Inversion of Matrices with Variable Length Mantissa by Jordan's Method on 1620

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INVERSION OF MATRICES WITH VARIABLE LENGTH MANTISSA BY JORDAN'S METHOD ON 1620

Modifications or revisions to this program, as they occur, will be announced in the appropriate Catalog of Programs for IBM Data Processing Systems. When such an announcement occurs, users should order a complete new program from the Program Information Department.

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Enclosures : corresponding cards decks

BRIEF DESCRIPTION

INVERSION OF MATRICES WITH VARIABLE LENGTH
MANTISSA BY JORDAN's METHOD ON 1620

a) Author : R.-N. Ménégaux
94, rue Réaumur
Paris (2e) France

b) Subroutine enabling to invert a matrix already in core with up to 45 digits of mantissa. Room must be spared for both matrices.

c) Needs at least the basic 1620 with automatic divide and indirect addressing. It asks for 3147 positions in itself.

d) Solved by Jordan's method.

e) Operating time depends of the mantissa length.

f) Written in SPS II Version II with variable length mantissa.

g) Uses floating point subroutines.

h) Numbers in floating point only.
The origin matrix is destroyed after inversion.

i) Trials with 10 x 10 (3 mn : execution time) and 6 x 6 matrices.

j) Language : English

k) None

l) This program and its documentation were written by an IBM employee. It was developed for a specific purpose and submitted for general distribution to interested parties in the hope that it might prove helpful to other members of the data processing community. The program and its documentation are essentially in the author's original form. IBM serves as the distribution agency in supplying this program. Questions concerning the use of the program should be directed to the author's attention.

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WRITE UP

INVERSION OF MATRICES WITH VARIABLE LENGTH

MANTISSA BY JORDAN'S METHOD ON 1620 (CARD)

DECK KEY

1) Symbolic deck

We have used the numerotation of Symbolic programmation sheets, i. e. 25 lines for one sheet. The sheet number is punched in columns 1-2, the line number in columns 3-4-5.

We have here :

Cards from 01 010 to 01 140	main program with the calling sequence
Cards from 01 150 to 10 200	Subroutine "INVER" in itself

2) Assembled deck

The whole assembled deck is made of cards numbered sequentially from 00 000 to 00 168, punched in columns 76-80.

3) Sample deck

It is here only one card with in it the following matrix :

$\bar{1}0000000000000000\bar{0}1\bar{2}0000000000000000\bar{0}1\bar{3}0000000000000000\bar{0}1\bar{4}0000000000000000\bar{0}1$

I - GENERALITIES

a) Author : R. N. MENEGAUX
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Paris (2e) France

b) Subroutine enabling to calculate the inverse matrix of an origin matrix previously in core in a variable length mantissa form (up to 45). A simple calling sequence is to be included in the main program. A second array must be given to store the inverse matrix. The origin matrix is destroyed in the operation.

c) Requires automatic divide and indirect addressing and asks for 3147 positions in itself (without the SPS II, Version II, subroutines).

d) Inversion is made by the Jordan's method. At first, it places an unity matrix in the second array.

Then, the loop is the following :

1. Find the greatest element (pivot) of the considered column.
2. Change the rows of both matrices to place the pivot on the main diagonal of the origin matrix.
3. Divide the whole row by the pivot.

4. Let appear zeros on the considered column in multiplying and subtracting rows from the pivot row.
5. Takes the next column and go to (1).

At the end, the origin matrix is filled up by a unity matrix, while the inverse matrix is at its own place.

e) The execution time is proportional to the square of the mantissa length.

f) Written in SPS II Version II with variable length mantissa.

g) Uses floating point subroutines.

h) Dimensions of possible matrices :

Let L be the length of the mantissa,
and N be the no. of rows or columns of the origin matrix.

As the no. of positions of core required is :

Subroutine itself	3147
Tables	400
Floating point subroutines	2330
	5877

Then the formula is :

$$2N^2 = \frac{1}{L+2} \quad \text{(memory - main prog. - 5877)}$$

Where "memory" = 20k, 40k, 60k

and "main prog." is the place taken by the main program including the calling sequence.

- Note that the elements of the matrix are in floating point form only.

- The program uses 58 symbols.

i) Trials with two matrices of 10 x 10 and of 6 x 6, with a length of 16 positions mantissa (it took 3 mn for the 10 x 10 matrix, 100 % filled up).

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II. MANUAL OPERATING

Does not occur.

