PRADIS

GUIDE TO THE PROGRAM

THE SOFTWARE FOR SIMULATION OF NON-STATIONARY PROCESSES IN MECHANICAL SYSTEMS AND SYSTEMS OF OTHER PHYSICAL NATURE

VERSION 4.2

Contents

1. BASIC INFORMATION ABOUT THE PROGRAM SET PRADIS......5
1.1. SEQUENCE OF STUDYING THE DOCUMENTATION AND THE OVERALL DIAGRAM OF WORK WITH THE PROGRAM SET......5
1.2. FILE STRUCTURE......6
1.3. LIBRARIES OF EXPANSIBLE COMPONENTS AND THE FILE OF THE SYSTEM CATALOG......6
1.4. PROCEDURES PRADIS. PROCEDURE CALL-IN WITHOUT THE PARAMETERS AND CHECKING THE CORRECTNESS OF THE INSTALLATION OF THE COMPLEX......7
1.5. PROCEDURE OF FULFILLMENT OF ASSIGNMENTS (SLANG)......10
1.5.1. Functions of the procedure of fulfillment of assignments......10
1.5.2. The diverse variants of the progress of task under the administration of procedure SLANG......12
1.5.3. Progress of the complete task......13
1.5.4. Fulfillment of assignments at the point of calculation and preparation of file for mapping of results for the already formed model......14
1.5.5. Repeated restart based on the fixed point of retention with the replacement of the parameters......16
1.5.6. Fulfillment of assignments at the point of shaping of file for mapping of results for the already formed model......17
1.6. PROCEDURE OF THE MAINTENANCE SYSTEM CATALOG (ARM)......18
1.6.1. Functions of the procedure of the maintenance the system catalog......18
1.6.2. Brief information about the current composition of the expansible libraries......18
1.6.3. The complete enumeration of themes, on which it is possible to obtain the reference information......20
1.6.4. Obtaining reference information for the sake of the concrete theme......20
1.6.5. Start of the programs of user in dynamic and user libraries and exception of expansible components from the libraries PRADIS......21
2. CONTROL BESIDES THE WORK OF THE COMPUTATIONAL NUCLEUS......23
2.1. THE DESCRIPTION OF THE CALL OF THE PROGRAM OF INTEGRATION AND OF VARIABLES DISPLAYED DURING CALCULATION......23
2.2. KEY PARAMETERS OF THE PROGRAM OF INTEGRATION......24
2.3. TASK OF THE INTERVAL OF INTEGRATION (END)......27
2.4. CONTROL BESIDES THE STEP OF THE CONCLUSION OF RESULTS FOR THE CURRENT PROGRAM OF INTEGRATION (OUT)......28
2.5. CONTROL BESIDES ACCURACY IN THE INTEGRATION AT THE POINT OF THE TIME (DRLTX, DABSX)......31
2.5.1. Algorithm of estimation and control of the precision......31
2.5.2. Key parameters, which determine the value of the permissible local error......34
2.6. EXPLICIT LIMITATIONS DOWN THE STEP OF INTEGRATION (SMAX, SMIN, CONTROL)......36
2.7. CONTROL BESIDES THE DECREASE OF HIGH-FREQUENCY FLUCTUATIONS (CONTROL AND WEIGHT)......40
2.8. ALGORITHM OF THE SOLUTION OF THE SYSTEM OF NONLINEAR EQUATIONS AGAINST THE STEP OF INTEGRATION. KEY PARAMETERS, WHICH CONTROL THE PROCESS OF THE SOLUTION (DABSU, DRLTU, DABSI, DRLTI, ITR)......46
2.9. CONTROL BESIDES THE PROCESS OF SOLVING THE SYSTEM OF NONLINEAR EQUATIONS WITH THE AID OF THE KEY PARAMETERS OF THE PROGRAM OF THE INTEGRATION......51

2.9.1. Maximum quantity of iterations down the step of integration (ITR)........................ 52
2.9.2. Precision of the solution of the system of nonlinear equations and the guaranteed second iteration (DABSI, SECOND)..54
2.10. STEP OF THE RETENTION OF THE STATE OF CALCULATION (SAVE)............55
2.11. CONTROL BESIDES THE CONCLUSION OF CHECK-OUT INFORMATION ACCORDING TO MODEL (DEBUG)...55
2.11.1. Check-out information on the process of solving [SnLU].. 58
2.11.2. Check-out information on the control of local error against the step of integration and control besides the method of forecast according to accelerations (DEBUG, PREDICT)...62
2.11.3. Selection of the simplest example with an abrupt change in the potential for one of the degrees of freedom (DABSX, IGNORE, CONTROL, DEBUG)...................64
2.12. RARELY UTILIZED KEY PARAMETERS OF THE PROGRAM OF THE INTEGRATION...71
2.12.1. Linear forecasting on the accelerations against the beginning of step (PREDICT)..71
2.12.2. Control besides time mark before the text regime (TIMER)..................................71
2.12.3. Selection of basic variable for evaluating the local error (FLAG).......................... 71
2.12.4. Selection of the diagram of integration (SCHEME).. 71
2.12.5. Checking the inertia properties of degrees of freedom against the beginning of calculation (CHECKM).. 72
2.12.6. Account of the value of the step of the integration, recommended for the sake of the models of elements (IGNORE)..72
2.13. INTERACTIVE CONTROL OF WORKING PROGRAM (<ALT-C>).......................73
3. VISUALIZATION OF OBJECT ABOUT THE RESULTS OF THE CALCULATION.........74
3.1. GENERAL CONSIDERATIONS..74
3.2. DIVISION OF THE DESCRIPTION OF THE IMAGE OF THE OBJECT.................... 75
3.2.1. Start of the description of graphic means in the description of the layer of the image 75
3.2.2. Positioning image beyond the shield and the task of the motion of observer for the flat case...81
3.2.3. Positioning image beyond the shield and the task of the motion of observer for the three-dimensional case..83
3.3. CONTROL BESIDES THE COLOR OF THE IMAGE...87
3.4. CONTROL BESIDES THE VISUALIZATION 89
3.4.1. Key parameters of the program of integration CHANGE and MODE...................... 89
3.4.2. Use of a means of the replacement of the parameters i REPLACE.......................... 89
3.5. EXPLANATIONS TO SOME SITUATIONS...93
4. SOME INFORMATION ABOUT THE PROGRAM OF THE FACTORIZATION.............. 94
4.1. ALGORITHMS OF THE RENUMBERING OF COMPLEX PRADIS. 94
4.1.1. Special features of the algorithms of the renumbering..94
4.1.2. Levels of the optimization of matrix structure (key parameter OPTIM)...................99
5. PROGRAM OF THE MAPPING...102
5.1. DIVISION OF TASK AT THE POINT OF MAPPING OF THE RESULTS OF CALCULATION. DIFFERENCE BETWEEN THE OUTPUT AND THAT REFLECTED BY VARIABLES. 102
5.2. GENERAL INFORMATION ABOUT THE PROGRAMS OF MAPPING. KEY PARAMETERS, WHICH ASSIGN THE REFLECTED INTERVAL OF TIME (START, END). 103
5.3. PROGRAM OF THE PREPARATION OF DATA FOR MAPPING OF THE RESULTS OF CALCULATION BEYOND THE SCREEN OF DISPLAY (DISP). 106
5.3.1. General information about the program of mapping DISP. 106
5.3.2. Determination of the independent variable with graphing (FROM). 107

5.3.3. Automatic scaling of graphs on the minimum-to the maximum value of variables before the interval of mapping (SCALE). 107
5.4. PROGRAM OF THE CONCLUSION OF THE TABLE OF THE RESULTS OF CALCULATION BESIDE THE TEXT FILE (TABL). 108
5.4.1. General information about the program of mapping TABL. 108
5.4.2. Example of the use of a program and the description of the structure of the conclusion of the results of calculation. 109
5.4.3. Step of the construction of the table of results (OUT) and control besides the size of conclusion (FORMF). 112

1. BASIC INFORMATION ABOUT THE PROGRAM SET PRADIS

1.1. SEQUENCE OF STUDYING THE DOCUMENTATION AND THE OVERALL DIAGRAM OF WORK WITH THE PROGRAM SET

Is thus, on your computer established program set PRADIS. This is sufficiently developed software, intended for conducting the complex calculations of transient processes. The study of its possibilities fully will require as with the work with another analogous software, the specific efforts. In this case the work experience with the finite-element programs can to a considerable degree prove useful. However, it is necessary to have in mind that although the sphere of application PRADIS and finite-element programs they intersect before what-that degrees, but do not overlap completely.

Basic special feature of work PRADIS - this is the presence in the process of extent on the time being simulated. Not one task being simulated can be solved otherwise as as a result the examination of what-either the process of that or other duration.

The authors, creating documentation on PRADIS, pursued the purpose to maximally facilitate to the beginning user first steps before the mastery of bundle. Before our opinion, the order of the study of documentation must be the following:

- *"General description of system"*. This simple document useful to read still before you will study installation PRADIS on your computer. It will give to you a certain idea about the designation of bundle, its basic component parts, before what-that degrees will allow to become acquainted for the sake of the terminology, accepted before other documentation.
- *"Instruction beyond the installation of complex"*. It contains all necessary information on the installation of complex down your computer.
- *"The management of user. Teaching aid"*. It is intended for the express-acquaintance with the basic possibilities of complex and rapid beginning of work with it. The authors imperatively recommend to user the finding of the time, necessary for studying of this document and fulfillment of the given there examples.
- Present document, reference books on the libraries PRADIS, *"reference book on the errors"* and *"description of the language Of pradiSlang"* are intended for the daily work with the complex and studying some questions, which against each given moment require more detailed study. After acquaintance with the first divisions of each document, which contain general information, and primary quick survey should be always held they near at hand as the basic reference books. Hardly should be in detail studied advantage these documents, without having before themselves what-or the specific objectives, on which in you arose questions.
- *"The start of the programs of user in the libraries of complex"* and *"basic mathematical methods"* they are intended for the qualified user. They give the possibility to be dismantled with the basic principles of the operation of computational nucleus PRADIS. The study of these documents will make it possible to independently expand the possibilities of complex before one or other sphere or another of its application.

Thus, present document besides (possibly), its first head, it is not intended for reading by the beginning user. If you against its present moment study, then you, most probably, they already solved, at least, several tasks, described before *“the teaching aid”*, and attempted to solve one or several tasks in your region of activity. You visualize that for the forming of the mathematical model of what-or process user must:

- to obtain the design diagram of the process;
- to describe before the input language PRADIS initial data, the structure of object and its image;
- to shape task at the point of the calculation. In this case the text of the description of data, object and image of object must precede the text of the description of the task; to carry out task at the point of shaping and calculation of model with the aid of the command SLANG. Subsequently with the aid of the same command it is possible to carry out tasks at the point of the calculation for the already formed model.

Is in more detail examined below file structure PRADIS and its basic procedures (SLANG, ARM).

1.2. FILE STRUCTURE

****

1.3. LIBRARIES OF EXPANSIBLE COMPONENTS AND THE FILE OF THE SYSTEM CATALOG

Key file before the file structure of program set is the file of system catalog (ARMCTLG). It contains entire necessary information for the correct forming and the analysis of the model of object. Furthermore, before the system catalog is contained the necessary reference information, obtained as far as user before the regime ONLINE on the demands with the aid of the procedure ARM.

Library programs are subdivided in accordance with their designation. The programs, which realize the models of elements, compose the library of the models of elements. The programs, which convert the results of solving the system of differential equations beside the data, directly necessary at the point of user, are the library of the programs of the calculation of output variables. The library of graphic means is used for describing the image of object. The library of the programs of mapping contains the programs, which convert the results of calculation for the output to one or other external unit.

Compiler PRADIS uses the information, included in system catalog, for the syntactic control of the descriptions of the calls of various programs. In this case the information relative to these components is copied from the system catalog beside the working file and is used subsequently for the generation of working program.

ATTENTION! Some questions of the protection of copyrights are connected for the sake of the file of system catalog. Many programs PRADIS before various situations can use elements of system catalog as the constants. Therefore for the work with the system catalog (start or the exception from it of information) only regular procedure of the maintenance system catalog must be used.

1.4. PROCEDURES PRADIS. PROCEDURE CALL-IN WITHOUT THE PARAMETERS AND CHECKING THE CORRECTNESS OF THE INSTALLATION OF THE COMPLEX

The call-in of procedures ARM and SLANG without the parameters will lead down the delivery beyond the screen of your display of reference information about the permissible versions of the procedure call-in.

1. procedure of fulfillment of assignments SLANG.

```
=====================================================================
Use: slang [-m|-R] [-e|-s] [-pgoN] name1 [name2]
Start the solver PRADIS in a simulation mode.

Parameters:
 name1 File of the task
                The description in language PRADISland
 name2 Name of a preliminary task
                (When the work repeats with already constructed model)

Options:
 -pgoN the recording of graphic 3d information beside the file
                (GIP file), N means the counter of shown points
                (to derive each N-to [uyu] point), if N it is not
prescribed,
                then N=1
 -e to use the extended size of output to shield (on
                (by default)
 -s to use short size of output to the shield
 -R to evaluate the frequency of the conclusion
                on the screen in real time (by default),
                value of frequency of the display is taken
                from the parameter PRTTIME of [reshatelya] PRADIS (on
silence 30)
                current time is shown on conditions that
                the current time-last shown [vremya]>[chastota]
 -m to evaluate the frequency of the conclusion
                to the screen in time of a model,
                value of frequency of the output is taken
                from the parameter PRTTIME of [reshatelya] PRADIS (on
silence 30),
                current time is shown on conditions that
                the current time-last shown [vremya]>[chastota]
=====================================================================
```

2. procedure of the maintenance system catalog ARM.

```
=====================================================================
Use: arm [of <[klyuch]> of <[imya]1> [of <[imya]2> [of [imya]3… [of
[imya]N]]]]

Procedure of working binary catalog PRADIS.

        <[klyuch]>
         ? is derived information on the components, which are contained
before
           the binary catalog
         + it includes components in binary catalog and builds
           dynamic the plugin-library, if it is possible.
           If is not prescribed <[imya]1… N>, then it attempts to connect
```

```
            the templates
            from the file templet.txt before the current catalog.
          p automatically builds dynamic the plugin
            library include components in binary catalog.
          u adds functions beside the user library
            user.lib.
          # simply is built dynamic the plugin-library, if
            possibly
          ! are included components in the binary catalog
            If is not prescribed <[imya]1… N>, then it attempts to connect
            the templates
            from the file templet.txt before the current catalog.
          - it excludes components from the binary catalog
          * is derived contents of the built-in aid
            <[imya]1… N> not is applicable to this key
          n of [sozdaet] empty binary catalog before the current directory
            <[imya]1… N> not is applicable to this key
         <[imya]1… N>
          the names of the inquired components
====================================================================
```

Be convinced to finally besides the correctness of the installation of complex PRADIS is possible by the starting of programs from the catalog DINAMA \ OF TEST.

By command

```
> SLANG SWING
```

task at the point of the calculation is started spring-bar pendulum. With the fulfillment of this target beyond the display screen the following communications must be reflected:

```
   M (S 700) of syntactic errors is not discovered.


M (P 088): (OUTMAP: -1)
   COMMUNICATIONS OF THE PROGRAM OF FACTORIZATION.
              Structure of model after renumbering.
              Name of the global fragment: ╠[r] Of є[esh]
              Models of elements and degree of freedom:
M (P 004): (TURBOF: -1)
   COMMUNICATIONS OF THE PROGRAM OF FACTORIZATION.
       Statistics of the results of the symbolic factorization:
       Dimensionality of system of equations:       8.
M (P 005): (TURBOF: -1)
       The total number of the nontrivial elements:       52.
       Second nontrivial elements:        0.
       Filling of jacobian (%):    81.25
M (P 006): (TURBOF: -1)
       Nontrivial elements after the principal diagonal (parameter Q):
2.75
       Expenditures for the solution of system of equations:
       millions of operations with the floating point - 0.218E-03
M (P 007): (TURBOF: -1)
       millions of instructions of processor (integral operations,
passages and of taking) - 0.360E-03
       the size of index massif (KB) -  0.00
M (P 008): (TURBOF: -1)
       Sizes of the formed vectors:
       the massif of the state of calculation (KB) -  5.18
       address massif (KB) -  2.25
Time of information:
Model of time = of 0.000000000000e+000
```

```
     Estimated of time= of 0.000000000000e+000
     Expected of finish of time =…
     Current of time of step = 1.000000000000e-011
     Time of step of information (Eyler):
     Successful of steps = 1
     Unsuccessful of steps:
            Big of local of inaccuracy = 0
            Absent of convergence = 0
            Bad of results in of models = 0
            Bad Of jakobian = 0
     Iterative of step of information (Newton):
     Successful of iterations = 2
     Unsuccessful of iterations:
            Big of local of inaccuracy = 0
            Absent of convergence = 0
            Bad of results in of models = 0
            Bad Of jakobian = 0
     Operative of variables of information:
     Displacement p. A by means of the x axis = -2.489014957389e-034
     Speed p. A across the x axis = -4.978029914778e-023
     Acceleration p. A across the x axis = -4.978029914778e-012

     M (P 043): (MESSAG: -1)
        COMMUNICATIONS OF THE PROGRAM OF INTEGRATION.
            Identifier of the program: ╨рёўхЄ яЁецшээюую ьр Єэшър
     M (P 044): (MESSAG: -1)
            Time of the beginning of the integration:   0.0000
            Time of the termination of integration:   3.0000
            Dimensionality of system of equations:        8.
            Quantity of successful steps on the time:        357.
     M (P 045): (MESSAG: -1)
            Quantity of unsuccessful steps on the time because of:
                - it is inadmissible to the large local error:          0.
                - the absence of the convergence of the process of solving
[SnLU]:          0.
     M (P 046): (MESSAG: -1)
                - the unsatisfactory results of calculation before the models
of the elements:          0.
                - the poor conditionality of jacobian against the step of the
solution:       0.
     M (P 047): (MESSAG: -1)
            The total number of the successful iterations:       1046.
            The total number of lost iterations because of:
                - it is inadmissible to the large local error:          0.
     M (P 048): (MESSAG: -1)
                - the absence of the convergence of the process of solving
[SnLU]:          0.
                - the unsatisfactory results of calculation before the models
of the elements:          0.
     M (P 049): (MESSAG: -1)
                - the poor conditionality of jacobian against the step of the
solution:       0.
     M (P 043): (MESSAG: -1)
        COMMUNICATIONS OF THE PROGRAM OF INTEGRATION.
            Identifier of the program: ╨рёўхЄ яЁецшээюую ьр Єэшър
     M (P 044): (MESSAG: -1)
            Time of the beginning of the integration:   3.0000
            Time of the termination of integration:   5.0000
            Dimensionality of system of equations:        8.
            Quantity of successful steps on the time:        203.
     M (P 045): (MESSAG: -1)
            Quantity of unsuccessful steps on the time because of:
                - it is inadmissible to the large local error:          0.
```

```
                - the absence of the convergence of the process of solving
[SnLU]:          0.
     M (P 046): (MESSAG: -1)
                - the unsatisfactory results of calculation before the models
of the elements:         0.
                - the poor conditionality of jacobian against the step of the
solution:       0.
     M (P 047): (MESSAG: -1)
            The total number of the successful iterations:        406.
            The total number of lost iterations because of:
                - it is inadmissible to the large local error:          0.
     M (P 048): (MESSAG: -1)
                - the absence of the convergence of the process of solving
[SnLU]:          0.
                - the unsatisfactory results of calculation before the models
of the elements:         0.
     M (P 049): (MESSAG: -1)
                - the poor conditionality of jacobian against the step of the
solution:       0.
     M (P 050): (MESSAG: -1)
        LIST OF THE OUTPUT VARIABLES

                      N in sequence are identifier the quantity
                                                          the components
```

Task must be carried out without what-or communications about the errors.

1.5. PROCEDURE OF FULFILLMENT OF ASSIGNMENTS (SLANG)

1.5.1.Functions of the procedure of fulfillment of assignments

Program set PRADIS is intended for the analysis of the dynamics of technical systems, which assumes conducting the computations of significant duration. Therefore fulfillment of assignments is accomplished before the batch mode with the possibilities of interactive control besides the motion of computations. Any task is described in source language and further it is started by means of procedure SLANG.

Before the function of this procedure it enters:

- checking the presence minimally necessary for the fulfillment of assignments free space on the hard drive and before the working storage;
- checking the presence of necessary for the fulfillment of assignments files (including the file of task, files of the carried out modules, file of system catalog and others);
- the destruction of the files, which are located before the current subdirectory, whose names duplicate up the names of those created PRADIS the temporary files;
- the call of the carried out modules PRADIS before that order, before which this is provide ford by the task;
- the control of correctness of the completion of the caused programs, the delivery of the corresponding communications about the errors;
- the creation of the file of system press (SYSPRINT.TXT), beside which falls the listing of the analyzed task and communication of all worked out programs. If before the current subdirectory already was present file SYSPRINT.TXT, then it is re-named

beside the file SYSPRINT.BAK. File SYSPRINT.TXT contains text information, i.e., it can be processed, for example, by text editor.

1.5.2.The diverse variants of the progress of task under the administration of procedure SLANG

There are three versions of the progress of task under the administration of procedure SLANG:

1 VERSION:

- preprocessor working and the translation of the task;
- the factorization of the matrix structure;
- the arrangement of information before the base of data of model and, if this is necessary, the generation of the text of the causing module of working program, its translation and the assembling;
- the calculation of transient process with the aid of the formed or standard working program;
- the forming of file with the expansion .DAT for the subsequent mapping of results.

2 THE VERSION:

- preprocessor working and the translation of the task;
- processing the information, existing before the base of data of the formed model;
- the calculation of transient process with the aid of the formed or standard working program;
- the forming of file with the expansion .DAT for the subsequent mapping of results.

3 THE VERSION:

- preprocessor working and the translation of the task;
- processing the information, existing before the base of data of the formed model;
- the forming of file with the expansion .DAT for the subsequent mapping of results.

For the realization of the first, complete version of the progress of task, before the text of task must be present the divisions of the description of the analyzed object, task at the point of calculation and mapping of results. In this case with the call-in of procedure SLANG is indicated the name of the file, which contains this task:

```
> SLANG of <[imya] of [fayla]>
```

The different version of the call-in of procedure SLANG is used if necessary to carry out task at the point of the calculation and/or task at the point of mapping of the obtained results for the already formed model of object (second or third versions of the progress of task). Then with the call-in of the procedure of fulfillment of assignments is indicated the name of the file, which contains task at the point of the calculation and/or task at the point of the mapping, and the name of the model, for which the user wants to carry out this task:

```
> SLANG of <[imya] of [fayla]> of <[imya] of [modeli]>
```

IT IS IMPORTANT! The file, which contains the text of the description of object, and the files of the description of tasks must not have expansions.

Let us examine in more detail all versions of the progress of task under the administration of procedure SLANG.

1.5.3.Progress of the complete task

It is let us suppose necessary to examine transient processes before the simplest pendulum:

```
$DATA:
Mass = 1
I FRAGMENT:
# BASE: 1
# STRUCT :
Mass 'M (2; Mass);
[Zhestkost]'K (2 1; 10)
Gravitational force 'FG (2; Mass)
# OUTPUT:
[Skorost]'V (2; 1)
I RUN :         Calculation 'SHTERM (END=1)
I PRINT :         Result 'DISP ()
$ END
```

This file contains the description of the analyzed object (division i FRAGMENT), task at the point of the calculation (division of $RUN), task at the point of mapping of results after the fulfillment of calculations (division of $PRINT), i.e., are assumed the first, most complete course of task.

If the text of program is contained before the file TEST, then after the delivery of the command

```
> SLANG TEST
```

task will be consecutively processed ***by text preprocessor and by translator PRADIS***. For the successful work to preprocessor and to translator must be accessible the files of the system catalog of complex, texts of communications about the errors and, naturally, strictly task before the input language PRADIS. Besides formal syntactic analysis the translator checks the presence in the system catalog of information relative to one or other library program or another, references down which are located in the workable task. If against these stages it will not be discovered syntactic errors, the temporary files, created for the sake of translator, remain and procedure calls the program of factorization. Otherwise task is interrupted with the delivery of the corresponding communication. Let us recall here that the library program consists of object code and information part. By translator PRADIS is checked only the presence of the information part of the library program and correctness of its description before the text of the workable task. The presence of object code of library program before one of the objective libraries of complex is checked by the editor of connections before the stage of assembling working program.

The program of factorization accomplishes the optimum numeration of the equations of system, which ensures a maximally possible retention of the rarefied structure of jacobian in the course of Gaussian exceptions. All necessary structures of the linear equations given for the program of the solution of the rarefied systems (they they will be used beyond the stage of the work of the program of integration) are prepared. The final length of all necessary working massifs is determined as far as the program of factorization. For the successful work to the program of factorization must be accessible the file of system catalog, the file of the texts of communications about the errors and the temporary files, created for the sake of translator. If the work of the program of factorization was completed successfully, procedure calls database manager of model. New temporary files program factorization does not create.

In the case of the successful fulfillment of the enumerated stages of target all temporary files are destroyed. From this point on, the model of object is considered formed also independently of the results of fulfilling the calculation in this concrete task the user can realize tasks for the already formed model (to use the second version of the call-in of procedure SLANG).

After this, the procedure passes to the realization of task at the point of the calculation. Before this stage working program carries out the instructions, which are contained before the division of $RUN (i.e., is accomplished the sequential call of the programs of integration before that order, before which they they are described before the division of the description of task). In the case of the successful fulfillment at least of one step of integration before the current subdirectory will appear the file of the results of calculation TEST.RSL.

After the completion of procedure SLANG on the disk will be preserved the files:

- TEST.TRN - the file of the results of translation (constant part of the base of data of model);
- TEST.VAR - the file of the replaceable parameters (the variable part of the base of data of model).
- TEST.DAT - the file of the results of calculation for the subsequent mapping by program POSTPROCESSOR
- TEST.DIS, TEST.PNM, TEST.IID, TEST.MID, TEST.OID, TEST.RSL - official files.

1.5.4.Fulfillment of assignments at the point of calculation and preparation of file for mapping of results for the already formed model

The second course of task can be realized for the already formed model. Examples of the programs, which realize the second course of the task:

EXAMPLE 1. task at the point of the fulfillment of calculation before the range of time from 0 to 1 with the parameters, determined with shaping of the model of object, i.e., without a change in the initial data:

```
I RUN :
Calculation 'SHTERM (END=1)
I PRINT :
Result 'DISP ()
$ END
```

EXAMPLE 2. task, which contains the requirement to continue calculation based on the last place of the retention:

```
I RESTORE :
I RUN :
Calculation 'SHTERM (END=1)
I PRINT :
Result 'DISP ()
$ END
```

If the file of the results of calculation is absent, then after the fulfillment of the syntactic analysis of target user will obtain the communication:

```
E (R 020) calculation cannot be continued based on the last point of
retention because of the absence of the file of results.
```

Fulfillment of assignments will be interrupted.

EXAMPLE 3. task at the point of the calculation about the already formed model, for which it is necessary to replace the lists of the parameters, enumerated before the division i REPLACE:

```
I REPLACE :
Mass = 10
I RUN :
Calculation 'SHTERM (END=1)
I PRINT :
Result 'DISP ()
$ END
```

As it was said above, all these programs contain tasks at the point of the calculation and preparation of halliard for mapping of results after the fulfillment of calculation and is assumed the second version of the progress of task. If what-or from these tasks it was recorded beside the file with the name “OF RUNFILE”, the starting of task for the already formed model is executed a command

```
> SLANG RUNFILE TEST
```

where RUNFILE - the file, which contains the text of task at the point of the calculation and the preparation of halliard for mapping of results for the already formed model;

TEST - the name of the already formed model (this is assumed to be the presence in the current subdirectory of files TEST.TRN, TEST.VAR, and, possibly, TEST.INT - if for the analysis of the model of object it is not possible to use a standard working program).

In this case the task will be also processed by text preprocessor and by translator. Temporary files are created before the stage of preprocessor working and translation. If syntactic errors will not be discovered, temporary files remain for the working as far as database manager.

After this, the database manager is called as far as procedure. Before this stage of fulfillment of assignments is used the variable part of the base of data of model, whose initial copy is obtained based on the file TEST.VAR. The information is introduced beside this file:

- on the need of restoring the calculation based on the last place of the retention;
- on the parameters, which must be replaced before the already formed model for fulfilling the new calculation;
- on the order of call and the values of the key parameters of the programs of integration and programs of mapping.

The obtained file is used in the current task and after its fulfillment is destroyed. Therefore it is necessary to have in mind that all information about a change in the parameters (division of $REPLACE) after fulfillment of assignments loses. If we after calculation with the replacement of the parameters again repeat calculation, this time using a task already without the division of $REPLACE, before it the initial parameters, prescribed with the forming of model, will be used.

Since this version of the progress of task provides for the presence of the already formed model of object, the stage of generation and assembling of working program is absent. Working program either must be already formed for this moment or is assumed use for the analysis of the object of standard working program.

As it is possible to note from information given before this point, a quantity of programs, which work before the second version of the progress of task, in comparison with the complete version is less.

This economizes time with repeated analysis of the objects of one and the same structure, which are distinguished only by the composition of the parameters. For the large tasks appears the possibility to avoid not only the stages of the repeated forming of model, but also to repeat (or to continue) calculation anew in such cases for which it according to one or the other to reasons was not brought to completion.

1.5.5.Repeated restart based on the fixed point of retention with the replacement of the parameters

This need can arise for the calculations significant on the duration, when the model of object must be “derived” beside the specific state and before this state carried out several calculations, each of which is determined as far as different combination of the parameters.

Let us examine for simplicity an example from point 1.5.3 (analysis of the simplest spring pendulum). To let us suppose we need analyze swing of the pendulums for a period of second. The value of mass intermittently decreases after this. It is necessary to analyze before interval of 1… of 2 with three calculated cases:

1) mass decreases to 0.9 kgf;
2) mass decreases to 0.8 kgf;
3) mass decreases to 0.7 kg.

Let us at first shape model and let us analyze swing of the pendulums for period 1 of second. After this, it would be possible to carry out task with the replacement of the value of mass for the 1st calculated case and the restoration of the results of calculation based on the last place of retention. If we act in this manner, then for 2-GO of the calculated case will have to repeat integration from the very beginning (based on the zero time), since the data about the state of system at the moment of the time of t=1c will be lost. For the large models this approach can prove to be uneconomical.

Here we will examine the sequence of actions, necessary for retaining the results of precomputation and their further repeated restoration based on the place of retention with the replacement of the parameters.

1. let us carry out task at the point of shaping of model and calculation of fluctuations for period 1 of second by the command

```
> SLANG TEST
```

2. let us copy the obtained as a result fulfillments of this target the files (see point 1.5.3) for the sake of the command of the operating system:

```
> COPY TEST.* TEST1.*
```

The obtained files TEST1.* (by chain wheel they are marked all accessible expansions for the file with one name), will be used for further calculation with the replacement of the value of mass, and files TEST.* will preserve information about the state of system at the moment of the time of t=1c.

3. now let us shape task at the point of the replacement of the parameters and calculation based on the last point of retention T1:

```
I REPLACE :
Mass = 0.9
I RESTORE :
I RUN :
Calculation 'SHTERM (END=2)
I PRINT :
Result 'DISP ()
$ END
```

4. let us carry out task at the point of the replacement of the parameters and calculation based on the last point of retention for the formed model TEST1:

```
> SLANG T1 OF TEST1
```

After the fulfillment of this target the base of data of model TEST1 will correspond to the case of an abrupt change of the mass at the moment of the time of t=1 and contain the results of calculating the pendulum for the interval of time 0-2 s. let us note here also that, as in the previous cases, the fulfillment for TEST1 of one additional task with the title of $RESTORE, but without the title of $REPLACE will lead down one additional abrupt change in the mass to the initial value (1 kgf) at the moment of the time of t=2[s].

5. for fulfilling calculating the second and third versions it is possible thus to carry out the commands

```
> COPY TEST.* TEST2.*

> COPY TEST.* TEST3.*
```

and to create tasks at the point of the replacement of the value of mass and restoration of the results of calculation for the second and third versions, respectively T2 and T3.

If for fulfilling these actions in you it is insufficient disk memory, then all versions of calculations with the changed mass it is possible to carry out by the name TEST1. This will save to you disk space, but it will not make it possible to return to the analysis of the results of calculation for the first version, since they will be substituted by the results of calculation for the second, and then the third of versions.

1.5.6.Fulfillment of assignments at the point of shaping of file for mapping of results for the already formed model

The third version of the progress of task also can be realized only for the already formed model. Furthermore, it is implied that the calculations has already been performed for this model. In the general case, the tasks, which foresee only shaping of file for the subsequent mapping of results, contain only the division of $PRINT, for example:

```
I PRINT :
Result 'DISP ()
$ END
```

If task is, for example, recorded beside the file “OF OUTFILE”, then the starting of task at the point of mapping of results appears analogously for the sake of the starting of task at the point of the calculation and the mapping for the already formed model:

```
> SLANG OUTFILE TEST
```

where OUTFILE - the file, which contains the text of task at the point of shaping of file for the subsequent mapping of results for the already formed model;

TEST - the name of the already formed model.

In this case the task will be also processed by text preprocessor and by translator. Temporary files are created before the stage of preprocessor working and translation. If syntactic errors will not be discovered, temporary files remain for the working as far as database manager.

After this, the database manager is called as far as procedure. Before this stage of fulfillment of assignments is used the variable part of the base of data of model, whose initial copy is obtained based on the file TEST.VAR. The information about the order of call and the values of the key parameters of the programs of mapping is introduced beside this file.

This version of the progress of task is intended for the idea of results before the form after the fulfillment of calculation selected by user.

1.6. PROCEDURE OF THE MAINTENANCE SYSTEM CATALOG (ARM)

1.6.1. Functions of the procedure of the maintenance the system catalog

The procedure of the maintenance system catalog ARM is intended for:

- obtaining brief information about the current composition of the libraries of the complex;
- obtaining operational reference information about different components of the complex;
- the addition of modules down the libraries of complex and their exception from the composition of the libraries of complex.

