PRADIS

THE TEACHING AID

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

VERSION 4.2

Contents

ANNOTATION

This document is calculated at the point of the user, that takes up the study of program set PRADIS. Together with the account of the primary information, necessary at the point of novice, the solution of several problems is dismantled. The authors strove for the account of material from the simple to the complex. As for all similar benefits, it is extremely necessary that all actions, described here, would be carried out in parallel on THE COMPUTER(S). Desirable, so that not only would be reproduced the actions of the authors, but also were carried out the tasks, given before the text. This will help you more rapidly to begin to independently use a complex for the solution of its problems.

Brief annotation of the heads of present document.

Before **THE INTRODUCTION** are briefly examined the algorithms, assumed as the basis of complex PRADIS. Is given general idea about the method of the forming of the mathematical model of the object in the form of the system of differential equations. Is shown the sequence of numerical methods, which makes it possible to analyze the mathematical model of object before the prescribed time interval.

THE SECOND HEAD tells about the procedural guarantee of a program set. Are examined the procedures of the maintenance system catalog and the fulfillments of assignments, accessible down user before the standard configuration of complex.

IN **THE THIRD CHAPTER** based on the example to the mathematical model of spring pendulum is shown the sequence of the actions, necessary for forming and analysis of mathematical model with the aid of the complex PRADIS. The simplest means of mapping the results of calculation are examined.

IN **THE FOURTH CHAPTER** the means of mapping results are in more detail examined. Several new programs of the calculation of output variables and programs of mapping are dismantled. The concept of indicator down the internal variable is introduced.

Against the beginning **OF FIFTH HEAD** it is told about the means of the replacement of parameters and restoration of the state of calculation, urgent for the large tasks. The more complex example is further examined - the forming of the mathematical model of technological machine for the design analysis. The key parameter of the program of integration, which corresponds at the point of the maximum step of integration, is dismantled based on the example of calculation of one of the fragments of machine. Are introduced the means of the image of object in the course of computation.

IN **THE SIXTH CHAPTER** are dismantled the questions of the forming of the more complex image of object and other possibilities, given to user by the division of $SHOW. Are examined the key parameters of the program of integration, which correspond at the point of the precision of the solution of the system of differential equations.

1. THE INTRODUCTION

Creating this benefit, the authors several times took up writing of conducting. This proved to be unexpectedly complex problem, although about which to write was more or less clear. Even when already was in the rough written the fifth head, introduction as before remained “dark spot according to the bright background of concessional works”. The account of the introductory considerations apropos of application with the design of the mathematical models through two or three paragraphs unavoidably was rolled up to the deep theoretization. Depending on the mood of the one written, the text could be filled for the sake of violet philosophical melancholy or [slonopodobnymi] mathematical formulas. Result was, however, always identical. First, it always pleased the author. In the second place, no one stranger could read it, which served after reliable lock to the document as a whole.

It seems to us, that the lightened form and the style, which for the documents of a similar designation can be attributed to the frivolous, they nevertheless helped us to solve these problems. However, how this corresponds to the reality - to decide to the reader.

1.1. USE OF MATHEMATICAL SIMULATION OF PROCESSES BEFORE THE ENGINEERING CALCULATIONS

Against the beginning of head it would be desirable to propose to the attention of the reader

FAIRY TALE [O] HOW THE ENGINEER OF VA IT MADE WINCH, I THAT THIS LEFT

for the students of the young age and the engineers-the probationers

In a certain reign, a certain state there was a factory. And engineer [Vasya] and working Vanya worked at this factory. If we speak more precisely, worked there a great many people, but remaining people before our narration play the role unessential, unobtrusive.

Said somehow **LARGE PEOPLE** to Ivan to raise certain load down the height 1 meter of 10 centimeters and to immerse him down the platform transport. However, however he tried, however it were struck above the load of [bedolaga], so it could not it even down 10 centimeters raise. Then went Vanya to the engineer and he speaks:

- I heard, that in the countries of overseas, [zarubezhya] of [neblizhnego], for lifting the heavy loads is used [silnomoguchie] of winch. Help to me, rescue from the misfortune. [Nauchi] as to make a winch.

Learned VA Vanya, and that made a winch. However, only began to raise it down the platform load, as rope in winch it was broken, and load struck Vanya the foot. It is painful-it is extremely painful. Went Vanya to [Vase] and he said:

- VA, you is unjust!

VA itself saw that it was unjust. Therefore it reached [shibkomudruyu] book "strength of materials" and it began to count the rope of winch down the strength from the load of deterministic and linear. Soon fairy tale is shown, yes not soon the matter is done. Day considered VA rope, two were counted, one hundred sheets of the paper of writing exhausted, it used up two knobs of ball to the base. On the third day Vasiliy calculated entire. They made a new rope for the winch. Ivan began to raise load the second time, but wind here blew, load began to swing, and the unit of winch, on which the rope was wound, it was broken off. But this time not from static load, but from the load of dynamic. And struck the load of Ivan the hand. It is painful-it is extremely painful. And third time went Vanya to [Vase] and it said to it:

- VA, you is unjust!

VA understood that also this time it was unjust. It reached then the [zhutkokrutuyu] book "of machine parts" and it began to consider any dynamic loads, which act beyond the block and the rope stochastically and it is nonlinear. Day was considered, two were considered, down the third finally all loads it considered. They made to winch a new block. They wound down it rope. Ivan began to raise load down the platform, but this time did not maintain engine asynchronous, with the phase-wound rotor. Began to smoke, caught fire engine from the load of incredible. And fell load to Ivan down the head. Not because the engine burnt from the overloading. This still nothing. But because the brake in winch was normally extended, but not normally closed. Nothing he said this time Vanya [Vase] - drove away it on the coach of fast before the chambers white, resuscitative.

VA again understood that it was unjust. But book necessary it did not have time to already reach, because arrived above it people fiscal, and its [poveli] under the hands white beside the coach under [nazvanem] "of funnels". And saw no one since then either [Vasi] or winch Of [vasinoy]. And was called since then the matter the latter "[lebedkinoy] song".

But Ivan-fool cured himself and went before edge distant, the capital white-stone. He learned there down the engineer. And first whether clever he became, after load did fall to him down the head, then him learned there well, but it began to project such winches, that neither before the fairy tale to say nor foil to describe. But ropes it counted, and blocks, on the basis not only of static, but also dynamic load. But engines asynchronous were selected not only against the moment nominal, but counted currents root-mean-square, and the balance of thermal. But brakes in it were only normally closed, with the reserve large.

And I was there, and he used his winches. Honey-beer down the platforms cargo of plummets, itself and friends by them it treated. Yes here is the misfortune - it flowed across the whiskers, but it did not fall beside the mouth.

Certainly, the fairy tale - lie, yes before it hint, to good fine people the lesson:

1. as a rule, planning new technical object must be accompanied by competent engineering calculation.

2. with the calculation it is necessary to consider the large number of factors. This - different processes (mechanical, electrical, thermal), which occur before the object, and their mutual influence.

One of the methods, which makes it possible to consider with the calculation the large number of the factors - this is mathematical simulation. In the course of simulation the processes before the object or its elements are described in the form the system of differential equations.

Thus, on the model it is possible to reproduce behavior of object, interaction of various elements of it before what-that of concrete situation. For example, if VA used with the planning mathematical simulation, then load all three times would fall not beyond real Vanya, but beyond his model. Furthermore, in the course of simulation it easily could determine loads beyond the rope, block and engine. The emergency of engine before the model could prompt to it (if already it did not read the rule of Gosgortekhnadzor (State Committee of the Council of Ministers for Supervision of Industrial Safety and for Mining Inspection (RSFSR))), that the brake must be normally closed.

The enumerated advantages of the preliminary analysis of the projected object on the mathematical model are obvious. Certainly, some difficulties it would be possible to avoid and by the routine calculation. Most likely, rope would not be broken, brake would operate and so forth but to consider some things with the routine calculation would be sufficiently complicatedly. For example, swaying load will lead down the dynamic loads beyond the rope and the block, the nonuniformity of loads beyond the block will lead down the nonuniformity of torque on the engine and it is unknown, as this nonuniformity it will affect the thermal engine operating mode. The impossibility of the account of many factors before such calculations leads down the high and frequently unjustified safety factors. But most paradoxical proves to be the fact that even these high safety factors sometimes prove to be insufficient.

But based on the other side, to obtain the mathematical model of the object in the form of the system of differential equations also not so is simple. Who tested this bread, that will confirm that this is complicated even with the limited quantity of degrees of freedom before the model. It is first, necessary for the prescribed parameters of object to calculate the coefficients of equations. To in the second place, with the prescribed structure of object not be mistaken before writing of equations themselves. These two points prove to be, as a rule, key and very complex. The rate of the creation of models “is by hand” small, since is very high the probability of errors by this method, and detection and the search for these errors - nontrivial task. Thirdly, it is necessary to solve the obtained system of equations. Already significant experience of the application OF COMPUTER(S) is accumulated in the recent two decades before this direction; therefore this task bears more technical nature and as it seems to us, relatively more simple. However, entire problem before the complex is very imposing, and for the engineer the application of this technology is, as a rule, prohibitive luxury. In any case, no one will make it possible to spend each time one-two-three months, year, two and so forth for the creation of the single mathematical models of concrete objects.

Only possibility of applying the mathematical simulation before the engineering practice - by what-that by means to reduce time down the forming of mathematical model (system of differential equations) and entire process from the forming to the analysis to automate. Before the following subsection it is briefly described, as is realized the automation of the forming of model before the complex PRADIS.

1.2.AUTOMATION OF THE FORMING OF THE MATHEMATICAL MODEL OF THE TECHNICAL OBJECT

When we speak about the automation of the forming of the mathematical model in the form of the system of differential equations, we, of course, do not have in mind some extended at present approaches. Thus, for many contemporary programs it is necessary to introduce the system of equations obtained by user. This system must be preliminary recorded by user, on the basis of its knowledge of subject area. Other software propose to user to calculate and to introduce coefficients for the system of equations of the predetermined form. Many programs of such types do not require that the differential equations would be solved relative to higher derivative even they assume that the system of differential equations can be augmented by nonlinear algebraic and transcendental equations. All this is good, but nevertheless user, must write down equations. “As argonauts beside the old times”, we are set at the point of the table and extract the equations of Lagrange of the second order, suffering above each integral, driving in rebellious diameters, length and the moduli of elasticity beside the coefficients of equation and godlessly making mistakes before the signs. But then by months we fix model.

In PRADIS the forming of the mathematical model in the form of the system of differential equations as its subsequent analysis, is accomplished automatically. For the forming of system of equations the node analysis is used.

Entrance for the program set is the description of the object before the language of the description of object being simulated, which contains this information:

1) information about the structure of object (topology of object);

2) the parameters of object (description of geometry, materials so forth);

3) the description of the designed output variables, which are directly necessary at the point of the user as a result of the solution of the problem of analysis.

As can be seen from given here list, there is no need for introducing what-or information about the coefficients of equations and about their structure. How program does nevertheless obtain the necessary system of equations?

Let us visualize the certain children's designer, before whom of the cubes it is possible to make different objects - house, the machine - the model of the things, which exist before the real peace. For constructing each concrete model it is necessary to take the specific set of the cubes of the corresponding form and to connect by their also specific means. It is understandable that for the model of house it is necessary to take other cubes and to connect them differently, than for the model of tower crane. However, the models of the houses of different sizes, but one structure, can be gathered from the analogous before the form cubes, which are distinguished only by size. Indicate that the models of house and tower crane have the different structure (topology), and two models of house, which are distinguished by the sizes - identical.

Analogously is accomplished the forming of mathematical model with the use of a complex PRADIS. For this to user it is necessary from the existing set “of building blocks” (models of elements) to select necessary for constructing the required model of object. The base set of the models of elements in PRADIS differs from the set “of building blocks” before the children's designer before the basic the fact that before the designer is a limited quantity of elements of identical form. For example, 5 cubes with the side 10 cm, 3 cubes with the side 20 cm, ten parallelepipeds of the specific size and so forth at the same time, if what-that element exists in the library of complex PRADIS, the quantity of elements of such type, which can be used before the model of object, it is unconfined. Each of the “building blocks selected for the forming of the model of object” can be connected with other building blocks in the strictly defined places (degrees of freedom). A quantity and the designation of the degrees of freedom of the model of element is determined before its description. Selecting the different methods of connecting the models of elements, it is possible to describe the objects of different structure.

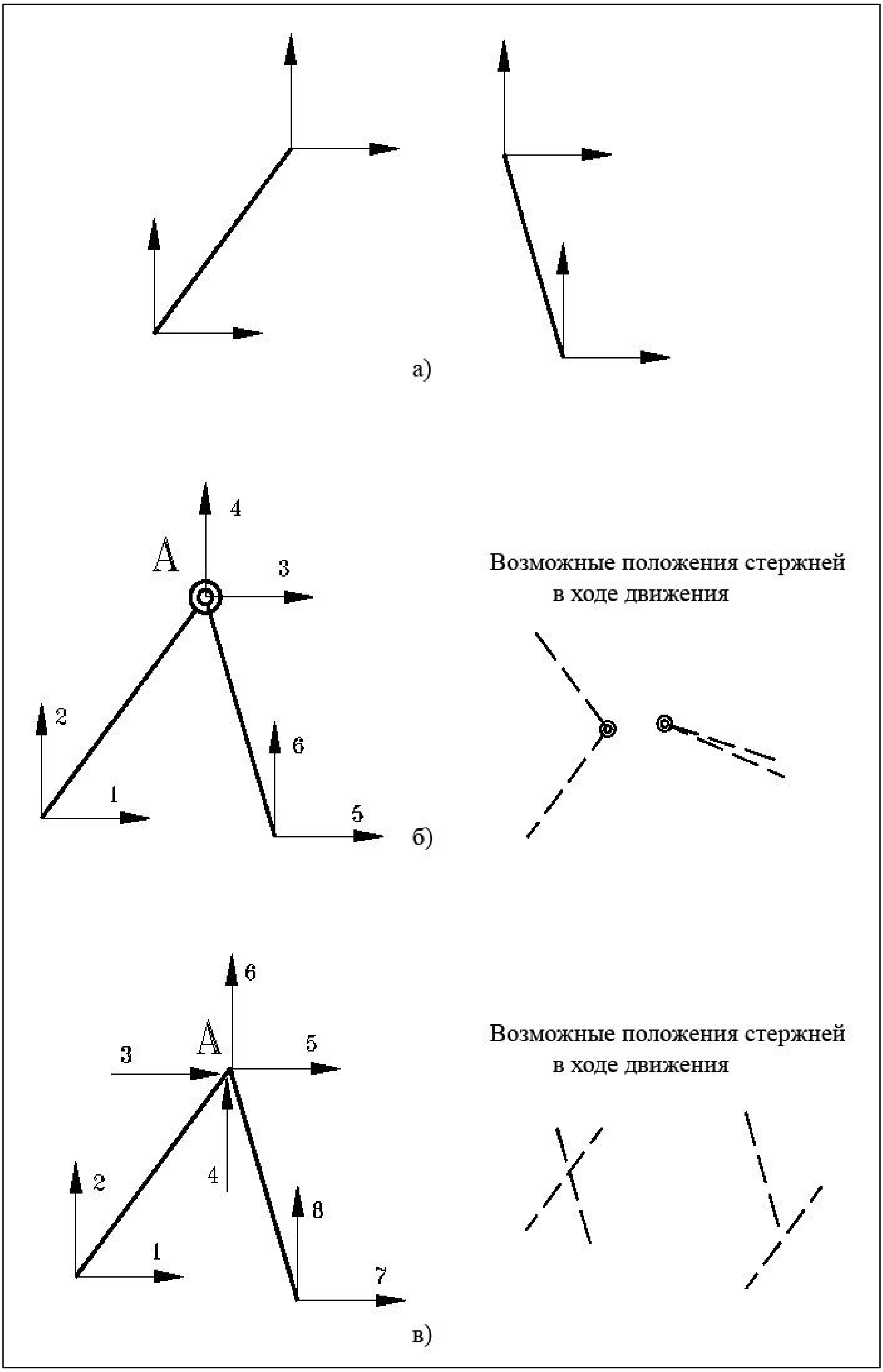


Fig. 1.1. Illustration of the forming of the model of object from "the building blocks":
a) as "the building blocks" are selected two rods, each of which has four degrees of freedom;
b) the articulated coupling of rods (two degrees of freedom general);
c) rods do not have general degrees of freedom.

Let us assume user wants to describe the object, which consists of two hinged fastened rods. If rods are yielding, then each of the rods has four degrees of freedom (Fig. of 1.1[a]). Combining rods at point A and [obyavlyaya], that the ends of the rods at this point move equally (they have the same degrees of freedom), we will obtain the articulated coupling of rods. In this case, each of the rods is as before described by four degrees of freedom, but their numbers for one of the ends of each rod coincide (Fig. of 1.1[b]). At the same time, combining rods at point A, but continuing each of the rods to describe by four degrees of freedom with the different numbers, we will obtain two rods, accomplishing the independent motion (Fig. 1.1[v]).

From a mathematical point of view, the connection of several elements on what-that degree of freedom is analogous for the sake of recording for this degree of freedom of the equation of equilibrium. In this case it is necessary to extract such equations for all degrees of freedom of system, including for the degree of freedom (degrees of freedom), connected for the sake of the coordinate system, relative to which is examined the motion. In PRADIS the degree of freedom, connected for the sake of the coordinate system, is called base. The description of the structure of the complete system of equations of equilibrium is actually equivalent to the description of the structure of object; therefore such equations are frequently called topological. The state of object before each of the degrees of freedom is described by the independent variable, which is subject to determination in the analysis run. Values of the independent variables before each of the degrees of freedom, with which is connected the model of element, are connected for the sake of the equations, which characterize this element (or component). Therefore such equations are called component. The substitution of component equations beside the equations of equilibrium leads down the automatic forming of the system of the differential equations - the mathematical model of object. In the general case this - the system of nonlinear differential equations, which subsequently must be solved by numerical method.

The described algorithm of the forming of mathematical model corresponds to the node analysis, whose basic condition illustrates [ris].1.2. Before the same figure component equations for the simplest elements of the mechanical systems are given - the one-dimensional elastic, one-dimensional viscous and point inertia of elements.

If we attentively examine the algorithm of the forming of the mathematical model of system about the node analysis, it is possible to arrive against several conclusions:

1) the process of the forming of mathematical model by node analysis is general-purpose are inasmuch as general-purpose the equation of equilibrium. It is possible to use it in those the fields of physics, where such equations exist and make physical sense, i.e., practically everywhere (mechanics - the equation of equilibrium, electronics - first Kirchhoff's law, the thermodynamics - the equation of the balance of heat fluxes, hydraulics - the balance of mass flow rates and so forth).

2) the variety of the tasks, which can be solved with the use of this approach, is limited as far as the variety of being had at the disposal of engineer “building blocks” - the models of elements.

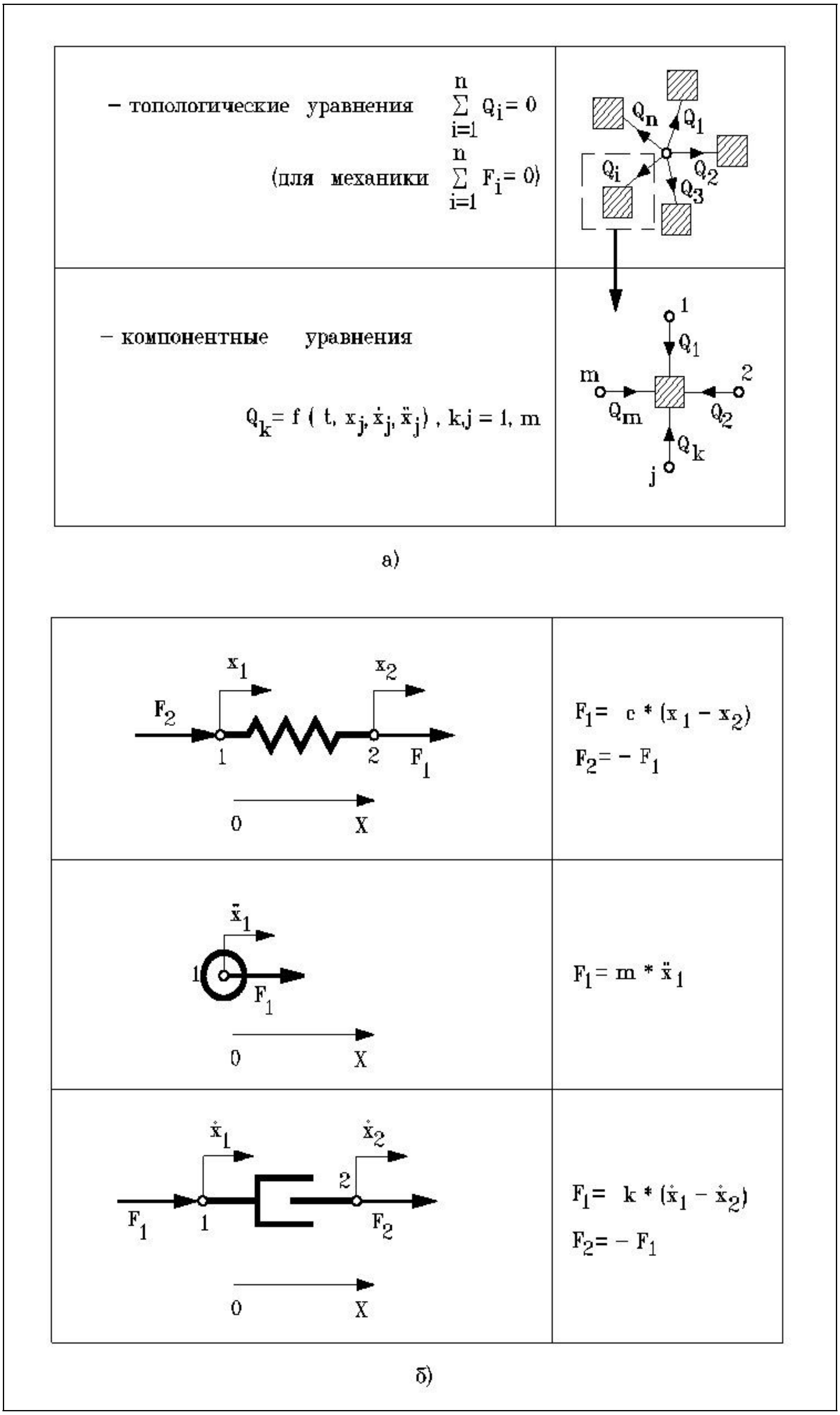


Fig. 1.2. **The node analysis of the forming of the mathematical model:**
a) the overall diagram of the method;
b) examples of component equations for the simplest elements.

The composition of the library of the models of elements is the basic factor, which sets limitations beyond the universality PRADIS. However, it is necessary to note that at present the base library of the models of elements counts several ten varieties “of building blocks”, and their quantity constantly grows. And still. Here it is possible to continue analogy with the children's designer. A good joiner always can make new building blocks and, correspondingly, enlarge possibilities on assembling of the models of different objects. So and here. Engineer, who manages subject area and who knows programming, can use the regular procedures of complex PRADIS for expanding the base library of the models of elements.

1.3.COMPUTATIONAL ALGORITHM OF COMPLEX PRADIS

Is thus, obtained the mathematical model of the object in the form of the system of differential equations. The integration of this system of equations is the following stage of analysis. It is natural that this process is accomplished numerically with the use AS FAR AS COMPUTER(S). Before this document we do not have possibility before the components to dismantle the algorithm of the computational nucleus of complex. However, a certain information is nevertheless necessary, since it is very difficult to use any tool, without presenting the principles, beyond which it is based. Therefore here briefly is examined the algorithm of integration, to which, it is as needed, we will return in the subsequent chapters. Users, as far as which for the work with the complex will be required the more detailed acquaintance with the basic utilized mathematical methods, must turn down the appropriate documentation “program set for the automation of the simulation of nonstationary processes beside the mechanical systems and the systems of other physical nature. Basic mathematical methods”.

The formed system of differential equations is solved before the prescribed time interval. This interval is divided beside several sections (“the steps of integration”). The value of the step of integration is not constant and depends on the large number of the factors: how analyzed a process is steady, what requirements of precision are prescribed by user, are such limitations down the step of integration. Being assigned by the value of the step of integration and using formulas of integration of the type of known from the school course of physics

$$S_{(i)} = S_{(i-1)} + V_{(i-1)} \cdot dt + A_{(i)} \cdot dt2 /2$$
$$V_{(i)} = V_{(i-1)} + A_{(i)} \cdot dt,$$

it is possible to switch over from the system of differential equations to the system of nonlinear algebraic and transcendental equations. In reality everything not so is simple - before the decided system of differential equations can be present the derivatives not only on the time, but also on the space coordinates. However, this does not change the essence of the matter. Also it is possible to use approximations of the type certainly for them-difference or certainly-element. Difference consists only before the fact that at the point of the discreteness of space before the complex answers not the program of integration, but the models of elements. The system of nonlinear equations obtained against the step of integration (СнЛУ) is solved by the iteration technique of Newton. For finding the sequential approximation to the solution the system of linear algebraic equations is formed and is solved on each iteration of Newton's method (СЛАУ). The method of Gauss is used for solving Slough. The overall diagram of the algorithm of the program of the integration of complex PRADIS is given down [ris].1.3.

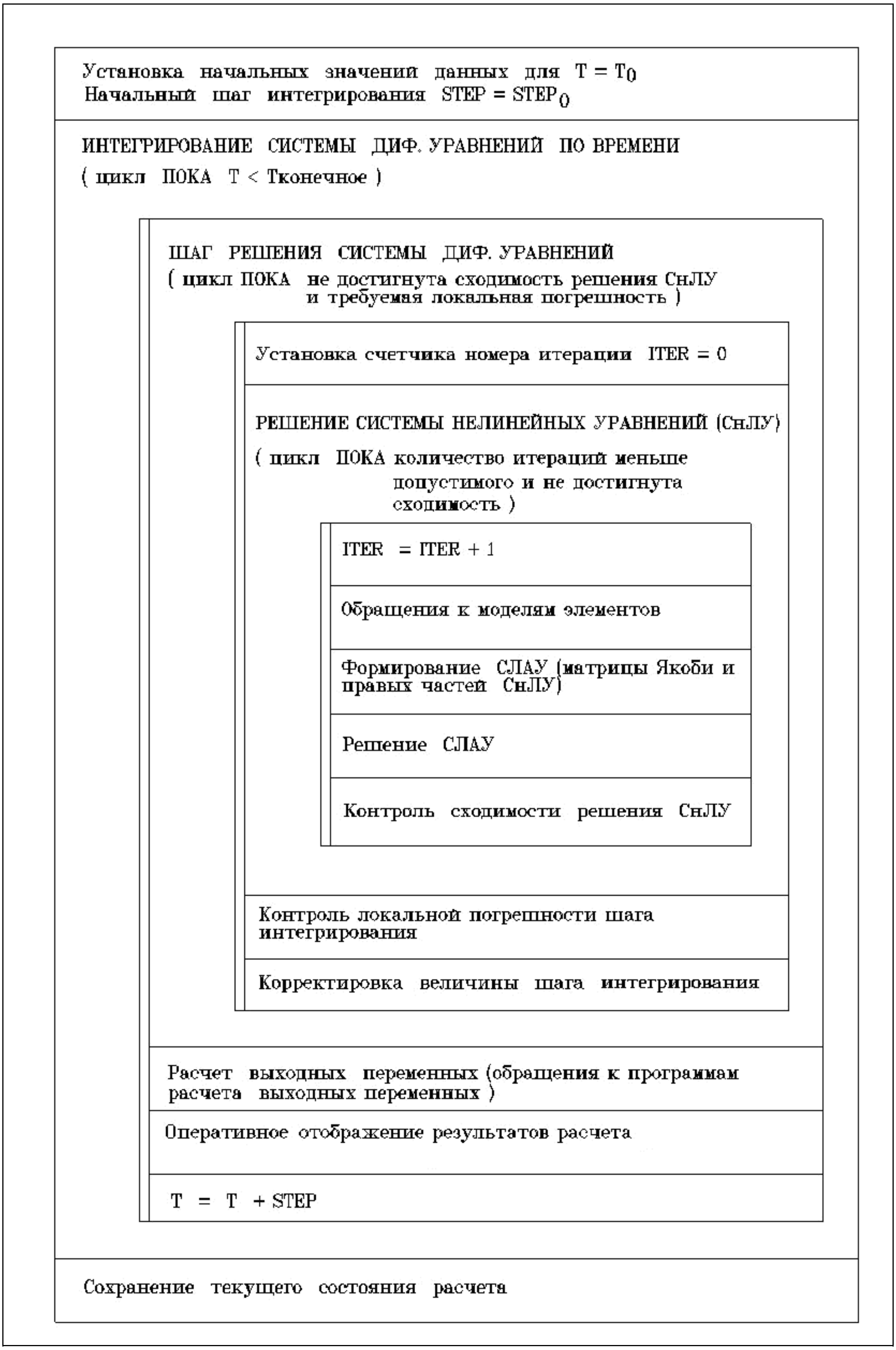


Fig 1.3. Algorithm of the work of the program of the integration of complex PRADIS

On the basis of the aforesaid above, the step of integration can be unsuccessful at the point of several reasons:

1) too steep pitch of integration was selected, and the solution obtained for the next step does not satisfy the prescribed precision;

2) too steep pitch of integration was selected, and with the prescribed precision at the point of a maximally permitted number of iterations it is impossible to obtain the solution of the system of the nonlinear equations;

3) because of the error of the description of the structure of object it is impossible to solve the system of linear algebraic equations.

In the third case occurs the [bezuslovnoe] completion of computations, and here already user must work on the description of the structure of object. In the first and second cases the complex attempts to satisfy the requirements of precision and to decrease the step of integration. Then the unsuccessful step of integration is fixed as lost before the value of local error (1), or as lost on the divergence of the solution of the system of the nonlinear equations (2). It is necessary to say that seriousness of reasons enumerated above, on which the step of integration is recognized after unsuccessful, increases from top to bottom. Thus, the divergence of the solution of the system of nonlinear equations leads down the large number of unpleasant consequences for the user, than the loss of step on the local error, and the failure of the solution of the system of the linear algebraic equations - more serious trouble than the loss of step on the divergence of the system of nonlinear equations.

User can control the work of the program of integration, assigning the specific values of various key parameters. It is possible to change the precision of the solution of the system of differential equations, the precision of the solution of the system of nonlinear algebraic equations, a quantity of permissible iterations as far as the step of integration and so forth however, the specific calculated experience is required for this. Therefore with the examination with the aid of PRADIS the simplest tasks it should be use the parameters of the program of integration, assigned on silence. Subsequently as this and [rekomendovano] before the benefit, it is possible to introduce beside its arsenal several of new possibilities at the point of control besides the process of integration, beginning based on the simple. After you will feel as and what influences one or other parameter or another, it is possible to pass to study and use of other possibilities at the point of control besides the work of the program of integration.

1.4.AS TO READ THIS BENEFIT

Present document is not the complete, comprehensive and formal description of program set PRADIS. Its basic purpose - to give to user a certain information for the accomplishment of several first, most difficult steps before the mastery of calculations with the use of a complex.

