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Balázs Dajka and Imre Hronszky

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CONTENTS

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NOT HAVE BEEN PUBLISHED

PREFACE:
Social Interpretation of Technics courses at the IUC/Dubrovnik

The objective of the Inter-University Centre of Post-Graduate Studies in Dubrovnik founded in 1971 is to encourage and promote cooperation among universities through teaching and research. This objective will be realized primarily by organizing postgraduate courses and research projects, as it is stated in the Constitution of the IUC. The Social Interpretation of Technics course was first given in 1983, on the request of the director general. Its title was Science, Technology and Everyday Life and it was organized by Tom Kitwood of Bradford and Imre Hronszky of Budapest Technological University whom the original idea came from. The general aim of the annual courses has been to provide a manysided and integrated understanding of technological change as a complex social phenomenon. The analysis have been based on disciplines ranging from philosophy through history, economics, and sociology to political theory. Special attention has been paid to the causes of technological transformation in different social systems and in both developed and developing societies. Various aspects of domination, in relation to class, culture, gender, and environment have formed an integral part of the annual courses.

As it has already been mentioned, the first course was entitled Science, Technology and Everyday Life. It had eight participants and ten resource persons, as they are called. After this rather modest beginning, the course got its final general name in the next year. The board of course directors was widened to include Günter Ropohl (Frankfurt), Srdjan Lelas (Zagreb), Boel Berner (Lund), Alois Huning (Düsseldorf). The course was devoted to philosophical, political, economic and sociological dimensions of technical practice in the modern world. It dealt with the ethical dimensions too. Fifteen students could enjoy the lectures of such outstanding scholars as Gernot Böhme (Darmstadt), Brian Eslea (Sussex), Peter Janich (Marburg), Bernward Joerges (Berlin), Wolfgang König (Berlin-West), Hans Lenk (Karlsruhe), Howard Rosenbrock (Manchester), Friedrich Rapp (then from Berli-West), and Walter Zimmerli (Braunschweig), who also lectured several times in the following years.

Technical and Social Development was the special title in 1986, the next year. The late Sally Hacker (Oregon), Jaap Jelsma (Twente), Eugeniusz Olszewski (Warsaw), and Harry Rothman (Aston) were "resource persons" among other outstanding scholars. The year 1986 has brought a deep change in the organizational work of the course. One of the originators, Tom Kitwood left the board. The reason was that he got a new type of research work with his university. Boel Berner gave up her directorship too. Imre Hronszky was chosen as the coordinating director and the board, smaller as it has become, worked just as enthusiastically as before. The main theme of the year was Explaining Technological Change. Gerd Fleischmann (Frankfurt), Johann Götschl (Graz), Jonathan Liebenau (London), Trevor Pynch (York), Zoltán Tar (New York) presented important papers among others. In 1987 the course was focusing on Normative Issues of Technology Development. Just to mention a few names, Hjalmar Krupp (Karlsruhe), Erika Hickel (Braunschweig), Rolf Homann (Zürich), Dieter Birnbacher (Essen), Ilana Löwy (Paris) read papers on the topic. Wolf Schäfer (then Frankfurt) gave a lecture in a joint session with the Philosophy of Science course. The course was partly held as a conference on Conflicting Values in Recent Technology Development.

Computers and Society was the topic for 1988. Tibor Vámos (Budapest) gave two important lectures. The one about computerization and democracy was organized together with the Philosophy and Social Science course. Besides him Hans Götschl, Thomas Bernold, Vitalij Gorokhov (Moscow), Ladislaw Tondl, Manfred Schmutzer (Vienna), Josef Hochgerner (Vienna), Edward G. Edwards (Bradford), Galina Belkina (Moscow) had a major role in maintaining a high scholarly level.

This year there were two problems to discuss. Perspectives of Automation: Labour and Leisure was the topic for the post-graduate course. Peter Scharf's (Siegen) and Alfons Schmidt's (Frankfurt) lectures balanced the overhelmingly philosophical presentations. Prof. Vlcek (Prague) a computer specialist gave an especially important talk. The course had a joint session with the Future Studies course where Penti Malaska (Helsinki) presented a paper. The second topic was discussed within the framework of a small "conference", or rather a workshop, entitled Cognitive Science as Basis for New Technologies (Possible Social Consequencies). Unfortunately, its organisation was not completely successful because of the large number of late cancellations. Once again Prof. Vámos helped to secure the scientific quality with a talk about those new developments in different fields that might become important in the further development of cognitive science.
The role of the Hungarian resource persons was especially significant throughout the series of the Social Interpretation of Technics courses. It is enough to mention Pál Tamás and János Farkas from Budapest who read remarkable papers nearly every year on the sociological side of the problems under discussion. In the beginning there was a fairly strong feministic participation in the annual courses, which , rather unfortunately, has diminished later. I have to mention Joan Greenbaum (New York), who gave two lectures on the sociology of computerisation, and also Siiv Friis (Lund), and Carolyn Merchant (New York) among others.

