                                       002748
C
                                                                                       002749
       DO 50 I=1, NEL
                                                                                       002750
       NRWI=NROW(I)
                                                                                       002751
       NCLI=NCOL(I)
       IF(NCLI.EQ.NRWI) GOTO 70
                                                                                       002752
                                                                                       002753
       LCNC=LCOL(NCLI)
                                                                                       002754
       CE(LCNC) = AK(I)
                                                                                       002755
       ITAG(LCNC) = NRWI
                                                                                       002756
       LCOL(NCLI) = LCNC+1
                                                                                       002757
   GOTO 50
70 DE(NCLI) = AK(I)
                                                                                       002758
                                                                                       002759
50
       CONTINUE
                                                                                       002760
\mathbf{c}
                                                                                       002761
C
            CALCULATE MATRIX LCOL
                                                                                       002762
                                                                                       002763
       DO 60 I=1.N
                                                                                       002764
       J=N-I+2
       LCOL(J) = LCOL(J-1)
                                                                                       002765
                                                                                       002766
60
       CONTINUE
                                                                                       002767
       LCOL(1) = 1
                                                                                       002768
       DO 80 I=1,N
                                                                                       002769
       IF(LCOL(I).EQ.LCOL(I+1)) LCOL(I)=0
                                                                                       002770
       RETURN
                                                                                       002771
                                                                                       002772
\mathbf{C}
                                                                                       002773
\mathbf{C}
       SUBROUTINE DATACN (N, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES)
                                                                                       002774
                                                                                       002775
\mathbf{C}
            THIS SUBROUTINE CALCULATES VALUES OF THE FOLLOWING VARIABLES:
                                                                                       002776:
\mathbf{C}
                                                                                       002777
\mathbf{C}
                                                                                       002778
Ċ
            NSEQ, LNXT, LF
                                                                                       002779
Č
       INTEGER LCOL(1), NOZE(1), NSEQ(1), ITAG(1), LNXT(1) COMPLEX CE(1), RE(1)
                                                                                       002780
                                                                                       002781
       LF=LCOL(N+1)
                                                                                       002782
       DO 10 I=1, LES
LNXT(I)=I+1
                                                                                       002783
                                                                                       002784
                                                                                       002785
10
       CONTINUE
                                                                                       002786
       LNXT(LES) = 0
                                                                                       002787
       DO 20 I=LF, LES
CE(I)=CMPLX(0.,0.)
                                                                                       002788
                                                                                       002789
20
       CONTINUE
                                                                                       002790
\mathbf{c}
            CALCULATE MATRICES NSEQ &CLNXT
                                                                                       002791
                                                                                       002792
                                                                                       002793
       DO 50 I=1,N
                                                                                       002794
                                                                                       002795
       IF (LCOL(I).EQ.0) GO TO 50
```

```
002796
       IF (LCOL(J).NE.0) GO TO 40
30
                                                                                    002797
       J=J+1
                                                                                    002798
       GO TO 30
                                                                                    002799
40
       LNXT(LCOL(J)-1)=0
                                                                                    002800
       NSEQ(I) = I
50
                                                                                    002801
       RETURN
                                                                                    002802
       END
                                                                                    002803
                                                                                    002804
\mathbf{C}
       SUBROUTINE DATECN (IN, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, LES, IAR)
                                                                                    002805
                                                                                    002806
C
           THIS SUBROUTINE CALCULATES VALUES OF THE FOLLOWING VARIABLES:
                                                                                    002807:
                                                                                    002808
C
           NOZE, RE
                                                                                    002809
\mathbf{C}
\bar{\mathbf{c}}
                                                                                    002810
       INTEGER LCOL(1), NOZE(1), NSEQ(1), ITAG(1); LNXT(1), IN(1)
                                                                                    002811
                                                                                    002812
       COMPLEX CE(1), RE(1):
                                                                                    002813
                                                                                    002814
           IF IAR.EQ.2 CHECK SYMMETRY
C
                                                                                    002815
ā
                                                                                    002816
       N= IN(1)
       IF (IAR.EQ.2) CALL SYMCN (IN, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, LF)
                                                                                    002817
                                                                                    002818
C
                                                                                    002819
           CALCULATE MATRIX NOZE
                                                                                    002820
Ċ
                                                                                    002821
       DO 20 I=1.N
       NOZE(I) = 0
                                                                                    002822
                                                                                    002823
       NE=LCOL(I)
                                                                                    002824
       IF (NE.EQ.0) GO TO 20
10
       IF(ITAG(NE).LE.0) GOTO 20
                                                                                    002825
                                                                                    002826
       NOZE(I) = NOZE(I) + 1
       NE=LNXT(NE)
                                                                                    002827
                                                                                    002828
       GO TO 10
       CONTINUE
                                                                                    002829
20
                                                                                    002830
       DO 30 I=1, LES
                                                                                    002831
       RE(I) = CMPLX(0...,0.)
                                                                                    002832
30
       CONTINUE
                                                                                    002833
\mathbf{C}
           CALCULATE ROWWISE STORED COEFFICIENT MATRIX 1
                                                                                    002834
C
                                                                                    002835
                                                                                    002836
       DO 70 I=1,N
                                                                                    002837
       NE=LCOL(I)
       IF (NE.EQ.0) GO TO 70
                                                                                    002838
40
                                                                                    002839
       IF(ITAG(NE).LE.0) GOTO 70
                                                                                    002840
       NR= ITAG(NE)
                                                                                    002841
       LI=LCOL(NR)
       IF (ITAG(LI).EQ.I) GO TO 60
                                                                                    002842
50
                                                                                    002843
       LI=LNXT(LI)
                                                                                    002844
       GO TO 50
                                                                                    002845
       RE(LI) = CE(NE)
60
                                                                                    992846
       NE=LNXT(NE)
       GO TO 40
CONTINUE
                                                                                    002847
                                                                                    002848
70
                                                                                    002849
       RETURN
                                                                                    002850
       END
                                                                                    002851
                                                                                    002852
\mathbf{c}
       SUBROUTINE SYMCN (IN, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, LF)
                                                                                    002853
                                                                                    002854
C
           THIS SUBROUTINE CHECKS THE STRUCTURAL SYMMETRY AND ORDERING OF
                                                                                    002855
C
                                                                                    002856
00000
           COLUMNS OF THE COEFFICIENT MATRIX. IF THE MATRIX IS NOT:
                                                                                    002857
                                                                                    002858
           SYMMETRICAL, NEW ZERO COEFFICIENTS ARE ADDED TO REACH SYMMETRY
                                                                                    002859
                                                                                    002860
```

```
COLUMNS ARE REORDERED IF NECESSARY No.
                                                                                      002861
                                                                                      002862
       INTEGER LCOL(1), NOZE(1), NSEQ(1), ITAG(1); LNXT(1), IN(1)
                                                                                      002863
      COMPLEX CE(1)
                                                                                      002864
      N = IN(1)
                                                                                      002865
      IS=0
                                                                                      002866
      DO 70 I=1,N
LC=LCOL(I)
                                                                                      002867
                                                                                      002868
       IF (LC.EQ.0) GO TO 70
                                                                                      002869
10
       IR= ITAG(LC)
                                                                                      002870
       IF(IR.EQ.0) GOTO 70
                                                                                      002871
C
                                                                                      002872
           CHECK IF THERE EXISTS AN ELEMENT SYMMETRICAL TO THE ONET
                                                                                      002873
C
           CONSIDERED
                                                                                      002874
C
\mathbf{C}
                                                                                      002875
      NLC=LCOL(IR)
                                                                                      002876
      IF (NLC.EQ.0) GO TO 30
LLC=NLC
20
                                                                                      002877
                                                                                      002878
      LLR= ITAG(LLC)
                                                                                      002879
         (LLR.EQ. I)
                      GO TO 60
                                                                                      002880
      NLC=LNXT(LLC)
                                                                                      002881
                                                                                      002882
      GO TO 20
                                                                                      002883
C
           MATRIX IS NONSYMMETRICAL-ADD NECESSARY ZERO COEFFICIENTO
\mathbf{C}
                                                                                      002884
                                                                                      002885
30
       IF (LCOL(IR).NE.0) GO TO 40
                                                                                      002886
      LCOL(IR)=LF
                                                                                      002887
      GO TO 50
                                                                                      002888
      LNXT(LLC)=LF
                                                                                      002889
40
       CE(LF) = CMPLX(0.,0.)
                                                                                      002890
50
                                                                                      002891
       IS= 1
                                                                                      002892
       ITAG(LF) = I
      NOZE(IR) = NOZE(IR) +1
                                                                                     002893
       IF=LF
                                                                                      002894
      LF=LNXT(IF)
                                                                                      002895
      LNXT(IF) = 0
                                                                                      002896
                                                                                      002897
C
C
           PROCEED WITH THE NEXT ELEMENT IN THE COLUMN UNDER
                                                                                      002898
                                                                                      002899
           CONSIDERATION
\mathbf{C}
                                                                                      002900
C
                                                                                      002901
60
      LC=LNXT(LC)
       IF (LC.NE.0) GO TO 10
                                                                                      002902
70
       CONTINUE
                                                                                      002903
       IF (IS.EQ.1.AND.(IN(7).EQ.0.OR.IN(7).EQ.2)) WRITE (6,130)
                                                                                      002904
                                                                                      002905
CCCC
           ROWS AND COLUMNS ARE ORDERED SUCH THAT INCREASING VALUES OF
                                                                                      002906
                                                                                      002907
           INDICES DESCRIBE THE NEXT NONZERO ELEMENTS IN EACH ROW AND
                                                                                      002908
C
                                                                                      002909
Č
                                                                                      002910
           COLUMN
                                                                                      002911
       IS=0
                                                                                      002912
                                                                                      002913
      DO 120 I=1,N
       I1=LCOL(I)
                                                                                      002914
80
       I I = I 1
                                                                                      002915
                                                                                      002916
90
       12=LNXT(11)
      IF (12.EQ.0) GO TO 110