All actions on the maintenance of system catalog are carried out by utilities PRADIS. Procedure ARM ensures:

- checking the presence of the files, necessary for the fulfillment of assignments (including the files, whose names were prescribed with the procedure call-in as the parameters, the files of the carried out modules, file of system catalog and others);
- the destruction of the files, which are located before the current subdirectory, whose names duplicate up the names of the created temporary files;
- the call of the usable modules before that order, before which this is provide ford by the task;
- the control of correctness of the completion of one or other module or another, the delivery of the corresponding communications about the errors;
- the creation of the file of system press (SYSPRINT.TXT), beside which falls the listing of the analyzed module and communication of all worked out utilities. If before the current subdirectory already was present file SYSPRINT.TXT, then it is re-named beside the file SYSPRINT.BAK. As a rule, the information, given beyond the shield during the work of the procedure of the maintenance system catalog, is duplicated up before the file SYSPRINT.TXT. As in the case with the procedure of fulfillment of assignments, file SYSPRINT.TXT can be processed by text editor and by other analogous means of the utilized operating system.

1.6.2. Brief information about the current composition of the expansible libraries

As it was already said above, each of the library programs consists of information part and object code. The information part of the program is located before the file of system catalog

ARMCTLG. Since into the composition of complex enter several expansible libraries, information on the modules of each of the libraries is united beside the corresponding to it catalog. Are distinguished the catalog of models, the catalog of the programs of the calculation of output variables, the catalog of graphic means and the catalog of the programs of mapping. Information about the contents of these catalogs can be obtained upon command

```
> ARM?
```

Structure of the reference information, obtained on this demand:

```
Reference information on the system catalog

Attributes of the system catalog of the complex Of pradis
Number of version 4.2
Year of creation by 0706
Series number 101
Identifier of ***********
Contents of the catalog of the models of the elements:

And m I to r and t to rel.un. n and z n and ch e n and e
…
BELTV the characteristic of belt, assigned tabular taking into account
the drawing
             the belt
BLOK elastic octagonal element (building block)
BRK elastic constraint for the sake of brittle failure
…
Contents of the catalog of the programs of the calculation of the output
parameters:

And m I to r and t to rel.un. n and z n and ch e n and e

The calculation of the acceleration of the
unit
ACSCUM the calculation of the criteria of damage from the
retarding
APRF the calculation of the approximated value tabular given one
             the function
BUKA the calculation of the [smasshtabirovannogo] value of the prescribed
variable
Contents of the catalog of the graphic means:
…
Contents of the catalog of the programs of the mapping:

And m I to r and t to rel.un. n and z n and ch e n and e

ACAD the preparation of given for the mapping graphs before the system
             AutoCAD.
DISP mapping the results in the form of graphs beyond the shield
display.
GRAFCH mapping the results in the form of symbolic graphs.
PA7TAB the construction of the table of results before the size pA-
7.
TAB mapping the results in the form of the table of
values.
TABL mapping the results in the form of the table of
values.
```

1.6.3.The complete enumeration of themes, on which it is possible to obtain the reference information

Besides information about the library modules before the system catalog can be present other useful reference information. The complete list of themes, on which it is located, (this list it contains including the list of the expansible components of the complex, on which there is a reference information) can be obtained on the demand

```
> ARM *
```

In response to this demand the user obtains the list sorted out alphabetically as far as the fact, which appears approximately thus:

```
Reference information on the system catalog.

Attributes of the system catalog of the complex Of pradis
Number of version 4.2
Year of creation by 0706
Series number 101
Identifier of **********

The list of themes, on which there is a reference information:
…
ATRC        BAL3DJ      BAL3DK      BALKA       BELT
BELTV       BLOK        BORDER      BRK         BUKA
C CIL3DC CMASS COS3E CYLDR
DEBUG       DEFORM      DELR        DFIA        DFIB
…
```

1.6.4.Obtaining reference information for the sake of the concrete theme

For obtaining the reference information for the sake of the concrete theme is used this form of the call-in of procedure ARM:

```
> ARM? <[tema] of [zaprosa]>
```

Obtained as a result of demand information, for example, on the model of element contains:

- name and the brief designation of the element;
- the list of the degrees of freedom of the model;
- the list of the parameters of the model;
- information about the structure of the working vector of the model;
- the log book of model.

This information can be useful at the point of the users - to the developers of the models of elements.

Example to reference information on the model of element (linear elastic one-dimensional dimensionless spring):

```
Information on THE MODEL of element K        :

     NAME: The constraint between two degrees of freedom is
elastic.
```

```
          FIELD OF APPLICATION :
Mechanics.
          DEGREES OF
FREEDOM:
           1 it is progressive (rotatory) the first linked body;
           it is 2nd it is progressive (rotatory) the second linked
body.

PARAMETERS:
           1 value of stiffness coefficient (K >= 0).
          ELEMENTS OF THE WORKING
VECTOR:
           1 energy, accumulated by element.

          Log book of the model of element K       :
          EXT = 2, ENT = 0, PAR = 1, STR = 0, WRK = 1,
          VPR = 0, STP = 0, WRP = 0, ADR = 1, IGN = 23
```

On the demand ARM? <[imya] of [temy]> it is possible to obtain also brief information about some elements of computational nucleus. For example, information about the program of integration SHTERM:

```
> ARM? SHTERM
```

It is again necessary to say that the information, obtained on the demand “ARM? ”, it is brief and it is intended for the operational use. Further information on one or other question or another should be searched for before the documentation.

1.6.5.Start of the programs of user in dynamic and user libraries and exception of expansible components from the libraries PRADIS

For obtaining of objective module, its start in dynamic library and start of reference information in the system catalog of complex is used the command ARM +. For example:

```
> ARM + OF MODEL
```

, So that this command would be correct, before the current catalog must be present the file MODEL.FOR (MODEL.F), which contains the text of library program.

On this command the procedure ARM accomplishes a call of compiler based on FORTRAN[a] (is assumed that user it already has the license copy of compiler). If syntactic errors it is not discovered, before the catalog DINAMA/PLAGIN appears the file MODEL.DLL

Before the file SYSPRINT.TXT falls the listing of the information part of the program with the appropriate communications. If before the system catalog information on this module was absent, then communication overhangs, that the log book of program is added beside the system catalog. Communication otherwise indicates that the log book of program is replaced before the system catalog.

Library program, as a rule, contains the reference information, intended for the start in system catalog. If the start of this information is passed successfully, utility gives the communication:

```
    M (the I 001) is processed and is introduced beside the system catalog
reference information on the switch oned module.
```

In the case of the absence before the workable module of reference information on the included module, in SYSPRINT.TXT falls the communication:

```
M (I 002) the included in system catalog module does not contain
reference information.
```

The normal completion of the utility of start is accompanied by communication about the successful completion of program.

If it is necessary only to include or to replace the information part of the program before the system catalog (for example, arose the situation, when was erroneously prescribed the log book of program), is used command “ARM! ”:

```
> ARM! MODEL
```

Finally, if it is necessary only to obtain and to include module in dynamic library, is used command “ARM #”:

```
> ARM # OF MODEL
```

In this case after the call of compiler and librarian the utility of the start of module in system catalog will not be caused.

The exception of reference down the library program from the catalog is accomplished by a command “ARM -” :

```
> ARM - MODEL
```

The addition of the library program of graphic means GPROG is accomplished by the command

```
> ARM p GPROG
```

For the start of subprogram SUBPROG in user library USER.LIB for the purpose of its further repeated use before different programs of models should be used the command

```
> ARM u SUBPROG
```

Each of the commands described above can be used for fulfilling the similar operation simultaneously for several modules, for example:

```
> ARM + OF MODEL PRVP TEST
```

After the completion of the operations of including/the exception of module one should test the correctness of the made work, having consistently carried out the commands of obtaining reference information (“ARM *”, “ARM?” and, for example, “ARM? MODEL”).

2. CONTROL BESIDES THE WORK OF THE COMPUTATIONAL NUCLEUS

Before the division of the description of task at the point of the calculation PRADIS-the program (let us recall that this division begins for the sake of the title of $RUN) user assigns one or several calls of the programs of integration. At the description of these calls he has an opportunity to manage work of the computer kernel, display of results during calculation and the program of factorization. Here we shall consider the management of operative display of results during calculation and work of a computer kernel. Opportunities of management of visualization and of the program of factorization are considered in other sections of this manual.

2.1. THE DESCRIPTION OF THE CALL OF THE PROGRAM OF INTEGRATION AND OF VARIABLES DISPLAYED DURING CALCULATION

Based on the following example it is possible to trace the basic elements of the description of the call of the program of the integration:

```
Calculation of process 'SHTERM (END=10, DRLTX=0.05;
                        Speed A (2) =(,10),
                        Speed B = (-10,1),
                        Speed B = (1,-10),
                        Speed C(3),
                        Speed C = (-1.1, "
```

Here “the calculation of process” - the identifier of the program of integration. On a course of calculation this identifier is displayed in the top part of the screen.

“SHTERM” - the name of the program of integration. Now the structure of PRADIS includes programs of integration SHTERM and NEWMARK.

“END=10, DRLTX=0.05” - the key parameters, given by user for this program of integration. Values of other key parameters of the program of integration are accepted by default.

After separator “; ” follows the list of the output variables, graphs and current numerical values of which must be reflected during the work this program of integration. Each of the output variables in PRADIS can be simple or multicomponent. In case of display of a multicomponent variable the number of outputing component should be specified. If the number of the component is not specified it means that the first component of a multicomponent variable should be outputed. In our example the first displayed variable is the multicomponent variable " Speed A ". The output of the second component of this variable is provided.

If at the description of the call of the program of integration the user has demanded to display such amount of output variables which exceeds the maximum permitted amount then the maximum permitted amount of variables will be displayed. The variables located in the beginning of the list specified by the user will be chosen for display.

The description of the call of the program of integration without the indication of the list of the reflected variables is possible:

```
Calculation of process 'SHTERM (END=10, DRLTX=0.05)
```

Such call of the program of integration is equivalent to the requirement of the user to display all the output variables described in the task during the calculation. Values of the bottom and top limits for these variables are accepted by default. If the amount of output variables in the task exceeds the restriction on the maximum possible amount of displayed variables then the maximum possible amount of variables will be displayed. In this case the user cannot affect composition of displayed variables.

It is necessary to remember that the display of results during the calculation does not influence their display after calculation. This a quantity of output variables before the program indicates, for example, that if - ten, and on the course of computation were reflected three, then after the fulfillment of calculation were accessible for the mapping all ten described output variables.

To the variables of programs the integrations (SHTERM, NEWMARK) are added:

- PRTTIME - the value of the frequency of conclusion with the calculation in seconds (on silence of times 30 seconds of real time).
- OUTPER
- OUTVAR

2.2. KEY PARAMETERS OF THE PROGRAM OF INTEGRATION

Management of work of the program of integration is executed by means of key parameters. In table 2.1 the list of all admissible key parameters of the program of integration is given and the purpose of each of them is briefly characterized.

In the column "Restrictions on parameter" of the table 2.1 intervals of admissible values of the corresponding key parameter are specified. On-to silence it is considered that lower and upper boundaries of interval are the allowed values of the key parameter. Otherwise near to the bottom or to the top value of the interval symbols of excluding brackets (accordingly] or [) are specified. As limits of the interval values of other key parameters can be used. Quantity RLMAX specified as the top limit of the interval of admissible values is telling that the value of this key parameter can be arbitrary large number permitted by PRADIS compiler. In the same column in brackets the default value of this key parameter is specified. For example, for the key parameter END is indicated the interval of the allowed values] of 0… RLMAX (any number, permitted by translator PRADIS and larger 0). Value of this key parameter on silence - 0. value given on silence is inadmissible; therefore with each call of the program of integration user must assign the value of the key parameter END.

Before your versions of complex the values of the key parameters of the program of integration, taken on silence, can differ from those given before this table. Enumeration and the values of the key parameters of the program of integration for your version of complex PRADIS can be obtained upon command

```
> ARM? SHTERM
```

Table 2.1. The list of key parameters of the program of integration.

Name	Purpose of the parameter	Restrictions on parameter	Note
END	Time of the termination of integration	] 0… RLMAX (0)	It is obligatory, subsection 2.3
OUT	The minimal step of the output of the results of calculation	0… RLMAX (0)	subsection 2.4
SMAX	The maximal step of integration	$1.*10^{-11}$…	subsection 2.6

Name	Purpose of the parameter	Restrictions on parameter	Note
		RLMAX (0.01)	
SMIN	The minimal step of integration	1. $*10^{-11}$… SMAX ($1*10^{-11}$)	subsection 2.6
ITR	The maximal number of iterations on a step of integration	1… RLMAX (5)	subsection 2.9
SAVE	Step of preservation of a current condition of calculation	0… RLMAX (1e10)	subsection 2.10
DRLTX	RELATIVE component of the admissible local error /LE/ on a step of integration	] 0… RLMAX (0.001)	subsection 2.5
DABSX	ABSOLUTE component of the admissible local error on a step of integration	] 0… RLMAX (0.1)	subsection 2.5, 2.11.3
DRLTU	RELATIVE component of the admissible error of definition of argument during the decision of set of the nonlinear equations/SnLE/	] 0… RLMAX (0.001)	subsection 2.8
DABSU	ABSOLUTE constituting the permissible error in the determination of argument in resolving [SnLU]	] 0… RLMAX (0.01)	subsection 2.8
DRLTI	RELATIVE component of the admissible discrepancy of the right part during the decision of SnLE	] 0… RLMAX (0.001)	subsection 2.8
DABSI	ABSOLUTE component of the admissible discrepancy of the right part during the decision of SnLE	] 0… RLMAX (0.1)	subsection 2.8, 2.9
OPTIM	Degree of optimization of initial matrix structure of the generated model	0… 4 /0, 1,2,3,4/	Operates the program of factorization
SCHEME	the method of the integration: implicit Shtremer's method/0/, implicit Newmark's method/1/, obvious Euler's method/2/. Values SCHEME=2 and CONTROL> 0 are incompatible.	0… 2 (0)	subsection 2.13
SECOND	Indication of compulsion of the second iteration in the decision of SnLE.	0… 1 (0)	subsection 2.9
FLAG	he indicates that it is accepted after basic variable during the solution [SnLU] and the estimation [LP]: travel/1/ or speed/2/	1… 2 (2)	subsection 2.13
SCALE	Permits/1/ or forbids/0/ changing limits of construction of graphs of displayed variables (for which these limits are not explicitly set) during the calculation	0… 1 (0)	subsection 2.13
CONTROL	the limit of the decrease of step on the criterion [LP]; requirement at the point of the decrease of step on the criterion [LP] lower than value CONTROL are ignored. It simultaneously serves for the	0… SMAX (0)	subsection 2.6, 2.7, 2.11.3

Name	Purpose of the parameter	Restrictions on parameter	Note
	compulsory decrement of high-frequency fluctuations		
WEIGHT	Weight factor defining together with parameter CONTROL the degree of the decrement of high-frequency fluctuations. Tentatively with WEIGHT=1. at 1 period quench themselves oscillations with the period < of 10*CONTROL.	0… RLMAX (1.)	subsection 2.7
CHECKM	Permits/1/ or suppresses/0/ the check of inertial properties for all degrees of freedom of object on the first iteration of a first step.	0… 1 (1)	subsection 2.13
PREDICT	The sign of constant/0/ or linear/1/ forecast on accelerations in the beginning of a step	(0)	Subsection 2.13, 2.11.2
MODE	the regime of the initialization of the shield: text/1/, graphic/2/	1… 2 (2)	subsection 2.13
CHANGE	Specifies to impose (1)/0/ the images of current positions of object at visualization or on each step to erase/1/ the previous image, replacing it with current		Operates a subsystem of visualization of object
DRAWFCT	To display/1/ or not/0/ the process of symbolical factorization on the screen	(1)	Operates the program of factorization
TIMER	The flag operating the output on the screen of the mark of time of integration at absence of a graphical mode	(1)	subsection 2.13
DEBUG	Sign of the debugging output	0… RLMAX	Subsection 2.11
IGNORE	Specifies to the program of integration to consider(0) or not/1/ the recommended by models of elements size of a step of integration	0… 1 /0/	subsection 2.13, 2.11.3

The user should set up the program of integration for every concrete loadcase. Thus, as a rule, a plenty of factors is taken into consideration. Among them important role play such factors, as the required precision of the solution, the time, which available in user down the solution of problem, does appear calculation by trial (check-out) or final, the possibility in principle of obtaining the solution (possibly, rough) - for the models of large size. As a rule practically in each calculation values of the key parameters defining local accuracy of the decision (DRLTX, DABSX) should be determined.

Other important parameters from those examined are the key parameters, which determine the time of integration (END; this key parameter is required), the accuracy in the integration of high-frequency component (CONTROL, WEIGHT) and the parameters, which set limitations beyond the step of integration (SMIN, SMAX).

Before this division that part of the key parameters of the program of integration, which refers to control besides computational nucleus, is examined. As it was already said earlier, the key parameters, the controlling work programs of factorization and by the visualization of object, they will be described in the appropriate chapters of present management.

2.3. TASK OF THE INTERVAL OF INTEGRATION (END)

It is assumed that the analyzed process always begins based on the zero time. The time interval of process, which is subject down analysis, is assigned with the aid of the key parameter END. In the simplest case before the division RUN is assigned the call of one program of integration. Then the parameter END, naturally, must be such so that all interesting the user events would be accommodated in this interval of time. Example of this call:

```
Interesting me process 'SHTERM (END=1)
```

The analyzed process can be characterized as far as several stages, which interest user down different degree. Typical situation is such situation, at which is simulated a certain preparatory stage (acceleration, filling, approximation so forth), then occurs a comparatively short-term and most interesting for the user action (impact, working stroke, what-or external action), and then the, possibly, specific stage of aftereffect (analysis of emergent before action as a result system transient processes). The utilized in PRADIS automatic regulation of the step of integration in many instances makes possible at the point of user not to trouble itself by the task of the parameters of the program of integration before each stage. However, it is necessary to always remember that if the interval of integration will be broken beside several subintervals, then each of them, most probably, it is possible to integrate more rationally (with the appropriate precision and the step).

Before the division i RUN of task at the point of the calculation user has the capability to determine the call of several, following one after another, the programs of integration. In this case each subsequent program of integration will continue the fulfillment of calculation based on that place, on which it was interrupted by the previous program. Therefore tasks at the point of the calculation before the examples given below are practically identical:

EXAMPLE 1.

```
Calculation of entire process 'SHTERM (END=1)
```

EXAMPLE 2.

```
Calculation of stage 1 'SHTERM (END=0.45)
Calculation of stage 2 'SHTERM (END=0.55)
Calculation of stage 3 'SHTERM (END=1)
```

Before the second example the first call of the program of integration will lead down the calculation of process before the interval [of 0 - 0.45], the second call - before the interval] of 0.45 - 0.55], the third - before the interval] of 0.55 - 1]. Thus, will be analyzed the same interval of process per second as before the first example.

However, there are several differences:

1) as has already been spoken above, before each stage of integration before the second example it is possible to assign its requirements at the point of the accuracy in the integration.

2) if the program of integration before example 2 before the first or second stage at the point of what-or to reasons it will interrupt, then working program will not complete work, but it will switch over to the following stage of integration. In this case it will begin based on that moment, on which the previous stage was completed actually.

3) unessential differences can be at the moments of passage based on the stage to the stage of integration. For example, for guaranteeing the prescribed precision, toward the end the first

time interval (let us say, at the moment of time 0.445), to the program of integration it is possible to take a step 0.01 s. toward the first example it will make a step of this value, and the following solution will be obtained for moment of time 0.455, and the secondly - only step, sufficient for the completion of the interval of integration (i.e., - 0.05). The second interval of integration in this case will be also begun based on step 0.05.

4) with each call the programs of the integration of the drawing of variables reflected on the course of computation are built only for the time interval, analyzed by this program of integration. Furthermore, if several calls of the programs of integration in the task, then for each of them user can assign different lists of variables reflected on the course of computation.

Not always before the fulfillment of calculation it is obvious, to what moment of time it is necessary it to carry out (for example, it is difficult previously to predict, when are completed the fluctuations before the mechanical system, caused by impact action). Therefore the cases, when the prescribed before the program of integration time does not completely encompass user the time interval, are frequent. Similar situation occurs and when working program was interrupted or was completed, without having finished integration for the prescribed interval (for example, it could not continue integration at the point of the requirements of precision). In both cases appears the need for continuing the analysis of process based on that place, on which it was interrupted. Then it is possible to use directive RESTORE. If in the task at the point of the calculation is indicated the title of $RESTORE, and before the data base for the analyzed model data from the previous calculation remained, then calculation will be continued based on that place, on which it was interrupted. For example, user carried out integration of process for period 1 of second, after assigning the following call of the program of the integration

```
Calculation of process 'SHTERM (END=1)
```

It was explained that the analyzed event before this time interval yet was not completed, and is required to continue analysis at the point of the elongation still approximately of 0.2 s. then user it must carry out the following task at the point of the calculation of the already formed model:

```
I RESTORE
I RUN :
Calculation of process 'SHTERM (END=1.2)
```

When before the interval [of 0, 1] the integration was completed successfully, this task will ensure the analysis of process before the interval] 1, 1.2].

IT IS IMPORTANT! Fulfillment of assignments for the already formed model without the title of $RESTORE leads down the loss of the results of the previous calculations (if they there is). In this case the calculation will be produced based on the zero time.

2.4. CONTROL BESIDES THE STEP OF THE CONCLUSION OF RESULTS FOR THE CURRENT PROGRAM OF INTEGRATION (OUT)

In PRADIS the process of the calculation of the required characteristics and their final formulation in the form of output results are divided. Strictly the calculation of output variables occurs against each step of integration. If we nothing undertake, then the values of all output variables for each step of integration will be preserved before the file of the results of *.RSL.

Before one recording of the file of results is stored the information about current time (8 bytes) and the values of all output variables, which correspond to this moment of time. In this case the volume of the file of results can be estimated about the following formula:

The V = (N+4) * 8 * (1 + J1 + J2 +… + Jn)

where the V size of the file of results before the bytes,
It is n-th a quantity of steps of integration,
Ji - a quantity of components for i-y of output variable.

If the volume of conclusion is very great, and for reasons of the savings of time down subsequent processing of results (or in the case of the shortage of disk space) there is no need for preserving the results of calculation with that temporary step, with which the integration was conducted, then conclusion can be limited. This is ensured by the task of the minimum step of the conclusion of the results of calculation with the aid of the key parameter OUT. In this case the precision of calculation will not suffer, but the values of output variables will remain before the file of results NOT MORE FREQUENTLY than it is prescribed as far as the parameter OUT. For example, it is necessary to design process for elongation 1 s, but the obtained results to derive not more frequently than through 0.1 s.

Corresponding to this call of the program of the integration:

```
Process 'SHTERM (END=1, OUT=0.1)
```

Information about the behavior of object before the spaces between the brought-out values will be lost, and it is not possible to reset by any other means, as soon as by the repeated conducting of calculation with the more detailed conclusion.

IT IS IMPORTANT! The files of the results of the majority of the calculations meeting in practice are not extremely large (as a rule, ten KB). But the situation, when actually it is necessary to control the process of conclusion beside the file of the retention of results, is sufficiently rare. This can happen for the calculation, close down the traditional finite-element, when information about the state of all or majority of the degrees of freedom and elements of the model of object is derived. Therefore at first it should be not misused by the use of the key parameter OUT.

The most typical cases:

1) the step of integration, determined as far as precision and questions of convergence, very small and several orders of less than the period of the processes analyzed by you. Or the step of integration is not very great, but is extremely great the volume of concluded against the step of integration data. Then, apparently, at the point of you it is necessary to use the parameter OUT. In this case it is possible to be guided by such considerations. In order to draw the sinusoid resembling itself, it is necessary to use not less than 8-10 points down half of period. Hence it follows that the parameter OUT must be not more than 1/15… 1/20 from the period of that of most flowing rapidly from the interesting you processes.

2) the step of integration exceeds the parameter OUT. The retention of data occurs with that step, with which the calculation occurs, i.e., in this case the parameter OUT is ignored.

3) the parameter OUT is too great. There is a risk of the incorrect interpretation of results (Fig. 2.1). It is evident that for the case OUT=0.02, shown before the figure, the resulting graph, constructed for the sake of the program of mapping, little is similar down the real process. And this despite the fact that ALL POINTS, which were used for graphing, they correspond TO EXACT SOLUTION. Misfortune only before the fact that was used few these points.

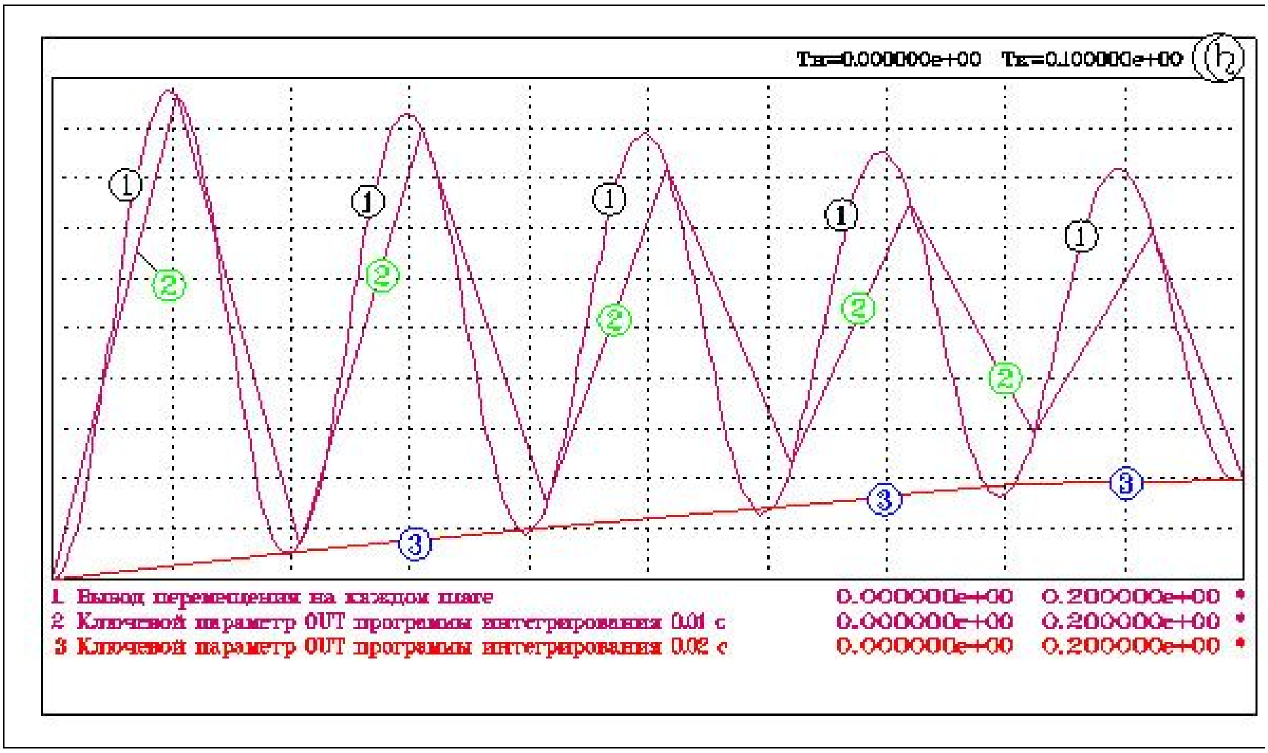


Fig. 2.1 **Influence of the key parameter OUT beyond the conclusion of the results of calculation.**

2.5. CONTROL BESIDES ACCURACY IN THE INTEGRATION AT THE POINT OF THE TIME (DRLTX, DABSX)

2.5.1.Algorithm of estimation and control of the precision

The mathematical model of technical object is represented in the form the system of differential equations.

Let us examine here the numerical solution of one differential equation

F (the X, X', of the X '', T) = 0 (2.1)

, bearing in mind that the solution of the system of differential equations is obtained analogously. As is known, the solution of equation (2.1) is the large number of integral functions of the X (t), that are differed from each other regarding arbitrary constants. These constants must be determined from the initial conditions. Thus, we obtain the function, which corresponds down differential equation (2.1) and prescribed initial conditions (Xo and X'[o]).

An error in the numerical solution is determined as far as the fact that against each step the integrated function is replaced by the line segment. This error is called ***a local error*** in the step of integration. It is accumulated from one step to the next, which leads down an increase in the distance between the exact solution and the position of integral function against the current step - i.e. to an increase ***in the accumulated error*** (or still they speak - global error) the solution. Let us assume during the solution of what-or task were made several steps of integration, also, down to N-mu to the step of integration is accumulated ***the specific error***. After this, the integration became absolutely precise. Even with these conditions the accumulated error in the solution ***will not remain constant***. Its value ***depends on the behavior of integral curve at the point in question***. Therefore, depending on specific conditions, a local error in the step of integration can differently influence the accumulated error. If the nature of change of the solution of du such, that an increase in the value of function leads down an increase in the value of its derived (=[umenshenie] of the function - to the decrease of derivative, i.e., the signs of the first and second derivative coincide), the distance between the integral curves increases. So behave functions of the type Y=X ** N with X > 0, Y=EXP (the X) on the entire domain of definition and so forth in this case the accumulated error in the solution is more than the sum of local errors in each step of integration. It is natural that with an increase in the slope of function this difference grows. Furthermore, the value of the accumulated error in the solution will increase even in the absence local error against the sequential steps of integration. But if with an increase in the value of function derivative decreases (signs of the first and second derivative they are distinguished), then the accumulated error in the solution is less than the sum of local errors in all steps of integration. So behave functions of the type Y=X ** N with X < 0, Y=SQRT (the X) on the entire domain of definition and so forth

At complex PRADIS, as a rule, a local error in the solution is evaluated relative to speed (here and below all reasonings are conducted before the terms of mechanics, but they remain valid and for other subject areas. It is necessary to only remember that the analogs of the speed before other subject areas are the potentials, temperature, pressure, and by the analogs of the forces - currents, expenditures). [Ris].2.2 illustrates the method of determining the local error in the step of integration.

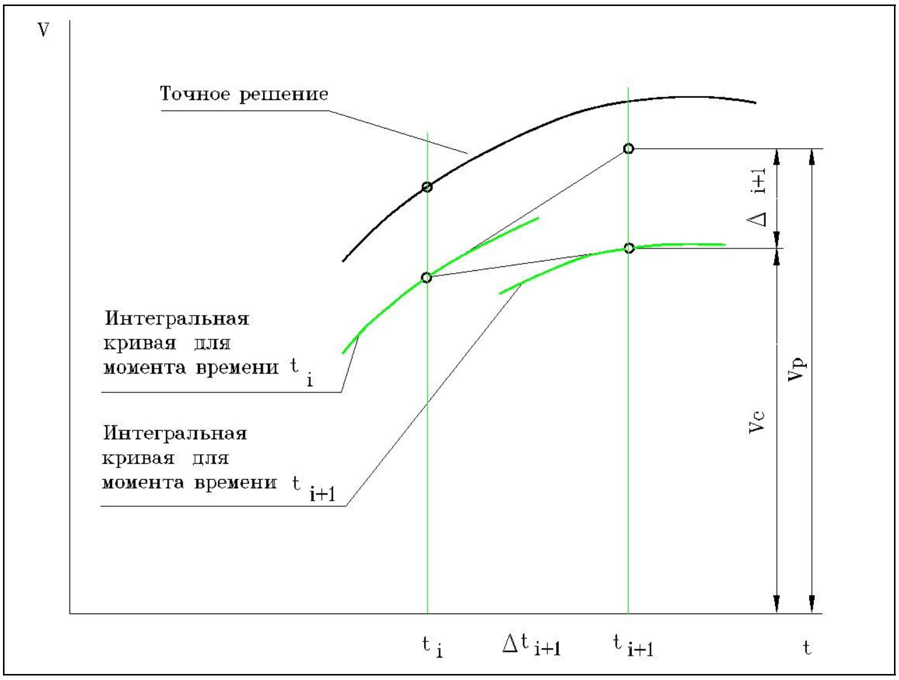


Fig. 2.2. To the determination of local error against the step of integration.

For solving equation (2.1) one of the implicit one-step methods of the integration (before the technical applications basic it is Stormer's method, for the training and research tasks it can be used the method of Newmark) in PRADIS is used. In any event, for the implicit method the fulfillment of the step of integration beside two stages is characteristic. During the first stage is accomplished ***explicit forecast***, on the second - the iteratively repetitive ***correction***. Before the brackets let us note that any explicit method of integration is a special case of implicit, when there is no correction of the solution. If we speak about the geometric interpretation of the implicit method of integration ([ris].2.2), then the fulfillment of forecast is equivalent to replacement of integral curve before the interval of time [t (i), to t (i+1)] by segment of tangent to it at point with the abscissa t (i). The second stage is reduced down the location of the angle of tangent inclination to integral curve at point with the abscissa t (i+1) and the replacement of integral curve before the interval of time [t (i), t (i+1)] by the section of this tangent. From a mathematical point of view the second stage of the solution (***correction***) is the iterative process of solving the system of nonlinear equations, which is obtained against each step of integration based on the reference system of differential equations after substitution beside these equations of the implicit formulas of integration. In more detail about the algorithm of the solution of the system of nonlinear equations it will be said below, and also before the document "***PRADIS. Basic mathematical methods***".

The value of speed, obtained by explicit forecast, let us designate Vp, the corrected value of the speed - Vc.

By construction, these values are located on the different sides from the locally precise value of speed, which lies beyond the current integral curve. Let us note what against each step of integration to if obtain the locally precise value of speed, then we will not deviate from exact solution. In reality is obtained the error, which does not exceed in the most adverse case of value Vp - Vc. As the estimation of the absolute value of local error against the step of integration the value in PRADIS starts

$$\iota\Delta_{+1} = |(Vp-Vc)/2| \qquad (2.2)$$

Based on figure 2.2 evident also that the decrease of the step of integration leads also down the decrease of the value of local error, since the difference between the forecast and the correction with the smaller step decreases (this assertion correctly for the majority of the cases, with exception of the processes, before which the speed on what-or degree of freedom it changes intermittently). Therefore, if the current local error exceeds that permitted, prescribed by user, then program automatically decreases the step of integration.