Most of the course directors felt their duty to give a lecture each year. The courses generally had about 20-22 participants in addition to the 25-28 resource persons every year from the second year on. Participants and resource persons came from 12-13 countries each year. In 1987 the Soros Foundation Committee of the Hungarian Academy of Sciences provided opportunity for publishing a selection from the materials of the course. It genereously supported a special volume of Doxa, the Foreign language periodical of the Institute of Philosophy of the Hungarian Academy of Sciences. A year later the editors of

Scientia Jugoslavia generously offered to publish selected materials from the 1988 course. They will be printed in a special issue by the end of 1989.

(Copies to be requested: Sci. Yug. 41001 Zagreb, Trg. marsala Tita 3, POB 327)

Imre Hronszky

TECHNICAL DEVELOPMENT AND MORAL RESPONSIBILITY

György Licskó

The participants of the Section for the Social Interpretation of Technics listen to and discuss some 30-40 lectures annually concerning the consequences and related social problems of the development of technics and other issues. We can present these problems in a very interesting manner and with a large degree of self-assurance. However, very little attention is paid to the essence of technics. It is generally the case that we are most certainly familiar with a number of definitions but none can be considered as being good beyond doubt. The large number of available definitions creates uncertainty rather than bringing about a firm approach to the interpretation of technics. In this brief paper I am not going to add another definition of technics to the list that is already quite long (there are more than two hundred of these in fact.)[1] I wish to confine myself to making an attempt to underline the essence of technics.

The definitions which consider one or another of the components of technics (means of production, science, invention and its application, human activity and so on) as essential are seen as deficient and one-sided, while those which list too many of the composite elements cannot be used because there are no set parameters beyond which one cannot go. Certainly, the fact that at times and places one or another of the composite elements of technics came into the picture, and, in turn, distracted attention from the others, also had part to play in the formulation of one-factor definitions. Development which occurs at an ever faster pace has led to increased individual specialization in terms of objectivization, information, knowledge and methods. Simultaneously, specialization has had an impact on man's whole way of thinking. Under such conditions this thinking tends to adopt a one-sided approach to complex phenomena. We know, however, that increasing specialization has brought about the demand for integration. The majority of studies written in recent years on the concept and essence of technics appear to show that the demand for integration is gaining the upper hand.

The present tendency of thinking focused on the essence of technique indicates that researchers are attempting to establish a complex concept capable of including as many composite elements as possible. It is true that efforts of this kind are designed to satisfy a realistic demand, but it is also quite clear that the more they endeavour to meet this requirement, the more awkward and more complicated the definition formulated in this spirit will be. In my view, the problem of giving a definition presently arises from the fact that the rapid development of, and changes in technics render the concept so dynamic that it can no longer be treated according to the conventional rules which govern the formulation of definitions. Thus a new and different method must be sought for clarifying the essence of technique.

The essence of technique

On the basis of facts made available by archeology and cultural history it is the generally accepted view today that technics is as old as man himself. Accordingly, like work, technique can be regarded as a category of social ontology. Both work and technique are the most obvious proofs of man's carrying on goal-oriented, and non-instinctive activity. Work is a purposeful activity performed in the interests of meeting specific human and social needs, and the only thing by which man can perform this purposeful activity with increasing efficiency is technique. Man needs tools, methods, knowledge, ability, skills, organization and many other things to be able to increase the efficiency of his activity. In relation to one another all these elements taken together make up technology and it is common to each of them that they contribute to the enhancement of the efficiency of human work.

While animals adjust themselves to the environment, man can change it. Performing work is the precondition for changing the environment and, as a result of work, a constant relationship is brought about between man and his environment. Since in this reciprocal relationship man is the active party, new possibilities are constantly being created for the performance of conscious activity. However, these can only be taken full advantage of if they are first recognized and if this is followed by the establishment of the appropriate means, tools, methods and organizational forms, along with the development of the required individual abilities. In other words, the need for the use and subsequent implementation of new possibilities calls for the development of technique. It follows from increasing efficiency that we can always include new things in the sphere of our activities and that we can develop ever more intensively the things to which our activity has already been extended. This is why we can regard technique as a category of social ontology of primary importance. Without it, that is, without increasing the efficiency of goal-oriented activity, the human abilities providing for the dynamism of modulating the environment would not be able to develop. Man is forced to bring these abilities into play by the endeavour to make his work more efficient - in other words, to help the technical possibilities of his relationship with his environment develop.