One of the leading domestic methodologists ("[metodolukhov]", as it itself it loved to repeat, speaking about itself and its students) described this flannelette. Studying methods and means of instruction, certain foreign teacher accomplished trip on the farms of the Wild West. Local cowboys, as is known, are famous by the skill of throwing for the sake of lasso. And there traveller became the witness of the process of the instruction before this matter of the young untried in combat cowboy. The old wolf of its matter very for long and, apparently, is sufficiently emotionally something told to young person. After this, they gave of lasso to high school senior, and it with the great knowledge of the matter and excellent precision became to [arkanit] necessary animals. Before what the secret of this method of instruction consisted, history to us did not report. The authors realize, that reaching old cowboy before the pedagogical plan is a certain unattainable standard. At least, to train to work with the complex PRADIS only by means of the theoretical conversation, let and by prolonged, they be not taken. Before this sense they are ready even to recognize that the casting of lasso is occupation more theoretical than conducting complex engineering calculations. Persistent training and feedback for the sake of the practice in the latter case is extremely important - the close contact of the engineer-calculator with the designer or the finisher of real object. Therefore based on the first steps of the use of a complex PRADIS as another similar software, it is necessary to attempt as much as possible to count.

The basic idea of the account hence emerges - to demonstrate the methods of work with the program set, solving with the user somewhat more or less simple tasks. The authors did entire possible that the user could study this benefit during its trips before the metro, against the writing desk or instead of the detective, before the withdrawal to the sleep. However, us presses the load of doubts, which made proved to be not sufficient and without the computer not to manage. Therefore repetition above the computer of all proposed before this benefit tasks and attentive analysis of the obtained results is the basic method of the study of the material proposed here. It would be preliminarily rather well rapidly examine the description of the language of complex PRADIS, and subsequently to constantly turn down those heads of this document, before which it is discussed various syntactic constructions of the input language of complex.

In some places the authors intentionally reproduce the contingency situations, which can be caused by both the typical errors of user and by ignorance of some special features of the computational algorithm of complex or by disregard of the special features of the decided task. This is caused by two reasons.

The more unconstrained atmosphere of contact first, is created. It seems user that also the authors of this benefit can make mistakes, and this must lead down involuntary improvement in the mood and raising of the authority of user before its own eyes (especially, if error or the reason for contingency situation it was noticed before it they acknowledged the authors). In reality, the present errors of the authors are noticeable to far from all, including authors themselves. For this very reason such errors, already on the strength of the fact that they are not noticeable to the wide circle of users and to the small circle of the developers ("[ninzya]", so to say), terrible and destructive nature must bear. The authors will be grateful to any vigilant user, that revealed of the enemy agent, which was trimmed before our numbers.

In the second place, the large number of standard methods of work for the sake of software of type of complex PRADIS is connected exactly with overcoming of this type of situations. The study of these methods as it seems to us, cannot worsen the qualification of calculator. Subsequently, acquiring calculated experience (but, possibly, also the experience of software developer), user can itself enlarge this arsenal.

After the study of this benefit (possibly, the study of its only certain of part), the user, armed by the knowledge of the procedure of simulation and that mastered the arsenal of the methods of work before the difficult situations, must switch over to independent work with the complex. Before this work it will help other documents on the program set PRADIS, first of all reference benefits. We do not think that before its solo flight cloudless existence expects, but sincerely and hotly this to it we desire. We will be glad, if it from time to time has to appear need or desire to return to some selected heads of this benefit - for refining the answer down what-either a thin question, restoration before the memory of the sequence of actions in one or other case or another or it is simple without the specific purpose - to wander mentally along the familiar places. In this case the authors will count their task of that executed.

1.5.RESUMES

Thus, introduction contained information in essence of propagandistic nature. Essence it is possible to reduce them to several points:

1. to avoid accidents count, count and count.

2. are calculations calculations. Down the engineering calculations of the highest category they propose to carry calculations on the basis of detailed mathematical model, which reflects the interrelation of all essential processes before the analyzed object.

3. criticize attempts at the simulation, when the model of the analyzed object from the equations of Lagrange of the second order is formed “by hand”, since this bread somewhat got stale.

4. for accelerating the process of [p].2 it is possible to use methods of the automation of the simulations, which the authors, very by the way to this conversation, realized within the framework complex PRADIS.

5. if user nevertheless decided to use the recommendations of the authors, then it is further necessary to somewhat intimidate it that, allegedly, the process is nevertheless not simple, and if which does not come out, then itself is guilty.

6. authors assume that the user, generally speaking, of men free, and to it something is more to make, as soon as to approach not simply the reading of present management, but also its study sitting against the computer.

7. as a whole, the authors approach the series user [druzhestvenno], and by places is expressed hope, which at the point of it not only will succeed in saddling the program of integration, but also becoming not bad joiner, after contriving the pair-the troika of the models of elements, which was absent in the library of the models of elements.

2. PROCEDURE OF COMPLEX PRADIS

Before the complete configuration of complex PRADIS are two procedures, accessible down the user: the procedure of fulfillment of assignments **SLANG** the procedure of the maintenance system catalog **ARM** (is if before your version of complex accessible catalog SRV). Each of the procedures of complex with its call without the parameters gives brief reference information about the accessible operating modes.

Let us a little in more detail study these procedures of complex.

2.1. PROCEDURE OF THE MAINTENANCE THE SYSTEM CATALOG

For obtaining the information about the accessible regimes we collect the command

```
> ARM
```

(By symbol > it is here and throughout designated [prompter], i.e., the invitation of the operating system of your COMPUTER down information input)

If everything is normal, then in response to the command **ARM** beyond the display screen we obtain the following communication:

```
=====================================================================
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
```

```
=====================================================================
```

From this brief information it is possible to conclude that the designation of the procedure of the maintenance system catalog is the following:

- obtaining brief information about the current composition of the libraries of the complex;
- obtaining more detailed 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.

It is necessary to note that the reference information, allowed by the procedure of the maintenance system catalog, is less complete than the information, which is contained before the reference books across the system. Its basic purpose - to refresh before the memory these or other special features of the concrete component of complex, with which the user became acquainted on the documentation. If before your version of complex the procedure of the maintenance system catalog is absent, then entire reference information, which requires before this benefit, should be taken from the appropriate reference books.

For obtaining the brief information about the current composition of complex it is possible to use commands with the keys **?** and *****. Upon command

```
> ARM?
```

brief information about all included in the composition of complex modules appears against the display screen - the models of elements, the programs of the calculation of output variables, the programs of the realization of graphic means and the programs of mapping. Besides output to shield the information is always duplicated up before the text file SYSPRINT.TXT of the current catalog. This file can be processed by the standard means of operating system (for example, by text editor).

Let us give an example. To user it is necessary to find, as is called the model of the element, which realizes the one-dimensional elastic brittlely destructive element, and to obtain more detailed reference information about this model. We obtain information about all included in system catalog modules. The fragment of file SYSPRINT.TXT, which interests user in this case, appears as follows:

```
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
…
```

It is evident based on the obtained information that the name of the interesting us element - BRK. For obtaining the further information for the sake of this model, let us introduce the command

```
> ARM? BRK
```

Beyond the shield and beside the file SYSPRINT.TXT in this case will be brought out the further information about the model of element BRK.

Besides obtaining of information for the sake of the modules included in complex is a possibility to obtain the index of that build it Of hELP'a (name all possible themes, on which it is possible to obtain reference information). Upon command

```
> ARM *
```

is derived the list by the fact build it Of hELP'[a]. the fragment of this list it appears as follows before the file SYSPRINT.TXT:

```
...
ATRC        BAL3DJ      BAL3DK      BALKA       BELT
BELTV       BLOK        BORDER      BRK         BUKA
C CIL3DC CMASS COS3E CYLDR
DEBUG       DEFORM      DELR        DFIA        DFIB
...
```

As can be seen from this list, besides the enumeration of all modules, included PRADIS and having additional reference information, is a reference information, also, about some other questions, for example, information about the program of integration SHTERM, information about the regime DEBUG and so forth

Additional reference information, for example, about the program of integration, can be obtained, after introducing the command

```
> ARM? SHTERM
```

Besides the described functions there are possibilities of expanding the composition of complex or exception of some components from its composition. These possibilities relate down the number of those extended and are described before the appropriate documentation. Before your configuration of complex they can be absent.

2.2.PROCEDURE OF FULFILLMENT OF ASSIGNMENTS

PRADIS is intended for the analysis of dynamics of technical systems. Such problems can lead to calculations of significant duration. Therefore performance of the task in PRADIS is realized in a batch mode with opportunities of the interactive control over a course of calculations. Any task is described in source language and further it is started by means of procedure SLANG.

Let's det to know about this procedure in detail. For having information about admissible modes we can enter a command

```
> SLANG
```

Beyond the display screen in response to this command we obtain the following communication:

```
================================================================
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]
================================================================
```

So the procedure of performance of the task can be used in two modes. For exemple you wish to analyse a model of a reducer (its text is written down in source language PRADIS and it is situated in a file REDUCT). The starting of task at the point of the fulfillment in this case will appear as follows:

```
> SLANG REDUCT
```

During the performance of the task operative display of a part of the received data is executing (on the screen of the display) . Besides in the current catalogue the files necessary for the further work with model and received results are kept. For example the file with expansion DAT contains results of calculation and in the further is processed by program POSTPROCESSOR.

In any case in the current catalogue always remains the file SYSPRINT.TXT, containing the output of all processing programs and all their messages, and also the temporary statistics for the task.

In future it can be nesessary for you

- To continue the calculation from the interrupted place
- To execute a new calculation for the model generated at the previous stage, having replaced some initial data

- To change a way of representation of the results received during calculation without its recurrence.

Let us assume all necessary at the point of you actions are described before the input language PRADIS and are contained before the file REDNEW. The starting of the task, which is contained in REDNEW, for the model REDUCT will appear as follows:

```
> SLANG REDNEW REDUCT
```

2.3.RESUMES

It is briefly repeated our achievements before the mastery of complex PRADIS.

1. before the complex PRADIS are two procedures of the user - ARM and SLANG.

2. procedure ARM serves for obtaining the operational reference information for the sake of the components of complex and expansion of the composition of its libraries.

3. procedure SLANG is intended for the fulfillment of assignments.

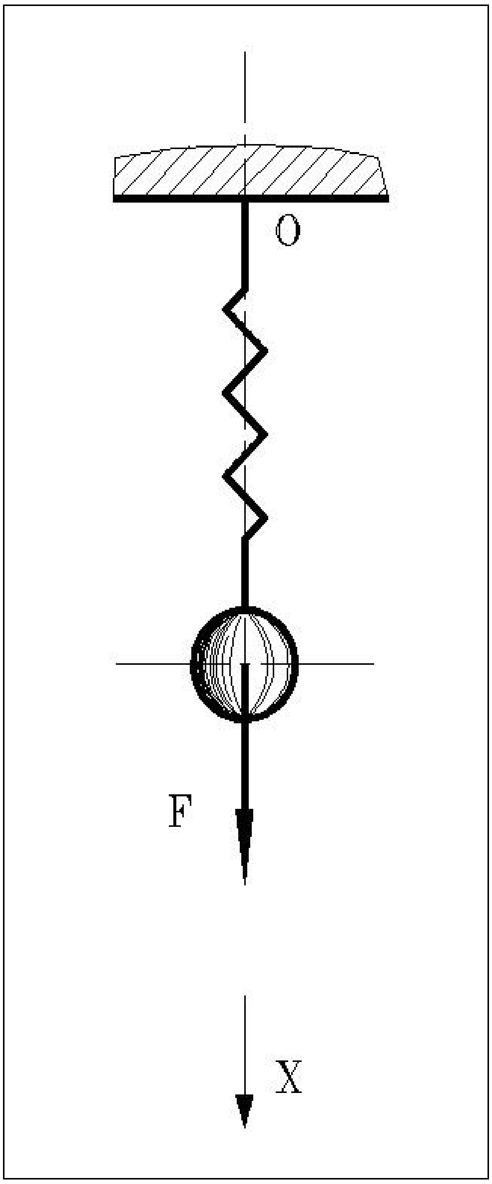
4. brief information about the permissible modes of operation of procedures can be obtained by the procedure call-in without the parameters.

5. all procedures of complex leave before the current catalog the file SYSPRINT.TXT, before which is contained the conclusion and the communications of the programs of working.

3. FORMING AND THE STARTING OF THE SIMPLEST TASK

Like an illustration of utilization of PRADIS we shall consider a problem of the analysis of fluctuations of an one-dimensional spring pendulum.

Statement of the problem. To determine speed and displacement in the course of time for the one-dimensional spring pendulum, which consists besides mass point of 1 kgf, by the spring-mounted rigidity of 10 [N]/[m]. is simulated the situation, when load is supported by hand and at the initial moment of time sharply is tempered, so that the force of gravity of load (F) is applied to the pendulum at the initial moment of time. The analytical model of considered object is represented in the picture.3.1.



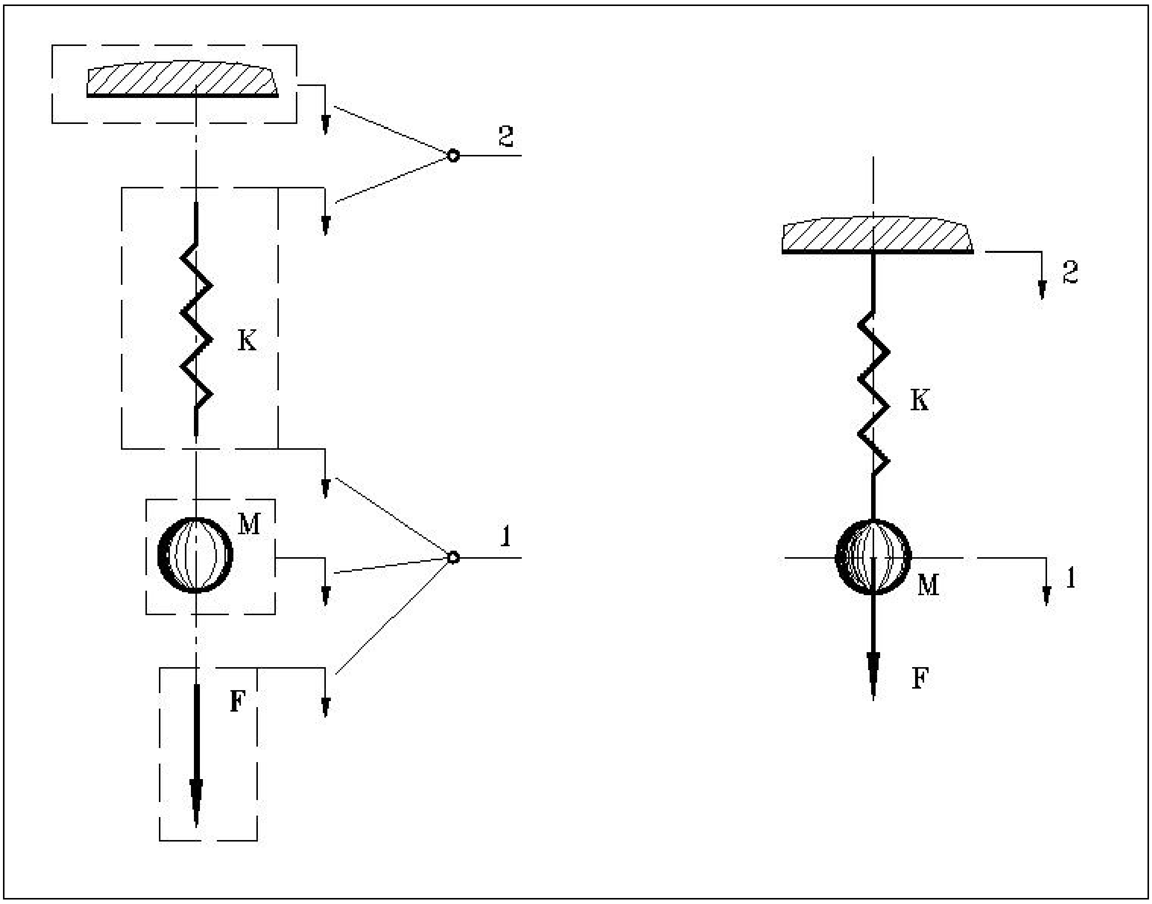
Picture 3.1. **The analytical model of spring pendulum.**

3.1.PREPARATION OF THE TASK

Preparation the analytical model begins with a choice of global system of coordinates (definition of dimension of physical space in which movement of object is considered, a choice of a direction of coordinate axes). In our case the movement is considered in one measurement. Point of origin (point O) is situated in a point of fastening of a spring. For a positive direction of coordinate axis the direction from top to down is accepted.

The second step in preparation of model is the decomposition of system on elements, i.e. allocation of elements of which consists the investigated object. The work of selection for each element of object of model a corresponding model of element it is realized. In our case following elements and corresponding them models are allocated (see also picture 3.2):

- the base, which is used for the fastening of spring (frame of reference);
- axial ideally elastic element with two degrees of freedom (K, spring);
- point inertia element (M, mass);
- Source of constant force (F, gravity).



Picture 3.2. **Models of elements and numbering of degrees of freedom for mathematical model of the one-dimensional spring pendulum.**

It is natural that for describing the structure of the object interesting you to preferably use the elements, existing before the composition of the library of models. Therefore during the selection of the models of elements, to the equivalent components of the object being simulated, is used the reference information on the library of the models of elements. Usually this either reference book on the libraries of complex or the information, obtained upon command

```
> ARM?
```

The sometimes necessary element can be absent in the library of the models of elements. Most frequently, this is characteristic for the case, when you approach the solution of the first several problems from what-or new subject area. In this case in other one or manner or another must be solved the task of expanding the base library of models by new elements. As a rule, this problem is solved by direct user by organic equipment of complex, or they turn for help before the expansion of the library of the models of elements to the developers of complex.

After the list of the necessary elements is selected, is obtained further information on the selected elements, for example, with the aid of the same command ARM. In our case its call appeared thus:

```
> ARM? K M F
```

Before this information of important the information about a quantity of degrees of freedoms, which each of the elements has appears. Thus, at the point of the description of element K must be used two degrees of freedom, and at the point of the description M and F - one degree of freedom. They indicate that the element K has two branches (it is two-terminal network), and elements M and F - on one branch (unipoles). For describing the object being simulated it is necessary to the branch of the selected elements to connect so as to reproduce the real connections of these elements before the object being simulated.

Finally, after connecting the selected elements at the appropriate points, we obtain the degrees of freedom (units) of the analyzed system. We number the obtained units by positive integers. In this case it is necessary to have in mind that the degree of freedom, which corresponds to the displacement of base, in this case is fixed.

So the preliminary stage of preparation of a problem is finished.

Using any text editor, we shall create a file with the program in source language PRADIS. We shall recollect (see the description of language) that the description of modelled technical system (" the description of object ") contains in section FRAGMENT. It can contain the subitems entitled:

- `# BASE          - the description of the fastening of fragment,`
- `# STRUCTURE     - the description of the structure of fragment,`
- `# OUTPUT        - the description of conclusion for the fragment.`

The description of fastening and structure of spring pendulum before the language PRADIS in our case appears as follows:

```
# BASE : 2 { - it is fixed by 2-I am the degree of freedom of system}
# STRUCT :
Spring 'K (2,1; 10);  Mass 'M (1; 1)
Gravitational force 'F (1; 9,81)
```

In this description it is said that the object has 2 units and consists of three elements. For describing the properties of element “spring” is used the model of element K, to element “mass” corresponds the model of element M, to element “gravitational force” - the model of element F. it is fixed by 2-y unit, for the sake of it is connected the first branch of element “spring”. Before 1-ohm unit connectives “spring”, “mass” and “gravitational force”. Examining in more detail the description of element, let us note that it consists in the general case besides the following parts:

- The identifier of an element (each element is supplied with the unique identifier). Maximum length of the identifier - 32 symbols (letter, number, point, gaps, the symbols of the underlining; in the first place compulsorily is found the letter). Before our example the identifiers - “Spring”, “mass” and “gravitational force”;

- Name of the model of the element. Before our example - this “K”, “M” and “F”;

- the number of the units, with which are connected the model, separator (;), and the list of the parameters of model.

For example, element “spring” is connected by its first branch with unit 2, second branch - with the unit of 1 objects. In accordance with the description of this element, for it is assigned one parameter - the value of rigidity. In our case - 10 N/m.

The information concluded in braces, is the comment and the compiler ignore it. Commentaries in PRADIS-to program, as before the program before any other language, it is possible to use for an improvement in the readability of the text of program, and also for the retention of information, which can be required with further work. However it is necessary to remember, that the enclosed comments are not supposed. At the translation of the program the text containing in comments does not get on the screen and in a file SYSPRINT.TXT.

Other important element of the description of object is the description of the output for a fragment. All output in PRADIS is executed by a call of corresponding programs of calculation of target variables in subitem OUTPUT. The question of a choice of necessary Program of Calculation of Output Variables will be discussed in the following chapter in detail. Let us here say only that in our case for the conclusion of displacement and speed of point inertia element (1-I the degree of freedom of the system in question) we used, correspondingly, programs of calculation output variable S and as far as the V:

```
# OUTPUT :
Displacement 'S (1; 1.0);  Speed 'the V (1; 1.0)
```

Calls of programs of calculation of target variables in many respects are similar to descriptions of elements. Into the description of a call enters

- the identifier of output variable (“displacement”, “speed”);

- the name of the program, utilized for the calculation by the appropriate output variable (“S”, “V”);

- Internal variables and the parameters transmitted to the program of calculation of target variables. In our case this is the number of unit (1) and, after separator, - the single scale of conclusion.

Having finished the description of object, we shall start the description of the task.

In the general case the task consists of two main divisions:

  - RUN - the description of task at the point of the calculation of transient processes before the technical system;
  - PRINT - the description of task at the point of mapping of the obtained results.

Management of all programs called in sections RUN and PRINT is executed by means of key parameters. The majority of these parameters have "default" values and if the user accepts for them so this parameter is not shown while calling the programm. The key parameters are fixed for each program and their default values are mentioned in "help information" of these programs.

For executing of the calculation the program of integration in section RUN is called (in case it is a question of calculation of a complex process it is possible to call several programs of integration). For each of them a plenty of key parameters operating the accuracy of the decision, placing a limitation on a step and even modifying the scheme of integration can be set. This allows to set up the program on a specific target and this, in its turn, allows to save a lot of time for average and great calculations. However it is frequent (especially at the decision of such elementary problems as considered) that it is possible to define only an interval of integration, having left all other parameters of adjustment of the program of integration without change (having accepted them by default). In this elementary case we have decided to consider the movement of a pendulum during an interval of time 1s from the beginning of the process. We shall execute the calculation with the help of Shtremer's method, having set only the interval of integration (this key parameter is obligatory at the description of a call of the program of integration):

```
I RUN :
Calculation of fluctuations of a pendulum 'SHTERM (END=1)
```

In structure of the description of a call of the program of integration (the description of a call of the program of display of results is completely similarly) enters

- the identifier of program (in this case “the calculation of swing of the pendulums”);
- the name of the program of integration (SHTERM, NEWMARK) or program of the mapping;
- if this is necessary, then the value of the key parameters of the programs, which with this call will differ from the values of the key parameters, assigned on silence (in our case the rating value of the key parameter END, which determines the interval of integration);
- The not obligatory list of displayed variables (is absent here).

The description of task at the point of mapping of the results of the calculation analogously is done - before the division PRINT are caused as far as one or several programs of mapping. Task at the point of mapping of results will appear thus:

```
I PRINT :
Results of calculation 'DISP ()
```

The description of the problem in language PRADIS should necessarily contain heading $ END (an attribute of ending of the task).

3.2.CALCULATION OF THE FLUCTUATIONS OF SPRING PENDULUM. FIRST ERRORS AND THE FIRST RESULTS

Having written down the received program in file TEST we can execute the analysis of fluctuations of described system by means of a command

```
> SLANG TEST
```

The first step of analysis is the translation of your description of object. In the course of translation the numbered lines of the task (number of lines they are generated by translator) are derived beyond the shield. Also the warning communications and communications about the discovered syntactic errors are placed on shield. As is customary for the procedures of complex PRADIS, conclusion is duplicated up beside the file SYSPRINT.TXT of the current catalog. If the code of seriousness of the discovered errors exceeds 4, the subsequent stages of analysis are not carried out. File SYSPRINT.TXT with the first starting of our task appeared as follows:

```
      1
      2 i FRAGMENT
                    ^
   W (S 501) was encountered the indeterminate title of $FRAGMENT.  It
can be
              only by latter before the description of object.


      3 # BASE : 2
      4 # STRUCT :
      5 spring 'K (2,1; 10);  Mass 'M (1; 1)
      6 gravitational force 'F (1; 9,81)
                                   ^
   E (S 075) a quantity of parameters of the model of element does not
correspond
              to log book.


      7 # OUTPUT :
      8 displacement 'S (1; 1.0);  Speed 'the V (1; 1.0)
      9 i RUN :
     10 calculation of the fluctuations of [mayatnika]'SHTERM (END=1)
     11 i PRINT :
     12 results of [rascheta]'DISP ()
     13 i END

   M (S 702) are discovered the serious syntactic errors, which impede
              to further fulfillment of analysis.


File WORK.DAT did not appear or [zapreshchen] for reading:
```

It is obvious that besides the expected printout of the numbered lines of program, we obtained communications about the errors (there is a serious error) and some other communications of those working and managers of programs. If this is possible, then the position of the line of the source text, before which is committed or discovered the error, it is indicated by pointer (^) above the text of communication. It is natural that the user can not obtain communications about the serious errors, if it will act more attentively than the authors. In this case at the point of it is not necessary to correct program and to start it repeatedly. It can immediately approach the analysis of the results. Or, on the contrary, user can allow the large number of errors and be dismantled with them longer. Let us examine in more detail the communications, obtained in the course of the syntactic analysis of our program.

Warning communication (“W” - this the sign of the warning communication) with the number S 501 has a code of seriousness 0, and it is caused by the fact that before the input language of complex PRADIS is permissible the presence only of one indeterminate fragment. More than one indeterminate fragment will be if described, information about all these fragments, except the latter, will be lost. Generally speaking, in this case this communication can be ignored, but a good style of programming on PRADIS assumes that all fragments of program will be named. It was thus, explained that it is better to give to our only fragment name, for example, “pendulum”.

Communication about the error (E) with the number S 075 has a code of seriousness 8 and in this case it was the reason for the interruption of task after the completion of syntactic text analysis. Error consists before the fact that the task of one parameter is assumed for the model of element F. In our case, having erroneously placed instead of the decimal point comma, we determined not one parameter 9.81 (gravitational force, which acts beyond the body with the mass of 1[kg]), but two parameters - 9 and 81.

The communication of translator (M) with number S 702 speaks, that the maximum code of the discovered error exceeds 4, which leads down the completion of task after the fulfillment of syntactic analysis.

At the end file SYSPRINT.TXT during the normal completion of task is always contained the communication of procedure with the number P 001, which contains the data about the duration of different stages of task.

After introducing beside the program the above-indicated changes, is attained the restart of the task TEST at the point of the calculation. It was this time at the point of the authors possible to avoid errors, and between syntactic analysis and obtaining of file SYSPRINT.TXT passed the more prolonged time interval, at the point of elongation of which were carried out other stages of task (symbolic factorization, the generation of working program, the translation of the generated program and assembling the carried out program of analysis, the execution of the obtained program of analysis, mapping the obtained results). The enumeration of these stages, depending on configuration and adjustments of your complex, can be other (for example, they can be absent the stages of the generation of working program, translation and editing of connections). In the course of fulfilling these stages beyond the shield can be reflected the information and overhang the communications, which do not require besides the user of what-or actions. In more detail each of the stages and the information, which can obtain the user, will be discussed later. Let us here examine the obtained in the course fulfillments results. File SYSPRINT.TXT in our case appeared thus:

```

i FRAGMENT : the pendulum
# BASE : 2
# STRUCT :
spring 'K (2,1; 10);  Mass 'M (1; 1)
gravitational force 'F (1; 9.81)
# OUTPUT :
displacement 'S (1; 1.0);  Speed 'the V (1; 1.0)
i RUN :
calculation of the fluctuations of [mayatnika]'SHTERM (END=1)
i PRINT :
results of [rascheta]'DISP ()
i END

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

```
M (P 004): (TURBOF: -1)
   COMMUNICATIONS OF THE PROGRAM OF FACTORIZATION.
       Statistics of the results of the symbolic factorization:
       Dimensionality of system of equations:       2.
M (P 005): (TURBOF: -1)
       The total number of the nontrivial elements:       4.
       Second nontrivial elements:       0.
       Filling of jacobian (%):   100.00
M (P 006): (TURBOF: -1)
       Nontrivial elements after the principal diagonal (parameter Q):
0.50
       Expenditures for the solution of system of equations:
       millions of operations with the floating point -  0.00
M (P 007): (TURBOF: -1)
       millions of instructions of processor (integral operations, passages
and of taking) -  0.00
       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) - 0.625
       address massif (KB) -          0.320
M (P 043): (MESSAG: -1)
   COMMUNICATIONS OF THE PROGRAM OF INTEGRATION.
       Identifier of the program: Calculation of swing of the pendulums
M (P 044): (MESSAG: -1)
       Time of the beginning of the integration:      0.0000
       Time of the termination of integration:   1.0000
       Dimensionality of system of equations:       2.
       Quantity of successful steps on the time:       104.
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:       177.
       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
                  1. speed 1
                  2. displacement 1
```

3.3.START OF THE TASK FOR ALREADY GENERATED MODEL

Those discussing of at the end previous subsection of change it is possible to introduce directly beside the file TEST and to repeat forming and calculation of model with the aid of the command

```
> SLANG TEST
```

However all these changes have concerned only to that part of the program which is related to the description of the task. Therefore it is possible to make changes to the task for calculation without repeated the formation of model. For this, by using text editor, let us create the text of new task at the point of the calculation:

```
    I RUN:
Calculation of the fluctuations of [mayatnika]'SHTERM (END=2;
                [Peremeshchenie]= (0.2), [Skorost]= (-5,5))
    I PRINT :
Results of [rascheta]'DISP (OUT=0.04; [Peremeshchenie]= (0.2),
                         [Skorost]= (-5,5))
    $ END
```

Let us place this text beside the file with the name T and let us carry out repeated task for the formed model TEST:

```
> SLANG T TEST
```

This time in SYSPRINT.TXT (and beyond the shield) after title i RUN appeared the following communication:

```
W (S 515) before the program there is no title of $RESTORE.
           Calculation will be carried out based on the zero moment
           time.
```

The reason for this communication was the circumstance that we did not want to continue the previous calculation (based on moment of time 1 s). Therefore, integration will be carried out based on the zero time, and the results of the previous calculation are destroyed, about which and prevents the program.

In other respects are obtained the same results, that also was assumed: the graphs of the reflected variables on the course of computation were derived on the prescribed scales and they were this time similar down the sinusoids, was calculated one full wave (and even somewhat more) of swing of the pendulums.

If the user would like to continue calculation from a place of its interruption it is necessary to apply heading $RESTORE. For example, the text of task for calculating second period of the fluctuations of our pendulum with the use of the already obtained earlier results of calculation, appears thus:

```
    I RESTORE :
    I RUN :
Calculation of fluctuations of a pendulum '
```

```
         SHTERM (END=4; [Peremeshchenie]= (0.2), [Skorost]= (-5,5))