IF (1TAG(11).LT.ITAG(12)) II=12

IF (1TAG(11).LT.ITAG(12)) GO TO 90
                                                                                      002917
                                                    12
                                                                                      002918
                                                                                      002919
       IS= 1
                                                                                      002920
       IF (I1.EQ.LCOL(I)) GO TO 100 60
                                                                                      002921
                                                                                      002922
CCC
                                                                                      002923
           EXCHANGE TWO ELEMENTS
                                                                                      002924
      LNXT(10) = 12
                                                                                      002925
```

```
002926
       LNXT(II)=LNXT(I2)
                                                                                      002927
      LNXT(12) = I1
                                                                                      002928
       I1= I2
                                                                                      002929
       GO TO 90
       LCOL( I) = I2
                                                                                      002930
100
       LNXT(II)=LNXT(I2)
                                                                                      002931
                                                                                      002932
       LNXT(I2) = I1
                                                                                      002933
       I1= I2
                                                                                      002934
       GO TO 90
C
                                                                                      002935
           PROCEED WITH THE NEXT ELEMENT IN THE COLUMN UNDER
                                                                                      002936
                                                                                      002937
           CONSIDERATION
C
                                                                                      002938
C
                                                                                      002939
       IØ= I1
110
                                                                                      002940
       I1=LNXT(I1)
       IF (I1.EQ.0) GO TO 120
                                                                                      002941
                                                                                      002942
       GO TO 80
       CONTINUE
                                                                                      002943
120
       IF(IN(7).EQ. 1.OR. IN(7).EQ. 3) RETURN
                                                                                      002944
       IF (IS.EQ.1) WRITE (6,140)
                                                                                      002945
                                                                                      002946
       RETURN
                                                                                      002947
\mathbf{c}
      FORMAT (1H ,/, " INITIAL COEFFICIENT MATRIX NONSYMMETRICAL") FORMAT (1H ,/, " REORDERING OF THE ELEMENTS OF EACH COLUMN")
                                                                                      002948
130
                                                                                      002949
140
                                                                                      002950
                                                                                      002951
\mathbf{C}
                                                                                       002952
C
       SUBROUTINE SORDCN (N,LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, LF, IAR, 180)
                                                                                      002953
                                                                                      002954
      +NINT)
                                                                                      002955
\mathbf{C}
           THIS SUBROUTINESSIMULATES AND ORDERS GAUSS ELIMINATION 100
                                                                                      002956
C
                                                                                      002957
\mathbf{c}
                                                                                      002958
           FOR NONSYMMETRICAL MATRICES
C
                                                                                      002959
\mathbf{C}
           BASED UPON THE ZOLLENKOPF ALGORITHM PRESENTED IN
                                                                                      002960
C
Č
                                                                                      002961
            " LARGE SPARSE SETS OF LINEAR EQUATIONS "
                                                                                      002962
                                                                                      002963
\mathbf{C}
           - PROCEEDINGS OF THE OXFORD CONFERENCE OF THE HISTITUTE OF
                                                                                      002964
C
                                                                                      002965
C
Č
           MATHEMATICS AND ITS APPLICATIONS, HELD IN APRIL 1970-
                                                                                      002966
                                                                                       002967
           J.K.REID, EDITOR, ACADEMIC PRESS, 1971, PP.75-96
                                                                                      002968
\mathbf{C}
                                                                                      002969
                                                                                      002970
       INTEGER LCOL(1), NOZE(1), NSEQ(1), ITAG(1), LNXT(1)
                                                                                      002971
       COMPLEX CE(1), RE(1)
                                                                                      002972
       N1 = N - 1
       IF(N1.EQ.0) RETURN
                                                                                      002973
       DO 140 J=1,N1
                                                                                      002974
                                                                                      002975
       K=NSEQ(J)
                                                                                      002976
       MIN=NOZE(K)
                                                                                      002977
       M=J
                                                                                      002978
       J1 = J + 1
                                                                                      002979
       IF(J1.GT.NINT) GO TO 160
                                                                                      002980
C
           FIND THE COLUMN M WITH THE MINIMUM NUMBER OF ELEMENTS
                                                                                      002981
\mathbf{C}
                                                                                      002982
                                                                                      002983
       DO 10 I=J1, NINT
                                                                                      002984
       K=NSEQ(I)
                                                                                      002985
       IF (NOZE(KO.GE.MIN) GO TO 10
                                                                                      002986
       MIN=NOZE(K)
                                                                                      002987
       M= I
                                                                                      002988
10
       CONTINUE
                                                                                      002989
C
            INTERCHANGE INDICES WITHIN NSEQ FORECURRENT J AND M
                                                                                      002990
C
```

```
002991
   160 CONTINUE
                                                                                          002992
       KP=NSEQ(M)
                                                                                          002993
       NSEQ(M) = NSEQ(J)
                                                                                          002994
       NSEQ(J) = KP
                                                                                          002995
       LK=LCOL(KP)
                                                                                          002996
20
        IF (LK.LE.0) GO TO 140
                                                                                          002997
\mathbf{C}
                                                                                          002998
            TAKE THE NEXT ELEMENT FROM MINIMAL COLUMN M
                                                                                          002999
                                                                                          003000
       K= ITAG(LK)
                                                                                          003001
       LA=0
                                                                                          003002
       LI=LCOL(KP)
                                                                                          003003
       IP= ITAG(LI)
                                                                                          003004
       L=LCOL(K)
                                                                                          003005
       I = ITAG(L)
                                                                                          003006
30
       IF (I-IP) 50,40,90
                                                                                          003007
C
                                                                                          993998
C
            TWO NONZERO ENTRIES ARE SUMMED
                                                                                          003009
C
                                                                                          003010
40
       LA=L
                                                                                          003011
       L=LNXT(L)
                                                                                          003012
       I = ITAG(L)
                                                                                          003013
       IF (L.LE.0) I=N+1
GO TO 100
                                                                                          003014
                                                                                          003015
       IF (I.NE.KP) GO TO 60
                                                                                          003016
50
                                                                                          003017
            DELETE UPPER (OR LOWER) DIAGONAL ENTRY REMAINING AFTER 18
C
                                                                                          003018
            PERFORMING GAUSS ELIMINATION
\mathbf{C}
                                                                                          003019
                                                                                          003020
       LN=LNXT(L)
                                                                                          003021
       IF (LA.GT.0) LNXT(LA)=LN IF (LA.LE.0) LCOL(K)=LN
                                                                                          003022
                                                                                          003023
       LNXT(L)=LF
                                                                                          003024
       LF=L
                                                                                          003025
       CE(L) = CMPLX(\emptyset.,\emptyset.)
RE(L) = CMPLX(\emptyset.,\emptyset.)
                                                                                          003026
                                                                                          003027
       NOZE(K) = NOZE(K) - 1
                                                                                          003028
       L=LN
                                                                                          003029
       GO TO 70
                                                                                          003030
       LA=L
60
                                                                                          003031
       L=LNXT(L)
                                                                                          003032
       IF (L.LE.0) GO TO 80
I=ITAG(L)
70
                                                                                          003033
                                                                                          003034
       GO TO 30
                                                                                          003035
C
                                                                                          003036
C
            LAST ELEMENT IN THE COLUMN
                                                                                          003037
                                                                                          003038
80
       IF (LI.LE.0) GO TO 120
                                                                                          003039
       I = N + 1
                                                                                          003040
       GO TO 30
IF (IP.EQ.K) GO TO 100
IF (LF.LE.0) GO TO 130
                                                                                          003041
90
                                                                                          003042
                                                                                          003043
CCC
                                                                                          003044
            ADD NEW NONZERO' ENTRY
                                                                                          003045
                                                                                          003046
       LN=LF
                                                                                          003047
       IF (LA.GT.0) LNXT(LA)=LN
                                           . .
                                                                                          003048
       IF (LA.LE.0) LCOL(K)=LN
                                                                                          003049
       LF=LNXT(LN)
                                                                                          003050
       LNXT(LN) = L
                                                                                          003051
       ITAG(LN) = IP
                                                                                          003052
       NOZE(K) = NOZE(K) + 1
                                                                                          003053
       LA=LN
                                                                                          003054
C
                                                                                          003055
```

