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Modelling of Organization and Management by the Information-Processing System

This paper presents the methodology of modelling nature's and society's systems, with the help of state parameters and of motion law, by using the cybernetics' concepts of adjustment (control), information and entropy; it determines also what is the organization and management of a socio-economic system, and the relation between them.

Further, the cybernetic systems (their organization and management) are modelled by information processing systems with adjustment-selfadjustment structure (S_2) with negative and positive feedback.

Systems are reality's objects we meet with in every field of nature and society. The complexity of the systems and of the relations between them made it difficult, and put off the understanding of the fact that, in the knowledge activities, we must describe the systems we have to deal with, and accomplish their representation or modelling so as to understand the phenomena and processes which are getting on, in order to discover natures and society's laws. It is the merit of the XX-th century of having reached this conclusion, which led to the working out of the systems theory and of cybernetics.

The understanding of the notion of system, and of the universality of systems' presence in all aspects of objective reality, leads to the ever deeper understanding of the fact that, in the modelling (model's drawing up) activity, there is a need for working out the systems modelling methodology.

The first question we have to answer, and which, more or less systematically, all nature's and society's sciences and at present especially the management science, endeavour to answer is "How to represent a system, how to work out the model of a system ?"

The representation of a system Σ (if we neglect the theoretical or conceptual systems drawn up by man, which are considered as models) can be done by the following sides:

a) — A set of elements E;

b) — A set of internal relations R_i between the elements of E, and a set of external relations R_e between the elements of the environment;

c) — The three sets E, R_i, R_e have a dynamic character, are variable in time;

d) — The finality (purpose) of the system; in the nature, the system's finality is materialized by the nature's laws, and for the socio-economic systems, the purpose, the objectives of the system are drawn up consciously by man.

We note that the fourth side of the above representation or definition of system Σ leads to the individualization, to the characterization of each system. The industrial enterprise, for instance, has as finality to manufacture certain products, achieving some profits, i.e. the finality contained within the plan targets. The electrons in an atom behave themselves so that the atom system be in minimal energy state, the molecules of two gases in a mixture behave themselves so that the entropy of the system be maximal a.s.o.

The quality of the representation, or of the dynamic model associated to the system, depends essentially on the kind of description of the finality of the natural systems (anorganic, organic and particularly biological ones [1]).

This finality is based upon the nature's laws, on the one hand, and for the economic-social systems, on the other hand, on the objectives, drawn up by the decision maker, and which must be reached by the system in various time intervals.

Which is the first step of the drawing-up methology of the model M associated to system Σ ? The answer to this question consists in describing the elements and relations of Σ with the help of the parameters associated to the state, which have to reflect the dynamic behaviour of the whole system. From the point of view of the history of sciences, the first answer to this question has given by the Newtonian mechanics, which associated to the simplest mechanical system, the material particle or material "point", the *state* of this system, is composed of an assembly of six parameters x, y, z, and $\frac{dx}{dt} = v_x$, $\frac{dy}{dt} = v_y$, $\frac{dz}{dt} = v_z$. As such, it is composed of the co-ordinates of the point and of the components of its speed in an orthogonal reference system $(0, x, y, z)$. (We note that the state parameters depend on time, so as to be able to describe the dynamic character of the system-see point c) in the system's definition).

By associating to the simplex mechanical system the state $S(x, y, z, v_x, v_y, v_z)$ we can describe its behaviour in a state space with a number of dimensions equal to the number of components of the state associated to the system *plus* one (time axis). So as to represent it (see Fig. 1) we shall consider

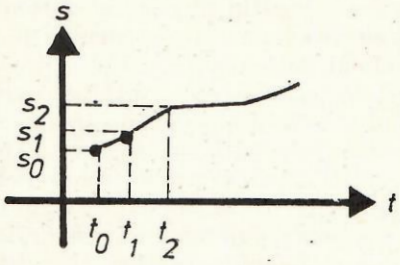


Fig. 1

the plane (S, t) at each moment $t_0, t_1, t_2, \ldots$, having a state $S_0, S_1, S_2, \ldots$, and as much, in the case of the material point, determined values of the state parameters:

$S_0(x_0, y_0, z_0, v_{x_0}, v_{y_0}, v_{z_0}; t_0)$, $S_1(x_1, y_1, z_1, v_{x_1}, v_{y_1}, v_{z_1}; t_1)$ etc. ...

We note that to the state space of each system, on considering its dynamic behaviour, a trajectory can be associated which is described by the state of the system at various moments, and as such, by various sets of values associated to the state parameters, at various values associated to the time. *Consequently, the state of the system is the first element of its modelling necessary to describe its dynamic behaviour.*

The basic problem of the Newtonian mechanics, as in fact of any science, is to be able to foresee the behaviour (in the future) of the system. The Newtonian mechanics solved this problem by associating to the mechanical systems the famous *law of motion* $\bar{F} = \overline{ma}$, where $\bar{F}$ is the (vectorial) sum of the forces acting upon the mechanical system $\bar{m}$ is its mass, and $\bar{a}$ is the acceleration of the system.

Using the *system's state* as first element of modelling the system, and *the motion law as second system modelling element*, the (Laplacian) mechanical determinism principle was drawn up: "If we know the initial state S_0 of the system (position and speed of the mechanical system at moment t_0) and the law of motion, we can *determine* at any moment $t > t_0$ (subsequent) the state S of the system".* Accordingly, if we generalize, we obtain the causal determinism principle: if we have the initial state and the law of motion of a system whatever, we can foresee its behaviour (or *to determine* any state of the system) in the future.