Increasing efficiency can be taken into account equally with each factor that is included in the definition of technics, but is not exclusively attached to any of them. Similarly, we can speak of the effectiveness of the application of means, tools, methods or systems in the same manner as we can speak of the efficiency of knowledge, skills, organization or solutions. Thus we can denote two areas of technique that belong to one another: the area of objective factors and that of subjective ones. As for the objective factors, which take the form of means, tools and machine equipment, these have now grown to be immensely powerful and can give the impression that they have a predominant role to play within the whole complexity of technique. However, the technical development taking place today reveals that automation puts the role played by the human factor very much into the focus of attention. But this statement is also true the other way around. By this I mean that scientific knowledge and methods, or sophisticated individual skills, can only prove to be technical factors in the operation of complicated assemblies of objects that have assumed enormous dimensions if they correspond to the above-mentioned list. Thus technique whose objective and subjective sides are interpreted in the above manner can only make goal-oriented human activity efficient or can only increase its efficiency if they are combined and are in mutual relationship with one another.

In this context mention can also be made of the problem of what is termed technological determinism. In this field determinism can only mean that the mutual adequacy of the objective and subjective sides of technology is a necessary requirement. Individual know-how which ensures smooth and undisturbed operation, as well as the social needs and organizational framework that accept the technical equipment and can provide for all the conditions demanded by use, is required for the optimum operation of any technical equipment or device.

Efficiency which has been increased by way of the acquisition of particular technical complexities can, however, be utilized in different ways. The method and objectives of use can be determined by factors other than those mentioned only too emphatically by technical determinism. As a rule, each increase in technical efficiency can lead to an increase in the efficiency of the culture in which it was developed or by which it was adopted. The opportunities for utilization can be judged on the basis of the kind of activity being carried on by the people of a certain culture, or the way the different activities are classified according to their order of values.

For example, feudal European culture in the Middle Ages adopted harness-making technology from equestrian normadic peoples who had a migratory and predatory way of life, but feudal European culture used this technology first and foremost to increase the efficiency of land cultivation and land transport. In other words, the peoples of feudal Europe did not become migratory equestrian nomads after their adoption of this technology. As far as our age is concerned, a period which enjoys a developed air transportation network, those people who helped develop this did not even think that passanger aircraft could enhance the efficiency of the activities of terrorists at a later stage. Recognition of the opportunities and translating into practice - what lies in them - a process that is embodied in the activity's becoming more effective - is to a very large extent the function of the system of activities which is acquired and practised by the individuals of a specific culture.

The moral responsibility of technical development

Let us carry on the socio-ontological examination of technique which is formulated on a most general plane and relate it to a narrower field. I wish to discuss briefly the divergence between technial progress and moral demands, which may well have existed as early as Antiquity, but which has become an acute and problematic issue in our world of advanced technology. The possibility of this divergence was forcefully mentioned in a most dramatic fashion by Sophocles, one of the greatest artictic figures of Ancient Greece. This is what the chorus praising man says, among other things, in his play, *Antigone*:

"Clever beyond all dreams
the inventive craft that he has
which may drive him one time or another to well or ill."

The idea formulated by Sophocles so admirably, and with classic conciseness and artistic power raises two very serious questions: Firstly, on what does it depend that man uses the products of his creative powers for good or bad ends? Secondly, can an example of human creative work be automatically bad or harmful by itself?

The first question has implications for both the individual and for society. Individually a person can be evil, or a madman running amok, and as such he can utilize anything against another person or other people. This possibility also arises from the ontological essence of man. A human being acting consciously is capable of recognizing that the means at this disposal can be used in different ways and for different purposes. Man has been familiar with this problem ever since the prehistoric age. However, it emerged as a very serious issue when science and technique began to develop by leaps and bounds and, as a result, increasing potential came to be concentrated in the objects created by man. It is profoundly horrific to imagine what would happen if a terrorist managed to hijack an aircraft with nuclear weapons on board - hopefully such an eventuality is quite impossible. The rapidly growing efficiency of science and technics contributes to the increased efficiency of the people who can take advantage of the achievements of their joint development in their day-to-day activity. In this respect we can accept the view put forward by Carlo M. Cipolla that: "There is nothing more dangerous than technical knowledge when unaccompanied by respect for human life and human values ... Instructing a savage in advanced techniques does not change him into a civilized person; it just makes him an efficient savage."[2]

However, the problem becomes much more complicated if we take society as our point of departure, and not the individual. There is much depressing historical evidence to testify to the effect that there exists not only primitive savagery; there is also "civilized savagery", however paradoxical the term may sound. The technics of large-scale homicide was first applied in Europe. Knowledge or what is termed culture based upon the humanities cannot therefore be a guarantee by itself against civilized barbarism. It cannot ensure that the achievements of science and technics are not used for inhuman purposes. Guarantees of this can only be provided by completely open political conditions under which no totalitarian power can silence or eliminate moral responsibility. Where it is impossible to speak openly and make democratic decisions concerning the use of means and methods, there will always be a danger of abusing the increasing efficiency of science and technics.

