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The Analysis of Entropic Conditions-a New Method of Investigating the Cybernetic-Industrial Systems

"The creation of a modern economy of a high efficiency imposes the promotion in all branches of the advanced science and technology achievements."

N. Ceauşescu

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INTRODUCTION

In my previous works * I showed that the most comprehensive of the definitions given to the cybernetic system applied in industrial activity might be considered the following: *a cybernetic system is an ensemble of some interacting elements comprising people and machines integrated into the achievement of a determined objective through the handling and control of materials, of information, of energy and of human activity.*

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* We are referring especially to the works: Bîrlea Ştefan: *The System Concept in Economic Cybernetics. Progress of Cybernetics.* The Gordon and Breach Science Publishers, London, 1969, Vol. II and Bîrlea Ştefan: *Concepte cibernetice aplicate la conducerea şi organizarea industrială* (Cybernetic Concepts Applied in Industrial Management and Organization) Studii şi cercetări de calcul economic şi cibernetică economică, no. 5, 1969.

From the mathematical point of view, it is considered that a certain system S may be described at moment (t) as being a transforming structure of the form:

$$S = \{X,\ Y \mid A\}$$

where:

X represents the set of input signals;
Y — the set of output signals;
A — the operational structure specific to the respective system.

It was also demonstrated that five classes of fundamental operators different from the operator null were sufficient: α (management operators), φ (adjusting operators), φ (production operators), γ (circulation operators) and σ (scientific-technical and informational operators) to define with sufficient precision any cybernetic-economic system. The rest of operators may be considered as belonging to the category of the operational set θ (null operators). Thus, any cybernetic-industrial system has an operational structure of the form $A = \{\alpha, \rho, \varphi, \gamma, \sigma, \theta\}$.

The irreducible cybernetic-industrial system is the place of work (S_m) for the symbolic description of which we shall act as follows:

There are given:

$$S_m = \bigcup_{i=1}^{i=2} S_i$$

S_1 = the system of labour (human);
S_2 = the system of the means of work;
X = the object of work before transformation;
Y = the object of work after transformation.

The cybernetics of the place of work derives from the fact that practically, two operational substructures are included inside the human system, thus

$$S_1 = S_{1,1} \oplus S_{1,2},^{*)}$$

where:

$S_{1,1}$ refers to the effectual activity of the human system having as an operational substructure $A_{1,1}$:

$S_{1,2}$ — the adjusting activity having as an operational substructure $A_{1,2}$.

The connection in which these subsystems are found is presented in Fig. 1.

Thus, $S_m \{X,\ Y \mid A_m\}$

where:

$$A_m = \frac{A_{1,1} \otimes A_2}{1 - A_{1,1} \otimes A_{1,2} \otimes A_2}^{**}$$

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* Not to be confounded with the sign (+), because the point is question is about a set of systems.

** Not to be confounded with the sign (x) (multiplied), because the point is question is about an operational product.

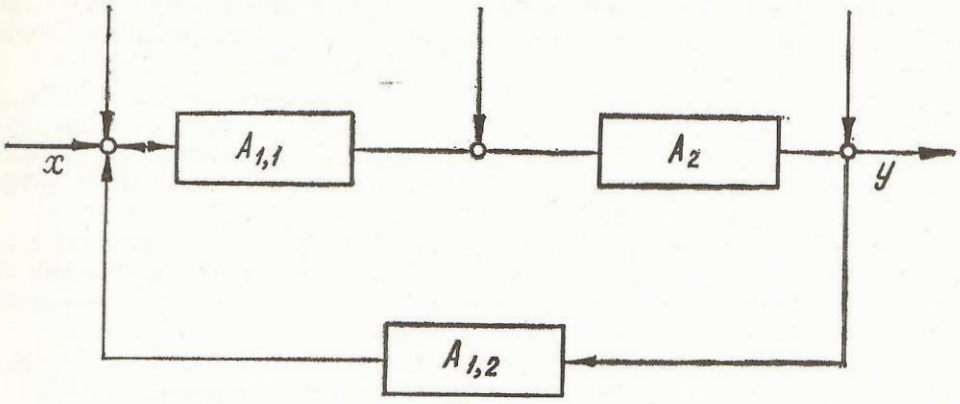

Fig. 1

This relation explains the capacity of the system of annuling to the limit the effect of perturbations through its selforganization.

As can be noticed, the operational control structure of the irreducible cybernetic-economic systems is of a human nature. Theoretically, it might be partly replaced by structures of an artificial nature which, however, include logical elements based on a preestablished programme (the partial automation of the decision).

However, it should be mentioned that in the case of a place of work, entirely automated, only the effectual human operational structure $A_{1,1}$ can be replaced. Thus $A_{1,1} \in A_2$ is a condition for automation. In this case, structure $A_{1,2}$ becomes a supervision structure which can never be taken over by the technical part of the system, its profoundly human nature being irreplaceable. For example, even in the very simple case- the push on the start button of a completely automated system, the choice of the time when the order is given to start the process, the establishment of the work programme are operations in which the human factor is impossible to be replaced.

