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Some Methodological Problems of Cybernetics

In the modern era of gigantic development of scientific knowledge precision and accuracy of methodological standpoints in science acquire exceptional importance. It is not by chance that in the Draft Program of the CPSU the need for working out philosophical problems of modern natural science was noted among the most important problems of science in the era of transition from socialism to communism. This Program principle is of particularly great current importance for the young science, cybernetics, which has gone through a period of establishment and development of its fundamental principles and concepts.

The dawn of the cybernetic era relates to the middle of the present century. As far as Minerva's owl is concerned, at daybreak it is frequently blind, for, as is well known, it loves to fly about only at midnight. For this reason, from its philosophical heights beyond the clouds it did not immediately give attention to the "ugly duckling" which was born unexpectedly into the glorious family of sciences, and when it did notice it, it even attempted to crush it in its talons. However, now this is all past, and the "duckling" has already grown up long ago.

Philosophical analysis of the results of cybernetics, certainly, is very expedient. It can bring benefit both to philosophy, because it cannot help but be considered along with the progress of special sciences and should be developed in accordance with their achievements as well as to cybernetics itself, because such an analysis can assist in its self-realization as an independent science, assist in the accomplishment of those magnificent problems which have been set before cybernetics in the Draft Program of the CPSU.

Important methodological problems of cybernetics have been analyzed in the collection Philosophical Problems of Cybernetics, published by Sotsekgiz this year. However, it is perfectly natural that the results obtained by cybernetics will be the subject of philosophical analysis for many years to come.

We shall discuss some of the philosophical and methodological problems of cybernetics which are interesting in the analysis of the developmental prospects of this young science.

Control and Optimization

With such a great event in the history of knowledge as the appearance of an entire scientific discipline in itself (and now there is no reason to doubt that with the appearance of cybernetics the situation was precisely so) there could not help but be serious philosophical consequences.

In order to analyze these consequences more accurately it is expedient to approach cybernetics genetically. We shall not analyze the theoretical and technical premises of cybernetics, which have been quite fully analyzed in Soviet literature, but we shall touch only on one very essential aspect of the birth process of cybernetics. This aspect is associated with the fundamental fact that the birth of cybernetics was determined by the rise of the category of control to prominence in our era both in the field of knowledge and in social practice. According to the figurative expression of Professor N. A. Bernshteyn, who noted that the problem of control of power is no less complicated, important and sapid than energetics itself which is subject to control, the "problem of the rider" has begun to become more important than the problem of the "horse" (Leningrad, 1).

It is perfectly obvious that an analysis of the concept of control is very important.

The category of control is a very broad concept which characterizes chiefly certain characteristic features of human activity. When we speak of control we get a historic image which is well known even from school textbooks: Ramses II driving a chariot. Certainly, there is no doubt of the fact that here we have run across one of the simplest types of control. Control is highly varied; we say: the nervous system controls the development of the living organism; the worker controls the machine; the people control the government, etc. What is control?

In the most general form control can be defined as the regulation of a system (by system we mean any object in the real world), that is, putting it into correlation with certain objective regularities. The higher forms of the control process are associated with such a complex type of causal relationship as expediency.

Characterizing control with respect to form, it may be stated that this is a process of communication between the controlling and the controlled systems.

Such a definition is very similar to the definition of causality as the relationship of two phenomena -- cause and effect. Actually, there is a certain similarity between the concepts of control and causality. First of all, the fact attracts attention that the concept of causality and control are anthropomorphic, that is, they are related in their origin to an analysis of human activity. How much wonder we see in the [illegible] when he becomes confident that he can control his hands! F. Engels noted that the concept of causality arose from the observation of human activity.

There is nothing unnatural in the fact that many scientific concepts (such as work, order, law, etc.) characterizing a broad class of processes are anthropomorphic in their origin. For man as a material system cannot be separated from all other systems; man is not foreign to nature; he is in a material unity with it; therefore, many features which were first seen by man in his own natural activity are justified with respect to all of nature.

The problem of the anthropomorphic origin of many scientific concepts was analyzed specially by V. I. Lenin in Materialism and Empiriocriticism. In this work Lenin presents the statement by L. Feuerbach from his classic work, The Essence of Christianity, to the effect that we compare natural phenomena with similar human phenomena; in order to make them understandable to us we apply human expressions and concepts to them, for example: order, purpose, law; such expressions need to be applied to them from the nature of our language.

In revealing the objective content of these concepts Lenin emphasizes: "Order, purpose, law are essentially nothing more than words, whereby man translates the affairs of nature into his own language in order to understand them; these words are not without meaning, are not without objective content" ... (Works, Fifth Edition, Vol 18, page 158).

The concept of control is of very ancient origin. However, in contrast to the concept of causality the concept of control is not only anthropomorphic but is also sociological in its origin, that is, it is related not only with the characteristics of the activity of man as an individual but chiefly also with the characteristics of the social life of man. It is not by chance that in the past the term "cybernetics" was proposed in 1843 by the French scientist Ampere for the purpose of designating the science of control of government. Even before this the ancient Greek philosopher Plato applied the term "cybernetics" to public life, which designated the art of steering ships so important for ancient Greece.

Speaking about the similarity between these general concepts -- causality and control -- we should emphasize their differences also. First of all, causality is a form of objective relationship in which one phenomenon (cause) produces or generates another (action or effect), while in control we are dealing with the regulation of an already existing system (thereby, certainly, one system can be generated by another but this is not an essential condition of control).

Further, control is associated with processes of regulation, while causality occurs, to be sure, in processes of disorganization; disorganization of a system, transition to a disorderly state is also accomplished in accordance with the principle of causality.

Academician V. A. Trapeznikov in his report "Problems of Technical Sciences in the Development of Automatic Control and Technical Automation Facilities" defines control as a corrective influence upon an object associated with a change in its material and energy processes (Leningrad, 2). He distinguishes three elements in the control process: 1) the selection of the desirable course of the process; 2) monitoring its course; 3) action on a system which provides for its development along a desirable line.

We have already noted that the concept of control arose long before cybernetics. It is natural to put the question of what exactly is specific for cybernetic control.

Here, in our opinion, we need to distinguish four characteristic features:

1. Cybernetics is characterized by the most general and abstract approach to control. Cybernetics rests on the general form of control processes, being abstracted from their specific content. The effect of a catalyst on the course of mechanical process, the role of enzymes in the process of metabolism, the order to attack by a commander of troops -- all these so heterogeneous phenomena are analyzed from the viewpoint of control by cybernetics. Even grammar is now regarded as a controlling system.

Such a general approach to control makes it possible for cybernetics to generalize on this concept. However, this general cybernetic approach to control does not free us of the need for conducting a specific special study of these processes. Thus, if we say that enzymes control metabolism and a catalyst controls the course of mechanical reaction this does not relieve us of the need for special physiological or chemical investigation.