The successes obtained in practice by the Newtonian mechanics are well known, and they are the basis of the technical achievements in the last three centuries.

Consequently, so as to model a system, it is necessary to solve the following two problems:

a) Which *parameters* do we associate to the *state* of the system?

b) Which is the "*law of motion*" (equation of state) which we work out *by using the state of the system*, and which allows us to describe the trajectory in the space of the states?

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* The Newtonian motion law being a second order differential equation, its general solution depends on two arbitrary constants, which can be determined, if we know the initial position and the initial speed.

These problems were solved in physics in various manners, for various systems. Thus, for the electromagnetic systems, as parameters of state were considered the electric field, the magnetic field, the electric induction, the magnetic induction, the electric charge and the current density or the scalar and vector potential, and as law of motion the Maxwell equations of the electromagnetic field. For the gravitational systems, the components of the energy-impulse tensor and Einstein's gravitational field equations. For the quantum systems the parameters from the Newtonian mechanics were supplemented with quantum numbers (spin, baryon number, lepton number, strangeness or hypercharge etc.) and as law of motion, the Schrödinger equation or the equations of Dirac, Klein-Gordon etc. were used.

The mentioned laws of motion *were postulated* in each separate case by each author, and the consistency of the associated models, as such, of the parameters of the state and of the respective equations of the law of motion, were validated by experince. Accordingly, the modelling effort was to be made again each time, for various systems and in each case the two problems associated to the modelling of the mentioned system Σ had to be solved.

But even in physics, not to mention the complexity of the biological, economic and social systems, things do not present themselves in the simplified mode, described above, according to the causal determinism (classical) principle. The quantum (undulatory) mechanics raised a problem, fundamental through the uncertainity relations of Heisenberg, who brings forward for discussion the causal determinism principle in the form presented above.

In the case of quantum mechanics, the state of the system at a moment $t > t_0$ can not be determined but with a certain probability, and as concerns the determination of the initial state (states) of the history of the initial parameters, seeing the uncertainity relation of Heisenberg, their measurement contains a statistical uncertainity.

In the knowledge problems, besides the (classical) "causal determinism", certain sciences (statistical mechanics, quantum mechanics etc) used the principle of "*statistical determinism*", which consists in *determining in probability the state S* on the basis of the (statistical) knowledge of the previous state (or the history) and of the law of motion.

We consider in the following, that both principles presented above are equally necessary to the modelling of the real systems, in the framework of the dialectic determinism, which achieves the connection between the objective character of the reality and the relative character of the models. We shall also consider necessary, in all systems modelling processes, to achieve the ratio adjacent-subjacent (macrostates-microstates) which presumes the necessity of using both sides presented within the dialectic determinism. As such, the knowledge process penetrating into the subjacent in order to determine the individual behaviour of the elements of the system, must describe microstates and laws of motion, which associated as a "mean" (statistically) to the collective behaviour are already described causally at the adjacent level: classical mechanics at adjacent level as against quantum mechanics at subjacent level; electromagnetism — Maxwell equations as against electron theory — Lorentz equations; phenomenological thermody-

namics based upon the three principles*as against statistical thermodynamic mechanics. It is also necessary, at the level of a branch, department, territory, etc. to use statistically determined mean values, for instance, for material consumptions and with their help to carry out balances between "necessary" and "available" (existing) or to determine the deviations between "planned" and "achieved". In proportion as we use these mean values in adjacent, we can undertake the minute, individual (in subjacent) knowledge of the specific consumptions and thus to master their dynamics.

So as to make complete the conceptual framework of the notions, necessary to define organization, management and relation between organization and management, we shall extend the correspondence for reality — representation — model, started above for systems. Consequently, we use the "representation" as it was considered by Marx — *a transference in the brains of the objects from reality, and their transformation within our mind.*

The mathematical-logical model is considered by us as a representation having sufficient logical and quantitative elements, for being able to be used for the (quantitative) study or for simulating the system's behaviour in the future.

With respect to the system Σ, we shall represent and associate corresponding models, in the first place, to the phenomena processes, structure and essence characterizing it.

We represent the phenomena as the dynamic behaviour of the system Σ and one models them as strings of states (macro-states) of the system Σ. We represent the processes as the dynamic behaviour of the subsystems and one models them as strings of states (micro-states) of the subsystems. By structure we represent the set of elements and subsystems of Σ and one relation of hierarchical order among them. In order to model the structure we use taxonomic models and the relation of order. By essence we represent the set of all the internal relations of Σ and we model it using also taxonomic models and the mathematical relations (order, equivalence, function).

The modelling of the organization with the help of entropy, of information, of informative entropy is proposed by ever more authors [2], [3], [4], [5], information and entropy being associated to the level of determination — indetermination, organization-disorganization, of the system; the synergetic effect characterizing the running of the whole system, makes a distinction between its behaviour as a whole and the behaviour of the "sum" of its subsystems.

In the light of this approach, we consider that new prospects are opened for outlining the notion of organization. If we note the place of structure and essence with respect to system Σ, it gets clear that these are the basic elements we must take into account, in order to answer the question "what is organization"?

Organization is "essence and structure of system Σ".

We point out that we understand by structure the set of elements from Σ, the set of its subsystems and the order relation between them, of the type

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* Conservation of energy, growth of entropy and inaccessibility of the absolute zero temperature.