Let us examine another issue. What is the extent to which any new achievement of the development of science and technique can be detrimental? Obviously, to this category belong weapons, the means designed to be used for destruction. These are not worth discussing. Instead, let us focus our attention on those means which are not intended for war purposes, yet their efficiency is far higher than that of those in which the achievements of science have not as yet been objectivized. In general, the supporters of technical determinism emphasize that man has to adapt himself to the technical milieu he has himself brought about. The view which holds that technique as such is neutral and only its use can be valued in a positive or negative way runs counter to the above concept. I believe that we must challenge both concepts. In my opinion, on the one hand man is not necessarily put at the mercy of technical alienation and, on the other hand, each level of technical development has an impact on man's activity as a whole. For man is an integral part of a technique that is operating efficiently. It is he who operates, regulates and applies it, therefore he is structurally incorporated in it as a subjective factor. "A boy", writes Cipolla, "playing with a mechanical toy and a scientist using a computer will both be deeply affected in the workings of their minds, their inclinations and their curiosities by the gadgetry they are using. The technologies nurtured by a culture may easily have a cumulative effect on it."[3]

The ideas I have quoted appear to be arguments in favour of technological determinism. In fact they do not completely support this principle. For if the means, methods and knowledge used or possessed, respectively, by man have an influence to exert on him, then they will invariably induce a certain active reaction in him. Let me repeat that the objective and subjective components of technique jointly embody the structure operating efficiently. Man is a part of this system who can, or even, as a result of his ontological characteristics, is obliged to, change the whole system constantly. And if the possibility or compulsion for change prevails, then the only issue that remains problematic is the factor that determines the change.

One of the most outstanding and versatile historians of our century, Arnold J. Toynbee, was very intensively concerned in the 1960s with the influence exerted by science and technique on society. This was quite natural. The renowned scholar was close to his 80th birthday, and had experienced the impact of scientific and technical development, the pace of which had abruptly accelerated as though it was some sort of shock. In his studies dating from this period (*Change and Habit; The Challenge of Our Time; Experiences*) he examined the reasons lying behind the divergence between the heart and the mind - to use figurative terms. In Toynbee's view, the heart which, in other words, is man's biological and emotional state, is of a static nature in contrast to the mind, which is equal to science and technique, and which is of a dynamic character. In previous ages, the dynamism of the mind and the static nature of the heart were in harmony. However, this harmony came to be disrupted in the wake of the industrial revolution and, by the second half of the twentieth century, the divergence had grown too great. The development of science and technics leads to changes of such a fast pace that man is incapable of catching up biologically, emotionally and morally. Man's nature cannot change at so fast a pace compared to that at which our artificial environment, the scene of our day-to-day life, changes or at which we change it.

Cipolla singles out the same problem with reference to ethics. He writes: "The fact is that technology develops cumulatively, while ethics does not; technology is easy to impart while ethical wisdom is difficult to disseminate. The development of technology over past centuries has been dramatic. But has it been proportionate to our ethical standards and our philosophical and social maturity?"[4] Both authors I have quoted are free from nostalgic illusions. They are fully aware that the development of science and technique is an irreversible process. Toynbee describes the divergence or conflict between the mind and the heart as the third world war of mankind and adds that its outcome is totally unpredictable. Cipolla, however, emphasizes that - as I quoted earlier - the increasing efficiency of science and technology must be accompanied by moral demands corresponding to it.

Now, I believe, we have taken at least one stride forward towards a solution. Today we are richer in terms of experience and lessons gained and learned than we were before the 1970s. Today we know that the goal we must try to achieve is not to dominate Nature but to avoid conflict with our natural environment, or at least not to create conflict. This recognition gears the development of science and technique in a direction which truly corresponds to man's interests instead of going against them. This is the only way, namely by recognizing our real opportunities, in which we can avert the incalculable consequences of boomerang effects. In any case, the past one and half decades have had a sobering influence on societies that have become intoxicated by the belief that science and technique can be omnipotent. The exclamation marks accompanying the proud statements prompted by the above belief have been transformed into question marks at several points. Therefore we can now formulate a more realistic judgement of the value of the role being played by science and technique, without aiming to reduce their real value.