```
TAKE THE NEXT ELEMENT FROM THE ROW WHOSE INDEX IS THE SAME AS
                                                                                    003056
                                                                                    003057
C
                                                                                    003058
           THE COLUMN INDEX FOR WHICH THE GAUSS ELIMINATION PROCESS IS
                                                                                    003059
Ċ
           EXECUTED
                                                                                    993969
                                                                                    003061
C
                                                                                    003062
      LI=LNXT(LI)
100
       IF (LI.LE.0) GO TO 110
IP=ITAG(LI)
                                                                                    003063
                                                                                    003064
                                                                                    003065
      GO TO 30
110
       IF
         (L.GT.0) IP=N+1
                                                                                    003066
       IF (L.GT.0) GO TO 30
                                                                                    003067
                                                                                    003068
\mathbf{C}
           TAKE THE NEXT ELEMENT FROM THE COLUMN FOR WHICH THE GAUSS
Ċ
                                                                                    003069
           ELIMINATION PROCESS IS EXECUTED
                                                                                    003070
\mathbf{C}
                                                                                    003071
                                                                                    003072
120
      LK=LNXT(LK)
      GO TO 20
WRITE (6,150)
                                                                                    003073
                                                                                    003074
130
                                                                                    003075
       TAR= 1
                                                                                    003076
      RETURN
                                                                                    003077
140
       CONTINUE
      RETURN
                                                                                    003078
                                                                                    003079
      FORMAT (" DIMENSIONED AREA TO SMALL IN SORDON")
                                                                                    003080
150
                                                                                    003081
      END
C
                                                                                    003082
                                                                                    003083
\mathbf{C}
      SUBROUTINE REDUCN (N,LCOL, NSEQ, ITAG, LNXT, CE, RE, DE', NINT)
                                                                                    003084
C
                                                                                    003085
C
           THIS SUBROUTINE PERFORMS REDUCTION OF A NONSYMMETRICAL MATRIX
                                                                                    003086×
č
                                                                                    003087
           THE FINAL MATRIX CE CONTAINS THE SEQUENCE OF R.L MATRICES
                                                                                    003088
C
                                                                                    003089
\mathbf{c}
           BASED UPON THE ZOLLENKOPF ALGORITHM PRESENTED IN
                                                                                    003090
\mathbf{C}
C
                                                                                    003091
Ċ
           " LARGE SPARSE SETS OF LINEAR EQUATIONS "
                                                                                    003092
                                                                                    003093
           - PROCEEDINGS OF THE OXFORD CONFERENCE OF THE INSTITUTE OF
\mathbf{C}
                                                                                    003094
                                                                                    003095
C
C
C
           MATHEMATICS AND ITS APPLICATIONS, HELD IN APRIL 1970-
                                                                                    003096
                                                                                    003097
           J.K.REID, EDITOR, ACADEMIC PRESS, 1971, PP.75-96
                                                                                    003098
\mathbf{C}
                                                                                    003099
\mathbf{C}
       INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1);;
                                                                                    003100
      COMPLEX CE(1), RE(1), DE(1), D, CF, RF
                                                                                    003101
C
                                                                                    003102
           THE ELEMENTS OF FACTOR MATRICES ARE: CALCULATED IN EACH !!
                                                                                    003103
C
                                                                                    003104
C
           STEP ACCORDING TO THE FORMULAS:
                                                                                    993195
C
C
                                                                                    003106
Č
                                                                                    003107
           L(II) = 1/A(II)
                                                                                    003108
С
                                                                                    003109
           L(IJ) = A(IJ)
                                                                                    993119
           R(IK) = A(IK) / A(II), FOR J, K#I AND A() BEING THE COEFFICIENT
C
                                                                                    003111
Č
                                                                                    003112
                                                                                    003113
           MATRIX.
                                                                                    003114
      DO 100 J=1, NINT
                                                                                    003115
                                                                                    003116
      KP=NSEQ(J)
      D= 1/DE(KP)
                                                                                    003117
      DE(KP) = D
                                                                                    003118
      LK=LCOL(KP)
                                                                                    003119
                                                                                    003120
       IF (LK.LE.0) GO TO 100
```

. ______

```
10
       RE(LK) = D*RE(LK)
                                                                                      003121
       LK=LNXT(LK)
                                                                                      003122
       IF (LK.GT.0) GO TO 10
                                                                                      003123
       LK=LCOL(KP)
                                                                                      003124
20
       K= ITAG(LK)
                                                                                      003125
       IF(K.LE.0) RETURN
                                                                                      003126
C
                                                                                      003127
C
            ELEMENTS OF FACTOR MATRICES L(J) AND R(J)
                                                                                      003128
                                                                                      003129
       CF=RE(LK)
                                                                                      003130
                                                                                      003131
       RF=CE(LK)
       LI=LCOL(KP)
                                                                                      003132
       IP=ITAG(LI)
                                                                                      003133
       L=LCOL(K)
                                                                                      003134
30
       I = ITAG(L)
                                                                                      003135
       IF
          (L.LE.0) I=N+1
                                                                                      003136
       IF (I-IP)
40
                  50,60,70
                                                                                      003137
50
       L=LNXT(L)
                                                                                      003138
       GO TO 30
                                                                                      003139
C
                                                                                      003140
           ELEMENTS OF REDUCED MATRIX A(J)
\mathbf{C}
                                                                                      003141
                                                                                      003142
60
       CE(L) = CE(L) - CF * CE(LI)
                                                                                      003143
       RE(L) = RE(L) - RF * RE(LI)
                                                                                      003144
       L=LNXT(L)
                                                                                      003145
       I=ITAG(L)
                                                                                      003146
       IF (L.LE.0) I=N+1
GO TO 80
                                                                                      003147
                                                                                      003148
70
       IF (IP.NE.K) GO TO 80
                                                                                      003149
       DE(K) = DE(K) - CF * CE(LI)
                                                                                      003150
80
       LI=LNXT(LI)
                                                                                      003151
       IF (LI.LE.0) GO TO 90
                                                                                      003152
       IP=ITAG(LI)
                                                                                      003153
       GO TO 40
LK=LNXT(LK)
                                                                                      003154
90
                                                                                      003155
       IF (LK.GT.0) GO TO 20
                                                                                      003156
100
       CONTINUE
                                                                                      003157
       RETURN
                                                                                      003158
       END
                                                                                      003159
\mathbf{C}
                                                                                      003160
\mathbf{C}
                                                                                      003161
       SUBROUTINE SOLVCN (N,LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                      003162
\mathbf{C}
                                                                                      003163
C
           THIS SUBROUTINE SOLVES LINEAR EQUATIONS BY A SEQUENCE OF
                                                                                      003164
                                                                                      003165
00000000000
           MATRIX MULTIPLICATIONS
                                                                                      003166
                                                                                      003167
           BASED UPON THE ZOLLENKOPF ALGORITHM PRESENTED IN
                                                                                      003168
                                                                                      003169
            " LARGE SPARSE SETS OF LINEAR EQUATIONS "
                                                                                      003170
                                                                                      003171
           - PROCEEDINGS OF THE OXFORD CONFERENCE OF THE INSTITUTE OF
                                                                                      003172
                                                                                      003173
           MATHEMATICS AND ITS APPLICATIONS, HELD IN APRIL 1970-
                                                                                      003174
                                                                                      003175
C
C
           J.K.REID, EDITOR, ACADEMIC PRESS, 1971, PP.75-96
                                                                                      003176
C
                                                                                      003177
      INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1) (COMPLEX CE(1), RE(1), DE(1), V(1), CF, SUM ),
                                                                                      003178
                                                                                      003179
C
                                                                                      003180
           FIRST PART OF THE SOLUTION
C
                                                                                      003181
С
           B1=L(N)*L(N-1)*...*L(1)*B.
                                                                                      003182
                                                                                      003183
       IF(N.EQ. 1) GOTO 60
                                                                                      003184
       DO 20 J=1, N
                                                                                      003185
```

```
K=NSEQ(J)
                                                                                       003186
       CF = DE(K) *V(K)
                                                                                       003187
       V(K) = CF
                                                                                       003188
       L=LCOL(K)
                                                                                       003189
       IF (L.LE.0) GO TO 20:
10
                                                                                       003190
       I = ITAG(L)
                                                                                       003191
       V(I) = V(I) - CE(L) * CF
                                                                                       003192
       L=LNXT(L)
                                                                                       003193
       GO TO 10
                                                                                       003194
       CONTINUE
20
                                                                                       003195
C
                                                                                       003196
            SECOND PART OF THE SOLUTION
C
                                                                                       003197
           X=R(1)*R(2)*...*R(N)*B1
                                                                                       003198
C
                                                                                       003199
                                                                                       003200
       DO 50 JJ=1,N1
                                                                                       003201
       J=N-JJ
                                                                                       003202
       K=NSEQ(J)
                                                                                       003203
       SUM= V(K)
                                                                                       003204
       L=LCOL(K)
                                                                                       003205
30
       IF (L.LE.0) GO TO 40
                                                                                       003206
       I=ITAG(L)
                                                                                       003207
       SUM=SUM-RE(L)*V(I)
                                                                                       003208
       L=LNXT(L)
                                                                                       003209
       GO TO 30
                                                                                      003210
       V(K)=SUM
40
                                                                                      003211
       CONTINUE
50
                                                                                       003212
       RETURN
                                                                                       003213
       V(1) = V(1) * DE(1)
                                                                                      003214
       RETURN
                                                                                      003215
       END
                                                                                      003216
\mathbf{C}
                                                                                      003217
C
                                                                                      003218
       SUBROUTINE ASLECN (N,LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                      003219
C
                                                                                      003220
           THIS SUBROUTINE SOLVES THE LINEAR EQUATIONS OF THE ADJOINT
C
C
C
                                                                                      003221
                                                                                      003222
           SYSTEM BY A SEQUENCE OF MATRIX MULTIPLICATIONS
                                                                                      003223
C
                                                                                      003224
       INTEGER LCOL(1), NSEQ(1), ITAG(1), LNXT(1); COMPLEX CE(1), RE(1), DE(1), V(1), CF, SUM
                                                                                      003225
                                                                                      003226
C
                                                                                      003227
           FIRST PART OF THE SOLUTION
\mathbf{C}
                                                                                      003228
           B1=R(N)*R(N-1)*...*R(1)*B.
                                                                                      003229
                                                                                      003230
      N1 = N - 1
                                                                                      003231
      DO 20 J=1,N1
K=NSEQ(J)
                                                                                      003232
                                                                                      003233
       CF=V(K)
                                                                                      003234
       L=LCOL(K)
                                                                                      003235
10
       IF (L.LE.0) GO TO 20
                                                                                      003236
       I = ITAG(L)
                                                                                      003237
       V(I) = V(I) - RE(L) * CF
                                                                                      003238
      L=LNXT(L)
                                                                                      003239
       GO TO 10
                                                                                      003240
       CONTINUE
20
                                                                                      003241
                                                                                      003242
           SECOND PART OF THE SOLUTION
                                                                                      003243
C
           X=L(1)*L(2)*...*L(N)*B1
                                                                                      003244
                                                                                      003245
      N2 = N + 1
                                                                                      003246
      DO 50 JJ=1,N
                                                                                      003247
      J=N2-JJ
K=NSEQ(J)
                                                                                      003248
                                                                                      003249
      SUM= V(K) *DE(K) *
                                                                                      003250
```