Accordingly, the human factor intervening in the unfolding of economic processes imposes considerable restrictions in applying in the economy the theory of systems in technics and automatics, in the stage of development they are at present a.s.o., because it implies the quantification of the way in which man reacts to specific situations, generated by the functioning of the system to which he belongs. *)

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* We do not propose to develop this idea in the present study. We think that one of the most interesting subjects of multidisciplinary research will be, in the future, the measuring of the reaction of the human factor. On the basis of some interesting ideas found in the works: Ene Haralambie [5], Paul Sultan [19] I. S. Ibraghimov [8], I. Papadache [15], N. E. Kobrinski [9], Edmond Nicolau and C. Popovici [13, 14], C. Bălăceanu and C. V. Negoiță [12] and many others, the real possibility results of creating models which should simulate the behaviour of the human factor. In our opinion, these models will envisage the development of impact sciences between the technical and economic-social ones, through a common instrument of investigation and analysis — cybernetics.

The cybernetic-economic systems integrating into their structure the objects of work, the means of work and the human factor must also include the totality of activities specific to each of the component subsystems.

As regards *human activities*, it should be underlined that a first division may be made into *individual activities* (biological, of thinking, creation, physical, of work, defence, conservation, etc.) and *collective activities* (of production, communication (exchange of information), of synthesis, analysis, prognosis, management and organization, etc.).

In their turn, the *activities of human collectivities* may be grouped into activities of management and social organization, of production, technical-scientific, social-cultural, of exchange of information and relations with other collectivities, of defence and conservation.

As regards the *technical systems* included in the cybernetic-industrial systems (the object of work and means of work) they represent proper activities which usually accomplish the multiplication or facilitation of human activities (the multiplication of physical force, of the posibilities of communications and exchange of information, of the energetic capacity or—(with the introduction of logical computing and data processing systems-the multiplication of intellectual activities, etc.). The *biological systems* which usually can be found in industrial cybernetics in the form of objects of work are characterized by activities proper to their transforming structure *).

From the point of view of cybernetics, we consider important the following categories of activities: *of management* (analysis, prognosis, decision), *of adjustment* (programming, selfcontrol, interior information transfer) and *the effectual activities* (of production, scientific-technical, of circulation and exchange, etc.).

It should be mentioned that at present, the quantification of these activities and computing methods of the cybernetic-industrial systems raises many problems. Thus, it can be said that the basic method used in industry and, generally, in economy for the quantification of various phenomena and the management of economic processes is the method of successive approximations. The advantages of this method consist in its application there, where no possibilities exist for directly measuring the respective phenomena and the facilitation of the investigation of a large variety of domains, regardless of their internal structure and their homogeneity. In spite of all these advantages, the method has important servitudes, because, besides implying a big volume of work for successive iterations (the gradual approach to the cognition of the phenomenon), it contains a high probability of error **). We consider that the application of cybernetics may contribute to partly eliminating these disadvantages. We have in view the introduction from the very beginning of conventions which should ensure, on the one hand, the

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* The fact is taken into consideration that modern industry is operating, to an ever greater extent, with biological systems (bacterian, micro-organisms, etc.).

**) Significant in this direction is the conclusion reached by prof. Manea Mănescu in his work [11], page 59 and the following, according to which a cycle of at least three iterations must be achieved in drawing up an economic plan, on a nation-wide scale, the degree of precision of the plan continously growing with the increase in the number of iterations.

increase in the level of precision already at the first iterations and, on the other hand, reduce the volume of work for each iteration.

After long studies and researches, the author's conclusion is that one of the most adequate methods for foreseeing the evolution and for efficiently conducting the cybernetic-economic systems should be based on the measuring of "the entropy standard" contained in the system and the ensurance of its being permanently minimized.

Thus, it is a well known the fact that the global efficiency of an economic unit *does not depend only on the material means it disposes of, but, also on how they are being used* for the attainment of the final goal. The guiding functions in the economic just as in any systems, are very complex, being an expression of the practical materialization of the fundamental attributes of management: prognosis, organization, co-ordination, the initiation and guidance of actions, control, the formation, training and promotion of personnel, etc. In this connection, the extension of the methods of quantification also to the guiding functions is of particular importance. In the author's opinion, the level of entropy of a system attests to the level of its organization, respectively, the way in which management is exercising one of its fundamental attributes, namely ORGANIZATION. That is why, we devote the present study to the problem of the quantification of entropy contained by the cybernetic-industrial systems, on the basis of practical experiments made on the model of discrete flow systems (machine-building plants). Considering the generalization of the use of the theory of entropic conditions drawn up by the author liable to the economic systems and in other fields of activity, some basic elements of the theory are presented first.

I. THE BASES OF THE THEORY OF ENTROPIC CONDITIONS

1.1. *The Entropic condition — a general property of the cybernetic systems*

By definition, we shall consider that the *entropic condition* is the general property of the cybernetic systems of containing inside them perturbations which oppose the finalization of the goal (the specific actions) of the respective systems.