Scientific and technical development can also have a positive effect on the further development of certain moral norms. However, the divergence which was mentioned earlier undoubtedly exists. But it is not so sure that its existence is a major problem. True enough, it may well be the source of numerous dangers. It may degrade certain values and emotions, and could cause both thinking and action to get carried away or pushed into extremes and excesses. However, we are firmly of the opinion that it would be a greater danger if divergence between the heart and mind, between technical rationalism and moral demands, failed to develop. In logical terms this would be possible in two cases: either if dynamic development were prevented by force or if we completely adapted ourselves to alienated technical rationalism and translated Aldous Huxley's "Brave New World" into practice. Neither of the two is the path to take. Man rejects both the return to some sort of earlier and poorer state as well as complete adaptation to alienated technical rationalism of any kind.

Settlement of the problem calls for the development of human abilities which are demanded by the rapidly growing efficiency of science and technique at a very high level. This is the field in which the normative issues of technical progress can be identified. In an ontological sense, man can be defined as a being consciously changing the conditions of his subsistence. This is the very activity for which he uses increasingly efficient technique. In the final resort it is labour and technique that bring about the development of man's needs and demands which can lead him to success. These demands are partly individual abilities and partly the ability to cooperate with others. The use of even the simplest tools can develop in man the individual and cooperative abilities which are essential for the performance of successful labour. The more complicated and efficient the means and methods of labour, the greater the role of human abilities necessary for applying them.

The accelerated pace of the development of science and technique in fact renders dubious the mutual adequacy of the objective and subjective factors of activity. But the sheer recognition of the problem and its expression constitute results. It prompts us to seek the ways and means of ensuring adequacy. I believe that in this field the most important thing of all is to establish and become fully aware of a "multidimensional responsibility". There is an excellent basis of principle and methodology paving the way to the understanding of the above problem.

This is provided in a study written by János Neumann over thirty years ago. Neumann poses the question as follows: "Can we survive technique?". What he meant is whether or not we can survive the consequences of the rapidly growing efficiency of the means and methods at our disposal. Neumann considered survival to be possible and formulated a highly important fundamental principle as the precondition for it. His point of departure was the assumption that the application of science and technics has reached the level making it possible artifically to disturb or reproduce processes in Nature. In terms of time and space, however, Nature is of a scale very different from that of human life. Nature - as Neumann wrote - operates thermo-nuclear processes everywhere and it operates them well, but their minimum space demand is equivalent to the distance between the stars above us. However, man, operating a nuclear reactor (or an atomic bomb), has an incomparably smaller space at his disposal. It can be added that the same applies to the time available to man. What follows from this comparison? It follows that if in our own micro-world (on our globe) we reproduce thermo-nuclear reaction which is adequate for the macro-cosmos, we must perform the job more accurately, more considerately and in a controllable fashion. Otherwise chain reaction, due to its inherent nature, will assume macro-cosmic dimensions and wil destroy man.

It is true that Neumann's example is a pointed one, but it is highly instructive and can be generalized. It can be regarded as an analogue for each efficient intervention having an impact on man's conditions of subsistence. Let us try to imagine the unforeseeable consequences of a genetical intervention that turns out to be detrimental in retrospect. The application of efficient means, methods and knowledge calls for a different type of discipline, responsibility, prudence and reliability to be displayed or borne by man compared to the type needed in the less developed periods of science and technique. Earlier the errors in activity could be recognized and eliminated while it was being carried on, or else its harmful consequences were not so devastating. Today, however, we can, as a rule, recognise that error or negligence can lead to consequences which are often impossible to set right.

Therefore, the rapid progress made by science and technique prompts man to elaborate and acquire norms which can render safe the use of "super efficient" methods and means. We know only too well that there has always been a need for discipline, responsibility and reliability. Let us take a look at transport in general and mass transport in particular. A couple of centuries ago the principal means was the coach. Naturally, there had to be a person then to be in charge of the service and its organization. But it would be impossible to compare the responsibility borne hundreds of years ago by the man directing the coaches and that borne by people controlling air traffic at any major airport. As long as the anthropomorphic tendency dominated human activity, there was no danger of irreversibility looming on the horizon. Modern science and the technique of machines, however, deprive our activity and our thinking of their anthropomorphic character. The latter tendency concentrates the powers of the human brain and Nature in the world of objects fashioned by man. The new dimensions of responsibility, discipline, reliability and so forth must be developed in order to "keep things under control".