However, sometimes it is to inconvenient assign the permissible error in the form in a certain absolute value [Δ]. This will occur always, when the absolute value of speed is great. Then the difference between the forecast and the correction even in tenth and one hundredths of a percent can lead down the fact that the absolute value of local error will be too great (and, therefore, this it will lead down splitting of the step of integration). In such cases for the control of precision it would be possible to use an estimation of the relative value of the local error

$$\varepsilon\ \varepsilon\eta\tau_{\text{ of i+1}} = \Delta\ \varepsilon\eta\tau_{\text{ of i+1}} / |Vc| \qquad (2.3)$$

If the obtained estimation of a relative local error 1+ιε νι is less than the prescribed by user permissible value [ε], it is considered that the current step satisfies the requirements of precision.

But also this estimation is not general-purpose. In the region of the low values of speeds even during the small estimation of absolute error the estimation of relative error will be too great, and it will pass integration with the unjustifiably low step. Although this, as a rule, is not required. And actually, usually user it will hardly disturb a question, with what precision the value of the speed is determined - 1% or 100%, if its instantaneous value is equal to 0.00001 m/s, and amplitude value for this process - 1 m/s.

Thus, on the basis of the reasonings given above, it becomes clear that before the region of the great significances of the speeds for the checking of the precision of the obtained solution to preferably use a relative error, and before the region of the low speeds - absolute. Therefore against each step of integration and for each variable the program of integration calculates its value of the permissible local error. This value is obtained as follows:

1) user assigns the values of relative and absolute components of the permissible local error (respectively, [ε] and [Δ]). Considerations, by which it must be guided with their selection, will be clear from the further consideration.

2) the allowed value of local error for each degree of freedom against the current step of integration is determined as far as the program of integration at the point of the dependence

$$[\Delta] = [\Delta] + [\varepsilon] * |Vc| \qquad (2.4)$$

3) for evaluating the local spacing accuracy of integration value $\iota\Delta_{+1}$ is compared [Δ]. If is fulfilled relationship Δ (i+1) < [Δ], then it is considered that the required precision is achieved.

We analyze expression (2.4). If the absolute value of the speed |Vc| it is great, then the second member of the right side of this expression, who characterizes the influence of relative error, becomes determining or commensurate based on by prescribed absolute the component permissible error (certainly, if it is not prescribed, that absolute component of an error in the solution exceeds the maximum value of speed. It is assumed that [Δ] it is assigned within reasonable limits and does not exceed several tenths of percentage or several percentages of the amplitude value of speed). When velocity Vc is low, the influence of this term becomes negligible, and on estimation of error absolute component of the permissible local error will have a basic effect. Therefore the program of integration has two key parameters, that determine the local error - DRLTX and DABSX. DRLTX assigns ***relative*** component of the permissible local error, and DABSX - ***absolute*** component of the permissible local error. For determining the permissible absolute error in the step of integration depending on the instantaneous value of speed is used expression (2.4), which taking into account the introduced key parameters will take the form

$$[\Delta] = DABSX + OF\ DRLTX * |Vc| \qquad (2.4.[a])$$

One additional lyric retreat. Fig. 2.2. can create impression, that the value of speed, obtained by forecast, is more precise than the final solution, obtained by correction. This occurs because at point with the abscissa ti the value of speed, which is been initial for this step of integration, already differed from exact solution. In this case the deviation was down that side, which was characteristic for the implicit method of integration. Therefore each subsequent implicit step of integration will increase this error. If integration was carried out by explicit method, then the speed at point with the abscissa ti would be also found with the error. However, its value would be located on the other side from the integral curve. Therefore each explicit step of integration would also increase this error. It is considered that the precisions of the explicit and implicit methods of integration with the use of formulas of the integration of one order are identical. It is another matter that the explicit method of integration is characterized by some unpleasant special features (instability of method and the inconvenience of the estimation of a local error in the integration), because of which at present it is used sufficiently rarely.

2.5.2.Key parameters, which determine the value of the permissible local error

On the basis of the aforesaid in the preceding point, for the task to the permissible local error of integration the user can use two key parameters of the program of the integration - DRLTX and DABSX. DRLTX assigns the value OF RELATIVE component of the permissible local error, and DABSX - the value OF ABSOLUTE component of the permissible local error.

It is natural that the key parameters DABSX and DRLTX implicitly control the value of the step of the integration - the higher the assigned precision of the solution, the less must be the step of integration, in order to ensure this precision.

Let us give an example of the analysis of the process, before which the speed changes on the nondamping sinusoid with an amplitude 1. numerical solution it will give deviations from the exact solution. It is known that the implicit diagrams of integration, including and utilized in PRADIS, possess some “damping” properties. This means that the solution for the process of ideal free fluctuations without the damping, obtained numerically with the aid of the implicit methods, will have the damped nature. In this case the damping rate will be the higher, the greater the step of integration in comparison with the period of natural oscillations.

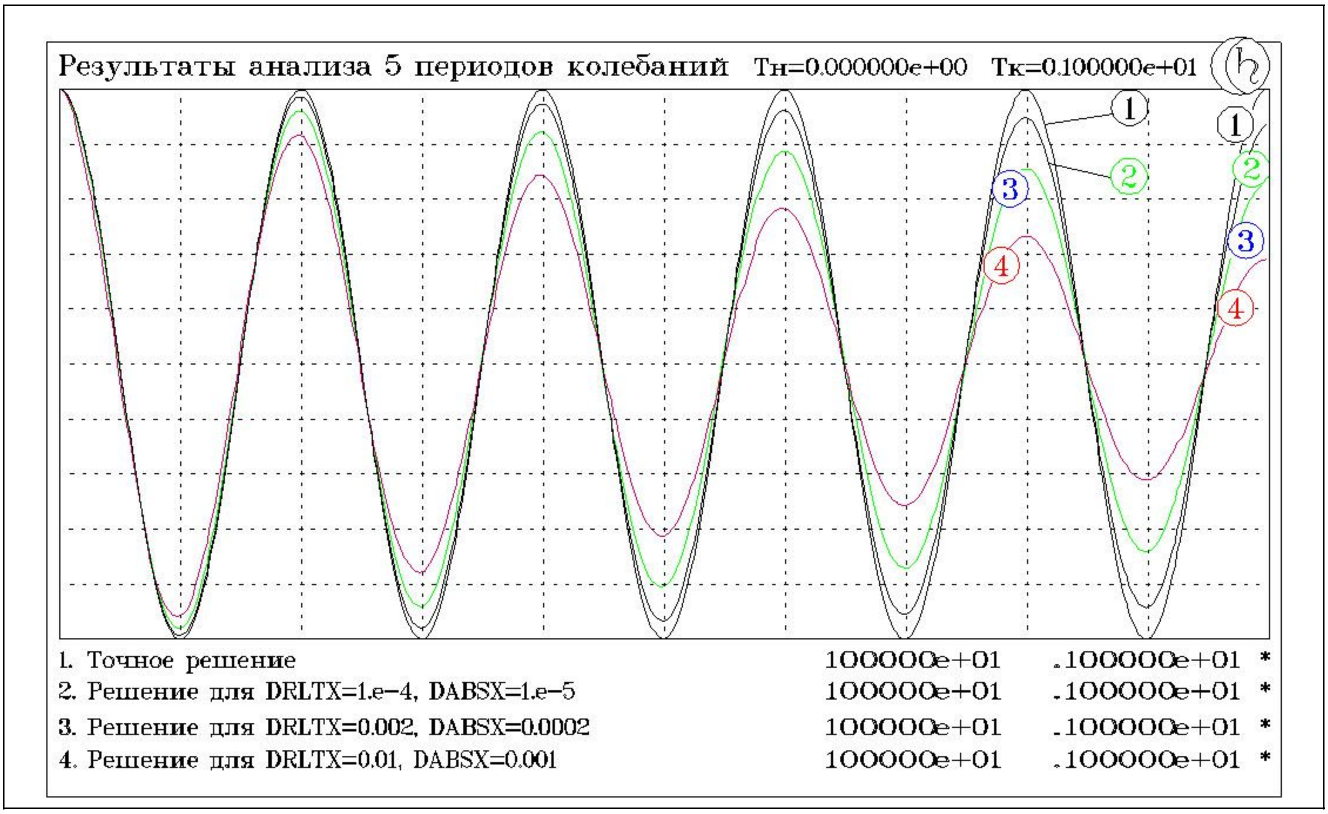


Fig. 2.3. Comparison of the results of integration with the different values of the key parameters.

Let us conduct a series of the numerical experiments, where we will assign the different values of absolute and relative components of local error and study their influence beyond the obtained results. Considerations, by which we are guided with the task to error in one or other case or another, approximately following. For example, a desirable relative error in the integration - 10%. Near the amplitude value of speed this will determine an error in the solution of approximately 0.1 m/s. So that the influence of absolute error beyond the obtained result near the amplitude value of speed would be not too great, let us assign in this case its value 0.01 m/s. Then the resulting permissible error in the region of the maximum value of speed will be 0.11 m/s. If the instantaneous value of speed will be 0.1 m/s, then the permissible error will be 0.02 m/s (20% of the value of the solution), the relative value of error will be more with the smaller values of speeds.

We will compare results past the accumulated error (amplitude of the fifth of fluctuation) and the computational expenditures. The obtained graphs of the first 5 fluctuations for the different values of local error are given down [ris].2.3., numerical results and the statistics - before Table 2.2.

And since and it was to be expected, the greater the permissible error in the step of integration, the greater the value of total (accumulated) error. Hence it follows that the prolonged (in comparison with the period of characteristic oscillations) the process it is analyzed, the harder must be the requirements at the point of a local error in the solution. Furthermore, local precision to a considerable degree influences computational expenditures.

Table 2.2. Influence of the key parameters DRLTX and DABSX beyond the precision of the solution and the computational expenditures.

N of the calculation	N of graph down [ris].2.3.	DRLTX	DABSX	[Amplituda]5-GO of the fluctuation	Steps	Iterations
1		1.$*10^{-5}$	1.$*10^{-6}$	0.97205	8243	9468
2	2	1.$*10^{-4}$	1.$*10^{-5}$	0.91414	2624	4627
3		5.$*10^{-4}$	5.$*10^{-5}$	0.81775	1184	2258
4		1.$*10^{-3}$	1.$*10^{-4}$	0.75199	843	1634
5	3	2.$*10^{-3}$	2.$*10^{-4}$	0.66763	600	1163
6	4	1.$*10^{-2}$	1.$*10^{-3}$	0.40105	277	538

Before the real calculations should be always focused attention on the values of the key parameters DABSX and DRLTX accepted.

Value DABSX on silence (0.1) corresponds to calculation with average accuracy (DRLTX=0.1%) of the process, where the speeds compose tens to hundreds of meters per second (i.e., temperatures compose tens to hundreds of degrees, potentials - tens to hundreds of volts, pressure - tens to hundreds of MPa). For the processes, where the speed of one - tens of meters per second, this value DABSX corresponds to rough calculation. In this case even for the amplitude values of speeds the given value DRLTX will not have effects on the forming of the value of the permissible error (determining it will become DABSX).

Thus, the adjustment of the program of integration at the point of silence corresponds to the rough calculation of the majority of real processes. This is done so that against the first stages of the work on the model it would be possible to quickly estimate the first results and to fix model. Therefore thought, that the program of integration (especially the parameters, the managers precision solutions) in the final analysis must be tuned down the analyzed process, is very and very important.

Down the value of the assigned key parameters DRLTX and DABSX in each specific case of real calculations will influence such factors, as the size of model, the duration of the analyzed process, the required precision of the solution, time down the solution of problem, which is had at the disposal of user. With the task of the key parameter DABSX it is necessary to consider the amplitude values of the most characteristic speeds. As a rule, error is assigned for the speeds (or the minimum amplitudes of potential variables before the mixed problem) minimum before the amplitude. Thus, if is solved the problem of the analysis of hydromechanical device, potential variables for the hydraulic units (pressure) will most likely have values less before the absolute value than the value of potential variables for the mechanical units. Therefore the value of the key parameter DABSX in this case must be assigned, on the basis of the required precision of the obtained results for the hydraulic units.

2.6. EXPLICIT LIMITATIONS DOWN THE STEP OF INTEGRATION (SMAX, SMIN, CONTROL)

To the algorithm of the automatic calling sequence of integration it is necessary to indicate a certain range, in limits of which can be selected sequential step. The range of the variation of the step of integration is determined as far as the key parameters SMAX and SMIN.

The value of the step of integration under no conditions cannot exceed the step, determined as far as the key parameter SMAX, and to be less than prescribed as far as the key parameter SMIN.

Integration always begins based on the step, determined as far as the parameter SMIN (it is done two such steps). The estimation of local error is produced about the results the first two steps. If error is less than permitted, then program increases the step of integration (however, in any event its value it cannot exceed SMAX). If on the motion of integration local error exceeds that permitted, then the attempt to decrease the step of integration is made. When the minimum step of integration does not ensure the prescribed precision, occurs the stop of the current program of integration with the delivery of the corresponding communication:

```
R 008 the assigned magnitude of the minimum step of integration not
        it ensures to the required precision.
                 SUPPLIED GIVEN:
                 the current time : <[znachenie]>
```

The decrease of the current step of integration occurs in two more cases: with the divergence of the process of solving the system of nonlinear equations against the step of integration also at the point of the recommendations of the models of elements.

From the key parameters, which limit the range of a possible change in the step of integration, it is more frequently used AS FAR AS SMAX. On silence its value is taken after equal to 0.01 s, and it is natural that it is desirable to change it in accordance with the duration of the analyzed process (the higher values of the key parameter SMAX they correspond to more prolonged processes). However, an infinite increase in the key parameter SMAX can finally lead down worsening in the convergence of the solution of the system of nonlinear equations against the step of integration and down the high temporary expenditures for analysis.

The situation, when in the course of computation the program of integration does not lose steps on the divergence of the process of solving [SnLU], is possible. However, before what-that moment about recommendation of one of the models of elements step is crushed to the minimum and calculation completes emergency by communication about the divergence of the solution Of [snLU]. If this occurred, then certain increase in the minimum step of integration with the aid of the key parameter SMIN can save situation. In the remaining cases an increase in the parameter SMIN in comparison with the value given on silence is not recommended.

Obtaining communication **R 008** (see above) can push slightly user to the decrease of the minimum step of integration. However, before the majority of the cases they do not lead these actions down the positive result. The appearance of this communication is most frequently connected for the sake of the calculation of the objects, which contain degrees of freedom with the indeterminate inertial characteristics. In the case of analysis of mechanical systems the appearance of this type of models is caused, as a rule, as far as neglect by the not playing large role inertia properties of various degrees of freedom of object. This idealization can prove to be useful - for example, the exception of parasitic oscillations. However, user must clearly visualize the consequence of this step. Since the value of speed for this degree of freedom can change **instantly**, in the program of integration will appear the problems with the estimation of local precision for these units. These problems are caused as far as the fact that the forecast on the speeds will be oriented down to the previous value of acceleration, and the corrected the value of speed for this unit is attained with the infinitely high acceleration (instantly, at the point of the zero time interval). In this case splitting step does not save, if the value of the obtained potential jump exceeds the permissible local error.

Before an example before Fig. 2.4. i-y the step of integration was completed at the point of an abrupt change in the speed. The next step of integration gives too great an estimation of local error (Vpi+1 -Vci+1), that exceeds that permitted. Before the figure it is evident that splitting the value of step up to the minimum in no way will be able to influence this estimation. The calculation of this system must be completed by the delivery of communication R 008 and by the curtailment of integration.

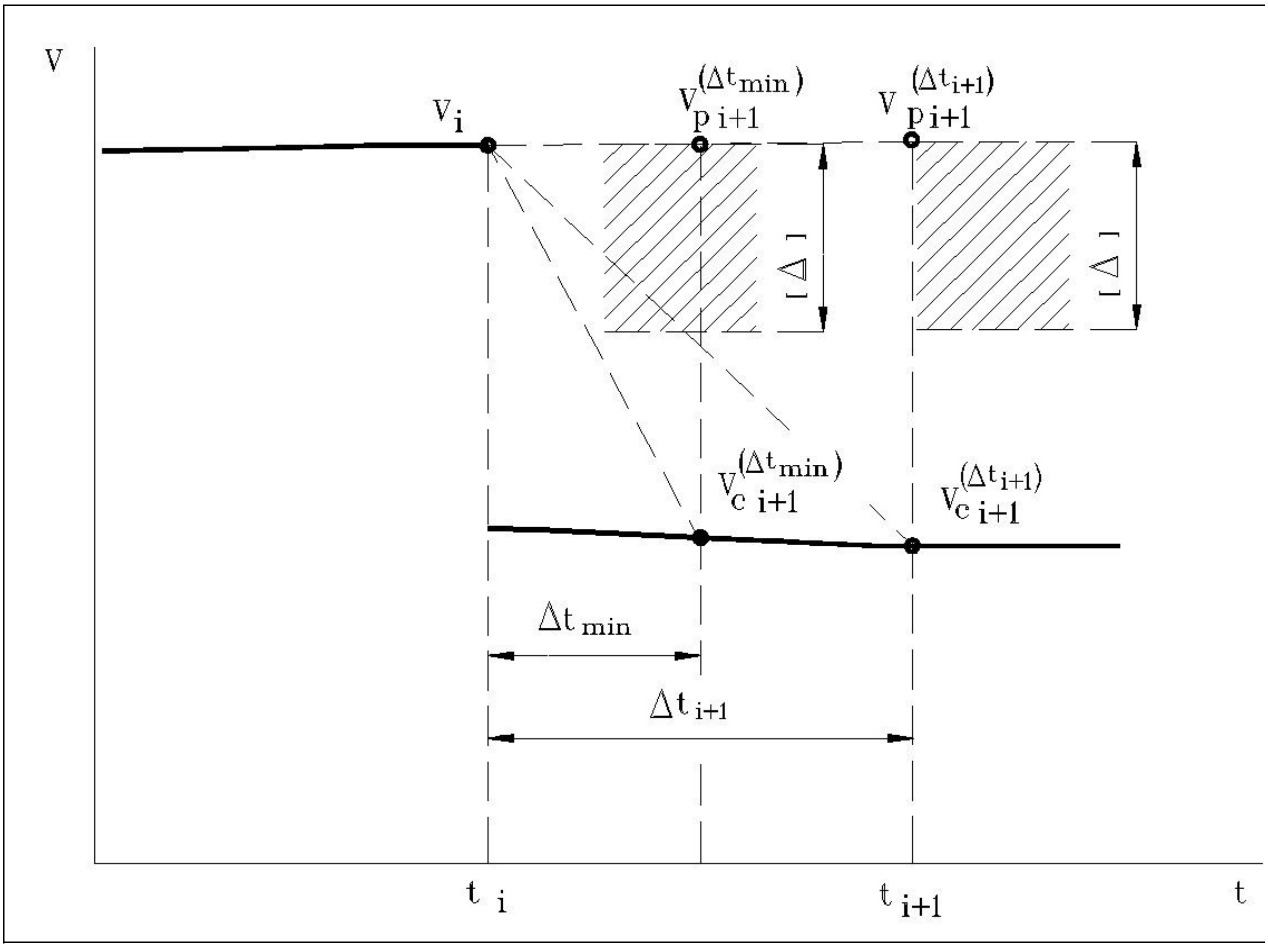


Fig. 2.4. Splitting the step of integration in the case of an abrupt change in the potential does not lead down an improvement in the estimation of local error.

Principally this situation [preodolevaetsya] in two ways.

The first - this, as it follows from Fig. 2.4. , an increase in the key parameters DABSX and DRLTX so that the permissible local error in the step of integration would exceed velocity discontinuity. But after overcoming of section down a velocity jump we must be subdued with the fact that remained time of calculation for the program of integration will be passed with these lowered requirements at the point of the precision, i.e., we will obtain the considerably larger accumulated error toward the end in the calculation. Furthermore, very selection of such values DABSX, DRLTX, which would ensure the required local error with the small “clearance”, requires the time (see point 2.11.3).

For the user there is an alternate (recommended by the authors) path of overcoming the emergent difficulties. Selecting it, user seemingly tells the program of the integration: *“I want to conduct the calculation of process with the prescribed requirements about the local precision, but in those places, where for the satisfaction to these requirements it is necessary to strongly crush the step of integration, I do not want to descend lower than the step of the specific value and am prepared in this case to go for a certain reduction in the precision, but only in these places”*. The value of the step, lower than which user would not want to descend with the calculation when splitting step it is dictated by the requirements of local precision, is determined as far as the key parameter CONTROL. Thus, CONTROL - this is the lower limit of the decrease of step on the criterion of local error.

Several generalities, which are concerned this parameter:

1. CONTROL limits the decrease of step only on the criterion of local error. On the course of computation step value of integration can descend below CONTROL (but not lower than SMIN), if this is caused by the poor convergence of the solution Of [snLU] or [rekomendovano] what-or by the model of element.

2. if the phenomenon of a velocity jump is encountered in the analyzed interval of time the limited quantity of times, then with the passage of such sections the program of integration at first decreases the step to the value CONTROL, it makes several steps of this value, and then sufficiently rapidly is reduced the value of the step of integration down the acceptable value. Therefore with the first calculated girders of new task are recommended the assigning of low value CONTROL (1e-6). Depending on the results these the computed value CONTROL subsequently can be reduced or increased.

2.7. CONTROL BESIDES THE DECREASE OF HIGH-FREQUENCY FLUCTUATIONS (CONTROL AND WEIGHT)

Frequently is encountered the case, when it is necessary to analyze the prolonged process, which has several events of peak nature (for example, collision with several rebounds), which it is not compulsory to count with the high precision. Analysis of the technical system, which has the wide range of natural frequencies, is in practice even the more extended case. In this case desirable to analyze [s] grow prettier by precision only those processes, whose period exceeds the specific, predetermined value. In this case the user can "be built" from high-frequency idle components, establishing the boundary of the decrease of step for reasons of precision. This is ensured by the task of the key parameter of the program of integration CONTROL. The value of step can become less than is determined CONTROL, only with the condition of the divergence of the process of solving [SnLU] or as far as the recommendations of the models of elements. Besides its straight function - control besides lower boundary of the step of the program of integration at the point of the criterion of local error, the parameter CONTROL ensures the forced decrease of high-frequency fluctuations. Let us examine at first influence beyond the statistical indices of calculation and precision of the obtained results of the key parameter CONTROL.

In order to explain the aforesaid, let us examine a test example of the system, which has the sufficiently large scale of natural frequencies. These are the set of the spring pendulums, which have the mass of the load of 1 kilograms, but the spring of different rigidity:

N of the pendulum	Spring constant	Oscillatory period
1	4	3.14 s = T
2	400	T/10
3	40 000	T/100
4	1 *106	T/500
5	4 *106	T/1000

The excitation of pendulums is ensured by the task by the initial velocity, equal to 1 m/s.

Let us assume that us interest the processes, which have the period of oscillations Of t/10, and processes with the frequency Of t/100 above are idle and before the real system they will rapidly go out because of the structural damping. Thus, task is reduced to integrate with the prescribed precision processes with the period T and T/10, that lie against the frequency range interesting us. Ignoring higher frequencies is not end in itself, but it is desirable so that their presence would not cause excessive computational expenditures.

Text of the program, which describes this test example:

```
I DATA :

 Rigidity Pi = 4 {T = 3.14 s}
 Rigidity Of pi10 = 400 {T = 3.14/10 s}
 Rigidity Of pi100 = 40000 {T = 3.14/100 s}
 Rigidity Of pi500 = 1 E6 {T = 3.14/500 s}
 Rigidity Of pi1000= 4 E6 {T = of 3.14/1000[s]}
 Mass = 1;      The initial velocity = 1.


I FRAGMENT : Tuning fork
```

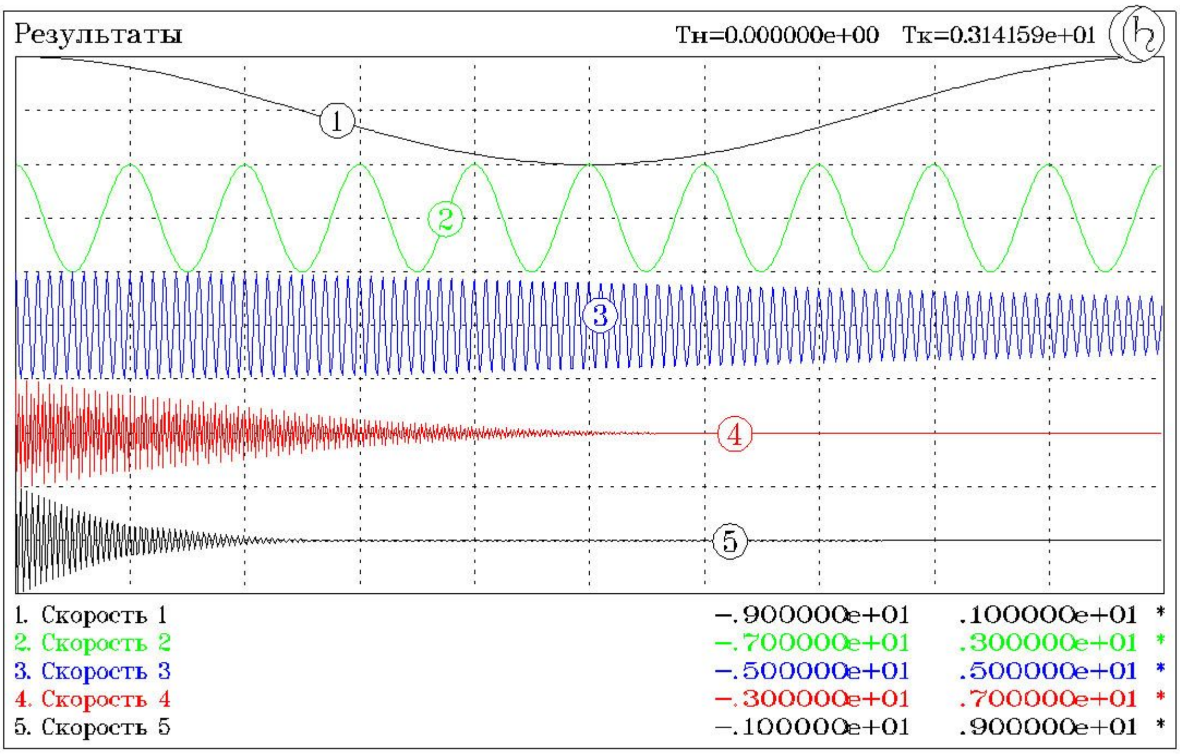
```
# BASE : 1
# STRUCT :
Spring 1 ' K (1 2; Rigidity Pi);
Spring 2 ' K (1 Oe; Rigidity Of pi10);
Spring 3 ' K (1 4; Rigidity Of pi100);
Spring 4 ' K (1 5; Rigidity Of pi500);
Spring 5 ' K (1 6; Rigidity Of pi1000);
  'VN (2; The initial velocity);  'VN (3; The initial velocity);
  'VN (4; The initial velocity);  'VN (5; The initial velocity);
  'VN (6; The initial velocity)
 Mass 1 ' M (2; Mass);  Mass 2 ' M (3; Mass);
 Mass 3 ' M (4; Mass);  Mass 4 ' M (5; Mass); Mass 5 ' M (6; Mass)
# OUTPUT :
Speed 1 ' the V (2; 1); Speed 2 ' the V (3; 1); Speed 3 ' the V (4; 1)
Speed 4 ' the V (5; 1); Speed 5 ' the V (6; 1)

I RUN :
Process of fluctuations 'SHTERM (END=3.1416, DRLTX=1.E-5, DABSX=1.E-5;
       Speed 1= (-9,1), speed 2= (-7,3),
       Speed 3= (-5,5), speed 4= (-3,7), speed 5= (-1,9))


I PRINT :
Results 'DISP (;
       Speed 1= (-9,1), speed 2= (-7,3),
       Speed 3= (-5,5), speed 4= (-3,7), speed 5= (-1,9))

$ END
```

The results of calculation about this example are given before Fig. of 2.5.[a]. before the upper part of the field of graphing it is located the lowest-frequency process. Each of the graphs, located below, corresponds to the process of larger frequency. Before the lower part of the field of graphing - the high-frequency process.

As has already been spoken above (point 2.3.2), the damped nature of the obtained solution is determined as far as the selected method of integration. Down [ris].2.5.[a]. it is evident that in the time, which corresponds to one period of lowest-frequency oscillations, the harmonics with the period Of t/1000 and T/500 are extinguished completely (i.e., the accumulated error for them it becomes to the equal value of initial amplitude). The amplitude of fluctuations with the period Of t/100 decreased approximately 2, but practically it did not change for the harmonics Of t/10 and T.

On Fig. of 2.5[a] it is necessary to say also that it is obtained with the aid of the program of mapping ACAD. Since from the considerations of the savings of disk space for its construction the limited quantity of points is used, high-frequency components are depicted not accurately - the apparent frequency of these harmonics is less than in actuality (this effect it is analogous down the described before subsection 2.4 effect from the application of too great key a parameter OUT).

а)



б)

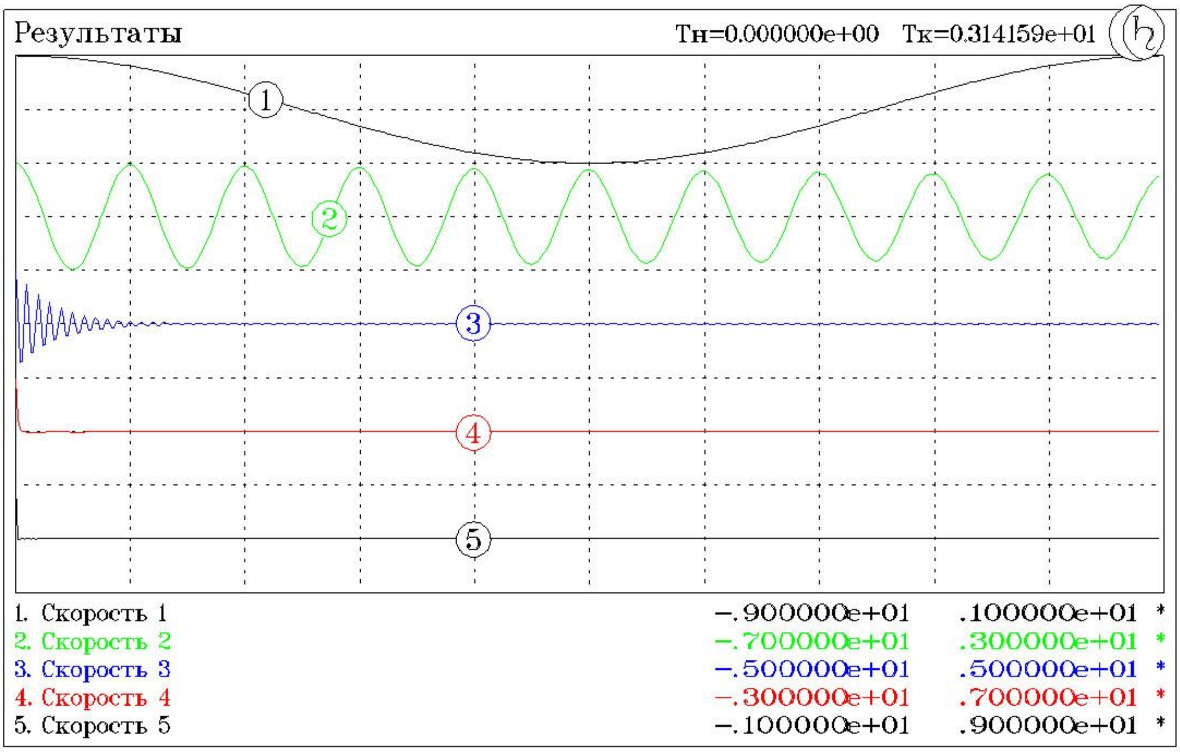


Fig. 2.5. The results of calculating the test example, which contains several oscillatory circuits with the large spread of the natural frequencies:
a) the parameter CONTROL is not prescribed;
b) the parameter CONTROL corresponds 1/10 minimum periods of natural oscillations.

For obtaining solving [ris].2.5[a] were spent 280720 steps of integration (557258 iterations).

Now for the formed model let us carry out task at the point of the calculation, where let us determine the parameter CONTROL (let us assign its value 10 times of less than the frequency of the lowest-frequency vibrations):

```
I RUN :

Process of [kolebaniy]'SHTERM (END=3.1416, DRLTX=1.E-5, DABSX=1.E-5,
                    CONTROL=3.141592 E-4;
   Speed 1= (-9,1), speed 2= (-7,3),
   Speed 3= (-5,5), speed 4= (-3,7), speed 5= (-1,9))

        I PRINT :

Results 'DISP (;
   Speed 1= (-9,1), speed 2= (-7,3),
   Speed 3= (-5,5), speed 4= (-3,7), speed 5= (-1,9))

$ END
```

The obtained results ([ris].2.5.[b]) show that an error in the calculation of fluctuations with the period Of t/10 from one fluctuation to the next grows more intensive. Error accumulated at the point of 10 fluctuations with the period Of t/10 composed 25% of the initial amplitude (amplitude of the tenth of the fluctuation - 0.745 m/s). Then all high-frequency components were filtered practically immediately, which affected the computational expenditures - 9961 steps (17743 iterations). Thus, the expenditures of time for the solution decreased 30. Pay at the point of this improvement in the form in the increase in the error in the calculation high-frequency of the harmonics interesting us is not excessive.

ATTENTION! One should remember that the value of minimum step, given by the key parameter CONTROL, cannot exceed the value, given by the key parameter SMAX. The task of value CONTROL is less than SMIN although it is permissible, it is thoughtless - in this case with an attempt at the program of integration to crush the step, equal DOWN SMIN, the calculation will stopped and the key parameter CONTROL will not operate.

One of the possible problems, which can stand before the user, consists before being achieved a maximally accurate result for the harmonics of process with the period more than the specific value, as far as possible having maximally " crushed" the idle (higher) frequencies, which do not influence or which insignificantly influence the result. This is achieved as far as the specific combination of the key parameters WEIGHT and CONTROL. On silence the value of the key parameter WEIGHT equally 1 or ensures damping at one period of oscillations, whose period by an order exceeds the value of the parameter CONTROL.