Thus, it results that each cybernetic system is characterized by two diametrically opposed properties, namely; the first tends to organize the totality of its effectual elements and to use them with a view to finalizing the proposed goal and, the second tends to disorganize these elements and to interrupt, the functioning of the whole system. Were there not the second property, all the systems would finalize *the goal proposed without any deviations from the established programme*, and each effectual element would have the probability of achievement equal to the unit (certitude). Obviously, such systems can be only "the perfectly organized" ones, that is "idealized" (turned abstract).

The property we are referring to reveals the intrinsec connection existing between the theory of cybernetic systems and the materialist-dialectical

philosophy, representing the full confirmation of the application in cybernetics of the law of "the struggle of opposites" *).

We shall consider, by convention, that *the size of the entropic condition* of a system is equal to its entropy, respectively to the quantity of information contained by it. We shall also accept the following definitions:

message = the concrete form by which the objective reality is reflected;

information = the totality of messages allowing the description and transmission, through a material socket, of the structural quality of a system;

entropy = the proportion of the level of non-determination of a system estimated by measuring the quantity of information achieved by the respective system.

It results that the well known relation of Claude Shannon [20] about the size of entropy (H) (more correctly, negentropy) according to which

$$H(A_n) = -\sum_{k=1}^{k=n} p_k \log p_k$$

where:
A_n is a finite field of probability

$$A_n \begin{pmatrix} a_1 & a_2 \dots a_n \\ p_1 & p_2 \dots p_n \end{pmatrix}$$

$$0 \leqslant p_k \leqslant 1, \quad \sum_{k=1}^{n} p_k = 1$$

may also be applied in the analysis of the cybernetic systems in economy.

If we are referring to the irreducible cybernetic-economic systems-the places of work, the entropic component parts are simultaneously introduced through: the subsystem of labour = man; the subsystem means of work = = machine, tool etc.; the subsystem object of work = raw and related materials, semi-products, pieces to be processed, etc. If we are referring to complex systems: workshops, sections, enterprises branches etc., an entropic component is also appearing, namely the correlation entropy.
Thus, in an ensemble of economic systems:

$$S = S_1 \cup S_2 \cup \dots \cup S_n,$$

we shall have a summated entropy

$$H(S) = H(S_1) + H(S_2) + \dots H(S_n)$$

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*) "At a more careful examination we see ... that the two poles of an antagonism, the positive and negative, are as inseparable as opposed they are and, that in spite of their antagonism, they are interdependent; we also see that the cause and effect representations are valid as such only if they are applied for an isolated case, but, as soon as we regard the isolated case in its general connection with the world as a whole, they merge and blend in the representation of universal interaction in which the causes and effects continuously change their place, what is now and here an effect becoming there and then, a cause and, inversely" (F. Engels: *Anti Dühring*, ESPLP, 1955, page 30).

that is, the general relation might be written as follows

$$H\left(\bigcup_{\alpha=1}^{d=n} S\alpha\right) = \sum_{\alpha=1}^{\alpha=n} H(S\alpha) \tag{1}$$

where

$$H(S\alpha) \subset H(S\alpha)\, H(S\alpha - 1)$$

respectively, the connection entropy among the systems is included through the conditioning of the fields of probability.

The theoretical consequence of the above hypotheses is that the fundamental properties of entropy formulated in the mathematical theory of information *) can be adequately applied to economy, as follows:

a) $H_n(p_1 \ldots p_n) \geqslant 0$ the entropy is always non-negative.

This property signifies in economic cybernetics the presence of a certain degree of disorganization. This presence has an objective character, because, as it was pointed out at the beginning, *the entropic condition is the general property of the cybernetic-economic systems.*

b) Relation $H_n(p_1 \ldots p_n) = 0$ is satisfied if there is an i, so that $p_i = 1$, $p_k = 0$ then $k \neq i$, $1 \leqslant k \leqslant n$. This property is formulated as follows: if a field of probability has *one* single event and the others are impossible, its entropy is null. This property exists only theoretically for the cybernetic-industrial systems. Nevertheless, there are systems, especially, technical ones, with a higher level of reliability which, sometimes, include human presence at which entropy may be approximated as being practically null.

c) $H_n(p_1 \ldots p_n) \leqslant H_n\left(\frac{1}{n} \ldots \frac{1}{n}\right)$. The entropy is maximum when $p_1 = p_2 = p_3 \ldots p_n$, which might be formulated as follows: *non-determination is maximum when all events are equally probable.* This property is found in the cybernetic-industrial systems only when the maximum risk concerning the possibility of interrupting a process is confirmed, and, then, as a rule, the system degrades. For example, the probability of interrupting the process of a concatenated technological system is equal for all installations, a fact which implies, in the event of a damage risk, the degradation of the whole system **).

d) $H_{(n+1)}(p_1, \ldots p_n, 0) = H_n(p_1 \ldots p_n)$,

which would be formulated that two finite probabilistic fields of the form

$$\begin{pmatrix} B_1, \ldots B_n, & B_{n+1} \\ p_1 \ldots p_n & 0 \end{pmatrix}, \quad \begin{pmatrix} B_1 \ldots B_n \\ p_1 \ldots p_n \end{pmatrix}$$

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* The mathematical formulation of the properties we refer to may be found in Silviu Guiaşu [7]. The interpretation of these properties for applying them in economy and the working out of a theory on the application of the entropic theory in economy belong to the author of the present study.