The most important of the dimensions of the kind mentioned above are irreversibility and the irredeemable. The more efficient we can make our own activity, the more we have to make plans and think in the two categories listed above. This is a demand that is brought about by the development at an accelerated pace of science and technique. This is why we can assert with good reason that this development has also a positive influence to exert even on the progress of socio-ethical norms. It makes man assess the expected consequences of his activity in longer perspectives in terms of both space and time.

The development of science and technique is not a venture without inherent danger. The anxiety voiced by Cipolla in this context is quite justified. Efficient technology is only too easy to spread, but the norms needed for safe application can only be established and made into general demands to be met in a period extending to several decades. Toynbee's anxiety is also warranted. It is not certain that man's biorhythm is capable of following the increasing pace of technical development without suffering damage. Obviously, the optimum pace has to be found.

In our age we have to adjust ourselves to the changing environment several times even during the relatively short period of one generation. As regards problems of the above kind today, there are many issues left to be settled. At the very least we cannot as yet supply answers to all questions with appropriate certainly.

One thing, however, we know for sure: we cannot turn back. Man is not prepared to abandon the results he has achieved today in terms of his self-assertion. The people engaged in scientific and technical activities will not conceal their future discoveries from now on. We have to reckon with divergence between the heart and the mind, between technical development and socio-ethical demands. But the fact that we have recognized this divergence offers us the opportunity to keep it within optimum limits and to develop the tendencies designed to counter-balance its detrimental influence: the new dimensions of responsibility, disciplined operation and reliability in cooperation. In technical facilities a large amount of scientific knowledge and many human abilities come to be objectivized. To operate them effectively increasingly involves a new type of responsibility and new moral demands.

Technical University, Budapest

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scientific and technical activities will not cease; their future discoveries from now on. We have to reckon with divergence between the heart and the mind, between technical development and socio-ethical demands. But the fact that we have recognized this divergence offers us the opportunity to keep it within optimum limits and to develop the tendencies designed to counter-balance its detrimental influence: the new dimensions of responsibility, disciplined operation and reliability in cooperation. In technical facilities a large amount of scientific knowledge and many human abilities come to be objectivized. To operate them effectively increasingly involves a new type of responsibility and new moral demands.

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ETHICAL ASPECTS OF LONG-TERM ENVIRONMENTAL AND SOCIAL IMPACTS OF TECHNICAL DEVELOPMENT

Dieter Birnbacher

1. New temporal dimensions of technological impact

The subject I am going to deal with is future ethics. Future ethics is a rather recent offshoot of applied ethics, arising out of the necessity to consider ethical problems connected with the long term effects of present actions - actions both by commission and by omission. I say "necessity" of considering the ethical side of long effects because future ethics is, once again, coming onto the scene rather late. The facts are already there, long before ethics has come round to ask whether they should be allowed to happen. Again, the owl of Minerva spreads its wings, after the real world's problems have had time enough to accumulate. Instead of preventing these problems from being there in the first place, all that philosophy can do is to contribute to their practical solution in an Hegelian act of "Aufhebung", transforming them into theoretical problems in a purely intellectual realm, and deliberately forgetting, for a while at least, that they are at the same time out there in the real world.

One source of the problems from which future ethics derives its *raison d'être* is the fact that modern technology has provided the means to control man's future history on a hitherto unprecedented scale. The physical dimensions and the time span of the side-effects of man's technical control of his environment continue to expand. The potential physical impact of the carbon dioxide emissions produced by the combustion of fossil fuels equals those of major changes in the earth's climatic history. The physical impact of an all-out nuclear exchange between the superpowers equals or even exceeds that of an astrophysical cataclysm such as that which probably led to the extinction of dinosaurs in geological time. On the other hand, the delay time of the effects produced by present technical procedures may amount to several generations. Insofar as the changes introduced into the environment by modern technology are irreversible, the effects may even be felt by all future generations ever to live - a rather uncanny idea. The nuclear bomb, for one thing, cannot be "disinvented". Even if all the nations possessing the bomb at the present moment should agree to scrap their nuclear arsenals within a year's time, knowledge about the bomb's construction and potential use would not so easily become lost. The bomb would go on to constitute a threat - indeed a threat to all future generations - even if it only existed in blueprint.

A second source of the problems future ethics is dealing with is the expansion of what we *know* about technology's long-term risks. Scanty though this knowledge is in many respects, it is sufficient to confront us with moral dilemmas unknown to our more comfortably ignorant ancestors. The growth of prognostic knowledge - itself dependent on advances in prognostic technology - makes it increasingly difficult to absolve oneself from *ex post* reproaches by pleading *ex ante* ignorance. As knowledge about the probable or potential long-term effects of present technology advances, moral pressure to take responsibility for them increases. Knowledge, control and responsibility are linked to each other, and since lost innocence is lost forever, the pressure of responsibility can only grow and never diminish.