''chief-subordinate". The considered set is not chaotically disposed in time and space; its elements occupy a place or another one, determined at a given moment or at another one, in terms of their hierarchy, and the set of dynamic relations between subsystems (and elements) which make out the *system's own essence and which determine its dynamic behaviour.*

The management (associated only to social systems) has as object the *knowledge and mastering of phenomena from the systems' level and of processes located at the level of their subsystems*, and as such the determination of the trajectories in the space of states (space associated both to the system and to each subsystem separately) and the ensurance of the correction of deviations from the projected trajectory, during the carrying on of phenomena and processes (continuous harmonization of objectives with resources [6]). We can state in this way, that *the relation between organization and management is a dialectic relation of the type essence-phenomenon*, and the structure and essence determine the behaviour of the system as a whole, as well as of its subsystem, the management being helped by a good organization of the system, in achieving its objectives and in mastering the phenomena and processes specific to the system [7].

Relations in time and space were established between the constitutive elements of these systems, namely as a result of the interaction between information and energy (substance) [8], so that these formed various structures.

It is necessary, so as to model organization and management, to deepen the systematic approach and to supplement the above established correspondence, by using the concepts of cybernetics.

Cybernetics, defined by Norbert Wiener as "*science of adjustment (control) and of communication in machines and living beings*" studies the adjustment and information as objects of the reality and formulates the laws associated to them. It is hence necessary, for understanding the contribution of cybernetics to the deepening of the methods of systemic approach, to "represent" adjustment (control), entropy and information (6, 7, 8 in the annexed Table 1).

The representation of control using feedback, as interaction between information (entropy) and energy (substance) is done according to Fig. 2.

This representation contains two intuitive sides deduced from experience:

a) The *first side* is associated to the intuition of keeping the value of a parameter between certain variation limits, in a certain time interval,

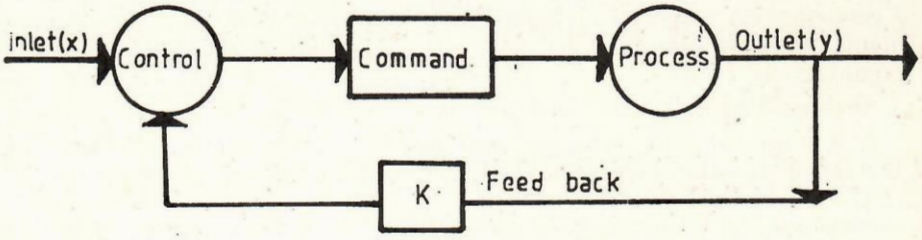


Fig. 2.

or the stability * of a trajectory in a certain tube (maintaining the temperature in an enclosure between certain limits, maintaining the pressure in a boiler, the evolution trajectory of a missile, or maintaining the stability of the trajectory of an enterprise — in the space of its states etc.); it corresponds to *adjustment (control) with "negative" feedback.*

b) *The second side* is associated to the intuition of amplification (instability) of some magnitudes from the ouput (input) of the process, of the errors or deviations which appear, which lead to chain reactions (e.g. in chemistry, electronic amplifiers, resource, biology etc.) and which may lead to the destruction of the system or to the modification of its structure (as is more manifested in biologic or social evolution); it corresponds *to adjustment (control) with "positive feedback".*

So as to model the adjustment, we shall "represent" in the first place the information and entropy and the relation between them. We shall represent information as a measure of organization (determination) of a system, and entropy as a measure of indetermination (disorganization) of a system. We shall consider firstly a particular system, consisting of n elements of commutation with two stable positions (0 and 1). We associate to them the 2^n binary numbers which can be formed with n binary digits.

Each binary digit 0 or 1 can be added to each binary number formed with $n-1$ digits and if we have 2^{n-1} binary numbers formed with $n-1$ digits, then with n digits we can form $2^{n-1} \times 2 + 2^n$ binary numbers (for $n = 1 : 2^1 = 2$; $n = 2 : 2^2 = 4$; $n = 3 : 2^3 = 8$ combinations of binary numbers a.s.o.).

We shall call *structure* (microstructure) each element of commutation in a certain position (microstate). We shall call *configuration* (of structures) each of the 2 combinations of structures (in correspondence with the 2^n binary numbers). We note that we may associate the configurations with the states (macrostates) of the system, each state having n parameters with two values (0, 1) (two microstates), because the states of the system can be also associated with binary numbers. We shall consider also the states (macro and microstates) of the system as equally probable.

In order to represent information and entropy, we shall consider that *we can generally establish a one-to-one correspondence between states and structure configuration, in any system.*

Let N_0 be the number of structure *configurations* ** (of possible, distinct, equally probable states) of system Σ at moment t_0 and N_1 the number of structure configurations (of possible, distinct, equally probable states) at moment t_1 (before and after modifying the information in Σ).

We define *information (information quantity)* through a function of ratio $\frac{N_0}{N_1}$; this function is considered as logarithmic, in order to be able

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* A state S_0 is stable if, as a result of a perturbation the system comes back to its initial state S_0, after having passed in a new state S_1.