III. CALLING SEQUENCE

The calling sequence to be included in the main program, is the following :

```
TFM NREEL, xx, 10          , NO.OF ROWS OR COLUMNS
TFM AELM, xxxxx            ,, ADDRESS OF ORIGIN MATRIX
TFM AELN, xxxxx            ,, ADDRESS OF INVERSE MATRIX
TFM LGM, xx, 10            , LENGTH OF MANTISSA
TFM FINSP + 6, ± + 48
TFM FERR + 6, ± + 24
B    INVER
Error Return
Normal Return
```

So, you must fill the following constants :

- "LGM" by the length of the mantissa (up to 45).
- "NREEL" by the number of rows or columns of the origin matrix.
- "AELM" by the address (to the extreme right) of the first element of the origin matrix.
- "AELN" like "AELM" for the inverse matrix you wish.

Note that those references and what they contain are not modified by the execution of the subroutine : they remain available at the end of the program.

Control will be given back to the second instruction following the last instruction of the calling sequence (here "B INVER") if the inversion has been done normally.

If not, the following message will be printed :

"THE MATRIX IS SINGULAR"

then control will automatically be given back to the first instruction

../...

following the "B INVER", where a branch to an error procedure may be put.

No essential zeros have been considered in this subroutine.

The origin matrix is supposed to be previously stored in sequence row by row from the left to the right. The inverse matrix will be given in the same form.

So the sequence must be :

Element (I, J) with I = 1 J = 1
then I = 1 J = 2

.....

I = 1 J = NREEL
I = 2 J = 1

etc...

The program is provided in SPS II, Version II, form to enable users to compile it with their own program (and their own length of mantissa).

T R I A L ON A SAMPLE PROBLEM

Let us find the inverse matrix of the origin matrix following :

$$\begin{vmatrix} 1 & 2 \\ 3 & 4 \end{vmatrix}$$

Let suppose the calling sequence be :

```
DEBUT   NOP
        RNCD    10000
        TFM     NREEL, 2, 10
        TFM     AELM,  10017
        TFM     AELN,  11017
        TFM     LGM,   16, 10
        TFM     FINSP + 6,*+ 48
        TFM     FERR + 6,*+ 24
        B       INVER
        H                          ( error return)
        TD      11 072,400
        WNTY    11 000
        H                          ( end of program)
        B       DEBUT
```

WE add there the subroutine "INVER" itself in its symbolic form.

The whole program is compiled in SPS II, Version II, with automatic division and variable length of mantissa (here, equal to 16) subroutine (Deck numbered 5).

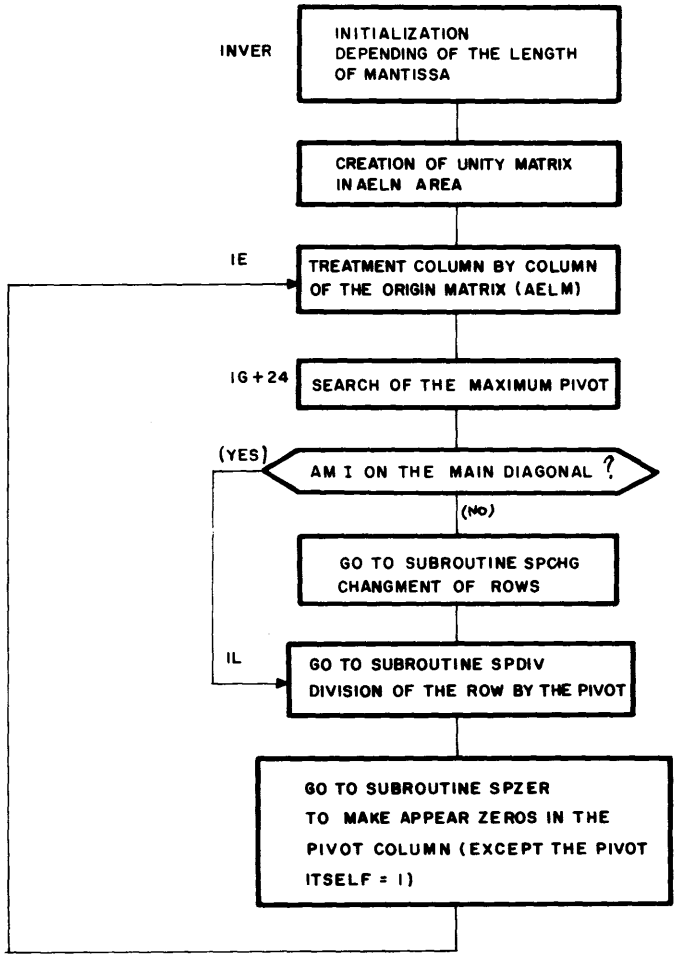
The data matrix is called when the assembled program is loaded. It has been punched on a card under the following form :

$\bar{1}000000000000000\bar{0}1\bar{2}000000000000000\bar{0}1\bar{3}000000000000000\bar{0}1\bar{4}000000000000000\bar{0}1$

This matrix is loaded, under their form, from address 10000.