In the following, I shall discuss three topics in the ethics of long-term technological impacts, in an admittedly fragmentary and tentative way: 1. the question of the right and wrong of the common practice of *discounting* future values and disvalues and the associated tendency to restrict responsibility to the near future by weighting short-term good and harm more heavily than long-term good and harm;

2. the question of how to deal, in theory, with *irreversible* changes directly and indirectly produced by modern technology; and

3. the problem of the criteria to follow in judging the acceptability of long term technological *risks*.

Though central to any satisfactory future ethics, these three questions, and especially questions 2 and 3, are still largely an agenda for the future. There has been a certain amount of discussion, but it is fair to say that the issues are as widely open today as they were in the early 1970s.

2. Discounting future values and disvalues

One of the obstacles standing in the way of an ethically acceptable assessment of potential long term harms and benefits of present actions and omission is the practice of *discounting* future values and disvalues common in economics. In discounting, future values are calculated as less valuable, and disvalues as being less of a disvalue, today than at the time they will actually come about. The later the date of incidence of the future event, and the higher the rate of discount chosen, the greater the difference between what the future value is worth *then* and what it is worth *now*.

A majority of economists take discounting of future values for granted, mostly because it seems to fit in a natural way the phenomenon of time preference, of valuing the more remote in time less than the near-at-hand, common both in private and collective planning. It largely remains for the philosopher to raise the question as to the *justification* of this piece of deliberate myopia. The question to ask is: how *can* discounting future values and disvalues possibly be justified? After all, position in time is not a feature that alters somehow the inner nature of a value. Whether the value is of a subjective kind like pleasure or knowledge, or of an objective kind like beauty or truth, position in time cannot make a difference to the amount of value these states of affairs carry with them. How can a time-bomb that will with certainty kill 100 people in a hundred years time be any less of an evil than a time bomb killing the same number of people in 10 years hence, or right now?

There are quite a number of jobs economists want discounting to do, and each application of the device has to be examined on its own merits and demerits.

First, discounting is applied to future monetary values in order to account for the phenomenon of *interest*. Future monetary values are calculated to be less worth now than they will be in several years time because in an economy with a positive real rate of interest a smaller sum of money is needed now to yield the same sum then. This is fair enough. Future money is not the same as money now, because money now means that I can possibly profit from interest by making an investment that yields me more money in the future. Likewise, in an economy with a positive real rate of interest, a future harm that can be fully compensated by money, is less of a harm *now* than it is *then*. The amount of money I have to save now in order to compensate the damage then, will be less than the cost of the damage at the time when it actually occurs.

There can be thus no objection in principle to the discounting of future values whenever this is applied to *monetary* values or to future benefits and future harms that can be adequately compensated in monetary terms. It should however be clear that the legitimacy of discounting in such cases depends on a presupposition, namely that the assumed real rate of interest will obtain during the whole time from the present to the incidence of the future value. Discounting future monetary values thus involves a heavy piece of economic forecasting. As is well known, however, economic forecasting is riddled with all kinds of uncertainties. Planning models that assume in an a priori manner that economic growth is going on at the present rate indefinitely, must be viewed with some suspicion. Even if discounting future monetary values is justified in principle, it is not in effect justified whenever the underlying assumptions about the continuity and stability of economic growth seem to be highly idealized.

Second, discounting of future values is directly applied to future utilities and disutilities in order to account for the common phenomenon of time preference. Time preference as a psychological phenomenon is a complex of various different tendencies. Most prominent among them are the tendencies of *pure time preference* and of *limited altruism*. Pure time preference is the tendency to prefer a value in the near future to an otherwise equal value in the far future, and to prefer a disvalue in the far future to an otherwise equal disvalue in the near future. Limited altruism is the even more familiar phenomenon of preference for own benefits to the benefits of others. For the psychological discounting of harms and benefits very far in the future, limited altruism is the crucial explanation. Even if we do not care sufficiently for harms and benefits falling into our own probable lifespan, we care even less for harms and benefits beyond our individual deaths.