2. Characteristic of pre-cybernetic control is the fact that it operated chiefly with simple systems and dynamic laws.

Cybernetics extends the concept of control to include the area of complex systems and statistical laws. Let us dwell on the concept of a complex system, which is exceptionally important for cybernetics. The very great present-day mathematician J. Neumann in his work The Logic of Automata (Leningrad, 3) makes the logical analysis of a complex system with the aid of the concept of the so-called "axiomatic procedure". This operation consists of three steps. In the first step the complex system is regarded as the sum of simple elements. In the second step these simple elements are studied; and, finally, in the third, a logical chain of simple elements is constructed which make up the complex system. Certainly, here as early as the first step we come across a very essential simplification, where we regard a complex system as a sum of simple ones. However, as the first approximation such an approach to the study of complex systems may be considered justified.

W. Ashby in his work, Introduction to Cybernetics (Leningrad, 5) very thoroughly analyzes the problem of the complex system. W. Ashby justifiably emphasizes the fact that in a complex system we do not have a simple summation of elements but rather a statistical averaging in which the new qualities of the complex system appear which are absent in any of the elements constituting the system. W. Ashby presents examples of the appearance of such new properties in complex systems. Thus, for example, not a single molecule of a tire placed on a moving wheel behaves like the tire as a whole. The separate molecule of rubber does not stretch, while a piece of rubber is capable of stretching.

W. Ashby emphasizes the special unification of elements in biological systems. Here, he expresses dialectical considerations similar in spirit to the striking aphorism by F. Engels, "parts exist only in a cadaver", in which the inseparability of the elements of the biological system as long as it preserves its capacity of activity is emphasized.

The interesting considerations of W. Ashby with respect to a complex system are to a considerable degree devaluated by his subjectivistic philosophical premises, according to which the complexity of a system depends solely on the subject knowing it. Such subjectivism only confuses the analysis of such a profound dialectical object as a complex system.

Control of a complex system is of a stochastic nature, that is, the functions of the controlling and controlled factors are different. In complex systems a transition from one state to another can be accomplished by different means which, however, lead to the same general result. Thus, with increase in the temperature of a gas 15 to 17° C various distributions of the rates of movement of the molecules can occur. The number 8 can be obtained as the result of raising 2 to the third power and as a result of multiplying 2 by itself three times, etc. ($8=2^3=2x2x2=1+1+1+1+1+1+1+1$).

Here we are approaching the possibility of applying the concept of an algorithm to control. According to the definition of A. A. Markov, Corresponding Member of the Academy of Sciences USSR, "an algorithm is a precise prescription for determining the calculation process which leads from variable basic data to the results sought"

(Leningrad, 4). It is perfectly natural that by analogy with a calculation algorithm a control algorithm can be defined as a prescription relating to the interrelationship of controlling and controlled systems.

A characteristic feature of an algorithm is that of ignoring the time factor (that is, the number of elementary operations or steps in which the result sought will be obtained). The same controlling impulse can pass through different routes in a complex system as long as it leads to regulation of the system, that is, control of it.

We can draw the conclusion that in cybernetics not only is the control system generalized on (a transition to complex systems) but the very process of control is generalized (a transition from a single-valued dynamic control to a stochastic control).

In order better to characterize the third, exceptionally important characteristic of cybernetic control, let us compare two examples.

On a spring day we walk along the street and we see how a yardman with a long pole knocks down the icicles from the roofs of tall buildings so that they do not fall on the heads of the passersby. This is mechanical control, associated with a direct mechanical effect on the object under control. However, here we shall go further and we see how a boy raises a flock of pigeons into the air by a swing of a pole to which a rag is attached. Here, there is no direct mechanical effect on the object under control (the flock of pigeons). This is control by means of a signal effect. The pigeons receive the information, which shows them the need for flight. Here the most characteristic feature of cybernetic control is shown -- control by means of a signal which carries some kind of information.

In contrast to this, examples of automatic control which occurred in the past presupposed direct mechanical connection and contacts. For example, we have the mill shaker and Watt's steam engine governor.

So, the utilization of information -- the signal for control -- is a characteristic feature of cybernetics.

The fourth most important characteristic of cybernetic control lies in the unity of control and optimization. Cybernetic processes are connected directly with optimization specifically. While control is qualitatively connected with expediency, optimization gives a quantitatively concretized interpretation of this connection. Optimization is the practical quantitative concrete realization of control, which includes the characteristics of its quantitative measure in the control process.

Through this the quantitative criterion for comparison of the controlling influences is worked out.

The colossal practical significance of cybernetics is intrinsic in the mastery of general methods of optimization of the most varied processes. Cybernetics makes it possible to reckon with the total effect of many factors in a complex dynamic system in which there is such a high degree of interrelationship between the elements that the axiom "select the factors one by one" becomes inapplicable to it. If there is a multitude of different factors, the dialectical combination of the submultiples of the values of these factors (for example, in selecting a place for building a regional electric power station) makes it possible to find their extreme value.

Therefore, optimization is the upper limit of a homeostatic state. The functional nature of cybernetics is connected with the concept of homeostasis. Cybernetics regards the interaction of the system and the medium from the viewpoint of their dynamic equilibrium which is accomplished along a closed curve on the basis of a feedback mechanism rather than along a separate arc. Thereby, the specific characteristics of the medium are abstracted from the intrinsic structure of the system itself ("black box").

Here, we observe a dialectical transition in knowledge from the external to the internal. The first form of investigation of complex dynamic systems was associated with such a functional approach. To be sure, this first form cannot be absolutized. In the expression of W. Ashby, here we are dealing with the "geometry" of complex systems, but their "physics", which studies their internal qualitative structure, needs to be constructed also. However, as a first approximation this method uncovers great possibilities for investigating systems which possess a considerable degree of internal resonance. Thus, we can distinguish three features of cybernetics essential for philosophical analysis: 1. A determinative role in cybernetics is played by control processes and optimization. 2. Cybernetics possesses a functional nature. 3. Characteristic of the cybernetic approach is an account of information communication.

On the basis of all this we can give a kind of "operational" definition of the new science: cybernetics is a science which makes a functional approach to control processes and optimization of complex dynamic systems in which the role of information is essential.

The Nature of Information

We saw that together with concepts of control (optimization) and homeostasis the third fundamental concept of cybernetics is the category of information. The functional nature of cybernetics finds its expression in the formal nature but not the content of the modern information theory. Successful development of methods of measuring the quantity of information has been made secondary to the analysis of information from the qualitative, content aspect. Such a stage in natural scientific knowledge, when methods of quantitative investigation of a phenomenon have already been found -- the qualitative nature of which phenomenon is not yet perfectly clear -- is entirely natural. However, this qualitative aspect, which up to now has been overshadowed, is expediently analyzed from general philosophical methodological standpoints in order to proceed with a discussion of the prospects of further development of the information theory, prospects of transition from the modern formal information theory to an information theory with content.