Dumping from address 10000, after execution of the subroutine, we have the unity matrix, and from address 11000, we have the final result, written on annex.

FLOW CHART — INVERSION OF MATRICES



```
01010DEBUT NOP                                                    INVER
01020      RNCD10000                                              INVER
01030      TFM NREEL,2,10     ,NO. OF ROWS OR COLUMNS             INVER
01040      TFM AELM,10017     ,,ADDRESS OF ORIGIN MATRIX          INVER
01050      TFM AELN,11017     ,,ADDRESS OF INVERSE MATRIX         INVER
01060      TFM LGM,16,10      , LENGTH OF MANTISSA                INVER
01070      TFM FINSP+6,**+48                                      INVER
01080      TFM FERR+6,**+24                                       INVER
01090      B   INVER                                             INVER
01100      H                                                      INVER
01110      TD  11072,400                                          INVER
01120      WNTY11000                                              INVER
01130      H                                                      INVER
01140      B   DEBUT                                             INVER
01150INVER TFM I,0                                                INVER
01160      TF  LGT,LGM                                            INVER
01170      CF  LGT-1                                              INVER
01180      AM  LGT,2,10                                           INVER
01190      M   NREEL,LGT                                          INVER
01200      SF  95                                                 INVER
01210      TF  N,99                                               INVER
01220      M   N,NREEL                                            INVER
01230      SF  95                                                 INVER
01240      TF  NN,99                                              INVER
01250      TF  AUN,AUNR                                           INVER
02010      TF  AZER,AZERR                                         INVER
02020      SF  -AUN                                               INVER
02030      SF  -AZER                                              INVER
02040      A   AUN,LGM                                            INVER
02050      AM  AUN,1,10                                           INVER
02060      A   AZER,LGM                                           INVER
02070      AM  AZER,1,10                                          INVER
02080      TFM -AUN,1,10                                          INVER
02090      TFM -AZER,-99,10                                       INVER
02100      TF  AMEM,AMEMR                                         INVER
02110      SF  -AMEM                                              INVER
02120      A   AMEM,LGM                                           INVER
02130      AM  AMEM,1,10                                          INVER
02140      TFM -AMEM,0,10                                         INVER
02150      TF  AMEB,AMEBR                                         INVER
02160      SF  -AMEB                                              INVER
02170      A   AMEB,LGM                                           INVER
02180      AM  AMEB,1,10                                          INVER
02190      TFM -AMEB,0,10                                         INVER
02200      TF  J,AMEB                                             INVER
02210      SM  J,2,10                                             INVER
02220      TF  AMEBB,J                                            INVER
02230IA    C   I,NN                                               INVER
02240      BE  IB                                                 INVER
02250      TF  AN,AELN                                            INVER
03010      A   AN,I                                               INVER
03020      TFLS-AN,-AZER                                          INVER
03030      A   I,LGT                                              INVER
03040      B   IA                                                 INVER
03050IB    TFM I,0                                                INVER
03060IC    C   I,NN                                               INVER
03070      BNL ID                                                 INVER
03080      TF  AN,AELN                                            INVER
03090      A   AN,I                                               INVER
03100      TFLS-AN,-AUN                                           INVER
```

```
03110      A    I,N
03120      A    I,LGT
03130      B    IC
03140ID    TFM  I,0
03150IE    C    I,N
03160      BE   FINSP
03170IF    M    I,NREEL
03180      SF   95
03190      TF   J,99
03200      TF   JJ,I
03210      TFLS-AMEM,-AZER
03220IG    C    JJ,N
03230      BE   IJ
03240      TF   AM,AELM
03250      A    AM,I
04010      A    AM,J
04020      TFLS-AMEB,-AM
04030      CF   -AMEBB
04040      TFLS98,-AMEB
04050      FS   -AMEB,-AMEM
04060      BNF  IH,-AMEBB
04070      B    IM
04080IH    TFLS-AMEM,98
04090      TF   K,JJ
04100IM    A    J,N
04110      A    JJ,LGT
04120      B    IG
04130IJ    CM   -AMEM,-99,10
04140      BNE  IK
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04150      PCTY
04160      WAITMESSA
04170      PCTY
04180ERR   B    G
04190IK    C    K,I
04200      BE   IL
04210      B    SPCHG
04220IL    C    SPCIV
04230      B    SPZER
04240      A    I,LGT
04250      B    IE
05010FINSP B    0
05020SPCHG M    K,NREEL
05030      SF   95
05040      TF   K,99
05050      M    I,NREEL
05060      SF   95
05070      TF   J,99
05080      TFM  JJ,0
05090SGA   C    JJ,N
05100      BE   SGE
05110      TF   AM,AELM
05120      A    AM,K
05130      A    AM,JJ
05140      TFLS-AMEM,-AM
05150      TF   AN,AELM
05160      A    AN,J
05170      A    AN,JJ
05180      TFLS-AM,-AN
05190      TFLS-AN,-AMEM
05200      A    JJ,LGT
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05210          B    SGA                          INVER
05220SGB       TFM  JJ,0                         INVER
05230SGC       C    JJ,N                         INVER
05240          BE   SGD                          INVER
05250          TF   AM,AELN                      INVER
06010          A    AM,K                         INVER
06020          A    AM,JJ                        INVER
06030          TFLS-AMEM,-AM                     INVER
06040          TF   AN,AELN                      INVER
06050          A    AN,J                         INVER
06060          A    AN,JJ                        INVER
06070          TFLS-AM,-AN                       INVER
06080          TFLS-AN,-AMEM                     INVER
06090          A    JJ,LGT                       INVER
06100          B    SGC                          INVER
06110SGD       B    IL                           INVER
06120SPDIV     M    I,NREEL                      INVER
06130          SF   95                           INVER
06140          TF   K,99                         INVER
06150          TF   AM,AELM                      INVER
06160          A    AM,K                         INVER
06170          A    AM,I                         INVER
06180          TFLS-AMEM,-AM                     INVER
06190          TF   JJ,I                         INVER
06200SVA       C    JJ,N                         INVER
06210          BE   SVB                          INVER
06220          TF   AM,AELM                      INVER
06230          A    AM,K                         INVER
06240          A    AM,JJ                        INVER
```