The less the assigned magnitude of the key parameter CONTROL, the more must be the value WEIGHT, in order to ensure the decrease of approximately the same band of idle frequencies. For retaining the adjustment for the filtration of the nearest high frequencies it is necessary to adhere to the exemplary rule

CONTROL2 * OF WEIGHT = const

The greater the value of this work, the greater the frequency spectrum and the more effectively it will be extinguished. With the identical value of work, the greater will be the value WEIGHT and the less the value CONTROL, the selective will be the effect of the decrease (the more precise they will be considered low frequencies even the stronger it is to be extinguished high). However, this effect will be accompanied by the specific increase in the computational expenditures.

The results of the comparison of the solutions for four different combinations of keys CONTROL and WEIGHT are given before Table 2.3.

The graphs of the results of the first calculation, as has already been spoken, were given before Fig. of 2.5.[b], the second - down [ris].2.6.[a], the fourth - down 2.6.[b]. high-frequency fluctuations here approximately correspond to the results Fig. of 2.5.[b] (down [ris].2.6.[b] they attenuate somewhat less). The results of the third calculation visually differ little based on Fig. of 2.6.[a]; therefore they are not given on the graphs.

Table 2.3. Influence of the key parameters CONTROL and WEIGHT beyond the precision of results and the computational expenditures.

N	N of the figure	CONTROL	WEIGHT	Amplitude 10-GO of fluctuation 2-GO of the pendulum	Steps	Iterations
1	2.5.[b].	T/104	1	0.745	9961	17743
2	2.6.[a].	T/105	50	0.767	22866	34938
3	-	T/106	5000	0.829	25138	39278
4	2.6.[b].	T/106	1000	0.900	38705	73238

Certainly, the given example does not encompass all possible situations with the real calculations. Yes even it is not possible to give out general-purpose recommendations for all cases. It is possible that it would be better to not at all frolic of this type by experiments, and to count entire real frequency spectrum of the object being investigated. However, the time of the solution of the complete problem of [ris].2.5.[a]. depending on the type of machine can reach ten minutes, disregarding besides the cheapness of iteration (only 5 equations) and insignificant, in comparison with many real tasks, frequency spectrum (3 orders). In this case high-frequency components nevertheless it was possible “to save” not for long. It impresses the necessary for obtaining of result quantity of iterations. Frequently in the practical cases the parameter CONTROL can play role not so much indicator down the fact that “me the fluctuations with the period of the less specific value do not interest”, as by acknowledgment of the fact that “i do not have time down the investigation of fluctuations with the period less than the specific value”.

Sometimes value CONTROL - the result of a compromise between the step of integration and the precision. Assigning CONTROL, calculator seemingly tells program so that it as far as possible would ensure the prescribed precision. But as soon as the value of the required step of integration will become too small, then is the possibility in principle of obtaining what-or results in this section of process should be preferred accuracy in the integration.

The role of the key parameters CONTROL and WEIGHT before the calculated practice is sufficiently great. As a rule, high-frequency oscillations before the real construction attenuate very rapidly because of the damping before the materials, structural damping and so forth the account of this type of processes before the models of technical objects is most frequently impossible, yes even it is not expedient, if it is not the object of independent of experiment. Therefore it is frequently not only useful, but also very desirable to exclude based on the examination idle frequencies.

а)

б)

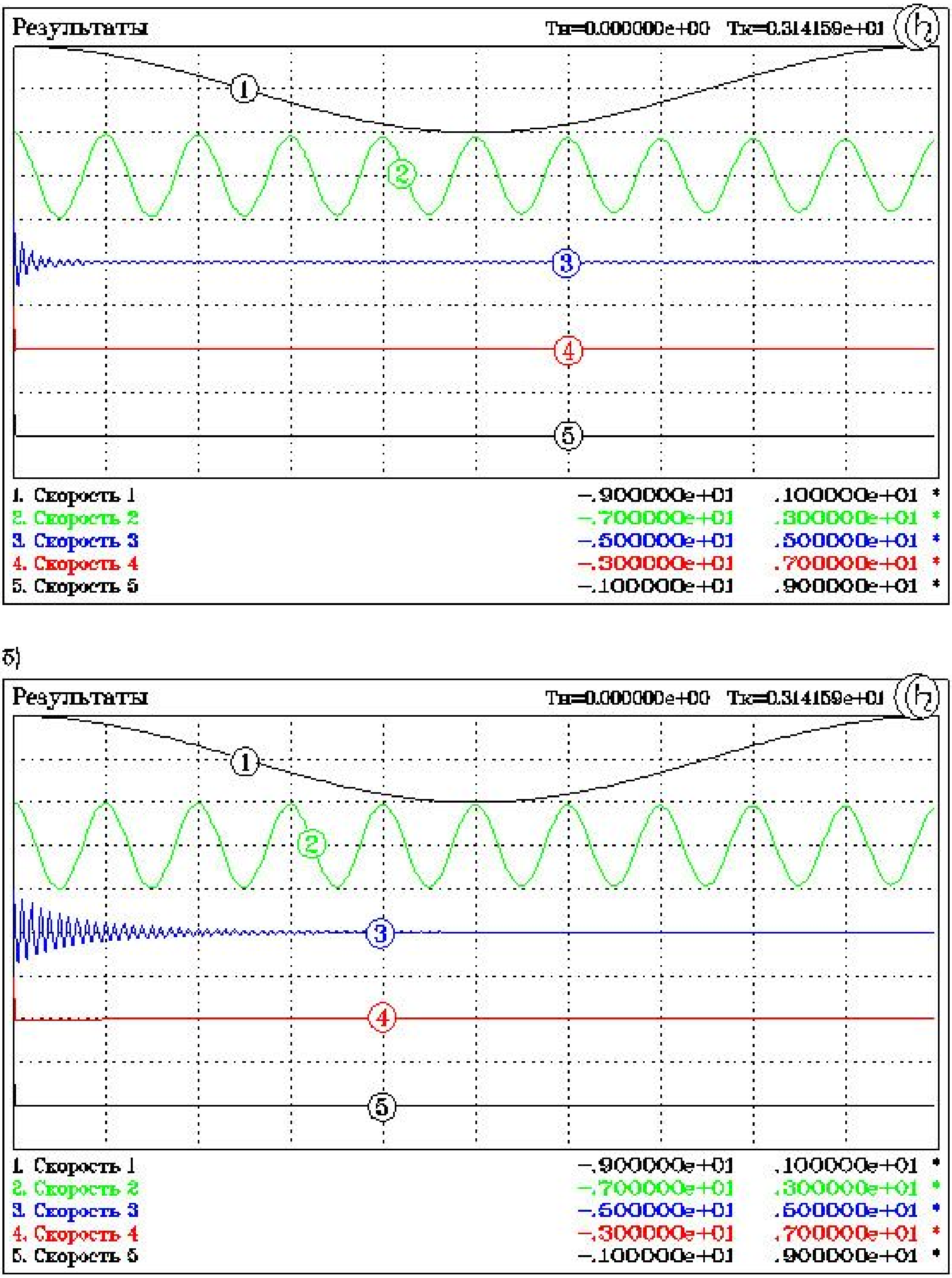


Fig. 2.6. **Results of calculating the test example for the different values CONTROL and WEIGHT:**
a) CONTROL is equal to 1/100 minimum periods, WEIGHT=50;

b) CONTROL is equal to 1/1000 minimum periods, WEIGHT=1000.

In the practical cases as it seems to us, it follows to use that fact that the desensitization of the precision of calculation first of all affects the high-frequency components of process. Therefore, conducting the first rough estimates, it is possible to try simply to count with the low precision. Let us say, to establish local precision not higher than 1-5% of the amplitude value of characteristic speeds (potentials). Subsequently an increase in the precision of calculation can lead down the fact that the program of integration will begin to track higher frequencies and “to be caught” at the point of too small, before your opinion, values of the step of integration. Then should be introduced beside the action the parameter CONTROL, assigning its value approximately of the same order or somewhat less than the values of step, at the point of which “was caught” the program of integration. Or to use the combinations of the parameters CONTROL and WEIGHT in the manner that this was discussed above, i.e., to assign CONTROL one-two orders less than the step, at the point of which “was caught” the program of integration, with a simultaneous increase IN WEIGHT.

2.8. ALGORITHM OF THE SOLUTION OF THE SYSTEM OF NONLINEAR EQUATIONS AGAINST THE STEP OF INTEGRATION. KEY PARAMETERS, WHICH CONTROL THE PROCESS OF THE SOLUTION (DABSU, DRLTU, DABSI, DRLTI, ITR)

Against each step of integration the system of differential equations is converted beside the system of nonlinear equations (СнЛУ) relative to finite increments in the independent variables:

F (U) = 0 (2.5)

The system of nonlinear equations is solved iteratively with the use of Newton's method. The geometric interpretation of method is given before Fig. 2.7.

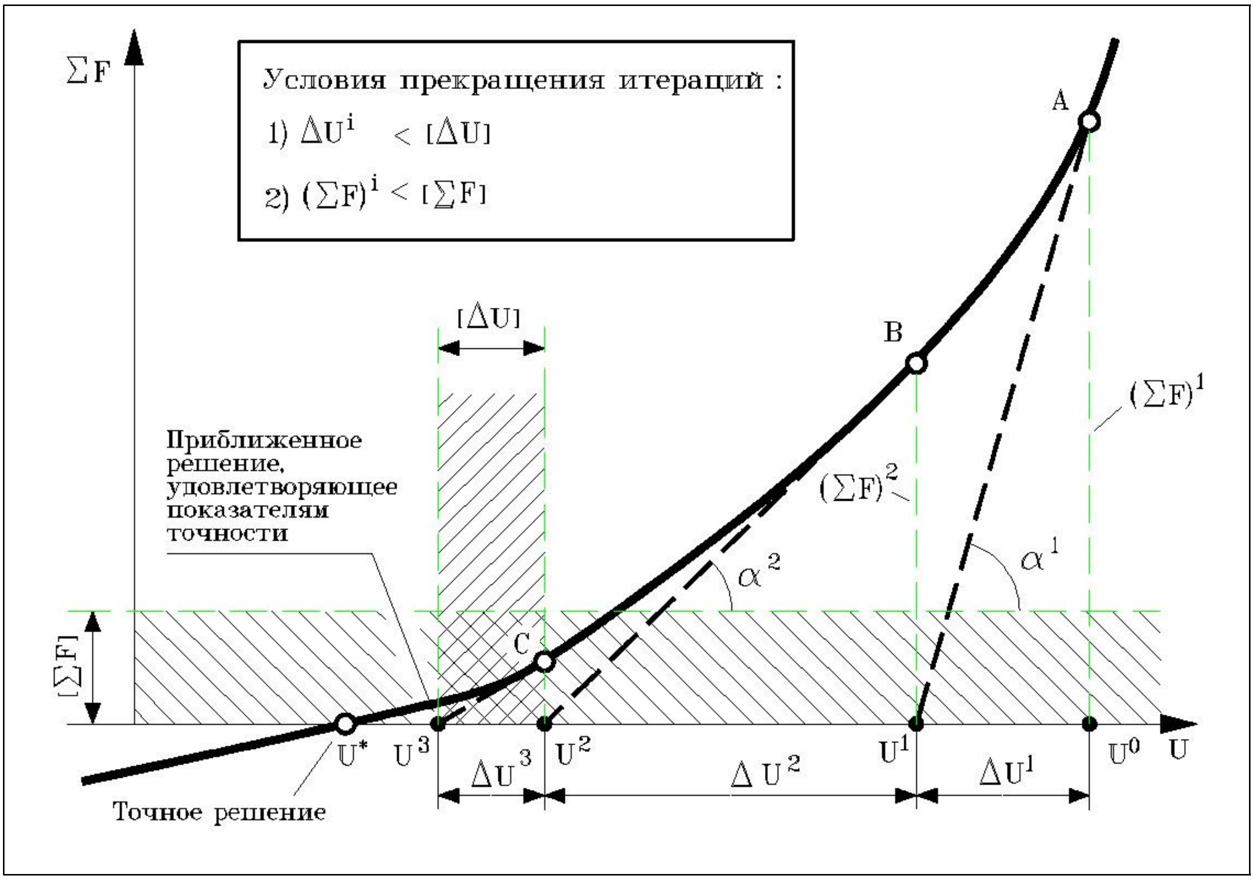


Fig. 2.7. Search for the solution of nonlinear equation by Newton's method.

Let us recall that for the mechanics the speeds will be the independent variables before our unpackings.

Let us limit here down the examination of one equation, bearing in mind that the solution of system of equations is accomplished analogously. Where this is necessary, we will make down the multidimensional case.

The content of algorithm briefly is described below. The more detailed account of the algorithm of forming and solution of the system of nonlinear algebraic equations see document "***PRADIS. Basic mathematical methods***".

Step 1. selection of the initial approximation - value U0.

As the initial approximation to the solution against the first step of integration are used the initial conditions of the decided differential equation (in the case of system of equations - the vector of initial conditions). Against each subsequent step as the initial approximation the extrapolation of the solution based on the previous step is used.

Step 2. computation of the right side of the equation (calculation of discrepancies on the current iteration).

The values of the forces (moments) or other flow variables are calculated for the instantaneous value of the independent variable before each of the models of elements, if the discussion deals for the sake of the solution of problem before another subject area. Discrepancy is determined as far as the summing up of the obtained values of the forces of the models of elements. If is solved system of equations, i.e., model it has more than one degree of freedom, then discrepancies are located for all equations of system with the instantaneous values of the independent variables. Before Fig. 2.7. the discrepancy for the first iteration is determined as far as the value of function F (u) at point A. the obtained value discrepancy Σ F (i) is used for finding the increases as far as independent variable dU (i) (**step 3)** and for the upper estimation of error the solution of the nonlinear equation on that flowing of iteration (**step 4)**.

Step 3. determination of new values of the independent variable.

Increase in the independent variable is determined from the relationship

dU (i) = - Σ F (i)/tg (α (i)) (2.6)

As can be seen from Fig. 2.7, value tg (α) appears derivative F (u) at point U (i-1).

In the case of solving the system of equations dU it is vector and is calculated based on the formula:

dU (i) = - Σ F (i) * [Y (i) $^{-1}$] (2.6.a)

Here Σ F (i) - the vector of the discrepancies (right sides) of the equations of the system;

Y (i) - the jacobian of system, calculated for the instantaneous values of the independent variables;

[Y (i) -1] - the storage operation of jacobian.

Entire writing of the equation of 2.6.[a]. is the symbolic idea of the process of solving the system of linear algebraic equations with the matrix of coefficients Y (i), the vector of unknowns dU (i) and the vector of the right sides - ΦΣ (i).

New value of the independent variable:

U (i+1) = U (i) + dU (i) (2.7)

Step 4. checking of the precision of the solution. If the precision of the solution is insufficient, and a quantity of permitted iterations is not exhausted, passage to step 2.

The precision of the solution is checked both before the value of discrepancies and before the value of increases in the independent variable. The feasible accuracy of the solution is determined as far as the same algorithm as with the control of a local error in the integration.

For the forming of the permissible value of increase in the independent variable on this iteration the values of absolute and relative components of the permissible error, prescribed by user, are used.

[dU (i)] = DABSU +|U (i)|* DRLTU (2.8)

F (i) approaches zero (value U (*) at the point of [ris].2.7). Therefore for guaranteeing the possibility to assign a relative error in the solution as far as the discrepancies, for each degree of freedom of object is calculated additionally the sum With the evaluation of the precision of the solution of system of equations at the point of the value of discrepancies (what is actually the control of the precision of the observance of the conditions of equilibrium), is a small special feature. The fact is that with the exact solution of the system of nonlinear equations the discrepancy of **of the modules** of forces (moments). This value is used with the determination of the relative part of the permissible error in the solution:

[ΦΣ (i)] = DABSI + Σ|F (i)| * DRLTI (2.9)

If the increase in the independent variable dU reached on this iteration does not exceed the permissible increase (formula 2.8), i.e.,

d U (i) < [dU (i)], (2.10)

and the discrepancy reached Σ εητ of ¦F (i) ¦ does not exceed the allowed value of discrepancy, i.e.,

Σ|(F (i)| < [ΦΣ (i)], (2.11)

is counted that the solution of nonlinear equation obtained. Before the process, depicted beyond Fig. 2.7. , the prescribed precision is reached on the third iteration.

If the reached on this iteration increase in the independent variable dU exceeds the value, found based on formula (2.8) at least for one degree of freedom, or the discrepancy reached Σ εητ|F (i)| they exceed the allowed value of discrepancy, found based on formula (2.9), at least for one equation, it is considered that the solution is not yet achieved. In this case, if a quantity of perfect iterations does not exceed that permitted by user (parameter ITR), then is accomplished passage to **step 2.** if a quantity of permissible iterations exhausted, then occurs splitting the current step of integration. The attempt to complete the new step of integration from the same point is made.

As it was already said above, the process of splitting step both because of too great local an error and because of the divergence of the solution Of [snLU], it cannot continue infinitely (minimally allowed value of the step of integration limited as far as the assigned magnitude of the key parameter SMIN). If the program of integration does not reach convergence during the solution Of [snLU] with the minimum value of the step of integration, then the process of integration ceases with the delivery of communication R 006 about the divergence of the solution of the system of the nonlinear equations (see **reference book on the errors**). As a rule, if this communication is obtained, and the value of the key parameter SMIN is established on silence, then the attempt to decrease the value the key parameter SMIN situation will not improve. Generally, the poor convergence of Newton's method most frequently speaks about the not completely correct description of the structure of the model of technical system. In many instances, if before the model is not contained nonlinearities of the type of contact elements or elements, which reproduce the law of dry friction, then because of the divergence of Newton's method there must not be lost more several tenths of percentage of the total number of steps, and a quantity of lost steps must decrease with an increase in the permitted quantity of iterations as far as the step of integration (parameter ITR, see below).

The basic reasons, which can lead down the poor convergence of the process of solving [SnLU]:

- too small a value of the parameter ITR. If the assigned magnitude of local error makes possible at the point of the program of integration to accomplish the steps of integration (rough solution) sufficiently large before the value, then the permitted quantity of iterations it can not be sufficient for achievement convergence. The periodic sharp decrease of the step of integration (the times) with its subsequent slow increase can be the sign of this situation;

- error in the description of the structure of the object (for example, the fixed unit, to which it is applied kinematic action, or the erroneous connection of the rotational degrees of freedom of one model for the sake of the translational degrees of freedom of another). Many errors of the description of structure can be revealed with the aid of the simple test, which for the complex calculations can precede the entire subsequent work with the model. Its algorithm of such. All fixed degrees of freedom of model are freed, to what-or to the unit of the model (it must be close down to center the masses of system) is applied the force, directed, for example, vertically upward. In this case must be observed the motion of entire model upward, according to the direction of the applied force. With the aid of this test it is especially good to reveal the errors of the description of the structure of the finite-element fragments;

- the limiting value of the parameters of what-or from the models. In this case the parameters of the model of element are such, that they actually reduce its behavior down the calculated case, not provide ford by this model of element. For example, girder element with the improbably large dimensions of cross section (very extended error!) or the strongly elongated triangular final element. This situation can be corrected only by the improvement in the description of structure, with which one degenerate element is replaced by several elements of correct form or several degenerate elements are replaced by one element, which corresponds down the prescribed design diagram. To the degeneracy of the parameters can be attributed and unjustifiably high rigidity for the elements being deformed, which the user considers conditionally nondeformable. For similar "absolutely rigid" of elements should be, nevertheless, evaluated an order of magnitude of the real rigidity of the body being simulated;

- the model of technical system contains certain quantity of contact elements and elements of dry friction. Attempts at the application of steep pitch of integration in such cases can lead down the poor convergence of the solution Of [snLU];

- the step of integration was reduced on requirement of one of the models to the value of minimum step (or close down it), and with this value of step was not achieved the convergence of the solution Of [snLU]. The sign of this situation is a good convergence of the solution Of [snLU] before entire remaining analyzed time interval. In this case can help certain increase in the value of the key parameter SMIN (see subsection 2.6);

- error in the description of the jacobian of the model of element. This situation especially frequently is encountered in the beginning developers models of the elements, which disregard the comprehensive preliminary numerical check of the jacobian of model as this described before the document "***start of the programs of user in the libraries of complex***". Situation cannot be brought down the more or less satisfactory with the aid of the key parameters program of integration without the appropriate correction of the erroneous model of element.

Before the algorithm of the program of integration several branchings, intended for decreasing the probability of the divergence of the solution of the system of nonlinear equations, are provide ford. The process, which makes it possible with the prescribed local error to make steep pitch on the time, is very unpleasant before this sense, but with the realization of this step the convergence of the solution of the system of nonlinear equations cannot be achieved. Several steps, lost on the divergence of the solution of the system of nonlinear equations, will in that case fall down each successful step of integration. ***The basic time of operation of the program of integration will be spent uselessly***. Therefore, with the loss of step is included the limitation down the step of integration at the point of the criterion of local error, which does not allow at the point of the step of integration grow too rapidly. Furthermore, the program of integration limits an increase in the step and when a quantity of iterations down the step of integration exceeds 80% of the quantity of iterations permitted by user.

Summing up the aforesaid before this subsection, it is necessary to note that by user must be determined the values of four parameters, which influence the precision of the solution of the system of nonlinear equations. The parameters DRLTU and DABSU determine the permissible increase in the independent variable on the last iteration of the method of Newton (precision of the solution of the system of nonlinear equations at the point of the argument), and DRLTI and DABSI - the permissible discrepancy (permissible difference from zero right sides of each of the equations). In this case it is necessary to consider that the relative part of the permissible discrepancy of forces (moments) is formed for the sake of the multiplication of the parameter DRLTI as far as the sum of the modules of the forces (moments), applied to the appropriate degree of freedom of the model of object from the models of elements.

The poor convergence of Newton's method can be the reason for unjustifiably high computational expenditures both due to the loss of the steps of integration and due to the decrease of the value of the step of integration. Therefore monitoring of the convergence of Newton's method for each calculation and control besides convergence is one of the most important questions, confronting the calculator. Let us examine below the application of the key parameters, which assign precision, together with other key parameters, that control the process of solving the system of nonlinear equations.

2.9. CONTROL BESIDES THE PROCESS OF SOLVING THE SYSTEM OF NONLINEAR EQUATIONS WITH THE AID OF THE KEY PARAMETERS OF THE PROGRAM OF THE INTEGRATION

Before this subsection let us examine a simple example of the calculation of a drop in the coin by edge beyond the elastic support. Coin with the diameter of 2 centimeters it is possible to roughly present in the form the model, which consists of 6 elastic triangles. We consider that gravitational force is applied to center the masses of coin. The force of the elastic interaction of coin with the base for simplification in the formulation of task is also applied to center coins. We will derive the displacement of the center of gravity of coin and the difference of displacements by means of the y axis between the points A and D (since the task before the setting is absolutely symmetrical, this value is in many respects determined as far as an error in the solution of the system of nonlinear equations). The design diagram of model is depicted before the upper right side of [ris].2.8., and the text of task before the input language PRADIS is given below:

```
                I DATA:
Point O = 0, 0          ;   Point A = of 1.0 E-2, 0.
Point B = of 0.5 E-2, 0.869 E-2 ;   Point C = -0.5 E-2, 0.869 E-2
Point D = -1.0 E-2, 0.        ;   Point E = -0.5 E-2,-0.869 E-2
Point F = of 0.5 E-2,-0.869 E-2
Material = 1.E-3, 2.E11, 0.3, 7800; Force of gravity = - 0.025
Parameters of support = 0.5, 1.E7

                I FRAGMENT:
        # BASE : 15
        # STRUCT:
[Tr].1'TRGUL (1 2 Oe 4 5 6; Point O, point A, point B, material);
[Tr].2'TRGUL (1 2 5 6 7 8; Point O, point B, point C, material);
[Tr].3'TRGUL (1 2 7 8 9 10; Point O, point C, point D, material);
[Tr].4'TRGUL (1 2 9 10 11 12; Point O, point D, point E, material);
[Tr].5'TRGUL (1 2 11 12 13 14; Point O, point E, point F, material);
[Tr].6'TRGUL (1 2 13 14 Oe 4; Point O, point F, point A, material);
Gravitational force 'F (2; Gravitational force);
Support 'UPRL (15 2; Parameters of support);
Support 'MD (15 15 15; 0, 0);
        # OUTPUT:
Displacement of the center of gravity 'the X (2; 1)
Difference of displacements A_D y 'DX (4, 10; 1)
```

```
I RUN:
Calculation 'SHTERM (END=1)
I PRINT :
Result 'DISP ()
$ END
```

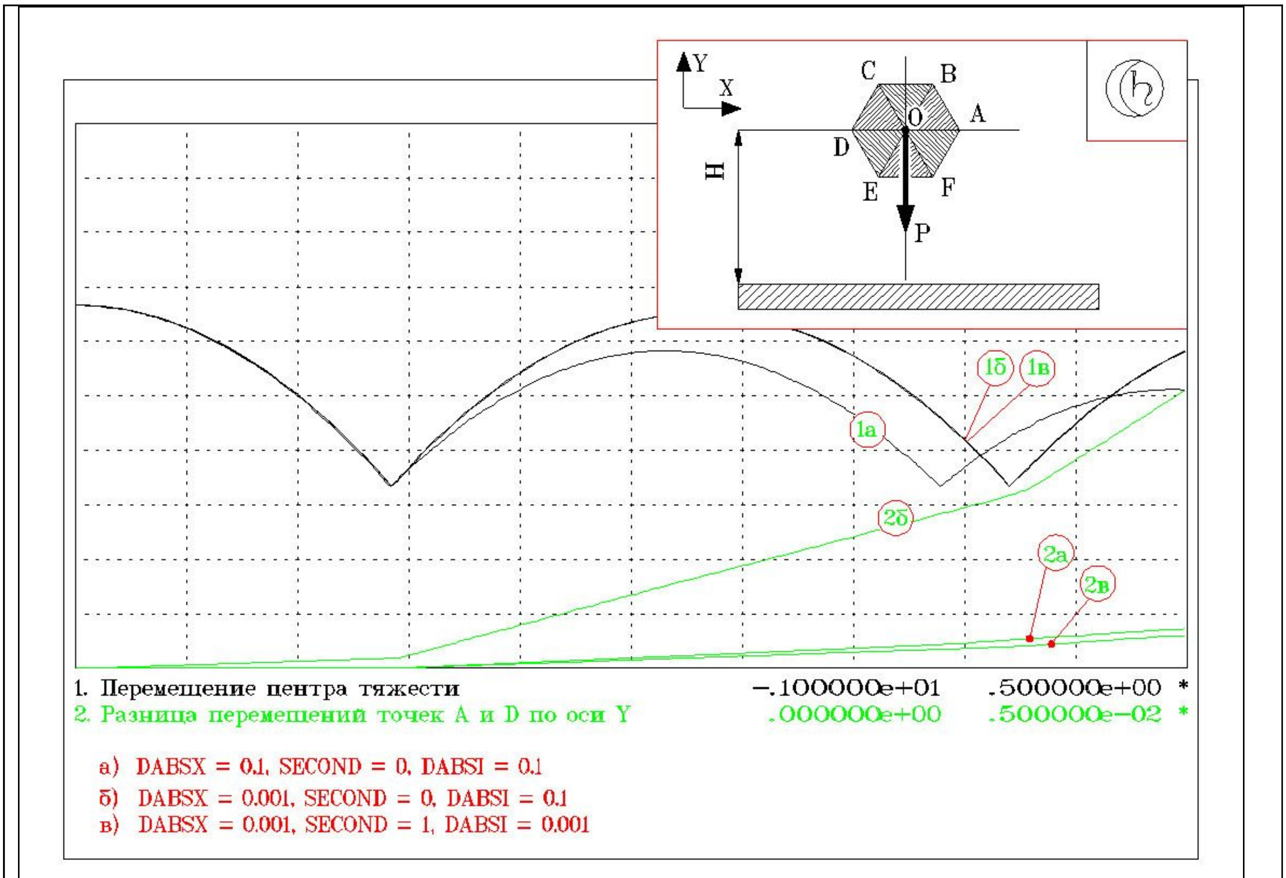


Fig. 2.8. **Test example for the illustration of influence beyond the results of calculating the parameters DABSI, DABSX, SECOND.**

The statistics of the solution of this problem not so easily it was predicting previously. Significant quantity of steps because of the divergence of the solution of the system of nonlinear equations was lost. The step of integration on the average did not exceed 3e-4, were accomplished approximately 3.9 iterations down the step of integration. In this case worsening in the statistical indices is observed after the first rebound of coin from the obstacle.

The reason for this phenomenon consists of the following. The elastic vibrations begin after the impact beside the tele- coins. Insignificant inaccuracies before the determination of the instantaneous values of displacements according to all degrees of freedom because of the high rigid characteristics lead down the relatively high discrepancies of efforts and, as a result, to the divergence of the process of solving the system of nonlinear equations. Before its rigid parameters this task, generally speaking, is already close down the limitations, superimposed by the calculation grid of computer for the idea of the numbers with double precision. Certainly, it is possible to easily filter out the high-frequency component (by use of the corresponding combination of the key parameters CONTROL and WEIGHT). However, this will increase the inevitable errors, [vnosimye] beside the calculation of the process of impact. Let us assume that in this case we want to avoid these additional errors.

2.9.1.Maximum quantity of iterations down the step of integration (ITR)

The first, that we can make - this to solve the large number of iterations against the step of integration. By these we will raise the probability of the successful completion of the step of integration.

As a result it is possible to hope at the point of an improvement in the calculated statistics (decrease of the total number of steps and iterations) due to:

- the decrease of a quantity of the lost steps;
- increase in the average step of integration and decrease as a result of this total number of steps.

Table 2.4 is given the statistics of the results of calculating the test example with the different values of the parameter ITR. A sharp improvement in the statistical indices of calculation occurred with ITR=7, and statistics monotonically is improved with the great significances ITR. Furthermore, beginning for the sake of ITR=11, began to decrease a real quantity of iterations as far as the step of integration. This improvement is supposedly connected for the sake of the substantially increased step of the integration (it began to increase to the value SMAX). The damping properties of the method of the integration (high-frequency component with the steep pitch of integration it is extinguished more rapidly) as a result more strongly appeared.

Before the graph "of iterations down the step" of table 2.4 before the numerator is indicated the ratio of the total number of iterations to the total number of steps, before the denominator - a quantity of successful iterations to a quantity of successful steps.

Before the graphs "it is lost steps" and "lost iterations" before the numerator are given losses on the local error, before the denominator - on the divergence of the solution of the system of nonlinear equations.

Table 2.4. Influence of the parameter ITR beyond the statistics of the results of calculating the test example.

ITR	The total number			It is lost	
	the steps	the iterations	iterations down the step	the steps	the iterations
5	4060	16431	4.05/3.90	6/539	15 /2695
6	3717	16656	4.48/4.31	5/388	13 /2328
7	788	4786	6.07/6.01	5/70	12/490
8	719	4607	6.41/6.28	4/63	8/504
9	458	3169	6.92/6.80	5/33	17/297
10	435	3085	7.09/6.82	4/43	8/430
11	301	2068	6.87/6.67	4/18	8/198
12	273	1842	6.75/6.51	3/14	6/168
13	251	1471	5.86/5.73	6/4	37/52
14	201	1075	5.35/5.37	4/0	17/0
15	194	1116	5.75/5.83	4/0	8/0

It would be desirable to note at conclusion of conversation about the key parameter ITR that not for all tasks an increase in the permitted quantity of iterations as far as the step of integration can lead down an improvement in the statistical indices of the work of the program of integration. Thus, before Table 2.5 they are brought the statistics of the work of the program of integration for one of the real tasks with ITR=5 (value on silence) and ITR=9, ITR=15.

Table 2.5. Statistics of the calculation of the hydro-shock absorber of automobile.

ITR	The total number			It is lost	
	the steps	the iterations	iterations down the step	the steps	the iterations
5	2234	7646	3.42/3.07	132/336	544/1680
9	3144	10618	3.38/2.96	578/16	2932/144
15	3252	11118	3.42/2.92	635/Oe	3443/35

It is evident that in this case an increase of the permissible quantity of iterations as far as the step of integration leads down worsening in the statistics of calculation because of an increase in the losses about the local error. The calculated cases (dry friction, impact interactions), can be encountered, where an increase in the quantity of iterations as far as the step of integration not at all leads down what-or to the decrease of the lost steps on the divergence of the solution Of [snLU].

For a significant quantity of real tasks the optimum value of the key parameter ITR is located before interval of 5-7. If the large number of steps, lost on the divergence of the process of solving the system of nonlinear algebraic equations, is observed, it is possible to try the large number of iterations down the step of integration how this is assigned on silence.

2.9.2.Precision of the solution of the system of nonlinear equations and the guaranteed second iteration (DABSI, SECOND)

Let us study here one additional aspect of the test problem of [ris].2.8., namely by the precision of the solution of the system of nonlinear algebraic equations. As we already agreed above, this precision can be evaluated according to the value of variable “difference of displacements A_D y”. Since the task is symmetrical, the difference of the displacements of these points is caused as far as an error in the solution: in the course of solution before the units of diagram the discrepancies, which do not exceed before the absolute value of the permissible error, remain. These random “efforts” lead down the turning of coin.

As can be seen from Fig. 2.8. , total turning with the calculation of a drop in the coin with the parameters of local precision, prescribed on silence, is found within satisfactory limits. In the case of calculation with the more stringent requirements at the point of a local error in the solution (DABSX=0.001) an error in the solution of the system of nonlinear equations sharply grows.

With the stiffening of requirements at the point of the local error the program of integration decreases the value of step. By this conditions for obtaining the solution on the step of integration are facilitated, and for guaranteeing of a convergence to method Newton sometimes is required only one iteration. The parameters, which assign the precision of the solution of the system of nonlinear equations for this task are sufficiently rough. As far as this is caused a sharp increase in the accumulated error in the solution of the system of nonlinear equations.

Simplest resolution of a question, which frequently removes problem, is calculation with the requirement of the obligation of the second iteration for the method of Newton (key parameter SECOND=1). By this the convergence of method is checked, even if first approximation satisfies the prescribed error, and simultaneously is refined the solution (this that is more effective, that before the close environment of the solution Newton's method converges ultralinearly).