```
003251
       L=LCOL(K)
                                                                                             003252
       IF (L.LE.0) GO TO 40
30
                                                                                             003253
       I = ITAG(L)
                                                                                             003254
       SUM=SUM-CE(L) *V(I) *DE(K)
                                                                                            003255
       L=LNXT(L)
                                                                                             003256
       GO TO 30
                                                                                             003257
       V(K)=SUM
40
                                                                                             003258
50
       CONTINUE
                                                                                             003259
       RETURN
                                                                                             003260
       END
                                                                                             003261
\mathbf{c}
                                                                                             003262
\mathbf{C}
       SUBROUTINE RSLECN (N, IAF, LCOL, NOZE, NSEQ, ITAG, LNXT, CE, RE, DE, V, VV, LF
                                                                                             003263 at
                                                                                             003264
      1, LES, IAR, CCE, RRE, DDE, ISUB1, ISUB2)
                                                                                             003265
\mathbf{C}
            THIS SUBROUTINE REPEATS THE SOLUTION OF THE LINEAR SPARSE
                                                                                             003266
00000000
                                                                                             003267
            SYSTEM FOR ALTERED COEFFICIENTS AND/OR RIGHT HAND SIDE
                                                                                             003268
                                                                                             003269
                                                                                             003270
            VECTOR
                                                                                             003271
                 INTERACTIVE FACTOR SHOULD BE ODD (1,3 OR 5) IF CHANGES
                                                                                             003272
            TAF
                                                                                             003273
                                                                                             003274
            WILL BE DONE IN THE INTERACTIVE MODE
                                                                                             003275
       INTEGER LCOL(1), ITAG(1), LNXT(1), NOZE(1), NSEQ(1)
COMPLEX COEFF, CE(1), DE(1), V(1), RE(1), VV(1), CCE(1), RRE(1), DDE(1)
                                                                                             003276
                                                                                             003277
                                                                                             003278
       REAL TEXT(80)
                                                                                             003279
C
            LM, LE COUNTERS OF CHANGES IN COEFFICIENT N+1MATRIX AND RIGHT H
                                                                                             003280 h
C
                                                                                             003281
                    SIDE VECTOR, RESPECTIVELY
                                                                                             003282
C
                    IS USED TO STOP THECINTERACTIVE PROCESSION
                                                                                             003283
\mathbf{C}
                                                                                             003284
C
                                                                                             003285
       LM=0
                                                                                             003286
       LE=0
                                                                                             003287
       IADR= 1
                                                                                             003288
10
       IEND=0
                                                                                             003289
            RESET THE VALUES OF THE ELEMENTS OF THE COEFFICIENT MATRIX TO THOSE OF THE CURRENT SET IN PREPARATION FOR NEW CHANGES
                                                                                             003290
                                                                                             003291
\mathbf{C}
                                                                                             003292
\mathbf{C}
                                                                                             003293
       DO 20 I=1,LES
                                                                                             003294
       CE(I) = CCE(I)
                                                                                             003295
       RE(I) = RRE(I)
                                                                                             003296
       CONTINUE
20
                                                                                             003297
       DO 30 I=1,N
DE(I)=DDE(I)
                                                                                             003298
                                                                                             003299
       CONTINUE
30
                                                                                             003300
                                                                                             003301
             USER SUBROUTINES
\mathbf{C}
             THE USER HAS ACCESS TO THE CURRENT FORM OF THE ANALYZED SYSTEM
                                                                                             003302
C
             MATRIX V CONTAINS THE CURRENT RIGHT HAND SIDE VECTOR CE, DE, RE CONTAIN THE CURRENT COEFFICIENT MATRIX
                                                                                             003303
Č
                                                                                             003304
                                                                                             003305
                                                                                             003306
       IF (ISUB1.LE.0) GO TO 50
       CALL USUB1 (ISUB1, LCOL, ITAG, LNXT, CE, RE, DE, V)
                                                                                             003307
                                                                                             003308
        IEND=1
                                                                                             003309
       DO 40 I=1,N
                                                                                             003310
        VV( I) = V( I)
                                                                                             003311
       CONTINUE
40
                                                                                             003312
       CONTINUE
50
                                                                                             003313
       WRITE (6,440)
CALL READL (TEXT)
                                                                                             003314
                                                                                             003315
        CALL FINDSYM (TEXT, 1HN, LCHM)
```

```
CALL FINDSYM (TEXT, 1H*, NOQNS) 100
                                                                                        003316
        IF (NOQNS.EQ. 1) IADR= 1
                                                                                        003317
        IF (LCHM.EQ.1.AND.ISUB1.LE.0) GO TO 160
                                                                                        003318
        ISUB1=ISUB1-1
                                                                                        003319
        IF (LCHM.EQ. 1) GO TO 130
                                                                                        003320
60
        WRITE (6,450)
                                                                                        003321
        READ*, NCHM
                                                                                        003322
        IF (NCHM.GT.0) GO TO 70
                                                                                        003323
        WRITE (6,460)
                                                                                        003324
        GO TO 60
                                                                                        003325
70
        IEND= 1
                                                                                        003326
        LM=LM+1
                                                                                        003327
C
                                                                                        003328
Č
            CHANGE SUCCESSIVELY ALL MATRIX ELEMENTS YOU WANT
                                                                                        003329
                                                                                        003330
       DO 120 I=1,NCHM
                                                                                        003331
        WRITE (6,470)
80
                                                                                        003332
90
        CONTINUE
                                                                                        003333
       READ*, NROW, NCOL
                                                                                        003334
        IF (NROW.GT.N.OR.NROW.LE.O.OR.NCOL.GT.N.OR.NCOL.LE.O) GO TO 100
                                                                                        003335
        WRITE (6,480)
                                                                                        003336
       READ*, COEFF
                                                                                        003337
C
                                                                                        003338
            THE NEW ELEMENT MUST BE ENTERED INTO CE OR REDEPENDING ON WHICH OF THESE MATRICES IS TO STORE THE VALUE OF THIS ELEMENT
\mathbf{c}
                                                                                        003339
C
                                                                                        0033401
\mathbf{C}
            AFTER THE SIMULATION AND ORDERING PROCESS
                                                                                        003341
                                                                                        003342
       CALL CHNGE (IEX, NROW, NGOL, COEFF, LCOL, ITAG, LNXT, CERE, DE)
                                                                                        003343
       IF (IEX.EQ. 1) GO TO 110
GO TO 120
                                                                                        003344
                                                                                        003345
C
                                                                                        003346
C
            WRONG DATA
                                                                                        003347
                                                                                        003348
       WRITE (6,490)
100
                                                                                        003349
       GO TO 90
                                                                                       003350
C
                                                                                       003351
Č
            NEW NONZERO ELEMENT IN COEFFICIENT MATRIX
                                                                                       003352
C
                                                                                       003353
       WRITE (6,500)
WRITE (6,510)
110
                                                                                       003354
                                                                                       003355
       READ*, LCAN
                                                                                       003356
       CALL FINDSYM (TEXT, 1HC, LCAN)
                                                                                       003357
       IF (LCAN.EQ. 1) GO TO 80
                                                                                       003358
       RETURN
                                                                                       003359
120
       CONTINUE
                                                                                       003360
C
                                                                                       003361
C
            REPEAT BIFACTORIZATION
                                                                                       003362
C
                                                                                       003363
130
       IAR=0
                                                                                       003364
C
                                                                                       003365
            STORE THE NEW VALUES OF THE ELEMENTS OF THE COEFFICIENTS.
\mathbf{C}
                                                                                       003366
\mathbf{C}
           MATRICES
                                                                                       003367
Ċ
                                                                                       003368
       DO 140 I=1, LES
                                                                                       003369
       CCE(I) = CE(I)
                                                                                       003370
       RRE(I) = RE(I)
                                                                                       003371
140
       CONTINUE
                                                                                       003372
       DO 150 I=1, N
DDE(I)=DE(I)
                                                                                       003373
                                                                                       003374
150
       CONTINUE
                                                                                       003375
       NINT=N
                                                                                       003376
       CALL REDUCN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, NINT)
                                                                                       003377
       IF (IAR.EQ. 1) RETURN
IF (NOQNS.EQ. 1) GO TO 230
                                                                                       003378
160
                                                                                       003379
                                                                                       003380
```