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06250          CM   -AM,-99,10                   INVER
07010          BNE  *+36                         INVER
07020          A    JJ,LGT                       INVER
07030          B    SVA                          INVER
07040          FD   -AM,-AMEM                    INVER
07050          A    JJ,LGT                       INVER
07060          B    SVA                          INVER
07070SVB       TFM  JJ,0                         INVER
07080SVC       C    JJ,N                         INVER
07090          BE   SVE                          INVER
07100          TF   AN,AELN                      INVER
07110          A    AN,K                         INVER
07120          A    AN,JJ                        INVER
07130          CM   -AN,-99,10                   INVER
07140          BNE  *+36                         INVER
07150          A    JJ,LGT                       INVER
07160          B    SVC                          INVER
07170          FD   -AN,-AMEM                    INVER
07180          A    JJ,LGT                       INVER
07190          B    SVC                          INVER
07200SVD       B    IL+12                        INVER
07210SPZER     M    I,NREEL                      INVER
07220          SF   95                           INVER
07230          TF   K,99                         INVER
07240          TFM  J,0                          INVER
07250SPA       C    J,K                          INVER
08010          BE   SRF                          INVER
08020          C    J,NN                         INVER
08030          BNL  SRF                          INVER
08040          TF   AM,AELM                      INVER
08050          A    AM,I                         INVER
```

```
08060       A    AM,J                                    INVER
08070       TFLS-AMEM,-AM                                INVER
08080       TF   JJ,I                                    INVER
08090SRB    C    JJ,N                                    INVER
08100       BE   SRC                                     INVER
08110       TF   AM,AELM                                 INVER
08120       A    AM,JJ                                   INVER
08130       A    AM,K                                    INVER
08140       TFLS-AMEB,-AM                                INVER
08150       FM   -AMEB,-AMEM                             INVER
08160       TF   AN,AELM                                 INVER
08170       A    AN,JJ                                   INVER
08180       A    AN,J                                    INVER
08190       FS   -AN,-AMEB                               INVER
08200       A    JJ,LGT                                  INVER
08210       B    SRB                                     INVER
08220SRC    TFM  JJ,0                                    INVER
08230SRD    C    JJ,N                                    INVER
08240       BE   SRE                                     INVER
08250       TF   AM,AELN                                 INVER
09010       A    AM,JJ                                   INVER
09020       A    AM,K                                    INVER
09030       TFLS-AMEB,-AM                                INVER
09040       FM   -AMEB,-AMEM                             INVER
09050       TF   AN,AELN                                 INVER
09060       A    AN,JJ                                   INVER
09070       A    AN,J                                    INVER
09080       FS   -AN,-AMEB                               INVER
09090       A    JJ,LGT                                  INVER
```