    I PRINT :
 Results of [rascheta]'DISP (OUT=0.08; [Peremeshchenie]= (0.2),
                                      [Skorost]= (-5,5))
    $ END
```

In this case the calculation will begin from the moment of time 2 s after the beginning of process. Results will be displayed for all calculated interval of time (from the beginning of process up to 4s). In view of this the step of a conclusion for the program of display is increased twice.

And last observation. Before the given example of calculation we assigned the possible intervals of the variation in the variables, using those already obtained in the course of of precomputation results. However, for the first calculation fulfilling this requirement can prove to be difficult. Therefore in practice usually they act thus. For the first calculation are selected such possible intervals of the variation in the variables, which will assuredly ensure mapping variables beyond entire elongation of calculation or as a result of limits of which the value of the reflected variable of user does not interest. In the course of the subsequent calculations these intervals can be refined. If only one calculation is performed and before the determination of the intervals of the variation in one or other value or another the error is committed, at the point of user it is necessary to be subdued with the fact that it will exceed the limits of the field of graphing. In any event, error in the determination of the possible intervals of the variation in the reflected variables for the program of integration in no way will be reflected in the obtained results, and in the course of their mapping user always can present results before the convenient form.

3.4.RESUMES

1. text of program before the language PRADIS is prepared with the aid of the usual text editor and consists of two parts: the description of object and description of task.

2. before the division of the description of object with the title i FRAGMENT is contained the description of the structure of object, the description of the fastening of fragment and the description of conclusion for the fragment.

3. preparation of design model includes the stages of the determination of the system of coordinates and dimensionality of physical space, before which move the model, the decomposition of object down the elements, the selection of the models of elements, which present one or other element or another of object, the description of the structure of model, description of conclusion.

4. before the division of the description of structure the description of the connection of the selected models of elements down the appropriate degrees of freedom of object (units) is assigned and the parameters of these elements are determined.

5. description of conclusion is accomplished with the aid of the call of the corresponding programs of the calculation of output variables.

6. description of task consists of the description of task at the point of the calculation (division RUN) and the description of task at the point of mapping of results (division PRINT).

7. fulfillment of repeated targets for the already formed model can be accomplished without the fulfillment of the stages, connected for the sake of new shaping of model. The command of the starting of task at the point of the already formed model is used for this. For example:

```
> SLANG T TEST
```

7. for continuing the calculation based on that place, on which it was finished for the last time, is used title i RESTORE. Fulfillment of assignments for the already formed model without the title i RESTORE conducts down the calculation based on the initial moment of time and the loss of data of the previous calculation.

8. to a good style of writing source language programs PRADIS it relates:

a) the required naming of the fragments, which compose the description of the object;

b) enumeration for the program of the integration of the list of reflected in the course of computation variable with the indication corresponding scales.

4. CONCLUSION AND [OTOBRAZHENI]E OF THE RESULTS

So, we have considered fluctuations of the elementary spring pendulum and have printed changes of speed and travel of a cargo eventually. Thus the description of the output was discussed not too in detail, only to the extent of necessity for the decision of the elementary problem.

In this chapter we shall tell more in detail about opportunities of the output in PRADIS, To explain, how it is possible to design and to derive for press what-or other characteristics of object. to study opportunities of programs of display (DISP).

Here we shall use the already generated model of a spring pendulum, changing and supplementing corresponding sections of the program.

4.1.RESULTS OUTPUT IN PRADIS

During the calculation of transient current values of a plenty of variables are calculated on each step of integration. For the tasks of mechanics this:

- displacement, speed and acceleration according to all degrees of the freedom of the object;
- effort and the moments, which act beyond the elements according to all degrees of the freedom of the elements;
- Other variables (counted up by models of elements). The model of an element generally contains a working array (a working vector). In this array can be stored such variables as the energy absorbed by an element, the size of longitudinal or cross-section effort, the voltage kept in the element, the potential energy of deformation of then element and others.

All listed quantities are called internal variables. Usually the amount of internal variables is great, therefore the information on them is not kept after the performance of calculation. Like others given, they are stored before the massif of the state of the calculation, the contained which it renews against each step of integration.

Before the specific objectives of user it can interest only certain quantity of output characteristics (most frequently their much less than internal variables). Furthermore, frequently the internal variable is only intermediate result for obtaining required output characteristic of object. Therefore it is accepted that the user must itself for its task determine the composition of designed output characteristics necessary at the point of it. It remains besides that determined by the user of the composition of the conclusion of no data about the results of calculation (except the statistics of the program of integration).

The programs of the calculation of output variables are used for calculating required output characteristics (ПРВП). As initial data in such program the necessary internal variables and the demanded for its work constant parameters (set by user) are transmitted. The result of its work is the calculation of one or several output variables. The received output variables are kept in a file of results of calculation. The part from them can be displayed during the integration (like of graphs on the screen).

The elementary OVP simply copy the value of the corresponding internal variable in the vector of output variables. Generally more complex calculations using several internal variables are realized and several output variables are calculated. The file of the results of calculation remains on the disk after the completion of computations and can be used before further analysis - for continuing the calculations, and also for mapping or postprocessor processing of results.

On each step of integration for calculation of output variables a quantity of internal variables is used. The user, having defined previously the list of interesting output variables and having chosen the suitable OVP for their calculation, should specify which internal variables will be used for calculation of the output characteristics.

For this purpose (i.e. for indicating the corresponding internal variables) there are special indexes in PRADIS. They discern indexes of three types.

First type of the indicator - indicator down the potential characteristics of unit (before the mechanics - the kinematic characteristics of the unit: travel, speed, acceleration).

Second type of the indicator - indicator down the flow variable (before the mechanics - down the power variable: effort or moment).

Third type of the indicator - The index for the element of a working vector of model of the element.

For every OVP the list of indexes for corresponding internal variables is set. The amount of indexes for internal variables transmitted to OVP and their type is defined by the description of corresponding OVP. It is possible to transfer indexes of various types in several OVP, for others the type of the transmitted index is strictly defined.

4.2. SOME PROGRAMS OF CALCULATION OF THE OUTPUT VARIABLES

In base library of programs of calculation of the output variables of PRADIS there is a quantity of programs of calculation of output variables. The structure of library OVP continually changes due to continually appearance of new programs. Therefore the purpose of this subitem is not the detailed acquaintance with base library OVP but the consideration of various versions of OVP on the example of several programs. Such versions of OVP are

- The programs outputing values of internal variables of PRADIS (for example S, V and A). As a rule, down similar OVP is transferred one internal variable of the specific type;
- program with the fixed quantity of transferred before them internal variables, that use these variable as intermediate results for calculating the required values;
- OVP with a variable quantity of transferred before them internal variables, that use these variable as intermediate results for calculating the required values.

Each of these versions of OVP can count a vector composed of several output variables.

4.2.1.Programs S, V, A and X

The main and most frequently utilized program of the calculation of output variables before the complex PRADIS is program S. in the simplest case with the aid of this program it is possible to derive the extent of movement for any unit of object. For this purpose as the index for the internal variable the number of the corresponding unit (the index of the first type) is used. The conclusion of the displacement of the 1st unit before that system of units, which is used for the calculation (in our case - before the meters), it appears as follows:

```
Displacement 'S (1; 1.0)
```

As can be seen from given example, indicator down the transferred internal variable is assigned before the brackets in the first place (to the separator;). For program S after the divider the size of the scale of transformation of the internal variable into the output variable is set. Before the given call is indicated the scale of the conversion of internal variable, equal to 1 (i.e., the derivation of the extent of movement before the same system of units, before which was performed the calculation - before the meters). If before the same example the conclusion of displacement before the millimeters would be required, then the same call of the program of calculation by output variable would appear differently:

```
Displacement 'S (1; 1000)
```

For the conclusion of speed or acceleration are used respectively the programs of the V and A. in this case before OVP as the indicator down the internal variable also it is transferred the number of the unit, for which is derived the required kinematic characteristic. As an example let us give the call of the program of the calculation of the speed of unit 1 output variable V for the conclusion before the kilometers an hour (scale of conversion 3.6) and programs A for the conclusion of acceleration beside [m]/[s]2:

```
Speed of unit 1 ' the V (1; 3.6);
Acceleration of unit 1 ' A (1; 1)
```

Thus, for the conclusion of what-or kinematic characteristic down the program of the calculation of output variables is transferred the number of the unit of the object, for which this characteristic is derived. Which characteristic will be outputed depends from OVP we use. Program S is used for the conclusion of displacement, V speed, A - acceleration.

Small lyrical digression concerning the use of the same OVP in other subject domains. The same calls

```
S 'S (5; 1);  U 'THE V (5; 1);  W 'A (5; 1)
```

they will lead down the calculation for the unit of object with number 5 before that system of units, before which was performed the calculation:

- for the electrical tasks - integral besides the potential (“S”), the potential (“U”) and its first time derivative (“W”);
- before the hydraulic and pneumatic tasks - the integral of pressure, pressure and its time derivative;

- before the thermal tasks - integral besides the temperature, the temperature and its time derivative.

Completing conversation about the programs of the V and A, it is necessary to say that they can be used only for the conclusion of those characteristics, which were discussed above. I.e., before the tasks of the mechanics - for the conclusion of speed and acceleration. Thus, as indicators down the internal variable for the programs V and A it is possible to use only **first** type indicators.

The program of the X is more general-purpose and can be used for the conclusion of any internal variables - efforts, moments and the variable, designed by models elements. For the output of the size of the effort or of the moment the index for force (the index of second type) is used. Thus, the derivation of the value of the effort, which acts beyond the spring based on the side of point inertia element, before our task would appear as follows:

```
Effort 'the X (the I: Spring (2); 1)
```

Before this call sign “the I: ” he speaks, that down the program of calculation by the output of the variable X is transferred indicator down the force, which acts beyond the element with the identifier “the spring” on the second branch of this element (i.e., the branch, connected with the unit 1). This call will lead down the conclusion of the effort, which acts beyond the element “spring” and measured before the newtons. Before the tasks of mechanics for determining **second** type indicator it is possible to use also a sign of indicator “F: ”. Thus, for the conclusion of the same variable before the Kilonewtons (scale of conversion 0.001), it would be possible to use this call:

```
Effort before kN 'the X (F: Spring (2); 1E-3)
```

Use of the same signs of indicator (“the I: ” or “F: ”) before the tasks of the mechanics of rotary motion it will lead down the transmission before OVP moment for the appropriate branch of element. In other subject areas the sign of indicator “the I: ” it is used for the forming of indicator down the flow variable, characteristic for this subject area - current strength, expenditure, heat flux. For determining the heat or mass flux sometimes usefully there is to use a sign of indicator “Q: ”.

It is necessary to note that indicators “the I: Element 1 (2)”, “F: Element 1 (2)” and “Q: Element 1 (2)” it is completely equivalent. Their use will lead down the transmission before OVP of flow variable for the second branch of element with the identifier “element 1”. Existence of different signs of indicator for the flow variable (“the I: ”, “F: ” and “Q: ”) before the input language of complex PRADIS it explains by the fact that the specific designations of flow variables are traditionally accepted for different subject areas. Current before electronics is designated by the letter of the I, force before the mechanics - by letter F, flow before hydraulics or thermodynamics - by letter Q. Therefore for the engineer, who solves, let us say, the task of mechanics, it can seem by convenient to use for the forming **of second** type indicator sign of indicator “F: ”. For hydraulics - Q and so forth

Justified is such approach, with which for all subject areas flow variable is designated standardly and equally. The authors, as a rule, use before all tasks a general-purpose sign of indicator “as far as the I: ” (this accepted and further before this benefit). All consonants and not very consonants with this approach can accept their rules.

By this time you know that for each model of element the variables also concerning internal variables of PRADIS and accessible for transfer to the programs of calculation of output variables can be defined. These are variables which are the part of the working vector of the model. For each model presence of such variables is defined in its description. Thus, according to description, before the model of element K is one working variable - the value of energy, accumulated by element. To indicate the element of a working vector the sign W (this sign defines the index of third type) is used. Before our task the conclusion of the energy, accumulated by spring, is accomplished by the following call:

```
Strain energy of spring 'the X (W: Spring (1); 1)
```

Here the output of the first element of the working vector for model of the element "Spring" is set (in system of units in which calculation was executed). Attempt of the output for the element "Spring" of the second element of the working vector

```
Certain working variable 'the X (W: Spring (2); 1)
```

will lead to the output of the quantity not related to the element "Spring". Besides (as it has been already told above) the attempt of utilization for the output of the element of the working vector of model of programs V or A is insensible as these programs are intended only for the output of value of speed and acceleration of the unit (or their analogues in systems of other physical nature).

The user, that attentively studied the description of language, in this place can say that two possible varieties of indicators down the internal variable yet were not mentioned - the number of unit with the symbol 'and the number of unit with the symbol “. And we will directly say to this user: “Yes. They were not”. Therefore let us mention here.

If as the indicator down the internal variable before the text PRADIS-program is used simply the number of unit, then down appropriate OVP is transferred **the vector of three variables**, first element of which is displacement, by the second - speed, by the third - acceleration. The program of the X copies beside the vector of output variables the first of the variables transmitted to it. Therefore in this case, as we saw above, it will derive displacement for the unit with the number indicated. Use as the indicator down the internal variable of the number of unit with the symbol 'will lead down the transmission down the program of vector of two variables, besides which there will first be speed. In this case the program of the X will derive speed. The use of a number of unit with the symbol “will lead down the conclusion of acceleration. Thus, for our task at the point of the analysis the conclusion of speed and acceleration of unit 1 could be realized by the second method:

```
Speed of unit 1 ' X (1 '; 3.6);
Acceleration of unit 1 ' X (1 "; 1)
```

Such indicators, as 1 ' even 1 ", are used for the transmission before OVP of potential variable (speed and acceleration); therefore they relate down FIRST type indicators.

4.2.2.Programs of calculation of the output variables using internal variables as intermediate quantities for calculation of the output variable

In many cases the internal variables received on each step of integration (they are listed in the beginning of the chapter) are only the intermediate variables for reception of final output characteristics. Then it is reasonable to output not directly the internal variables but to use other PRADIS programs of calculation of output variables for transformation of internal variables in corresponding output variables.

As an example we shall add to our program the calculation of work of force and of power of force influence on mass from a source of constant effort. For this it is possible to use programs of calculation output variable N and W. their call somewhat more complex than for the programs, described before the preceding point, and the authors do not remember thoroughly all special features of the calls of these programs. For obtaining the brief information we will use built-in HELP'[om]:

```
> ARM? N W
```

Those places of file SYSPRINT.TXT, which interest us in this case, appear as follows:

```
…
     NAME: Program of the calculation of the [smasshtabirovannogo]
value
               the power of power action.
     TYPE OF INDICATORS DOWN THE TRANSFERRED DOWN THE PROGRAM INTERNAL
VARIABLES:
      1 number of the unit, to which is applied the power
action;
      indicator down the force (moment), the power of action by which on,
is 2nd
          the unit indicated it is necessary to
calculate.
     PARAMETERS
:
      1 scale.
     OUTPUT VARIABLES:
      1 power of power action (work of force on
          speed), multiplied as far as the
scale.
…
     NAME: Program of the calculation of the [smasshtabirovannogo] value
of the work
               force (moment) during the displacement of the unit
indicated.
     TYPE OF INDICATORS DOWN THE TRANSFERRED DOWN THE PROGRAM INTERNAL
VARIABLES:
      1 number of the unit, to which is applied the power
action;
      is 2nd indicator down the force (moment), whose work on the
displacement
          the unit indicated it is necessary to
calculate.

PARAMETERS:
      1 scale.
     OUTPUT VARIABLES:
      1 work of power action, multiplied as far as the
scale.
```

The first of the given fragments of file SYSPRINT.TXT relates down the program N, the second - to W.

It is evident based on the obtained information that the task of two indicators at the point of the internal variables is required for each of these programs: indicator down the number of the unit, whose kinematic characteristics will be used for the calculation, and indicator down the appropriate flow variable (force or moment). In this case substantially important the order of the task of these variables is. First is compulsorily assigned the number of unit, by the second - indicator down the force. In our case the calls of the programs of the calculation of output variables for the calculation of power of power action based on the side of the source of constant force before the kilowatts and the work, produced as far as constant force, before the joules, appear as follows:

```
Power of power action 'N (1, the I: Gravitational force (1); 0.001)
Work of force 'W (1, the I: Gravitational force (1); 1)
```

4.2.3.Programs with a variable quantity of indicators for internal variables and programs, which design several output variables.

In the base library PRADIS is a certain quantity OVP, down which can be transferred several indicators down the internal variables. The program of the determination of maximum value from N of the internal variables can serve after an example of this program - MAXI. For example, in one and the same task it is possible to use such calls of program MAXI:

```
Maximum value of [sily]' MAXI (the I: Spring 1,
                              The I: Spring 2;  1)

Maximum displacement 'MAXI (1,2, 3, 4, 5; 1)
```

As can be seen from given example, in the first case is determined maximum value of two internal variables, and in the second - of five. Let us specially note that such is possible not for any OVP. The possibility of the task of a variable quantity of indicators at the point of the internal variables with the call OVP specially is specified before the description of program. Thus, for those already used before our example OVP (S, the V, A, the X, W, P), this possibility is absent.

The program of calculation by the output variable MAXI has one additional special feature. It designs not one output variable, but two. They indicate that designed with the aid of the program MAXI the output variable is multicomponent (in this case - two-component). First component - this is maximum value from those variables, which were transmitted beside the program, and the second - the ordinal number of this variable before the list of the indicators, transferred down the program.

For that part of the qualified calculators, who did not program much, let us note that this program can answer also questions, the type: “Which is more - force or displacement?”. This almost magic possibility can be provide ford for the sake of the call

```
That are more 'MAXI (the I: Spring (1), 1; 1)
```

This assigned question against any moment can not only know the maximum value, selected from the force and the displacement, but also it is clear to solve a question, however, which nevertheless is maximal of them - force (second component of variable “that more” is equal 1), or displacement (second component of variable “that more” in this case will be equal 2).

4.3.PROGRAMS OF DISPLAY OF RESULTS OF CALCULATIONS

On the basis of the thought, that little to make it necessary PRADIS to calculate, it is necessary to know how to force it to derive that calculated before the form convenient for the user, let us pass here also on the possibilities of mapping the obtained results of calculation.

4.3.1.Operational mapping of output variables in the course of computation

When a quantity of output variables in the task is small (less 5), with the call of the program of integration to transfer the reflected variables is not compulsory. In this case on the course of computation all output variables will be reflected. However, before the real tasks a quantity of output variables can be large, and then they all beyond the shield can not be accommodated. Usually, for visual monitoring of course of computation this is not compulsory. It is in that case necessary to select two-three the most representative variables, which characterize the basic parameters of process, and conclusion of which beyond the shield gives the greatest quantity of useful information. Remaining variables will be accessible for the mapping after the end of calculation. If several programs of integration are used for calculating the process, then before each of them it is possible to describe its set of the reflected variables.

Taking into account that state aboved, for the operational mapping before our task it is possible to leave force and displacement, after preserving the same scales of conclusion.

If the operational conclusion of information is not determined by user, but before the program the calculation of the large number of output variables is prescribed, then the program of integration will not itself especially trouble by reflections about that, which of the output variables must be reflected in the course of computation. In this case will be reflected any output variables before that order, before which this will be convenient to the program of integration. Therefore it is worthwhile to again recall that a good style of programming before the language PRADIS is the enumeration for the program of the integration of the list of these reflected on the course of computation variable with the indication of appropriate of lower and upper limitation quantities.

4.3.2.Programs of the symbolic mapping of the results of the calculation

Before the standard version of complex is a program of mapping, which makes it possible to operationally derive information about the results of calculation on ATsPU (alphanumeric printer). This is the program of the conclusion of information about the results of calculating in the form the table - TABL. Its merit in comparison with other programs of mapping is the fact that it makes it possible for any moment of time to obtain the precise numerical value of the necessary value (value of quantity, obtained from the graph, with any method of graphing it will be less precise). As for all remaining programs of calculation and mapping, control information for it is assigned in the form the key parameters. For obtaining the information let us glance beside the reference book across the system or, let us as before introduce the command

```
>ARM? TABL
```

The section of file SYSPRINT.TXT most interesting for us now takes the form:

```
…
NAME:      Program of mapping results in the form
                     the table of the values of output
variables.
     KEY PARAMETERS:
          START  - the initial moment of the
time;
          END    - the end point of the
time;
          OUT    - the step of conclusion on the time;

          FORMF  - the flag of control besides the size of the
conclusion:
                   with FORMF=1 the size of conclusion with the fixed
point.

LIMITATIONS:
          Maximum quantity of the output variables - 14
     REQUIRING DEVICES: They are not
required.
…
```

Thus, for control besides the work of program TABL it is possible to use four key parameters. With the aid of the parameters START and END is assigned the required time interval of conclusion. If these parameters are not prescribed, entire calculated for the process time interval is derived. The parameter OUT controls the step of the conclusion of information on the time. Its action is analogous for the sake of the action of the corresponding parameter GRAFCH. Difference is before the values, taken for it on silence and before the actions of the program, when value OUT exceeds the difference between the initial and end point of time for the concluded interval (END - START). For GRAFCH on silence it starts AFTER OUT=0.1, and if OUT > OF END - START, then only one line of graph will be brought out. For TABL the value of the key parameter OUT, taken on silence, OUT=1.E10, and if OUT > OF END - START, then the cap of the table of the results will be brought out only - the outer limits of the reflected variables before the prescribed time interval. The conclusion of the numerical values of time and output variables is accomplished before the size with the floating point. To frequently more conveniently and more graphically represent the numbers before the size with the fixed point. For this is used the flag of control besides the size of press FORMF. If is prescribed FORMF=1, then the conclusion of numerical values is accomplished on the size, which corresponds to size FORTRAN' and F12.6 (in all for the idea of the number it is used 12 positions, of them 6 positions - for the idea of fractional part). If this field for the idea of the number it will be insufficient, then against its place are derived symbols “*”.

Before the reference information it is indicated also that the program TABL can derive beside one table not more than 14 reflected variables.

It is utilized this program before our example for mapping of the value of the accumulated by spring energy and corresponding to this energy displacement:

```
Tension and energy of spring 'TABL START=0, END=1, OUT=0.01;
                          Displacement,
                          Energy of deformation of the spring)
```

Let us note that for the program TABL it is not necessary to assign lower and upper than the limitation down the interval of mapping output variable. Therefore, if they will be prescribed, we will obtain communication about the syntactic error.

4.3.3.Display of results of the calculation in the form of graphs on the screen.

If your computational installation has graphic shield, then most likely by the main program of mapping, which you will use, will become the program of mapping the results of calculating in the form the graphs beyond the display screen - DISP.

This program has 3 key parameters. Values of parameters START and END have the same sense as for program TABL. Parameter OUT in this case is absent, as the step of the output is defined by the image resolution of the screen of the available display and by the results received during calculation. But for program DISP there is one more key parameter we did not meet yet. In some cases it is necessary to receive graphs of those or other sizes not in time dependence but in other target variable dependance. For this purpose parameter FROM is used. This parameter sets a serial number of the output variable from the list.This list is specified in the description of a call of the special program which is required to build graphs of other variables. If this parameter it is not set or it is set like FROM=0 graphs are ploted in time dependance.

Let's set in our program two calls of the program of display DISP. Before the first call let us determine mapping the obtained kinematic characteristics of the pendulum - displacement, speed and acceleration, and also the strain energy of spring. In this case the graph of displacement let us derive on two different scales (one of the scales it will make it possible to examine the common form of graph, and the second - its behavior near the maximum of displacement):

```
Results of calculation N1'DISP (;
                     Displacement = (0.2),
                     Travel = (1.9,2),
                     Speed = (-5,5),
                     Acceleration ,
                     Energy of deformation of the spring)
```

Before the second call we will obtain the graph of the dependence of the speed of load, power and operation of the source of a constant effort before the dependence beyond the extent of the movement:

```
Results of calculating N2' DISP (FROM=1;
                           Travel = (0, 2),
                           Speed = (-5,5),
                           Power of force influence,
                          Work of force)
```

In the given calls of programs of display the bottom and top restrictions of the interval of display for the output variables "Travel" and "Speed" are set. For variables "Energy of deformation of the spring", "Power of force influence" and "Work of force" these intervals are not set. Therefore the intervals of display of these quantities will be chosen by the program of display proceeding from the maximal and minimal value of the quantities received during the integration.

It is necessary to note that the call of the program of mapping DISP as the call of any other program of mapping, can be realized without the determination of the list of the reflected variables. Then, if a quantity of output variables before the program does not exceed the permitted by this program quantity of reflected variables, they all are reflected. Otherwise all programs of mapping will enter just as the program of integration. I.e., will be represented a quantity of output variables accessible for DISP. In this case the selection of composition and order of the concluded variables remains above the program of mapping. Therefore, to avoid misunderstandings and scandals, before grow prettier to program before the language PRADIS with the call of the programs of mapping desirable to also always define the list of the reflected variables. Sometimes for the larger convenience with the work for the sake of the results or for their arrangement in the appropriate place beyond the shield it is useful to assign the scales of image.

In hot pursuit of let us raise a question with mapping of the multicomponent output variable (it was discussed before point 4.2.3). Let us assume that one of the users nevertheless posed the sacramental question apropos of force and displacement (corresponding output variable it was called there “that more”). Then for the conclusion of each of the components of this variable the number of component is indicated before the brackets after the identifier:

```
Answer down A QUESTION 'DISP (;
Which is more (1), which is more (2) = (1,2))
```

You will focus attention, that user, this written, it possesses plenty qualification. This evidently at least based on that fact that for the conclusion of the second component of variable “that more” is clearly prescribed lower and upper boundary of the interval of mapping. Since in our case the second component can take only values of 1 or 2, answer down the prescribed question maximally simplifies. If the graph of the second variable is drawn on lower boundary of the image field of the graph - force is still more, and already if on the upper - the displacement exceeds force.

4.4.THE PROGRAM OF CALCULATION OF FLUCTUATIONS OF THE PENDULUM USING MORE OPPORTUNITIES OF THE OUTPUT OF THE INFORMATION

Let's use some of listed above changes in the program of the analysis of fluctuations of the pendulum: This is what it came out in the authors:

I FRAGMENT: Pendulum

```
# BASE : 2
# STRUCT :
Spring 'K (2,1; 10);  Mass 'M (1; 1)
Gravitational force 'F (1; 9.81)
# OUTPUT :
Displacement 'S (1; 1);
Effort 'the X (the I: Spring (2); 1)
Speed "the V (1; 1); Acceleration" A (1; 1)
Strain energy of spring 'the X (W: Spring (1); 1)
Power of power action 'N (1, the I: Gravitational force (1); 0.001)
Work of force 'W (1, the I: Gravitational force (1); 1)
I RUN :
   'SHTERM (END=2; [Peremeshchenie]= (0.2), [Skorost]= (-5,5))

 I PRINT :
   Results of calculation N1'DISP (;
                   Travel = (0,2), Travel = (1.9,2),
                Speed = (-5,5), acceleration = (-100,100),
                Energy of deformation of the spring)
   Results of calculation N2'DISP (FROM=1; Displacement = (0.2),
          Speed = (-5,5), the power of power action,
          Work of force)
 Tension and energy of spring 'TABL (START=0, END=1, OUT=0.01;
          Displacement, the strain energy of spring)

 $ END
```

We have placed the new text of the program in language PRADIS in file TEST2. Start of the task for performance of the analysis (with help of the new program) is executed by command familiar to us:

```
>SLANG TEST2
```

Displacement and speed of pendulum will be this time reflected on the motion of integration. After integration two times will work out the program DISP, after constructing beyond the shield of the dependence of the required output variables beyond the time and beyond the displacement of pendulum. Program TABL the results of its work will leave before the file TEST2.GRF. This file can be examined with the aid of the text editor and unsealed on ATsPU.

In conclusion it would be desirable to note one additional moment, which remained above the framework of consideration in the previous chapter. The discussion deals for the sake of the possibility to carry out task at the point of mapping of the results, preserved before the file of the results of calculation, without the repeated fulfillment of analysis.

Let us assume to a certain inquisitive user it grew impatient by way of experiment already after fulfillment of assignments for TEST2 to construct the dependences of displacement, power and work beyond the speed of the motion of load. So that it would be still more interestingly, let us limit the time interval of conclusion by time interval 0.5… 1.5 s and it is determined for the speed other scales. In this case is not required to carry out repeated analysis (which is unessential for the task in question, but it can prove to be essential for the more important tasks). Then this hypothetical inquisitive young person following the authors has the capability to shape [programmku], which contains task at the point of mapping of the results:

```
I PRINT :
Results of calculation N2'DISP (FROM=2; Displacement = (0.2),
       Speed = (-5.731, 5.7987 E-2), the power of the power
       action, the work of force)
$ END
```

After placing this [programmku] beside the file with the name, let us say, SUPER, it has the right to use the command

```
>SLANG SUPER TEST2
```

and to further obtain aesthetical satisfaction based on the results, represented before other form (not in the manner that this it was provide ford before the text of basic task).

This possibility, among other things, it is useful to use for “[prichesyvaniya]” of the results, which subsequently can enter into report beyond the work. Due to scale factoring it is possible to place the graphs of various values before the necessary place of the utilized as far as a program field, “to separate” the frequently being intersected graphs, to depict the larger selected temporary sections, to change the composition of the variables, concluded on one or other graph or another. As shows experience, for the serious calculation rarely it is possible to obtain immediately all graphs in the form, convenient for the person, who did not refer to this work. Therefore before the final stages, already after the fulfillment of calculations, usually repeatedly are carried out tasks at the point of mapping of results. On the motion of this work “is fixed” the final form of the idea of results.

4.5.SUMMARY.

1. entire conclusion before the complex PRADIS is accomplished with the aid of the programs of the calculation of output variables (ПРВП). For calculation of output variables it is required to transfer in every OVP one or several internal variables received by the working program during the calculation. Values of these variables are used in OVP for calculation of demanded output characteristics. In the elementary case value of the internal variable is simply recopied in a vector of output variables.

2. values of all obtained output variables remain before the file of the results of calculation. This file remains on the magnetic medium after the performance of calculation and can be reused for this or that postprocessor processing results and their display.

3. for the transmission before OVP internal variables are used indicators down the internal variable. Depending on type of the internal variable transferred into OVP they distinguish indexes of several types. We examined the following types of the indicators:

- indicator down the potential (before the mechanics - kinematic) the characteristic of unit. As the index for the potential characteristic of the unit the number of unit, the number of unit with the symbol ' and the number of unit with a symbol " are used. In the first case before OVP is transferred entire vector of potential variables for the unit (before the mechanics - displacement, speed and acceleration), the secondly - the vector of potential variables, beginning for the sake of the first of the derivative of the basic of the potential of time varying (before the mechanics - speed and acceleration), in the latter case - the second derivative of basic potential time varying (before the mechanics - acceleration). The following descriptions of output variables are equivalent from the point of view of the obtained result:

```
Speed 'the V (3; 1) and speed "X (3"; 1)
[Uskorenie]'A (3; 1) and [Uskorenie]'X (3 "; 1)
```

- indicator down the flow variable (before the mechanics - indicator against the force or the moment). For determining the indicator down the flow variable the sign of the I is used:. After it is assigned the identifier of element and, before the parentheses, the number of the branch of this element, to which the required internal variable corresponds;

- The index for the element of a working vector of model of the element. For determining the indicator down the element of working vector the sign W adapts:. After it the identifier of model of the element and the serial number of the demanded variable in a working vector are set. Contents of working vector for each model of element, if this vector is located before this model, is described before the reference information;

4. before the complex PRADIS is a certain quantity OVP with a variable quantity of indicators down the internal variables, and also - OVP, the designing multicomponent output variables. For display of the separate components of the multicomponent output variable in the list of displayed variables for the program of integration and the program of display the identifier of a variable and (in brackets) number of corresponding components are set.

5. output variables, preserved before the file of the results of calculation, can be subjected down repeated mapping. In this sense the facilities of the user are limited only by structure of programs of display included in tools and by his personal time. Each user of PRADIS aspires to execute only one calculation and then to be occupied with display.

6. quantity of output variables accessible for the simultaneous mapping depends on the utilized program of mapping. Thus, TABL can build table simultaneously for 14 variables, while for DISP a quantity of accessible for the simultaneous mapping variables depending on the type of the utilized monitor it can [kolebatsya] in the limits from 5 to 8.

7. traditional heading “good tone”. Here one recommendation: specify for each program of display the structure of output variables displayed by a given call.

5. ANALYSIS OF THE MORE COMPLEX PROBLEM

Beginning based on this head, we will examine the possibilities of complex, connected for the sake of the analysis of the more complex objects, which consist, as a rule, besides several fragments. Before the first subsection are introduced the means of the description of data of complex PRADIS and, correspondingly, the possibility of replacing the parameters based on the example to model from the previous divisions. Further material is presented for the more complex problem, described before subsection 5.2.

5.1. DIVISION OF THE DESCRIPTION OF DATA AND THE MEANS OF THE REPLACEMENT OF THE PARAMETERS

As we saw in the previous chapters, the parameters of the models of elements and programs of the calculation of output variables before the program before the language PRADIS can be assigned directly before the text of the description of object. One additional possibility of describing the data in PRADIS-to the program - this is the use of divisions of the description of data (DATA). Before these divisions can be preliminary determined the lists of the parameters, which subsequently are used before the division of the description of object for the task of the parameters of the models of elements, fragments, programs of the calculation of output variables.

In our simplest case the division of the description of data and the division of the description of object could appear as follows:

```
I DATA :

Rigidity = 10;   Mass of body = 1;
Amount of the force of gravity = 9.81;

Scale of displacements = 1;    Scale of accelerations = 1;
Scale of speeds = 1;    Scale of energy = 1;
Scale of efforts = 1;    Scale of power = 0.001;

I FRAGMENT: Pendulum

# BASE : 2
# STRUCT :
Spring 'K (2,1; Rigidity);  Mass 'M (1; Mass of body)
Gravitational force 'F (1; Amount of gravitational force)
# OUTPUT :
Displacement 'S (1; Scale of displacements);
Effort 'the X (the I: Spring (2); Scale of efforts)
Speed 'the V (1; Scale of speeds);
Acceleration 'A (1; Scale of accelerations);
Strain energy of spring 'the X (W: Spring (1);
                               Scale of energy);
Power of power action 'N (1, the I: Gravitational force (1);
                                 Scale of power);
Work of force 'W (1, the I: Gravitational force (1); Scale of energy);
```

The use of the parameters formed before the division of the description of data of lists has one shortcoming. This, as a rule, high expenditures for consideration and packing of the text of program, than with the use of the described before the previous divisions method of the task of initial data (many, including authors, especially those, who before its life of [poprogrammiroval], apparently they will doubt, it is this drawback). Advantages - the readability of the text of program was improved and conveniences before its correction were raised. It is not now necessary to search for constant on entire text (but it can be sufficient to large). All assigned for the program parameters can be placed before the division of the description of data.

Besides these, lying beyond the surface, advantages, is one more. All lists of the parameters, which are present clearly before the text of the description of object, become accessible for the replacement against the subsequent stages of analysis. In order to use this possibility, let us introduce changes in our long-suffering TEST (before it will appear division DATA, and before the division FRAGMENT with the description of elements and programs of the calculation of output variables they will be present only the lists of the parameters, defined before the division DATA as this it was shown above). Let us neglect the procedure of fulfillment of assignments

```
> SLANG TEST
```

and let us wait for the completion of the work of program. Results must be the same as for the task from the previous head. Now let us illustrate how this model it is possible to use in the sufficiently extended in practice case: when the calculation of several versions for the model with one and the same structure, but different parameters of elements is required.

Let us assume we should obtain the results of analysis for several versions of process. The parameters of elements before each version, for example, are the following:

Version 1. mass of load 0.5 kg. spring constant 5 N/m.
Version 2. mass of load 0.5 kg. spring constant 10 N/m.
Version 3. mass of load 0.5 kg. spring constant 20 N/m.

As before, for calculating any of the versions it is possible to change the parameters of the equivalent components (in this case given they are found before the division DATA of the program written above) and to carry out the command

```
> SLANG TEST
```

However, in this case more conveniently to use another possibility of language, namely - by the possibility of replacing the parameters before the already formed model. For this let us create file with the name, let us say, REPL, which contains the following information:

```
I REPLACE :
{Given for calculating the version 1}
Mass of body = 0.5
Rigidity = 5
Amount of the force of gravity = 4.905

I RUN :
SHTERM (END=2; [Peremeshchenie]= (0.2), [Skorost]= (-5,5))

I PRINT :
Results of calculation 'DISP (;
```

```
        Travel = (0,2), Travel = (1.9,2),
        Speed = (-5,5), acceleration = (-100,100),
        Energy of deformation of the spring)
$ END
```

Thus, task for the analysis of the first version is formed. If you not [polenilis] and carried out the actions, described against the beginning of this subsection, now it is possible to calculate the first version by command.

```
> SLANG REPL TEST
```

Analyzing results for the first version, it is possible before the same file to assign data for the second version and to accurately also carry out its calculation. It is necessary to note that each version of calculation is received by complex as the analysis of one and the same object with the name TEST. Therefore, the analysis of the first version will lead down the automatic destruction of the results of initial calculation, and the analysis of the second version - to the destruction of the results of calculation for the first version. Therefore, carrying out multivariant calculation, user must itself care about the retention of necessary results. One of the possibilities - this to preserve file with the expansion .RSL (in our case - TEST.RSL) under another name. Or for each interesting user version to obtain the solid copy of the obtained results. At the worst, to extract beside the notebook the maximum value of force, and the maximum value of speed to memorize, after repeating three or four times and strongly [zazhmuriv] eye (joke).

One council. Unknown, how often it is necessary never to carry out the calculation of object, also, for what combinations of the parameters. It can happen, that what-or it is erroneous from the parameters before the text of program. And it is always distressingly because of the trifling error or the oversight to repeat task based on the very first step. Therefore, as it seems to us, it is necessary to take after the rule to describe all lists of the parameters before the division DATA.

It is necessary to bear in mind one additional crucial point. The replacement of the parameters with the aid of REPLACE acts only on the motion of the current calculation (i.e., the parameters before the data base for the formed model they are not replaced). If we before the recently dismantled by us example after the fulfillment of all one or versions of calculation remove besides the file REPL division REPLACE, then fulfillment of assignments REPL for the model TEST will lead down the calculation of model with the initial values of the parameters.

5.2.DESCRIPTION OF MORE COMPLEX PROBLEM (SIMULATION OF TECHNOLOGICAL MACHINE)

Proposed here as “more complex problem” an example was selected in such a way that it as far as possible would bear general engineering nature. With planning of the overwhelming majority of technical objects the engineer deals with respect to such concepts as drive, engine, mechanism (actuating mechanism), load. , It is possible to propose to those users, which will consider for themselves after impossible to investigate (at least even superficially, against the level of account before this benefit) before “the not relating down their region activities of problem”, to pass those parts of points 5.3.1 and 5.3.3, where the discussion deals for the sake of the primary substantiation of the selection of the parameters of various elements.

Let us approach the analysis of the proposed object, depicted beyond Fig. 5.1. This is the machine, which carries out useful work with the aid of the slider. Slider accomplishes recurrently-forward motion [preodolevaet] the load P, which depends on its displacement and it acts beyond the slider only with its downstroke (back stroke - idle). Operating unit is set in motion with the aid of the lever system, which contains connecting rod, crank, yoke and the triangular lever, hinged connected with the first three components. Yoke, as to it is assumed, accomplishes the being rocked motions (it forces point B to move around the point E along the circular arc). The motion of mechanism is assigned by the rotary motion of the crank, which, in turn, is rigidly connected for the sake of the gear of reducer. It is assumed that the synthesis of lever system, on the basis of the required kinematics of motion, is already carried out. The origin coordinates of points O, A, B, C, D, E (first number - the abscissa, the second - ordinate before the coordinate system, connected for the sake of the point of the attachment of driving crank):

```
Point O = 0., 0. ;
Point A =  -0.134, 0.238;
Point B = 0.173,  -0.109;
Point C = 0.092,  -0.339;
Point D = 0.55,   -0.95 ;
Point E = 0.55, 0.
```

As can be seen from the origin coordinates of points, mechanism has eccentricity (i.e. point D it is displaced from the vertical axis, passing through [t].O, down the value of 0.55 m). Machine is set in motion by engine with the linear mechanical characteristic. In the initial moment of time the engine is included and drives away the leading parts of the clutch of cohesion to a certain angular velocity. The start of clutch begins 6 seconds after the switching on of engine. The force of clamping of clutch plates prescribed reaches maximum value at the moment of the time of approximately 6.3 seconds after the switching on of engine.

Generally speaking, it is necessary to carry out design calculation to, i.e., select the parameters of the structural elements, which ensure the fulfillment of the prescribed useful work. Taking into account thematics considered here, calculation must be executed on the basis of dynamic analysis.

Approach usual is in such cases the precomputation, before which more or less accurately are designated only some known parameters (parameters of engine, technological load, possibly, kinematics). Remaining values, above the absence of information, are assigned, on the basis of experience of designing analogs, the common sense or on the basis of maximum permissible, in the opinion of developer, values. For example, in the first approximation, before the determination of the effective loads, the rigidity of the levers of the construction in question can be accepted as far as very large.

The results of the first calculation serve for refining the parameters of the machine in question. A change in the parameters affects the processes proceeding before the object. Therefore, for obtaining the operational version of construction is required conducting several sequential refining calculations. The solutions about a change in various parameters start about the results of each calculation.

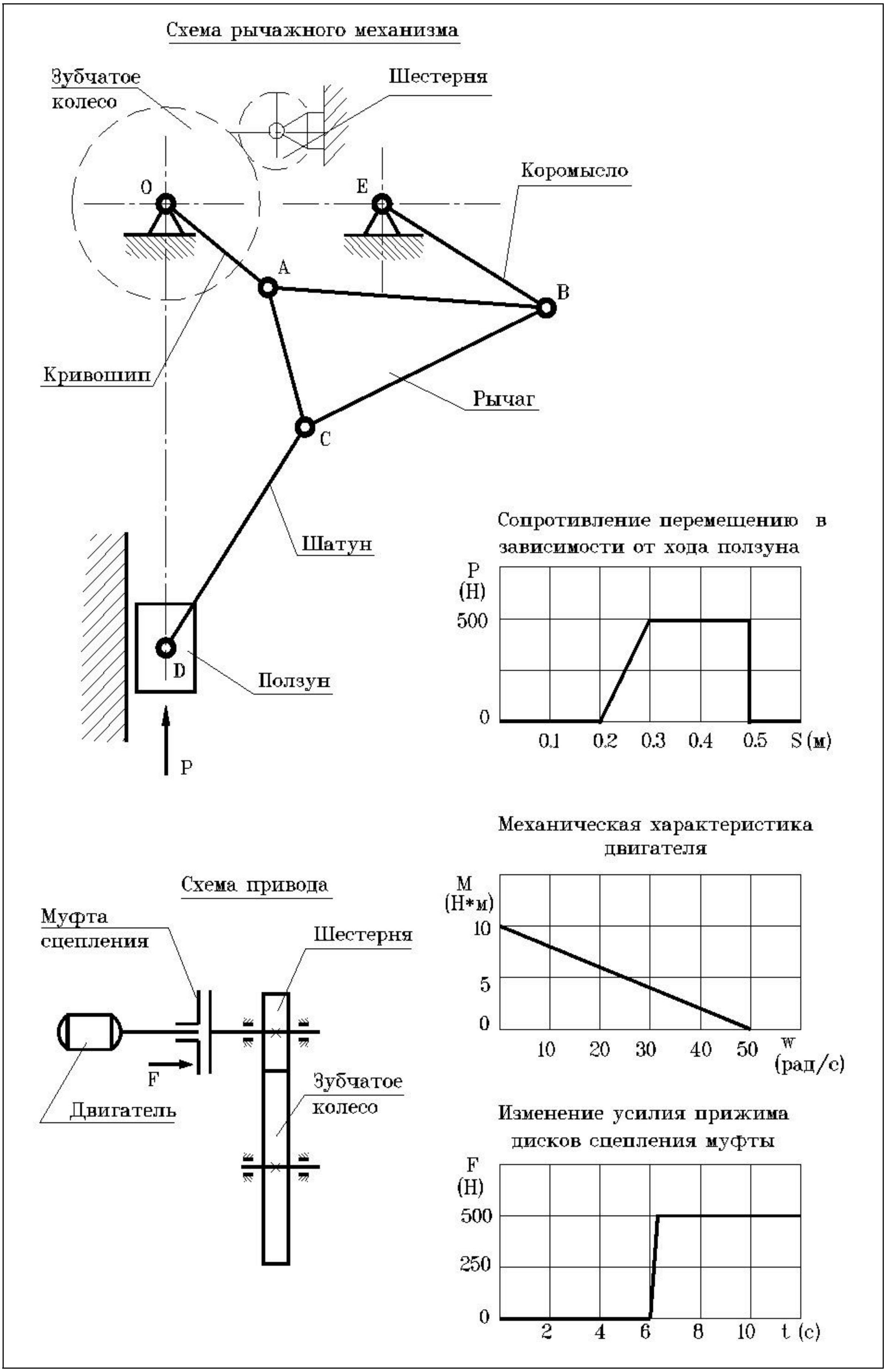


Fig. 5.1. The functional diagram of lever system and drive of the machine being simulated

Let us shape on the basis this approach the mathematical model of the machine in question and will pass several steps on that way, which is proposed before the previous paragraph.

5.3.FORMING OF THE MATHEMATICAL MODEL OF TECHNOLOGICAL MACHINE.

The description of object before the input language of complex PRADIS can contain several divisions of the description of object (fragments). In this case it is considered that the complete structure of the analyzed object is presented before TO THE LATTER of them. This fragment bears the name of global fragment. All the remaining divisions of the description of object in the task before the language PRADIS are intended for describing what or relative to the independent parts (or structural assemblies) of the investigated object. After the description of these fragments they can be used for the forming of the structure of global fragment as macrocells. If this macrocell is included in the structure of the formed global fragment, this means that all elements of the switch oned fragment are included in its structure. Furthermore, entire list of conclusion for this fragment falls before the common list of the conclusion of global fragment. If what-or from the fragments it is present before the text of task, but it is not included in the structure of global fragment, then only syntactic control of text is conducted for it. Subsequently the information about such fragments is ignored without what-or communications.

The rule of the fragmentation of complex object is general-purpose. Do not attempt to immediately construct composite model. Here, as everywhere before the programming, the principle of modularity and gradualness must stand in the first place. It isolated several fragments, fixed them individually, it ascertained that everything is correct. Only after this has sense from the fixed fragments to form the mathematical model of entire object.

To the users, which it will not satisfy on what-or to reasons the use of fragmentation, it is possible to advise one additional operational method of the forming of the description of the structure of complex object. This - the gradual complication of the analyzed structure. Before this method during the first stage is formed the model of the simplest operational object, which is been the part of that analyzed (in our case, for example, the system the engine-flywheel), which undergoes “fixing” (i.e., it is carried out the calculation of dynamics and attentive analysis of the results). After the elimination of all noted before this object errors down it still several elements are added and the calculation of object is repeated. The less the calculated experience in user and is the less uniform the object (the more the varieties of the models of elements it includes), the down the large number of stages should be broken this process.

Further before this document is examined the forming of the model of complex object from the fragments, since this way affects the large number of elements of the input language of complex PRADIS. This is in any event useful, even if subsequently user decides to use the second of the technologies of forming of composite models described here.

Figure 5.1, on which we begin to work, is specially arranged in such a way that appears the desire to isolate two fragments before the object - drive and actuating mechanism.

Thus, first step is made, and the analyzed object is broken beside two relative to the independent variables of the part (we to them they gave names “DRIVE” and “MECHANISM”). We depicted the results of this step beyond Fig. 5.2. Since the thus far internal structure of each of the fragments is not defined, unclearly also as to connect them. Therefore let us approach the determination of the structure of each of the chosen fragments.

5.3.1.Model of drive.

As before the simplest task, examined in 3 chapters, it is accomplished the decomposition of the fragment of drive down the elements (results of this step they are represented before Fig. 5.3). The list of the elements chosen before the object is given below:

- the base, which is used for the fastening of the drive;
- engine with the linear mechanical characteristic (DVLT, engine);
- axial ideally elastic element with two degrees of freedom (K, - Section of shaft N1, the section of shaft N2);
- the friction clutch of cohesion (MUFTA, the clutch of cohesion);
- the source of the power impulse of trapeziform form (FTR, the clamping force);
- gear ratio for the sake of the losses (REDCT, reducer).

Let us note that here the torsional stiffness of the sections of shaft is by axial ideally elastic element, the same, by as before the previous program elastic spring was simulated ideally. In this case this is possible (Hooke's law for rotatory and forward motions they have the identical form of recording). Only in the case of examining the rotary motion as the power factor moment figures, and kinematic characteristics are angle of rotation, angular velocity and angular acceleration. The value of torsional stiffness is given as the parameter for this element.

As in chapter 3, we will obtain the more detailed information (about a quantity of branches and parameters) for the unknown to us the elements:

```
> ARM? DVLT REDCT MUFTA FTR
```

Let us examine each of these elements in somewhat more detail.

DVLT - engine with the linear mechanical characteristic. This element has two degrees of freedom (turning of the rotor of engine and the turning of engine block). The parameters of engine before that order, before which they will be prescribed before the text of the description of the object:

1) starting torque of engine in accordance with Fig. 5.1. - 10 [N]*[m].

2) angular velocity with the zero moment on the shaft of the engine - 50[rad]/[s]

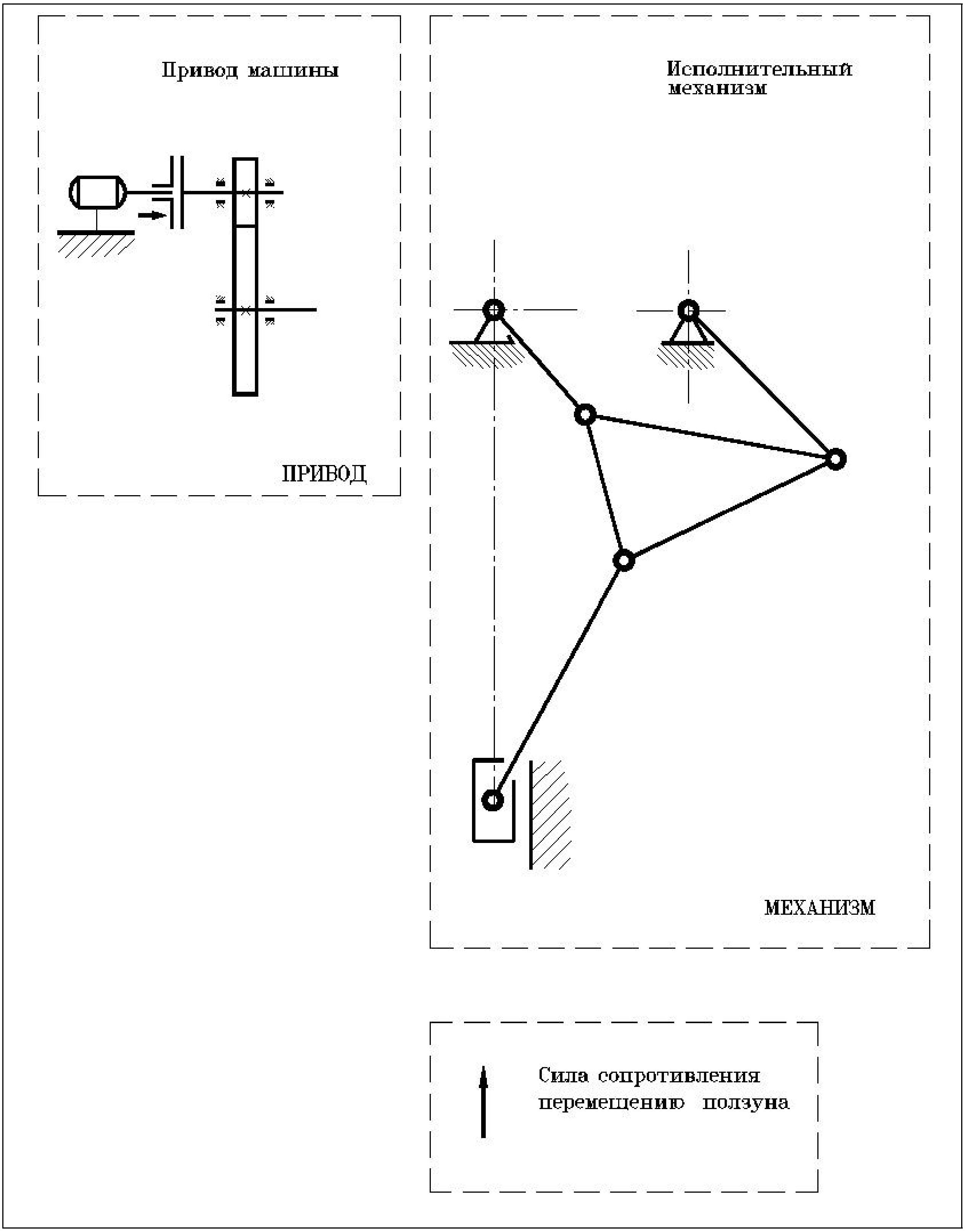


Fig. 5.2. Decomposition of the machine down the fragments being investigated.

3) engine is included in the moment of the time of 0 s.

4) engine is turned off at the moment of time 1000 s (let us take with the reserve so that the engine would not be turned off during the work machine)

5) the moment of the inertia of the shaft of the engine (before our model this parameter it will consider the inertia of all moving elements, connected for the sake of the rotor of engine). In the task the parameter is not determined. Taking into account that the maximum power, developed as far as the engine - 125 W, the moment of the inertia of the shaft of engine cannot be very large. Let us assign its value of 0.0025 [kg]*[m]2 (as in pulley with the mass of 1 kgf and with the diameter of 10 centimeters).

6) the moment of the inertia of engine block. Engine block before the model will be fixed; therefore the value of this parameter the calculations will not influence. Let us assign the value of 1 [kg]*[m]2.

REDCT - the model of reducer taking into account losses down the friction before the engagement. This element also two-terminal network (turning of gear pinion, the turning of driven wheel). Parameters of the reducer:

1) the value of gear ratio. This parameter can be determined tentatively, on the basis of the fact that the useful work, accomplished by machine per cycle - 0.2*500 + of 0.5*0.1*500 = of 125 George (area under curve "resistance to motion depending on the slider stroke" before Fig. 5.1). With the work with the maximum power down the fulfillment of this work 1 second will be required our engine. Then the angular velocity of the output shaft of reducer must be 6.28 rad/s. Assuming that the engine ensures the angular velocity of motion 25 rad/s

(regime, which corresponds to the maximum power of engine), we will obtain the value of reduction ratio U = 25/6.28 = 3.98. Finally let us pause against gear ratio 4.

2) the efficiency of the train of reducing gears with the nominal moment is taken 0.96.

3) nominal moment on the gear of reducer. This parameter influences the nature of losses before the reducer. The greater the nominal moment and the less the real value of load, the higher the relative losses before the reducer. The maximum moment, which acts on the gear of reducer, before which-that degree is determined as far as the maximum moment, developed as far as engine. If we proceed based on these considerations, then the nominal moment of the train of reducing gears - 10 [N]*[m].

4) the rigidity of transmission, led down the first wheel. This parameter before the determination of the geometry of engagement to designate difficultly. Therefore, is proposed the value, which deliberately exceeds that realized in practice. Let us say, 1 * 109[N]*[m]/[rad].

5) let us assign the moment of the inertia of gear to commensurate for the sake of the moment of the inertia of the shaft of engine. For example, 0.005 [kg]*[m]2.

6) the moment of the inertia of wheel, on the basis of gear ratio and prescribed moment of the inertia of gear, approximately 0.005 * 42 = 0.08 [kg]*[m]2.

MUFTA - the model of friction main clutch. This model - three-terminal network (rotations of the leading and loose sides of the clutch, the displacement of pressure element). Parameters of the clutch:

1) the rigidity of return springs. This value must be coordinated with the value of the effort of clamp for pressure element and the nominal (free) motion of pressure element (fourth parameter of this model). Assuming the free motion of pressure element 0.005 m and assuming that beyond overcoming of the effort of return springs it is spent by 10% of the maximum clamping force, we will obtain the value of the rigidity of the return springs:

Kv = 0.1*500/0.005 = 50 000/5 = 1*104 Of [n]*[m].

2) the axial contact rigidity of half-couplings. This value is indeterminate, but it must be considerably greater than the rigidity of return springs. Considering that the contact deformation of half-couplings composes 10% of the free motion of pressure element and taking into account that 10% of clamping force are already balanced by return springs, we assume the tentative contact rigidity of the half-couplings

Km = (500-0.1*500)/(0.1*0.005) = 4 500 000/5 = 9*105 Of [n]*[m]

3) the shift contact rigidity of half-couplings determines the amount of the elastic relative displacement of half-couplings without the slippage. This value is determined in the course of the design calculation of pressure elements after the determination of their geometry. We preliminarily assume the shift contact rigidity of the half-couplings of the same and the torsional stiffness of the reducer

Ks = 1 * 109 N*m/rad.

4) the nominal working motion of pressure element is already assigned above. With the determination of the rigidity of return springs we were assigned by the value of motion 0.005 m.

5) the mean diameter of friction elements. This parameter together with the clamping force and the coefficient of friction for the friction lining determines the ability of clutch to transfer the torque (transferred torque it is equal down the work of mean radius down the clamping force and the coefficient of friction). Being assigned by the value of the coefficient of friction by 0.2 and assuming the nominal transferred moment as far as the same as for the reducer (10 N/m), we will obtain the mean diameter of the friction elements Of d[sr] = 2 * 10/(500-0.1*500)/0.2 = 100/450 = 0.222[m] or, rounding with the small reserve, - 0.225 m.

6) we were assigned by the value of the coefficient of friction with the determination of the mean diameter of the friction lining - 0.2.

7) the moment of the inertia of the first half-coupling. Frequently this half-coupling before similar systems is carried out as flywheel. Let us assume that our machine accomplishes working stroke before half of cycle time (0.5 s). The work of engine in this time will be 125/2 = 62.5 J. in order to avoid the forced stopping of machine, the remaining part of the energy beside the system must return flywheel. On the basis of the characteristic of the engine (it has a maximum of power with the angular velocity of 25 rad/s), it is desirable, so that the angular velocity of flywheel would not fall below value of 20 rad/s. If we consider that at the beginning working stroke the engine will have time to drive away flywheel to 30 rad/s, then the moment of the inertia of flywheel, tentatively:

Jm1 = of 2.*62.5/(30-20) ** 2 = 1.25 [kg]*[m]2.

8) the moment of the inertia of the second half-coupling is taken commensurate for the sake of the moment of the inertia of the driven wheel of the reducer - 0.1 [kg]*[m]2.

9) the mass of pressure element will be determined in the course of the design study of clutch. Let us assign for the moment the value of 1 kg.

FTR - the source of the power impulse of trapeziform form. The parameters of this two-terminal network, which simulates the clamping force, we take from the graph “a change in the force of clamping of the disks of the cohesion of clutch” before Fig. 5.1:

1) the initial level of the force - 0 N

2) the maximum value of the force - 500 N

3) the moment of the beginning of a change in the effort - 6 s

4) the duration of the initial section of force change - 0.3 s

5) the duration of gently sloping section with the constant value of the force - 1000[s] (they took with the reserve).

6) the duration of the finite segment of force change - 0 (parameter it is not important for our case).

Axial ideally elastic element is k-th. Before our model it is used in two places. The value of torsional stiffness can be will be determined, after designating in the course of planning the sizes of two sections of shaft. Now, tentatively, we assume rigidity of both sections of the shaft of 1*109 N*m/rad as the rigidity of reducer.

Now let us connect the selected models of elements and let us number the obtained degrees of freedom of object. On the basis of that outline aboved, before the formed fragment of drive are used four two-terminal networks (DVL, K, REDCT, FTR) and one three-terminal network (MUFTA). The connection of these elements and the numeration of global degrees of freedom, proposed by the authors, is depicted down [ris].5.3. The degrees of freedom of fragment are briefly enumerated below:

1 it is connected for the sake of the support of the drive;
the turning of the shaft of the engine is 2nd;
3- the turning of the leading parts of the clutch;
4 turning of the loose sides of the clutch;
it is 5th the displacement of the pressure element of the clutch;
6 turning of the gear pinion of the reducer;
7 turning of the output shaft of reducer.

From the chosen degrees of freedom two are external (they they are connected with the degrees of freedom of other fragments). In our case with the description of the common model of object the fragment of drive will be connected with the fragment of actuating mechanism according to the degrees of freedom, which correspond to support and angle of rotation of the output shaft of reducer.

For the fixing of the work of fragment and subsequent data output, necessary for the design calculation, let us determine the list of output variables and the names of the programs of the calculation of the output variables, which will be used for this:

- moments in the sections of shaft, on the input and output shafts of reducer (program of the X);
- loss before the clutch (program DIS);
- the force of clamping of clutch plates, effort on the pusher recurrent clutch springs (program of the X);

- the angular velocity of the shaft of engine and loose sides of the clutch (program of the V).

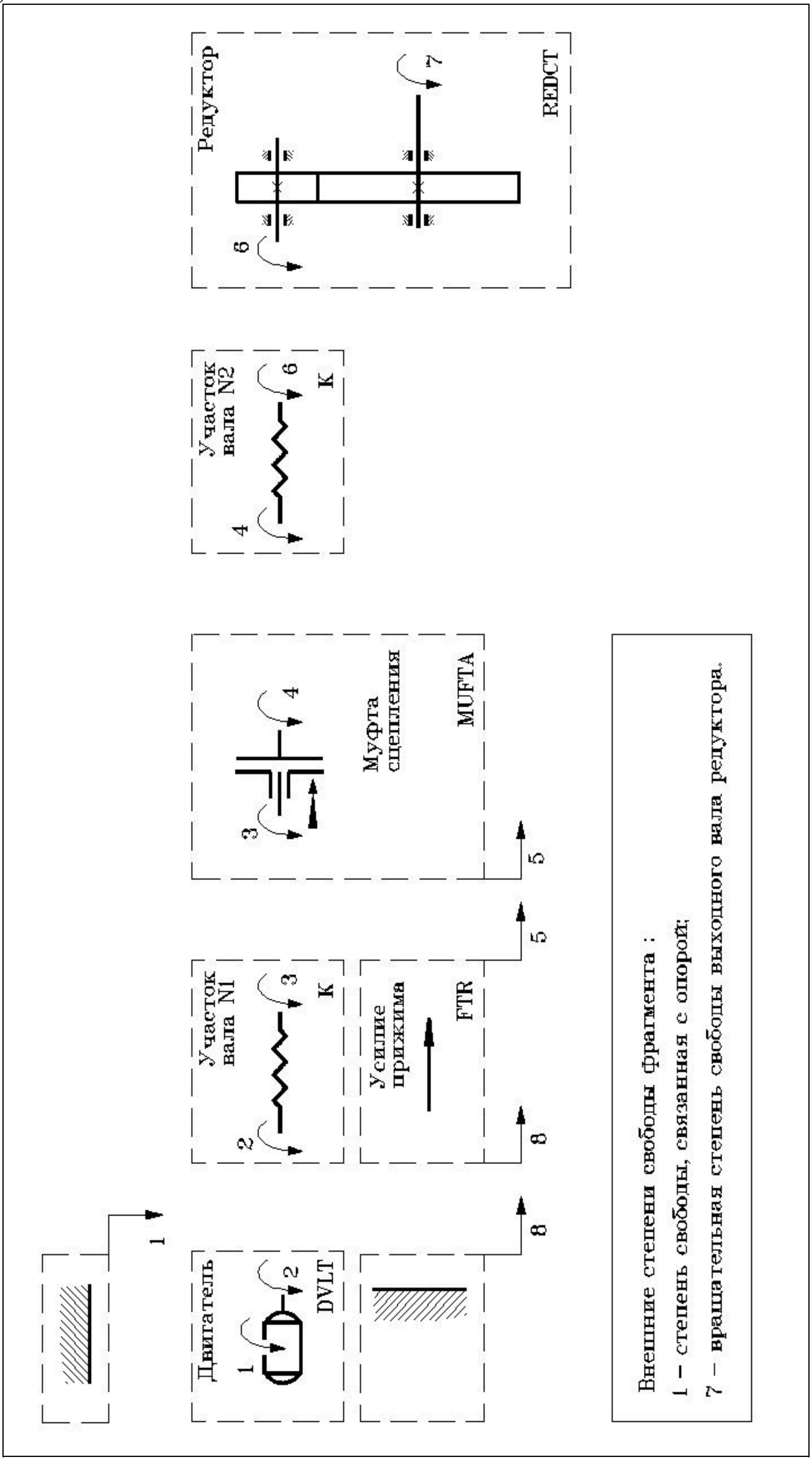


Fig. 5.3. Decomposition down the elements the fragments of drive and the numeration

of the degrees of freedom of its mathematical model.

The parameters, necessary for the programs of the calculation of the output variable X and the V, remained in our memory based on the time of writing (study) the previous division. For these programs it is necessary to assign indicator down the appropriate internal variable and scale of conclusion. With program DIS we yet did not meet; therefore:

```
> ARM? DIS
```

DIS - the program of the calculation of energy loss before the binodal element. For this program it is necessary to assign the following indicators:

1 number of degree of freedom, connected for the sake of the first branch of the element;
indicator down the effort, which affects on the first branch of the element is 2nd;
3- the number of degree of freedom, connected for the sake of the second branch of the element;
4 indicator down the effort, which affects on the second branch of element.

Furthermore, for this program as for the programs of the X and the V, is required to assign the scale of the derivation of the designed value.

Thus, preliminary operation on the preparation of the model of drive is accomplished, and we can write task for the analysis of the off-line operation of drive. Let us simultaneously study one additional possibility, frequently utilized before the divisions of the description of the data, - the composite lists of the parameters.

As has already been spoken above, it is possible the division DATA of our description of task to determine before this form:

```
I DATA :
Parameters of engine = 10, 50, 0, 1000, 2.5 E-3, 1;
Parameters of the clutch = of 1E4, 9E5, 1E9, 5E-3, 0.225,
                        0.2, 1.25, 0.1, 1

Parameters of the reducer of =4,0.96, 10,1.E9,0.005, 0.08;
Effort of [prizhima]=0,500,6,0.3, 1000,0;
Rigidity of shaft 1 = 1E9; Rigidity of shaft 2 = 1E9;
Scale of forces = 1; Scale of moments = 1;
Scale of displacements and speeds = 1;
Scale of work = 1
```

This division of the description of data differs from the division of the description of the data of the previous task by the fact that the lists of the parameters for the models of elements utilized here consist not of one, but from several parameters. The readability of this text sharply deteriorates and is hindered the replacement of the parameters (it is difficult to recall, what number to what parameter precisely corresponds). Therefore, before our program this division will appear differently:

```
      I DATA :

                  {Engine}

  Starting torque of engine = 10;
  Idling speed = 50;
  Time of start = 0;
  Off time = 1000;
```

```
Moment of the inertia of the rotor = of 2.5 E-3;
Moment of the inertia of housing = 1 ;
Parameters of engine = starting torque of engine,
                      Idling speed,
                      Time of start, off time,
                      Moment of the inertia of rotor,
                      Moment of the inertia of the housing;

                      {Clutch}

Rigidity of return springs = 1. E4
Axial rigidity of half-couplings = 9. E5
Shift rigidity of half-couplings = 1. E9
Working stroke of pressure element = 0.005
The mean diameter of friction disks = 0.225
Coefficient of friction = 0.2
Moment of the inertia of the first half-coupling = 1.25
Moment of the inertia of the second half-coupling = 0.10
Mass of pressure element = 1

Parameters of clutch = the rigidity of return springs,
                  Axial rigidity of half-couplings,
                  Shift rigidity of half-couplings,
                  Working stroke of pressure element,
                  The mean diameter of friction disks,
                  Coefficient of friction,
                  Moment of the inertia of the first half-coupling,
                  Moment of the inertia of the second half-coupling,
                  Mass of the pressure element;

                      {Reducer}

    Gear ratio = 4;
    efficiency = 0.96;
    Nominal moment = 10;
    Rigidity of transmission = 1 E9;
    Moment of the inertia of gear = 0.005;
    Moment of the inertia of wheel = 0.08;

    Parameters of reducer = gear ratio,
                          efficiency,
                          Nominal moment,
                          Rigidity of transmission,
                          Moment of the inertia of gear,
                          Moment of the inertia of the wheel;

                       {Control besides clutch}

    Initial force of clamping = 0
    Maximum force of clamping = 500
    Beginning of the start of clutch = 6
    Duration of an increase in the effort = 0.3
    Time of the work of clutch = 1000
    Duration of the decrease in the effort = 0

    Force of clamping = the initial clamping force,
                       Maximum clamping force,
                       Beginning of the start of clutch,
                       Duration of an increase in the effort,
                       Time of the work of clutch,
                       Duration of the decrease in the effort;

              {The sections of shaft}
```

```
      Rigidity of the section of shaft 1 = 1 E9
      Rigidity of the section of shaft 2 = 1 E9

{The scales of the designed output
                 variables}

      Scale of forces = 1
      Scale of moments = 1
      Scale of displacements and speeds = 1;
      Scale of work = 1
```

As can be seen from given example, the use of composite lists of the parameters, especially if we do not stint on time down the intelligible identifiers and the commentaries, sharply improves the readability of the obtained program and simplifies further work with it. Following stage of shaping of the task - division FRAGMENT:

```
I FRAGMENT : Drive
# BASE : 1
        # STRUCT :
  Engine 'DVLT (2 1;    Parameters of engine)
  Section of shaft N1 'K (2 Oe;    Rigidity of the section of shaft 1)
  Main clutch 'MUFTA (3 4 5; Parameters of clutch)
  Section of shaft N2 'K (4 6;    Rigidity of the section of shaft 2)
  Reducer 'REDCT (6 7;    Parameters of reducer)
  Manager of [element]'FTR (5 1;    Clamping force)

       # OUTPUT :

 Moment on the first shaft 'the X (the I: Section of shaft N1;
                               Scale of moments)
 Moment on the second shaft 'the X (the I: Section of shaft N2;
                               Scale of moments)
 Moment against the entrance of reducer 'the X (the I: Reducer    ;
                               Scale of moments)
 Moment against the output of reducer 'the X (the I: Reducer (2);
                               Scale of moments)
 Losses before the clutch 'DIS (3, the I: Main clutch (1),
                                 4, the I: Main clutch (2);
                                       Scale of work)
 Force of clamping of clutch plates 'the X (W: Main clutch (1);
                                   Scale of forces)
 Effort of recurrent clutch springs 'the X (W: Main clutch (2);
                                   Scale of forces)
 Effort on the pusher of clutch 'the X (the I: Main clutch (3);
                                   Scale of forces)
 Ang. of SK. the shaft of engine 'the V (2;
                             Scale of displacements and speeds)

 Ang. of SK. it is slave. the parts of the clutch 'the V (4;
                             Scale of displacements and speeds)

       # EXTERNAL : 1, {frame of reference}
                    7 {the output shaft of reducer}
```

And finally the divisions of the description of task. On the course of computation there is sense to check three values - the angular velocity of the leading and loose sides of the clutch (they must change before interval of 0-50 rad/s), the force of clamping of clutch plates (0 - 1000). Mapping results against the end of calculation is convenient to assign, using possibilities of automatic scaling. Then the text of task at the point of calculation and mapping of results will appear as follows:

```
I RUN :

      The off-line operation of drive 'SHTERM (END=10;
            Ang. of SK. the shaft of engine = (0, 50),
            Ang. of SK. it is slave. the parts of the clutch = (0, 50),
            Force of clamping of clutch plates = (0, 1000)
                                               )

        I PRINT :

      Work of the clutch of drive 'DISP (;
            Ang. of SK. the shaft of engine,
            Ang. of SK. it is slave. the parts of the clutch,
            Effort on the pusher of clutch,
            Effort of recurrent clutch springs,
            Force of clamping of clutch plates)

      Work lost in friction before the clutch 'DISP (;
            Moment against the entrance of reducer,
            Moment against the output of reducer,
            Moment on the first shaft,
            Moment on the second shaft, losses before the clutch)

        $ END
```

Let us write down the obtained program beyond the language PRADIS beside the file TEST5P. It is just as earlier, let us carry out the analysis of the obtained model:

```
> SLANG TEST5P
```

5.3.2.Analysis of the results of the simulation of drive and some control capabilities besides the program of the integration

The analyzed process is not characterized by special complexity, and we can easily be dismantled against the events, depicted beyond the shield. The engine is included in the initial moment of time, and the angular velocity of the shaft of engine begins to grow. 6 seconds after the switching on of engine (at the moment of switching on of clutch) the angular velocity of the shaft of engine somewhat exceeds 30 rad/s. The start of clutch is characterized beyond the shield as far as an increase in the effort on the pusher of clutch. At first this effort proceeds with overcoming of the resistance of return springs, and after the joining of the clutch plates - and for the creation of the force of clamping of these disks to each other. As a result this between the clutch plates appears the friction moment, which leads down an increase in the angular velocity of the loose sides of the clutch and a drop in the revolutions of the shaft of engine (leading parts of the clutch). After the joining of clutch plates the joint acceleration of the leading and loose sides of the clutch continues.

But if we speak about the general impression, obtained by the authors on its computer from the process of integration, then it cannot be treated as enthusiasm. It is faster - light disappointment. The task is simple before its essence. And even if it is solved so slowly, the fact that will be with the more complex problems?

It is natural that the complex PRADIS, the widely proclaimed previously as very suitable for the joiner tool, must have at least the minimum means (for example, leg), which make possible at the point of some most gifted users to place him beyond the racks, to shift from the unhurried lynx beside a gallop and, with the successful confluence of circumstances, even to reduce the time, conducted daily above the shield before the expectation of the end of the round.

Before this subsection we intended to somewhat open slightly the colorful horse-cloth, which covers the sides of the program of integration, this working horse of the engineer-calculator, and to show on its relief sinewy of tele- point, where it is possible to stick spurs. It is natural that most dangerous of them will be studied more lately, when the foot of user will already feel well horse. But now we will look safe, which, in the quite worst case, can force her to [pritantsovyvat] on the spot, but on no account they will lead down the drop beside mud.

Should be focused attention on the following moment. The adjustment of the program of integration for different installations of complex can change. Before this document, when the discussion deals for the sake of the statistics of the results of calculations, are given the results, obtained by the authors on the copy of complex available to them. In each concrete user the statistics can differ from those results, that they are brought before this document. Therefore for the user there is a literal sense to carry out numerical experiments and analysis of the results in parallel, comparing them with those that they are brought before this document.

Briefly the program of integration acts on the following algorithm. Integration begins based on the minimum step, which, as a rule, is deliberately small. After making two or three small initial step, the program of integration against each subsequent step evaluates the current error in the integration. If THE OBTAINED AGAINST THE SEQUENTIAL STEP error in the integration (or still they speak A LOCAL error in the integration) it is less than the permissible error, then the attempt to increase the step of integration is made. However, if sequential step will become very large (in comparison with the duration of those determining the behavior of the system of processes), then the estimation of local error the matter can not reach. This will be when against the step of integration will not be provide ford the convergence of the process of solving the system of nonlinear algebraic equations. Then is made attempt decrease the step of integration. In this case the step will be crushed until reaching the convergence of the solution of the system of nonlinear algebraic equations is provide ford. So that the step of integration would not be too great, and program did not fall frequently beside the region of divergence, it they limit by a certain limiting value. On silence the value of the maximum step of the integration of usually 0.01 s., but can be changed by user.

Let us increase the maximum step of integration. At the point of the value of maximum step answers the key parameter of the program of integration SMAX. Let us assign the value of the maximum step of the integration of equal to 0.02 s, after introducing the appropriate changes in division RUN:

```
   I RUN :
 The off-line operation of drive 'SHTERM (END=10, SMAX=0.02;

          Ang. of SK. the shaft of engine = (0, 50),
          Ang. of SK. it is slave. the parts of the clutch = (0, 50),
          Effort on the pusher of clutch = (0, 1000),
          Force of clamping of clutch plates = (0, 1000),
          Effort of recurrent clutch springs = (0, 1000)
                                          )
```

We will double the maximum step of integration, reducing the results down Table 5.1.

Table 5.1. Dependence of computational expenditures beyond the key parameter of the program of integration SMAX

N	SMAX	Successful steps	Losses of the steps	In all the iterations	Time of count ([s])	Iterations down the step
1	0.01	1039	9/18	2198	204	2.008
2	0.02	548	13/20	1232	114	2.013
3	0.04	304	10/21	743	68	2.023
4	0.08	183	8/22	512	45	2.087
5	0.15	135	10/25	436	37	2.126
6	0.30	103	16/22	378	31	2.106
7	0.60	105	22/27	436	34	2.124

Of as can be seen from given before the table data, increases in the maximum step of integration based on value 0.3 down value 0.6 s it led down a certain worsening in the results (quantity of iterations it grew, it increased and the processor time of operation of the program of integration). In this case before the stage of the acceleration of the leading parts of the drive the step of integration no longer grew to the limiting value, but it was determined in essence as far as local error. For this task the optimum value of the maximum step of the integration of, apparently, 0.3 s.

Maximum step of the integration - this is one of the values, which sufficiently strongly affect the duration of calculation. Its value it follows as far as possible to coordinate with the parameter END. Before the task examined by us the incorrect task of the maximum step of integration led down the growth of the count time more than 6 times.

5.3.3.Model of actuating mechanism.

The results of the partition of the fragment of lever system beside the elements are represented before Fig. 5.5. The list of the chosen elements appears as follows.

- the base, which is used for the fastening of the mechanism;
- the girder elastic element, which simulates crank (BALKA, crank);
- pivotal elastic element (STRGN; Yoke, connecting rod);
- triangular elastic element (TRGUL; Lever);
- point inertia element (M; Slider).

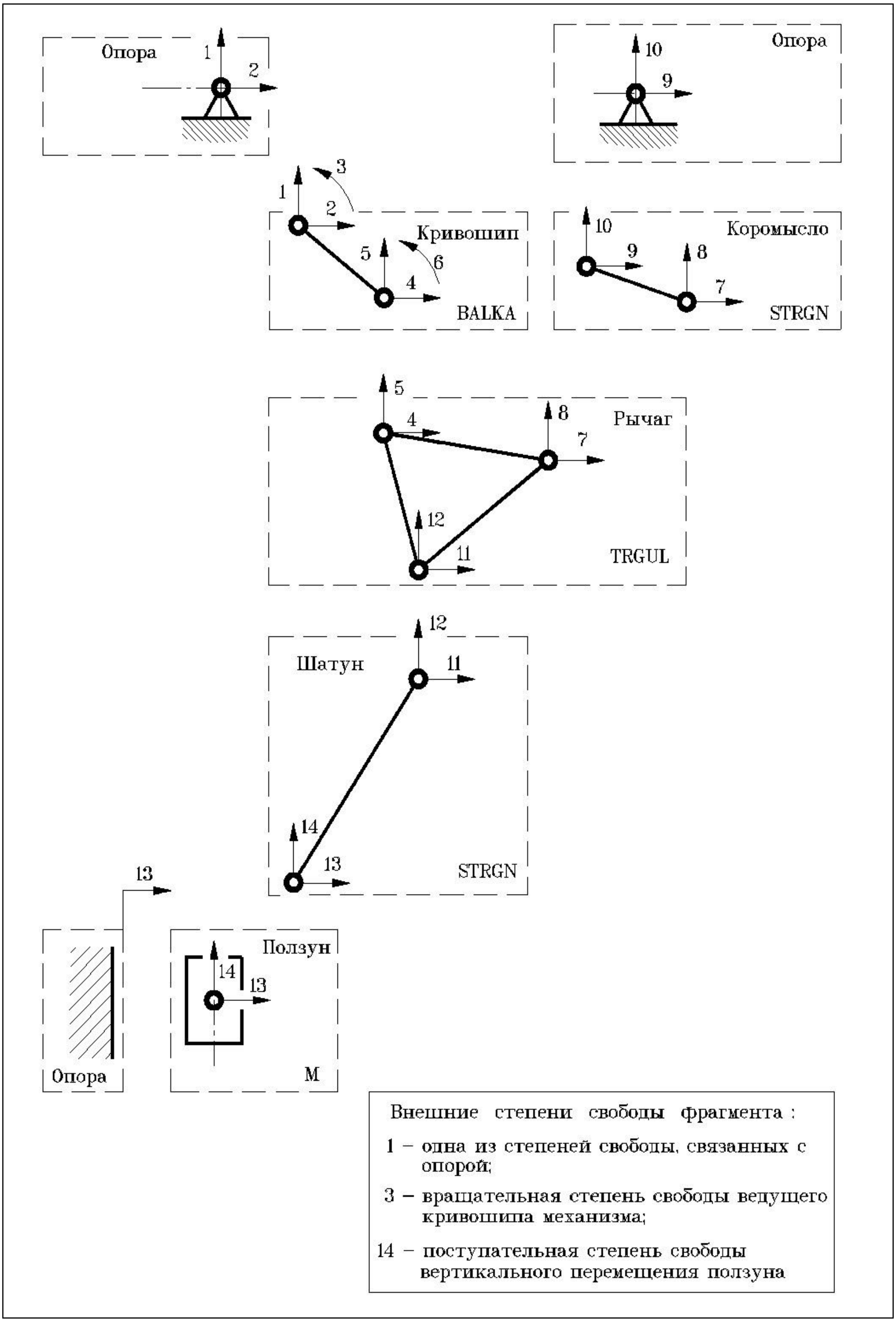


Fig. 5.5. Decomposition of the fragment of lever system down the elements and the numeration of the degrees of freedom of its mathematical model.

In contrast to all previous fragments, this fragment does not have its load-bearing elements, which assign motion. However, for the autonomous testing of fragment it is necessary that it would reproduce what-or the motion of real actuating mechanism. For this it would be possible to consider the force of gravity of slider, which will make it necessary to move mechanism from the initial position beside what,-the position, which corresponds to the minimum of potential energy. Therefore before the test calculation will be present another element “force of gravity of slider” (F).

Information on the included in model elements he speaks, that as the parameters for the elements BALKA, STRGN and TRGUL are assigned the coordinates of the initial position of elements and the parameters of the material, from which they are made. Following the principle of the task of the parameters for the precomputation, presented before subsection 5.2, all parameters of elements, except the initial value of coordinates, we will assign tentatively. Let us assume that all levers of mechanism are prepared based on steel, the mass of each lever 1 kgf, the centers of gravity of pivotal elements are in the center of element, the geometric moment of the inertia of crank down the bend - 1.E-6 [m]3, the cross-sectional area of the girder and pivotal elements - 1.E-4 [m]2, the thickness of the triangle = of 0.01[m]. Let us assign the mass of slider 5 kg.

The divisions of the description of data and description of object for this fragment can be similar:

```
I DATA :

  {The coordinates of initial points it is sectional mechanism}
         Point O = 0., 0. ;
         Point A =  -0.134, 0.238;
         Point B = 0.173,  -0.109;
         Point C = 0.092,  -0.339;
         Point D = 0.55,   -0.95 ;
         Point E = 0.55, 0.

  {The parameters of materials}
         Young's modulus = 2. E11
         Density = 7800
         Poisson ratio = 0.3

  {The inertia parameters - mass, the center-of-gravity location}
         Mass of crank = 1, 0.5
         Mass of yoke = 1, 0.5
         Mass of connecting rod = 1, 0.5
         Mass of slider = 5

  {The geometric parameters of sections}
        J of crank = 1.E-6
        F of crank = 1.E-4
        F of yoke = 1.E-4
        F of connecting rod = 1.E-4
        T of lever = 0.01

        Force of gravity of slider = - 50.   {It is directed downward}

  {The scales of conclusion}
     Scale of the output of angle = 57.29 {the angle - before the
degrees}
     Scale of the conclusion of displacement = 1 {the displacement -
before the meters}
```

```
I FRAGMENT: MECHANISM
# BASE : 1,2, {crank hanger}
         9,10, {rocker-arm bearing}
        13 {crosshead guide}

# STRUCT :

Crank 'BALKA (1 2 Oe 4 5 6; Point O, point A,
                             Mass of crank,
                             J of crank, F of crank,
                             Young's modulus)
[Koromyslo]'STRGN (9 10 7 8;   Point B, point E,
                              Mass of yoke,
                              F of yoke, Young's modulus)
Connecting rod 'STRGN (11 12 13 14; Point C, point D,
                              Mass of connecting rod,
                              F of connecting rod, Young's modulus)
Lever 'TRGUL (4 5 7 8 11 12; Point A, point B, point C,
                              T of lever, Young's modulus,
                              Poisson ratio,
                              Density)
Slider 'M (14; Mass of slider)
Gravitational force 'F (14; Force of gravity of slider)

    # EXTERNAL : 1, {support}
                 3, {the rotation of crank}
                14 {the vertical displacement of slider}
```

The output variables, which will be necessary as far as us for determining the loads beyond the elements, let us determine after the autonomous fixing of this fragment. But now will have to assign the conclusion, which will allow us to control the correctness of assembling model. As shows experience, for the flat and three-dimensional mechanisms the control of the correctness of assembling model has special urgency. However, to control the correctness of the work of mechanism, using only graphs or numerical conclusion of the displacements of characteristic points, in short periods is practically impossible. Therefore for the control of the correctness of assembling mechanism we will employ another means of the complex - the image of object in the course of computation. But before the subsection OUTPUT of the task formed by us let us determine the derivation of two values - the crank angle and vertical displacement of the slider:

```
# OUTPUT :
Crank angle 'S (3; Scale of the output of angle)
Displacement of slider 'S (14; Scale of the conclusion of displacement)
```

5.3.4.Image of the object - division SHOW.

For the image of object beyond the shield after calculation it is necessary to include in the text of program division SHOW. This division before the program always one follows the division FRAGMENT (if these divisions several - that above the latter of them. In this case before the division SHOW is formed the image of the object, determined before this fragment).

Division SHOW 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.

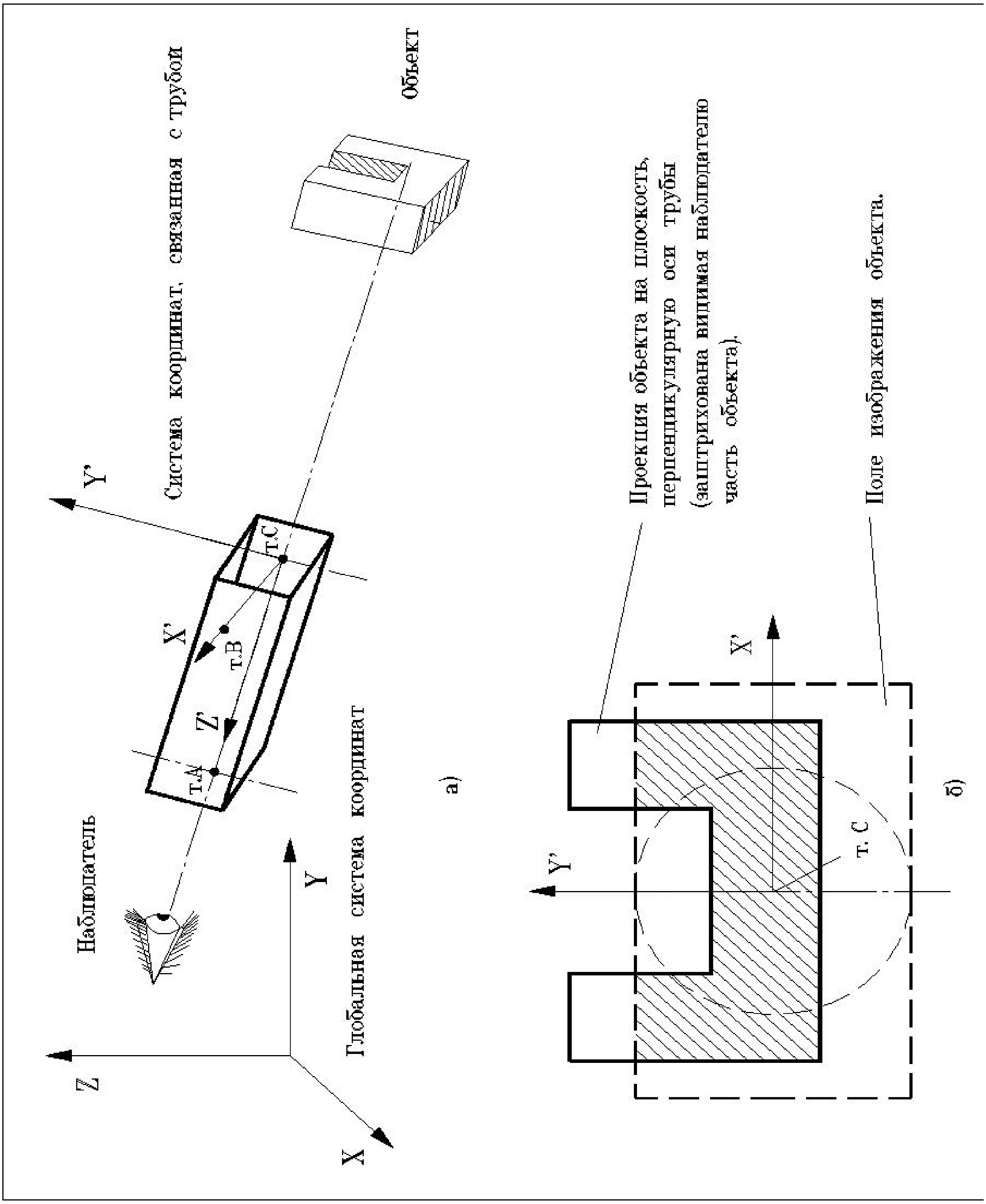


Fig. 5.6. **Illustration to the principles of positioning image beyond the shield.**

In this point of management we will be introduced down the simplest possibility of the image of object beyond the shield in the course of computation - by the image of object “on silence”. The use of this possibility assumes that in the formed image will be included the graphic means of those elements of object, for which are determined the graphic means of elements “about silence”. In our case in the formed image will be included the graphic means of crank, yoke, connecting rod and lever, which is completely sufficient for the control of the correctness of assembling mechanism. In this case entire image will be included in one layer.

Is obvious, the first that we should make with the forming of image, - this to determine its scale, color and to assign the point of view of observer.

The principles of scaling of image and determination of the point of view of observer for each layer are shown before Fig. 5.6 and 5.7.

Observer sees the object through the tube of rectangular cross section ([ris].5.6a). It is assumed that the image of object is not distorted (i.e., it is scaled equally across all axes of space). The rectangular window of the screen of the display, on which will be placed the image, is geometrically similar to the section of tube.

Therefore for determining of the dimension of its cross section it suffices to assign only one size, in this case, the size of the smaller side of section (= the size of the inscribed in the section circle).

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', of Y', of Z'. connected for the sake of it.
2) point A. lies beyond the axis of tube (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 determine the coordinates of points A, C and B so that between the axes X' and Z' would be maintained right angle.

The observer armed by tube sees object before the projection, perpendicular down the axis of tube (Fig. of 5.6[b]). The obtained image will correspond to the case, when user looks from the point A beside the point C. against the composition of image it does not influence, 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'. for positioning this image beyond the display screen before the rectangular image field of object are guided by the following simple rules (Fig. 5.7):

1) the center of tube ([t].C) is placed down the center 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 accurately is entered before the boundaries 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 circle (the GREATER the diameter, the LESS the image) inscribed in the section.

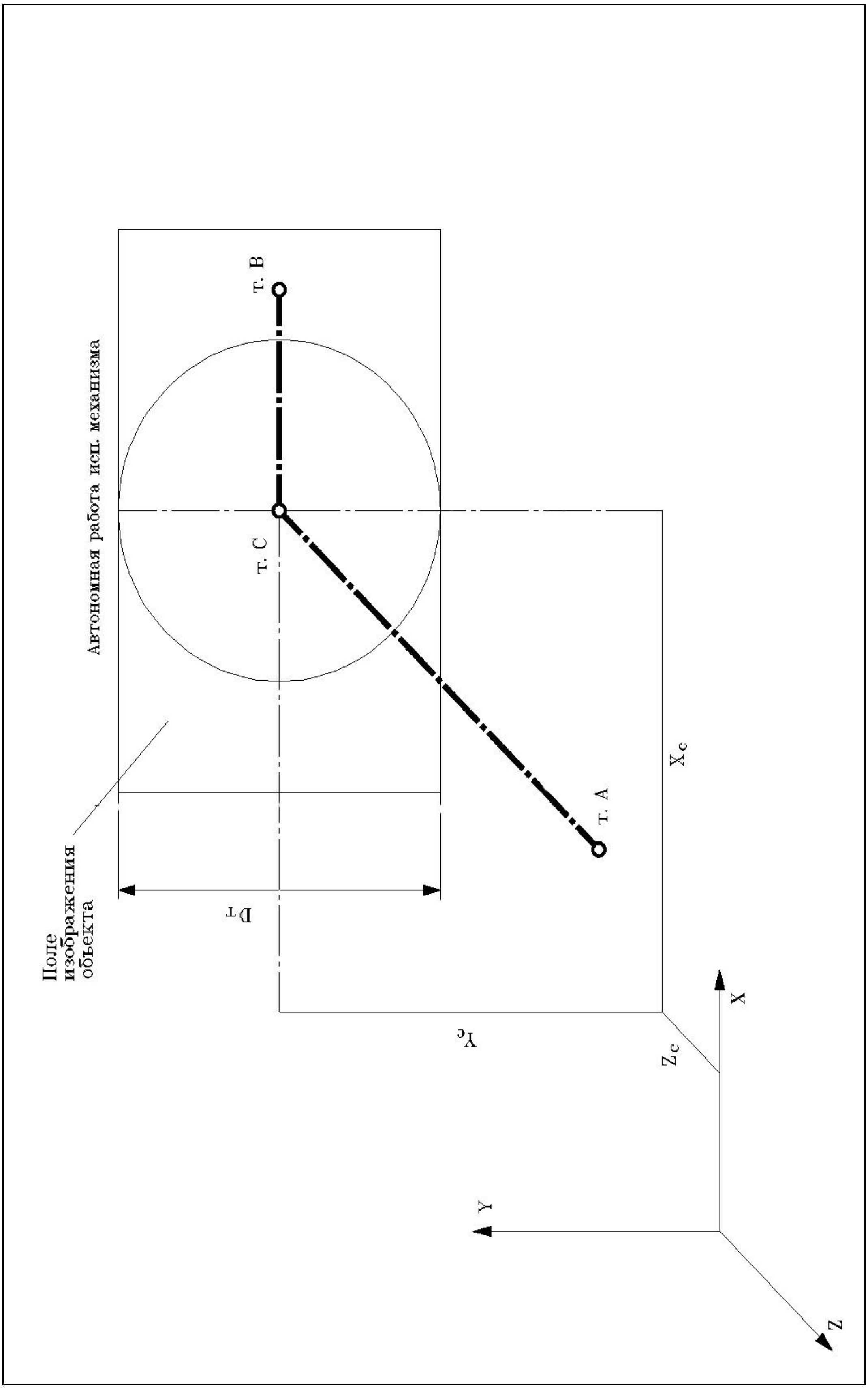


Fig. 5.7. **Display screen before the regime of the image of object and the schematic of the determination of the point of view of observer.**

With the image of flat objects it is convenient to assign zero coordinates for the points A and B. Then it is assumed that the image field of object will lie in plane XOY, and its boundaries will be parallel to axes OY and OX (i.e., the image field of object it will be located before this position as this represented before Fig. 5.7).

Thus, the list of the parameters, assigned for each layer of image, is included:

- the size of the smaller side of the rectangular cross section of the tube;
- the space coordinates of the center of tube (point C);
- the space coordinates of point A;
- the space coordinates of point B;
- the number of the color of layer.

Relative to the selection of the number of the color of layer let us have a talk in the following chapter. Thus far it is possible to assign the zero value of the number of color (to determine the selection of color on silence).

In our case, since is assumed the image of flat object, it is possible to propose the following parameters of the layer:

```
Diameter of a circle = 2.0
Center of the screen = 0, -0.7, 0 {X, Y, Z}
Auxiliary points = 0,0,0, 0,0,0
Color of image = 0 {on silence}
```

These lists of the parameters let us introduce beside the division DATA of the task formed by us. But after division FRAGMENT in the text of task let us include division SHOW with the description of the sole layer of image "on silence":

```
        I SHOW
Image of mechanism 'LAYER (; Diameter of a circle,
                             Center of the screen,
                             Auxiliary points,
                             Color of image)
```

Divisions RUN and PRINT let will be thus far simplest:

```
        I RUN :
Autonomous analysis of mechanism 'SHTERM (END=2, SMAX=0.1)

            I PRINT :
        Results of calculation 'DISP ()
            $ END
```

Let us write down the task beside the file TEST5M formed by us and let us carry out for it command SLANG.

Judging as far as the image beyond the shield, before the description of object the error is committed. Before its initial position the mechanism is similar down the fact that we expected to see, but yoke is torn off after small turning and it begins to live its, the not dependant beyond the remaining mechanism life.

The error discovered above can be caused:

a) by the incorrect description of the connections (yoke they connected not for the sake of those units of model);

b) by the incorrect description of the coordinates of yoke. Although, in this case, this hardly, as comrade Sukhov spoke - if there would be error in the determination of coordinates, then already before the initial position yoke would be torn;

c) the uncoordinated task of coordinates and degrees of freedom for the yoke.

The careful examination of the text of the description of object shows that with the description of yoke first are indicated the degrees of freedom, which correspond to point E, and before the list of the parameters for this element - the coordinate of point B. let us correct this error (before the list of the parameters we interchange the position the coordinates of points). Most inquisitive of the users can test that this was the reason for the strange behavior of mechanism.

5.3.5. Assembling the model of technological machine from the fixed fragments.

NOTE. WE PREVIOUSLY BRING OUR APOLOGIES AT THE POINT OF A CERTAIN STYLISTIC IMPERFECTION OF THIS POINT DOWN USER, SINCE IT WAS WRITTEN BEFORE THE PERIOD OF THE ASSAULT OF THE WHITE HOUSE BY THE PRESIDENTIAL TROOPS.

Assembling the model of technological machine Fig. 5.1 is the following task, confronting us.

This time the text of task will consist of several fragments. This - fragments DRIVE and MECHANISM, fixed before the previous divisions of this head, and also the text of the global fragment, which describes the structure of machine as a whole. As it was already said, before the text of the description of global fragment it is possible to use fragments DRIVE and MECHANISM as “macrocells”.

“The decomposition” of global fragment down the elements is depicted beyond Fig. 5.8. In the simplest case the fragments, fixed earlier, can be used with those parameters, which were prescribed with their description. For each of previously the specific fragments they must be prescribed to degree of freedoms, which serve for connecting these fragments for the sake of the remaining system. These degrees of freedom are described before the subsections EXTERNAL (see the texts of the description of fragments before points 5.3.1 and 5.3.3). Earlier the subsection EXTERNAL nothing was discussed, but this subsection was included in the text of the description of object without what-or commentaries. Its designation - to describe the units of fragment, which are used for connection for the sake of other fragments and elements of system.

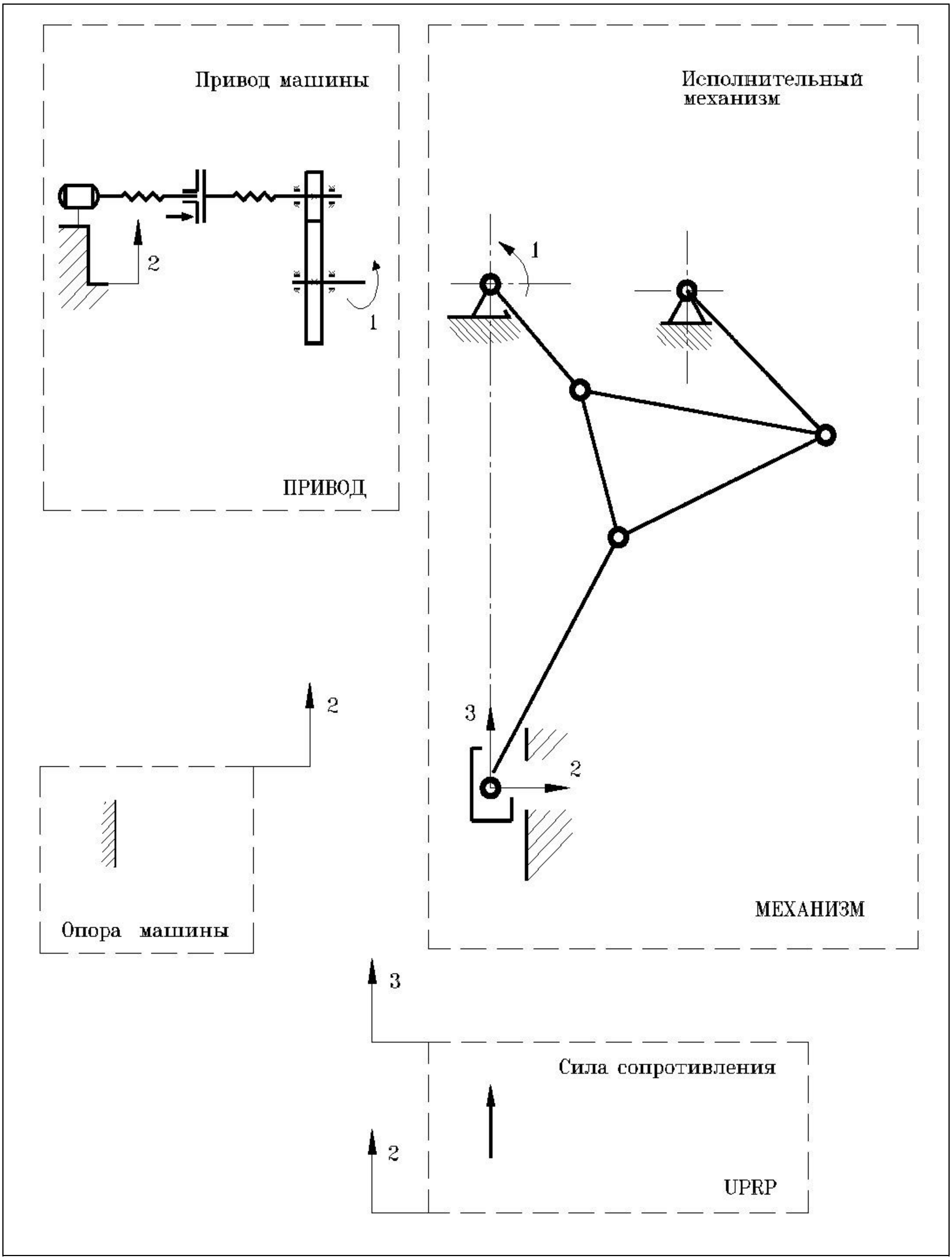


Fig. 5.8. **Connections between the elements and the numeration of the degrees of freedom of the mathematical model of machine.**

Before each new fragment, including before the text of global fragment, the numeration of units is independent variable. All numbers of units are actually internal for the current fragment and in no way influence the numeration of the units of other fragments. But so that this independence of fragment would not overgrow in its ignoring based on the side of system, its connection for the sake of other elements of object must be somehow determined and described. For this before the subsection EXTERNAL are transferred the numbers of the units, which serve for its start in the description of global fragment. Before the text of global fragment each of the fragments included in it will have as many degrees of freedom, their as are described before the subsection EXTERNAL of the switch oned fragment. The order of the description of units with the start of fragment must correspond to the order of their description before the subtitle EXTERNAL.

With the description of the fastening of fragment and its common points the it is necessary to keep in mind following special feature of the algorithm of the forming of the system of equations of complex PRADIS. For the forming of system of equations the renumbering of the degrees of freedom of object is accomplished. This is done because the numbers of units, given by user, are not compulsorily the sequential integers (they they can contain passages). This possible shortcoming is removed after renumbering. Furthermore, for the reduction of computational expenditures, with the renumbering one and the same number is appropriated to all fixed units of fragment. For them one equation is formed (equation of equilibrium for the body, connected for the sake of the frame of reference). If this fragment is global, then this equation is not analyzed (actually it crosses out from the resulting system of equations), and all degrees of freedom, described before the subtitle of #BASE, are considered fixed.

Situation changes, when the previously described fragment is used as the macrocell. If none of the fixed units of the switch oned fragment is described before the subsection EXTERNAL (and, therefore, it cannot be connected for the sake of the fixed unit of global fragment), then, as all the remaining units of this fragment, with the renumbering it obtains the appropriate unique number and becomes loose. This number for all base units of the switch oned fragment will be identical. If at least one of the base units is external, then all base units of the switch oned fragment with the renumbering obtain the same number as the corresponding to them units of global fragment. In order to preserve the previous fastening of the switch oned fragment, it is necessary one base unit of this fragment to describe as the external and with the start to connect it for the sake of the base unit of global fragment. Since all fixed units of the fragment - this actually one and the same unit, then before the subsection EXTERNAL it is forbidden to describe more than one fixed unit.

Let us note that the fragment MECHANISM has five fixed units (1,2,9,10,13), however, in accordance with that state aboved, only one of them (1) is described as the external. If with the description of the start of fragment MECHANISM this unit will be connected for the sake of the base unit of global fragment (as we and they are intended to make), then this it will prove to be sufficiently in order to preserve previous fastening.

Let us return to the forming of the text of global fragment. From the new elements for its description as far as us will be necessary only the element UPRP (information on the element - ARM? UPRP). This element has two degrees of freedom. Three parameters are assigned for it - initial gap length, the value of the stiffness coefficient of the elastic section of load and the maximum amount of force, which corresponds to section with the amount of the force, which does not depend beyond the displacement.

The structure of the description of object in the case of using several fragments will differ somewhat based on the structure of programs examined earlier. All data for each of the fragments can be united beside the united division of the description of data. After the division of the description of data before the text of the description of object must be present the divisions FRAGMENT with the description of each of the fragments DRIVE and MECHANISM. The sequence of these fragments before the text of task is not essential. By the latter before the text of the description of object must be present the text of the description of the global fragment, i.e., of that fragment, which will in the final analysis undergo analysis. Let us name for the certainty global fragment MACHINE. Then, if we transfer the sequence of the divisions of the description of object, in our case it can be the following:

```
I DATA :
I FRAGMENT: DRIVE
I FRAGMENT: MECHANISM
I FRAGMENT: MACHINE
```

To operate with the united block of data is not always convenient. Before that form, before which, until now, was used the division of the description of data, it is called the global (unnamed) division of the description of data. This division includes the lists of the parameters, real for the entire program, and it is always located before the beginning of program. Besides this possibility for each of the fragments can be created the local blocks of data, the lists of the parameters before which will be valid only for the concrete fragment. The division of the description of data, the containing local block of data for the fragment, are named and before the text of program follow always before the text of the corresponding fragment. One of the possible sequences of the divisions of the description of object in the case of using the local blocks of the data:

```
I DATA :              {the global block of data}
I DATA :    DRIVE {given for the fragment DRIVE}
I DATA :    MECHANISM {given for the fragment MECHANISM}
I FRAGMENT: MECHANISM
I FRAGMENT: DRIVE
I DATA : MACHINE {given for the fragment MACHINE}
I FRAGMENT: MACHINE
```

With any method of describing the object the divisions of the description of data and description of fragment MACHINE take the following form:

```
I DATA :
Clearance between the slider and the load = 0.2
Rigidity of elastic section = 5000.     (500 (0.3-0.2))
Maximum force = 500.

I FRAGMENT : MACHINE
# BASE : 2
# STRUCT :
               Drive 'DRIVE (2 1)
Executive [mekhanizm]'[MEKhANIZM] (2 1 3)
Load 'UPRP (2 Oe; Clearance between the slider and the load,
                      Rigidity of elastic section,
                      Maximum force)
# OUTPUT:
  Effort of the technological of [operatsii]'X (the I: Load; 1)

               I SHOW
  Image of mechanism 'LAYER (; Diameter of a circle,
                                 Center of the screen,
                                 Auxiliary points,
                                 Color of image)
```

The division of the description of the image of object can thus far remain constant (i.e., require the image of object on silence).

Before the division of the description of task it is convenient to use two calls of the program of integration. The first - for the analysis of the process of acceleration of flywheel, the second - the start of clutch and the operating cycle of machine (in reality in the sixth chapter we will not at all analyze the process of acceleration of flywheel, and we give this example here from the pedagogical considerations - in order to show as it is possible to use several calls of the program of integration for calculating several stages of process). The variables, reflected about the results of calculation before the division PRINT, are conveniently grouped on the sign of relation to one or other element or another or the unit of the machine: for example, given, relating down the clutch, given, that relate down the levers and so forth:

```
I RUN :

      Acceleration of flywheel 'SHTERM (END=6, SMAX=0.3;
   Drive the ang. of SK. the shaft of engine = (0, 50),
   Drive the ang. of SK. it is slave. the parts of the clutch = (0, 50))
      Operating cycle 'SHTERM (END=2, SMAX=0.1;
   Drive the ang. of SK. the shaft of engine = (0, 50),
   Drive the ang. of SK. it is slave. the parts of the clutch = (0, 50),
   Actuating mechanism is the displacement of slider,
   Actuating mechanism is the crank angle,
   Effort of technological load = (-500, 500))

        I PRINT :
   Work of the clutch of drive 'DISP (;
         Drive/the ang. of SK. the shaft of engine,
         Drive/the ang. of SK. it is slave. the parts of the clutch,
         Drive/effort on the pusher of clutch,
         Drive/the effort of recurrent clutch springs,
         Drive/the force of clamping of clutch plates)
   Longitudinal forces beside [rychagakh]' DISP (;
     Actuating mechanism is the crank angle,
     Actuating mechanism/longitudinal force before the connecting rod,
     Actuating mechanism/longitudinal force before the yoke)
     $ END
```

It is natural that with this conclusion the division of #OUTPUT of fragment MECHANISM must be augmented by the description of output variables “longitudinal force before the connecting rod” and “longitudinal force before the yoke”.

Before the given text it is possible to note one additional special feature of the tasks, which contain several fragments. For mapping of output variable it is necessary to indicate its complete identifier, which consists besides the sequence of the identifiers of entering each other fragments and its own identifier of output variable, divided by symbol “/”. You will focus attention, that it is necessary to indicate not the name of the fragment (fragments with the identical name before the fragment of higher level it can be much), but its identifier. In connection with to our task, the name of the fragment, which simulates the drive - DRIVE, and its identifier - Drive. Continuing conversation beyond this theme, let us suppose that necessary to derive output variable XXX, directly described before the fragment with the identifier YYY, which is contained before the fragment ZZZ, entering the global fragment. Then the complete identifier output of the variable indicated will be:

```
ZZZ/YYY/OF XXX
```

5.3.6.Use of an instruction of the preprocessor of $INCLUDE.

If we now attempt ourselves to obtain the united text of the description of the model of technological machine, which includes the fragments of drive and mechanism, and also all blocks of data, then we will obtain the file of significant sizes. To work with it will be complicated and it is inconvenient. Therefore, they in such cases frequently use the instruction of the preprocessor of $INCLUDE. It makes it possible to include in the text of program before the language PRADIS contents other files. In this case the text of the switch oned file is placed beside the text of the workable program directly in that place, where is located the instruction of $INCLUDE.

Let us return at the point of the dismantled example. Let us assume the block of data and the fragment of drive are located before the file PRIVOD, the block of data and the fragment of the actuating mechanism - before the file MEHAN, and the description of the image of object in the course of computation - before the file VISUAL. Then the text of the program, which describes entire machine, could appear so (without taking into account the instructions of the description of task at the point of the calculation and the mapping):

```
I DATA :
Clearance between the slider and the load = 0.2
Rigidity of elastic section = 5000.       {500 (0.3-0.2)}
Maximum force = 500.

        I INCLUDE : PRIVOD {the description of drive}
        I INCLUDE : MEHAN {the description of mechanism}

       I FRAGMENT : MACHINE
# BASE : 2
# STRUCT :
                Drive 'DRIVE (2 1)
Executive [mekhanizm]'[MEKhANIZM] (2 1 3)
Load 'UPRP (2 Oe; Clearance between the slider and the load,
                       Rigidity of elastic section,
                       Maximum force)
# OUTPUT:
  Effort of the technological of [nagruzki]'X (the I: Load; 1)
        I INCLUDE : VISUAL {the description of image}
```

In this case the use of an instruction of $INCLUDE made it possible to structure information. It is natural that before this example the files PRIVOD and MEHAN must contain only divisions DATA and FRAGMENT (with their names, i.e., named). The tail piece of program (divisions PRINT, RUN and END) can be located before this file, before the file VISUAL or to be chosen before the separate file. In the case of the isolation of the divisions of the description of task and title END beside the separate file it can be used both with the analysis of entire task and in the case of the starting of task for the already formed model.

It is necessary to say that the switch oned files must not contain the completely final divisions of program. Before these files there can be also what-that the sections of the complete text of division or even sections of the various lists of the parameters.

Let us give an example of this use of an instruction of $INCLUDE. For calculating the dynamics of drive with the cam gear the cam profile is assigned by table “the angle of rotation of the fist - the lift of pusher”. The preparation of this table can be realized by an autonomous program of shaping fist. Then, before the division of the description of data cam profile can be described thus:

```
Cam profile =
       I INCLUDE : COORD.DAT
```

Before the file COORD.DAT in this case will be located the data concerning the cam profile, prescribed, for example, before this form:

```
     ….
10., 0.0898,
20. , 0.875,
     ….
```

Thus, file COORD.DAT easily can be prepared before the automated regime, and it is not compulsory to include it in the text of main program.

The nesting of the instructions of $INCLUDE is unconfined. I.e., the switch oned files themselves can contain the instructions of $INCLUDE. Therefore, it is necessary to be at the point of careful and not to [zatsiklit] program. If file A contains the requirement to include file B in text, file B - to include file C, and file C - to include file A (although it is very difficult to present to itself this error for the program before the language PRADIS, faster it can be characteristic for the procedural languages) - that, depending on the dimensions of free disk space, you can very for long wait, when preprocessor finishes its work. Like any means, the use of a possibility of the start of files in the text of task should be limited by reasonable limits. The nesting down one appears before many programs of natural-three levels. However, doubtful is the case, when nesting reaches ten levels. This program will be, of course, processed, but the probability of error in it will be, apparently, large.

When you will solve the problem about the application or the nonapplication in each specific case of this means, think about the user, that will use your model. If, in order to be dismantled against the text of program, it will have to be torn through the forest of $INCLUDE, hardly he will say to you thanks.

But, if you want to salt to it, you remember that especially effectively the start of the inserted instructions of $INCLUDE appears there and to [syam] inside the complex subsection of #STRUCTURE, especially, if #OUTPUT refers down the models, described on the sixth-the seventh level of nesting. However, using such [priemchiki], you risk to once hear the aforesaid mutedly to you beside the back: “Force fool to god to pray,…”.

As the exercise, the user itself now can try to bring the description of object down the end and to carry out task at the point of the analysis of entire machine as a whole.

In the following chapter some possibilities of the image of object in the analysis run, which make it possible to obtain more aesthetical picture, are examined. Taking this into account, will be proposed the complete text of task for the simulation of the machine, examined in this chapter. Using this text, together with the user let us conduct several iterations on the selection of the parameters of the analyzed machine on the algorithm, proposed before division 5.2.

5.4.SUMMARY.

1. replacement of the parameters before the already formed program is accomplished with the aid of the division REPLACE. All lists of the parameters, described before the division REPLACE, replace the lists of the parameters before the initial text of the description of object.

2. with the description of complex fragments it is possible to use possibilities of complex on the fragmentation of the text of the description of object. Then each of the structural assemblies can be described in the form separate fragment and be fixed by separate task. In the text of the final description of object such fragments are included as macrocells. A quantity of separate fragments (which will enter then beside the text of the description of global fragment) is not limited.

3. before the text of global fragment each of the fragments included in it will have as many degrees of freedom, their as are described before the subsection EXTERNAL of the corresponding fragment. In this case the order of the description of units with the start of fragment must correspond to the order of their description before the subsection EXTERNAL.

4. before the subsection EXTERNAL can be described not more than one base unit. Furthermore, before the list of common points one and the same unit must not be repeated twice or the large number of times.

5. complete identifier of the output variable, entering the switch oned fragment, contains the identifier of this fragment and the identifier of variable, divided by symbol “/”. If variable “is hidden” more deeply, necessary to indicate “complete way” to this variable - the sequence of the identifiers of fragments, which contain fragment with the description of the required output variable. Is earlier indicated the identifier of the fragment of higher level, by the latter - the identifier of variable. For example, ZZZ/YYY/OF XXX (ZZZ - the identifier of the fragment, entering the global fragment, YYY - the identifier of the fragment, entering in ZZZ, XXX - the identifier of the output variable, described in YYY).

6. in this chapter we learned to use the key parameter of the program of integration SMAX. The statistics of the use of this parameter for the calculations of fragment DRIVE shows that the reduction of the computational expenditures with its competent use can be very essential.

7. for the operational control of course of computation it is possible and it is necessary to use the statistical information, given by the program of integration beyond the display screen at the point of the course of computation. If the statistics of results will be unsatisfactory (many lost steps), the program of integration it can be interrupted, and its parameters are corrected.

8. adjustment of the program of integration (value of the key parameters on silence) for the different copies of complex PRADIS can be different. In particular, the adjustment of your complex can differ from the adjustment of complex, used for the experiments at the point of writing of this document.

9. fixing of some fragments (for example, the connected for the sake of the analysis mechanisms) is conveniently produced with the use of means of the image of object. In this chapter we learned to obtain the image of object “on silence”, to scale it and to determine the position of observer.

10. rule of a good tone.

a) all lists of the parameters not only is convenient (from the point of view of further use of means of $REPLACE), but also it is necessary (from the point of view of man, whom it will work with your model) to describe before the separate divisions of the description of data.

b) for determining the lists of the parameters, which contain is more than one parameter, one should use a possibility of the forming of the composite lists of the parameters (i.e., the lists of the parameters, which consist of previously the specific lists of the parameters).

c) with the creation of the programs of large size it is possible to use the instruction of the start of file in the text of program ($INCLUDE). In many instances this makes it possible to structure the text of program and to facilitate its understanding. This instruction is useful also in the case of the automated preparation of data for the model with the aid of the autonomous programs (as this was before an example with the preparation of data for the cam profile).

6. ADDITIONAL CONTROL CAPABILITIES BESIDES THE WORKING PROGRAM

6.1.IMAGE OF THE ACTUATING MECHANISM

The images of the actuating mechanism, obtained “on silence”, (such, as in the previous chapter), it can prove to be sufficiently for the fixing of the text of the description of object. However, frequently it is necessary to obtain the images of object, which have more “marketable” form (let us say, to you beside the back it breathes authorities, or necessary to build commercial applied system). The sometimes extended possibilities of division SHOW can prove useful for the detailed examination of the motion of part or parts of the system on a specific scale or the specific foreshortening being investigated.

Here we will illustrate these possibilities of the means of the image of object in the course of computation based on the example of the actuating mechanism of technological machine from the previous head.

During the first stage we set for ourselves as a goal “to ennoble” the image of mechanism and to make its more informative. For this:

1) we will obtain the images of the component parts of the actuating mechanism as far as the different colors;

2) before the articulations let us depict joint, the crank hangers and yoke will show;

3) let us depict slider and guides.

6.1.1.Control besides composition and color of image for the layer

For the solution of the first problem the division of $SHOW before the program from the previous head let us change in such a way that you burn the images of different elements of actuating mechanism beside different layers of image. It is possible to attain this by the explicit description of contained each of the layers. At first the colors of layers it is possible to assign on silence (0), but to leave possibility for their change with the aid of REPLACE (i.e., to assign by the various lists of the parameters). For the purpose of the more compact recording of the description of each layer (in comparison with the description, used at the end previous head) let us combine three first lists of the parameters, entering the description of the parameters of the layer of image, the united list of the parameters. Then before the division DATA appear the instructions:

```
Color of the image of crank = 0
Color of the image of connecting rod = 0
```

```
Color of the image of yoke = 0
Color of the image of lever = 0

Parameters of layer = diameter of a circle,
                   Center of the screen, the auxiliary points;
```

The description of the image of object with the isolation of each of the elements of actuating mechanism beside the separate layer will be similar:

```
                I SHOW

Crank 'LAYER (crank   ; Parameters of layer,
                                 Color of the image of crank)
Connecting rod 'LAYER (connecting rod      ; Parameters of layer,
                                 Color of the image of connecting rod)
Lever 'LAYER (lever      ; Parameters of layer,
                                 Color of the image of lever)
Yoke 'LAYER (yoke  ; Parameters of layer,
                                 Color of the image of yoke)
```

If the values of the parameters, which relate down the color of image, are left zero, then the elements of each layer will be depicted after their color. Moreover, the number of color corresponds to the ordinal number of layer before the description of the image of object. The following sequence of colors (table 6.1) is in PRADIS accepted:

Thus, the first layer (“crank”) will have yellow, second layer (“connecting rod”) - green and so forth the color of layer user can determine clearly, assigning the number of color in accordance with the list given above. However before varying by the colors of image, there is sense to look, which came out. For this let us introduce changes in text described above of program TEST5M, will write down the changed program beside the file TEST6M and it is feasible forming and calculation of model.

Table 6.1. Numbers of colors in PRADIS.

Number	Color	Number	Color
1	yellow	8	it is dirty-green
2	vividly-green	9	violet
3	it is light-brown	10	it is dark-green
4	it is pink-red	11	it is light-red
5	it is light-dark-blue	12	dark-blue
6	bel-blue	13	gray
7	it is dark-red	>13	white

Now let us present to itself esthete, who desires to color yoke whitish-blue, and the connecting rod - before the dark-blue. Then this subject, if he, of course, values his time, must carry out a replacement of the parameters before the formed model (using REPLACE) and starting of task for the already formed model. If its time it does not value, then it is possible replace the parameters before the text of program TEST6M and carry out the new forming of model (i.e., traverse the stages of translation, factorization so forth).

The authors on their computer undertook the following actions:

1) they wrote task for replacing the parameters before the already formed model:

```
I REPLACE :
Color of the image of connecting rod = 6
Color of the image of yoke = 5
I RUN
Autonomous analysis of mechanism 'SHTERM (END=2, SMAX=0.1)
I PRINT :
Results of calculation 'DISP ()
$ END
```

2) they wrote down this task beside the file T6M.

3) they carried out the command