In order to accomplish this it is advisable to analyze the origin of the modern information theory. Its characteristic feature is the fact that it was developed as a generalization of methods of statistical physics in the field of information processes. Such a characteristic of the information theory is expressed in two principles: 1) the connection between n e g e n t r opy and the quantity of information is accepted in the theory of information; 2) the thesis that information cannot be either matter or energy is accepted in the information theory.

True, W. Ashby in his Introduction to Cybernetics treats the information as a system which, while not being matter, is in no way associated with matter. However, the worthlessness of this approach is evident, because it leads to the acceptance of a mystical principle alien to matter, the assumption of which is incompatible with scientific knowledge.

There is one result here -- in order to reveal information from the aspect of its content it is necessary to recognize it as a system which, while not being matter, is inseparably connected with it. It should be stated after analyzing the situation that in our opinion progress in this matter can be accomplished on the basis of utilization of the leninist theory of reflection. (Our attention was called to this in the work Lenin on the Unity of the World (Leningrad, 6), 1960).

As is well known, in his work Materialism and Empiriocriticism Lenin advanced the tenet of the hypothetical property of reflection inherent in all matter as a whole. With the aid of this profound consideration Lenin showed the route to the philosophical and natural scientific solutions of the problem of the origin of consciousness.

In the materialism which existed prior to Marx there were two extremes in the solution of this problem: the first extreme was associated with the fact that the origin of consciousness was declared unknowable, chance; the second extreme was associated with the idea that consciousness amounted simply to matter; from the viewpoint of proponents of this view consciousness had never originated essentially, because it was no different from matter.

Both these extremes were justified historically in the past, but now it is evident that they do not hold up.

Lenin, developing materialism further and surmounting difficulties of the old materialism, advanced the consideration of the attribute of reflection, based on world materialistic tradition. In analyzing the polemics of Diderot and d'Alembert Lenin says that it may be supposed that the attribute of reflection exists in all matter, and this attribute is precisely the dialectical factor sought which connects matter and consciousness.

What is the characteristic feature of this attribute of reflection? The fact that under conditions of the inorganic world it is not a sensation but rather is a property which during the course of development is capable of leading to sensation.

This idea of Lenin finds its expression most completely in his polemics with the machist, C. Pearson, who attempted to show that "it is illogical to claim that all matter is conscious". Speaking against Pearson, Lenin said the following: "However, it is logical to suppose that all matter possesses a property which is essentially akin to sensation, the property of reflection" (Works, Fifth Edition, Vol 18, page 91).

Lenin uses the expression "it is logical to suppose" here. Is not this a suspicious approach to science that we obtain here? Dialectical materialism in no way minimizes the importance of logical necessity in scientific theory. Dialectical materialism only emphasizes thereby that logical necessity of the cognitive process is a reflection of the necessity of the very real world.

"Sequence in thought", wrote Engels, "at all times must have assisted insufficient knowledge in progressing further" (Leningrad, 7).

Therefore, in saying that the substrate of information is reflection, we can approach a content analysis of information itself. Then on the basis of such an approach we can analyze information in a qualitative sense. Information is regulated reflection. Then, noise will naturally be unregulated reflection.

With such a manner of formulating the problem, in our opinion, a number of difficulties existing in the information theory immediately falls away. First of all, an analysis into the quality of the content of information processes of the objective property of reflection shows that information is a real system, existing independently of the will and the consciousness of man. This means that information processes of reflection in the real world do not cease to exist when man does not perceive the information. This means that not only the electrical impulse (the signal carrying the information) but also the information, which in its content represents the type of reflection, constitute reality.

On the basis of such an approach to the content of information processes the general natures of information and noise are shown as two different types of reflection which, like the other attributes of matter -- space, time, and movement -- have the nature of objective content inseparable from matter.

Further, with such an approach the very connection between n e g e n tropy and information becomes more intelligible and profound. While n e g e n t r o p y expresses order of the material substance, information expresses order of an attribute of matter, reflection. Associating the property of reflection with order of matter, Lenin presents the statement by Diderot who regarded the capacity of sensation as "a universal property of matter or a product of its organization".

The centuries-old experience of mankind is evidence of the unity of the material substance and all of its attributes -- space, time, movement, and reflection. This principle of the unity of matter and its attributes is the most important principle in dialectical-materialistic monism. But since material substance and the attribute of reflection are in unity, the expression of their order -- negentropy and information -- are also in unity.

Thus, as a first methodological conclusion we can formulate the principle that the connection between n e g e n t r o p y (characterising the order of matter) and information (characterizing order of reflection) serves as the most important expression and confirmation of the unity of matter and its attributes.

As a second conclusion from our analysis we should emphasize that the fundamental principle of the physical content of mathematical models, which comes from I. Newton, is further developed in the idea of the connection between n e g e n t r o p y and information. With such an approach the coincidence of mathematical formulas expressing entropy and the quantity of information cannot be stochastic.

The third methodological conclusion is particularly important for substantiating cybernetics itself. The main idea of cybernetics, the idea of unification of processes of control and communication, obtains its substantiation specifically in the treatment of information as reflection.

Control is a process of regulation of material systems; information is associated with the regulation of the attribute of reflection. By virtue of this it is natural that the unity of control processes and information processes stems from the connection between material substance and the attribute of reflection.

In the analysis of the developmental prospects of the information theory it seems to us advisable to discuss three problems stemming from a recognition of the fact that information is an actually existing system.

1. First of all, let us dwell on the problem of extending the law of conservation to include the area of information (the defect of the information theory, associated with the absence of laws of conservation in it, was noted by A. A. Kharkevich (Leningrad, 8), Corresponding Member of the Academy of Sciences USSR. It seems to us that for the purpose of making this extension it is necessary to take into consideration the total information and noise in a given system. In our opinion, information and noise are not preserved separately but rather their total is preserved in a closed system ($J+N=constant$; this figure characterizes the unity, interconnection and interchangeability of both forms of reflection). A discussion of this approach can have definite meaning, in our opinion.

2. The problem of specific characteristics of reflection deserves attention; for example, the features of space-time characteristics of the reflection processes. Here, it should be taken into consideration that these characteristics can be different in principle from the space-time properties of material processes (as is stated by the idealist E. Wasmuth in mystically treating the time of information). However, their specific characteristics cannot be denied a priori.

3. It is very important to analyze the dialectical interrelationship between information and noise in order to contrast the dialectical analysis with the thesis so frequently expressed by N. Wiener of the unidirectional expenditure of information, which is essentially an extension of the idea of "thermal death" to the field of information in the form of some kind of "information death".