**) The ideas about this and the following properties are enlarged in the work *„Analiza stărilor entropice, o nouă metodă de investigare a sistemelor industriale"* (The Analysis of Entropic Conditions, a New Method of Investigating the Industrial Systems), which will be published in the next issue of the journal.

have the same non-determination. This property is of a very great importance in economic cybernetics and is applied in the reunion of the discrete systems or in combining the system with concatenated technologies with discrete expectation processes. For example, if we have a transfer line (S_1) with operators $\{a_{11}, a_{12} \ldots a_{1n}\}$ associated with the *preceded* (S_2) storage of semi-products with operator $\{a_{21}, a_{22} \ldots a_{2n}\}$ if the damage probabilities are: where

$$\{p_{11}, p_{12}, \cdots p_{1n}\}$$

and

$$p_{1i} \geqslant 0, \ \Sigma p_{1i} = 1;$$

where

$$\{p_{21}, p_{22}, \cdots p_{2n}\}$$

$$p_{2i} = 0$$

thus, the storage does not interrupt fabrication;
then, the production system is

$$S = \bigcup_{i=2}^{i-1} S_i$$

and the fabrication section, as a whole, will have the entropy $H(S) = H(S_1)$ because, the entropy introduced by the storge is null: $H(S_2) = 0$.

Of course, things would be otherwise had the association been inverse, respectively, the taking of the case of the supply storage when the concatenation would have determined that $p_2 \geqslant 0$ and, hence:

$$H(S) = H(S_1) + H(S_2)$$

e) If $A\alpha$ and $B\beta$ are two finite, independent fields of probability, we have:

$$H_{\alpha\beta}(A_\alpha + B_\beta) = H_\alpha(A_\alpha) + H_\beta(B_\beta)$$

This property applied in economic cybernetics is tackled just as in the above case, if $S_1 \bigcap S_2 = \oslash$, respectively, if the systems are disjunct. Their association determines the appearance of a sum of entropies in case that

$$p_{1i} \geqslant 0 \text{ and } p_{2i} \geqslant 0$$

f) Being given two certain fields of probability $A\alpha$ and $B\beta$, the degree of non-determination of a field of conditioned probability is smaller than that of the field of un-conditioned probability contained by it:

$$[H_\beta(B_\beta) \mid A_\beta \leqslant H_\beta(B_\beta)$$

(dependent or independent events).

We shall apply this property in the case of discrete systems, to what we call the relation entropy, respectively, the entropic component which may be introduced, for example, by the interruption of the functioning of a certain place of work (S_{m1}) in the irreducible system (S_{m2}) and, inversely, because of the difference of productivity.

The above properties show that the entropic condition derives from the perturbations opposing the functioning of a system and, thus, it reflects *a negative performance* of the cybernetic systems. The correction capacity of the perturbating factors generated by the incertitude existing in the functioning of any cybernetic system, regardless of its nature (technical, biological, economic, social) expresses the *positive* performance of the cybernetic systems, synonymous with that of preserving their identity with themselves, that is of selfadjustment.

In the author's opinion, the relation in which these performances are found, one towards the other, is one of the most interesting problems of cybernetics, applied in industry and in economy, in general. Although the present work does not propose to tackle the total aspects linked with the theory of the entropic conditions of the cybernetic systems *), we want to warn the reader that the decisive factor through which cybernetic-technical or cybernetic-economic systems with low or high entropy "can be created" is *the operational structure.*

We shall consider, by convention, that *the homogeneous transformation* is the performance ensured by a transforming structure made up of operators which do not change the intimate character (the quality) of the input signal. For example, within an electric system, if we apply a certain electric power on the input we shall have electric power too on the output, of course, with different characteristics in keeping with the transformation occuring inside the system.

In the same context by, *nonhomogeneous transformation* we mean the performance of a system achieved by operators which can change the intimate structure of the input signal. The biological systems, the industrial and agricultural production systems, the economic organizations and the complex technical systems (comprising multiple processes) may be given as examples.

In the author's opinion, there are no systems with homogeneous transformations in economic cybernetics. All the cybernetic-economic systems, compulsorily including the human operational component part as a conscious factor imply nonhomogeneous transformations. As a rule, knowledge is turned into work activities and through the latter, the object of work is subjected to a homogeneous or nonhomogeneous transformation. This, however, is only one of the input signals in the cybernetic-economic system, because the other one represents the signal of a human character.

The general scheme of a cybernetic-industrial system in relation to the medium is presented in Fig. 2.

