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SOCIETY IN THE TECHNICAL AGE

In his book *Der Mensch und die Technik* (Zurich, 1953, p. 18), the Swiss engineer Gustav Eichelberg painted a humorous picture of the overall development of society, which he represented as a 60 km. marathon race, with each kilometer representing 1,000 years.

This extraordinary race is run as follows:

The major portion of the route passes through a virgin forest where nothing undergoes visible changes. Only toward the end of the route, after some 58-59 km. do the first signs of civilization appear: the rudimentary tools of primitive man, rock paintings. During the last kilometer the first tillers of the soil finally appear.

Three hundred meters from the finish the runners find themselves on a stone-paved roadway leading past the Egyptian pyramids and the fortifications of ancient Rome. At 100 meters the buildings of medieval cities come into view. The finish is 50 meters away. A man of intelligent, understanding appearance can be seen watching the race: Leonardo da Vinci.

There are only 10 meters left to go. The runners start off by the light of torches and the murky glow of oil lamps, but on the very

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last stretch a miracle occurs: electric lights flood the road, carts are replaced by motorcars, the roar of planes is heard. The runners are blinded by floodlights, surrounded by reporters, radio, television...

Thus the last 10 meters represent the last 100 years, in other words, the stretch during which as many changes have occurred as during all the preceding periods of human evolution. These changes are characterized by the fact that the two basic currents of human activity, production and scientific research, vied with each other for first place, and by combining, swept forward like an all-transforming flood. This is one of the principal reasons for the powerful acceleration in the pace of scientific and technical progress during the last century. Thanks to this fusion of science and production or technology, man has been able to harness the limitless potentialities of the forces of nature.

There is more to it, of course, than merely the acceleration of the pace of scientific and technical progress. If formerly the domain of technology was limited to the sphere of production of material goods, it is now involved in the whole structure of social life. Technology has created a revolution in transport, and has taken the firmest of footings in our civilization, our everyday life, our leisure time.

A great step forward in qualitative terms has taken place in technical development, which makes it necessary to regard in a new light both the whole former course of scientific and technical progress and prospects for the future. Cybernetics and bionics put forward principles for the technology of the future (technology without machines, for example, or apparatus representing a symbiosis of a living organism with inert matter), such that they are no longer compatible with accepted ideas. The revolution in technology is accompanied and conditioned by the revolution in science, in technical thought, in the conception of the world. Technology influences social relationships, ideology, moral relationships, and poses new problems for society.

The great discoveries of science and technology make powerful forces available to man, and the social and economic problems of scientific and technical progress assume ever greater importance as these forces grow in magnitude.

Modern technology assists man in his work, and at the same

time imposes new exigencies on the most complex forms of human activity. It increases the productivity of work, and at the same time raises in the most acute form the problem of job transfer and retraining. It conditions the increase in free time and can help to "kill" it with passive forms of entertainment. It creates comfort and services in everyday life, and modifies the rhythm of life.

The scientific and technical revolution poses many pressing problems in social and economic terms as a result of the professional, sectorial and social advances which it produces. It makes demands on the organization of production, on its technology, on its distribution. Contemporary scientific and technical progress not only changes the nature of the worker's task after the automation of production processes, but also conditions and modifies the nature of leisure time which constantly tends to increase.

At the present time, when revolutionary discoveries in production, production methods and technology follow one another in endless succession, when certain new technical inventions become obsolete before they have had time to find a wide application in production, it is essential to have a particularly flexible and forward-looking technico-economic strategy, calculated in terms of decades and not years, and based not on any one specific aspect of the scientific and technical revolution, but on its general line. The mobility of technology must be matched by a correspondingly mobile scientific and technical policy. It is important to concentrate in advance both efforts and resources not only on that sector of this revolution which determines the face of *today's* production, but also on the one which will determine it *tomorrow.*

In order to achieve maximum effectiveness, this scientific and technical policy must be based on a rigorous system of theoretical principles of technical development and of identification of the laws of the "auto-movement" of technology. Otherwise, under present conditions, social forecasting and the effective direction of social processes are impossible. The analysis of the laws proper to technical progress and of the nature of their interaction with social and economic laws, makes it possible to find one's way better in the special circumstances of the modern scientific and technical revolution.

The questions of our epoch cannot be fundamentally resolved without dialectic interpretation of the whole history of technology,

without the discovery of the principles of its auto-movement. The sociological problems of the development of technology are indissolubly linked with the problems of the development of science as part of an overall system. In short, it is one single area of knowledge, for, in our opinion, modern science (in particular the natural sciences) can in a certain sense be considered as a *potential technology*, and technology, in its turn, as *materialized science*, the "materialized science of knowledge" (K. Marx).