The list of philosophical problems of information theory which we have touched on is far from exhausted, but even the problems which we have noted show the importance of dialectical materialistic generalization on the experience of studying information processes.

Insofar as the highest form of reflection is characteristic of the human brain and insofar as information processes of cybernetic systems are now being treated as reflection, to that degree we can proceed with an analysis of the interrelationship of the brain and the cybernetic machine.

Interrelationship of Man and Machine

Attempts at technical modelling of certain aspects of human thought activity, as is well known, were made very long ago. However, this, certainly, was only the prehistory of the vigorous developmental process of "thinking" apparatuses associated with cybernetics. From the very practice of development of cybernetic technique grew the theoretical problem of the interrelationship of man and the cybernetic machine. This problem was a modern modification of the profound problem of the nature of human thinking, closely connected with the main problem of philosophy. It may be supposed that in the future the general-world-outlook role of this problem will increase. The appearance of new materials for the solution of this problem is one of the deep-seated philosophical consequences of the origin and development of cybernetics.

Before proceeding with the analysis of this problem it is advisable to make two preliminary comments:

1. In the history of science there have been situations where for the solution of a problem which has already occurred in all its details there is insufficient material on hand. Under such conditions an attempt to solve the problem definitively in all its details come what may is worthless. In our opinion such a situation is occurring in modern cybernetics. By virtue of this, the consideration expressed in the literature to the effect that many arguments essential to the solution of the problem of the interrelationship of the brain and the machine will be found only at the end of the present age when both man and cybernetic apparatuses will reach a greater degree of perfection appears justified to us.

Therefore, the absolutization of the current status of the problem "man and machine", the directing of all efforts to reach a definitive solution at the expense of attention to other important philosophical and methodological problems of cybernetics can do harm to the development of this science, leading to metaphysical extremes.

2. Such extremes as the "sensational" approach to cybernetics ("automata can do everything", it is simply necessary to provide a number of units for them comparable with the number of neurons in the brain) or like the "ostrich" approach (in the expression of A. Tu-ing (Leningrad, 9) "there can be nothing in common between the brain and the machine") are absolutely non-constructive.

With the current status of cybernetics it is advisable, without predetermining the future results, to analyze the general philosophical aspects of the problem under analysis and from this standpoint to analyze arguments advanced on this subject in the literature.

First of all, it is necessary to emphasize that an analysis of the property of reflection as a substrate of cybernetic processes makes it possible to find a certain criterion for comparing the brain and the machine. Without predetermining the specific boundaries of progress of the brain and the machine we can formulate the principle that the dialectical-materialistic formulation of the problem of the interrelationship of the brain and the machine is fundamentally inimical to idealism, which separates man's thinking from the work of cybernetic machines, denying any kind of similarity between them whatever, and to metaphysics which identifies them.

Based on these general considerations we can set about an analysis of two very significant approaches to the problem under analysis. The first approach is associated with the algorithmic viewpoint of the solution of the problem of the interrelationship between man and machine given by A. Türing (Leningrad, 9). With such an approach the rules and regulations of functioning and the possibility of algorithmization of their actions are made the main basis for likening the brain to the machine. A thorough critical analysis of the contradictions in the rationalizations of A. Türing has been given by Professor S. A. Yanovskaya in the foreword to the Russian translation of this work (Leningrad, 9).

We should like to note simply as an addition that Türing's thesis, according to which from the very fact of the rules and regulations of behavior of an object it follows that the given object is a machine (Leningrad, 9), is based on a tacit denial of the specificity of the laws of human behavior (socialness, activity, etc.).

After assuming the identity of the laws of behavior of man and the operation of the machine in a manner which is unclear, A. Türing gives his formulation of the problem a certain covering of tautologism. Actually, the fact is obtained that the machine can think, because the laws of its behavior are of the same quality as the laws of human behavior, while these laws are of the same quality because the machine can think. With such an approach we obtain essentially the question "how is it possible for the machine not to think?" rather than "can the machine think?". A comparison of the brain and the machine is thereby converted into a purely quantitative area, an area of seeking the maximum completeness in the number of behavioral laws (under the supposition that they belong to the same class of laws). After assuming without any special basis for this that all behavioral laws belong to the same class it is easy to draw a conclusion that any systems which possess behavior are identical.

The utilization of the machine's learning capacity as an argument cannot surmount the intrinsic contradiction of the given viewpoint in the matter of the interrelationship of the brain and a cybernetic system either.

The second viewpoint on the solution of the problem of the interrelationship of man and machine leads to an excessive assimilation of them, based on the thesis that consciousness in the final analysis should become characteristic of machines by virtue of their capacity of self-reproduction.

The basis of such an approach is the idea of the possibility of self-reproduction of machines, stated by J. Neumann, when they reach a certain degree of complexity. Academician A. I. Kolmogorov is engaged in the mathematical substantiation of this conclusion. This idea is a very interesting theoretical consideration. As far as the practical aspect of these ideas is concerned, naturally there is much here that is unclear. However, the theoretical conclusion from the idea of self-reproduction of machines, according to which by reproducing themselves cybernetic apparatuses of necessity come to possess consciousness, seems to us to be inadequately reasoned out. Such a viewpoint has not been argued in its three most important aspects. First of all, only experimental study of the very mechanism of self-reproduction of machines (and this is so far impossible, because in practice this mechanism has not yet been accomplished) can show how near this process is to life.

Secondly, even if a similarity in principle is found empirically between the process of self-reproduction of cybernetic apparatuses and the evolution of life it should be taken into consideration that the similarity of processes does not of necessity lead to an identity of their results. Therefore, from a recognition of the capacity of self-reproduction of cybernetic systems it should not at all follow of necessity that they must ultimately possess consciousness.

Finally, thirdly (this, I daresay, is the most essential fact) at their very origins the process of self-reproduction of machines and the evolution of organic matter, which led to consciousness, are different in principle in the respect that the impulse for the development of machines was the conscious creative act of man, while the evolution of organic matter certainly began without any kind of participation of a conscious principle whatever.

Along this line the deep-seated conditionality of the analogy frequently made (9) between the solution of the experimenter who studies which machine is best and natural selection should be noted. An analysis of these two viewpoints permits us to draw the conclusion that neither the first nor the second gives a consistent solution to the problem of the interrelationship of man and the machine. It seems to us that in the analysis of the interrelationship of brain and machine it is advisable to avoid reducing them to a common level on the basis of inadequately argued extrapolations but rather to analyze the concrete features of similarity and difference between them which can be demonstrated in the current status of the problem.