```
003381
            USER SUBROUTINE
                                                                                              003382
0000000
            THE USER HAS ACCESS TO THE CURRENT FORM OF THE ANALYZED SYSTEM
                                                                                              003383
                                                                                              003384
            MATRIX V CONTAINS THE CURRENT RIGHT HAND SIDE VECTOR
                                                                                              003385
                                                                                              003386
            CE, DE, RE CONTAIN THE CURRENT COEFFICIENT MATRIX
                                                                                              003387
                                                                                              003388
       IF (ISUB2.GE.1) CALL USUB2 (N, LCOL, ITAG, LNXT, CE, RE, DE, V) IF (ISUB2.GT.0) IEND=1
                                                                                              003389
170
                                                                                              003390
       ISUB2=ISUB2-1
WRITE (6,520)
                                                                                              003391
                                                                                              003392
                                                                                              003393
       CALL READL (TEXT)
       CALL FINDSYM (TEXT, 1HN, LCHE) CALL FINDSYM (TEXT, 1H*, NOQNS)
                                                                                              003394
                                                                                              003395
                                                                                              003396
        IADR=1
       IF (NOQNS.EQ.1) IADR=2
IF (LCHE.EQ.1) GO TO 230
DO 180 J=1,N
                                                                                              003397
                                                                                              003398
                                                                                              003399
       V(J) = VV(J)
                                                                                              003400
                                                                                              003401
       CONTINUE
180
                                                                                              003402
       WRITE (6,530)
                                                                                              003403
       CONTINUE
190
                                                                                              003404
       READ*, NCHE
       IF (NCHE.GT.0) GO TO 200
WRITE (6,540)
GO TO 190
IEND=1
                                                                                              003405
                                                                                              003406
                                                                                              003407
                                                                                              003408
200
                                                                                              003409
       LE=LE+1
                                                                                              003410
       DO 220 J=1, NCHE
WRITE (6,550)
                                                                                              003411
210
       READ*, NROW, COEFF
                                                                                              003412
                                                                                              003413
        IF (NROW.GT.N.OR.NROW.LE.0) GO TO 290
                                                                                              003414
       V(NROW) = COEFF
                                                                                               003415
220
       CONTINUE
                                                                                              003416
C
            SOLUTION WITH NEW RIGHT HAND SIDE VECTOR
                                                                                               003417
\mathbf{C}
                                                                                               003418
\mathbf{C}
                                                                                               003419
230
        IF (IEND.EQ.0) RETURN
       DO 240 J=1,N
                                                                                               003420
        VV(J) = V(J)
                                                                                               003421
                                                                                               003422
240
       CONTINUE
                                                                                               003423
\mathbf{C}
                                                                                               003424
C
             ADJOINT GRAPH SOLUTION
                                                                                               003425
\bar{\mathbf{C}}
        IF (IAF.EQ.1) GO TO 270
IF (NOQNS.EQ.1) GO TO 250
                                                                                               003426
                                                                                               003427
                                                                                               003428
        WRITE (6,560)
                                                                                               003429
        CALL READL (TEXT)
                                                                                               003430
\mathbf{C}
             LSOLA REMEMBERS THE CURRENT ORDERING CONCERNING THE SOLUTION
                                                                                               003431
C
             OF THE ADJOINT SYSTEM OF EQUATIONS
                                                                                               003432
                                                                                               003433
\mathbf{C}
                                                                                               003434
       CALL FINDSYM (TEXT, 1HN, LSOLA)
                                                                                               003435
250
        IF (LSOLA.EQ. 1) GO TO 270
        CALL ASLECN (N, LCOL, NSEQ, ITAG, LNXT, CE, RE, DE, V)
                                                                                               003436
       WRITE (6,570) LM, LE. WRITE (6,570) WRITE (6,370)
                                                                                               003437
                                                                                               003438
                                                                                               003439
       FORMAT(1H, /, "SOLUTION", /)
CALL PRINT (N, V)
                                                                                               003440
                                           1 :
300
                                                                                               003441
                                                                                               003442
       DO 260 J=1,N
                                                                                               003443
        V(J) = VV(J)
                                                                                               003444
260
        CONTINUE
        IF (IAF.EQ.5.AND.IADR.EQ.1) GO TO 10
                                                                                               003445
270
```

```
IF (IAF.EQ.5) GO TO 179
                                                                                        003446
        IF (NOQNS.EQ.1) GO TO 280
                                                                                        003447
        WRITE (6,580)
                                                                                        003448
        CALL READL (TEXT)
                                                                                        003449
                                                                                       003450
             LSOL REMEMBERS THE CURRENT ORDERING CONCERNING THE SOLUTION
 C
                                                                                       003451
 \mathbf{C}
             OF THE ORIGINAL SYSTEM OF EQUATIONS
                                                                                       003452
                                                                                       003453
        CALL FINDSYM (TEXT, 1HN, LSOL)
                                                                                       003454
 280
        IF (LSOL.EQ.1.AND.IADR.EQ.1) GO TO 10
                                                                                       003455
        IF (LSOL.EQ. 1) GO TO 170
CALL SOLVCN (N,LCOL,NSEQ, ITAG,LNXT,CE,RE,DE,V)
                                                                                       003456
                                                               1...
                                                                                       003457
        WRITE (6,590) LM, LE
                                                                                       003458
        WRITE(6,300)
                                                                                       003459
        CALL PRINT (N, V)
                                                                                       003460
        IF (IADR. EQ. 1) GO TO 10
                                                                                       003461
        GO TO 170
                                                                                       003462
C
                                                                                       003463
C
            WRONG DATA
                                                                                       003464
 C
                                                                                       003465
290
        WRITE (6,600) -
                                                                                       003466
        GO TO 210
                                                                                       003467
C
                                                                                       003468
440
       FORMAT (1H , " WILL YOU CHANGE THE COEFFICIENT MATRIX? ", / " TYPE Y
                                                                                       003469
      1ES OR NO")
                                                                                       003470
       FORMAT (1H , " NUMBER OF ALTERED COEFFICIENTS")
FORMAT (1H , " NUMBER OF CHANGES SHOULD BE A POSITIVE INTEGER")
450
                                                                                       003471
460
                                                                                       993472
       FORMAT (1H, " ENTER ROW AND COLUMN INDEX OF NEW COEFFICIENT")
FORMAT (1H, " ENTER NEW COEFFICIENT VALUE")
470
                                                                                       003473
480
                                                                                       003474
       FORMAT (1H , " ELEMENT OUT OF THE MATRIX: AREA", / "
490
                                                                 WRITE CORRECT VA
                                                                                       003475
      1LUES")
                                                                                       003476
       FORMAT (1H , " SIMULATION AND ORDERING PROCESS WILL BE COMPLETILY R
500
                                                                                       003477
       1EPEATED")
                                                                                       003478
       FORMAT (1H , " TYPE CANCEL IF YOU MADE A MISTAKE") FORMAT (1H , " WILL YOU CHANGE THE RIGHT HAND SIDE
510
                                                                                       003479
                     " WILL YOU CHANGE? THE RIGHT HAND SIDE VECTOR? ", /" TY
520
                                                                                       003480
      1PE YES OR NO")
                                                                                       003481
       FORMAT (1H , " ENTER THE NUMBER OF CHANGES IN THE RIGHT HAND SIDE V
530
                                                                                       003482 i
      1ECTOR")
                                                                                       003483
540
       FORMAT (1H , " NUMBER OF CHANGES MUST BE A POSITIVE INTEGER. REENTE
                                                                                       003484
      1R A NEW ONE")
                                                                                       003485
550
       FORMAT (1H , " ENTER THE ROW INDEX AND THE VALUE OF THE NEW COEFFIC
                                                                                       003486 H
      1 IENT")
                                                                                       003487
       FORMAT (1H, "DO YOU NEED AN ADJOINT SOLUTION?", /, "TYPE YES OR N
560
                                                                                      003488
                                                                                       003489
       FORMAT (1H ,/, " ADJOINT SYSTEM",/)
FORMAT (1H ," DO YOU NEED AN ORIGINAL SOLUTION?",/," TYPE YES OR
570
                                                                                       003490
580
                                                                                       003491 ··
      1NO")
                                                                                       003492
590
       FORMAT (1H , " CHANGES IN ELEMENTS", I3, " CHANGES IN RIGHT HAND SIDE
                                                                                      003493 H
      1", I3)
                                                                                      003494
       FORMAT (1H , " INDEX OUT OF RANGE, ", /, " WRITE CORRECT VALUES")
600
                                                                                      003495
                                                                                      003496
                                                                                      003497
\mathbf{c}
                                                                                      003498
       SUBROUTINE FINDSYM (TEXT, SYMB, IFLAG)
                                                                                      003499
C
                                                                                      003500
C
           THIS SUBROUTINE FINDS SYMBOL SYMB IN THE TEXT STRING TEXT
                                                                                      003501
Č
                                                                                      003502
         IF SYMBOL HAS BEEN FOUND THE OUTPUT VALUE OF IFLAG
                                                                                      003503
\mathbf{C}
                                                                                      003504
\bar{\mathbf{c}}
           WILL BE EQUAL 1, OTHERWISE 0
                                                                                      003505
                                                                                      003506
      REAL TEXT(1)
                                                                                      003507
       IFLAG=0
                                                                                      003508
       DO 10 I=1,80
                                                                                      003509
       IF (TEXT(I).EQ. 1H) GO TO 10
                                                                                      003510
```