The scientific and technical revolution in progress in the modern world is having a revolutionizing effect on every aspect of social life. It is important to expose the objective logic of this process, to distinguish the essential trends of technical progress and their forms of social manifestation. Such is the task of the sociological theory of technology. This is developing at the "meeting point" of a variety of social sciences (historical materialism, history of technology, political economy, scientific communism, psychology of the engineer) and of natural sciences (technology, cybernetics, bionics). Reflecting the intermediate situation of the subject of its investigations, technology, between man (society) and the work-subject (nature), this science is naturally based on social and natural laws.

The theoretical basis for the development of contemporary sociological problems of technology can already be found in the works of K. Marx, and in particular, in *Das Kapital*, together with the preparatory manuscripts of this work. These manuscripts, which reveal the original approach adopted by Marx to the study of technology, an approach different from that of previous investigators, make it possible to reach a deeper understanding of the essence of production by means of machines, of the laws of development of technology, the stages through which it has passed, and the relationship between technical and economic factors. Marx was able to predict trends in the development of technology which are only now beginning to become clearly evident.

"THE AUTO-MOVEMENT" OF TECHNOLOGY

In order to understand the internal logic of the development of technology, it is not sufficient to study the economic relationships between such and such a society, considering the laws of the dev-

elopment of technology as a special case, a function of social and economic laws.

Primitive socialism, however, continues to make itself felt in certain works devoted to the problems of the contemporary scientific and technical revolution, in which technology is reduced to a function of the economy. During the life time of Marx, the economist Proudhon had also tried to deduce technological factors from economic factors. Specifically, he attempted to explain the appearance of machines by the division of labor. In this respect Marx pointed out that "the machine is no more an economic category than the ox which pulls the plough." On the basis of the division of labor in general, to arrive at one of the instruments of production, i.e. the machine, "is simply to make nonsense of history."

Inasmuch as technology is a phenomenon which cannot be reduced to economic phenomena, it is natural to wonder what are the internal motive forces in the development of this phenomenon, what are the particular contradictions that arise from the start, what are the real laws. In general, the internal contradictions of technical development are either reduced to contradictions in the construction of the machines, in the relationship between the whole of the technical system and its individual parts, or to discord between the different areas of the technology of production. But these are *specific* contradictions which do not throw light on the process of the "auto-movement" of technology. When this question is resolved, the problem arises of the permissible level of abstraction.

The abstraction will prove itself empty and unreal if it is allowed to lose the specific, essential character of the phenomenon under analysis. This loss is inevitable if the sphere of logic proper to technological development is limited to technology *on its own.* As has already been said, technology occupies an intermediate place between the social individual who applies it, and nature as the subject of the work. Considered apart from human activity technology is a material object of nature as dead as a pile of stones. Only in the process of human activity can it become a technical means. That is why, when showing the logic proper to technological development, it is not possible to make abstractions of human activity. This would be an unacceptable level of abstraction,

which would lead us to overlook the essential nature of technology, its most intrinsic characteristic.

Whilst, on the one hand, the technical instruments of work are material objects of nature, they are, on the other hand, called upon to act as an extension of man's natural organs of work, to be an inanimate part of a living system. The theoretical analysis of the logic proper to technological development must accordingly consist of the study of these two aspects of this reciprocal relationship. The researchers who take account only of one, either fall into an idealistic interpretation of technology, as a direct product of human ideas and objectives, or into a strictly technical interpretation, as a means of work in itself.

The paradox, by consequence, lies in the fact that the internal logic (proper) of technological development by no means exists within itself alone. It is conditioned by the intermediate place occupied by technology, by its relationship with both man and nature. This being so, the determining factor is the first aspect of this reciprocal relationship, the historical and logical relationship between technology and the organs of work of social man, his "natural instruments of production," since it is to the work of man that technology owes its creation. It is only within the processes of work, only in association with rational human activity that technology is capable of functioning as such.

The analysis of the simplest act of work is the starting point for the sociological theory of technology, the logical first link in the chain of investigation. Man comes into the world with empty hands. His action upon nature is limited to the simple strength of his muscles. The very necessity for the appearance of technology is explained by the weakness and imperfection of man's natural organs of work, their inability to act directly upon the unyielding material of nature, to adapt nature to his needs. This initial contradiction between the physical structure of man and his need to transform nature was resolved historically by the appearance of technology.