Such a comparison, despite its inexhaustive character, may be of certain practical significance, because it is capable of assisting in the development of neurophysiology, on the one hand, and in the formulation of problems which should be kept in mind in the construction of improved cybernetic systems, on the other. Such a comparison can enrich cybernetics and neurophysiology mutually.

In making a comparison between the activity of the brain and the operation of machines we see that there is a certain similarity in structural connections and relations between them. This similarity is explained by the fact that in both brain and cybernetic systems we are dealing with the property of reflection. In our opinion, this similarity finds its expression in three main factors: 1. The capacity of cybernetic systems to accomplish a number of logical operations according to a set program. 2. The capacity to react to external influences according to a closed curve on the basis of the mechanism of feedback connections according to the schema "automat -- medium" (the lower automata). 3. The capacity to compare signals from the environment, by the "trial-and-error" method, with its own natural test programs formulated on the basis of generalization in its intrinsic mechanism, consisting of elements with variable control thresholds (the higher automata). However, in the brain and the cybernetic system we run across qualitatively different forms of reflection. At the current stage the difference between brain and machine is much greater than the similarity between them.

A comparison of the brain and the machine is more expediently made along the line of comparing their intrinsic mechanisms, associated with the attribute of reflection, rather than along the line of their material substrates, the differences in which are obvious, or along the line of a purely formal comparison of the algorithms of human and machine behavior.

For this purpose it is necessary to turn to factual data existing in modern cybernetics, physiology and psychology. Interesting material for the solution of the problem under analysis is contained in the article by D. MacKay, "The Formation of the Concepts of Automatons" (Leningrad, 10) and in the work of the Soviet investigator, B. Kh. Gurevich, "Reasoning Automata and the Higher Functions of the Brain" (Leningrad, 11). B. Kh. Gurevich gives a thorough critical analysis of the possibilities of higher automata described by D. MacKay.

These works permit us to draw a number of conclusions with respect to differences in the functioning of the brain and the operation of machines. D. MacKay divides automata into "automata of the first kind" (lower) and "of the second kind" (higher) depending on their abilities to generalize on environmental effects. In the lower automatons only a filtration and recoding of signals from the environment are accomplished; they have no intrinsic mechanism which compares the condition of the system with the nature of the environmental effect. These lower automata operate according to the following schema: environment-automat. The higher automata are different; they have an intrinsic mechanism which compares signals from environment with their own trial programs. This intrinsic mechanism proves to be a kind of analogue of the environment.

It is entirely natural that in the lower automatons everything is strictly determined by the very construction of the automaton. In the higher automatons there is greater flexibility in the succession of trial programs depending on the environmental signal. As an example MacKay selects an automatic driver, which drives its machine over a winding road. If the road has a regular alternation of curves and after each turn to the right there is a turn to the left and after each turn to the left there is a turn to the right this picture of the road is generalized on, and the automat develops a readiness to turn the machine to the right after a left turn without waiting for the signal from the environment. The automat figured out, so to speak, the road structure. The automat foresees, so to speak, the corrective signals from the road, that is, it correlates the route of the machine with the road before it can deviate from the road profile, before making an error.

MacKay explains this ability of the higher automatons by the fact that these automatons have intrinsic mechanisms consisting of elements with a variable control threshold. If the activity of a given element is successful, its excitability threshold is reduced, whereas the excitability threshold of all the other elements is increased. Thus, in these automata we observe a reduction of the probability of all actions with the exception of those which have been successful; this process is accomplished through the coordination of excitability thresholds of elements in the intrinsic mechanism of the automaton with the statistical structure of the environment.

Therefore, we see that the intrinsic mechanism of the higher automaton is to some degree an analogue of the environment. Therefore, the higher automaton is not only capable of "perceiving" signals from the environment but can "perceive" the responses of its own intrinsic mechanism coordinated with the environment. According to D. MacKay this capacity of the higher automaton of perceiving symbols (D. MacKay called them "concepts") elaborated by the intrinsic mechanism is a "logical definition of consciousness".

This "thinking" criterion of a machine, this "definition of consciousness", in our opinion, is indubitably more productive than the purely behavioral, profoundly imitative criterion of A. Turing according to which the machine is considered "thinking" if during a long enough period of time, when the machine is answering questions, a man putting these questions cannot determine whether a machine or a man gave him the answers.

In the foreword to the collection "Automata" (Leningrad, 10) Professor A. A. Lyapunov justifiably emphasized the inadequacy of Türing's criterion, if only because it does not show the difference between solving a problem and simple mechanical rote-learning response.

In contrast to the purely superficial criterion of Türing, in the definition of D. MacKay presented above we see an attempt to analyze the problem of "thinking" machines according to content. Actually, in MacKay's definition an essential characteristic of thinking is missing -- the mediation of the reaction to the external influence by signals of the internal analogous mechanism. However, if we turn to an analysis of this "mediation" in its essence, we shall see the difference in principle between the work of machines and cerebral activity. This fact has been justifiably emphasized by B. Kh. Gurevich in the analysis of D. MacKay's article.

We can distinguish several essential features in the qualitative difference between the work of machines and cerebral activity:

I. In the work of machines the elements of mediation are based on a certain ability to generalize. However, this "machine generalization" is qualitatively different from human generalization. In analogue work of machines "removal" from the environment is impossible. The analogue mechanism of the machine copies, so to speak, some aspects of the environment (in D. MacKay's automaton the road is copied). In the higher automata we see only a minimum ability to generalize with maximum complexification of the direct reflex interaction with the environment.

B. Kh. Gurevich justifiably notes two lines of adaptive forms of activity: 1) in insects, by virtue of the monotony of their actions, the forms of generalization are extremely poor, but instincts are exceptionally well developed and represent very complex accumulations of direct reflex connections with the environment; 2) the second route of development of the adaptive activity is seen in man and mammals. In them mechanisms of generalization are developed with simultaneous increase in the plasticity of the nervous system.

B. Kh. Gurevich notes justifiably that the construction of modern automata shows certain analogies with the nervous systems of insects. The machine is capable of generalizing only within the limits of a single class of events; it cannot go into another class. Man, on the other hand, generalizes on events of other classes. D. MacKay's automaton is capable of taking past experience into account only when subsequent events belong to the same class as previous ones (the alternation of left-hand and right-hand turns in the road remains unchanged).

II. By virtue of this, the machine, coming across phenomena of a new class, either stops or begins to organize its activity on the basis of "trial and error". The machine acts statistically, taking into consideration successful and unsuccessful actions. The "trial-and-error" method is not characteristic of human activity. Here, we should note two facts: A. The machine seeks the solution by means of a purely statistical processing of the tests. A negative test result gives the machine only negative information, that the problem cannot be solved in this way, without telling anything about how to solve it.

In man the negative result of experience speaks not only for how not to solve the problem but also raises the curtain on how to seek the solution.