Consequently, no null entropy will ever be possible because the inverse connection deriving from the medium compulsorily introduces an entropic component.

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*) It is worth mentioning that on a world plane, preoccupations in this matter started relatively recently, in the last few years. We cannot overlook the fact that two personalities from among our Academician Octav Onicescu, who introduced the concept of "informational energy" and, Nicolae Georgescu Roegen with his work Analytical Economics [6] were leading the studies in this matter.

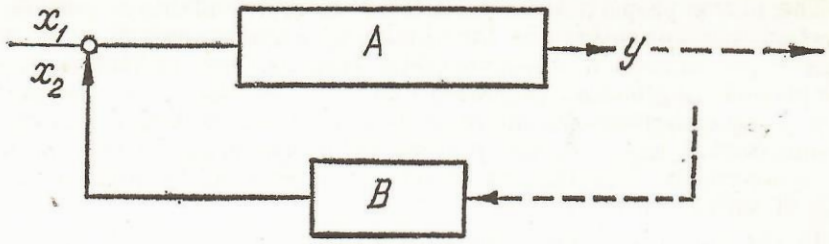

Fig. 2

In other words, if $H(A)$ could be null (considering A as an isolated abstracted system) reality obliges us to take into consideration

$$H(S) = H(A) + H(B) + H(M)$$

where: $H(M)$ is the entropy of the interconnection medium.

In literature, one often meets the approximation by which *the entropic condition of the system is being neglected or is considered constant.* Obviously, at first sight, it can be affirmed that the use of such an approximation would lead to "the idealization" of the functioning of the considered system. In practice, however, the enunciated approximation is used because there are many systems whose functioning is being achieved, in certain time intervals, close or even very close to the ideal case. These systems have compulsorily the property that

$$A(t_i) = const.$$

where

$$t_0 < t_i < t_1.$$

In the time interval $T = t_1 - t_0$ the system is functioning in conditions of atemporality. The entropy of the considered system is also constant, satisfying the condition:

$$H(t_i) = const.$$

where

$$t_0 < t_i < t_1.$$

Thus, it results that if the initial entropy succeeeded in being low, then the atemporal systems preserve for a long time (for the T time interval) the property of functioning with the initial efficiency, respectively the system is stable *).

Such systems are, as a rule, the electric ones, where A is constant and is equivalent to the relations between the transformed Laplace, Fourier or

*) Sharing the points of view in connection with the stability of the systems expressed by Popov [16] Porter B. [17] Schultz [19] and other authors, we draw attention to the fact that as regards the cybernetic-economic systems, the notion of stability must still be studied thoroughly.

Hilbert of the two signals, the mechanical, fluid systems which use heavy fluids as well as all the other natural or artificial systems within which homogeneous transformations are taking place between the input and output signals.

But, things are entirely different in the case of the systems carrying out nonhomogeneous transformations, qualitative changes taking place between the input and output signals. In almost all these cases, the interval $T = t_1 - t_0$ for which $A(t_1) = constant$ is sensibly reduced, which obviously determines a change in the entropic component of the system. But, the greatest changes in the entropic conditions appear in the case of the temporal systems characterized by the property:

$$A(t_{i-1}) \neq A(t_i) \neq A(t_{i+1})$$

where from:

$$H(t_{i-1}) \neq H(t_i) \neq H(t_{i+1})$$

Consequently, in the case of the developed temporal systems, such as the cybernetic systems in industry, we witness a nearly continuous change in the entropic condition. It is worth mentioning that also in the case of the systems characterized by an operational constant value, the approximation of the entropic condition *remains still an approximation* valid only for a certain time interval, because in reality both the operational structure, and, especially, its entropic component are continuously changing at these systems too. The sense of this change is directed towards *the increase of entropy, a general tendency of all systems in nature and in society.*

The fundamental observation we want to make is that although between the transformation in time of the operational structure (A) (the positive performance of the system) entropy (H) (its negative performance) there is an interdependence, it has a random character. Thus, the size of the entropic condition may increase in a certain proportion, while the operational structure of the system may be more rapidly enriched, stagnate or even regress. Hence the possibility of increasing the efficiency in the functioning of a cybernetic-industrial system by diminishing the entropic component or by changing the proportions between it and the operational structure of the respective system. Consequently, the idealistic interpretations in applying the notion of entropy in technics, nature and in economy and society result, in our opinion, because of the very fact that their authors did not analyse also the aspects linked with the capacity of each system of diminishing its entropic component by selfadjustement-a problem we want to refer to in continuation.