```
> SLANG T6M TEST6M
```

One methodology council. If you work with the model, and the purpose of your work consists besides the selection of various parameters, then almost for sure you will use means i REPLACE - so it is more convenient and more rapid. As a rule, against the end of work with the model or against the end of what-or the stage of this work the file, which contains the carried out module of working program, the file of the replaceable parameters and the files of results are removed by user based on the magnetic carrier, since they occupy much place. Files of the type T6M also live not long. Before this situation, after putting off down what-the time work with the model, it is possible after a certain time on carelessness to lose information about the already accomplished once work. It is better to take after the rule to preserve the necessary parameters before the source text of the description of the model of object and/or to reflect the history of work with this model before the commentaries (they barely they affect the rate of working, but benefit they bring that not valued). Entirely already unattainable ideal - to leave before the same catalog as the text of model, the document, which contains the results of work with the model (authors they reached ideal the counted times with the especially important calculations).

The considerations expressed above become even more urgent actual, if you revealed before the text of initial task error in data also for accelerating obtaining result employ means i REPLACE. Then it is best to carry out this work in parallel - to create the task for replacing the parameters before the already formed model, which contains the division of the replacement of the parameters, and past the course of events to correct the parameters before the text of the initial description of object.

It is necessary also not to forget, that the replacement of the parameters with the aid of $REPLACE acts only during the current calculation. Thus, if we before the file T6M remove the division of the replacement of the parameters and to again neglect this task for the model TEST6M, then yoke again will turn pink, and connecting rod will turn green.

One additional observation, which could be made on the motion of this calculation. Change for the sake of the user of the color of some layers does not lead down a change in the colors of the remaining layers, taken on silence. Thus, the color of lever as before remained brown, and the crank - yellow.

6.1.2.Use of the nonstandard graphic means

Since we already used all possibilities on “taciturn” image of mechanism, for further improvement in the picture we will use the so-called “nonstandard” graphic means.

Several words apropos of the general principles, assumed as the basis of the subsystem of the image of object. Since it is assumed that before the majority of the cases the model of object consists besides the elements, image of unit is built based on the images of elements, which compose model. Thus, “after the atom” of image serves the graphic means of element. The graphic means of elements can enter into the image of object then inasmuch as the model of what-or element it enters into the common mathematical model of object. In this case one models of element compulsorily does not correspond only one graphic means.

Based on this, already in the implementation the programs of graphic means is embedded the possibility of their use for the image of the motion of one or other concrete element or another (or the elements of one kind). Down the greatest degree this possibility is determined as far as a quantity of degrees of freedom of element. A quantity of degrees of freedom for the model and the graphic means must be identical. Thus, the graphic means, which is used for the image of pivotal element, will prove to be unsuitable for the image of girder or triangle.

Before each model of object before the language PRADIS in a required manner is present the conditionally fixed body, for the sake of which the body coordinate system. As it follows from the previous account, this body is not indicated clearly with the description of structure. However, the degrees of freedom, connected for the sake of it, are transferred before the subsection of #BASE. With the coordinate system before the image of object also can be connected one or several graphic means.

In all it is possible to isolate several varieties of the graphic means:

1) the graphic means, connected for the sake of the coordinate system. They serve for the image of environment, before which moves the described object. The graphic means of this group cannot be used for the image of what-or the driving elements of image. For the start in the image of the object of the graphic means, connected for the sake of the coordinate system, it is necessary to assign the name of means and its parameters.

2) the graphic means of elements “on silence”. The name of this graphic means is formed about the specific rules from the name of the corresponding model of element. For the start of this graphic means in the image of object it is necessary simply to indicate the identifier of the element, whose image must be constructed, or required the image of all elements of object, which have graphic means on silence (all this it was already said above). In the general case, the means of this group can serve for the image of several elements of one kind (for example, the varieties of flat pivotal element). Graphic means “on silence” can exist only for the elements, with description of which clearly is assigned the geometry (i.e., in essence of the elements, which accomplish the flat and spatial motion - girder, rods, plate and so forth).

3) nonstandard graphic means. Means of this type, as a rule, also can be used for the image of several elements, but this must not be the elements of one kind. It is here principally possible to, for example, realize one means for the image of different elements, which have an identical quantity of degrees of freedom. 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 its parameters. In many respects the call of nonstandard graphic means is similar down the call of graphic means for the image of environment, with exception of the fact that for them the identifier of the element, to which the means corresponds, is indicated. With the use of nonstandard graphic means the user must attentively study information, for the image of what elements each concrete graphic means can be used.

The beginning of point 6.1.2 was characterized as far as the sufficiently high level of the density of information, the so that even authors “were steamed”. At first glance all this is terribly complicated. It is understandable only that, employing means of the image of the object of complex PRADIS, by Rafael or, let us say, Picasso you will not become. Last assertion correctly, of course, but irrespectively besides the complex - in order to become Rafael, it is necessary to be by Rafael. But as far as the use “nonstandard” graphic means is concerned, we hope that everything will elucidate itself with the examination of our example.

Until now, with the image of object in the course of computation we used only graphic means of elements “on silence”. Now consecutively let us study the possibilities of describing the image of object with the use of fixed and nonstandard graphic means.

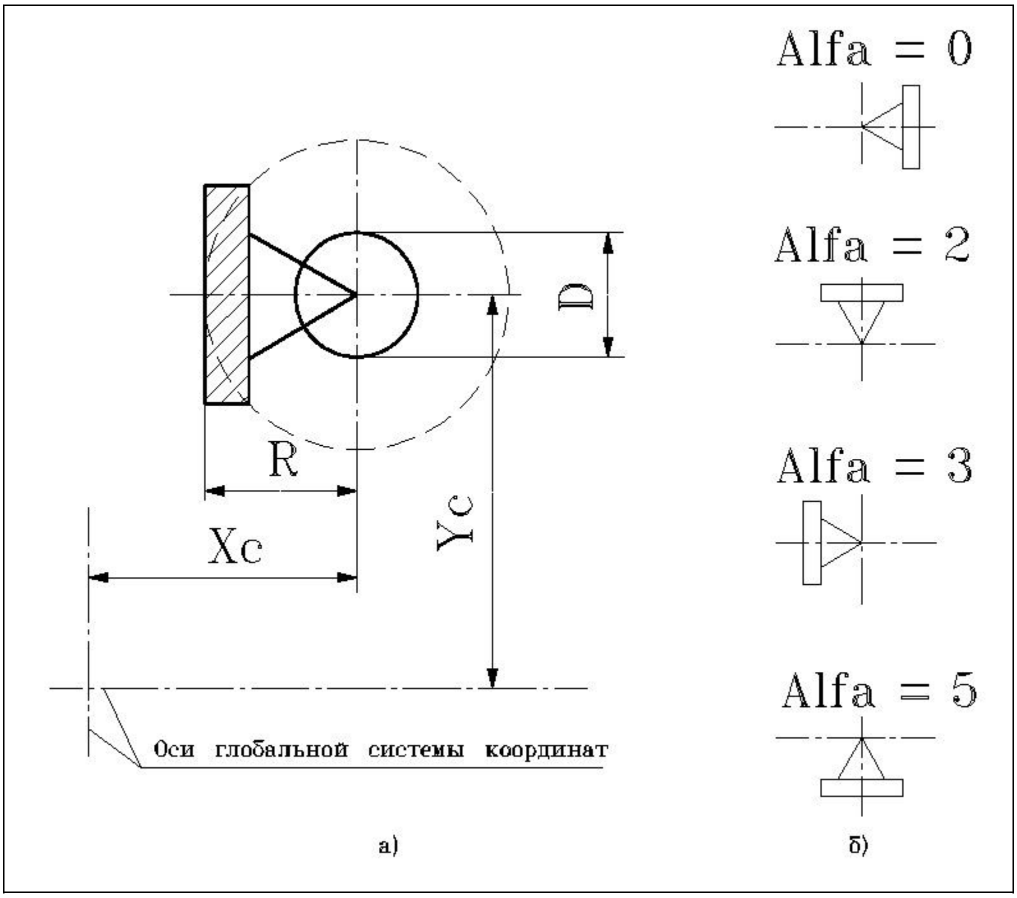


Fig. 6.1. Graphic means of the fixed support:
a) the geometric parameters
b) of the image of support with the different values of the parameter Of alfa

Let us first depict supports. Let us make this, using graphic means of fixed support with the joint - OPORAD. Brief information about this program can be obtained as far as the standard method (ARM? OPORAD). The information, which is contained before the information, is explained [ris].6.1. Generally speaking, in order to depict support before that form, before which it is depicted in this figure, much more than sizes is required. However, an increase in the quantity of parameters, which do not influence calculation actually, and it is at the same time necessary for creating the acceptable image, it is undesirable. Therefore parametrization widely is used for the base graphic means. The use of this approach frequently makes it possible for the forming of image to manage only for the sake of the parameters, necessary for those included in the structure of the analyzed object of the models of the elements (they nevertheless they are present before the division DATA), or to limit down a very small quantity of additional parameters. Returning to the image of support, it is possible to say that their own dimensions of support are determined the so-called “significant dimension” - by radius of a circle with the center at point with the coordinates Xc and Yc, passing through the pole footing as this is shown before Fig. of 6.1[a]. Beyond the figure this circle is depicted after dotted line. If in the model of object is included the model of element “joint”, then the diameter of joint is assigned before the list of the parameters of this model of element. If joint they are absent based on the structure of model as in our case, then frequently they come running down the method, with which all mobile joints and joints of fixed supports depict after the circles of one size, which substantially reduces a quantity of parameters, which must be assigned. The coordinates of support before the conglobulation of coordinates (Xc, Yc) are present before the model of object for determining the position of that element, which in this place is connected with the support (in our case this - the point O, with which is connected crank, and the point E, with which is connected the yoke). For the overwhelming majority of the cases the support can be depicted in parallel to one of the axes of the coordinates of shield (as this shown before Fig. of 6.1.[b]). At the same time, if we determine for such positions the precise value of angle before the radians, this it will cause in average person (not knowing how to obtain before mind six-seven signs after comma during the multiplication as far as the number π) the specific complexities. The task of angle before the degrees saves only partly, since the task of angles before the radians is accepted for the majority of programs before the complex. In this case it was decided to go for the limitation, with which the value of the angle, which assigns the position of support, is rounded to the nearest value from number 0, π /2, π, 3/2p. The image of support beyond the shield with the different values of the parameter Of alfa is shown down [ris].6.1[b].

For the image of crank hanger let us assign the value of the parameter Of alfa=5, while for the rocker-arm bearing Of alfa=0. the sizes of supports and joints let us select as far as such that they would correspond to the images of the levers of the mechanism (picture it must “look”). Before our opinion, for the size of the support - this approximately 0.10, for the diameter of the joint - 0.05. The value of coordinate Zc, which is required for the total determination of the position of support before the space, in this case is unimportant. Therefore Zc=0. of the image of supports let us describe before the separate layer.

With the fixed coordinate system the image crosshead guide will be connected also. The survey of the graphic means existing in the base library shows that for obtaining the fixed image of what-or complex flat contour can be used the program KONTUR, as parameters of which are assigned ten pairs of the coordinates of the points, which determine this contour. Average (= lazy before a good sense of this word, i.e., not desiring to spend its time on the trifles) user PRADIS, that arose before the prospect to determine for training task ten (!) vapor of the abstract points, the sole purpose of selection of which is the adornment of image, will not be by this occupied. Since the coordinates of contour, in this case specially found for this case by the authors before the nearest bushes, will play the specific role before the following presentation, we propose for the counter of press to use an author's design. (You will focus attention, that in this case seemingly is done the favor to user). The coordinates of the points of the contour of counter let us give below before the unit of data of the newly formed program.

Let us switch over to the image of moving elements. The survey of the list of the graphic means of base library with the purpose to find means for the image of mobile joints leads us down the following result:

1) for the image of joint before our task it is possible to use graphic means of the point, which moves in the plane (DOTD, [ris].6.2.);

2) this graphic means it cannot be connected not for the sake of one of the elements, which are present before the structure of the model of mechanism (DOTD has three degrees of freedom, rods - four, triangle and the girder - on six).

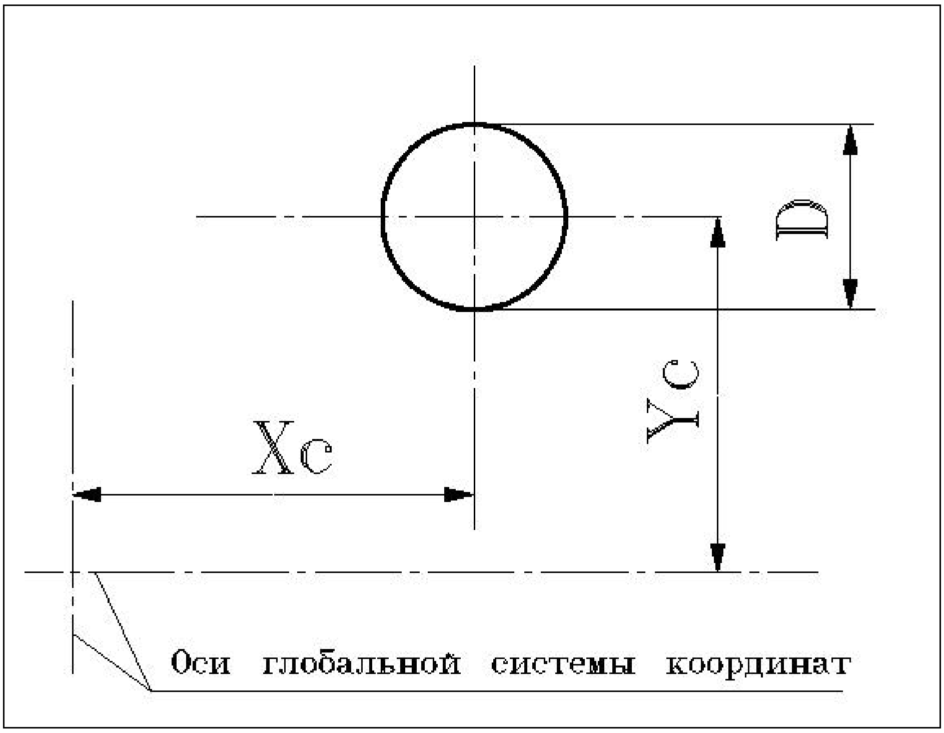


Fig. 6.2. The geometric parameters of graphic means DOTD.

On the whole, this situation is the direct consequence of simplification in the model. We it gathered in such a way as not to consider the property of real joints before the object, but to depict these joints we want. In a word, “and [voditsy] to drink, and [portki] not to wet”. The rubbing in of glasses causes usually additional unproductive labor expenses. It is possible to manage for the sake of the minimum blood in this case, after introducing beside the model of mechanism to account for the inertia properties of joint the point inertia elements, which accomplish the plane motion (element MD). If we consider that they will not affect especially the dynamic processes, then it is possible to assign both mass and moment of the inertia of joint equal to 0. but, once already at the point of us nevertheless it is necessary to introduce this element beside the description of the structure of model, let us assign the mass of the joint of commensurate for the sake of the masses of levers. For example, 0.03 kg. the moment of inertia, taking into account that angular coordinates before the model before all mobile units nevertheless are absent, let us take as equal to 0. natural that subsequently, as a result allegedly the assumed design study of unit, these parameters must be refined.

We will form the identifiers of the new elements, which were appeared before the description of the structure of actuating mechanism, in accordance with the letter designations of the corresponding points Fig. 5.1. (“Joint A”, “joint B” and so forth). With this change in the structure of model it is possible to now connect for the sake of these elements graphic means DOTD, after assigning, for the convenience, for the sake of the same sizes of joint, as for the supports. Graphic means DOTD makes it possible to depict as the circle (parameter of filling in this case must be prescribed equal 1), so also the circle (parameter of filling it is equal to 0).

Since we here touched the concept “minimum blood” (to the left you will go - horse you will lose), then it is possible to indicate a maximally bloody way (to the right you will go - of head you will be deprived). In this case this study of document “the start of the programs of user in the libraries of complex. Management of user. ”, and writing the firm graphic means of joint, which can be connected for the sake of the necessary elements.

For the image of slider it is possible to use graphic means of the rectangle, which moves in the plane (RECTD). Its parameters are assigned on the same principle, that also for the element DOTD (coordinate of center, the sizes - height and width). Exception is the fact that this means always " fills” for the sake of the current color of image. As in the case with the use DOTD, it must be linked for the sake of the element MD for the simulation of slider to, i.e., use not model M (it has one degree of freedom), but MD (three degrees of freedom, transverse and angular degrees of freedom they are connected for the sake of the coordinate system).

And finally the order of the description of the layers of image. With its determination one should consider that the layer of image, described earlier, and be drawn will be also earlier. If we speak about our program, i.e., sense to at first draw fixed supports and contour of the guide, then - slider, the levers of mechanism, and finally mobile joints.

In parallel to reasonings given before this point by us were introduced changes in the text of file TEST6M. Taking into account that, beginning based on the fifth head, as the examples are given voluminous programs, above which it becomes the not evidently living text of management, from the authors entered the proposal to give only the fragments of the texts of these programs with the substantial changes. In this case beyond the user the responsibility for obtaining of the final text of program is laid. Since hereabout there were no readers against the moment of decision making, proposal collected the necessary majority of voices. Therefore we here give substantial changes of describing of object and its image, and also promised above coordinates of the contour of the counter:

```
I DATA
                 * * *
Coordinates of counter = 0.5, 0.1, 0.5, 0.,
                    0.75,-0.2, 0.75,-0.4,
                    0.601,-0.65, 0.601,-1.55,
                    0.0,-1.55, 0., -1.65,
                    0.9,-1.65, 0.9, 0. ;
             * * *
I FRAGMENT: MECHANISM
# BASE:  * * *, 15
# STRUCT:
             * * *
Joint A 'MD (4 5 6; 0.5, 0)
             * * *
Slider 'MD (13 14 15; Mass of slider, 0)
             * * *
        I SHOW
Supports 'LAYER ((OPORAD;  Point O, 0., the size of support, 5,
                           Diameter of joint),
                  (OPORAD;  Point E, 0., the size of support, 0,
                           Diameter of joint);
                           Parameters of layer,
                           Color of the image of support)

Slider 'LAYER (slider (RECTD; Point D, the width of slider,
                              Height of slider);
                              Parameters of layer,
                              Color of the image of slider)
Counter of [mashiny]'LAYER ((KONTUR;  Coordinates are steadfast);
                              Parameters of layer,
                              Color images are steadfast)
                 * * *
Joint 'LAYER (joint A (DOTD; Point A, the diameter of joint, 1),
                   Joint B (DOTD; Point B, the diameter of joint, 1),
```

```
Joint C (DOTD; Point C, the diameter of joint, 1),
Joint D (DOTD; Point D, the diameter of joint, 1);
Parameters of layer,
Color of the image of joint)
* * *
```

Let us note as the necessary note that the chain wheels before the text of program are not everywhere the part of the text before the language PRADIS. This - the tracks of scissors, directed by the authors. From the working text of program TEST6M was cut the familiar to the reader and were left only some new program library, for the sake of which dealt the discussion before this point.

6.1.3.Connection of the layer of image for the sake of the moving coordinate system

You did sit sometimes on the connecting rod of mechanism? It is sometimes interesting to look, as behaves the surrounding situation (in this case, naturally, on the model, without the risk to [zashibitsya]), if you accomplish what-[nibud] complex motion. Here - flat (but nothing it prevents you on the leisure from gathering three-dimensional mechanism, and to give a ride already three-dimensional and even more nonlinearly).

With the description of image in PRADIS-to program it is possible to connect what-either the concrete layers of image with these or other degrees of freedom of model. For this let us return to [ris].5.6 and will recall that the point of view of observer down the object is assigned by the position of points As (here it is placed observer), Bs and Cs (assigns the position of shield and its rotation). Index “s” here is used in order not to entangle the designation of these points with the characteristic points of mechanism. If we want the coordinate system to make mobile, then in this case no longer will succeed in then dashingly defining the initial position of auxiliary points as this was earlier, even if the image of object is located before the plane OXY. It is best all to connect in all for the sake of what-or by real image points. In our case is proposed observer to plant above the point C of connecting rod (abscissa and the ordinate of points As and Cs they will be equal down abscissa and ordinate of the point C of connecting rod, the z coordinate of point As will be equal to, for example, 1, point Cs - 0), and point Bs to place beside the point D. furthermore, it is necessary to connect the layer of image for the sake of the degrees of freedom of these points (C and D of connecting rod). For determining the displacement of the coordinate system, connected for the sake of the layer of image, it will be necessary to assign nine degrees of freedom - The X, Y, Z for each of the points As, Bs, Cs. In our case the degree of freedom, which determines motion by each of these points about the z axis, will be connected for the sake of the base coordinate system. Degrees of freedom on to x and y axes for the points As and Cs must be connected for the sake of the appropriate degrees of freedom of point C, Bs - with the degrees of freedom of point D. the order of the task of the degrees of [vobody] of points As, Bs and Cs with the description of the layer of the image of the same and with the task of the origin coordinates of these points - Xc, Yc, Zc, Xa, Ya, Za, Xb, Yb, Zb.

Taking into account the made changes the description of layer for the image, for example, of crank before the coordinate system, connected for the sake of the connecting rod, will appear thus:

```
Crank 'LAYER (crank; Parameters of layer,
                            Color of the image of the crank;
                     11 12 1 11 12 1 13 14 1)
```

After returning to the text of the task TEST6M, let us introduce beside it changes for the purpose to depict mechanism before the moving coordinate system (for all layers of image they will be assigned the same degrees of freedom as for the layer before the given above example). Let us write down the obtained task beside the file TEST63M. Those being curious can carry out for the task TEST63M command SLANG and sit on the connecting rod during the motion (authors they did not refuse to themselves before the pleasure).

6.2.CONTROL BESIDES THE PRECISION OF THE SOLUTION OF SYSTEM DU

On the motion of the fixing of the model of mechanism let us continue here the study of problems of control besides the work of the program of integration. Before this subsection let us examine the key parameters, the solutions of the system of differential equations controlling precision, and special features of computational algorithm connected for the sake of this.

6.2.1.Final text of the program, which realizes the model of the mechanism

For the global purposes, formulated in chapter 5 (realization of several iterations of the design calculation of machine with the sequential refinement of its parameters) and the fulfillment of the fact that was promised before the title of subsection 6.2, we will sculpture in this point the text of final program for the analysis of mechanism.

As the basis for the final text it is utilized program from the file TEST63M. Let us remove before this text the connection of the layers of image for the sake of the moving coordinate system (so that would not turn itself the head), but beside the subsection OUTPUT let us add the description of the output variables, which can be necessary as far as us for the analysis of the fitness for work of mechanism. In this case let us lay aside a question with the calculation of crank and lever (in reality they they will be, apparently, the special structural elements, whose calculation is specific. For example, crank can be executed in the form eccentric wheel or crankshaft). For us the information about the value of the longitudinal forces before the yoke and the connecting rod will be important, which before these elements will determine the value of the compressive (stretching) stresses. Since the model of rod does not receive transverse loads, the effort interesting us can be brought out with the aid of the program ROUT (it is designed resultant as square root from the sum of the squares of components). Since the effort and stress are connected for the sake of Hooke's law (Sigm = OF P/F = = 1/F * P), as the scale for the computations can be selected value 1/F, and then the value of stress will be designed directly. Thus, before the block of describing the data and the subsection OUTPUT of this task will appear the following descriptions:

```
I DATA :
Scale of the conversion of [napr].[shatuna] = of 1.E4
Scale of conversion by [napr].[korom]. = 1.E4
                    * * *
I FRAGMENT : MECHANISM
                  * * *
# OUTPUT :
```