It would be possible to reach the same results as far as the stiffening of requirements at the point of the precision of the solution of the system of the nonlinear equations (as a rule, most effective it is the use of the key parameter DABSI).

The results of the calculations of test task with different combinations of the key parameters of the program of integration are given down [ris].2.8.

2.10. STEP OF THE RETENTION OF THE STATE OF CALCULATION (SAVE)

The parameter SAVE serves for the intermediate retention of the state of calculation at the point of the case of the failure OF COMPUTER(S). It is useful to use it before the prolonged calculations, when the probability of the failure OF COMPUTER(S), electrical power loss and other unforeseen events grows.

Was if used the parameter SAVE, and the mentioned failure occurred against the stage of the work of the program of integration, for restoring the task based on the last place of retention is required to undertake the following actions (let us assume the name of the task - “TASK”):

1) if before the current catalog (where it was carried out task) there is a file INTEGR.EXE, it is necessary to rename it beside the file “OF TASK.INT”;

2) file VAR.DAT in the case of the absence of file TASK.VAR to rename beside the file TASK.VAR;

3) file TRANS.OUT to rename beside the file TASK.TRN;

4) file RESULTAT.OUT to rename beside the file TASK.RSL;

5) to create task at the point of the calculation about the already formed model (let us assume this task it will be contained before the file “OF REST”). In this task before the title of $RUN to indicate the title of $RESTORE;

6) to carry out task for the already formed model by the command

```
> SLANG REST TASK
```

Calculation must be continued based on the last place of retention.

If the work of the program of integration completes normally (after the preset time of integration or at the point of the requirement of the user, that pressed <Alt-C>)), retention of results occur automatically.

2.11. CONTROL BESIDES THE CONCLUSION OF CHECK-OUT INFORMATION ACCORDING TO MODEL (DEBUG)

The material, given before the present subsection, is important despite the fact that the key parameter DEBUG will be importanthardly used as far as you frequently. However, the study of the proposed here examples will allow you deeper “to feel” the used in PRADIS computational algorithms.

Furthermore, with obtaining of communications about the divergence of the process of solving the system of nonlinear equations or about the losses of the steps on the criterion of local error, user has a possibility to identify degree of freedom or a model, because of which this occurs. This information is irreplaceable with the inclusion in the composition of the complex of the new models of elements. It also can reveal those or other tactlessness before the description of the structure of the analyzed object.

Check-out information before the process of calculation can be derived by the task of the key parameter of the program of integration DEBUG. Since entire check-out conclusion uses internal numeration of the degrees of freedom and models, before the use of the key parameter DEBUG it is necessary to include in the last division of $FRAGMENT of the analyzed object the subsection of #MAP and to repeat the process of the forming of the model of object. In this case beside the file SYSPRINT.TXT will fall the complete list of the models of elements, included in the structure of the analyzed object. The internal numbers of the models of elements will be used for the numeration of the models of elements before this list. After identifier and name of model are derived the internal numbers of the degrees of freedom, for the sake of which is connected this model of element. If it is intended to conduct several calculations for the formed model and there is the probability that the information, given out on the demand of #MAP, can be required subsequently, it is necessary to preserve the obtained file SYSPRINT.TXT, after renaming or after copying for the sake of its command of operating system.

After this, it is possible to carry out the calculation, for which must be realized check-out conclusion. Are given below the rules, following which user can control content and completeness of the conclusion of check-out information.

The key parameter DEBUG is assigned in the form

```
DEBUG = OF NNNNLP,
```

where NNNN - the optional part, which determines the number of the unit, on which is produced check-out conclusion. In the absence this part or with NNNN=0 is derived check-out information on all units.

L the optional (in the absence NNNN) part, which determines conclusion LEVEL of check-out information. In the absence this part is counted L=0.

P - the sign OF THE CONTENT of check-out information.

Permissible combinations of values L and P:

P=1- the conclusion of check-out information on the process of solving the system of the nonlinear equations of/[SnLU]/against the step of integration.

Conclusion level:

L=0 - conclusion on each iteration;
L=1- the conclusion only in the absence of convergence at the point of the maximum permissible number of iterations;
P=2- the conclusion of check-out information about the results of the control of a local error in/[LP]/of integration.

Conclusion level:

L=0 - conclusion against each step of the integration;
L=1- conclusion only with the loss of step because of inadmissibly large [LP];
P=3- the united conclusion of check-out information for P=1 and P=2.

Examples of the use of the key parameter DEBUG:

'SHTERM (END=1., DEBUG=2) - It corresponds to the demand of check-out information about the results of control [LP] against each step for all units.

'NEWMARK (END=1., DEBUG=11) - It corresponds to the demand of check-out information on the process of solving [SnLU] only in the absence of convergence against the step before what-or unit.

'SHTERM (END=1., DEBUG=2413) - It corresponds to the demand of check-out information both on the process of solving [SnLU] in the absence of convergence against the step and about the results of control [LP] with the development inadmissible [LP]. Conclusion is accomplished only on unit 24.

The check-out information, concluded based on the key parameter DEBUG, in any event falls beside the file SYSPRINT.TXT. If are prescribed the text regimes of shield (value of the key parameter MODE=0 or MODE=1), then the output of check-out information is duplicated up to shield.

Let us examine based on example from subsection 2.9 information, obtained as far as user before the file SYSPRINT.TXT with the use of the key parameter DEBUG.

As has already been spoken above, it is newly attained assembling the model of coin, after including before the division of the description of object FRAGMENT subtitle MAP (it will follow at the end the text of the description of the object before the title of $RUN or the title of $SHOW). After the realization of assembling model the process of calculation it is possible to interrupt and to analyze the new communication, which was appeared before the file SYSPRINT.TXT:

```
M (D 001) OF THE COMMUNICATION OF THE PROGRAM OF FACTORIZATION.
            Structure of model after renumbering.
            Name of the global fragment          :
            Models of elements and degree of freedom :
1 support (MD) 15 15 15
2 support (UPRL) 15 14
3 forces of gravity (F) 14
4 [Tr].6 (TRGUL) 13 14 6 5 9 8

5 [Tr].5 (TRGUL) 13 14 4 7 6 5

6 [Tr].4 (TRGUL) 13 14 2 1 4 7

7 [Tr].3 (TRGUL) 13 14 11 Oe 2 1

8 [Tr].2 (TRGUL) 13 14 10 12 11 Oe

9 [Tr].1 (TRGUL) 13 14 9 8 10 12
```

This is the news bulletin of the program of factorization, which contains the information about the internal numbers of the models of elements. Before the communications about the error in what-or the model of program library of integration refers precisely down these internal numbers of elements. For example, before the communication:

```
E (R 013) the value of the parameter of the model of the element
           it lies out of the region of the allowed values.
           SUPPLIED GIVEN:
                the name of the model of the element      : TRGUL
                the ordinal number of the model :         4
```

the program of integration refers down the model of element from our example with the identifier “Of [tr].6”.

After the number of model is printed out its identifier before the text of the description of structure (for example, “support”, “support”), after identifier before the brackets is given the name of model (MD, UPRL, TRGUL), and further - the list of the degrees of freedom, with which the model of element is connected. You will focus attention, that before this list of the number of degrees of freedom they do not correspond to their numbers before the user description of the structure of fragment. Since the program of factorization accomplishes an optimum renumbering of degrees of freedom for the purpose of the decrease of filling of the jacobian (see the division of 4 present management), subsequently the program of integration will operate for the sake of these new (internal) numbers of degrees of freedom. Specifically, the list of the models of elements and numbers of degrees of freedom for this purpose and is given.

After generalizing the information given before the text of the communication of the program of factorization, we will obtain the following correspondence between the degrees of freedom in the initial task and the internal numbers of degrees of freedom:

Initial numbers of the degrees of freedom of model (designation of points Fig. 2.8.)	Internal numbers of degrees of freedom
1 2 (point O)	13 14
3 4 (point A)	9 8
5 6 (point B)	10 12
7 8 (point C)	11 Oe
9 10 (point D)	2 1
11 12 (point E)	4 7
13 14 (point F)	6 5

Now we will carry out task for the already formed model, assigning with the calls of the program of integration the different values of the key parameter DEBUG.

2.11.1.Check-out information on the process of solving [SnLU]

With the appearance of a divergence of the process of solving [SnLU] for the development of its reason and list of degrees of freedoms, before which this divergence is manifested, is assigned the conclusion of check-out information first with the value DEBUG = of 11. In this case the task at the point of the calculation for the already formed model will appear as follows:

```
          I RUN:
Calculation 'SHTERM (END=1, DEBUG=11)
          I PRINT :
Result 'DISP ()
```

```
$ END
```

After fulfillment of assignments (it is possible to interrupt after the loss of several steps because of the divergence of the process of solving [SnLU]), the beginning of file SYSPRINT.TXT will appear as follows:

" check-out information on the process of solving [SnLU] "

```
     Designations:
     Time   - the model time;
     Step   - the value of the step;
     Nstep  - the number of the step;
     Niter  - the number of the iteration;
     Px     - the index of convergence regarding the value of the
argument;
     Pf     - the index of convergence regarding the value of the
function;
     X value of the argument;
     dX     - increase in the argument;
     f      - the value of function (deviation from 0.);
     Fs     - the scaling value for the function
              (sum of the abs. values of the components of right side).

     Prescribed maximum permissible standards of the errors:
     DABSU=.100E-01 DRLTU=.100E-02
     DABSI=.100 DRLTI=.100E-02

     Time=.2869457 Of step=.297E-03 NStep= of 72 Niter= 5
      2-> Px=.62E-02 Pf=1.6 X=-.47E-04 dX=-.62E-04  Fs= .16 f= .16
      3-> Px=.87E-01 Pf=1.4 X= of 3.0 dX=-.11E-02  Fs= .14 f=-.14
      5-> Px=.87E-01 Pf=1.4 X= of 3.0 dX= .11E-02  Fs= .14 f= .14
      7-> Px=.95E-01 Pf=1.3 X= of 3.0 dX=-.12E-02  Fs= .13 f= .13
      9-> Px=.62E-02 Pf=1.6 X=-.22E-03 dX= .62E-04  Fs= .16 f=-.16
     12-> Px=.95E-01 Pf=1.3 X= of 3.0 dX= .12E-02  Fs= .13 f=-.13
```

Thus, for each case of the absence of the convergence of the process of solving [SnLU] in this case beside the file SYSPRINT.TXT is derived the following information:

- the current time of the process being simulated (this time, which corresponds to the initial moment of time for the current step of integration, the end of the current step of integration it corresponds to moment of time TIME+STEP);
- the value of the current step of integration (with which the convergence was not achieved);
- the number of the step of the integration;
- the number of iteration. Since is prescribed the conclusion of check-out information only for the steps of integration lost on the divergence, conclusion is accomplished for the last iteration of the step of integration.

Lower than this line is brought out information on each of the degrees of freedom of model, for which was not achieved the convergence against this step. Information for each degree of freedom is given on the separate line before the following order:

- the internal number of degree of freedom;
- the index of convergence regarding the value of argument Px. This index is calculated as follows. For each degree of freedom beyond each iteration of Newton's method is calculated the permissible absolute increase in the independent variable, on the basis of the values of the key parameters DABSU and DRLTU, and also the instantaneous value of the independent variable X (about formula 2.8) given by user. The index of

convergence is defined as the ratio of the increase in the independent variable to that permitted reached. Thus, if the index of convergence exceeds 1, then for this degree of freedom is not achieved convergence on increase in the independent variable;

- the index of convergence regarding the value of function. For determining the allowed value of the deviation of right side from zero are used the values of the key parameters DABSI and DRLTI, and also the sum of the absolute values of the components of right side (formula 2.9). If the ratio of the achieved deviation from zero to that permitted for what or degree of freedom exceeds 1, then for this degree of freedom is not achieved the required precision of fulfilling of the law of conservation for the flows (not executed the condition of equilibrium);
- instantaneous value of the independent variable (the X) and the obtained increase in the independent variable (dX) on this iteration;
- the sum of the absolute values of the components of the right side Of fs=S|F (i)| and deviation from zero right sides of f=SF (i) (algebraic sum of forces or moments, applied from the models of elements, connected down this unit).

Data analysis, given before the fragment of file SYSPRINT.TXT in question, shows that for the first time the absence of the convergence of the solution of the system of nonlinear equations was discovered against 72 steps of integration with the value of the step of integration 0.297e-3 (current time of the process of .2869457 c). Divergence was discovered for 2, 3, 5, 7, 9 and 12 degrees of freedom of object (i.e., the degrees of freedom, which describe motion across the axis of the X points A and D, and motion across the y axis of points B, C, E and F - see the correspondence of the internal degrees of freedom of object to degrees of freedom before the source text, obtained with the data analysis on the demand of #MAP above). All cases of the divergence - based on the parameter Pf (inadmissibly high difference from 0 right side).

It is not always understandable with the task of this regime of the conclusion of check-out information, is absent the convergence of the process of solving the system of nonlinear equations principally, or to the program of integration simply was not sufficient the permitted quantity of iterations for the completion of obtaining the solution. For the more detailed analysis of the process of convergence it is possible to assign the requirement to derive check-out information about the process of solving the system of nonlinear equations on each iteration of Newton's method. But in this case it is necessary to have in mind that the volume of conclusion will grow considerably. Therefore let us carry out the following task for the already formed model:

```
        I RUN:
Calculation 'SHTERM (END=.2866487)
Calculation 'SHTERM (END=1, DEBUG=201)
        I PRINT :
Result 'DISP ()
        $ END
```

The first call of the program of integration will allow us close to match up moment of time interesting us, before the second call is prescribed the conclusion of check-out information on the process of solving the system of nonlinear equations for the second degree of freedom ON EACH ITERATION of Newton's METHOD. For the first program of integration the value of the key parameter END was found as a difference in the current model time, for which was for the first time noted the divergence, and the current step of integration.

In this case the title of check-out information before the file SYSPRINT.TXT will be the same; therefore it is not given. The beginning of check-out information corresponds to 75 step of the integration:

…

```
Time=.2866487 Of step=.159E-03 NStep= of 75 Niter= 1
2->Px=.27     Pf=.22E+03 X= .25E-03 dX= .27E-02 Fs= 28. f=-28.
The required precision is not achieved, passage down the following
iteration.

Time=.2866487 Of step=.159E-03 NStep= of 75 Niter= 2
2->Px=.30     Pf=16.     X= .29E-02 dX=-.30E-02 Fs=1.7 of f=1.7
The required precision is not achieved, passage down the following
iteration.

Time=.2866487 Of step=.159E-03 NStep= of 75 Niter= 3
2->Px=.22E-02 Pf=8.9 X=-.68E-04 dX= .22E-04 Fs=.90 of f=.90
The required precision is not achieved, passage down the following
iteration.

Time=.2866487 Of step=.159E-03 NStep= of 75 Niter= of 4 2->Px=.19E-04
Pf=.56E-03 X=-.46E-04 dX=-.2E-06 Fs=.5E-03 f=.6E-04
The convergence is achieved on the iteration; passage to the error
analysis in the integration at the point of the time.
…
```

It follows from the given information that the process of solving the system of nonlinear equations converges, the parameters of divergence Px and Pf from one iteration to the next decrease substantially and on 4 iterations enter into the permissible limits. The first divergence in this case was discovered against 80 steps (difference with the previous calculated case consists before the fact that the interesting us time interval the program of integration went with the more fine pitch than in the preceding case). Increase in the step to much the same the value (.256e-3) led down the divergence:

```
…
Time=.2876186 Of step=.256E-03 NStep= of 80 Niter= 1
2-> Px=1.4     Pf=.31E+03 X=-.20E-03 dX=.14E-01 Fs=46. f= 46.
The required precision is not achieved, passage down the following
iteration.

Time=.2876186 Of step=.256E-03 NStep= of 80 Niter= 2
2-> Px=.68     Pf=.27E+03 X=.14E-01 dX=-.68E-02 Fs=38. f= 38.
The required precision is not achieved, passage down the following
iteration.

Time=.2876186 Of step=.256E-03 NStep= of 80 Niter= 3
2-> Px=.56 Of pf=98.     X=.68E-02 dX=-.56E-02 Fs=11. f= 11.
The required precision is not achieved, passage down the following
iteration.

Time=.2876186 Of step=.256E-03 NStep= of 80 Niter= 4
2-> Px=.94E-01 Pf=69.     X=.12E-02 dX=-.94E-03 Fs=7.4 f= 7.4
The required precision is not achieved, passage down the following
iteration.

Time=.2876186 Of step=.256E-03 NStep= of 80 Niter= 5
2-> Px=.18E-01 Pf=3.4 X=.28E-03 dX=-.18E-03 Fs=.34 f= .34
The required precision is not achieved, the number of iteration maximum;
recovery down 1-yu iteration with the decrease of the step
…
```

In this case to program permitted quantity of iterations was not sufficient for the successful completion of the step of integration (since the indices of the convergence of the process of the solution substantially were improved from one iteration to the next). With this convergence properties as in the analyzed case, an increase in the permissible quantity of iterations for solving the system of nonlinear equations can lead down an improvement in the statistical indices of the solution (that also was obtained above before point 2.9.1).

2.11.2.Check-out information on the control of local error against the step of integration and control besides the method of forecast according to accelerations (DEBUG, PREDICT)

For the conclusion of check-out information about the lost steps of integration at the point of the criterion of local error is assigned the key parameter DEBUG=12. Task at the point of the calculation, where will be accomplished this conclusion, appears as follows:

```
        I RUN:
Calculation 'SHTERM (END=1, DEBUG=12)
        I PRINT :
Result 'DISP ()
       $ END
```

After fulfillment of assignments (it is possible to interrupt after several steps on the criterion of local error it will be lost), the beginning of check-out information before the file SYSPRINT.TXT will appear as follows:

```
<<[Otladochnaya] information on the control of local error (ЛП) "

Designations:
Time    - the model time;
Step    - the value of the step;
Nstep   - the number of the step;
Pv      - the index of value [LP] (n. < 1.);
Vold    - the value of the controlled variable against the previous step;
Aold    - derivative of the controlled variable;
Vp      - the explicit forecast of the value of the controlled variable;
Vc      - corrected on the basis of the implicit solution
          the value of the controlled variable.

Prescribed maximum permissible standards [LP]:
DABSX=.100 DRLTX=.100E-02


Time=.2851990 Of step=.100E-01 NStep= 39
  1-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
  3-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
  5-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
  7-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
  8-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
 12-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
 14-> Pv=34.   Vold=-3.51 Aold=-12.3 Vp=-3.63 Vc= 3.51
…
```

It is derived for each integration beside the file SYSPRINT.TXT lost on the criterion of a local error in the step:

- the current time of the process being simulated (as in the preceding case, this - moment of time, which corresponds to the beginning of this step of integration);
- the value of the current step of integration (with which the convergence was not achieved);
- the number of the step of integration.

Lower than this line is brought out the list of the degrees of freedom of model, for which a local error in the step of integration exceeds that permitted. Information for each degree of freedom is given on the separate line before the following order:

- the internal number of degree of freedom;
- the index of convergence on the criterion of local error, which is calculated as follows. For each degree of freedom beyond each step of integration is calculated the allowed value of local error, on the basis of the values of the key parameters DABSX and DRLTX, and also the instantaneous value of the controlled potential variable Vc given by user (see formula 2.4.a). The index of convergence is defined as the relation of the current local error in the step (it is evaluated according to values Vp and Vc - formula 2.2) to the instantaneous value of the permissible local error in the step. I.e., if the index of convergence exceeds 1, then a local error in the step of integration exceeds that permitted;
- the instantaneous values of the controlled variable and its derivative against the previous step of integration. Based on these values the value of the integration of the value of the controlled variable forecasted against this step (it also it depends on the given value of the key parameter PREDICT) is calculated;
- forecast and corrected of the value of the controlled variable for this step of integration.

As it was said above, the value of the controlled variable forecasted for this step of integration is determined depending on the instantaneous value of the key parameter PREDICT.

If PREDICT = 0, then Vp = Vold + Of aold * OF STEP (it is used a constant forecast on the accelerations). If PREDICT=1, then is used already linear forecasting on the accelerations, i.e., the forecast of the acceleration of this step is calculated based on the formula

Ap = Aold + OF STEP * DA,

where DA - the rate of change in the acceleration.

For computing the forecast on the speed is used already this value of acceleration. The beginning of check-out information with the calculation with the given value of the key parameter PREDICT=1 they are given below:

```
…
Time=.2852140 Of step=.559E-05 NStep= 61
  1-> Pv=1.0 Of vold=-1.57    Aold= .209E+06 Vp=-.61E-01 Vc=-.27
  8-> Pv=1.0 Of vold=-1.57    Aold= .209E+06 Vp=-.61E-01 Vc=-.27
…
```

It is here evident that the value of the speed Vp forecasted for this step already differs from the value Of vold + Of aold*STEP. This, in turn, exerted influence beyond the estimation of local error, value of the step of integration and general statistical indices of calculation. In this case they deteriorated (comparison can be conducted for the task in question, after assigning the key parameter ITR=10 for the purpose of the decrease of influence beyond the results of the statistical analysis of the cases of the divergence of the process of solving [SnLU] and after designing entire process for the duration of one second). However, the general worsening in the statistical indices of calculation for the present instance it is not possible to name the general-purpose phenomenon. In certain cases the task of the key parameter PREDICT can improve the statistics of calculations.

2.11.3.Selection of the simplest example with an abrupt change in the potential for one of the degrees of freedom (DABSX, IGNORE, CONTROL, DEBUG)

Still some interesting, before our opinion, example can become the illustration of the use of the key parameter CONTROL for calculating those processes, where the instantaneous potential jumps variables are present.

Let us examine the simplest example. Before Fig. of 2.9.[a], b. are depicted the design diagrams of the simplest mechanical and electrical systems, for which is characteristic problem considered here. Before the electrical system the generated by source potential of the 1st unit, while before the mechanical - assigned speed 1-y of degree of freedom they have a shape of the pulse of rectangular form. Let us give program for the analysis of process before the appropriate mechanical system:

```
I DATA:
Rigidity = of 1E5;   Mass = 1;   Viscosity = of 1.E2
Speed = 0, 1, 0.5, 0, 0.2, 0, 1.e10
I FRAGMENT:
#BASE: 3
#STRUCT :
[Induktivnost]'K (2 Oe; Rigidity); [Inertsionnost]'M (2 ; Mass)
Damper 'MU (1 2; Viscosity)
Excitation 'VTR (1 Oe; Speed)
#OUTPUT:
Speed 1 'the V (1; 1);        Speed 2 'the V (2; 1)
Number of step 'STATNS ()
Iterations down [shag]'STATNI ();     Logarithm of step 'STATST (; 0)
#MAP
I RUN :
Calculation 'SHTERM (END=1)
I PRINT :
Result 'DISP (;    Speed 1, speed 2,
                       Number of step,
                       Iterations down the step, the logarithm of step)
$ END
```

Before this program for the derivation of the current statistical parameters of the process of calculation are used the programs STATNS (conclusion of the number of the current step of integration), STATNI (conclusion of a quantity of iterations on this step of integration) and STATST (derivation of the value of the current step of integration).

As it was expected, calculation was completed by crash. In order to assign the goal-directed conclusion of check-out information, we analyze the internal numeration of the degrees of freedom of the model in question, information about which is brought out in SYSPRINT.TXT (before the global fragment it is present the subtitle of #MAP):

```
M (D 001) OF THE COMMUNICATION OF THE PROGRAM OF FACTORIZATION.
           Structure of model after renumbering.
           Name of the global fragment          :
           Models of elements and degree of freedom :
1 excitation (VTR) by 1 Oe
2 damper (MU) 1 2
3 inertness (M) 2
4 inductance (K) 2 Oe
```

Thus, the numeration of the units of model after factorization remained before (as before Fig. 2.9.). Before this example us will most of all interest check-out information about the first degree of the freedom, for the sake of which is connected not one inertia element. By the way, before the file SYSPRINT.TXT is one additional front-pager, which diagnoses the described by us situation, namely:

```
W (R 031) before the formed model is present unit,
   inertial characteristics of which are not determined.
           SUPPLIED GIVEN:
              the number of unit (after renumbering):         1
```

The appearance of this communication speaks, that in the case of the actions, which produce an abrupt change in the potential variable, for such units there can be the problems.

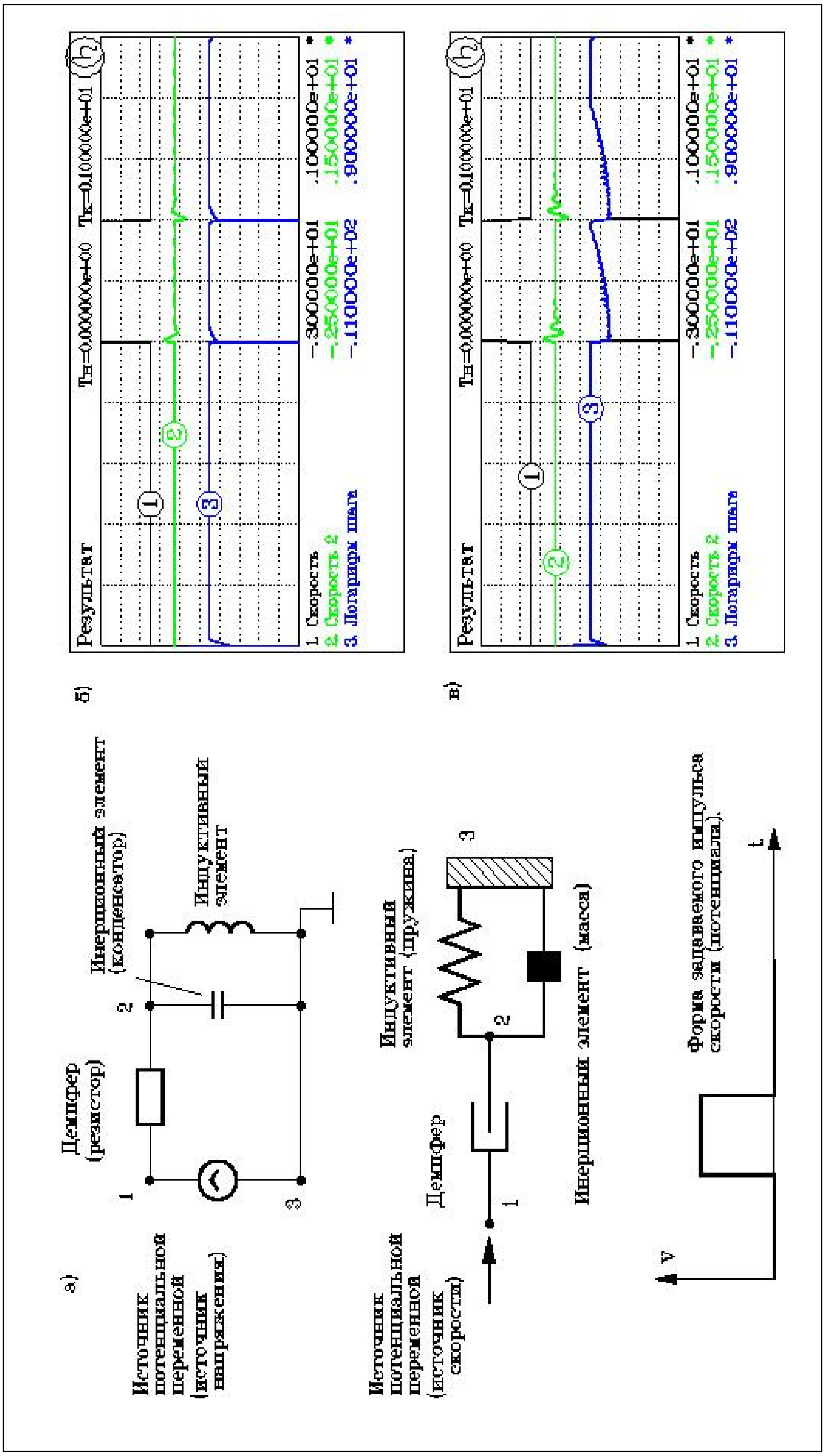


Fig. 2.9. **Comparison of the different methods of the simulation of processes for the sake of an abrupt change in the potential variable:**
a) the design diagram of electrical and mechanical systems, the potential of the 1st unit change intermittently;
b) the results of calculating the mechanical system, obtained by an increase in the permissible local error;
c) results are the obtained uses of the key parameter CONTROL.

Let us carry out the following task for the already formed model:

```
        I RUN :
Calculation 'SHTERM (END=1, DEBUG=102)
        I PRINT :
Result 'DISP (; Speed 1, speed 2,
                    Number of step,
                    Iterations down the step, the logarithm of step)
        $ END
```

The parameter DEBUG=102 assigns the conclusion of check-out information on the control [LP] for the first degree of freedom against each step of integration. Interesting us fragment of check-out information from the file SYSPRINT.TXT:

```
…
Time=.4801106 Of step=.100E-01 NStep= 53
1-> Pv=.00   Vold= .000   Aold= .000   Vp= .000   Vc= .000
[LP] in the limits of standard.
Passage down the next step of integration. The selection of step is
determined
by requirement of one of the models of element.

Time=.4901106 Of step=.989E-02 NStep= 54
1-> Pv=.00   Vold= .000   Aold= .000   Vp= .000   Vc= .000
[LP] in the limits of standard.
Passage down the next step of integration. The selection of step is
determined
by requirement of one of the models of element.

Time=.5000000 Of step=.100E-10 NStep= 55
1-> Pv=5.0     Vold= .000 Aold= .000   Vp= .000   Vc= 1.00
[LP] exceeds standard.
Step is minimum. STOP with the communication about the error.


E (R 008) the assigned magnitude of the minimum step of integration not
         it ensures to the required precision.
      SUPPLIED GIVEN:
           the current time :      .50000
…
```

The following thus, occurred. Down the value of the step of integration, selected after the completion of calculation for the interval of the time Of time=.4801106…. Time+Step = .4901106 (53-y the step of integration), began to be shown “the influence” of the being approached front of impact impulse. Model of element (in this case - VTR) " warned” the program of integration that if will be continued the integration with the previous step, then will be passed the beginning of the impact front (it will prove to be inside the analyzed interval). This is evident based on the communication of the program of the integration : “The selection of step is determined as far as requirement of one of the models of element”. As a result this the program of integration somewhat decreased the step of integration and as far as its 54 step " selected” the remained time interval throughout the beginning of impact. Further, in order to overcome the beginning of impact front, the minimum step of integration was selected, but also it did not help to manage the local error, since the new value of the speed of the first degree of freedom is established instantly.

It is possible to attempt to rush by the beginning of impact front “based on the attack”, after forbidding to the program of integration to react on the recommendation of model up the selection of the step of the integration:

```
I RUN :
Calculation 'SHTERM (END=1, DEBUG=102, IGNORE=1)
I PRINT :
Result 'DISP (; Speed 1, speed 2,
            Number of step,
            Iterations down the step, the logarithm of step)
$ END
```

If you attempted to reproduce this action, then they already ascertained that this does not help. Fragment of file SYSPRINT.TXT:

```
…
 Time=.4801106 Of step=.100E-01 NStep= 53
  1-> Pv=.00   Vold= .000   Aold= .000   Vp= .000   Vc= .000
 [LP] in the limits of standard.
 Passage down the next step of integration. The selection of step is
determined as far as the estimation
[LP] against the current step.

 Time=.4901106 Of step=.100E-01 NStep= 54
  1-> Pv=5.0   Vold= .000   Aold= .000   Vp= .000   Vc= 1.00
 [LP] exceeds standard.
 Recovery down the beginning of step with the decrease of the value of
step.

Time=.4901106 Of step=.160E-02 NStep= 54
  1-> Pv=.00   Vold= .000   Aold= .000   Vp= .000   Vc= .000
[LP] in the limits of standard.
Passage down the next step of integration. The selection of step is
determined as far as the estimation
[LP] against the current step.

Time=.4917106 Of step=.100E-01 NStep= 55
  1-> Pv=5.0   Vold= .000   Aold= .000   Vp= .000   Vc= 1.00
[LP] exceeds standard.
Recovery down the beginning of step with the decrease of the value of
step.

Time=.4917106 Of step=.160E-02 NStep= 55
  1-> Pv=.00   Vold= .000   Aold= .000   Vp= .000   Vc= .000
[LP] in the limits of standard.
Passage down the next step of integration. The selection of step is
determined as far as the estimation
[LP] against the current step.

Time=.4933106 Of step=.100E-01 NStep= 56
  1-> Pv=5.0   Vold= .000   Aold= .000   Vp= .000   Vc= 1.00
[LP] exceeds standard.
Recovery down the beginning of step with the decrease of the value of
step.

Time=.4933106 Of step=.160E-02 NStep= 56
  1-> Pv=.00   Vold= .000   Aold= .000   Vp= .000   Vc= .000
[LP] in the limits of standard.
Passage down the next step of integration. The selection of step is
determined as far as the estimation
[LP] against the current step.

Time=.4949106 Of step=.100E-01 NStep= 57
  1-> Pv=5.0   Vold= .000   Aold= .000   Vp= .000   Vc= 1.00
[LP] exceeds standard.
Recovery down the beginning of step with the decrease of the value of
step.
…
```

What did occur? In this case against 53 steps on our requirement the program of integration did not obey the recommendations of the model of element and attempted to make 54 steps of integration maximally large. After obtaining too great local an error, it crushed step to value 0.0016 s, in this case the step of integration ended throughout the beginning of impact front. Therefore step was completed successfully. Since in the limits of this step everything was satisfactory, the program of integration again attempted to increase the step of integration (against 55 step), again was obtained too great an estimation of local error and so forth, until via tests and errors it completes integration before that very time interval to the initial moment of an increase in the impact front, which was in the preceding case [preodolen] at the point of one step of integration. This occurred much more lately (79-y the step of integration). In this case the step of integration was crushed to that minimally permitted and program was completed emergency, since the required local precision was not provide ford. At least, this case of applying the key parameter IGNORE is not the illustration of its successful use. (Yes even hardly it is possible to select this illustration sufficiently simply. As a rule, the use of this key parameter worsens the statistical indices of calculation).