```
09100       B    SRB                                     INVER
09110SRE    A    J,N                                     INVER
09120       B    SRA                                     INVER
09130SRF    B    IL+24                                   INVER
09140LGM    DC   2,00                                    INVER
09150LGT    DC   3,000                                   INVER
09160AELM   DC   5,00000                                 INVER
09170AM     DC   5,00000                                 INVER
09180AELN   DC   5,00000                                 INVER
09190AN     DC   5,00000                                 INVER
09200K      DC   5,00000                                 INVER
09210NN     DC   5,00000                                 INVER
09220I      DC   5,00000                                 INVER
09230J      DC   5,00000                                 INVER
09240JJ     DC   5,00000                                 INVER
09250K      DC   5,00000                                 INVER
10010ZER    DC   1,0                                     INVER
10020       DS   45                                      INVER
10030AZERR  DSA  ZER                                     INVER
10040AZER   DC   5,00000                                 INVER
10050UN     DC   1,1                                     INVER
10060       DS   45                                      INVER
10070AUNR   DSA  UN                                      INVER
10080AUN    DC   5,00000                                 INVER
10090MEM    DC   1,0                                     INVER
10100       DS   45                                      INVER
10110AMEMR  DSA  MEM                                     INVER
10120AMEM   DC   5,00000                                 INVER
10130MEB    DC   1,0                                     INVER
10140       DS   45                                      INVER
10150AMEBR  DSA  MEB                                     INVER
```

```
10160AMEB  DC  5,00000                                  INVER
10170AMEBB DC  5,00000                                  INVER
10180NREEL DC  2,00                                     INVER
10190MESSA DAC 23,THE MATRIX IS SINGULAR'               INVER
10200      DENDDEBUT                                    INVER
```