```
Stress before the connecting rod 'ROUT (the I: Connecting rod (1), the I:
Connecting rod (2);
                                Scale of the conversion of
[napr].[shatuna])
Stress beside [koromysle]'ROUT (the I: Yoke (1), the I: Yoke (2);
                               Scale of conversion by [napr].[korom].)
                          * * *
```

Taking into account the simplified nature of our illustrative example, this to us it can prove to be sufficiently.

Directly for the experiments with an error in the calculations the authors added beside their task the calculated of the speeds according to all degrees of the freedom of mechanism. The calculation of these output variables before the program will be absent with the analysis of entire machine.

6.2.2.Key parameters, which determine a local error in the integration

Here we will in more detail examine the algorithm of estimation and inspection of the precision of the solution of the system of differential equations, utilized before the complex PRADIS. Generally speaking, the mathematical model of technical object is represented in the form the system of differential equations. However, without the loss of generality, we can here examine the numerical solution of one differential equation

F (the X, X', of the X ", T) = 0 (6.1),

bearing in mind that the solution of the system of differential equations is obtained analogously. As is known, the solution of equation (6.1) is the large number of integral functions of the X (t), that are differed from each other regarding arbitrary constants. These arbitrary constants must be determined from the initial conditions. Thus, we obtain the function, which corresponds down differential equation (6.1) 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 of integration the integrated function is replaced by section or curve (depending on the used formula of integration). This, generally speaking, causes passage to the new integral function, which satisfies equation (6.1), but which does not satisfy the prescribed initial conditions. The error in the solution, obtained against the step of integration, is called local error. This error 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 specific [pogreshnost].[Posle] this integration it 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 before the environment of 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 [d].[u]. is such, that an increase in the value of function leads down an increase in the value of its derivative (= the decrease 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 already accumulated error in the solution will increase even in the absence local error. 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. Fig. 6.3. illustrates the method of its determination. For solving equation (6.1) one of the implicit methods of the integration (before the technical applications basic it is Stormer's method, for the training and research tasks frequently it can be used the method of Newmark) is used. In any event, for the implicit method of integration 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].6.3), then the fulfillment of forecast is equivalent to the replacement of integral curve before the time interval [of ti, ti+1] by segment of tangent to it at point with the abscissa ti. The second stage is reduced down the location of the angle of tangent inclination to the integral curve at point with the abscissa of ti+1 and the replacement of integral curve before the time interval [of ti, ti+1] by the section of this tangent.

The value of speed, obtained by explicit forecast, let us designate Vp, the corrected value of the speed - Vc (before Vc not minus, but dash!).

Here it is perhaps appropriate to by the way describe one case besides the blue childhood apropos of signs and letters before the text, which allow the double interpretation, and to the user - a little to be weakened. One time teacher said to student, who weakly have times in mathematics, that for obtaining the cherished troika of that it is necessary to learn by heart several paragraphs besides the textbook on the geometry. Next day, during the examination with the predilection, down a question “which the length of circle?” it was answered: “Two [Pe] of Che” how are earned 3 points - no one could keep balance on the feet, even teacher. Thus, again - here it was borne in mind dash.

By construction, these values (it is borne in mind Vp and Vc, for those, who it had time to forget) 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

$$\iota\Delta_{+1} = (Vp - Vc) / 2 \quad (6.2)$$

Based on figure 6.3 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. Therefore, if the current local error exceeds the permissible error, prescribed by user, then the step of integration must be reduced.

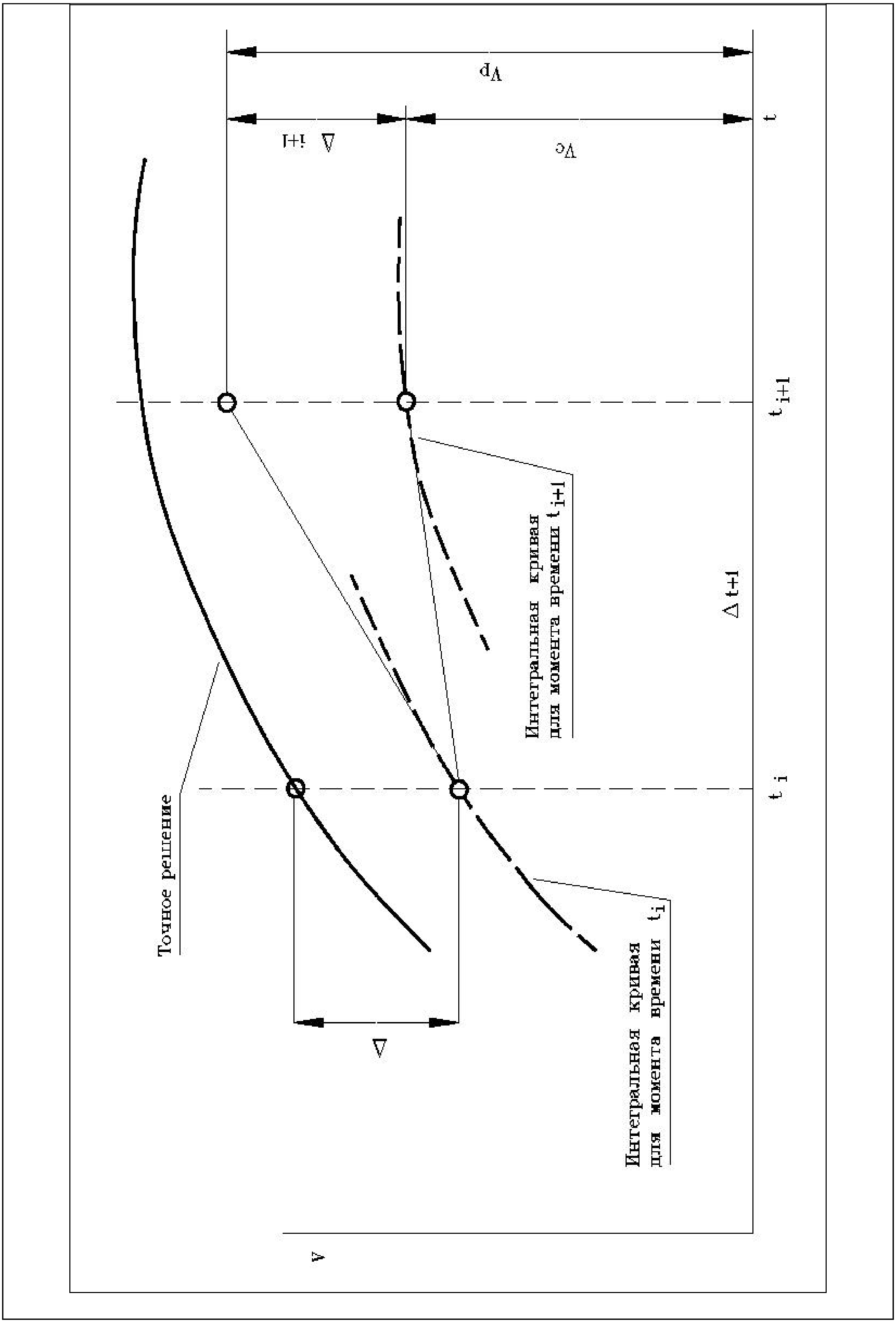

Точное решение
Интегральная кривая для момента времени t_i
Интегральная кривая для момента времени t_{i+1}
$\Delta t+1$
t_i
t_{i+1}
t
v
V_p
V_c
Δ_{i+1}
Δ

Fig. 6.3. **To the determination of local error against the step of integration.**

However, in certain cases an absolute error for evaluating the precision of computations to use inconveniently. 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. In this case for the control of precision it is useful to use a value of the relative value of the local error

$\Delta = 1+\iota\varepsilon\ \varepsilon\eta\tau_{\text{of } i+1}/Vc$ (6.3)

But also this estimation is not general-purpose. In the region of the low values of speeds relative error will be too great, and the program of integration will begin to strongly make small step. Although this, as a rule, is not required. And actually, usual 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 of 1[m]/c.

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. But where the division between the large and the small? (You will focus attention, a question from a series “to be or not to be? ”, “that there is truth?” and so forth with this one only question it is possible to please down the gold tablets of the history of humanity). Therefore, and bearing in mind the fateful mercilessness of this question, for the inspection of the value of a local error in the step of integration is used the value of the absolute error, obtained from the following considerations:

1) user assigns the permissible value of relative (before the region the high speeds) and absolute (before the region the low speeds) local error (respectively, [ε] and [Δ]).

2) the permissible value of absolute local error for the current step of integration is determined as far as the program of integration at the point of the dependence

$[\Delta] = [\Delta] + [\varepsilon] * Vc$ (6.4)

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

We analyze expression (6.4). If velocity Vc is great, then the second member of the right side of this expression, who characterizes the influence of relative error, becomes determining or commensurate for the sake of the prescribed absolute error (certainly, if it is not prescribed, that the permissible absolute error in the solution exceeds the maximum value of speed, but it is found within reasonable limits). When velocity Vc is low, the influence of this term becomes negligible, and on estimation of error the permissible value of absolute error will have a basic effect.

Therefore for the task to local error of integration user can use two key parameters of the program of the integration - DRLTX and DABSX. DRLTX assigns the relative value of the permissible local error (before the region the great significances of the speeds), and DABSX - the absolute value of the permissible local error (before the region the low speeds). For determining the permissible absolute error in the step of integration depending on the instantaneous value of speed expression is used (6.4).

One additional lyric retreat. Fig. 6.3. 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. Generally, the precision of the explicit and implicit methods of integration with the use of formulas of the integration of one order it is identical. It is another matter that the explicit method of integration is characterized by some unpleasant special features (instability of method), because of which, in spite of entire its simplicity, its use before the serious programs is problematic.

6.2.3.Numerical experiments with the local error

It is utilized the obtained before point 6.2.1 final description of the model of mechanism for several numerical experiments with the local error.

The nature of velocity change according to all degrees of the freedom of mechanism is such, that in the regions of extrema the integral curves will sharply diverge. In accordance with the fact that it was stated in point 6.2.2, in this place the maximum accumulated errors will be observed. Integral curve the accumulated error must be considerably less along remaining. If we obtain “precise” value of the speed before the region of extremum (for example, considerably by more precise calculation), then the comparison of the values of the speeds at extreme points will characterize the maximum value of the accumulated error.

Let us at first conduct precise calculation, after assigning DRLTX=1.e-5, DABSX=1.e-5. We will analyze two seconds of process. The accumulated error in this calculation can be estimated, comparing the maximum and minimum value of speed before the analyzed interval. Since the mechanism accomplishes vibration forward and backward in this time, dependences for the speeds must be symmetrical, the maximum and minimum speed - they are equal before the absolute value.

On the course of computation the value of the step of integration nowhere rose to that maximally permitted. In the limits of that step, which was determined as far as the prescribed local error, process was practically linear. Quantity of iterations down the step of integration on the average (16128+326)/(8118+163) of =1.987. On the local error are lost 163 steps. The results of the calculations the first two extrema of speeds according to all degrees of the freedom of mechanism are given before Table 6.2. Time of the calculation - 3167 s.

About these results it is possible to say that the accumulated error in the calculation is not very great, since the difference between the amplitudes of minimum and maximum speeds of about 0.5% or is less. - the value of the minimum, on some - the maximum, i.e., of that extremum, which is more before the absolute value).

Table 6.2. Extrema of speed according to the degrees of the freedom of mechanism, obtained by precise calculation.

Degree of freedom	Speed	
	Minimum	Maximum
3	-.19009 E+02	.19102 E+02
4	-.32736 E+01	.32931 E+01
5	-.42931 E+01	.43112 E+01
6	-.19009 E+02	.19102 E+02
7	-.26446 E+01	.26639 E+01
8	-.11539 E+01	.11377 E+01
11	-.40192 E+01	.40111 E+01
12	-.11734 E+01	.11577 E+01
14	-.16707 E+01	.16711 E+01

Table 6.3. Dependence of the amplitude values of speeds from the assigned magnitude of absolute local error.

	Speed according to the degree of the freedom					
DABSX	3		5		8	
	min	max	min	max	min	max
1.e-4	-18.345	18.826	-4.1497	4.2418	-1.1509	1.0605
0.001	-17.720	18.621	-4.0143	4.1904	-1.1489	0.9939
0.005	-17.110	18.267	-3.8758	4.1121	-1.1470	0.9229
0.01	-16.479	17.948	-3.7358	4.0379	-1.1450	0.8531
0.1	-13.688	16.651	-3.1138	3.7335	-1.1437	0.5939

Table 6.4. Statistics of the results of calculations.

N	DABSX	Successful the steps	Losses the steps	In all the iterations	Time calculation ([s])	Iterations down the step
1	1.e-4	1304	39/0	2682	510	1.997
2	0.001	652	16/0	1382	265	2.069
3	0.005	430	23/0	1164	212	2.570
4	0.01	309	32/1	944	170	2.760
5	-0.10	177	33/6	776	132	3.593

Thus, for the third degree of freedom - this 19.102 1/c, for the fifth of 4.3112 m/s, for the eighth 1.1539 m/s). Furthermore, before our further analysis let us somewhat limit a quantity of the degrees of freedom in question. We will analyze speeds according to the degrees of freedom with numbers 3, 5 and 8.

The value of the key parameter DRLTX let us assign on silence. Before our version of complex its value on silence composed 0.001. Therefore the precision of the results of calculations will influence in the primary meaning of the parameter DABSX. Let us begin to change the permitted absolute error, reducing the obtained results down tables 6.3 and 6.4.

Several commentaries to the calculations. Here, as it was proposed above, as the evaluation of the accumulated error in the solution we will use the accumulated error in the region of the extremum of speed.

First, the comparison of the first and second extrema of the speed for all degrees of freedom of mechanism and before all calculations shows that, as one would expect, the accumulated error of integration in the course of time grows (i.e., the integration of this process by implicit method in the final analysis it will lead down damping of fluctuations before the system).

In the second place, it is possible to compare the value of the accumulated error with the tentative sum of local errors in all steps of integration. If we speak about the third degree of freedom, then for the first calculation the sum of local errors in the steps of integration (tentatively 10^{-4}*1304 = 0.13) is considerably less than the accumulated error in the solution in the region of the second extremum (tentatively 19.102-18.345 = 0.757). For the second calculation this tendency remains, although the difference decreased (respectively, 0.652 and 1.382). Before the third and fourth calculations the accumulated error and the sum of local errors in the steps of integration is approximately identical. For the fifth calculation the sum of local errors in the steps of integration is imposing more than accumulated local error (17.7 and 5.4). This occurs because before the region of extremum the peak of the speed can be compared with the needle. And the nearer we are selected to the extremum, the more diverge the integral curves. Therefore the escalation of precision entails a disproportionate increase in the computational expenditures. Hence it is possible to draw the conclusion: as far as possible do not thrust nose beside the narrow slots, they can crush! Well and if we put jokes aside, then it is possible to say that the determination of the precise value of integral function in the region of peak extrema with the use of Stormer's method is the expensive undertaking. If “it is strong to you meth”, it is possible to for these purposes use a method of Newmark. It has the higher order of precision, and with the comparable computational expenditures the solutions found for the sake of it will be more precisely. But in this case you must be ready for the fact that your nose will fall beside all grooves by this method - even smallest, tracking on-of possibility all fluctuations, including are idle and in no way you interesting against the given moment. But if, God forbid, [zazorchiki] or impacts…

Before the third, let us focus attention on the fact that reduction in the requirements at the point of the precision of the solution it leads down worsening in the convergence of the solution of the system of nonlinear equations. This is understandable - as the initial approximation against each step of integration the solution, obtained against the previous step, is taken. Therefore, the greater the step, the more the initial approximation and the desired point are distinguished, and the large number of iterations is required for solving the system of nonlinear equations. Before the fourth and fifth calculations against some steps of integration appeared the divergence of the solution of the system of nonlinear equations at the point of the maximum permissible quantity of iterations (in our case was 5).

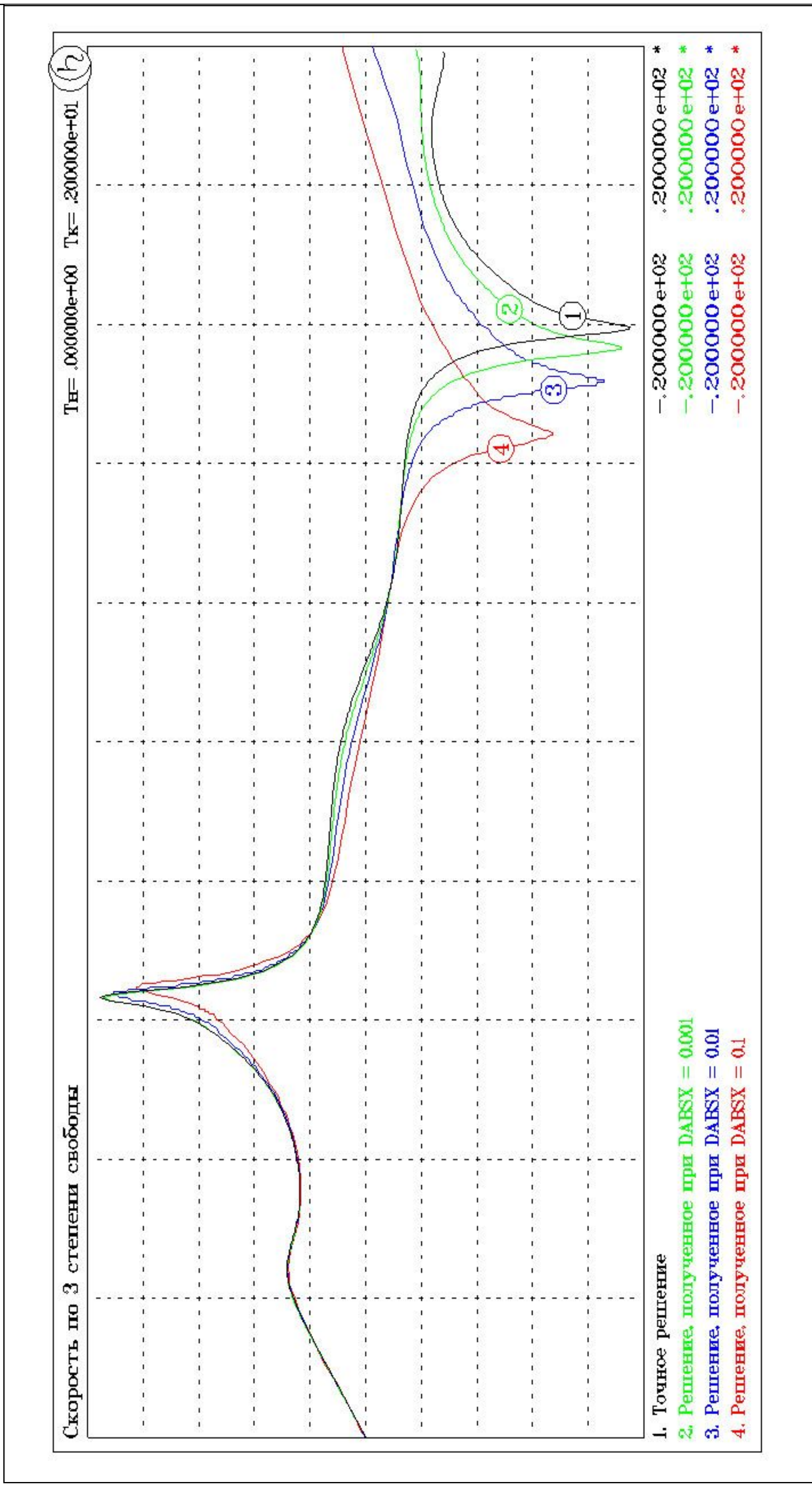


Fig. 6.4.	Influence of the key parameter DABSX beyond the results of integration.

Before Fig. 6.4. are given the results of integrating the speed according to the third degree of the freedom - exact solution (DABSX=1.E-5) and the solution for the different values of the key parameter DABSX.

As a whole, the optimum value of the permissible absolute error for this calculation lies, apparently, within limits of 0.01… of 0.005, if the moderate value of the accumulated error satisfies user. Further increase in the precision will require a more considerable increase in the computational expenditures.

6.3.CALCULATION OF THE TECHNOLOGICAL MACHINE

As it was proposed in point 5.3.6, let us gather the final text of program for the simulation of entire machine with the use of an instruction of the preprocessor of $INCLUDE. Since this program will be located before several files, it is expedient for the work with it to shape the new catalog, for example, OF MASHTST. File PRIVOD will contain the description of data and structure of the drive of machine, MEHAN - mechanism, VISUAL - the description of image. The text of main program will be located before the file TEST63.

Contents of file PRIVOD must differ from the program of the description of drive, obtained in fifth chapter. The fact is that program from the fifth head has small sizes. Therefore it was almost unimportant, drive away flywheel based on the zero speed, or assign the initial velocity of the flywheel of the equal datum speed of engine. For the large models this can play essential role. Before the fragment PRIVOD, which we will use here, the initial velocity of the shaft of engine is assigned by user. This is done with the use of a model VN (element, which assigns the initial velocity of that degree of freedom, with which it is connected). It is natural that before the file PRIVOD there are no divisions RUN, PRINT and title of $END.

File MEHAN contains the description of the structure of fragment MECHANISM, obtained before point 6.2.1 (without the divisions SHOW, RUN, PRINT and the title END). As it was spoken above, will here as far as us no longer be necessary to derive speeds according to different degrees of the freedom of mechanism.

File VISUAL contains the description of the image of object in the course of computation from the same program p. 6.2.1.

To the description of the object, given in 5.3.6 and completely used before the program TEST63, we added the description of task at the point of the calculation of one operating cycle of machine and the task at the point of mapping of output variables (as this was done beside 5.3.5 for the program, which does not use an instruction of $INCLUDE).

All data, which relate down the description of the geometry of object, were transferred from the unit of data of actuating mechanism beside the global block of data. This must be made because the division of the description of the image of object relates down entire object, but not to the separate fragments. Therefore before this division are accessible only those data, that they relate down the global fragment.

As always, let us neglect the procedure of fulfillment of assignments and let us conduct visual inspection on the spot.

About the results of the first calculation two facts strike: 1) clutch is too feeble, which leads down its late complete start (already after the fulfillment of working stroke). Furthermore, with each new working motion it slips (at the moment of the maximum acceleration of slider). 2) the levers of actuating mechanism experience the light loads (less than 10 MPa).

If we approach "design calculation of machine" in the first approximation, honestly, at least against the level of strength of materials, it is necessary levers to weaken. Let us accept as the tentative value of the permissible stresses the value of 100 MPa. But during weakening of connecting rods is necessary their checking down the stability. Before the task in question this is difficult to make by means of complex, since resolution of a question of stability assumes account before the model of the geometry of the cross section of levers. Either task it is necessary to reformulate (it is in detail to describe the geometry of the cross section of connecting rod and yoke, that it did not enter into our plans with writing of this document), or to make estimate calculations on the adjacent fence. We propose here to go along the alternate path. Assuming that the levers in the section, sufficiently removed from the joint, have continuous square section, we will obtain:

```
- the radius of inertia of the section i = OF SQRT (J/F) = OF SQRT (a **
2/12) = 3.46*a

- the flexibility of the levers Of lam = of mu*l/i = of 0.29*mu*l/a = of
0.29*l/a
                                  (mu for this case = 1)
```

For the connecting rod (taking into account that its length - 0.763 m), we will obtain Lam = 22.12 (coefficient of reduction in the permissible stress of approximately 0.95), for the yoke - 11.36 (coefficient it is close down one). If we decrease the cross-sectional area of levers 4 times, we will obtain the length of the side of section 0.005, and flexibilities will be: in the connecting rod - 44 (coefficient of reduction in the permissible stresses = 0.62, assuming that the material of the levers - cast iron; the value of the permissible stresses - 62 MPa), in the yoke - 22 (coefficient of approximately 0.95, the permissible stresses - 95 MPa). In this case it is necessary not to forget to correct the cross-sectional areas of levers and the scales of the conversion of efforts beside the stresses.

Apropos clutches we will vary only by one parameter - with the mean diameter of the friction lining (we consider that the coefficient of friction is determined as far as the material of the friction surfaces and is prescribed). Maximum moment on the second drive shaft - 32 [n]*[m]. for its guarantee clutch must have the mean diameter of half-couplings 0.640 mm (32 /500/0.2 * 2).

Taking into account the proposed changes the division REPLACE for replacing the parameters before the already formed model will appear thus:

```
I REPLACE :
 Scale of the conversion of [napr].[shatuna] = of 4.E4
 Scale of conversion by [napr].[korom]. = 4.E4
 F of the yoke = of 0.25 E-4 ; F of the connecting rod = of 0.25 E-4
 The mean diameter of friction disks = 0.640
```

Let us as usual, supplement this description for the sake of divisions RUN and PRINT and let us carry out the command of the starting of task for the already formed model:

```
> SLANG Of t63 TEST63
```

Beyond the shield after the passage of listing appears the communication about the absence before the text of the program of syntactic errors and, immediately after this, - the communication of database manager (S 145) about the fact that none of the lists of the parameters, prescribed by us for the replacement, is discovered before the source text of program.

Genuine absorbed by hypothetical design calculations for the imaginary technological machine, the authors encountered one of the limitations of the means of $REPLACE, about which it was said above - for the replacement are accessible those and only those lists of the parameters, which clearly are present before the text of the description of global fragment. However, by means in this task already described before this document it is not possible to attain this presence of the lists of the parameters, perhaps what to disembowel fragments and to build the united text of the description of the structure of machine. There is in PRADIS, however, a possibility to replace the lists of the parameters, also, before the fragments, included in the fragment of higher level. The complete size of the description of fragment is used for this. We will use here this method. Before the division of the description of data of global fragment let us include those lists of the parameters, which to us it was wanted to have before the division REPLACE (F of yoke, F of connecting rod, the scales of conversion so forth). In this case let us simultaneously recall that the list of the parameters "mean diameter of friction disks" is not used before the description of the structure of fragment DRIVE, but it enters into the composite list of the parameters "the parameters of clutch". Therefore for the forming of this list of the parameters it is necessary before the global block of data to have also a description of all parameters, entering the list of the parameters of clutch. The start of the fragments of drive and actuating mechanism before the subsection STRUCTURE of global fragment will in this case appear thus:

```
                Drive 'DRIVE (2 1;
                        Parameters of clutch = the parameters of clutch)
    Executive [mekhanizm]'[MEKhANIZM] (2 1 Oe;
                             Scale of the conversion of [napr].[shatuna] =
                             Scale of the conversion of [napr].[shatuna],
                             Scale of the conversion of [napr].[korom].=
                             Scale of conversion by [napr].[korom].,
                             F of yoke = F of yoke,
                             F of connecting rod = F of connecting rod)
          Drive 'DRIVE (2 1;
                        Parameters of clutch = the parameters of clutch)
    Executive [mekhanizm]'[MEKhANIZM] (2 1 Oe;
                             Scale of the conversion of [napr].[shatuna] =
                             Scale of the conversion of [napr].[shatuna],
                             Scale of the conversion of [napr].[korom].=
                             Scale of conversion by [napr].[korom].,
                             F of yoke = F of yoke,
                             F of connecting rod = F of connecting rod)
```

After the list of the assemblies of the connection of each of the fragments is assigned the description of those lists of the parameters OF THE SWITCH ONED fragment, which must be replaced by the lists of the parameters OF THE CURRENT fragment.

Certainly, in this case it is necessary to repeat the forming of model with the newly obtained text of program. Then subsequently it is possible for the replacing lists of the parameters to use the possibility of $REPLACE.

Let us introduce corrections beside the text of program TEST63 and let us carry out task at the point of the analysis and shaping of the model of machine (SLANG TEST63). The divisions of the description of data and replacement of the parameters will appear no longer so optimistic as at first:

```
                I DATA :
                        {Clutch}
  Rigidity of return springs = 1. E4
  Axial rigidity of half-couplings = 9. E5
  Shift rigidity of half-couplings = 1. E9
  Working stroke of pressure element = 0.005
  The mean diameter of friction disks = 0.640
  Coefficient of friction = 0.2
  Moment of the inertia of the first half-coupling = 1.25
  Moment of the inertia of the second half-coupling = 0.10
  Mass of pressure element = 1

        I REPLACE :
  Scale of the conversion of [napr].[shatuna] = of 4.E4
  Scale of conversion by [napr].[korom]. = 4.E4
  F of the yoke = of 0.25 E-4 ;           F of the connecting rod = of
0.25 E-4

  Parameters of clutch = the rigidity of return springs,
                  Axial rigidity of half-couplings,
                  Shift rigidity of half-couplings,
                  Working stroke of pressure element,
                  The mean diameter of friction disks,
                  Coefficient of friction,
                  Moment of the inertia of the first half-coupling,
                  Moment of the inertia of the second half-coupling,
                  Mass of the pressure element;
```

The results of calculating the new version with the intensive clutch and the weakened levers led down such results:

1) clutch works better, but it is linked nevertheless late. In the course of further work it slips. Let us increase the mean diameter of the friction lining to 1250 mm (maximum moment on the clutch of 62[n]*[m], 62/500/0.2/*2 = 1240).

2) stresses before the connecting rod and the yoke were respectively 21.6 MPa and 34 MPa. There is an even smaller reserve. It is decreased cross-sectional area 1.5 more times. The flexibility of connecting rod will compose 66 (coefficient of reduction in the permissible stresses - 0.38; the permissible stresses - 38 MPa). Flexibility of the yoke - 33 (respectively 0.77, 77 MPa).

New calculation led down the following results:
1) clutch practically does not slip.
2) stresses before the connecting rod and the yoke - 38 and 64 MPa. This approximately corresponds to the limiting values of the permissible stresses. Therefore with "the optimization" of the cross sections of profiles let us complete.

However, let us be examined a little back and let us look down the matter of the hands of our. Such piece with the levers from the heavy-gauge wire is set in action as far as the drive, where clutch is separated as far as the monumentality of its sizes. Its diameter approaches one-and-a-half meters (i.e. the machine - Clutch). It develops effort to 500 N (!), accomplishing approximately 1 working stroke per second. In this case the clutch fights in essence not with the technological load (its press it does not note), but with the inertness of the elements of actuating mechanism. World machine building did not know analogs and know will not be. True, if connecting rod actually has such transverse sizes, we, apparently, decided the problem about the nonintersection of the working zone of connecting rod and counters (language it is not turned to say that the press, is faster - the press-clutch) it is sufficiently accurately.

Our reasonings before subsection 5.3 apropos some machine parameters, apparently, must undergo serious correction as, apparently, and very “technical task” of [ris].5.1. First, it is not very serious to enclose vegetable-garden from the heavy-gauge wire. It is more than sense to, apparently, somewhat increase the permissible load beyond the slider (at least to 1000 N). For example, to combine in one working course of slider two operations. In this case rapidity of press it is possible to decrease (engine it will complete consumed work somewhat longer). It is possible to attain the decrease of rapidity due to an increase of the reduction ratio 2 times. In this case inertia loads from the actuating mechanism considerably will be lowered. In the second place, reduction in rapidity of machine beneficially will affect the dimensions of clutch. For decreasing the dimensions before the real construction, certainly, adapt multiple-plate friction clutches. For example, the force of clamping of the friction lining 500 N for the double-disk friction clutch will be equivalent to effort 1000 N for the single-disk.

Let us thus, introduce beside the description of machine the following changes - gear ratio of the drive - 8, the effort of the technological operation - 1000, effort for the pressure element - 1000 (equivalent clamping force for the double-disc clutch). Expected decrease of the dimensions of the clutch - approximately 4 * 2 = 8 times (if we do not consider the increased influence of technological load). Therefore let us return clutch before the first calculation for the new version to the initial sizes. Let us assign the cross-sectional areas of connecting rod and yoke on 0.25 sq. centimeters. Change of gearing of drive requires the interference before the text of fragment DRIVE; therefore for fulfilling this cycle of changes it is necessary to shape the new model of machine.

After several iterations, after leaving the cross section of rods before the rest, they selected the mean diameter of the clutch plates of the cohesion of clutch. If this size of approximately 300 mm, clutch does not slip.

For the subsequent calculations of clutch plates down the service life it is possible to use losses before the clutch with the start and the slippage. In order to obtain the value of this energy, it is necessary to model declutching at the end of the working stroke of press. In this case the accumulated value of energy exactly will characterize the work, spent on the destruction of clutch plates. In addition to this, assigning the calculation of the corresponding output variables, it is possible to solve such problems, for example, as the approximate determination of efficiency of machine, calculations at the point of the service life about the strength and the wear and so forth

It seems to us, that the hypothetical design calculation on this must be finished, since without taking into account the specific conditions of production, requirement for the constructions and dimensions of machine, design study of units it loses special meaning. Before our opinion, the given here example before what-that demonstrates the technology of the application of simulation with the planning to degree, beginning based on the draft estimations. It is natural that from the stage to the stage of the planning, when the projected object begins to outgrow by beef, model will be complicated. It is possible that on what-that stage the calculation of complete model for your COMPUTER will become difficult task, and at the point of you it is necessary to use more than fantasy and resourcefulness, forming the hypertrophied models, as this make large artists. In this case the unit interesting you is prescribed in entire view of your craftsmanship and talent, and that which in this case lies out of your sight - it is only draft, only for creating “working atmosphere” for the projected unit. It is natural that the simulation in this case becomes the fairly complicated variety of skill, the alloy of experience and craftsmanship. Only solid experience of the application of calculations for the real practical tasks will be able to give to you confidence before the correctness of the selection of one or other model or another for each specific designed case. Remember! What it placed before THE COMPUTER(S), then you will obtain based on it!

6.4.RESUMES

1. calculations will bring more than aesthetical satisfaction, if you will use the extended possibilities of describing the image of object (SHOW). In this case it is possible to control the composition of image, including before it these or other elements of object, by the color of the image of these elements, to select for some depicted elements nonstandard graphic means.

2. basic principle, assumed as the basis of the forming of the image: the image of unit is built based on the images of elements, included in the description of the structure of object. With these, and only these elements it is possible to connect what-or graphic means. Graphic means are united beside the layers of image, and from those, in turn, - are formed one or several images of object, which interest user.

3. at will user, it can connect one or several layers of image for the sake of the moving coordinate system.

4. checking of the local precision of the solution before the complex PRADIS, as a rule, is performed on the speeds. For control besides the precision of the solution the key parameters of the program of the integration are used: DRLTX - the permissible relative local error before the region of the high absolute values of speeds ([ε]), and DABSX - the permissible absolute local error in the region of the low absolute values of speeds ([Δ]). The permissible local error in the step of integration for each degree of freedom is determined as far as the dependence:

$$[\Delta] = [\Delta] + [\varepsilon] * V_c$$

5. accumulated error in the integration can be both more and it is less than the sum of local errors in all steps of integration. This is determined as far as the nature of the behavior of integral curves before the environment of the solution obtained against this step. If integral curves diverge (i.e., the signs of the first and second derivative coincide), then the accumulated local error is more than the sum of local errors in all steps of integration. For this reason it is sufficiently complicated to obtain the precise value of the speed before the region of the sharp extrema of integral curves.

6. application of simulation with the design calculation is reduced, as a rule, down conducting of a series of the sequential refining calculations. In this case what is simulated-or working for the projected object situation. The new, more rational values of the parameters are determined as far as the results of simulation. This change of the parameters in the general case entails a change in the characteristics of processes; therefore is required the refining calculation. Before our example for selecting the parameters of clutch and rods it was necessary to conduct two or three refining calculation.

7. corner of calligraphy. Our traditional heading contains two recommendations, which relate down the division of the replacement of the parameters (REPLACE).

a) preserve the glorious history of the replacement of the parameters before each concrete model. This can be made both before the commentaries, before the source text of program, and before the document, for the sake of special means prepared and being contained before the same catalog as model. Do not rely in this case on files of the type T6M or TTT - the tasks, which are used for replacing the parameters before the already formed model, and, all the more, at the point of their phenomenal memory.

b) try to form the model of object in such a way as not to trim to itself subsequently great possibilities on the replacement of the parameters before the already formed model. It should be previously provided for this, what lists of the parameters can be changed subsequently, especially if these lists of the parameters enter beside the blocks of data of the fragments, included in the current fragment. In this case the complete size of the description of the switch oned fragment with the indication of the parameters accessible for replacing the lists is used.

7. QUESTIONS TO THE TEACHING AID

NOTE. Chain wheel noted questions of the increased complexity.

7.1.QUESTIONS TO CHAPTER 1

1. designation of complex PRADIS.

2. name the mathematical methods, utilized PRADIS for forming and analysis of the mathematical model of object.

3. describe the node analysis of the forming of mathematical model.

4. what equations are called topological? What equations are accepted as the topological before the node analysis?

5. what equations are called component? Give examples of component equations. Before what form are written component equations for the node analysis?

6. that does represent the mathematical model of system, formed about the node analysis? You will explain the difference between the methods of connecting the rods Fig. of 1.1.[b]. and 1.1.[v]. (*) which will occur, if two rods will have only one general degree of freedom (for example, before the direction of x axis). (*) which will be, if rods are connected as before the example Fig. of 1.1[b].; however, the coordinate of ends of both rods different (including the ends, which have identical degrees of freedom)? Give examples and draw the possible positions of rods in the course of motion.

7. you will transfer the basic methods, utilized as far as a computational algorithm of complex PRADIS for obtaining solving the system du. Show the connection of these methods for the sake of each other.

8. what information about the object and before what form is initial data for the complex PRADIS? How beside the program is introduced system du?

9. describe the order of the study of teaching aid recommended by the authors.

7.2.QUESTIONS TO CHAPTER 2

1. name the procedures of the user of complex PRADIS.

2. are such the functions of the procedure of fulfillment of assignments?

3. you will explain concepts “process of the forming of model” and “fulfillment of assignments for the already formed model”.

4. name the basic functions of the procedure of the maintenance system catalog. You will transfer the files, which are appeared before the current catalog after the procedure of the maintenance system catalog.

7.3.QUESTIONS TO CHAPTER 3

1. describe the sequence of the steps, which the user for the forming of the mathematical model of object must undertake.

2. what other models of elements (except the model of a constant power action F) it would be possible to use for the simulation of gravitational force. Describe advantages and shortcomings in each of these methods what other phenomena of real process it would be possible to consider with the use as far as each of these models?

3. before what the difference of the processes of fluctuations before the mechanical systems Fig. 3.1. in the case of linear and nonlinear spring constants (rigidity of nonlinear spring is such, that before equipoise it has the same deformation, as spring with the linear rigidity). You will compare amplitude and oscillatory period in both cases. How it is better to conduct this comparison?

4. analyze the behavior of system Fig. 3.1. before the sufficiently prolonged time interval. Do correspond the obtained results of calculating the formed by you model of object? To the behavior of what object do correspond the results obtained as far as you?

5. which the precise value of the period of oscillations of this pendulum (about the formula from the course of physics)? What period of swing of the pendulums is obtained as a result calculation? Are distinguished the periods of the 1st and 5-GO of fluctuation? Will be able you to explain the obtained results?

6. you will transfer the model of the elements, which became they they were known as a result the study of the material of division 3, also, in the course of answers down questions.

7.4.QUESTIONS TO CHAPTER 4

1. that such “program of the calculation of output variables”? Describe the functions of the programs of the calculation of output variables before the complex PRADIS. What varieties of the programs of the calculation of output variables to you are known?

2. that such “internal variable”, “output variable” and “reflected variables”?

3. that such “indicator down the internal variable”? What indicators down the internal variables are used before the complex PRADIS?

4. you will transfer the programs of mapping complex PRADIS. For which is used each of the programs named by you? Describe the key parameters of each of the programs of mapping known to you. You will explain their designation.

5. by what methods it is possible to reflect the value of multicomponent output variable?

6. is it possible to for a second time reflect the results of calculation without its repetition? How this is done?

7. for some programs of mapping it is possible to establish upper and lower boundaries of the reflected variable. For what programs of mapping this is possible? What does occur, if these boundaries are not established? How in appearance graphs it is possible to learn, did establish the user of the boundary of the reflected variables or they were established automatically?

7.5.QUESTIONS TO CHAPTER 5

1. is it possible to continue the interrupted calculation based on that place, on which it was finished? Describe, as this is done.

2. how it is possible to change one or other list or another of the parameters of the formed model without carrying out its repeated forming?

3. which does occur with the joint use of divisions of $REPLACE and $RESTORE? To or after division FRAGMENT must be located the division of $REPLACE? But division i RESTORE?

4. what key parameters of the program of integration to you are known? You will explain their designation.

5. how one should obtain the mathematical models of complex objects? Give several examples. Describe the sequence of the divisions of the description of data and description of object before each of the examples given by you. Special attention you will give to concepts “fixed unit” and “common point”.

6. how it is possible to obtain the image of object?

7. how the image of object is placed in one or other region or another of shield and is scaled? Describe about the parameters of program LAYER and their designation.

8. what models of elements and program of the calculation of output variables you do know? You will transfer the degree of freedom and the parameters of the named by you models of elements. Name the sequence of the degrees of freedom and parameters.

9 (*). As the rod, described as follows will move,:

```
Rod 'STRGN (1 1 2 2; Point A, point B, material)
```

Describe the behavior of rod with the different values of the lists of the parameters "point A" and "point B". Describe the behavior of rod if one of the degrees of freedom (1 or 2) it is fixed.

11 (*). Before the division of the description of data the following lists of the parameters are prescribed:

```
A = 1,2, 3
B = 4, 5, 6
Point A =…
Point B =…
```

The model of the girder element is included in the division of the description of the structure of object:

```
Pendulum 'BALKA (A B; Point A, point B,…)
```

Task at the point of shaping of the model of object is let us assume that executed. Is possible whether now before the division i REPLACE: to carry out this replacement of the lists of the parameters:

```
I REPLACE:
A = 4, 5, 6
```

Base answer.

12 (*). As will work model ideal elastic element K in the case of the following description:

```
Support 'K (1 2 Oe 4; Rigidity)
```

Versions of the answers:

1. as two independent springs of identical rigidity. The first - between the degrees of freedom 1-3, the second - between 2 and 4.
2. as two independent springs of identical rigidity. The first - between the degrees of freedom 1-2, the second - between 3 and 4.
3. as one spring between the degrees of freedom 1,2 and 3,4, which accomplishes plane motion. If this version of answer is selected, then you will explain, as in this case the initial positions of the ends of the rod are considered.
4. your version of answer.

7.6.QUESTIONS TO CHAPTER 6

1. describe all known to you possibilities of the division of the forming of the image of object i SHOW.

2. is it possible in the image of the object several times to include the image of one and the same element?

3. what varieties of the programs of the realization of graphic means you can name?

4. you will explain concept “local error”. With the aid of what key parameters you can control local error?

5. is it possible to be achieved the best results before an example of [ris].3.1. how they were obtained with the answer down 5 question to 3 heads.