Raising the contradiction to this level, however, meant not its elimination, but the transition to a new character, that of the mobile contradiction between man and the instrument of production in the work process. The process of the progressive materialization in technology of the working functions of human labor,

of man's habits, his experience, his knowledge, is a form of development of this contradiction.

The interaction of the natural and artificial organs of man is based, in our opinion, on two principles: *the principle of functional unity* (both are instruments for transforming nature in accordance with the needs of society; this is the origin and the secret of the relative similarity between the organs of work in man and the technical means which simulate them) and *the principle of complementarity* (technology is called upon not to copy the organs of work in man, but only to complete them, to increase their productive capabilities; hence the specific nature, the relative autonomy in the development of technology). Not only does technology complete the human organs of work, but man himself completes technology with his hands, his energy, his nervous system, his brain—completes it up to the stage of automation.

The role of man in the technological system is that of a temporary replacement, a substitute. It is a role which he is gradually yielding to the real "actor" in the production arena, thus freeing himself from the technological functions which are not proper to him, and keeping to the creative functions which are natural to him, the functions of director.

Modern automation, the data from cybernetics, bionics, the psychology of technicians clearly reveal that the whole history of technology has been the *pre-history of automated systems*, and that the essential line of technological development lies in the development of an automated technology by the continuous materialization in technical apparatus of this and that human work function, and in the progressive elimination of the whole worker mechanism (operator-object).

The replacement of the "natural instruments of production" of man by artificial instruments, the materialization in technology of the functions of the human worker, the replacement of human power by the forces of nature represent the *essential principle* of the "auto-movement" of technology.

From this point of view the objective criterion for dividing technology into periods lies in radical modifications in the technological process linking together the different elements of the productive forces (man and technology), or, in other words, in the *technological method of production*. This category, which is impor-

tant in principle for the understanding of the internal processes of technological development, is not identical to the social method of production, which is a much broader and not technological category on a socio-economic basis.

Society experiences three essential historical processes in the association of man and technology in the production procedure, which are characterized in succession by manual labor, mechanization and automation. Consequently, the whole history of technology can be broken down into three essential stages: (1) the tools of manual labor (man is the principal link in the overall work mechanism; the type of relationship between man and technology is a *subjective* connection); (2) machines (the worker is a part of a semi-mechanical system; the type of relationship is an *objective* connection); (3) automated systems (man has his place outside the technological process; type of relationship: *free*). The principal content of the first stage is the specialization of tools; of the second—mechanization, and the third—cybernetization. The process of automation begins with the materialization in technology of the intellectual work functions. In our view, it is logical to divide this process in its turn into various levels in terms of the materialization of one or another functions of the technological process, and of the degree of automation. The absence of a clear boundary to the stages of technological development and the levels of automation has had a negative effect upon sociological research, leading to erroneous conclusions when, for example, the consequences of the creation of production lines and of semi-automation (which does not in fact belong to the technology of automated systems) were presented as the consequences of automation.

TECHNOLOGY AND NATURE

From a theoretical point of view it is important to follow not only the logical development of the "man-technology" system, but also that of the "technology-nature" system. Technology develops both by the materialization of work functions and by the transformation of virgin matter and natural processes into *work* matter and *technological* processes, transforming the automatic processes of nature into the automatic processes of technology. The working characteristics of technology, however modified they may be by the

transformative activities of social man, are characteristics of natural matter.

In nature's own laboratory, just as in the world of technology, all modifications take place as a result of various types of interaction of matter. Dependent upon the essential forms of movement of the matter, these interactions may be of a mechanical, physical, chemical or biological nature. In the same manner, the working properties of matter and the technological processes of action (technological processes) can be divided into mechanical, physical, chemical and biological. Although in modern production it is rare for any of these forms to appear in a pure state, their classification is indispensable in order to construct a model of the logical structure of production, and to reveal the position and the correlations of the various processes of the scientific and technical revolution, and their prospects for development.

In our present age, with its extraordinary rates of scientific and technical progress, the problem of scientific forecasts of technological development is particularly acute. Each of the main advances in the scientific and technical revolution expresses, in fact, the process of the *amalgam* of one or another science with production, the process of the materialization in technological form of the scientific knowledge of the properties of matter and their interaction, the process of the technological application of known forms of the movement of matter. What is the *chemisation* of production, if it is not a process transforming science into a direct productive force, a practical result of the close liaison between chemistry and production? In similar fashion one can speak of the *biologization* and the *physification* of production. The latter concept comprises the whole range of achievements of contemporary science, from electrification to the industrial application of electronics, nuclear energy and the laser.