As it was spoken before subsection 2.5, an increase in the permissible local error is principally possible (but not best) resolution of a question. In our case it is necessary to bring the permissible absolute local error in the step down the value, several which exceeds 0.5, since the velocity discontinuity for the first unit will be 1 m/s, which will give the estimation of local error (1-0)/2 = 0.5. Let us carry out this calculation, after assigning the appropriate value of the key parameter DABSX:

```
I RUN :
Calculation 'SHTERM (END=1, DEBUG=102, DABSX=0.500001)
I PRINT :
Result 'DISP (; Speed 1, speed 2, the number of step,
            Iterations down the step, the logarithm of step)
$ END
```

Let us restrain for the moment from the commentaries of the apropos obtained results of calculation and it is repeated it, after assigning the value of the key parameter CONTROL=1.E-8 instead of DABSX:

```
I RUN :
Calculation 'SHTERM (END=1, DEBUG=102, CONTROL=1.E-8)
I PRINT:
Result 'DISP (; Speed 1, speed 2,
            Number of step,
            Iterations down the step, the logarithm of step)
$ END
```

Before Fig. of 2.9.[b]. are represented the results of calculation and the nature of a change in the value of the step of integration for the case, when the calculated difficulties were “of [preodoleny]” the desensitization of the permissible local error. Before the figure it is evident that

- the step of integration at the moment of the beginning of pulse decreased to the value of that minimally permitted. The permissible local error in this case made it possible to continue calculation after the passage of the pulse edge. After this, the process, which began to determine the value of the step of integration, became fluctuations on 2-y of degree of freedom;
- the value of the step of integration fell down that minimally permitted two times (with the passage of front and trailing edge of pulse);

* fluctuations according to the second degree of freedom because of a large error in the integration went out slowly within one period.

An increase in the precision of calculations in this case is possible ***only by decrease of a maximally permitted value of step***, which is actually equivalent to passage to the diagram of integration with a constant step (is very wastefully).

The results Fig. of 2.9.[v]. are obtained by the second calculation with the value of the key parameter Of cONTROL=1.e-8. In this case in user the possibility to control the precision of the solution remains, assigning the desired value of the key parameter DABSX (for obtaining the given before the figure results the value of absolute component of the permissible local error it was equal to 1e-5). In this case:

* the value of the step of integration fell down that minimally permitted two times (with the passage of front and trailing edge of pulse). After the passage of each of the pulse edges the value of the step of integration was determined as far as fluctuations according to the second degree of the freedom;
* fluctuations according to the second degree of freedom in this case were tracked based on the required precision, since in the limits of the analyzed interval (with exception only of front and trailing edge of pulse) the value of the step of integration nowhere descended to the given value CONTROL.

If we in greater detail analyze the behavior of the program of integration in the region of leading impulse front, let us be turned again down the contents of file SYSPRINT.TXT:

```
     …
     Time=.4901106 Of step=.989E-02 NStep= 54
      1-> Pv=.00     Vold= .000  Aold= .000    Vp= .000    Vc= .000
     [LP] in the limits of standard.
     Passage down the next step of integration. The selection of step is
determined
     by requirement of one of the models of element.

     Time=.5000000 Of step=.100E-10 NStep= 55
      1-> Pv=.50E+05 Vold= .000  Aold= .000    Vp= .000    Vc= 1.00
     [LP] exceeds standard.
     Passage down the next step of integration. The selection of step is
determined
     with the value of the parameter CONTROL.

     Time=.5000000 Of step=.100E-07 NStep= 56
      1-> Pv=.50E+06 Vold= 1.00  Aold=.100E+12 Vp=.100E+04 Vc=1.00    ЛП
     it exceeds standard.
     Passage down the next step of integration. The selection of step is
determined
     with the value of the parameter CONTROL.

     Time=.5000000 Of step=.100E-07 NStep= 57
      1-> Pv=.55E-13 Vold= 1.00  Aold=.101E-05 Vp=1.00 Of vc=1.00
     [LP] in the limits of standard.
     Passage down the next step of integration. The selection of step is
determined as far as the estimation
     [LP] against the current step.
     …
```

Before the region of the leading impulse front of speed the derivative changed intermittently two times; therefore the program of integration it was necessary to complete two steps, equal down the given value of the key parameter CONTROL (56 and 57 steps of integration), after which the selection of the step of integration began to be produced on the requirements of local error. It is obvious that the application of the key parameter CONTROL in such or similar cases not is only justified, but also is very desirable from the point of view of the retention of the required precision of the obtained solution. Furthermore, in contrast to the calculation with the increased value of the permissible error, user does not deprive of itself the possibility to regulate the precision of the obtained solution.

2.12. RARELY UTILIZED KEY PARAMETERS OF THE PROGRAM OF THE INTEGRATION

2.12.1. Linear forecasting on the accelerations against the beginning of step (PREDICT)

Usually the program of integration as the initial approximation at the point of the accelerations against the beginning of step uses the acceleration, obtained against the previous step. In certain cases it is possible to improve the statistical indices of the work of the program of integration, if we make linear forecasting on the accelerations against the beginning of step. This it is possible to reach as far as the task of the key parameter PREDICT=1.

It is very difficult to give what-or the specific recommendations up the use of this key parameter. It is possible to try to use it before several calculations, and if for your tasks this brings benefit, it is better it to use. If worsening in the statistics is observed, return to the value PREDICT on silence.

2.12.2. Control besides time mark before the text regime (TIMER)

If user on what-that to considerations does not arrange the time mark, concluded beyond the shield by the program of integration before the text regime, it can abolish her conclusion (to assign TIMER=0).

2.12.3. Selection of basic variable for evaluating the local error (FLAG)

The estimation of local error can be accomplished on the displacements or on the speeds. As the independent variable at the point of the solution Of [snLU] also can be used both the velocity increments and the increases in the displacements. On silence is accomplished the estimation of local error about the speeds (FLAG=2). If is prescribed the value of the key parameter FLAG=1, then during the estimation of local error and the solution Of [snLU] as the basic variable to assume displacement. In this case it is necessary to have in mind that the recommendations up the selection of the values of the key parameters of the program of integration given above, which correspond at the point of the precision, will be real no longer always.

2.12.4. Selection of the diagram of integration (SCHEME)

The selection of the diagram of integration is accomplished usually by a call of the corresponding program of integration (SHTERM or NEWMARK). Sometimes this is convenient to make by a task of the key parameter SCHEME (especially, if suddenly it arose the improbable need to switch over to the explicit diagram of integration).

The calls of the programs of integration given before each of three examples are equivalent:

a) integration by the method of Newmark:

```
Calculation 'SHTERM (END=1, SCHEME=1)
Calculation 'NEWMARK (END=1)
```

b) integration by Stormer's method:

```
Calculation 'SHTERM (END=1)
Calculation 'NEWMARK (END=1, SCHEME=0)
```

c) integration by the explicit method:

```
Calculation 'SHTERM (END=1, SCHEME=2)
Calculation 'NEWMARK (END=1, SCHEME=2)
```

2.12.5.Checking the inertia properties of degrees of freedom against the beginning of calculation (CHECKM)

On the first iteration of first step working program usually checks the inertia properties of all degrees of freedom of object. For the mechanics this checking is the checking of the presence of masses for the progressive and the moments of inertia for the rotational degrees of freedom. If the inertia properties of what-or they are not determined from the units, then beyond the shield and beside the file SYSPRINT.TXT overhangs the corresponding communication.

User can choke the delivery of the warning communication, after assigning with the call of the first program of integration the key parameter this CHECKM=0. it can be required when it is solved the task, before which a similar situation is normal (such cases they are frequently encountered, for example, with the analysis of electronic circuits). However, it is necessary to remember that with the analysis of the objects, which contain degrees of freedom with the indeterminate inertia properties, the problems with the local precision can arise. It is high probability that as far as you it will be necessary in this case to use the key parameter CONTROL.

2.12.6.Account of the value of the step of the integration, recommended for the sake of the models of elements (IGNORE)

They influence the selection of the value of the sequential step of integration:

- the estimation of the local error;
- success and the rate of the convergence of the process of solving [SnLU];
- explicit limitations down the step of integration.

Sometimes appear the situations, when from the point of view of one or other model or another of element, included in the structure of the analyzed object, it is also desirable to limit the value of the step of integration. On silence these recommendations are considered by the program of integration. If user wants to ignore the recommendations of model up the decrease of the step of integration, it must establish the value of the key parameter IGNORE=1. most frequently the key parameter IGNORE it can be required the developers of the models of elements for testing of elements with the possibility of the forecast of step. With the use of this key parameter can arise some undesirable side effects, which it is discussed below.

1. The model of the source of strength (speed), which depends beyond the time and which contains it is piecewise-linear sections, establish the value of the step of such that the program of integration assuredly would fall beside the salient points of the dependence of effort beyond the time. In the case of the task of the key parameter IGNORE=1 is possible “the breakthrough” of these points of inflection, which will lead down the wave form distortion. If the step of integration exceeds the length of pulse, the investigated by you process can it “not note”.

2. The model of contact element or support forecasts, that through the time interval, equal down the recommended step, can begin the process of contact. This recommendation is done for an improvement in the conditions for work of Newton's method, since a change in the conditions of contact adversely affects its computational characteristics. The task IGNORE=1 can lead down the losses of steps on the divergence of the solution of the system of nonlinear equations against those moments, when the contact of those or others begins tel.

3. The models of some elements can with this step of integration “degenerate” (length, close down the zero, the indeterminate physical conditions, which lead down the fact that the model of element it loses physical meaning and so forth). The task IGNORE=1 can lead down the emergency halt of calculation.

2.13. INTERACTIVE CONTROL OF WORKING PROGRAM (<ALT-C>)

The possibilities of the interactive dialog of user with the working program (as a rule, this need and it does not appear) in PRADIS are not provide ford. The operational mapping of some variables of object they make it possible to follow the calculation (how it is correct and effective).

Can arise the need for interrupting calculation (for example, all interesting user processes has already been completed, or it is established that the calculation was incorrect and continued it must not be. Is possible the situation, when it is necessary to interrupt calculation with the correct retention of the current state of calculation for its possible continuation in the future). With the pressure of the key for <Alt-C> the work of the current program of integration will be interrupted on the completion of the current step of the integration (NOT INSTANTLY, so that if the model of the analyzed object is great, then the completions of step can be waited sufficiently for long!). If before the task the call one additional program of integration is described, then control is transferred to this program, in this case it begins the integration of process based on that moment of time, on which was interrupted the previous program. Before the transfer of control to the following program of integration the buffer of keyboard is cleaned. This is done in order not to cause the immediate completion of the new program of integration, if you randomly pressed down <Alt-C> several times.

3. VISUALIZATION OF OBJECT ABOUT THE RESULTS OF THE CALCULATION

3.1. GENERAL CONSIDERATIONS

The visualization of object is carried out after calculation by specific routine POSTPROCESSOR (see the appropriate document).

Let us transfer the basic possibilities, available in user with the preparation for task at the point of the image of the object,:

- image can be formed automatically according to the description of the structure of object, or the composition of the depicted elements is determined by user clearly;
- beyond the shield it is possible to simultaneously obtain several projections of the analyzed object, each on an arbitrary scale and before any combinations of the depicted elements;
- to observe is possible from the moving coordinate system, connected for the sake of what-or by moving part of the object.

The graphic means is the unit of image - the image element, which corresponds at the point of [otrisovku] of the specific part of the object. In view of this determination each graphic means must be connected for the sake of the counterpart of the object, i.e., “the skeleton” of image appears the structure of the model of object.

There are three basic varieties of graphic means, which are distinguished by their call:

- linked for the sake of the models of elements on silence;
- linked for the sake of the models of elements clearly;
- linked for the sake of the situation, i.e., being used for the image of the stationary parts of the object and its environment.

The first group of that enumerated was called standard graphic means, moreover only one standard graphic means can correspond to each model of element. The standard graphic means of the models of elements are used most frequently with the automatic forming of image according to the description of the structure of the object, when it is necessary to obtain image with the minimum expenditures based on the side of user and, so to speak, “without the undertakings”.

The second group unites, correspondingly, the nonstandard graphic means of the models of elements.

The graphic means of this group are used, in the first place, for the image of the parts of the object, which are represented by the models of elements, which do not have their graphic means on silence (i.e. not having, as a rule, single-valued geometric idea, for example, inertia elements, joint the like).

In the second place, nonstandard graphic means help to give the specific specificity, which makes image to image that more learned, more similar down the real object. And finally some nonstandard graphic means can serve not so much for the image of the current geometry, as for the reflection of the internal state of object (for example, coloring pour on deformations or of stresses).

With the aid of the graphic means of the third group - the graphic means of fixed elements, user has the capability to depict the important based on its point sight of the stationary part of the object, which are not present clearly before the description of the structure of model. This can prove useful both for the elementary improvement in the perception of image and for the visual tracking of the important indices of the fitness for work of object (for example, the control of intersection by moving parts of the boundaries of working zone).

Let us recall that the user can obtain primary information about the current composition of the library of the programs of graphic means on the demand:

```
> ARM?
```

But for obtaining further information about the concrete graphic means one should either make analogous demand with the indication of the name of means or revert to reference book about the programs of graphic means.

Agreement of quantity and type of the degrees of freedom of model and graphic means is the basic criterion of the fitness of the selected graphic means for the tying to the concrete model of element. It is not possible, for example, to use graphic means of girder for the image of plate. But! By program is checked only the agreement of a quantity of degrees of freedom, without the control of their type agreement. A control of the type of degrees of freedom remains on user.

Planning to obtain image beyond the display screen in the form one or several projections of object, user must correspondingly group graphic means in the formations of the following hierarchical level, called layers.

Sense of association beside the layers lies in the fact that the part of the parameters, necessary for obtaining of image and which are been general for the totality of several graphic means, to assign not for each graphic means, but directly for their totality.

Each layer of image is characterized:

- by initial arrangement beyond the shield;
- by the scale;
- by the color;
- by tying to the moving coordinate system.

An arbitrary quantity of graphic means can enter into the composition of layer. A quantity of layers before the image of object also is not limited.

3.2. DIVISION OF THE DESCRIPTION OF THE IMAGE OF THE OBJECT

For the image of object beyond the shield in the course of computation it is necessary to include in the text of task the division of $SHOW. This division before the program always one follows the division of $FRAGMENT. If several fragments, then the division of $SHOW is located above the latter of them.

The description of the image of object must always correspond to the last fragment of task in the sense that the tying of graphic means is possible only to those models of the elements, which enter into last fragment (directly or it is defined by example - by presence before the local fragments, entering as a result the last fragment).

The named lists of the parameters, utilized before the division of $SHOW, must be described either before the division of data of last fragment ($DATA of last fragment), or before the global division of data (unnamed division of $DATA).

3.2.1. Start of the description of graphic means in the description of the layer of the image

The division of #SHOW consists of the description of one or several layers of image. The description of each layer includes the enumeration of the entering it graphic means, the parameters of layer and, if necessary, the list of the degrees of freedom, for the sake of which is connected the moving coordinate system of observer.

We have isolated three varieties of graphic means. Let us examine examples of their start in the description of layer.

1) the standard graphic means - the means of elements on silence. The name of this graphic means searches for by program automatically on the name of the model of element. Therefore for the start of standard graphic means in the image of object it suffices to indicate only the identifier of the element, whose image must be constructed.

For example:

```
Images of some elements 'LAYER (
                     Element 1, element 13, element 25;
                     Parameters of layer)
```

It is possible to also require the image of all elements of object, which have graphic means on silence. In this case the list of the elements, included in the image of layer, is not indicated. For example:

```
All images on silence 'LAYER (; Parameters of layer)
```

Not all models of elements possess graphic means on silence. Therefore with shaping of the layer of image, which consists besides the standard graphic means, program take beside the attention only elements, which have means on silence. References down elements, whose its standard graphic means is absent, will be ignored.

Since the user is not previously informed, does have the element, whose identifier it places beside the description of layer, the standard graphic means, it can be deceived before its expectations and obtain the image of this element on silence. The question arises: how to learn, does have this model of element standard graphic means?

The name of standard graphic means is formed about the specific rules from the name of the model of element corresponding to it. Therefore, knowing the name of the model of element, it is possible to obtain the only possible name of the graphic means of this element on silence and to refine the presence of graphic means with this name before the catalog PRADIS.

Rules for forming the names of the graphic means, connected for the sake of the models of elements on silence, are the following:

- if the name of the model of element contains 4 or 5 symbols, then the name of standard graphic means is the reversed name of the model of element, for example:

the name of the model of the element	the name of graphic means on silence
PLSTU	UTSLP
STRGN	NGRTS
KNTO	OTNK

- if the name of the model of element contains 6 symbols, then before reversing of name last symbol is rejected, for example:

the name of the model of the element	the name of graphic means on silence
BALKA	AKLAB
BALKAN	AKLAB

BALKAD	AKLAB

- if the name of the model of element contains 3 symbols and less, then before the reversing it is supplemented for the sake of symbols “G” to 6 symbols, for example:

the name of the model of the element	the name of graphic means on silence
K	GGGGGK
MU	GGGGUM

2) nonstandard graphic means. For the start of nonstandard graphic means in the image of object it is necessary to indicate the identifier of the depicted element, the name of graphic means utilized for its image and the parameters of graphic means. With the use of nonstandard means the user must attentively study information, for the image of what elements each concrete graphic means can be used.

Example of the description of the layer of the image, which contains the nonstandard graphic means:

```
Images of some [elementov]'LAYER
     (Element 1 (IMAGE1; Parameters of the first means),
       Element 13 (IMAGE2; Parameters of the second means),
       Element 25 (IMAGE3; Parameters of the third means);
       Parameters of layer)
```

3) the graphic means, connected for the sake of the environment of object (graphic means of fixed elements). The means of this group cannot be used for the image of what-or the driving elements of object. For the start in the image of the graphic means, connected for the sake of the environment, it is necessary to assign the name of means and its parameters.

Example of the description of the layer, which contains the graphic means of the fixed elements:

```
Environment 'LAYER (
          (IMAGE1; Parameters of the first means),
          (IMAGE2; Parameters of the second means),
          (IMAGE3; Parameters of the third means);
          Parameters of layer)
```

A difference in the description of the graphic means of fixed element from the description of nonstandard graphic means consists in the absence the identifier of element.

Let us generalize the given information.

The division of $SHOW is included in program for describing the image of object.

It consists of the description of one or several layers of image. The composition of the layer of image can be most diverse and include both the image of entire object and its individual parts. Each layer is characterized as far as its scale of image, as far as its point of the sight of observer and as far as its color.

The basic elements of the description of the layer of image can be examined based on the example:

```
Layer 1 ' LAYER (model 1,
               Model 2 (PGO;  Parameters of means),
                        (PGO2; Parameters of environment);
               Parameters of the layer; 1 2 3)
```

Before this description:

“Layer 1” - the identifier of the layer of the image of the object;
“LAYER” - the name of the program of visualization, utilized in PRADIS;

“Model 1”, “model 2” - the identifiers of the existing before the composition of the model of object elements, whose images must be included in the description of layer. For the image of element with the identifier “model 1” is used the graphic means, which corresponds to this element on silence. For the image of element with the identifier “model 2” is used the graphic means “OF PGO”. The parameters of this means are determined as far as the list of the parameters with the identifier “the parameters of means”;

PGO2 - the name of the graphic means, connected for the sake of the fixed environment of object. The parameters of this means are assigned by the list of the parameters with the identifier “the parameters of environment”;

“The parameters of layer” - the identifier of the list of the parameters, which determines the initial attitude of observer. Distinguish two methods of describing the attitude of observer, described below before points 3.2.2 and 3.2.3. ;

“1 2 Oe” - the optional list of the degrees of freedom of object, for the sake of which is connected a change in the position of observer before the space. If this list of degrees of freedom is not indicated, it is considered that the position of observer before the space on the course of computation does not change. It is necessary to focus special attention on the fact that all degrees of freedom from this list must be encountered before the subsections of #STRUCTURE or #BASE of the latter from the divisions of $FRAGMENT.

An arbitrary quantity of graphic means can enter into the composition of the layer of image. A quantity of layers before the image of object also is not limited. There is a possibility of describing the image of all elements of object, which have graphic means on silence. In this case the list of elements and corresponding to them graphic means, included in the described layer of image, is not indicated.

Example of this description of the layer:

```
Layer 1 ' LAYER (; Parameters of the layer; 1 2 3)
```

NOTE. In image formed on this instruction will be included the graphic means of all elements, which have graphic means on silence and description of which before the structure of object it contains identifier. For example:

```
# STRUCT:

Lever 1 ' BALKA (1 2 Oe 4 5 6; Parameters of lever 1)
Lever 2 ' BALKA (4 5 6 7 8 9; Parameters of lever 2)
   'BALKA (4 5 6 7 8 10; Parameters of auxiliary element)
…
   I SHOW :
Image of object on silence 'LAYER (;
                               Parameters of image)
…
```

Before this example in layer “the image of object on silence” will be included the graphic means of elements “lever 1” and “lever 2”. The graphic means of element without the identifier in the image of object included will not be. It follows from the given information that by no means can be depicted the element of the structure of object, which does not have identifier. It cannot be included in the image of object, which is formed on silence. At the same time it cannot be included in the composition of the image, formed by user, since down this element cannot be made reference before the list of included in the composition of the layer of image elements.

Sometimes this special feature is conveniently used for the exception from the image of object, formed on silence, the images of separate elements. Pravda in this case “invisible” element becomes inaccessible not only for the image, but also for the conclusion based on it of flow variables and components of working vector.

Should be focused attention that in the case of shaping of the description of layer by user, i.e., by the explicit enumeration of the necessary for the mapping elements, the identifiers of elements must be unique. This is important to consider with the preparation of mathematical model, which consists besides the uniform fragments. Before such fragments, despite even the complete identity of structure, the identifiers of the models of the elements, planned for the explicit start in the description of image, it follows to make by those distinguishing.

Let us touch one additional special feature of the tying of graphic means, it is sufficient rare, utilized most frequently during the formulation of the image of object “to order” in conjunction with the development of new nonstandard graphic means. This special feature consists before the possibility of the tying of nonstandard graphic means to the specific group of internal variables. This possibility ensures transmission down the graphic means of information about the state of any degree of freedom of object, any flow variable and any component of the working vector of what-or from the models of elements, entering the model of object.

The start of the description of this graphic means in the layer of image occurs about the general rules for the nonstandard graphic means. But! As the object of tying can serve not only the model of element, but also the specially introduced formation, which unites the necessary group of internal variables and having the identifier, down which it is possible to refer with the tying of graphic means. This formation on the form is the variety of the program of the calculation of the output variable (ПРВП) with a variable quantity transferred down it internal variables (therefore sometimes this method of tying there is tying to OVP). Name of this OVP - ZERO. Before it is possible to transmit different quantity of internal variables of any type.

The graphic means, which have the capability of tying to OVP, can be distinguished as far as the nontrivial value of certified value UNV. The values of the elements of the log book of graphic means overhang along the demand

```
> ARM? <[imya] of the graphic of [obraza]>
```

and they are arranged before the text put out at the end, after reference information.

An example of the discussed case of the tying of nonstandard graphic means is borrowed from the model of the hydro-shock absorber of the automobile:

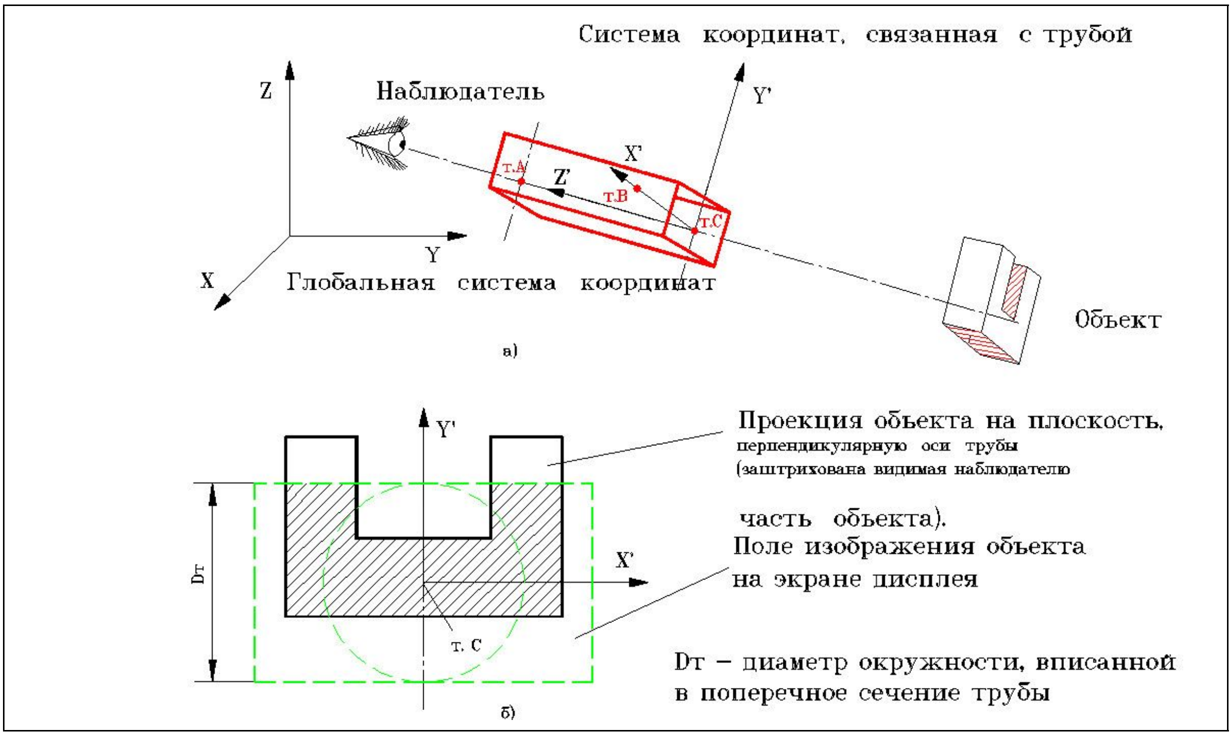
```
$FRAGMENT: AMORT
#BASE:  1, 10, 20
#STRUCT: …..

# OUTPUT:
Case for the valve of compression 'ZERO (6,7,6)
Case for the table 'ZERO (the I: Cavity above the piston (1),
                          The I: Cavity under the piston (1),
                          The I: Cavity of hydro-buffer (1),
                          The I: Hydro- pneumo- storage battery (1),
                          The I: Valve of compression (1),
                          The I: [Kalibrovan].[otv] of the valve of
compression (1),
                          The I: Bleeder valve (1),
                          The I: Valve of output (1),
                          The I: It is calibrated. [otv].[klapana] of
output (1),
                          The I: Bypass valve (1))
          …..
$SHOW:
```

```
     Valve of compression 'LAYER (
                Case for the valve of compression (IKLPSG;
                                                   Point O,
                                 Outer diameter of plunger,
                            the national diameter of internal tube,
                            Outer diameter of [zap]. element,
                           Internal. diameter is center. opening,
                            Internal. the diameter of supporting to
[pov].[sti],
                                    Diameter of the axes of [tsil]. [otv].,
                                    Diameter of [tsil]. openings,
                              Diameter of ring, the diameter of disk,
                                            Height of housing,
                                   Height of the locking body,
                             Height of the throttling ring,
               Height of the disks of valve, the permitted motion of disk,
                                   Height of slot channel,
                            Height of ring, the thickness of ring,
                                 Width of side opening,
                                       Colors of elements, 0);
                                            Tube 4, the color of the
framework 4)
         'LAYER (case for the table (TABLQ; Parameters of histogram);
                                           Tube 0, 0)…..
     $END:
```

Before the given example the graphic means of the valve of compression for the sake of the name IKLPSG is connected for the sake of the degrees of freedom 6, 7 and 6 by means of ZERO with the identifier “case for the valve of compression”, and the graphic means OF TABLQ, intended for the image of the histogram of expenditures, is connected for the sake of the necessary set of flow variables with the aid of ZERO with the identifier “case for the table”.

Fig. 3.1 explains the principles of positioning the image of layer beyond the shield.

Observer sees the object through the tube of rectangular cross section ([ris].3.1a). With the observer and, correspondingly, for the sake of the tube, through which is conducted the observation, is connected the local system of coordinates of X'Y'Z', which in the general case it can be mobile. The image of object is not distorted (i.e., it is scaled equally across all coordinate axes, the promising reduction of the sizes of the distant elements is not produced). Beyond the display screen is reflected the projection of object, perpendicular down the axis of the tube, i.e., of axis Z' (Fig. of 3.1[b]). It does not influence the composition of image, is located the part of the object as a result of the assumed position of observer or before it - entire object is projected down the plane, determined as far as straight lines X' and Y'. in this case the order of the image of elements corresponds to the order of their enumeration before the description of layer, and the order of the image of the layers - to the order of their enumeration before the division of $SHOW.



Picture 3.1. **Illustration to the principles of positioning image beyond the shield.**

Thus, ***regardless of the fact, nearer or further to the observer are located the depicted elements, the visibility of these elements is determined as far as the order of their description before the division of the image of object***.

For the arrangement the images beyond the display screen before the rectangular ***image field of object*** are guided by the following simple rules (Fig. of 3.1[b]):

1) the center of tube ([t].C) is placed down the center field of the image of object.

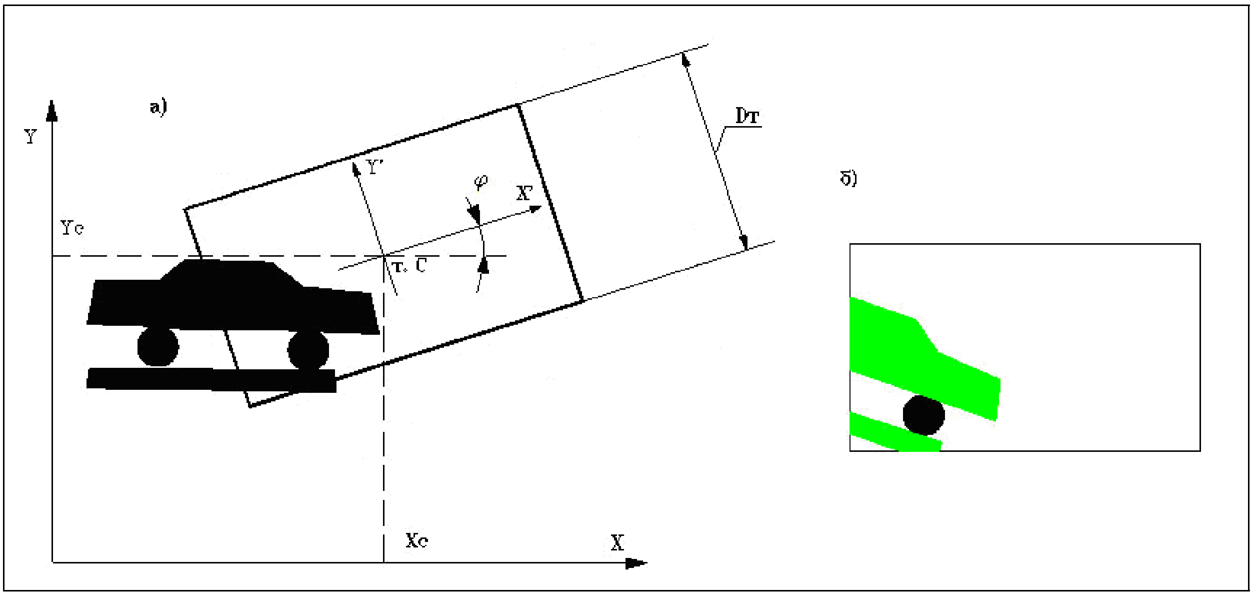
2) the axis X' of the connected for the sake of the tube coordinate system is arranged horizontally (from the point C to the right), axis Y' - it is vertical (from the point C - upward), axis Z' - it is perpendicular down the plane of shield (from the point C down the observer).

3) the cross section of tube coincides precisely for the sake of the boundary ***of the image field of object***. Therefore necessary scaling of image (i.e. the size of image beyond the shield) is reached as far as the selection of the corresponding value of the diameter of the tube of circle (the ***greater*** the diameter, the ***less*** the sizes it will have the obtained image) inscribed in the section.

User has the possibility to assign the initial position of tube and its motion before the space. There are two methods of this description, examined below in points 3.2.2 and 3.2.3. These methods are characterized by a quantity of parameters assigned for each layer and a quantity of degrees of freedom, which describe the motion of observer.

3.2.2. Positioning image beyond the shield and the task of the motion of observer for the flat case

Frequently is used the method of the image of the object, with which the axis Z' of tube coincides for the sake of the z axis of the conglobulation of coordinates (Fig. 3.2). This method is especially convenient for the image of the objects, which accomplish plane motion.



Picture 3.2. **Positioning image beyond the shield for the flat case (z axis' and Z they coincide):**
a) the size of the smaller side of shield (D[t]), of coordinate of center of the screen (X[s], Yc), the angle between the x axis' and the X (φ);
b) the image of object beyond the display screen.

For each layer, which uses this method of positioning the image, five parameters before the following order are assigned:

1) ***diameter of a circle, inscribed in the cross section of the tube*** - is determined the size of the space, which falls in the image field of object. Since the boundary of the image field of object beyond the display screen coincides precisely for the sake of the rectangle of the cross section of tube, for determining of the dimension of image it suffices to assign the size of the smaller side of the section of tube, equal down the diameter of the circle inscribed in the section;

2,3) ***abscissa and the ordinate of point C*** (before the conglobulation of coordinates), which is the center of the cross section of tube and is placed down the center field of the image of the object;

4) ***the initial angle*** between the axes X' and the X before the degrees;

5) ***the color of the image of the elements***, which belong to layer.

If for the layer of image are prescribed five parameters, is counted that the axis Z' of tube at the point of the elongation of entire calculation it remains parallel axis Z of fixed coordinate system. Then a change in the point of view of observer is possible only due to the motion of point C in the plane of XY (and of the motion of point A synchronous with it), and also turning of tube around its longitudinal axis. Thus, for changing the position of observer before the space (connection of observer for the sake of the moving coordinate system) it is necessary to assign the motion of tube according to three degrees of the freedom:

1) the displacement of point C by means of the axis of the X conglobulation of the coordinates;
2) the displacement of point C by means of the y axis of the conglobulation of the coordinates;

3) the turning of tube around the longitudinal axis (i.e., around the z axis).