```
003511
       IF (TEXT(I).EQ.SYMB) IFLAG=1 )
                                                                                    003512
10
       CONTINUE
                                                                                    003513
       RETURN
                                                                                    003514
       END
                                                                                    003515
C
                                                                                    003516
\mathbf{C}
                                                                                    003517
       SUBROUTINE READL (TEXT)
                                                                                    003518
           THIS SUBROUTINECREADS DATA FROM INPUT FILE 4 TO THE
                                                                                    003519
000000
                                                                                    003520
                                                                                    003521
           TEXT MATRIX
                                                                                    003522
           EACH ELEMENT OF THE INPUT FIELD IS STORED IN A SEPARATEA
                                                                                    003523
                                                                                    003524
                                                                                    003525
           ELEMENT OF THE TEXT ARRAYING
C
                                                                                    003526
                                                                                    003527
      REAL TEXT(1)
READ (4,10) (TEXT(I), I=1,80) ),
                                                                                    003528
                                                                                     003529
       RETURN
                                                                                     003530
                                                                                     003531
10
       FORMAT (80A1)
                                                                                     003532
       END
                                                                                     003533
\mathbf{c}
                                                                                     003534
\mathbf{C}
       SUBROUTINE CHNGE (IEX, NROW, NCOL, COEFF, LCOL, ITAG, LNXT, CE, RE, DE)
                                                                                     003535
                                                                                     003536
\mathbf{C}
                                                                                     003537
       INTEGER LCOL(1), ITAG(1), LNXT(1)
                                                                                     003538
       COMPLEX COEFF, CE(1), RE(1), DE(1)
                                                                                     003539
C
           THIS SUBROUTINE CHANGES THE VALUE OF ONE COEFFICIENT IN ROW
                                                                                     003540
C
                                                                                     003541
000000000000000
           NROW AND COLUMNANCOL OF THE COEFFICIENT MATRIX
                                                                                     003542
                                                                                     003543
           IF THE ELEMENT WAS NOT STORED IN THE COEFFICIENT MATRIXS
                                                                                     003544
                                                                                     003545
           OR THE COLUMN OR ROW INDEX IS BEYOND THE MATRIX AREA THEN
                                                                                     003546
                                                                                     003547
           APPROPRIATE INFORMATION IS PRINTED AND NO CHANCE IN COEFFI-
                                                                                     003548
                                                                                     003549
                                                                                     003550
           CIENTS IS MADE
                                                                                     003551
           IN THIS CASE FLAG IEX WILL BE EQUAL! 1, OTHERWISE 0
                                                                                     003552
                                                                                     003553
                                                                                     003554
       IF (NROW.EQ.NCOL) DE(NROW) = COEFF
IF (NROW.EQ.NCOL) RETURN
                                                                                     003555
                                                                                     003556
                                                                                     003557
       IS=LCOL(NCOL)
       IF (IS.EQ.0) GO TO 20
                                                                                     003558
                                                                                     003559
       ISS= IS
                                                                                     003560
       IF (ITAG(ISS).EQ.NROW) GO TO 50
10
                                                                                     003561
       IAS=LNXT(ISS)
                                                                                     003562
       IF (IAS.EQ.0) GO TO 20
                                                                                     003563
       ISS= IAS
       GO TO 10
IS=LCOL(NROW)
                                                                                     003564
                                                                                     003565
20
                                        50
                                                                                     003566
       IF (IS.EQ.0) GO TO 60
                                                                                     003567
       ISS= IS
                                                                                     003568
       IF (ITAG(ISS).EQ.NCOL) GO TO 40
30
                                                                                     003569
       IAS=LNXT(ISS)
       IF (IAS.EQ.0) GO TO 60
                                                                                     003570
                                                                                     003571
       ISS= IAS
                                                                                     003572
      GO TO 30
RE(ISS)=COEFF
                                                                                     003573
                                                                                     003574
       RETURN
                                                                                     003575
   50 CE(ISS) = COEFF
```

C

 \mathbf{C}

 \mathbf{C}

C

```
RETURN
                                                                                      003576
       WRITE (6,70) NROW, NCOL
                                                                                      003577
60
                                                                                      003578
       IEX= 1
                                                                                      003579
       RETURN
                                                                                      003580
       FORMAT (1H ,/, " ELEMENT FROM ROW: ", 15, " AND COLUMN: ", 15, " WAS NOT
                                                                                      003581
70
      1STORED IN THE PREVIOUS COEFFICIENT MATRIX",/)
                                                                                      003582
                                                                                      003583
                                                                                      003584
                                                                                      003585
       SUBROUTINE PRINTING IN)
                                                                                      003586
       INTEGER IN(1)
                                                                                      003587
                                                                                      003588
           PRINT INPUT DATA - VECTORAIN
                                                                                      003589
                                                                                      003590
                                                                                      003591
       WRITE(6, 100)
  100 FORMAT(///, 1H , "HIERARHICAL ANALYSIS OF LINEAR DECOMPOSED SYSTEMS
                                                                                      003592
      +(CSDSLE PACKAGE)",///)
                                                                                      003593
                                                                                      003594
       WRITE(6, 110)
  110 FORMAT(1H , "INPUT DATA", /, 1H , "-----",/,)
                                                                                      003595
       WRITE(6, 120) IN(4)
                                                                                      003596
  120 FORMAT(1H, " IN(4) - NUMBER OF
+BE RECALCULATED ",2(2H.),15,/)
WRITE(6,130) IN(5)
                       IN(4) - NUMBER OF SUBGRAPHS WHERE THE SOLUTION WILL
                                                                                      003597
                                                                                      003598
                                                                                      003599
                       IN(5) - NUMBER OF PROPER BLOCKS ",20(2H.),
                                                                                      003600
  130 FORMAT(1H , "
                                                                                      003601
      + I5,/)
       WRITE(6, 140) IN(7)
                                                                                      003602
  140 FORMAT(1H," IN(
+",10(2H.),15,/)
WRITE(6,150)IN(9)
                      IN(7) - INDICATOR FOR PRINTING INTERMEDIATE RESULTS
                                                                                      003603::
                                                                                      003604
                                                                                      003605
                       IN(9) - THE HIGHEST INDEX: OF ALL SUBGRAPHS", 15(2H.)
                                                                                      003606.)
  150 FORMAT(1H , "
                                                                                      003607
      +, I5,/)
       WRITE(6, 160) IN(10)
                                                                                      003608
                     IN(10) - NUMBER) OF MODIFIED SUBGRAPHS ",17(2HIII), I
  160 FORMAT(1H , "
                                                                                      003609
                                                                                      003610
      +5,/)
       WRITE(6, 170) IN(11)
                                                                                      003611
                       IN(11) - LENGTH) OF BASIC RECORD ",20(2H .), 15;//
                                                                                      003612
  170 FORMAT(1H , "
       WRITE(6, 180) IN(12)
                                                                                      003613
                       IN(12) - LENGTH OF ADDRESSING RECORD", 18(2H .); 15,/
                                                                                      003614
  180 FORMAT(1H , "
                                                                                      003615
                                                                                      003616
       WRITE(6, 190) IN(15)
  190 FORMAT(1H , " IN(15) - MAXIMUM NUMBER OF BASIC RECORDS", 16(2H .),
                                                                                      003617
      +15,/)
                                                                                      003618
       WRITE(6,200) IN(16)
                                                                                      003619
  200 FORMAT(1H, " IN(16) - MAXIMUM NUMBER OF EQUATIONS FOR THE SUBGRAP +H ",9(2H:),15,/)
                                                                                      003620
                                                                                      003621
       WRITE(6,210) IN(17)
                                                                                      003622
  210 FORMAT(1H," IN(1
+",10(2H.),15./)
WRITE(6,220) IN(18)
                      IN(17) - MAXIMUM AREA FOR SPARSE MATRIX CALCULATIONS
                                                                                      003623
                                                                                      003624
                                                                                      003625
  220 FORMAT(1H, " IN(18) -
+UBMATRIX", 6(2H, ), 15,/)
                       IN(18) - NUMBER) OF NONZERO ELEMENTSO IN THE MAXIMUM S
                                                                                      003626
                                                                                      003627
       WRITE(6,230) IN(19)
                                                                                      003628
  230 FORMAT(1H, " IN(19) - THE LOWEST INDEX: OF THE DECOMPOSITION NODES + ", 10(2H.), 15,/)
WRITE(6,240) IN(20)
                                                                                      003629
                                                                                      003630
                                                                                      003631
  240 FORMAT(1H , "
                      IN(20) - NUMBER OF DATA RECORDS ",20(2H .), 15;
                                                                                      003632
                                                                                      003633
       WRITE(6,250) IN(22)
                                                                                      003634
  250 FORMAT(1H , "
                      IN(22) - INDICATOR FOR RHS UPDATING FORMULA ", 14(2H
                                                                                      003635
      +.), [5,/)
                                                                                      003636
                                                                                      003637
       WRITE(6,260) IN(23)
  260 FORMAT(1H,"
+11(2H.), I5,/)
                       IN(23) - INDICATOR FOR OPERATIONS ON RANDOM FILES ",
                                                                                      003638"
                                                                                      003639
       WRITE(6,280) IN(25)
                                                                                      003640
```