** Or "complexions" in the meaning of Planck [9].

to gather information corresponding to distinct (independent) structure (state) configurations:

$$I = K\ln\frac{N_0}{N_1} = N\ln N_0 - K\ln N_1 \tag{1}$$

If $N_1 = 1$, hence Σ passes over to a unique, precisely determined configuration ($\ln 1 = 0$), it results:

$$I = K\ln N_0 \tag{1'}$$

So as to state precisely the constant K,we shall consider particularly $N_0 = 2^n$:

$$I = K\ln N_0 = Kn\ln 2$$

We agree to represent I (the information quantity) through n, the number of bit-binary digits*), so that we must consider:

$$K = \frac{1}{\ln 2}$$

then:

$$I = Kn\ln 2 = \frac{1}{\ln 2} n \cdot \ln 2 = n = \log_2 N_0 \ (N_0 = 2^n \rightarrow n = \log_2 N_0).$$

Considering P the number of distinct possible, equally probable state, associated in thermodynamics to the number of distinct structure configurations of the particles (e · g · a system of atoms having associated to each stable state a certain configuration of structures-atoms, described for instance by the electron positions on possible energy levels), the entropy is defined through the formulae (Boltzmann-Planck).

$$\varepsilon = k \ \ln P \tag{2}$$

where $k = 1 \cdot 38$ and 10^{-16} (ergs by degree centigrade) is the Boltzmann constant.

Comparing (1') with (2) and taking into account the correspondence $N_0 \leftrightarrow P$ (between configurations and states), it results that if we use in (1') Boltzmann's constant, the information (information quantity) can be also measured in (thermodynamic) units of entropy.

Le us remark that we have:

$$\frac{k}{K} = k\ln\ 2 = 1 \cdot 38 \cdot 0 \cdot 7 \cdot 10^{16} \approx 10^{-16}.$$

Using the correspondence at various moments t_0 ($N_0 \leftrightarrow P_0$) and t_1($N_1 \leftrightarrow P_1$) between configurations and states, we have, according to formula (1)

$$I = K\ (\ln N_0 - \ln N_1)$$

** It answers to our intuition that the information is proportional to the length n of a message.

or in thermodynamic units:

$$I = k(\ln N_0 - \ln N_1) = k(\ln P_0 - \ln P_1) = \varepsilon_0 - \varepsilon_1$$

according to (2).

Consequently, between information and entropy, we have the ralation:

$$\varepsilon_1 = \varepsilon_0 - I. \tag{3}$$

As such, the information appears as a negative term in the value of the total entropy of the (physical) system Σ. *Hence, the growth of information corresponds to a diminuation of entropy, and reciprocally.*

The measures associated to information and entropy are comparable and have inverse variation trends: the entropy is associated with the number of states (which characterizes indetermination), the information with the number of structure configurations (which characterizes organization).

But relation (3) *presumes a severe constraint*, which we considered, *neglecting the aspects concerning the information "value" with respect to conscience, to subject.*

For N (number of configurations of states), we can determine from Boltzmann's formulae, the Clausius formulae in thermodynamics $d\varepsilon = \frac{dQ}{T}$ (where Q is the heat and T — the absolute temperature) and also from Boltzmann's formulae we can infer (by associating various probabilities to the states) Shannon's formulae:

$$\frac{I}{N} = - K \sum_{i=1}^{s} p_i \ln p_i$$

where s is the number of microstates (in the macrostate).

This analogy between the quantitative models associated with some properties of the matter, which appear different (at least at first sight): thermodynamic properties, or properties of the information communication chanels was a concern of many authors. Some of them, more "optimistical" assert that Boltzmann, Clausius and Shannon's entropy represents the same objective reality [9], assertion which would lead to the physical equivalence of entropy and information. Other authors (for instance [10]), arque against the physical identity between information and entropy. We consider as source of these different opinions the fact that the representation of the information is not profound enough, so that the more perfect associated models allow to study the differences between entropy and information; the deepening of the information representation, of the semantic content, will presume in the first place the suppresion of the severe constraint of not taking into account the aspects connected with conscience, with the "value" of information for the subject.

For the time being, we shall use the associated quantitative model also in the case of social systems *(being nevertheless conscious of its limits)* in order to measure the organization degree, which is an unanimously accepted fact, in the context of the connection described by 3: "any growth of information in a system is associated with a diminution of the entropy in the same system".

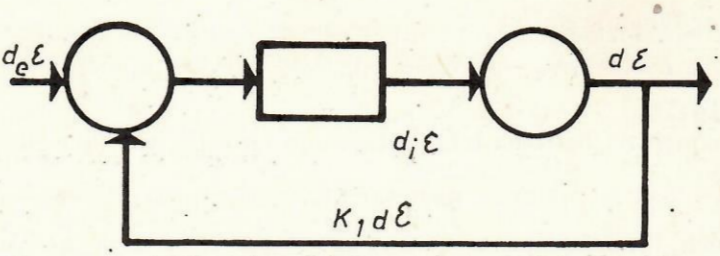


Fig. 3

Of course, the diminution of the entropy in Σ is accompanied by an entropy growth in another system, in the environment, according to the second law of thermodynamics ($d\varepsilon > 0$).

We consider [11] that the entropy growth $d\varepsilon$ results from the internal production of entropy $d_i\varepsilon$ and the transference (flow) of entropy (the exchange) with the environment $d_e\varepsilon$:

$$d\varepsilon = d_i\varepsilon + d_e\varepsilon. \tag{4}$$

We admit that the value of $d_e\varepsilon$ can be sufficiently negative, so that $d\varepsilon$ becomes negative (having $d_i\varepsilon > 0$):

$$d\varepsilon = d_i \cdot \varepsilon + d_e\varepsilon < 0.$$

The representation of control (adjustment) is given in Fig. 3.
According to Fig. 3, we have

$$d\varepsilon = d_i \cdot \varepsilon + d_e\varepsilon + K_1 d\varepsilon.$$

We consider the case when

$$d_i\varepsilon + d_e\varepsilon < 0.$$

Let ε be the entropy of the system in the unit of time; then we can determine K_2, such that:

$$d_i\varepsilon + d_e\varepsilon = K_2\varepsilon dt$$

where

$$K_2 < 0, \ |K_2| << 1.$$

We shall consider the "resonance" situation

$$K_1 = K_2 = K.$$

We have

$$d\varepsilon = d_i\varepsilon + d_e\varepsilon + K_1 d\varepsilon = K\varepsilon dt + Kd\varepsilon,$$

hence

$$\frac{d\varepsilon}{dt} = \frac{K}{1-K}\varepsilon. \tag{5}$$

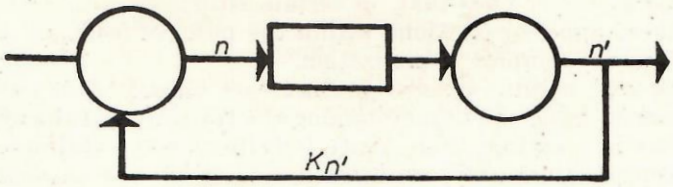


Fig. 4

Let ε_0 be the solution of the differential equation at the initial moment $t_0 = 0$; then, the general solution is:

$$\varepsilon = \varepsilon_0 e^{\frac{K}{K-1}t}$$

Indeed, through derivation we have

$\frac{d\varepsilon}{dt} = \frac{K}{1-K}\varepsilon_0 e^{\frac{K}{1-K}t} = \frac{K}{1-K}\varepsilon$ (hence the general solution verifies the differential equation (5)).

We note that, if the value of K is negative and $|K| << 1$, *the entropy diminishes when t increases, hence the information increases.*

So as to evidence that at "resonance" there appear conditions for a more complex organization, let us consider n, which is the number of subsystems which have a certain property (for example, of belonging to a minimal system). In this case, the representation of control (adjustment) is given in Fig. 4, where n' is the information on the number of subsystems at the output (outlet).

Considering $n' = \frac{dn}{dt}$, hence the output (outlet) variation of the system number, we have

$$\frac{dn}{dt} = n + K\frac{dn}{dt}$$

hence

$$(1-K)\frac{dn}{dt} = n, \quad \frac{dn}{dt} = \frac{1}{1-K}\, n.$$

Let n_0 be the number of subsystems at moment $t_0 = 0$:

$$n = n_0 e^{\frac{1}{1-K}t}.$$

We note that, for a value of $K = K_1 = K_2$ at resonance ($K < 0$ and $|K| << 1$), the number of subsystems increases with the time increase.

Let us remark also that for certain values of the feedback coefficient (coefficient of t the experimental function is positive or negative, consequently, we have negative or positive feedback.

Hence, even in the "simplistic" mathematical model we associated with control, which *always presumes transference of information from input to output*

through feedback, one can see that, in certain situations, (e.g. the considered resonance) there appear conditions within the positive feedback (information increase) of more complex organization.

Controls with negative or zero feedbacks are associated with the modelling of the management activities, of maintaining the trajectory of the system in the space of states in a certain tube, hence for effecting the trajectory stability, and *the controls (adjustments) with positive feedbacks are associated with the modelling of the organizing (reorganizing)* activities of development of the system structure.

It was proved in 12 that Newton, Maxwell, Schrődinger, Einstein's equations, the second principle of thermodynamics etc., are control equations with negative feedback, of the type:

$$\frac{\partial \varepsilon}{\partial t} = \Sigma(\varepsilon, S; r; t)$$

$$\frac{\partial s}{\partial t} = H(\varepsilon, S; r; t) \tag{6}$$

where ε is the entropy, S — the action, $r(r_1, r_2, r_3)$ — the position vector, e.g. $r_1 = x$; $r_2 = y$; $r_3 = z$; H and Σ functions or functionals (generalizing the formalism Hamiltonian — Jacobi) which through the symmetry of variables ε and S model the representation of the feedback (if ε is the input(inlet), this depends also on output (outlet) S etc.). Equation (4) describes a trajectory in the space of states, which is stable (negative or zero feedback); as such, the deviations appear within a tube around the trajectory, and are corrected.

In order to model the positive feedback control, we shall consider still the equations (6) with which we shall associate a potential function φ, so that $\frac{\partial \varphi}{\partial \varepsilon} = \Sigma$ and $\frac{\partial \varphi}{\partial S} = H$. We shall put the condition grad $\varphi = 0$, which delivers the critical points, wherein the equilibrium*, stability or instability of the system are characterized by the Hessian:

$$\left| \frac{\partial^2 \varphi}{\partial \gamma_i \partial \gamma_j} \right| \neq 0 \text{ — points of stabil equilibrium}$$

$$\left| \frac{\tau^2 \varphi}{\partial \gamma_i \partial \gamma_j} \right| = 0 \text{ — points of instability, if for instance, the characteristic}$$

equation has at least one positive root. According to figure 2, we shall model generally the control (adjustment) through:

$$\frac{dx}{dt} = f(x, y; t) \tag{7}$$

$$\frac{dy}{dt} = g(x, y; t)$$

* A state S_0 is a state of equilibrium of a system Σ, if all parameters of state S_0 are constant (in time).

with which we shall associate the conditions of stability or of trajectory invariance for the negative feedback, and conditions analogous with those of the theory of cathastrophes, for determining the instability points, using the potential function, the gradient and the Hessian, for the positive feedback.

Taking into account [12] the controls (which presume transference of information) are presented on all steps of matter organization, hence also in the depths of material world [8]. Still in [12] the existence of the information quantum (of the magnitude of Boltzmann's constant, K) was proved, and as such the interaction between information and energy (substance) within controls can model the process of particle generations or of formation of more complex structures (atomic nuclei, atoms, molecules crystals etc.).