1.2. *The evolution and degree of development of the cybernetic-industrial systems*

The problem of adjustment and selfadjustment in economic cybernetics has been and continues to be one of the most disputed subjects. We consider that, in essence, the dispute is carried on not so much in connection with the concept on adjustment and selfadjustment (it is known that for the technical systems, the theory of automatic adjustment is generally outlined), than

especially in connection with the practical way (the instrument) by which this concept is being materialized. It is worth mentioning that beginning with Norbert Wiener, Oscar Lange, Stafford Beer, Wan Egten, Boulanger, other pioneers of cybernetics ([10] pag. 21—15; [2] pag 83 a. s. o; [3]; pag. 3—9; [4]) have tried to extend the application of some principles of automatic adjustment in technics (the compensation of deviation, the elimination of perturbation, the control of error, etc.) as well as the effort of specialists in automatics or in the theory of systems: Truxal, Zadeh. C. J. Savant, Popov ([21] [22] [18] [15]) who have tried to enrich the basic concepts of the theory of systems and to draw up new criteria, especially on the stability of the dynamic systems. In spite of all this, in our opinion, a united theory has not yet been created in the problem of the functioning of the self-adjustable systems and thus of the cybernetic-economic ones. This, however, does not mean that the fundamental property which was at the basis of the analogies made by Wiener when he had created cybernetics-selfadjustment-has not an objective existence.

We also consider erroneous the conception according to which in economy, selfadjustment is exclusively achieved through the market. Indeed, the market is one of the adjustment instruments of the cybernetic-economic systems, but, from the cybernetic point of view, the economic laws, the economic policy with its whole instruments, the plan, the informational-decisional system, the system of managerial organs, etc. are but complex factors which altogether achieve the self-adjustment phenomenon. That is why, in the following, we shall try to present a point of view in connection with this thorny problem.

As it has already been pointed out, in industry, we have to do with evolutive systems which, except for the cases of recession, are, as a rule, in a process of development. Accordingly, the measure of the degree of development of a system becomes a size of utmost importance. Obviously, at the systems of the same class, as is the case with those in economy, the degree of development depends on the richness of the operational structure or, in the last analysis, on the absolute value (the norm) of output elements of the system $\| Y \|$ Thus, noting with $D(S)$ the degree of development of the system (S), we shall have relation

$$D(S) = \frac{\| y(S) \|}{\| y(S_0) \|} \tag{2}$$

where $\| y(S) \|$ is the norm of the output elements of the system (S), and $\| y(S_0) \|$ is the norm of the output elements of a comparison system (S_0) chosen by convention.

Of course, criteria of calculation for each element of the substructure of the system remain to be established, in order to compare each of these elements between them. It is well known that the economists have drawn up such criteria: production, income, consumption, etc. per head of the population, production, income, etc. per surface unit, etc. Considering the above relation as being satisfactory, it can be applied only in the cases that

$$S \sim S_0$$

that is, the systems have homologous structures.

Of course, in economic practice, especially in macroeconomy, such situations are less probable. But, they can be found in microeconomy. For example, a car factory whose total production approaches the optimum series is more developed than a factory of the same type which is working in smaller series, even if the technological structure can be the same. At the same, time, if we refer to the time factor, a place of work with three shifts is, from the cybernetic point of view, more developed than another of the same type where work is going on in two shifts.

An important place in the evolution of the system is held not only by its degree of development, but, also by acceleration — that is the rhythm in which it is developing. This results from taking into consideration the calculation elements previously defined by an efficiency function. Considering that the efficiency function has the form:

$$\psi = \frac{\| [At_i] \| - \| A [t_i - 1] \|}{| t_i - t_i - 1 |} \quad \text{for } \psi \geqslant 0;$$

$\psi \geqslant 0$ draws our attention to the fact that its size depends on:

$$\Delta = \| A_i \| - \| A_{i-1} \|$$

the highest rhythm being when

$\Delta \to max.$ for the time interval $t = t_i - t_{i-1}$.

It is obviously clear that the maximum value of Δ for the established interval depends on the volume of accumulations allocated in a previous interval, expressed in transforming operators of the effectual systems with low frequency. As a rule, they are production, services and circulation.

Consequently, the maximization for a longer period of the function $\psi(.)$ depends on a programme or on a policy consciously established by the people who propose to govern the respective cybernetic-economic system. This proves the necessity for the industrial systems to be compulsorily conducted on the basis of a specific function of forecast, planning or programming. The efficiency of this function which, as is known, is a fundamental demand formulated already by the forerunners of the science of management allows to achieve what cybernetics considers to be a fundamental element, namely the self-organization of the system. It is also known that one of the essential particularities of the economic systems is that they are functioning through the composition of the activities of several subsystems which, in their turn, are made up of a bigger or smaller number of subsystems of an inferior stage to the irreducible ones (the places of work). To measure the development of a system $D(S)$, according to relation (2), the homogeneity of the output is necessary. But, in this case too, the relation illustrates only the rhythm in which the system is developing in general and not also the way in which each component system is contributing to its good functioning. Or, the economic processes are set up by reuniting the individual processes of the set of systems contributing to their achievement.

Consequently, they always have a probabilistic evolution, the forecast and the measure of their development always containing a certain factor of error. There is a close connection between the size of this factor, the level of organization of the system and the efficiency with which is it functioning.