The logic of the relationship between the fundamental divisions of the scientific revolution and the actions of the technological methods which provide their basis, corresponds to the logic of the relationship between the principal forms of movement of matter in which the physical form is superior to the mechanical form but inferior to the chemical, whilst the latter yields to the biological form. Today one can see taking shape the forecast of Marx which said that as humanity assimilates the processes of "chemisation,"

mechanical work will yield more and more to chemical action. The advantage of the physical and chemical methods of technology over the mechanical methods lies in the fact that they make use of the "hidden" properties of a substance which are discovered at the microscopic level. Mechanical treatment is capable of modifying only the form of the work object; physical, and in particular, chemical methods produce a radical modification of the characteristics of the substance, its transformation to a new qualitative state, into a new substance.

As technology masters the "hidden" properties of matter, as it penetrates deeper into the microcosm, its practical achievements become effective. This revolutionizes technology itself, which is often a symbiosis of the application of physical and chemical methods. The association of physics and chemistry thus takes place not only in the domain of science but also in that of production.

But if chemical or physico-chemical methods are the most effective in the technological transformation of inorganic nature, methods of biological or biochemical action are necessary in order to transform organic nature with success. The foreseeable advance which will be made in technology, must be related, by the logic of things, to the practical utilization of the biological properties of nature.

Bionics make it possible to create a new type of technical means reproducing the working principles of the living organism. Technical bionics will produce a transformative effect on living nature, will make it possible to control heredity and to use the marvellous properties of living organisms for the well-being of man. Already projects are in hand for apparata in which a natural living organism is "mounted" within a technical system.

The reflex activity of the living organism is far more highly developed than the electronic control apparatus which exists and which attempts to imitate its action. This is why it is logical and theoretically possible to use, for example, the nervous system of an animal, so that the biological currents controlling the heart of this living organism simultaneously control a technological instrument. The organism of an animal is a highly-developed, autoregulating system, controlling the action of the heart, the lungs, the circulation of the blood etc. Any deviation within the organism is recorded by the nervous system and corrected by it. Consequently

if the technological instrument falters or begins to function badly, it will affect the nervous system of the animal which will hasten to carry out corrective action.

Unlike the technology of the past which was essentially a production technique, filling the role of a physical means of work, the technology of the future will find its way into every facet of human life: intellectual, emotional and physical. Bionic technology will appear in the form of artificial organs of the senses, of thought and of physical activity, which will amplify and complete the functioning of natural organs. The technological means for intellectual work which are now just beginning to be constructed, will look like stone axes by comparison with the future technology of science, with the future "organs of the human brain" (K. Marx).

They are destined to be an instrument of various forms of man's activity, and to serve him directly or indirectly. Such a technology will be adapted in the best manner possible to the potentialities of the human organism. These technological instruments will permit great intensification of the activity of the organs of thought, feeling, hearing. The "man-technology" system will thus take a new form, in which technology, in the full acceptance of the term, will fulfil the role of artificial organs of social man and will appear as a "humanized" technology.

What then is the place of automation amongst all the operations quoted of the scientific and technical revolution? By the very logic of things, automation is linked to the application of cybernetic data to production. But automation cannot be placed on the same level as the "physification," "chemisation" and "biologization" of production, which develop, *not parallel* with automation, *but thanks to it*. Automation holds a special place in the structure of contemporary production.

Automation is a definite stage in the level of development of the instruments of production themselves; it is that technological form adopted by the technological methods of action upon the work object. Historically, technological methods were developed first at the level of the tools of manual labor, then at the level of mechanization, and now it is happening at the level of automation. The great task for human activity consists in harnessing by means of technology the automatic processes of nature itself.

The methods of action upon nature are in no way indifferent to

their technological form. If the adequate form for mechanical technology was mechanization, if certain physical properties of nature (steam, electricity) could be used at the technological level by means of mechanization, it is simply no longer possible to dispense with automaticity in the application of numerous physical and chemical processes discovered by modern science.

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We have dealt here with technology and automation in the pure state, as it were. We have considered on its own merits the internal logic of the development of technology. In doing so we have made an abstraction in our minds of the social relationships within which alone technology can develop. Such an abstraction, admissible only for certain objectives, nevertheless represents an obviously one-sided approach to the analysis of the development of technology, since in reality technological progress is affected by the economic, political and ideological structures of society, which, in turn, are powerfully influenced by technology. But that is already the subject of special examination.