We can extend Norbet Wiener's definition as follows: "cybernetics is the science of control (with negative or positive feedback) and of information transmission and processing, *in nature and society*". Certainly, cybernetics studies only aspects connected with control and information, both in the fields of nature science and of society, with the mentioned limitations, concerning the stage of information representation and modelling, as such neglecting the aspects connected to the value of information with respect to the subject, to conscience. It is, therefore necessary that in the management science intervene the political sciences, the sciences concerning the human behaviour of groups and of social classes etc.

We note in the annex, that the information processing system models the organization and management of system Σ as such it must allow to simulate the dynamic behaviour of the system and of its subsystems, of the development of the structure and of its essence.

A system is cybernetic if it contains at least a control (adjustment) in its structure. The socio-economic systems are consequently cybernetic systems. We shall consider hence information processing systems similar with the cybernetic system, in order to model as faithfully as possible the socioo-economic systems.

Any cybernetic system in nature and society must ensure the stability of the trajectory in the space of states, hence it must correct both the deviations resulting from causes due to the external environment, and the deviations due to external causes. We shall consider within the model to be associated with the cybernetic system, that *the deviations resulting especially from the environment are corrected within a control, and these due to internal causes, within a selfcontrol.*

Unaffected by the complexity of the control and selfcontrol structure, any cybernetic system can be modelled (at least in a first approximation) through the control-selfcontrol binomial. In fact, during the control, the correction of those deviations is effected, which result especially from the external environment, and the interaction with the environment (development of the system) is carried out; the selfcontrol models the correction of the deviations resulting from the development of processes, internal to the system. This is valid for any industrial enterprise, man, cell, molecule, atom, etc., hence for cybernetic systems on all levels of matter organization. These systems carry out permanently negative-feedback controls for the interaction with the

environment, and negative-feedback selfcontrol for maintaining processes at subsystems' level, on stable trajectories. The fluctuations in the subjacent (zone of microstates $\{s\}$ associated with the subsystems) may lead, in critical points (of instability) within positive-feedback controls and selfcontrols (through amplification), to stationary states (for instance in biology or biochemistry), to dissipative structures [11] at adjacent level (level of macrostates $\{s\}$ at system's level).

The new structure (organization) allways appear in biology, biochemistry [11], as a result of the instability (amplification) of fluctuations from subjacent, hence as effect of the positive — feedback selfcontrols and possibly as a result of the negative-feedback control from subjacent, which stabilizes the produced amplification [13].

These processes present statistic and causal-determinist processes, which co-operate (the conflict does not develop itself) to the formation of the new structure: the statistically described fluctuations lead to an initial macrostructure of the system which, thereafter, evolves determinist-causally in stable regime, due to the negative-feedback controls determined by the new structure.

Hence, the positive-feedback control mechanisms lead to the reorganization of the system's structure and to the changing of its essence (hence, organization, change) reflecting the dialectic principle of qualitative jumps, which results from quantitative accumulations; the positive feedback control produces the generation of a new structure and essence, due to the action of disturbing (random) factors, which reflect internal fluctuations or changes of the external environment, and lead to a new system Σ', whose state must be described by the new parameters, and whose structure and essence are made up by the new subsystems and relations. The new system Σ'. with a superior organization, copes with more complex solicitations of the environment. The hierarchic structure results from the adjacent-subjacent relation, and is determined by the sequence of the instability from subjacent and of the stabilities from adjacent.

The structure of Σ can behave itself also as "memory" for the formation through the described mechanism of system Σ' with a hierarchically superior structure [1].

The scheme through which the new hierarchical organization produced by fluctuations, is obtained as follows:

$$\Sigma \rightarrow \underbrace{\text{Fluctuations} \rightarrow \text{Instabilities}}_{\text{Microstates}} \rightarrow \underbrace{\text{Causal determinism}}_{\text{Macrostates}} \rightarrow \text{Stationary regime } \Sigma'$$

Statistically (stochastically) — New hierarchic structure

Consequently, so as to model cybernetic systems (i.e. organization and management within them), we need the control-selfcontrol pair, in which there are achieved, on the one hand the interaction (including the organization improvement) with the external environment and the correction of the devia-

tions resulting from them and, on the other hand, the correction of the deviations (or their amplification leading to the new hierarchical structure), which result from the development of processes within the system.

The control-selfcontrol pair is also sufficient (at least in a first approximation) for modelling a cybernetic system, as it ensures the modelling, both of "homeostasis" processes and phenomena (homeostasis being the property of a system of maintaining the values of some state variables within certain limits) through negative feedback (management modelling), and of those of "ontogenesis" and "philogenesis" which achieve the structural reorganization and the change of essence, through positive feedback (organization modelling).

We start from the control representation with the help of the feedback (Fig. 2), in order to represent the information processing system.

It is necessary to couple two such representations, so as to represent the control-selfcontrol structure, taking into account that both the control and selfcontrol referring to the same managed process and also the control mechanism (of composition of the output signal from the controlled process with that from the input of the two loops of control and selfcontrol) must be a single one.

Consequently, we must compose a case ("Process") and a case ("Control") with two decision blocks and two feedbacks (Fig. 5).

We remark that selfcontrol is represented by three blocks like in Fig. 2 and the control differs by the partition of the decision block in two decision blocks. With selfcontrol, processes are modelled (behaviour of subsystems), while with control, phenomena (at system's level) are modelled.