```
280 FORMAT(1H, " IN(25) - MAXIMUM LENGTH OF DATA AND RHS RECORD", 13(2)
                                                                                                003641
       +H .), I5,/)
                                                                                                003642
        WRITE(6,270) IN(26)
                                                                                                003643
   270 FORMAT(1H , "
                          IN(26) - NUMBER: OF ALL DECOMPOSITION NODES", 15(2H.)
                                                                                                003644
       +, [5,/)
                                                                                                003645
        M = 26 + 1
                                                                                                003646
        L=26+IN(9)/2
                                                                                                003647
        WRITE(6,290)(IN(I), I=M,L)
                                                                                                003648
   290 FORMAT(1H ,/, " NUMBERS OF EXTERNAL NODES IN THE SUBSTITUTE SUBGRAP
                                                                                                003649
       +HS",//,(2014))
                                                                                                003650
        M=L+1
                                                                                                003651
        L=L+IN(5)
                                                                                                003652
   WRITE(6,300)(IN(I), I=M,L)
300 FORMAT(1H, /, " INDICES OF ALL PROPER BLOCKS",//,(2014))/
                                                                                                003653
                                                                                                003654
        IF(IN(22).NE.2) RETURN
                                                                                                003655
        M=L+1
                                                                                                003656
        L=L+IN(4)
                                                                                                003657
   WRITE(6,310)(IN(I),I=M,L)
310 FORMAT(1H,/," INDICES OF SUBGRAPHS WHERE SOLUTION WILL BE CALCULA +TED",//,(2014))
                                                                                                003658
                                                                                                003659
                                                                                                003660
        RETURN
                                                                                                003661
        END
                                                                                                003662
                                                                                                003663
C
                                                                                                003664
        SUBROUTINE PRINTNC(N, NROW, NCOL, V)
                                                                                                003665
                                                                                                003666
C
             THIS ROUTINE PRINTS THE NONZERO COEFFICIENTS OF A COMPLEX
                                                                                                003667
                                                                                                003668
\mathbf{c}
             MATRIX V
                                                                                                003669
                                                                                                003670
        INTEGER NROW(1), NCOL(1)
                                                                                                003671
        COMPLEX V(1)
                                                                                                003672
        IF(N.LE.0) RETURN
                                                                                                003673
        IF(N.GT.1) GOTO 100)
                                                                                                003674
        WRITE(6, 110)
                                                                                                003675
        WRITE(6,120)
                                                                                                003676
        GOTO 20
                                                                                                003677
100
        CONTINUE
                                                                                                003678
        IF (N.EQ.4.OR.N.EQ.2) GO TO 10: WRITE (6,70)
                                                                                                003679
                                                                                                003680
        WRITE (6,40)
GO TO 20
                                                                                                003681
                                                                                                003682
        WRITE (6,60)
WRITE (6,50)
10
                                                                                                003683
                                                                                                003684
        N3 = (N+2)/3
20
                                                                                                003685
        DO 30 I=1,N3
                                                                                                003686
        I_{\bullet}I = I
                                                                                               003687
        L0= I+2*N3
                                                                                               003688
        IF (LO.GT.N) LO=I+N3
                                                                                               003689
        IF(LO.GT.N) LO=I
                                                                                               003690
        WRITE (6,80) (NROW(J), NCOL(J), V(J), J=LI, LO, N3)
                                                                                               003691
30
                                                                                               003692
       RETURN
                                                                                               003693
                                                                                               003694
40
       FORMAT (1H ,11X,"
                                    REAL
                                                     IMAGINARY", 18X,
                                                                                               003695
      REAL IMAGINARY",/)
FORMAT (1H, "ROW COL",11X,"VALUE
1,11X,"VALUE",/)
FORMAT (1H, "ROW COL",11X,"VALUE
1,11X,"VALUE
      1 "REAL
                         IMAGINARY", 18X, "REAL.
                                                               IMAGINARY",/)
                                                                                               003696
                                                     IMAGINARY", 18X,
50
                                                                                               003697
                                                                                               003698
60
                                                                         ROW
                                                                               COL"
                                                                                               003699
                                                                                               003700
70
                                                                         ROW
                                                                                COL
                                                                                               003701
       FORMAT(1H, "ROW COL ",11X, "VALUE",/)
FORMAT(1X, I4, I5, 2E15.6, 2I5, 2E15.6, 2I5, 2E15.6)
FORMAT(1H, 16X, "REAL", 9X, "IMAGINARY",/)
FORMAT(1H, "ROW COL ",14X, "VALUE",/)
                                                                                               003702
80
                                                                                               003703
120
                                                                                               003704
110
                                                                                               003705
```

```
END
                                                                                            003706
\mathbf{C}
                                                                                            003707
\mathbf{C}
                                                                                            003708
       SUBROUTINE PRINTRS (N, V, NON) (
                                                                                            003709
C
                                                                                            003710
Č
             THIS ROUTINE PRINTS THE SUBVECTORS OF RHS
                                                                                            003711
                                                                                            003712
        INTEGER NON(1)
                                                                                            003713
       COMPLEX V(1)
                                                                                            003714
        IF(N.LE.0) RETURN
IF(N.GT.1) GOTO 100)
                                                                                            003715
                                                                                            003716
        WRITE(6, 110)
                                                                                            003717
        WRITE(6, 120)
                                                                                            003718
        GOTO 20
                                                                                            003719
100
       CONTINUE
                                                                                            003720
        IF (N.EQ.4.OR.N.EQ.2) GO TO 10
                                                                                            003721
       WRITE (6,70)
WRITE (6,40)
                                                                                            003722
                                                                                            003723
       GO TO 20
WRITE (6,60)
                                                                                            003724
10
                                                                                            003725
        WRITE (6,50)
                                                                                            003726
20
       N3 = (N+2)/3
                                                                                            003727
       DO 30 I=1,N3
                                                                                            003728
       LI=I
                                                                                            003729
       LO= I+2*N3
                                                                                            003730
        IF (LO.GT.N) LO=I+N3
                                                                                            003731
       IF(LO.GT.N) LO=I
WRITE (6,80) (NON(J),V(J),J=LI,L0,N3)
                                                                                            003732
                                                                                            003733
30
       CONTINUE
                                                                                            003734
       RETURN
                                                                                            003735
\mathbf{C}
                                                                                            003736
       FORMAT (1H , "
40
                                          REAL
                                                          IMAGINARY
                                                                                            003737
                       IMAGINARY
                                                                       IMAGINARY",/)
       1REAL
                                                       REAL
                                                                                            003738
       FORMAT (1H , "
50
                                          REAL
                                                           IMAGINARY
                                                                                            003739
       1REAL
                       IMAGINARY",/)
                                                                                            003740
       FORMAT (1H , " VARIABLE
60
                                                   VALUE
                                                                        VARIABLE
                                                                                            003741
       VALUE",/)
FORMAT (1H , " VARIABLE
                                                                                            003742
70
                                                   VALUE
                                                                        VARIABLE
                                                                                            003743
                VALUÉ
                                     VARIABLE
                                                               VALUE",/)
                                                                                            003744
       FORMAT (1X,3(16,2X,2E15.6))
FORMAT(1H,15X,"REAL",9X,"IMAGINARY",/)
FORMAT(1H," VARIABLE",13X,"VALUE",/)
80
                                                                                            003745
120
                                                                                            003746
110
                                                                                            003747
                                                                                            003748
\mathbf{c}
                                                                                            003749
\mathbf{C}
                                                                                            003750
       SUBROUTINE PRINT (N, V)
                                                                                            003751
                                                                                            003752
C
            THIS ROUTINE PRINTS THE SOLUTION VECTOR TO
                                                                                            003753
Č
                                                                                            003754
       COMPLEX V(1)
                                                                                            003755
       IF(N.LT.1) RETURN IF(N.GT.1) GOTO 100)
                                                                                            003756
                                                                                            003757
       WRITE(6,110)
                                                                                            003758
       WRITE(6, 120)
                                                                                            003759
       GOTO 20
                                                                                            003760
100
       CONTINUE
                                                                                            003761
       IF (N.EQ.4.OR.N.EQ.2) GO TO 10)
                                                                                            003762
       WRITE (6,70)
                                                                                            003763
       WRITE (6,40)
                                                                                            003764
       GO TO 20
                                                                                            003765
       WRITE (6,60)
WRITE (6,50)
10
                                                                                            003766
                                                                                            003767
20
       N3 = (N+2)/3
                                                                                            003768
       DO 30 I=1,N3
                                                                                            003769
       LI=I
                                                                                            003770
```

```
003771
        LO= I+2*N3
                                                                                                       003772
        IF (LO.GT.N) LO=I+N3
                                                                                                       003773
        IF(LO.GT.N) LO=I
                                                                                                       003774
        WRITE (6,80) (J,V(J),J=LI,L0,N3)
                                                                                                       003775
        CONTINUE
30
                                                                                                       003776
        WRITE(6,130)
                                                                                                       003777
        FORMAT(///)
130
                                                                                                       003778
        RETURN
                                                                                                       003779
\mathbf{C}
                                                                  IMAGINARY
                                                                                                       003780
                                               REAL
        FORMAT (1H , "
40
                                                                               IMAGINARY",/)
                                                                                                       003781
                                                             REAL
                          IMAGINARY
       1 REAL
                                                                                                       003782
                                                                  IMAGINARY
        FORMAT (1H ."
                                               REAL
50
                          IMAGINARY",/)
                                                                                                       003783
       1REAL
                                                                                                       003784
                        , " VARIABLE
                                                         VALUE
                                                                                 VARIABLE
        FORMAT (1H
60
        VALUE ", /)
FORMAT (1H , " VARIABLE
                                                                                                       003785
                                                                                                       003786
                                                                                 VARIABLE
                                                         VALUE
70
                                                                       VALUE",/)
                                                                                                       003787
                  VALUÉ
                                          VARIABLE
                                                                                                       003788
        FORMAT (1X,3(16,2X,2E15.6))