```
360007200500360020100500440001200276260005900274250001100002600090002690 -0000
260009500264310000000200260011400274250000000114900120000C0               -0001
4100000000036100000500016036570000-216033810010171603391J1017#0-1-0402-0462 -0002
160337300036160173 4-0522160163 8-05104900570000004800000000000#0-1-0462-0522 -0003
2511072004003811000001004800000000049004020000016034 1-0000#0-1-0522-0582 -0004
260337603373330337500000110337600000-223036570337632000950000C0#0-1-0582-0642 -0005
260340100079230340103657320009500000260340600099260353803533#0-1-0642-0702 -0006
260348203477320353000000320348K000002103538033731107538000-1#0-1-0702-0762 -0007
210348203373110348200 -1160353 000-1160348K000RR260359403589#0-1-0762-0822 -0008
320359M000002103594033731103594000-1160359M000-026036500364 5#0-1-0822-0882 -0009
320365-000002103650033731103650000-1160365-000-026034160365 0#0-1-0882-0942 -0010
120341 6000-226036550341624034110340646016801200260339603391#0-1-0942-1002 -0011
210339603411160379 -10374903764000 0#                          0-1-1002-1038 -0012
-3390-348K#                                                    1-1-1033-1043 -0013
210341103376490096600000160341 -0000240341103406460119401300#0-1-1044-1104 -0014
260339603391210339603411160379 -11514903764000 0#             0-1-1104-1152 -0015
-3390-3530#                                                    1-1-1147-1157 -0016
210341103401210341103376490108000000160341 -0000240341103401#0-1-1158-1218 -0017
460172801200270341103657320009500000260341600099260342103411#0-1-1218-1278 -0018
160379 -13014903764000000#                                     0-1-1278-1302 -0019
-359M-348K#                                                    1-1-1297-1307 -0020
240342103401460157201200260338603381210338603411210338603416#0-1-1308-1368 -0021
160379 -13914903764000000#                                     0-1-1368-1392 -0022
-365--3380#                                                    1-1-1387-1397 -0023
330365N000001603795-14334903764000 0#                          0-1-1398-1434 -0024
-0098-365-#                                                    1-1-1429-1439 -0025
160379 -14634903704000000#                                     0-1-1440-1464 -0026
-365--359M#                                                    1-1-1459-1469 -0027
```

4401494036 5N4901536000001603795-1517490376400000‡ 0-1-1470-1518 -0028

-359M-0098‡ 1-1-1513-1523 -0029

2603426034212103416034012103421033764901308000C0140359MC00RR‡0-1-1524-1584 -0030

4701644012003400000001023903659001003400000001024900000C00CC0‡0-1-1584-1644 -0031

2403426034114601680012004901740000004902268000004902730C0000‡0-1-1644-1704 -0032

2103411033764901206000004900000000002303426036573200095000C0‡0-1-1704-1764 -0033

2603426000992303411036573200095000002603416000991603421-0000‡0-1-1764-1824 -0034

2403421034014602034012002603386033812103386034262103386034 21‡0-1-1824-1884 -0035

1603795-1907490376400000‡ 0-1-1884-1908 -0036

-359M-3380‡ 1-1-1903-1913 -0037

2603396033812103396034162103396034211603795-1973490376400CC0‡0-1-1914-1974 -0038

-33E0-3390‡ 1-1-1969-1979 -0039

1603795-2003490376400000‡ 0-1-1980-2004 -0040

-3390-359M‡ 1-1-1999-2009 -0041

2103421033764901824000001603421-0000240342103401460225601200‡0-1-2010-2070 -0042

2603386033912103386034262103386034211603795-2129490376400C00‡0-1-2070-2130 -0043

-359M-3380‡ 1-1-2125-2135 -0044

2603396033912103396034162103396034211603795-2195490376400000‡0-1-2136-2196 -0045

-3380-3390‡ 1-1-2191-2201 -0046

1603795-2225490376400000‡ 0-1-2202-2226 -0047

-3390-359M‡ 1-1-2221-2231 -0048

2103421033764902046000004901680000002303411036573200095C00C0‡0-1-2232-2292 -0049

2603426000992603386033812103386034262103386034111603795-2363‡0-1-2292-2352 -0050

4903764000 00‡ 0-1-2352-2364 -0051

-359M-3380‡ 1-1-2359-2369 -0052

2603421034112403421034014602544012002603386033812103386034 26‡0-1-2370-2430 -0053

2103386034211403380000RR4702490012002103421033764902382C0000‡0-1-2430-2490 -0054

1603795-2513490374400000‡ 0-1-2490-2514 -0055

-3380-359M‡ 1-1-2509-2519 -0056

2103421033764902382000001603421-0000240342103401460271801200‡0-1-2520-2580 -0057

2603396033912103396034262103396034211403390000RR47C2664012C0‡0-1-2580-2640 -0058

2103421033764902556000001603795-2687490374400C00‡ 0-1-2640-2688 -0059

-3390-359M‡ 1-1-2683-2693 -0060

2103421033764902556000004901692000002303411036573200950C0C0‡0-1-2694-2754 -0061

26C3426000991603416-0000240341603426460333601200240341603 4C6‡0-1-2754-2814 -0062

4603360013C026033860338121033860341121033860341616037 95-2885‡0-1-2814-2874 -0063

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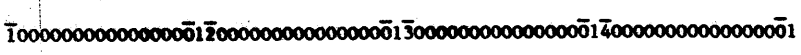
LIST OF SYMBOLS OF ASSEMBLED SAMPLE PROGRAM

Annex IV

00502	DE NF	00570	INVER	00636	IA	01068	IB	01080	IC
01194	ID	01206	IE	01230	IF	01302	IG	01494	IH
01536	IM	01572	IJ	01632	FERR	01644	IK	01680	IL
01728	FINSP	01740	SPCHG	01824	SGA	02034	SGB	02046	SGC
02256	SGD	02268	SPDIV	02382	SVA	02544	SVB	02556	SVC
02718	SVD	02730	SPZER	02776	SRA	02904	SRB	03114	SRC
03126	SRD	03336	SRE	03360	SRF	03373	LGM	03376	LGT
03381	AELM	03386	AM	03391	AELN	03396	AN	03401	N
03406	NN	03411	I	03416	J	03421	JJ	03426	K
03427	ZER	03477	AZERR	03482	AZER	03483	UN	03533	AUNR
03538	AUN	03539	MEM	03589	AMEMR	03594	AMEM	03595	MEB
03645	AMEBR	03650	AMEB	03655	AMEBB	03657	NREEL	03659	MESSA

INPUT SAMPLE PROBLEM



OUTPUT DUMP OF THE SAMPLE PROBLEM