In the author's opinion, the efficiency in the functioning of a system is higher as the systems contain a lower entropy *). The solutions for obtaining a low entropy are different, sometimes even opposed. For example: the diminishing of the entropy introduced in the production processes by the human factor by increasing the level of automation is visible; but, at the same time, the entropy of this factory can be reduced by increasing the direct intervention of man, if a maximum operational lay out is ensured, so that man power should carry out very simple work with a reduced probability of error.

From the technical point of view, the first solution corresponds to the idea of granting preponderence to the technological component of the entropy and is taking place, generally, in the industries with a continuous flow; the second solution corresponds, on the contrary, to the manual places of work linked between them by a forced rhythm of fabrication. The enumerated hypotheses are demonstrated and unreservedly appropriated in the applications specific to the technical systems; we consider that they can be extended in adequate conditions also to the cybernetic-industrial systems and even to any economic system.

Thus, it results that the use of a conventional method of calculating the entropy of a certain cybernetic-economic system creates the possibility of introducing a new criterion of comparing the global efficiency in the functioning of the economic organizations. If two cybernetic-economic systems of the same type (places of work, workshops, enterprises, etc.) have a different size of entropy, it is obvious that their level of organization and evolution are different too.

The introduction of this comparison indicator has the great advantage to take into consideration the total elements comparable among systems and not their sections, as advocated by the present methodologies.

For example, even if the means of production of a unit are more expensive than others, if they create, on the whole, a lower entropy of the cybernetic-industrial system, we can be sure that the efficiency of the respective system is higher, just as we can be sure that it is not the number of workers that determines the efficiency of the functioning of an industrial organization, but the ever lower level of human entropy which they are introducing into the system.

As a result of all these analyses, we have come to the conclusion that we should suggest the introduction of a new element in economic, practice, namely the measuring of the possibilities of turning to account the resources created by the "organization" factor.

For the quantification of this factor we propose the utilization of the following relation:

$$G(S) = \frac{H_0}{H(S)} \tag{3}$$

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* Interesting interpretations of the notions about "low entropy" and "high entropy" in economy are due to M. C. Demetrescu, N. Georgescu-Roegen and to Octav Onicescu who use the concept of informational energy.

where:

$G(S)$ — is the level of organization of the system (S);

H_0 — the entropy of a standard system considered as being perfectly organized;

$H(S)$ — the entropy of the system (S).

It is noticed that the highest level of organization may be equivalent to the unit.

The entropies are calculated with the relations:

$$H_0 = \frac{\sum_{i=1}^{i=m} \alpha_i H_{0i}}{n \sum_{i=1}^{i=n} \alpha_i} \tag{4}$$

$$H(S) = \frac{\sum_{i=1}^{i=n} \alpha_i \cdot H(S_i)}{n \sum_{i=1}^{i=n} \alpha_i} \tag{5}$$

where:

$\sum H_{0i}$ — is the sum of the entropies of the component systems of the standard system S_0;

$\sum H(S_i)$ — the sum of the entropies of the component systems of the system S;

α_i — the ponderability coefficients in keeping with the importance of the system (disorganization is smaller if, for example, an indirectly productive labour force is not present rather than the labour force on which production is directly dependent is missing). At the same time, disorganization is larger when the functionning of a technological equipment is interrupted rather than in the case of related equipment, etc. These coefficients are established on the basis of the own experience of the one applying the method.

Although for reasons of space, we are tackling only these aspects concerning the theory of the entropic condition of the cybernetic-economic systems, we are obliged to draw the reader's attention to the fact that the size of the entropic condition depends on the time factor, on the homogeneous or heterogeneous character of the transformation undergone by a system. This is the reason why, at the technical systems characterized by homogeneous transformations (a single category of operators invariable in time) the approximation is possible to consider that for certain time intervals they are functioning with a constant or null entropy (to approach them, from the mathematical point of view, as some idealized systems), a thing which in economy is practically impossible to tackle.

The method through which the above theory is being applied will conventionaly be called "The Method of Analysing the Entropic Conditions".