Example of the fragment of the program, which contains the description of the layer of image for the flat case:

```
     I DATA:
         Size of tube = 1
         Coordinates of point C = 0, 0
         Initial angle = of 30
         Color of image = 1
     …..

     I FRAGMENT :
     #BASE : 1,2, 3
     …..
     {the description of the structure of object and the description of output
variables}
     …..
     I SHOW:
     {For layer 1 is assigned the displacement of observer by means of the
axes:
               X 5-I am degree of freedom;
               Y - 6-I am degree of freedom.          }

              Layer 1 'LAYER (; Size of tube,
                                Coordinates of point C,
                                Initial angle,
                                Color of the image;
                                5, 6,
                                1 {the turning of tube relatively
                                    longitudinal axis it is forbidden})
     {For the layer 2 observers remain fixed} layer 2 'LAYER (; Size of tube,
                      Coordinates of point C,
                      Initial angle,
                      Color of image)
               …..
             $ END
```

3.2.3.Positioning image beyond the shield and the task of the motion of observer for the three-dimensional case

This method of positioning the image is most general common (Fig. 3.3). It makes it possible to describe the arbitrary initial position of observer before the space and to connect the moving coordinate system of observer for the sake of the elements, which accomplish any complex motion.

For determining the position of tube before the space the coordinates of the following points are assigned:

1) point C. lies beyond the axis of tube and is determined the center of the system of coordinates of X'Y'Z'. connected for the sake of it.

2) point A. lies beyond the axis of tube (axis of Z') and its direction before the space is determined together with the point C.

3) point B. determines the position of the plane, passing through axes Z' and X'. let us note that the point B must not lie directly beyond the axis of X', since sometimes it is to difficult assign the coordinates of points A, C and B so that between the axes X' and Z' would be maintained right angle. The direction of axis Y' is determined as far as vector product [CA] x [CB].

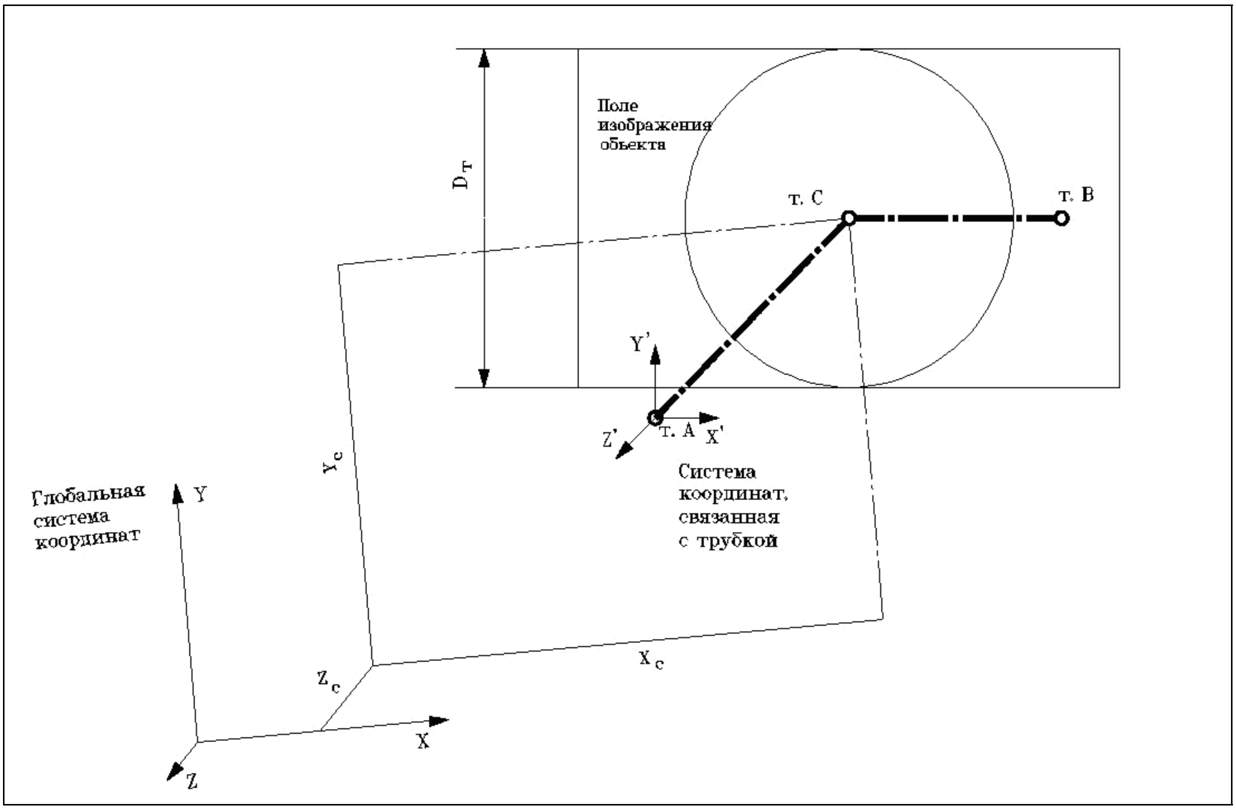


Fig. 3.3. Positioning image beyond the shield for the three-dimensional case.

Thus, the list of the parameters, assigned for each layer of image with the described method of positioning, includes 11 parameters:

1) diameter of a circle, inscribed in the cross section of the tube;

2,3,4) the origin coordinates of the center of tube (point C);

5,6,7) the origin coordinates of point A;

8,9,10) the origin coordinates of point B;

11) the number of the color of layer.

The list of degrees of freedom, which describes the displacement of observer before the space, contains the numbers of nine degrees of freedom:

1) the progressive displacement of point C by means of the axes of the X, Y and Z;

2) the progressive displacement of point A by means of the axes of the X, Y and Z;

3) the progressive displacement of point B by means of the axes of the X, Y and Z.

As before this list of degrees of freedom is optional and, if it is present before the description of the layer of image, it is assigned after the list of the parameters for this layer.

Example of the fragment of the program, which contains the description of the layer of image for the three-dimensional case:

```
I DATA:
   Size of tube = 1
   Coordinates of point C = 0, 0, 0
   Coordinates of point A = 1, 1, 1
   Coordinates of point B = 1, 0, 0
   Color of image = 0
 …..
I FRAGMENT :
#BASE : 1,2, 3
 …..
{the description of the structure of object and the description of output
variables}
…

I SHOW:
{For layer 1 is assigned the complex displacement of observer} layer 1
'LAYER (; Size of tube,
                      Coordinates of point C,
                      Coordinates of point A,
                      Coordinates of point B,
                      Color of the image;
      {the displacement of [t].C} {displacement p. A} {displacement p. B}
              4,5, 1, 4,5, 1, 6,7,8)
      {For the layer 2 observers remain fixed}
Layer 2 'LAYER (; Size of tube,
                      Coordinates of point C,
                      Coordinates of point A,
                      Coordinates of point B,
                      Color of image)
         …..
         $ END
```

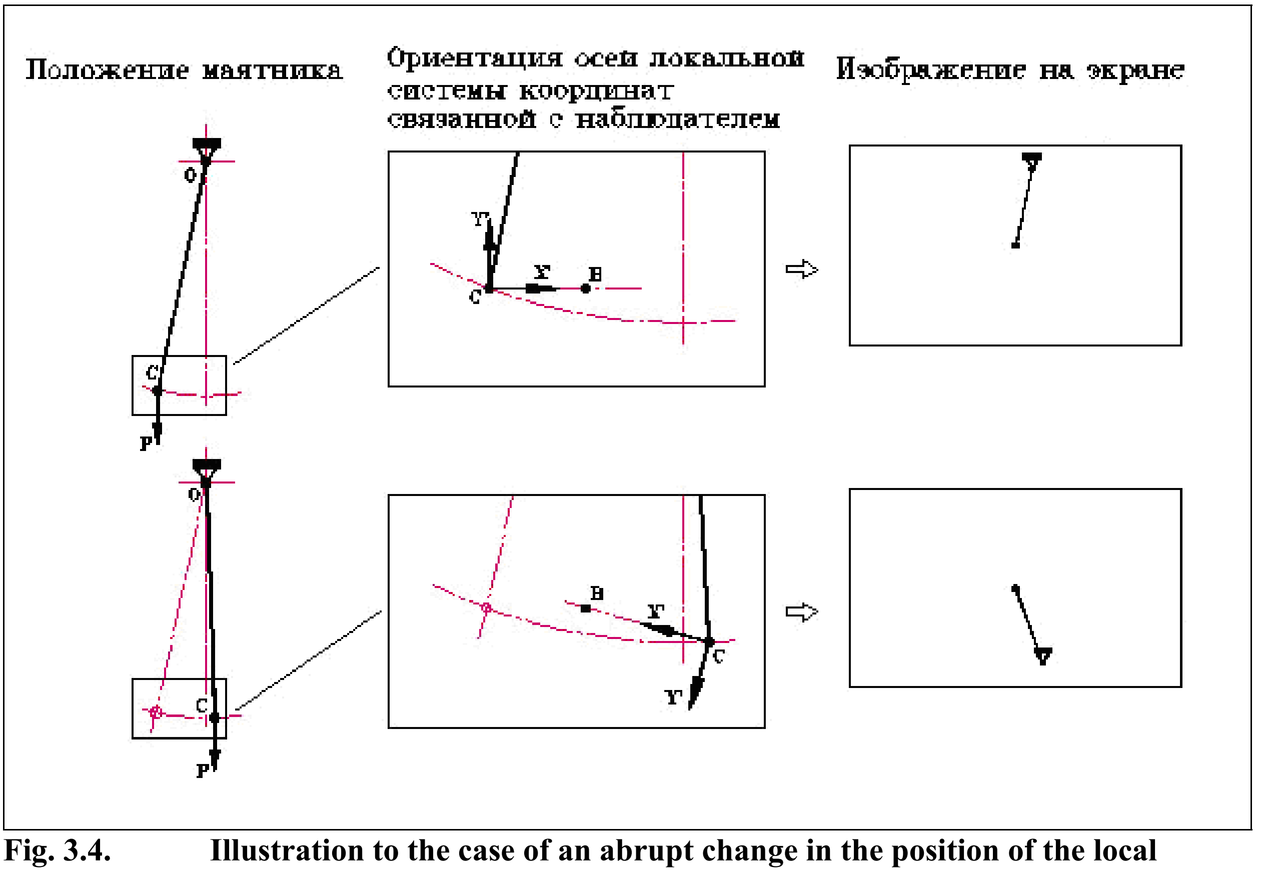


Fig. 3.4. **Illustration to the case of an abrupt change in the position of the local coordinate system, connected for the sake of the observer.**

To link the moving coordinate system of observer for the sake of the degrees of freedom of object is necessary accurately. For example, interesting effect can come out, if as a result motion according to the indicated for the connection degrees of freedom the direction SV, which determines the position of local axes X' and Y', will sharply change.

As an example let us examine the program of the analysis of small swing of the pendulums (Fig. 3.4). Observer is situated before the moving coordinate system. The center of tube is combined with the position of the moving end of the pendulum. The initial position of point B is close down the initial position of the center of tube. In the course of motion the point B remains fixed.

Text of an example down PradiSlang:

```
I DATA:
     Point O = 0, 0;
     Point C =    -0.1,-1;
     Point B =   -0.05,-1;
     Force =    -9.8;
     Inertness = 1., 0.5;
     Material = 1.e-4, 2.e11;
     Diameter of joint = 0.1
     Parameters of tube = 2.5,
                      Point C, 0., point C, 1., point B,
                      0., 0

I FRAGMENT: Pendulum

# BASE: 1,2, 3

# STRUCT :
          Pendulum 'STRGN (1 2 4 5; Point O, point C,
                                   Inertness, material)
             Force 'F (5; Force)
Joint of [nepodvizhnyy]'MD (1 2 Oe; 0, 0)
Joint of [podvizhnyy]'MD (4 5 6; 1, 1.)

# OUTPUT:
  Displacement of the end of the pendulum by means of the X 'the X (4; 1)
  Displacement of the end of the pendulum by means of Y 'the X (5; 1)


I SHOW:
  Pendulum 'LAYER ((OPORAD; Point O, 0,
                                        Diameter of joint, 2,0),
                 Pendulum,
                 Joint is fixed (DOTD; Point O,
                                        Diameter of joint, 1),
                 Joint is mobile (DOTD; Point C,
                                         Diameter of joint, 1);
                             Parameters of the tube;
                                        4 5 1 4 5 1 1 1 1)
I RUN:
     Small swing of the pendulums 'SHTERM (END=1)
I PRINT :
     Results of calculation 'DISP ()
$ END
```

Before the given example the end of the pendulum accomplishes small fluctuations with the amplitude, equal down initial deviation from the vertical axis. However, image beyond the shield can be interpreted as fluctuations with the spread, equal down the length of pendulum. Occurs this because of an abrupt change in the position of the local axis of X', passing through the fixed point B and the moving point C.

Let us note that if the vector product [CA] x [CB] is close down zero (before the initial position or in the course of motion), then the direction of axes X' and Y' becomes indeterminate. In this case the subsystem of visualization assumes the direction of the axes of the local coordinate system, connected for the sake of the tube, THE SAME as the direction of the axes of the conglobulation of coordinates.

A similar situation appears, if, for example, point A coincides for the sake of the point B. this fact can be consciously used, when this projection of object arranges user (at least for the first check-out girders of program) and (importantly!) - when the position of observer before the space does not change. It is in that case convenient to assign only the coordinates of the center of tube, and for the points A and B, without a moment's hesitation, to assign zero coordinates. In this case the image obtained beyond the shield corresponds to projection beyond the plane of XY. With further refining calculations about this model the necessary foreshortening of image can be selected by replacing the parameters - the coordinates of points A and B.

3.3. CONTROL BESIDES THE COLOR OF THE IMAGE

User can determine the color, by which the elements, which belong to this layer of image, will be drawn. Let us recall that at the point of the color of image answers the last parameter before the list of the parameters, assigned for this layer.

This parameter assigns the number of color before the palette PRADIS, which will be used for [otrisovki] of the elements of layer.

Numbers of colors before the palette PRADIS:

N	Color	N	Color	N	Color	N	Color
1	yellow	5	light blue	9	violet	13	gray
2	bright green	6	whitish-blue	10	dark green	14 it is above	white
3	light brown	7	dark red	11	bright red		
4	[rozovokrasnyy]	8	[gryaznozelenyy]	12	dark-blue		

If the number of color is prescribed equal to 0, then for [otrisovki] of layer is used the number of color, equal down the ordinal number of layer before the division the description of the image of object.

If the negative number of color is prescribed, then the color of [otrisovki] of layer will coincide for the sake of the color of the background of the image field of object, i.e., layer it will become invisible. The latter can be useful so that it is rapid (by replacing the parameter) “to rub over” beyond the shield the image of layer.

As an example of the designation of color let us examine the fragment of the program, before which the image of object consists of five layers:

```
…
   I SHOW:
Front view 1 'LAYER (;
                 Parameters of positioning layer 1,2)
View from left 'LAYER (;
                 Parameters of positioning layer 2,0)
Top view 'LAYER (;
```

```
                     Parameters of positioning layer 3,5)
    Isometry 'LAYER (;
                     Parameters of positioning layer 4,0)
    Joint is large 'LAYER (;
                     Parameters of positioning layer 5,100)
    …
```

Before the image of this object the elements of layer “front view” will be painted by the second color (green), since the color is prescribed clearly before the parameters of layer. The elements of layer “view from left” also will be green, since is prescribed the zero number of color, and this layer - the second before the description of image. The elements of layer “top view” will be light-dark-blue (fifth number of color), and layer “isometry” - it is pink-red (this layer the fourth before the description of image). The color of [otrisovki] of the elements of layer “connecting rod it is large” - white, since the number of color exceeds 13.

Before the real applications it is frequently necessary to depict elements after different color in the limits of one projection. In that case for obtaining this projection are described several layers, the lists of parameters of which are distinguished only by last parameter - with the number of color. For example:

```
I DATA:
FRONT VIEW = 2, 0,0,0
Color of crank = 5
Color of connecting rod = 2
Color of slider = 3
Color of joint = 4
…
        I SHOW:
                  Crank 'LAYER (crank;
                                               FRONT VIEW, the color of
crank)
                  Connecting rod 'LAYER (upper part of the connecting
rod,
                                                               Bottom of the
connecting rod;
                                                  FRONT VIEW, the color of
connecting rod)
     Joint 'LAYER (joint A (DOTD; Point A, the diameter of joint A, 1),
                              Joint B (DOTD; Point B, the diameter of joint
B, 1);
                                          FRONT VIEW, the color of joint)
…
```

One additional control capability besides color lies before the parameters of some nonstandard graphic means. Before such means as the parameters is present the, as a rule, assigned color range (example - coloring pour on the distributions of function). With [otrisovke] of such graphic means color control the parameters of means itself.

3.4. CONTROL BESIDES THE VISUALIZATION

The following limited control capabilities besides the image of the object are given to user:

- to [izobrazhat]/[ne] to depict the object;
- to derive beyond the shield the identifiers of the layers of the image;
- to establish the regime of image with the imposition beyond the previous personnel;
- to modify image by replacing the parameters of layers and parameters of graphic means.

Let us examine these possibilities in more detail.

3.4.1.Key parameters of the program of integration CHANGE and MODE

The regime of mapping, analogous down that utilized with the animated cartoon, is the most commonly used case of the image of object in the course of computation. In this case the current image of object completely renews from the step down to the step of integration.

For the renovation of the image of object in the course of computation PRADIS is used two-page technology. I.e., on the page, which is at the given instant invisible, the old image of object completely is rubbed over. The current image of object is drawn after this, and invisible page becomes visible. Against the next step of integration this process is repeated for another page and so forth

User can require to preserve the image of object against each step of integration to, i.e., superimpose sequence down the sequence without the rubbing. This can be required before some tasks for retaining the trajectory of the motion of one or other element or another or for the tracking of the possible intersection of the moving elements of the object with the fixed. This possibility is achieved as far as the task of the key parameter of the program of integration CHANGE=0. in this case all images of object, obtained with the work of the current program of integration, they will remain beyond the shield. Upon transfer to the following program of integration, even in the limits of one and the same task, the image of object renews.

As it was already noted before the previous divisions of present document, the key parameter MODE controls the regime of the initialization of shield. After assigning MODE=0 or MODE=1, it is possible to avoid the initialization of graphic regime and to thus forego both the visualization of object and the conclusion of graphs before the process of calculation.

Furthermore, with the aid of the key parameter MODE it is possible to change the position of the framework with the identifiers of the layers of image, key for <F1> output with the pressure. On silence these identifiers are derived before the lower left angle of view of object. If is prescribed MODE=23, then the framework with the identifiers of layers will be brought out before the upper left angle of view of object. This can be required, when the framework with the identifiers of layers prevents the examination of what-or image details. It is necessary to only have in mind that if the description of image consists of many layers, then the list of their identifiers will be long and a change in the position of the framework with the identifiers of layers will not improve situation.

3.4.2.Use of a means of the replacement of the parameters i REPLACE

Before the first part of the present management the possibility of fulfilling the new target for the already formed model was examined. In this case the user can employ means of the replacement of the parameters of $REPLACE. The lists of the parameters, determined in the new task before the division of $REPLACE, will replace the appropriate lists of the parameters before the initial model. This possibility entirely relates not only down the lists of the parameters, enumerated before the division of the description of the structure of object, but also to the lists of the parameters, which are present before the division of the description of the image of object.

Thus, carrying out task for the already formed model, user can change:

- the geometry of object and, correspondingly, the geometry of its image;
- the parameters, which directly determine these or other properties of the concrete geometric means;
- the parameters of the layers of image, i.e., actually the parameters of positioning image beyond the shield and the color of the image;

Example. Let us assume that user carried out with the aid of the procedure SLANG the forming of the following model:

```
 I DATA:
      {The parameters of the elements of pendulum}
Point O = 0, 0  ;
Point A = 0.5,  -0.5;
Point B = 1.0,  -1.0;
Point C = -1.0,  -0.5
M = 1 ;
J = 1
Material = 1, 0.5, 1E-6, 1E-4, 2E11
Material 2 = 0.1, 0.5, 1E-10, 2E11
Force of gravity = -20
       {The parameters of graphic means}
Size of support = 0.2;
Angle 1 = of 2;
Angle of 2 = 3
Diameter 1 = 0.1;
Diameter 2 = 0.1;
Diameter of spring = 0.1;
Quantity of turns = 20;
Length of pointer = 0.2
       {The parameters of the layers of image}
Size of shield = 2
Initial angle = of 0
Coordinates of center of the screen = 0., -0.9, The initial angle;
Color 1 = 0;
Color 2 = 0;
Color 3 = 0;
Color 4 = 0;
Color 5 = 0

 I FRAGMENT:

#BASE: 1

 #STRUCT:
Pendulum 1 ' BALKA (1 1 2 Oe 4 5; Point O, point A, material)
Pendulum 2 ' BALKA (3 4 5 6 7 8; Point A, point B, material)
Spring 'STERG (1 1 1 Oe 4 1; Point C, 0, point A, 0, material 2)
Mass 'MD (6 7 8; M, J);
Force 'F (7; Gravitational force)
Bracket 'MD (1 1 1; 0,0)
```

```
#OUTPUT:
Speed p. A across the axis X' of the V (6; 1);
Speed p. A across the axis Y' of the V (7; 1)
Angle of rotation of [mayatnika]' of the X (2; 1)
Effort on the spring 'the X (the I: Spring; 1)
Effort before the support across the x axis 'the X (the I: Pendulum 1   ;
1)
Effort before the support across the y axis 'the X (the I: Pendulum 1
(2); 1)

 I SHOW :

Supports 'LAYER ((OPORAD; Point O, 0,
                            Size of support, angle 1,0),
                   (OPORAD; Point C, 0,
                            Size of support, angle 2,0);
                  Size of shield,
                  Coordinates of center of the screen,
                  Color 1)

[Sharniry]'LAYER (bracket (DOTD; Point O, diameter 1,1),
                               Bracket (DOTD; Point C,
                                               Diameter 1,1),
                               Mass (DOTD; Point B,
                                               Diameter 2,1);
                  Size of shield,
                  Coordinates of center of the screen,
                  Color 2)

[Mayatnik]'LAYER (pendulum 1, pendulum 2;
                  Size of shield,
                  Coordinates of center of the screen,
                  Color 2)

[Pruzhina]'LAYER (spring (PRUG; Diameter of spring,
                  Size of shield,
                  Coordinates of center of the screen,
                  Color 2)

Force 'LAYER (mass (ARROW; Point B, the length of pointer, 5);
                  Size of shield,
                  Coordinates of center of the screen,
                  Color 2)

  I RUN :

 Calculation 'SHTERM (END=5, SCALE=1)

  I PRINT :
Swing of the pendulums 'DISP (;
                 Speed p. A across the x axis,
                 Angle of rotation of pendulum)
Efforts before the support 'DISP (;
                 Effort before the support across the x axis,
                 Effort before the support across the y axis)
  $ END
```

Now user can carry out task at the point of the calculation for the already formed model, using division of the replacement of the parameters of $REPLACE. Let us here discuss the possibilities of replacing only those parameters, which relate down the division of the description of the image of the object of $SHOW.

Only named lists of the parameters, which are determined before the division of the description of data and clearly to be present before the division of the description of image, are accessible for the replacement. Thus, for the graphic means of the joint

```
Bracket (DOTD; Point C, diameter 1, 1)
```

accessible for the replacement are the lists of the parameters “point C”, “the diameter 1”. The last parameter, prescribed directly before the description of the parameters of means (in this case it is equal 1), it is inaccessible for the replacement with the aid of the means REPLACE, since this parameter is not named - it lacks identifier.

From the lists of the parameters, intended for describing the parameters of layer, directly accessible for the replacement are the lists of the parameters “size of shield”, “the coordinates of center of the screen”, “color 2”.

IT IS IMPORTANT! You will focus attention, that the list of the parameters “of the coordinates of center of the screen” is composite. Before the division of the description of data this list of the parameters is formed with the use of another list of the parameters - “Initial angle”. In spite of this, the list of the parameters “initial angle” is inaccessible for the direct replacement before the division of $REPLACE, since it is not present clearly before the description of the image of object. In order in this case to change the value of the initial orientation angle of observer, it is possible to use this task:

```
I DATA:
      Initial angle = of 30

I REPLACE:
      Coordinates of center of the screen = 0., -0.9, The initial angle;

$RUN:
...
```

Since directly accessible for the replacement is the list of the parameters “of the coordinates of center of the screen”, it must be described before the division of $REPLACE. But the list of the parameters “initial angle” can be assigned before the division of the description of data, and then used for determining the list of the parameters “of the coordinates of center of the screen”. In the case in question it would be possible to enter and it is simpler:

```
 I REPLACE:
           Coordinates of center of the screen = 0., -0.9, 30;
$RUN:
...
```

And the latter, which would be desirable to say. Following task:

```
I REPLACE:
       Initial angle = of 30
       Coordinates of center of the screen = 0., -0.9,
       Initial angle;
$RUN:
...
```

it does not contradict the syntax of input language PRADIS. Therefore its syntactic analysis will be completed successfully, with the delivery of the communication of the translator “syntactic errors it is not discovered”. However, before the stage of the work of database manager of model the list of the parameters “initial angle”, prescribed for the replacement in this task, will not be discovered before the base of data (since it is not present clearly before the division of the description of image). There will be given out corresponding communication of database manager of S 145, and task will be completed emergency.

3.5. EXPLANATIONS TO SOME SITUATIONS

Concluding the examination of the basic possibilities of the image of object, the authors considered it necessary to additionally explain some situations, for the sake of whom can encounter the user.

1) the division of $SHOW is present before the description of task, nevertheless, the image field of object beyond the shield - empty, the image of object is absent.

There are three basic reasons for this situation.

First, incorrect positioning. It is possible to recommend for the beginning to increase the sector of survey, to for which increase by an order the value of the diameter of the tube of observation. If after this “lost” image does not appear beyond the shield, then probably, is erroneously selected foreshortening, i.e., the direction of the axis of tube.

In the second place, error in the parameters of the graphic means, connected for the sake of the idea of their geometric dimensions.

Third, rarer reason for the absence of image, - before the structure of image fell not one graphic means. This can occur, if image was formed under the assumption the presence for the models of elements, used before the structure of object, standard graphic means, and such it proved to be not for one model of element. This case easily is diagnosed, since the corresponding communications will be given out.

2) one of the image elements left far beyond the framework of the image field of object so far that the overcrowding of the digits of integer occurred with the conversion of its coordinates relative to center of the screen. The coordinates of this element become random, including those entering in the image field of object, which visually can be accompanied by appearance beyond the shield within the limits of the image field of the object of the inexplicable lines.

This situation can be observed in two cases.

With the attempt strongly to first, increase the size of the image of separate parts, “after aiming” the tube of observer at the component interesting and after accepting the size of the section of tube very small in comparison with the dimensions of the surrounding components.

In the second place, when image, is possible even been present at the initial moment beyond the shield, with the high speed “leaves” as a result of its limits and acquires on the course of computation beyond the limits coordinates relative to center of the screen. It is not difficult to estimate, by how many times the coordinates of the outermost element, whose graphic means is included in the description of the layer of image, it must exceed the assigned diameter of tube so that the suspicion down the described situation could arise. If the size of the image field of object, which corresponds to the height of the section of the tube of observer, composes order 300 pixels, and the maximally [predstavimoe] entire two-byte number - order 32000, the exceeding must be not less than 100 times.

4. SOME INFORMATION ABOUT THE PROGRAM OF THE FACTORIZATION

This head throws light on the following questions.

1) the need at the point of the internal numeration of degrees of freedom, the brief characteristic of the algorithms of optimum renumbering.

2) commentaries to the step by step picture of the process of symbolic factorization, the statistical indices of the results of the work of the program of factorization.

3) the key parameters of the program of integration OPTIM, DRAWFCT, which control the process of factorization.

4.1. ALGORITHMS OF THE RENUMBERING OF COMPLEX PRADIS.

4.1.1.Special features of the algorithms of the renumbering

Before the text of subsection STRUCTURE, with the description of the degrees of freedom of the object, down which is connected one or other model or another of element, user uses numbers of degrees of freedom (number of units). Numbers of the units - these are positive integer numbers. The order of their definition, the presence of passages before the numeration are unessential from the point of view of the construction of model before the complex PRADIS.

In the course of syntactic analysis the translator PRADIS automatically accomplishes a renumbering of units. There are several reasons for fulfilling this operation. Basic of them:

- the elimination of passages before the numeration of units and corresponding to them equations;
- the fragments, included in the text of the current fragment, have their numeration, and it is natural that this numeration must not enter beside the conflict with the numeration of the units of the current fragment.

Furthermore, for all fixed units is formed the united equation of equilibrium; therefore all fixed units have united internal number.

After the stage of translation the preparation stage of data for solving the system of the linear algebraic equations of the rarefied structure is accomplished (the so-called symbolic factorization). Before this stage PRADIS it analyzes the structure of the obtained system of equations for the purpose of the decrease of expenditures for its solution during the integration.

In order to be dismantled, as the decrease of expenditures is achieved, let us be turned for example before Fig. 4.1. Is here depicted grid with 25 units (4.1[a]). We will consider that each of these units is connected with all adjacent units by resistors. As experiments with different grids of this type showed, this case is one of unpleasant for the accepted before the complex algorithms of renumbering. If before the stage of translation the internal numbers of units will remain the same as before Fig. of 4.1.[a]., then the structure of system of equations, to this corresponding electrical diagram, will have a portrait, depicted beyond Fig. of 4.1.[b]. before this figure to each element of the analyzed system of equations it corresponds the specific cell. Empty cell means that this element has a zero value, a symbol "X" inside the cell - that this element is nontrivial.

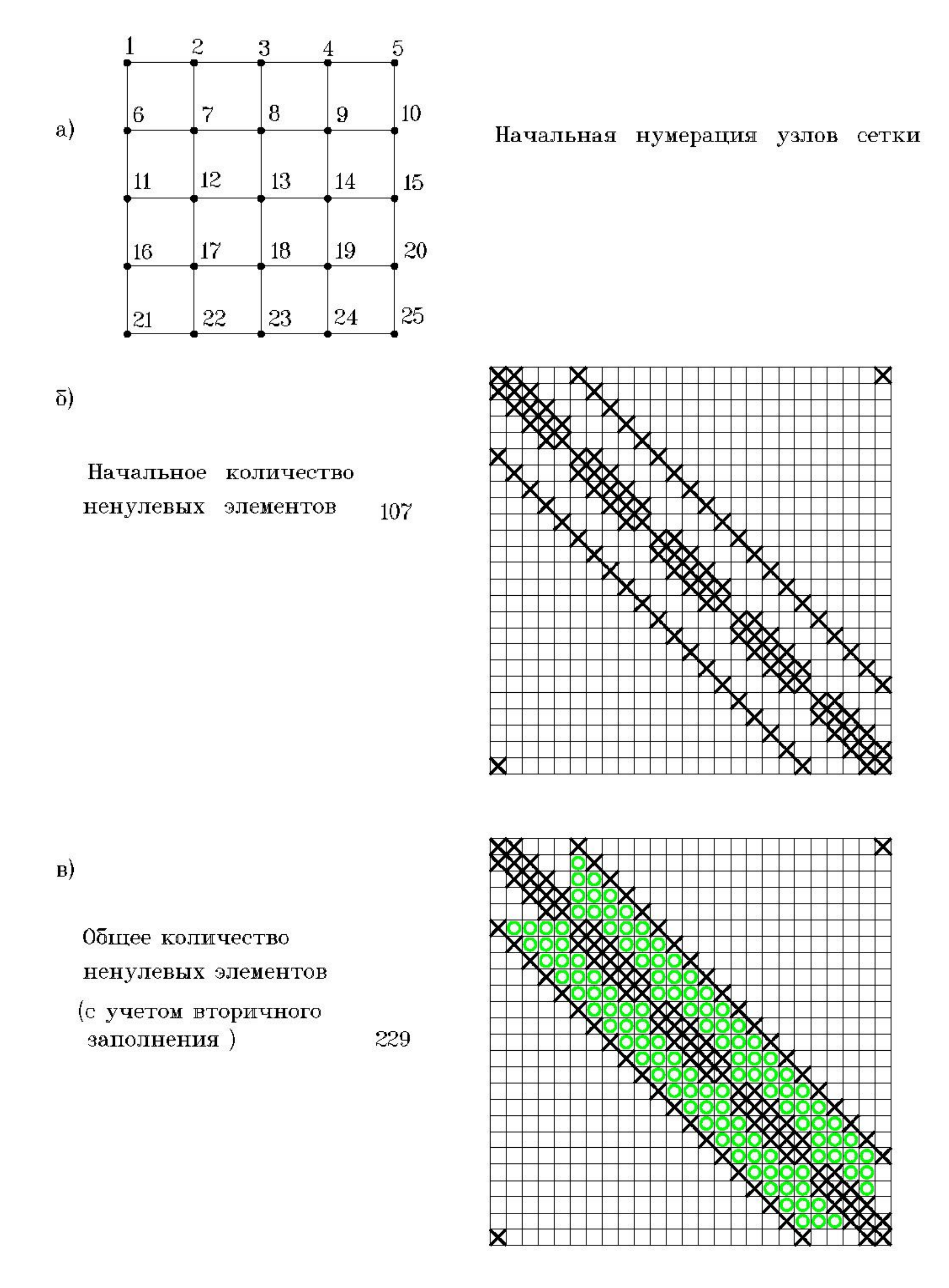


Fig. 4.1. Results of the work of the algorithm of the solution of the system of linear algebraic equations for the resistance grid:
a) the test resistance grid;

b) the arrangement of nontrivial elements before the primary structure of the jacobian;
c) the structure of jacobian after the fulfillment of forward stroke.