B. This is connected with the fact that in man reactions carried out in the execution of decisions taken after thinking about them are predominant. Man, so to speak, does not hack away seven times by the "trial-and-error" method but rather thinks seven times in order to slice off in one stroke, surely. Man is capable of accomplishing this operation because of the fact that in him the perceptions of a new event are included in past experience. In this connection we can consider B. Kh. Gurevich's opinion justified that in the strict sense there can be no absolutely new events for the brain.

P. K. Anokhin noted perfectly correctly the fundamental difference between the nervous system of man and the "black box" situation, from which cybernetics originates. As a matter of fact, if, for example, a chemist comes across a chemical substance unknown to him, even though he cannot say right away what its chemical composition is, he has some information about it on the basis of his past experience. He knows how this substance is obtained, etc.

In the development of human consciousness a tremendous part is played by the "experience of the race", which has been written about by F. Engels. Before beginning its work the machine is a tabula rasa, while man inherits information which synthesizes the experience of previous generations. A tremendous part is played by the mechanism of the human second signal system, which makes it possible for him from the very beginning not only to generalize on the connections within a single class of events but also to generalize universally on interclass connections on the basis of past experience. In this respect the following example is characteristic. When a little girl was asked where is a cat's foot, she showed it; when she was asked where is the cat's head, she also showed it. When she was asked where is the cat's muzzle, she was in difficulty. But when it was explained to her that the muzzle is the cat's "little face", she immediately showed it. Through this graphic example of formation of the human mind we can see how universal man's ability to generalize through operation with concepts becomes.

We see that the machine is not capable of foresight, because it essentially cannot synthesize past experience. It can "foresee" what has already been or what belongs to the same class as that which has already occurred.

III. The qualitative difference between man and the machine is seen not only along the line of generalization, associated with experience of the race, but also along the line of individual development. First of all, the multiprogram nature of machines is in contrast to the synthesis of all programs in man. Wiener emphasizes the fact that essentially the brain accomplishes a single complex program. "... the accomplishment of a single program", writes Wiener, "corresponds to the life of the individual" (Leningrad, 12). He notes that when the brain carries out a new program it is never able to erase the traces of previous programs. Aside from death, Wiener emphasizes, not a single process can clear the brain of information. It is quite different with machines. In them, turning them off after operation according to a single program can practically clear them of program traces. The second important feature of individual development of the nervous system is the ability to improve its basic properties.

IV. An exceptionally important feature of the brain, which distinguishes it from cybernetic systems, is the presence of so-called "nonspecific connections" in the brain. If the brain receives some signal, it exerts, first of all, a specific effect on the corresponding areas of the brain, for example, areas of vision, hearing and secondly, a nonspecific effect which excites the brain as a whole.

V. While in the machines all processes proceed in sequence according to a chain, in man, because of the ability of nonspecific stimulation entire neuron areas can go into action at the same time in the form of a burst. In contrast to this, in the machine we deal with homogeneous elements connected in a chain by means of uniform links which, true enough, can temporarily change their excitability thresholds in accordance with the effects of the environment. This is associated with the fact that in the brain and in the machine we have qualitatively different interrelationships between the integrity of the system and the differentiation of elements. Without mentioning the fact that in the machine both the integrity and differentiation are developed to a lesser degree than in the brain we should emphasize that they are, so to speak, placed next to each other. In contrast to this, in the brain there is an organic inseparable dialectical unity in the integrity of the entire system and a striking differentiation of its elements.

In the human brain a reorganization of the connections between 14,000,000,000 cells, with which the creative ability of the brain, intuitive solutions, and outbursts of fantasy are associated, can occur. In the machine continuous connections are effected like chains; the machine is incapable of sharp sudden transitions, of going beyond its starting principles.

In human thinking the most important discoveries have been made on the basis of fantasy, which represent an interruption in the continuity of the cognitive process. If, for example, we analyze the status of physics at the end of the 19th Century, it may be said that the machine might be able to calculate the quantitative indices of radiation and absorption of a black body with an accuracy of up to a millionth part of a unit, but it would not be able to arrive at the great idea of M. Planck that energy transmission is discontinuous. In the best case the machine can only reselect possibilities in the same plane on the basis of the "trial-and-error" method, but the actual world and information about it occur in many different planes, are voluminous and cannot be reduced to the same plane. The accidental entrance of the machine into another plane, into another class of phenomena which are not on the program is a catastrophe, a "psychosis" of the machine, a "dizziness of the monad", as was said by N. Wiener after Liebnitz. In man abruptly-appearing associations arouse a "background of unrealized thoughts", according to the expression of D. Poy, which is always present in the brain. For man such jumps are necessary in the transition from one theory to another. It is not by chance that at the present time many physicists place great hopes on an exceptionally bold "crazy idea", in the statement of N. Bohr, which will advance physics suddenly and far. Only man, based on his entire experience, can determine where and whither he should "jump" in the cognitive process. It was not for nought that K. Marx was so fond of the proverb: Hic Rhodus, hic salta! (Here is Rhodes, here jump!).

The ability to interrupt a continuous cognitive process on the basis of previous practical and theoretical experience during the course of integral rather than chain stimulation of the brain is an essential feature of human thinking which differentiates it qualitatively from the operation of the most perfect cybernetic machine.

We can draw the conclusion that in the modern higher automata there is a certain degree of similarity to animals and man along the line of the attribute of reflection. However, here we are dealing with stages in the development of the attribute of reflection which are very far from one another, and excessive approximation of them is without basis.

We see that the neurophysiological aspects of the problem, if we take into consideration the experimental data and reject speculative prejudiced schemata, not only give us no basis for identifying cerebral activity and operation of machines but rather, conversely, make it possible to reveal the essential features in the difference between them. An analysis of the literature on cybernetics shows that a comparison of man and machine is made along two lines.

The first is a comparison of the operation of machines and cerebral activity according to the situation today. This comparison (which is made with consideration of A. Türing's criterion as well as of the stronger criterion of D. MacKay) shows the insolvency of excessive approximation of thinking to the operation of machines and at least excludes an affirmative answer to the question of their identity.

The second line of the problem under study is constituted by the transference of this comparison to the future with consideration of progress of the machine (a) the improvement of elements of the machines -- replacement of vacuum tubes with small semiconductor units, the utilization of superconductivity, etc.; b) the increase in the number of elements of machines to an order of magnitude close to the number of neurons in the brain (10^{14}); c) consideration of progress of machines associated with the theoretical possibility of self-reproduction of them, etc.), and of man: (a) the elimination of the monopoly of knowledge; b) further increase in the "experience of the race"; c) action under conditions of abundance, the absence of concern for a piece of bread; d) the elimination of chaotic elements in social development).

In the analysis of this second line in our problem a certain degree of caution is necessary; peremptory, speculative solutions can lead us here into a blind alley.