REFERENCES

1. BĂLĂCEANU C., NICOLAU E.: *Les fondements cybérnétiques de l'activité nerveuse.* Ed. Monographies du collège de medicine des hôpitaux de Paris, 1971.
2. BEER STAFFORD: *The Cybernetics Cytohlast : management itself.* Progress of Cybernetics. Gordon and Breach Science Publishers, London, 1969.
3. BOULANGER GEORGES, R.: *Artificial Intelligence.* Progress of Cybernetics. Gordon and Breach Science Publishers, page 3—9.
4. EGTEN VAN R., J: *Noţiunea de comportament în cibernetică şi problema echivocului semantic.* (The Notion of Behaviour in Cybernetics and the Problem of Semantic Ambiguity). Documents of the International Congress of Cybernetics, Namur, 1969.
5. ENE HARALAMBIE: *Teoria reglării sistemelor sociale.* (The Theory of Adjusting the Social Systems), Ed. Academiei R. S. România, 1972.
6. GEORGESCU ROEGEN NICHOLAS: *Analytical Economics.* Harvard University, Cambridge, Massachusetts, 1966.
7. GUIAŞU SILVIU: *Aplicaţii ale teoriei informaţiei.* (Applications of the Theory of Information). Ed. Academiei R. S. România, Bucharest, 1968.
8. IBRAGHIMOV I., S., : *Cibernetica şi sisteme de comandă.* (Cybernetics and Control Systems). Papers presented at the 12th conference of young scientists and postgraduates of the Institute of Automatics and Telemechanics, 1965, I.D.T., 1970.
9. KOBRINSKI N., E: *Bazele ciberneticii economice.* (The Foundations of Economic Cybernetics). Ed. Ekonomika, Moscow, 1969.
10. LANGE OSCAR: *Introducere în cibernetica economică.* (Introduction to Economic Cybernetics). Ed. ştiinţifică, Bucharest, 1967.
11. MĂNESCU MANEA: *Preocupări cu privire la tehnica de elaborare a modelelor ciberneticii în economie.* Revoluţia ştiinţifică şi tehnică contemporană. (Preoccupations in the Technics of Elaborating the Models of Cybernetics in Economy. The Contem porary Scientific and Technical Revolution). Ed. politică, Bucharest, 1968.
12. NEGOIŢĂ C., V: *Sisteme de înmagazinare şi regăsire a informaţiilor.* (Information Storage and Retrieval Systems), Ed. Academiei R. S. România, 1970.
13. NICOLAU EDMOND, POPOVICI ALEXANDRU: *Introducere în cibernetica sistemelor discrete.* (Introduction to the Cybernetics of Discrete Systems), Ed. tehnică Bucharest, 1966.
14. NICOLAU EDMOND, POPOVICI ALEXANDRU: *Introducere în cibernetica sistemelor continui.* (Introduction to the Cybernetics of Continuous Systems), Ed. tehnică, Bucharest, 1972.
15. PAPADACHE I: *Automatica aplicată.* (Applied Automatics), Ed. tehnică, Bucharest, 1971.
16. POPOV B., M: *Hiperstabilitatea sistemelor automate.* (The Hyperstability of Automatic Systems), Ed. Academiei R. S. România, Bucharest, 1966.
17. PORTER B: *Stability Characteristics of a Class of Multilevel Dynamical System.* Kybernetes, vol. 1, Jan. 1972. Ed. Gordon and Breach Science Publishers, London, New York, Paris.
18. SAVANT C., J.: *Calculul sistemelor automate.* (The Calculation of Automatic Systems), Ed. tehnică, Bucharest, 1967.
19. SCHULTZ D., GIBSON J., E: *The Variable Gradient Method for Generating Liapunov Functions,* AIEE, ITG on Autom, Control 1 (4) 1963, pages 23—32.
20. SHANNON CLAUDE: *A Mathematical Theory of Communication Bell System.* Technical Journal, 1948, pages 379—423; 622—656.
21. SULTAN PAUL: *The Impact of the Union,* Labor Economics, Henry Holt and Company, New York, 1959.
22. TRUXAL J. C.: *Automatic Feedback Control System Synthesis.* Mc. Graw Hill Book Company, New York, 1955.
23. ZADEH L., A.: *On the Stability of Linear Varying Parameter Systems.* Appl. Phys., vol. 22, 1951.

ANALYSE DES ETATS ENTROPIQUES — UNE NOUVELLE METHODE D'INVESTIGATION DES SYSTEMES CYBERNETIQUES INDUSTRIELS

L'auteur définit un système cybernétique général et un système cybernétique industriel mettant en évidence les différences. On examine l'état entropique en tant que propriété générale des systèmes cybernétiques et des systèmes cybernétiques économiques tout spécialement, aboutissant à la conclusion que l'une des méthodes les plus indiquées pour prévoir l'évolution et pour diriger avec efficacité les systèmes cybernétiques économiques devrait être fondée sur le mesurage du "niveau d'entropie".

Enfin, on fait l'analyse de l'évolution et du degré de développement des systèmes cybernétiques industriels et, à cette occasion, on propose l'introduction d'un nouveau critère de comparaison de l'efficience globale dans le fonctionnement des organisations économiques — le calcul de l'entropie.

АНАЛИЗ ЭНТРОПИЧЕСКИХ СОСТОЯНИЙ— НОВЫЙ МЕТОД ИССЛЕДОВАНИЯ КИБЕРНЕТИКО-ПРОМЫШЛЕННЫХ СИСТЕМ

В настоящей статье автор определяет кибернетическую систему вообще и кибернетико-промышленную систему и выявляет различия между ними. Энтропическое состояние рассматривается как общее свойство кибернетических систем, в особенности кибернетических промышленных систем и выводится заключение, что один из наиболее целесообразных методов предвидения эволюции и эффективного руководства кибернетико-экономических систем должен основываться на измерении «уровня энтропии». В заключение подвергаются анализу эволюция и степень развития кибернетико-промышленных систем, причем предлагается ввести новый критерий сопоставления общей эффективности работы хозяйственных организаций — расчет энтропии.