This representation of the information-processing system, having a control-selfcontrol cybernetic structure, may serve to achieve the information-processing system as a *model of the object-cybernetic system*, if in the cases which served to describe the representation, the necessary models for the

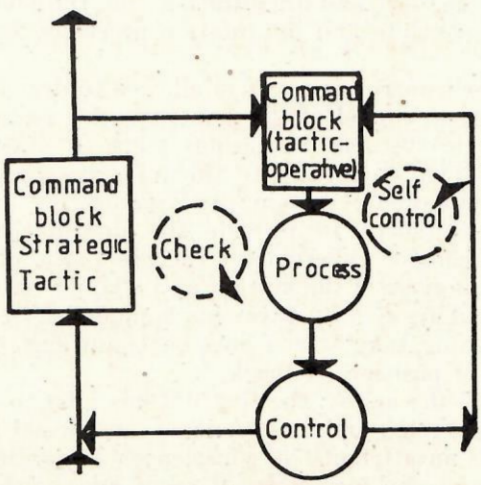


Fig. 5

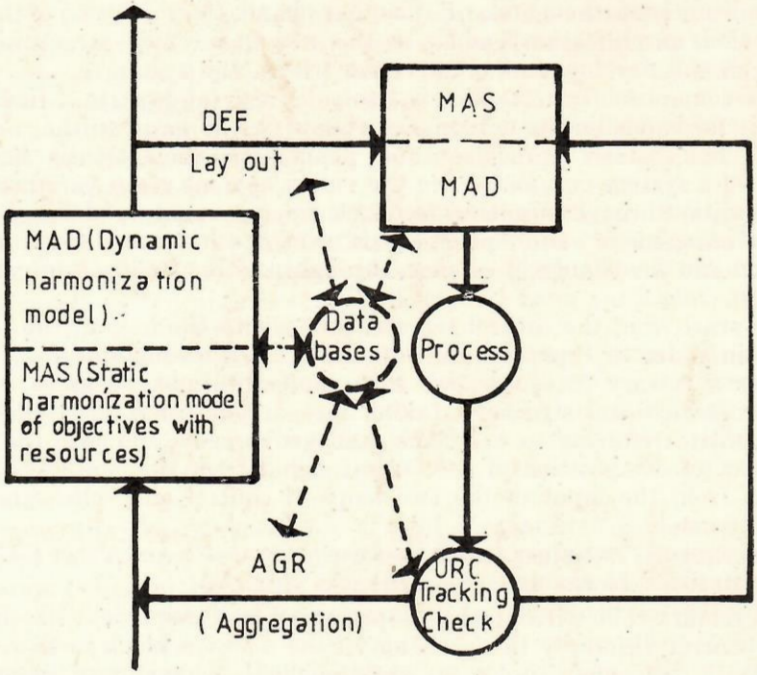


Fig. 6

planned management activities [6] and for the organization activities will be provided (Fig. 6).

Figure 6 presents, within the information-processing system, the models from [6] and their relations (law of motion in the space of states), necessary to model management and organization; the Data basis was also mentioned, which represents data and information processed by those models parameters of states).

The control-selfcontrol pair, which allowed to draw up the information-processing structure as model of the socio-economic system, may be used for modelling cybernetic systems on various steps of matter's organization.

We are now able to formulate the following theorem: for modelling a socio-economic cybernetic system (its organization and management), it is necessary and sufficient to provide the information-processing system with a control-selfcontrol cybernetic structure (with positive and negative feedbacks). The behaviour of the system as a whole is modelled in the control loop, and the behaviour of its subsystems is modelled in the selfcontrol loop.

Their functioning takes place both in conditions of negative feedback, and in conditions of positive feedback.

In the table in the annex, the first 9 items refer to systems from nature and society, item 10 refers only to economic and social systems, considering the management as an attribute of conscience. Organization has as measure the information, and the formation of more and more complex structures is determined by the (positive-feedback) controls, through the increase of

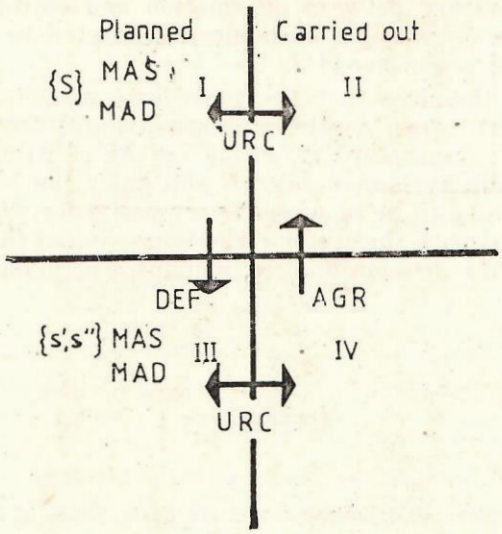


Fig. 7

information (information quantity) and the reorganization of the information itself [1].

In order to model organization and management with the help of the information-processing system, which the managers use for studying the future behaviour of the real system (simulation of the trajectory from the space of states) and to correct the deviations from the predetermined trajectory, hence to ensure the stability of the system dynamic behaviour, we must state in the best way the state of the system and the law of motion.

The values of the parameters of the system's state in various time moments (past or future) are kept in the Data basis, organized in four quadrants (Fig. 7), so as to ensure the comparison of the planned values of the parameters of state with the values carried into effect within the process, and the aggregating of data and information at the strategic management level.