It is not by chance that A. Türing, who believed that "we can hope that machines will ultimately compete successfully with people in all the purely intellectual areas" (Leningrad, 9), has to admit that the solution of this problem should pertain to the end of the present century.

In any case, any analysis of the problem of the interrelationship of man and the machine in the foreseeable future should be based on the fact of the productivity of automata with respect to the reasoning activity of man, which determines the entire subsequent evolution of the machine.

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The problem of the nature of human thinking is part of the problem of the nature of man, and this problem cannot be solved within the framework of physiology and psychology. It requires sociological analysis. For the highest is the clue to understanding the lowest.

It may be stated that while the secret of cybernetics lies in neurophysiology, the secret of physiology of higher nervous activity lies in sociology. By virtue of this, the most important role is played by the sociological aspect in the solution of the problem of the interrelationship of man and the machine. In the literature on cybernetics very frequently the comparison of man and machine is made in isolation from sociological analysis, whereas specifically the sociological aspects of the problem of the interrelationship of man and the machine permits us to find out the most essential differences between them.

Here, first of all, we should emphasize that human consciousness is a social product. We do not find the nature of the man Ivan or of the man Peter either in the man Ivan or in the man Peter; it is contained in the social relationship between them. Along this line we can make a comparison of the machine with man with consideration of their development. "Thinking" machines are being developed; they have taken only the first steps. The prospects for development of them are colossal. However, we cannot help but take into consideration the fact that man is developing at no less vigorous tempos and that man is also at the comparatively early stages of his development, at the beginning of a truly human history.

The construction of self-reproducing automata will bring about considerable progress in the development of cybernetic machines; they will gain the ability to complexify, the capacity of a certain self-evolution. However, this independence of evolution of automata will be very relative then, because it will be carried out on the basis of the "primary impulse" which will be given to this self-reproducing automatic system by man who imposes the starting program on the automat. By virtue of this any ideas of independent "society of machines", capable even of rebelling, as it were, against man, are of the nature of reactionary and baseless utopias. A kingdom of machines, even self-reproducing, cannot become independent, self-contained, without depending on man as the prime mover of cybernetic machines. In the first "automata", which played chess, people were hidden in order to fool the onlookers. Now, man "will be concealed" within the cybernetic machine openly, but not in the form of his corporeal substance but rather in the form of the initial information and the labor, which breathe life into the kingdom of dead-metal machines. Like the moon, the satellite of the earth, machines do not have their own sources of light.

The machine shines by reflected light of human reason. The determinative characteristic of the interrelationship of man and nature is the indirect character of this relationship: Man has placed an intermediate link between himself and nature -- the tool of production. "The agency of work", wrote K. Marx, "is a thing or combination of things which the worker places between himself and the object of his work and which serve him as a conductor of his actions to this object. He makes use of the mechanical, physical, chemical properties of things in order to make them act as tools of his power in accordance with his aims" (Leningrad, 13). This principle applies fully to cybernetic machines also. Only here, it should be added to Marx' formula that man has learned to make use of the property of reflection along with "mechanical, physical, and chemical properties of things".

Appearing as the connecting link between man and nature, the production tool is inseparably connected with man, being, in Marx' expression, an artificial continuation of his natural organs, to which man transfers a progressively greater number of his labor operations. However, the role of machines is not limited to the transference of a number of human production operations to them. The second exceptionally important aspect of the role played by machines lies in the fact that by means of machines man penetrates into areas of nature which are not available to him because of very great speeds, harmful radiation, etc.

The automaton is no more than a link in a closed chain -- "man -- nature". This link can become progressively longer and more complicated, but it does not become the entire chain. The automaton cannot occupy any other space in the universe except between man and nature. The space of automata can become progressively wider but it cannot cease to be only an intermediate space, cannot engulf man and nature. Always nature will be below the automaton and man above it.

The interrelationship of man and machine has a historic character and depends on social relations. Under conditions of an antagonistic society, where all the natural relations are distorted, turned upside down, the artificial organs of man -- production tools -- overcome the worker himself. The very transference of functions from the worker to the machine is of an antagonistic nature and reaches the point of complete displacement of the worker from production in the form of unemployment.

In a society based on private ownership there cannot be a reasonable interrelationship between man and machine: as long as man works he is enslaved by the machine, becomes an appendage of it; when man has no work he is separated from the machine.

In the current era in capitalistic countries the machine, which represents a weapon in the fight of capitalists against the workers and progressively greater enslavement of mental workers, is converted into a weapon. It is not by chance that N. Wiener delineates gloomy prospects, saying that soon in a capitalistic society a man with average capabilities will offer nothing for which he should be paid money. The working intelligentsia in a bourgeois society is between the Scylla of enslavement by the machine, transformation into an appendage of a cybernetic system, and the Charybdis of displacement by the machine.

The contradiction between mental and physical work in modern capitalistic society is acquiring a particularly deformed, perverted character -- mental work is being reduced to the level of subordination to the machine, like physical work. For the intelligentsia in a bourgeois society the way out lies in going to the real workers rather than to fantastic "ivory towers". The more solidly intelligentsia rally with the working class and its party, the sooner a society based on buying and selling will be replaced.

Under conditions of the planned organization of society based on collective ownership the transference of a progressively larger number of production functions from man to machine does not lead to antagonistic contradictions between them. Conversely, such a liberation of man from many operations of production is an essential condition for a reasonable interrelationship of man and machine, in which "machine is left for the machine", "the human, for man" . According to Marx' expression, the more productive functions are transferred to machine the more "the human develops in man". This is achieved by means of automation, which is the general line of development of Soviet forces of production on the road to communism, the main means of increasing the "free time" of the working class. However, this "free time" in itself is not at all unused time, empty, and devoid of social significance. "Free time" is the result and, at the same time, a necessary condition for social progress. In order to preserve the key, decisive positions in the process of control man must protect himself, always outstripping the development of machines. For this protection he needs "free time". If a person spends his time in playing dominoes, he does not accelerate social progress. In our opinion, we should speak of "productivity of utilization of free time" as an essential condition for increasing labor output.

From our entire analysis of sociological aspects of the interrelationship of man and machine the conclusion follows that the cybernetic machine is not a competitor of man but rather a companion, which immeasurably increases the power of the working man in a communistic society.

The development of cybernetic systems during the course of social progress will become a condition for the development of man, which is mentioned in the Draft Program of the CPSU. This development makes the excellent saying of the old humanists a reality: "In the world there are many great forces but nothing on earth is more powerful than man!".

The Nature of Cybernetics as a Science

Based on the characteristics of cybernetic processes presented above we can analyze certain essential facts associated with the nature of cybernetics as a science.