FORMAT(1H,15X,"REAL",9X,"IMAGINARY",/)

FORMAT(1H," VARIABLE",13X,"VALUE",/)
80
                                                                                                       003789
120
                                                                                                       003790
110
                                                                                                       003791
                                                                                                       003792
C
                                                                                                       003793
C
                                                                                                       003794
        SUBROUTINE PRINTI (N, V, LCOL, ITAG)
                                                                                                       003795
\mathbf{C}
                                                                                                       003796
              THIS ROUTINE PRINTS COLUMNWISE STORED MATRIX V
\mathbf{c}
                                                                                                       003797
C
                                                                                                       003798
              WHICH COLUMNS ARE STORED IN THE AREAS HAVING AND
C
                                                                                                       003799
Ċ
              STARTING ADDRESSES LOCATED IN ELEMENTS OF LCOL:
                                                                                                       003800
Ğ
                                                                                                       003801
                                                                                                       003802
        COMPLEX V(1)
INTEGER LCOL(1), ITAG(1)
IF(N.LT.1) RETURN
IF(N.GT.1) GOTO 110)
                                                                                                       003803
                                                                                                       003804
                                                                                                       003805
                                                                                                       003806
         WRITE(6,120)
                                                                                                       003807
         WRITE(6,130)
                                                                                                       003808
         GOTO 20
                                                                                                       003809
         CONTINUE
110
                                                                                                       003810
         IF (N.EQ.2) GO TO 10
        WRITE (6,80)
WRITE (6,50)
GO TO 20
                                                                                                       003811
                                                                                                       003812
                                                                                                       003813
                                                                                                       003814
         WRITE (6,70)
WRITE (6,60)
10
                                                                                                       003815
                                                                                                       003816
         CONTINUE
20
                                                                                                       003817
         DO 40 II=1.N
                                                                                                       003818
         NN=LCOL(II+1)-LCOL(II)
                                                                                                       003819
         WRITE (6,100) II
                                                                                                       003820
         N3 = (NN+2)/3
                                                                                                       003821
         DO 30 I=1,N3
                                                                                                       003822
         LI=LCOL(II)+I-1
                                                                                                       003823
         L0=L1+2*N3
                                                                                                       003824
         IF (LO.GE.LCOL(II+1)) LO=LI+N3)
                                                                                                       003825
         IF(LO.GE.LCOL(II+1)) LO=LI
                                                                                                       003826
         WRITE (6,90) (ITAG(J), V(J), J=LI, LO, N3) 1.1
                                                                                                       003827
         CONTINUE
30
                                                                                                       003828
         CONTINUE
40
                                                                                                       003829
         RETURN
                                                                                                       003830
       FORMAT (1H ,16X, "REAL",9X, "IMAGINARY",13X, "REAL",9X, "IMAGINARY",13
1X, "REAL",9X, "IMAGINARY",/)
FORMAT (1H ,16X, "REAL",9X, "IMAGINARY",13X, "REAL",9X, "IMAGINARY",/)
FORMAT (1H , "COL.",2X, "ROW",14X, "VALUE",13X, "ROW",14X, "VALUE",/)
FORMAT (1H , "COL.",2X, "ROW",14X, "VALUE",13X, "ROW",14X, "VALUE",13X,
                                                                                                       003831
50
                                                                                                       003832
                                                                                                       003833/
 60
                                                                                                       003834
 70
                                                                                                       003835
 80
```

```
1 "ROW", 14X, "VALUE", /)
                                                                                                              003836
         FORMAT (5X,3(15,2E15.7))
FORMAT (1H,14)
FORMAT(1H,16X,"REAL",9X,"IMAGINARY",/)
FORMAT(1H,"COL.",2X,"ROW",14X,"VALUE",/)
90
                                                                                                              003837
100
                                                                                                              003838
130
                                                                                                             003839
120
                                                                                                              003840
         END
                                                                                                              003841
                                                                                                             003842
\mathbf{C}
                                                                                                             003843
         SUBROUTINE PRINTS (N, V, LCOL, ITAG, LNXT) 300
                                                                                                             003844
\mathbf{C}
                                                                                                             003845
               THIS ROUTINE PRINTS THE SPARSE MATRIX
\mathbf{c}
                                                                                                             003846
                                                                                                             003847
         COMPLEX V(1), COLX(100)
                                                                                                             003848
         INTEGER LCOL(1), ITAG(1), LNXT(1), NROW(100)
                                                                                 21
                                                                                                             003849
         IF(N.LT.1) RETURN
IF(N.GT.1) GOTO 150)
                                                                                                             003850
                                                                                                             003851
         WRITE(6, 160)
                                                                                                             003852
         WRITE(6,170)
                                                                                                             003853
         GOTO 20
                                                                                                             003854
150
         CONTINUE
                                                                                                             003855
         IF (N.EQ.2) GO TO 10
                                                                                                             003856
         WRITE (6,80)
WRITE (6,50)
                                                                                                             003857
                                                                                                             003858
         GO TO 20
WRITE (6,70)
                                                                                                             003859
10
                                                                                                             003860
         WRITE (6,60)
                                                                                                             003861
20
         CONTINUE
                                                                                                             003862
         DO 40 II=1,N
                                                                                                             003863
         NN=1
                                                                                                             003864
         NX=LCOL(II)
                                                                                                             003865
         IF(NX.LE.0) GOTO 40 COLX(NN) = V(NX)
                                                                                                             003866
                                                                                                             003867
         NROW(NN) = ITAG(NX)
                                                                                                             003868
   120 NX=LNXT(NX)
                                                                                                             003869
         IF(NX.LE.0) GOTO 110)
                                                                                                             003870
         NN = NN + 1
                                                                                                             003871
         COLX(NN) = V(NX)
                                                                                                             003872
         NROW(NN) = ITAG(NX)
                                                                                                             003873
         GOTO 120
                                                                                                             003874
   110 IF(NN.LE.100) GOTO 130
                                                    1 :
                                                                                                             003875
         WRITE(6,140)
                                                                                                             003876
         RETURN
                                                                                                             003877
   140 FORMAT(1H ,/, " MATRIX CONTAINS A COLUMN HAVING MORE THAN 100 ELEME
                                                                                                             003878
       +NTS",/)
                                                                                                             003879
   130 CONTINUE
                                                                                                             003880
         WRITE (6,100) II
                                                                                                             003881
         N3 = (NN+2)/3
                                                                                                             003882
         DO 30 I=1,N3
                                                                                                             003883
         LI=I
                                                                                                             003884
         LO=LI+2*N3
                                                                                                             003885
         IF(LO.GT.NN) LO=LI+N3
IF(LO.GT.NN) LO=LI
                                                                                                             003886
                                                                                                             003887
         WRITE(6,90)(NROW(J), COLX(J), J=LI, LO, N3) ***
                                                                                                             003888
30
         CONTINUE
                                                                                                             003889
         CONTINUE
40
                                                                                                             003890
         RETURN
                                                                                                             003891
       FORMAT (1H ,16X, "REAL",9X, "IMAGINARY",13X, "REAL",9X, "IMAGINARY",13
1X, "REAL",9X, "IMAGINARY",/)
FORMAT (1H ,16X, "REAL",9X, "IMAGINARY",13X, "REAL",9X, "IMAGINARY",/)
FORMAT (1H ,2X, "COL",2X, "ROW",13X, "VALUE",14X, "ROW",13X, "VALUE",/)
FORMAT (1H ,2X, "COL",2X, "ROW",13X, "VALUE",14X, "ROW",13X, "VALUE",
114X, "ROW",13X, "VALUE",/)
FORMAT (5X,3(15,2E15.7))
FORMAT (1H ,14)
                                                                                                             003892
50
                                                                                                             003893
                                                                                                             003894
60
                                                                                                             003895/
70
                                                                                                             003896/
80
                                                                                                             003897
                                                                                                             003898
90
                                                                                                             003899
100
                                                                                                             003900
```

170 FORMAT(1H ,16X, "REAL",9X, "IMAGINARY",/) 160 FORMAT(1H ,2X, "COL",2X, "ROW",13X, "VALUE",/) END

003901 003902 003903 SOC-307

CSDSLE - A FORTRAN PACKAGE FOR THE SOLUTION OF SPARSE DECOMPOSED SYSTEMS OF LINEAR EQUATIONS

J.A. Starzyk and J.W. Bandler

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Revised:

Key Words: Linear systems, sparse matrix solution, decomposed systems, multiple solutions of linear systems

Abstract: CSDSLE is a package of forty-eight subroutines for solving sparse linear equations for the iterative simulation of very large systems. The equations are assumed to be in decomposed form as required by the main subroutine. Zollenkopf's bi-factorization-type algorithm is used to represent the solution of different submatrices. options of the package, when utilized properly, may save a significant amount of computer time and memory compared with the standard sparsematrix subroutines, including those which utilize simple decomposition or block decomposition. The package and documentation have been developed for the CDC 170/730 system with the NOS 1.4 level 552 operating system and the Fortran Extended (FTN) Version 4.8 compiler. The report includes 17 illustrative examples, including the use of mass storage, the implementation of changes in the coefficient matrix and changes in the right-hand side. Local area changes and their effects on the rest of the system are discussed. A comparison with the Harwell package MA28 not using decomposition is reported.

Description: Contains Fortran listing, user's manual. The listing

contains 3903 lines, of which 1640 are comments.

Related Work: SOC-289.

Price: \$250.00. Source deck or magnetic tape: \$500.00.

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