User, familiar for the sake of the strip algorithms of finite-element programs, can note here that the obtained system of equations has purely band structure (optimum for the strip algorithms). Typical finite-element program operates only with the tape of nontrivial elements. In this case the zero part of the system of equations before the memory is not stored also before the process of analysis the participation does not assume. The method of Gauss or his equivalent usually are used for solving the systems of the linear equations of the program of analysis. With the realization of the forward stroke of Gauss the portrait of system of equations will take the form, shown down [ris].4.1.[v]. (since the operations for the last equation, which characterizes the equilibrium of the fixed unit, PRADIS does not conduct, subsequently we do not take it into consideration). Here, as before the nontrivial elements, which were present before the initial matrix structure, were designated by the symbol "X", and the elements, which appear with the realization of the forward stroke of Gauss at least for one step of exceptions (second nontrivial elements), - by symbol "O". Second filling in this case is unessential from the point of view of strip algorithms, since does not increase the width of belt.

Let us note the crucial point, not considered by strip algorithms. In the course of solution the program previously dooms entire internal part of the tape down the filling (it would be possible to attempt the part of these elements to save). The width of belt before this example directly depends on a quantity of units on the side of the square of the analyzed grid. The greater the side of square, the greater the width of belt. In this case the total number of workable nontrivial elements will be tentative N*sqrt (N), where it is n-th the dimensionality of system of equations, and expenditure for the realization of the forward stroke of Gauss - tentatively N*N + of 2*N*sqrt (N). Thus, the necessary for solving the system of equations memory grows ultralinearly, and expenditure for the solution - it is quadratic. For the nonsquare grid it is possible to be achieved the best results.

The special feature of the majority of finite-element programs is the fact that the process of the factorization (decomposition) of the matrix of system of equations is carried out, as a rule, one time for each task. Therefore any overhead expenses with the fulfillment of decomposition must be justified during this single decomposition. Based on the other side, to the finite-element programs usually they do not present very stringent requirements on the memory. This typical program can "[virtualit]" - to use a hard drive for the simulation of the necessary working storage.

The special feature of the programs, which accomplish direct integration of the system of differential equations by implicit method, is the fact that at the point of the analysis run the system of linear equations it must be solved many hundred and thousands of times. Therefore desirable to construct a maximally effective algorithm of the solution of similar systems of equations both at the point of the memory and at the point of the time of the solution (memory is here also the limiting factor, since entire program must be accommodated before the working storage of machine. It is bad, if with all expenditures for the solution it is necessary to still "[virtualit]"). One of the approaches to this improvement - this is the straight account of all possible nontrivial elements. Before this algorithm of expenditure for storage of each nontrivial element they will grow, since for each of them it is necessary to memorize, as a minimum, its columnar or small index. Furthermore, it is sufficiently obvious that must grow preparation time at the point of the solution by this method. However, total computational expenditures must decrease due to the considerably smaller expenditures for the storage of matrix and the solution of system of equations (it is solved repeatedly against each step of integration). In the case of adopting this approach it follows the task of the minimization of the width of the tape of the decided system of equations to replace for the sake of the task of the minimization of the appearing second filling.

In PRADIS are used several algorithms, intended for the minimization of second filling. The results of work of three of them are demonstrated down [ris].4.2.

The simplest algorithm accomplishes a renumbering of units (and, correspondingly, equations before the reference system) on the criterion of the growth of a quantity of nontrivial elements before the line of initial matrix. The results of its work are shown before Fig. of 4.2.[a]. by a shortcoming in the algorithm it appears the disregard of an increase in the filling before one or other line or another of initial matrix already on the motion of exceptions.

Other two algorithms - minimum degree ([ris].4.2.[b]) and minimum local filling ([ris].4.2.[v]) - situation after the fulfillment of each step of exceptions is checked. In this case the algorithm of minimum degree against each subsequent step of exceptions as the leading line selects line with a minimum quantity of nontrivial elements, and the algorithm of the minimum local filling - the line, which causes minimum second filling against this step of exceptions.

As the statistics of the carried out calculations shows, the use of these algorithms makes it possible to obtain after the forward stroke of exceptions this structure of the matrix, with which an average quantity of nontrivial elements before the line after the principal diagonal (Q) remains approximately constant for each class of tasks. Value Q weakly depends on the size of the decided task. Taking into account this, expenditure for storage and solution of system of equations they will depend on the size of the decided task is practically linearly (if will be observed deviations from the linearity of an increase in the expenditures, then the time of the solution will be grow more rapidly than the required for the task memory).

As the illustration of these reasonings let us give statistics for two real tasks.

First task - this is the plate, loaded for the sake of the external pressure (task is topologically equivalent to the rectangular grid, which has for each unit it is written three equations, and about one equation as far as the edge, i.e., even more unpleasant than the given higher example).

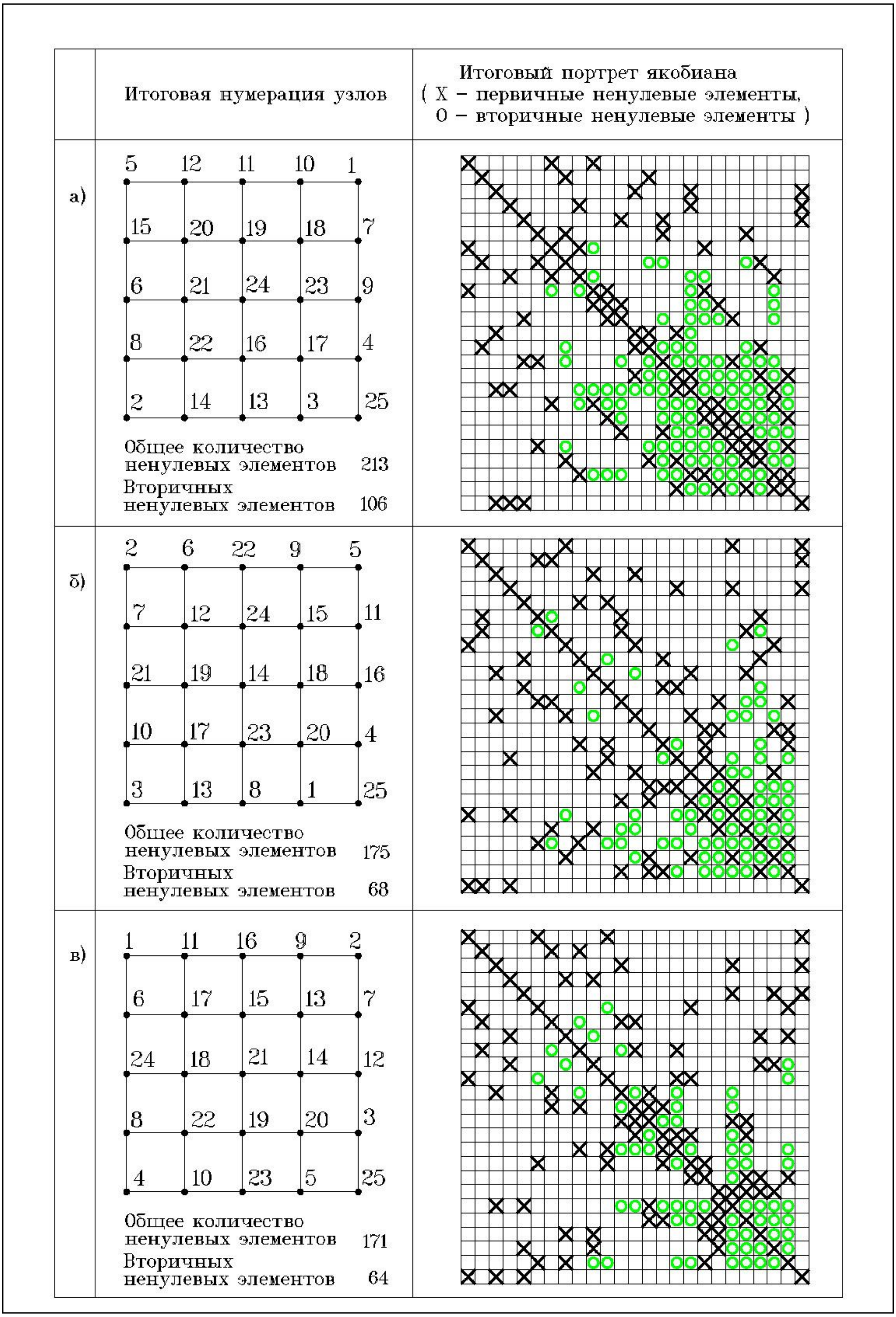


Fig. 4.2. **Results of the work of the algorithms of the optimum numeration of the units:**
a) the algorithm of ordering on the criterion of the growth of a quantity of nontrivial elements before the lines of the initial jacobian;
b) the algorithm of the minimum degree;
c) the algorithm of minimum local filling.

Second task - the finite-element model of crankshaft.

Table 4.1. Statistics of solution of the problem, which describes the behavior of plate under the external pressure.

Cole-before [st].[svobody]	2402	5042	7202	9002	9602	14402
Memory under the massifs (Мб)	3.29	7.24	10.5	13.5	15.0	23.0
[Kb]/[st]. of the freedom	1.37	1.44	1.46	1.50	1.56	1.60

Table 4.2. Statistics of solution of the problem, which describes the load of the fragment of finite-element shaft.

Cole-before [st].[svobody]	1450	2998	4462	9928	10498	23614
Memory under the massifs (Мб)	2.07	4.27	6.40	14.2	15.1	33.9
[Kb]/[st]. of the freedom	1.43	1.42	1.43	1.43	1.43	1.44

Before the first of the given examples an increase in the size of stands depending on the size of task (n) is subordinated down dependence 0.00279 * n * ln n, the secondly the sizes of massifs grow linearly depending on the size of task.

The structures of data utilized before algorithms described above require down the storage of each element of jacobian, except diagonal, 12 bytes of memory (8 bytes - down the storage of matrix element with the computations of double precision, 4 bytes - down the storage of its address). For the small tasks a certain loss in comparison with the strip algorithms, where down the storage of element are required approximately 8 bytes, is obtained. However, for the large tasks, where the gain, obtained by the algorithms of minimum degree and minimum local filling, must be significant, it is expected and the essential savings of expenditures for storage of jacobian.

4.1.2.Levels of the optimization of matrix structure (key parameter OPTIM)

The program of factorization for each task determines the necessary level of the optimization of filling about the size of this task (at the point of a quantity of degrees of freedom = to a quantity of equations before the formed system of equations):

Table 4.3. Selection of the optimization algorithm of filling depending on the size of the decided task.

Size of the task	Optimization level	Algorithm of the minimization of the filling
1 2	0	-
it is 2nd 9	1	the ordering of lines on the growth of a quantity of nontrivial elements before the initial state

10 49	2	the ordering of lines on the growth of the quantity of nontrivial elements, generated by each line before the initial state
50- 199	3	the minimum degree (against each step of exceptions as that leading it is selected the line, which contains a minimum quantity of nontrivial elements)
> 199	4	minimum local filling (against each step of exceptions as that leading it is selected the line, which generates a minimum quantity of new nontrivial elements)

This gradation of optimization levels explains by the fact that with the small dimensions of task the lowest levels of optimization give results not considerably worse, than elders, and in this case they require smaller computational expenditures. Beginning based on the boundary approximately 100 equations the elder levels of optimization they give confidently best results, in this case due to the decrease of filling, an increase in the expenditures for these methods not as is essential as for the optimization of the 1st and 2-GO of level.

For the tasks of any dimensionality, as a rule, the results, given by the method of minimum local filling, somewhat better than the results, given by the method of minimum degree. If the dimensionality of the task - to 200 equations, this gain can be disregarded, since the algorithm of minimum local filling works somewhat more rapid.

Generally, expenditures for the fulfillment of the identical step of exceptions grow depending on optimization level. I.e., they are less for the 0th of level and it is maximally high for the fourth. However, as a result of the fact that the elder methods of optimization considerably more effectively fight with the filling, they carry out the considerably smaller volume of work (sometimes down the orders). They work due to this for the large tasks and it is more effective from the point of view of the decrease of filling and it is more rapid.

User can clearly assign the level of the optimization of matrix structure, using the key parameter of the program of integration OPTIM. In this case the value of the key parameter OPTIM can be prescribed in the limits from 0 to 4 (depending on the required level of optimization). If the required level of optimization is prescribed by user clearly, then it starts after the program of factorization independently of the size of the decided task.

IT IS IMPORTANT! The value of the key parameter OPTIM is actual only with the forming of new model. The call of the program of factorization is not carried out during the starting of task for the already formed model and the optimization of filling is not produced. For changing the algorithm of renumbering the fulfillment of new target at the point of shaping of model is necessary. If in the task at the point of shaping and calculation of new model the call of several programs of integration is indicated, then starts the value of the key parameter OPTIM for the first program of integration.

For example, for the forming of new model is used the task, which contains the following task at the point of the calculation:

```
I RUN:
     First program 'SHTERM (END=1)
      Second program 'SHTERM (END=1.2, OPTIM=3)
…
```

In this case for the optimization of filling of jacobian will be used the value of the key parameter OPTIM on silence (since for the first program of integration it is not prescribed). The value of the parameter OPTIM for the second program of integration will be ignored.

5. PROGRAM OF THE MAPPING

5.1. DIVISION OF TASK AT THE POINT OF MAPPING OF THE RESULTS OF CALCULATION. DIFFERENCE BETWEEN THE OUTPUT AND THAT REFLECTED BY VARIABLES.

Before each PRADIS-to program must be present the division of task at the point of mapping of results after the fulfillment of the calculation - division i PRINT. This division always completes program. It is intended for the conclusion of results after the fulfillment of calculation at the point of different external units and idea of these results before the form convenient for the user. Before the division of $PRINT the programs of mapping are transferred before that order, before which they will be caused as far as the subsystem of mapping the results of calculation.

Several words about what values are accessible for the mapping after the fulfillment of calculation by the working program of complex PRADIS.

The analysis of processes before the models of fairly complicated technical systems leads down the need of calculating the large number (sometimes ten and hundreds of thousands) of different values against EACH step of integration. It is natural that the retention of all results of calculation for each moment of time is impossible. Therefore before the complex PRADIS there is a concept of output variable. Output variables are described before the subsections of #OUTPUT of the fragments, included in the description of the current object. As the results of calculation against each step of integration the information remains only regarding the output variables. This information remains on the hard drive before the file of the results of calculation.

After the fulfillment of calculation for the idea of results before the necessary form it is possible to use the programs of mapping results, described before the present division. It is natural that accessible for the mapping are only the values, described as output variables. The output variable, mapped into one or other form or another with the aid of the program of mapping, is called the here reflected variable. Concepts reflected by variable and output variable are sufficiently close (all reflected variables they must be output. Reverse is not always correct - the part of the output variables can be not claimed and not be reflected).

With the analysis of the results with the aid of the programs of mapping it is necessary to keep in mind, that the first recording beside the file of the results of calculation is accomplished before beginning calculation at the moment of time T = 0 (more precise, after the accomplishment of that initializing of the 0th of step by the first program of integration). Therefore before the majority of the cases the counting of the values of output variables will be produced from zero (or from the values, appropriated to output variable on 0-m step).

5.2. GENERAL INFORMATION ABOUT THE PROGRAMS OF MAPPING. KEY PARAMETERS, WHICH ASSIGN THE REFLECTED INTERVAL OF TIME (START, END).

Before this document two programs of the mapping are described:

DISP - the program of the preparation of data for mapping of the results of calculation beyond the display screen before the program of processing the results of calculation POSTPROCESSOR;

TABL - the program of the conclusion of the table of the results of calculation beside the text file;

Control besides the programs of mapping as by the program of integration, is accomplished with the aid of the key parameters. For each program of mapping is its set of the key parameters, depending on its designation. Identical are only key parameters START and END.

With the aid of the key parameters START and END the user can assign the interval of the time of mapping. Each of these parameters is optional. For the parameter START is accepted zero value on silence, for END - the value of 1.e10.

The value, given by user for the key parameter END, must exceed the value, assigned for the parameter START. Otherwise by the program of mapping is diagnosed the error, communication about which is placed on shield and beside the file SYSPRINT.TXT. Example of this communication:

```
     DISP:  Inadmissible combination of the parameters of the program
                         mapping.
             SUPPLIED GIVEN:
                      the identifier of the program    : Displacement of point
A
                      the parameter START                         :      10.000
                      the parameter END                             :
10.000
```

If the value of the key parameter END lies as a result of the upper limit of the actually calculated time interval, then will be reflected range from moment of time, prescribed AS FAR AS START, to last moment of time, for which there are results of calculation.

If determined as far as the parameters START and END the time interval lies as a result of the limits of the calculated interval, then the program of mapping gives the appropriate communication and stops. For example:

```
     DISP:  Prescribed for graphing temporary
                            interval lies out of the region of the results of
calculation.
             SUPPLIED GIVEN:
                      the identifier of the program     : Efforts before the
support
                      the beginning of the prescribed interval    :
10.000
                      the end of the prescribed interval      :      20.000
                      the time of the first results       :      .00000
                      the time of the last results  :      2.3785
```

In the examined above cases of the diagnosis of error in the key parameters with the delivery of the corresponding communication, the program of mapping, for which was discovered the error, stops, and further either control is transferred to the following program of mapping (if it there is), or the procedure of working task at the point of the mapping completes.

It should be noted that in the case of the repeated use of one and the same key parameter inside one program of mapping the last value of the key parameter will be used, in this case no diagnostic communications it overhangs. For example, in the following case

```
Results of calculation 'DISP (END=5, END=10)
```

the value of finite time will be accepted by the equal to 10 and this program of mapping will continue work.

Its list of the reflected variables can be indicated for each of the programs of mapping. If this list is not indicated, then the program of mapping derives a maximally possible for the utilized display unit (or for this concrete program of mapping) quantity of reflected variables.

Let us examine the structure of the call of the program of mapping onto the following example:

```
Results of calculation 'DISP (END = 5;
                        Variable 1 (2) = (10, 15),
                        Variable 2 = (, -15),
                        Variable 3 = (15, -15),
                        Variable 4)
```

Before this example is provide ford the call of the program of mapping DISP. To program is appropriated identifier “the results of calculation”. From the key parameters is determined only key parameter END, the values of the remaining key parameters are given on silence. Before this call of program it is derived four reflected variables. First of them (“variable 1”) it is multicomponent. Is assigned the conclusion of the second component of this variable (if we for the multicomponent variable do not indicate clearly the number of the concluded component, then on silence will be brought out the first component). For each of three first variables the list of parameters corresponding to this variable (in this case these parameters determine the limits of graphing of variable) is prescribed. For the reflected variable “the variable 2” the first of the parameters is taken on silence, for the variable “variable 4” both parameters are taken on silence.

The list of the parameters, which corresponds to each reflected variable, can be assigned by user only when this provide ford for the utilized program of mapping. In particular, program TABL does not have this list of the parameters. Therefore, if we before the example given above replace the call of program DISP as far as the call of program TABL, anything more changing, then this description will be erroneous.

The case of mapping the variable, which is derived based on the fragment, included in the fragment of upper level, differs from the usual case regarding the fact that the reference down the reflected variable must be composite and include both strictly the identifier of output variable and the identifier of fragment (or the sequence of the identifiers of fragments in the case “deep bedding” of the necessary output variable). Identifiers are separated based on each other by symbol”/“.

We give an example of a similar case, when before the program TABL is prescribed mapping the output variable, which is derived based on the fragment of the lower level:

```
{the switch oned fragment}
I FRAGMENT: [Amort]
# BASE:
# STRUCT:
Spring of the counter of shock absorber 'SV3KT (1 2 Oe 45 46 47;
                              Point A, point G,
                              Initial length of spring,
```

```
                                        Characteristic of compression of spring)
                    …..
    # OUTPUT:
    Effort on the spring 'the X (W: Spring of the counter of shock absorber
(2); 1)
                                                  …..
    {head fragment}
    I FRAGMENT:
    # BASE:   1
    # STRUCT:
    Counter of shock absorber '[Amort] (12,13,…., 34,35)
                                    ….
    I PRINT :
    Results of calculation 'TABL (;
    Counter of shock absorber/effort on the spring)
    $ END
```

5.3. PROGRAM OF THE PREPARATION OF DATA FOR MAPPING OF THE RESULTS OF CALCULATION BEYOND THE SCREEN OF DISPLAY (DISP).

5.3.1.General information about the program of mapping DISP.

This is the most frequently utilized program of mapping. With its aid the user can obtain the graphs of a change of the output variables before the dependence beyond the time or beyond another output variable directly beyond the display screen with the use after the end of the calculation of the program of processing data OF POSTPROCESSOR.

With the single call of program DISP it is possible to derive from 1 to 5 reflected variables. Two parameters are assigned for each of them - the lower and upper limits of graphing. If what-first of these parameters they are not prescribed, then program automatically determines the value of the corresponding limit of graphing regarding the maximum and minimum value, calculated either at the point of entire process (with SCALE=0), or before the time interval of mapping (with SCALE=1).

If for the mapping to program DISP is transferred the list of more than 5 variables, then will be reflected the first of 5 variables this list, and remaining variables will be ignored.

In the case of call DISP without the indication of the list of the reflected variables beyond the shield it is possible to paginally examine the graphs OF ALL output variables. On each such page it is reflected to five graphs.

Table 5.1 gives the enumeration of the key parameters of the program of mapping DISP with the indication of the designation of the parameter, range of its possible values and value on silence (before the brackets before the graph “of limitations down the parameter adopted”).

Table 5.1. *Enumeration of the key parameters of program DISP.*

Name	Purpose of the parameter	Restrictions on parameter	Note
START	the time of the beginning of the mapping	0… 1*1020 (0)	subsection 5.2
END	the time of [okonchaniyaotobrazheniya]	0… 1*1020 (1.e10)	subsection 5.2
FROM	the ordinal number of the variable (before the list of the reflected variables this program), taken at the point of the independent variable; with FROM=0 the graphs are built from the time	0… 5 (0)	subsection 5.3.3
SCALE	the sign of scaling of graphs before the interval of the conclusion; with SCALE>1 the minimum-maximum they are determined for the interval indicated	0, 1 (0)	subsection 5.3.4

5.3.2. Determination of the independent variable with graphing (FROM).

Usually time is considered with graphing as the independent variable. , In order to build graphs depending on one of the output variables, is used the key parameter FROM. It assigns the number of this variable before the list of the reflected variables, prescribed for this program of mapping.

Let us examine, for example, this call of program DISP:

```
Results of calculation 'DISP (FROM=1;
                                  Weight shifting,
                                  Weight shifting = (-0.50, -.55),
                                  Effort of impact)
```

Is here provide ford construction beyond the screen of the display of the graphs of two output variables: “Weight shifting” (second variable before the list, the value of the upper and lower limits of mapping this variable they are determined by user) and “effort of impact” depending on output variable “weight shifting”. Before the same example, will be if prescribed the key parameter FROM=2, as the independent variable will be selected also the variable “weight shifting”, but this time the limits of mapping (i.e., the left and right boundaries of the field of graphing) will be prescribed by user.

The parameter FROM is ignored in two cases.

First, the case, when the list of the reflected variables of program DISP consists of one variable.

In the second place, if the value of the parameter FROM exceeds a quantity of reflected variables, prescribed for the program of the mapping (here it is involved and the case of call DISP with the parameter FROM, but without the list of the reflected variables).

5.3.3. Automatic scaling of graphs on the minimum-to the maximum value of variables before the interval of mapping (SCALE).

Two methods of determining the limits of mapping the output variable usually are used:

- automatic determination based on the maximum and minimum reached in the time computed value of the variable;
- explicit definition by user.

Sometimes it is to convenient use automatic determination of the limits of mapping variables not based on the maximum and minimum value of variable at entire period of calculation reached, but based on the maximum and minimum value of variable before the reflected time interval. For this is used the key parameter SCALE.

If with the call of the program of mapping DISP is prescribed SCALE=1, then the limits of mapping those variables, for which they are not prescribed clearly, they are determined as far as the minimum and maximum value of variable before the reflected interval. Otherwise (if is not prescribed the key parameter SCALE, or prescribed AS FAR AS SCALE=0), the limits of mapping for such variables are determined as far as the greatest and smallest values of this variable in entire time of calculation reached.

5.4. PROGRAM OF THE CONCLUSION OF THE TABLE OF THE RESULTS OF CALCULATION BESIDE THE TEXT FILE (TABL).

5.4.1.General information about the program of mapping TABL.

A program of mapping TABL is conveniently used, when the precise values of what are necessary-or by output variable at the specific moments of time. Program creates text file with the expansion GRF, before which is contained the table of a change of the indicated reflected variables before the dependence beyond the time.

With the single call of program TABL it is possible to derive from 1 to 14 reflected variables. The parameters for the reflected variables are not assigned.

If for the mapping to program TABL is transferred the list of more than 14 output variables, then first 14 of them will be reflected, and remaining variables will be ignored.

In the case of call TABL without the indication of the list of the reflected variables the table of results will be built for 14 output variables. In this case user do not have a possibility to control the list of output variables (they they are selected by program TABL depending on their arrangement before the divisions # OF OUTPUT of the workable task. Beside the table of results will as a rule, fall the latter of 14 output variables).

Table 5.2 gives the enumeration of the key parameters of the program of mapping TABL with the indication of the designation of the parameter, range of its possible values and value on silence (before the brackets before the graph “of limitations down the parameter adopted”).

Table 5.2. ***Enumeration of the key parameters of program TABL.***

Name	Purpose of the parameter	Restrictions on parameter	Note
START	the time of the beginning of the mapping	0… 1*1020 (0)	[podrazdel]5.2
END	the time of the end of the mapping	0… 1*1020 (1*1010)	[podrazdel]5.2
OUT	the step of conclusion on the time	$1*10^{-20}$ … 1*1020 (1*1010)	[podrazdel]5.4.3
FORMF	the flag of control besides the size of the conclusion; with FORMF=1 the size of conclusion with the fixed point	0, 1 (0)	subsection 5.4.3

5.4.2.Example of the use of a program and the description of the structure of the conclusion of the results of calculation.

Let us assume that before the division i PRINT of the program of user is present the following call of program TABL:

```
Results of calculation 'TABL (OUT= 0.025;    Effort,
                              Speed,
                              Acceleration)
```

Let us allow also that the model, for which is accomplished the conclusion of results, is called TEST. Then, after fulfillment of assignments at the point of mapping of results, before the current catalog is created file TEST.GRF. It contains the table of the results of calculation for three indicated with the call of program TABL output variables. An example of analogous table is given before Fig. 5.2.

Before the upper part of the table the list of output variables reflected in this case is printed out. For each this variable they are indicated :

• the marker (symbol of the Latin alphabet, which before the table marked the column, which corresponds to this output variable);

• the identifier of the output variable;

• the number of the component of the output variable (this column it has a value only for the multicomponent output variables);

• the minimum and the maximum of the value of variable before the prescribed interval of conclusion. The interval of conclusion is designated above under the words “the minimum maximum before the interval: “before the brackets.

Before the left column of the table, formed for the sake of program TABL, is derived the time. The step of the construction of table is determined as far as the key parameter OUT (in this case - 0.025 s).

```
                                        Result
 Fogs-   Identifier is number the minimum the maximum
ker of variable [kompo]-       before the interval:
              [nenty] (.000000E+00 - .100000E+01)
 A effort 1     -.114637E+03 of .146368E+02
 B speed 1     -.249016E-08 .100000E+01
 C acceleration 1     -.100000E+03 of .100000E+03
 Step of the derivation of the table of the values:  .250000E-01
--------------------------------------------------------------
I time/Of [marker]I A I B I C of the I
The I---------------The I-------------The I-------------The I-------------
The I
I I I I I
I .000000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .250000E-01 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .500000E-01 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .750000E-01 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .100000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .125000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .150000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .175000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .200000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .225000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .250000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .275000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .300000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .325000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .350000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .375000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .400000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .425000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .450000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .475000E+00 I .000000E+00 I .000000E+00 I .000000E+00 OF THE I
I .500000E+00 OF THE I -.111022E-02 I .111022E-04 I .111022E-02 I
I .525000E+00 OF THE I -.914430E+02 I .100000E+01 of the I -.205591E+01 of
the I
I .550000E+00 OF THE I -.996542E+02 I .100000E+01 of the I -.722020E+01 of
the I
I .575000E+00 OF THE I -.100582E+03 I .100000E+01 of the I -.193287E+00 of
the I
I .600000E+00 OF THE I -.100054E+03 I .100000E+01 I .455801E+00 of the I
I .625000E+00 OF THE I -.999712E+02 I .100000E+01 I .492229E-01 I
I .650000E+00 OF THE I -.999941E+02 I .100000E+01 of the I -.946223E-02 I
I .675000E+00 OF THE I -.999983E+02 I .100000E+01 of the I -.829607E-03 I
I .700000E+00 OF THE I -.999965E+02 I .999967E+00 of the I -.329687E-02 I
I .725000E+00 OF THE I -.855700E+01 of the I -.855700E-09 I .205586E+01 OF
THE I
I .750000E+00 OF THE I -.345820E+00 of the I -.347407E-10 I .722018E+01 OF
THE I
I .775000E+00 I .580113E+00 I .580113E-10 I .193284E+00 OF THE I
I .800000E+00 I .543902E-01 I .538066E-11 I -.455800E+00 of the I
```

```
I .825000E+00 OF THE I -.288091E-01 I -.274052E-11 I -.492237E-01 I
I .850000E+00 OF THE I -.593950E-02 I -.497339E-12 I .946121E-02 I
I .875000E+00 OF THE I -.173626E-02 I -.443614E-13 I .829454E-03 I
I .900000E+00 I .189110E-03 I -.366850E-14 I -.152974E-03 I
I .925000E+00 I .432808E-04 I .212945E-16 I -.102346E-04 I
---------------------------------------------------------------
```

Fig. 5.2. Example of the table of the results of calculation, built for the sake of program TABL

5.4.3.Step of the construction of the table of results (OUT) and control besides the size of conclusion (FORMF).

With the aid of the key parameter OUT it is possible to control the step of the construction of the table of results. On silence its value is taken after equal to 1. of *1010. If user with the call of program TABL does not assign the parameter OUT or assigns such value, which exceeds the time interval of mapping, then beside the file with the expansion GRF overhangs only the cap of the table of results (list of those reflected output variable, their maximum and minimum values for the reflected time interval).

Otherwise, the table of results is built with the step, given by the parameter OUT. User must have in mind the following fact. Since, as a rule, the program of integration uses for the analysis variable step of integration, moments of time, which fall beside the table of [ris].5.2., they will not correspond precisely to moments of time, for which these results remained. Therefore the data, concluded beside the table, are obtained by linear interpolation of the corresponding values of variable based on the file of results.

One additional special feature of program TABL is the presence of the key parameter FORMF. It makes it possible to pass from the not always convenient form of the recording of the numbers with the floating point to the recording of the numbers with the fixed point on the size FORTRANA Of f12.6 (in all for the recording of the number it is used 12 positions, of them 6 for the recording of fractional part). For this is given the value of the key parameter FORMF = 1. if the number it is not placed beside the size indicated, against this place are printed the symbols "*".

Let us return at the point of the example Fig. 5.2. Let us suppose user interests the more detailed conclusion of the results of calculation for time interval of 0.5… of 0.8 s. with the step, let us say, 0.01 s. [pri] this are required to use a form of the idea of the numbers with the fixed point. Then the call of program TABL will appear as follows:

```
Results of calculation 'TABL (START = 0.5, END=0.8,
                             OUT = 0.01, FORMF = 1;
                             Effort, speed, acceleration)
```

The table, built with this call of program TABL, looks like before Fig. 5.3.

```
Result
 Fogs-   Identifier is number the minimum the maximum
 ker of variable [kompo]-       before the interval:
              [nenty] (.500000E+00 - .800000E+00)
  A effort 1     -.114637E+03 of .146368E+02
  B speed 1     -.249016E-08 .100000E+01
  C acceleration 1     -.100000E+03 of .100000E+03
 Step of the derivation of the table of the values:  .100000E-01
 ---------------------------------------------------------------
I[Vremya]/marker I A I B I C of the I
The I---------------The I--------------The I--------------The I--------------
The I
I I I I I
THE I .500000 I .000000 I .000000 I .000000 I
I .510000 I   -99.444039 I 1.000000 I   -59.313466 The I
I .520000 I  -100.659518 THE I 1.000000 I 35.134314 I
I .530000 I   -99.415579 I 1.000000 I   -20.779569 The I
I .540000 I  -100.464125 THE I 1.000000 I 12.266414 I
I .550000 I   -99.654178 I 1.000000 I    -7.220202 The I
I .560000 I  -100.247663 THE I 1.000000 I 4.234966 I
I .570000 I   -99.826511 I 1.000000 I    -2.462061 The I
I .580000 I  -100.119477 THE I 1.000000 I 1.425817 I
I .590000 I   -99.918980 I 1.000000 I     -.812921 The I
I .600000 I  -100.054389 THE I 1.000000 I .455801 I
I .610000 I   -99.964158 I 1.000000 I     -.249620 The I
I .620000 I  -100.023412 THE I 1.000000 I .130474 I
I .630000 I   -99.984773 I 1.000000 I     -.064701 The I
I .640000 I  -100.009689 THE I 1.000000 I .028182 I
I .650000 I   -99.994060 I 1.000000 I     -.009462 The I
I .660000 I  -100.003685 THE I 1.000000 I .000902 I
I .670000 I   -99.997894 THE I 1.000000 I .002046 I
I .680000 I   -99.999994 I 1.000000 I     -.001118 The I
I .690000 I  -100.000867 I 1.000000 I     -.000082 The I
I .700000 I   -99.997606 I .999978 I     -.002187 The I
I .710000 I     -.556439 THE I .000000 I 59.313434 I
I .720000 I .659541 I .000000 I   -35.134277 The I
I .730000 I     -.586982 THE I .000000 I 20.779691 I
I .740000 I .464183 I .000000 I   -12.266274 The I
I .750000 I     -.345820 THE I .000000 I 7.220184 I
I .760000 I .247660 I .000000 I    -4.234958 The I
I .770000 I     -.173486 THE I .000000 I 2.462055 I
I .780000 I .119477 I .000000 I    -1.425816 The I
I .790000 I     -.081018 THE I .000000 I .812919 I
I .800000 I .054390 I .000000 I     -.455800 The I
I I I I I
---------------------------------------------------------------
```

Fig. 5.3. The more detailed conclusion of the results of calculation for time interval of 0.5… of 0.8. Value of the key parameter FORMF = 1