Based on the recognition of the attribute of reflection as the basic content of cybernetic processes and emphasizing the fact that cybernetics is abstracted from concrete characteristics of this attribute an attempt may be made to reveal the philosophical aspect of the definition of the subject of cybernetics. To be sure, this aspect does not contradict the definition of cybernetics as a science of control and communication in man, animal and machine or the definition given at the beginning of the article, but only makes an attempt to clarify their philosophical significance.

In the light of all the considerations presented we have defined cybernetics as the "abstract science of general characteristics inherent in all the manifestations of the attribute of reflection in controlled and self-regulating systems" (Leningrad, 6). This definition, it seems to us, to a certain degree captures the essence of the subject of cybernetics from a philosophical standpoint. However, it is not exhaustive by virtue of the fact that it does not consider the classification of sciences within cybernetics itself. Actually, cybernetics is occupied with the experimental investigation, construction and study of models; therefore, this is a concrete and natural scientific discipline not just an abstract one. This is evidenced by the fundamental works of W. McCulloch and V. Pitts.

Finally, cybernetics takes up the solution (not in the laboratory but rather under production conditions) of purely technical problems on the control of technological processes. Such a variety of properties in a single science should not perplex us. For cybernetics is a synthetic science not only with regard to the subject of its study but also the methods of approaching the world. It seems to us expedient, speaking about the current status of cybernetics, to distinguish three scientific disciplines in it, three forms of specialization: 1. Theoretical cybernetics. The definition of cybernetics presented above can apply to this division of cybernetics. 2. Experimental cybernetics which is engaged chiefly in cybernetic modelling. 3. Technical cybernetics (a term introduced by the Chinese scientist, Chian Hsüeh-senem) takes up construction of systems which convert information about the environment into a controlling signal. the construction of systems capable of selecting the optimal technical conditions or assuring constancy of stable actions.

Cybernetics has already been created as an independent science. It seems to us that the time has come for beginning the teaching of a course of "general cybernetics" at mechanical-mathematical, physics and biological faculties of universities. Apparently, in the future it will be advisable to put the question of creating cybernetic departments and faculties in universities.

The course in "general cybernetics", it seems to us, is best constructed along the line of unity of the historical and the logical. This course can have five divisions: 1) the theoretical basis of cybernetics; 2) the subject and the aims of cybernetics; 3) the general study of the controlling and controlled complex dynamic systems with the fundamentals of the logic of automata; 4) the general information theory; 5) the basis of cybernetic modelling.

The birth of cybernetics as an independent science is an expression of a very characteristic general feature in the development of knowledge, consisting of the fact that with the development of the experimental basis of natural science the nature of the content of the attributes of matter is revealed progressively more completely. By virtue of this, along with sciences of material substance, sciences have arisen which investigate the characteristics of its attributes. Among these sciences are the following: geometry, science of the attribute of space; chronology (a term proposed by Academician V. I. Vernadskiy), the science of the properties of time; and cybernetics, the science of the general features of the attribute of reflection. Thereby, it should be noted that the nature of cybernetics as a science is associated not only with the general features of the attribute of reflection in itself, it is inseparably connected also with the characteristics of the complex dynamic systems. The specific characteristics of complex dynamic systems, the fact that the processes occurring in them cannot be reduced to electrodynamics alone, the distinctive nature of the processes of reflection occurring in them apparently make it possible to put the question of a special cybernetic form of movement. Complex systems which possess a comparatively well-developed capacity of reflection represent the material carriers of this form of movement.

The entire richness and complexity of the profound methodological and philosophical problems associated with the development of cybernetics are still being revealed. However, even now we can say with full justification that cybernetics has considerably reinforced the dialectical-materialistic standpoints in science:

1. After revealing a certain similarity in the activity of the brain and operation of cybernetic machines cybernetics has placed a natural scientific basis under the study of the material unity of the world. The achievements of cybernetics decisively repudiate idealistic attempts at perverted interpretation of consciousness. It is not by chance that the modern West German idealist, E. Wasmuth, suggests coming out against "the study of vanguardist technics which is being called cybernetics'" (Leningrad, 14).

2. If we turn to the methodological premises on which the authors of the fundamental works on cybernetics based themselves, we come to the conclusion that these premises are of an elementary dialectic nature. Such, for example, are the statements of N. Wiener concerning the connection between sciences and their synthesis. The cybernetic idea of the "necessary complexity" of a dynamic system, thanks to which this system, beginning with a certain moment, no longer breaks up into its elements but rather obtains the possibility of further development, also has a dialectical nature. In this case we are dealing (although it is not always realized by such scientists as N. Wiener, W. Ashby and others) with the dialectics of transition of quantitative into qualitative changes.

3. The achievements of cybernetics are expanding the field of our knowledge, are rejecting agnostic and sceptical representations of all kinds concerning the limitation of human knowledge. The most important philosophical conclusion from the development of cybernetics is associated specifically with the substantiation of the infinite power of the human reason. The entire experience of cybernetics shows that we are not only successfully studying but are also practically mastering at the present time those essential processes of the real world which previously we essentially did not know.

Cybernetics has expanded human knowledge in two very important areas: first of all, it has revealed the methods of quantitative knowledge of control processes, for which information relations are essential; secondly, it has formulated efficient means of knowledge and mastery of complex dynamic systems. Such an expansion of knowledge exerts a beneficial influence on all the natural and social sciences. Exceptionally great are the prospects of utilization of the achievements of cybernetics in knowledge and control of social life. In the solution of the problem of the application of cybernetics to social life it is necessary to fight against the a priori sceptical denial of the importance and promise of this application as well as against the "pancybernetic illusions", in which unsound hopes are expressed that cybernetics in itself will be able to put everything in the lives of people in smooth running order.

4. A characteristic feature of cybernetics, which is of very fundamental significance, is the fact that in the development of cybernetics the unity of the natural and social sciences is finding its exceptionally clear-cut expression. In characterizing this feature of development of scientific knowledge, Lenin wrote the following: "As is well known, the powerful trend from natural science to social science occurred not only in the era of Petty but also in the era of Marx. This trend remained no less powerful and possibly became even more so in the 20th Century" (Lenin, Works, Fourth Edition, Vol 20, page 176). The progressively intensified dialectical synthesis and mutual enrichment of natural and social sciences are exceptionally fruitful for the theory and practice of building of communism. The analysis of this characteristic feature in the development of scientific knowledge should be made on a large scale.

In conclusion, we can say that an analysis of the philosophical premises and methodological consequences of the development of cybernetics leads us to the conclusion that cybernetics is associated with dialectical-materialistic philosophy as its natural and necessary basis of world outlook and a consistently scientific method.

Subsequent development will strengthen this connection even more, which will assist in the more effective transformation of this young science into an important productive force in Soviet society en route to communism.

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