We consider as parameters of state the objectives and resources $S(o, r)$; we consider that the objectives vector consists of indicators and product quantities $S(i, p, r)$. The law of motion, due to the complexity of the socio-economic systems, is achieved with the help of models and programmes carried out for the electric computer and with the help of the decision makers who, in the ground of decision-making preparation (determination of objectives, corrections of deviations, measures of organization etc.) interactively with the help of the results obtained through the utilization of these models, decide the future behaviour of the system.

The attempts of transcribing in differential equation systems the law of motion of a socio-economic system (such attempts are done in the systems theory, optimal control, theory of the dynamic systems stability, etc.) have limits of principle, as they lead to "mechanicist" models (they describe generally reversible phenomena), which can not represent laws of the nature asociated with irreversible phenomena (for instance the law of entropy in thermo-

dynamics) or the ration between information and entropy in cybernetics, not to mention the irreversible phenomena connected to the flow of man's conscience or social conscience [14].

We consider therefore that the procedural models (interactive: man-electronic computer), which ensure an interweaving of the usages of logical-mathematic models (transposed as a rule on the electronic computer) and of the decision made by human factors who know the results obtained by their utilization, prove to be at present very useful for working out the law of motion associated with the system. The improving of the models, in order to help ever more the decision makers, remains a permanent task.

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ANNEX

Object in reality	Representation	Model
1. Σ — system	a) Set of elements E b) Set of internal relations R_i and of relations between the elements of E and the environment R_e c) Sets E, R_i, R_e are dynamic. d) Σ is associated with a purpose determined by the laws of nature for the natural systems, and by man, for the social systems.	A) State of the system $S(p_1, p_2 - p_n)$ p_i — parameters B) Law of motion (equation of state)
2. Phenomenon	Dynamic behaviour of a system	Sequence of states (trajectory) $S_0, S_1, S_2 \ldots$
3. Process	Dynamic behaviour of any associated subsystem $\sigma \subset \Sigma$	Sequence of states (trajectory) $s_0, s_1, s_2, - - (s \neq S)$
4. Structure (of the system)	Set of the subsystems (σ) and of the elements E of Σ, and a relation of their hierarchisation	Models of classification and order relation
5. Essence (of system Σ)	Set of relations between elements of the structure (relations between subsystems, between elements of Σ, between subsystems and elements)	Models of classification and relation of order, equivalence and function (functional)

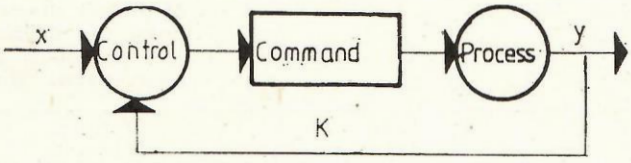


Fig. 8

$$\frac{dx}{dt} = f(x, y; t)$$

$$\frac{dy}{dt} = g(x, y, t)$$

6. Control a) with negative feedback Interaction between information and energy (substance) b) with positive feedback	a) Ensures the stability of a trajectory (in a tube) or of a variable in a given variation interval b) Ensures the amplification of some magnitudes at output of the process, and through the increase of information, to more complex organizations.	a) The trajectory described by the above law of motion is stable (invariant). b) Let φ be such that: $\frac{\partial \varphi}{\partial x} = f, \frac{\partial \varphi}{\partial y} = g$

Object in reality	Representation	Model
		x being the entirety of the variables, we have $\text{grad}_x\ \varphi = 0$ and $\left\| \frac{\partial^2 \varphi}{\partial x_i;\ \partial x_j} \right\| = 0$ with a supplementary instability condition
7. Entropy	Measure of disorganisation (indetermination) of a system.	$d\varepsilon = \frac{dQ}{T}$ (Clausius) $\varepsilon = k \ln P$ (Boltzmann) where dQ is the heat variation T the absolute temperature, k — Boltzmann's constant, P — number of (possible) stable states.
8. Information (quantity of information)	Measure of the degree of organization (determination) of system Σ.	$I = K \ln \frac{N_0}{N_1}$ $i = -K \sum_{i=1}^{s} p_i \ln p_i$ N_0 — number of configurations of distinct structures, before obtaining the information; N_1 — number of configurations of distinct structures, after obtaining the information; p_i — possibility associated with microstates: $i(i = 1, 2, \ldots s)$
9. Organization 10. Management	Structure and essence of Σ. Mastering of phenomena and processes (harmonization of the objectives with structures) $S\ (0,\ r)$.	Information-processing system having structure S_2 (controlselfcontrol) with positive and negative feedbacks.

LA MODELISATION DE L'ORGANISATION ET DE LA DIRECTION EN UTILISANT LE SYSTEME INFORMATIQUE

On présente la méthodologie par la modélisation des systèmes de la nature et de la société à l'aide des paramètres d'état et de la loi du mouvement. Utilisant les concepts de la cybernétique de réglage, d'information et d'entropie on détermine la signification de l'organisation et de la direction d'un système économique et social et leur relation. Dans la suite on mentionne les systèmes de la cybernétique (l'organisation et la direction) au moyen du système à structure de réglage et auto-réglage (S_2) ayant de réactions négatives et positives.

МОДЕЛИРОВАНИЕ ОРГАНИЗАЦИИ И УПРАВЛЕНИЯ ЧЕРЕЗ ИНФОРМАТИЧЕСКУЮ СИСТЕМУ

В работе приводится методология моделирования природных и общественных систем при помощи параметров состояния и закона движения, используя при этом кибернетические понятия регулирования, информации и энтропии. Определяется организация и управление социально-экономической системы, а также их соотношение.

Далее, упоминаются кибернетические системы, их организация и управление через регулирование — авторегулирование (S_2) отрицательной и позитивной обратной связью.

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