It should be obvious that discounting future utility and disutility is *imprudent* if it concerns our own individual future, and *immoral* if it concerns future generations. As concerns imprudence, whoever bases his personal life plan on discounting future benefits will inevitably come to regret this in due time. To the 50 years old, the 60th year of his life will be no further away as the 30th year to the 20 years old, but with a policy of discounting future utility he will not have saved enough to provide adequately for his old age. As concerns immorality, whoever bases his lifestyle, as modern technological society does, on a generous disregard for the losses to be suffered and the benefits foregone by future generations, will not be able to stand up to the elementary moral test of putting himself in the other's shoes. He certainly would not wish that his ancestors had discounted his own utility and disutility in the way he is discounting the utility and disutility of his grandchildren.

Thirdly, discounting is applied to future utility for reasons of intergenerational equality. In this application, the underlying motivation for discounting is not economic or psychological, but moral: given that economic growth and technological progress will make later generations vastly more wealthy (and their lives vastly more comfortable) than earlier ones, it is only fair that earlier generations do not feel called upon to save more for later generations than the minimum required to keep progress going. Discounting the utility that future generations will reap from their ancestors' investments is one way to achieve this equalization, because the rate of saving assuring the optimal growth of the economy will be far less with discounting future benefits than it would be without it.

For many ethicists intergenerational equalization will be a value important enough to justify temporal redistributions in one's own favour, provided a) that economic growth can be expected to go on and b) that economic growth really does make people happier. But apart from the question how realistic these latter assumptions are, I have to confess that I do not at all sympathize with this kind of egalitarian intergenerational thinking. My reason is that from a truly impartial intergenerational point of view (such as a temporal interpretation of John Rawls's original position) a growth path with the more overall utility for all generations would seem to be clearly preferable to a growth path with less overall utility but a more equalized intergenerational distribution. Even if earlier generations have to make heavier sacrifices for later generations in the utility maximizing scenario than in the equalizing scenario, a rational decisionmaker behind the "veil of ignorance" could do nothing better, in my view, than to choose the former.

But however one may think about this rather fundamental distributive question, it can safely be said that discounting future utility and disutility seems rather unsuited for the distributive job it is made to do in this application. Instead of making explicit the principles of distributive justice underlying the intergenerational redistribution, discounting clouds the issue by giving a distorted view of the facts. The problem of intergenerational distribution should be solved by explicitly giving criteria of intertemporal justice, not by representing the facts in such a way that problems of justice do not arise.

The conclusion of this brief discussion is that even if the discounting of future utilities for psychological reasons is excluded, difficult problems remain. One problem is to estimate the extent to which future utilities and disutilities will be capable of compensation by money. Even if it is irresponsible to discount future disutilities as such in present calculations, they will be legitimate candidates for discounting to the extent that they can be compensated by monetary values. To give an example: if gigantic dams will have to be built in a hundred years time to protect the North Sea coast from flooding due to the melting of parts of the Antarctic ice cap, the construction costs of these dams will doubtless be legitimate candidates for discounting (provided economic growth does not come to a halt and the real interest rate does not become negative). But what shall we say of the aesthetic losses suffered by the construction of these dams, of the interference with the subjective identity of the people living in those parts, or of the fear generated by such man-made natural disasters? The *Lebensgefühl* of whole generations, their basic attitude of trust and distrust in man's ability to control his environment by rational principles and technological means might conceivably change, and not for the better. I doubt whether such basic changes in attitude are in principle candidates for monetary compensation, i.e. that the disutility incorporated in such changes can be adequately measured by monetary gains.

3. The problem of assessing irreversibilities

I shall now briefly touch on another problem arising in the context of the evaluation of the long-term consequences of technological advance, the problem of irreversibilities. Knowing, or having good reasons to believe, that a technologically induced change in the world is irreversible, is generally held to constitute a good reason for preventing its happening. At the very least, it is held to constitute a good reason to give more than normal thought to the question whether introducing the change is really called for. In any case, irreversibility is taken to be a factor that tells against the introduction of the change, over and above the harm or risk implied in its consequences. What is rather obscure, however, is how this -

largely intuitive - reaction to irreversibility can be justified. In particular, the question arises if the factor of irreversibility can somehow be made commensurable with other risk factors, thereby opening a way to a rational assessment of its relative weight.

Irreversibility can be understood in a stronger and a weaker sense. Changes or states are irreversible in a weak sense if they cannot be reversed by human means, but might dissolve spontaneously without human intervention. Irreversible changes in this weak sense are most anthropogenic changes of climate. Changes or states are irreversible in a strong sense, on the other hand, if there is no chance of spontaneous dissolution. In some way or other we have to cope with them. Irreversible changes in this strong sense are the extinction of innumerate plant and animal species due to the expansion of civilisatory activities in the 19th and 20th centuries.

In the following I shall concentrate on strongly irreversible changes, and especially on those directly or indirectly caused by man. They have come about either by being deliberately sought (like the exploitation of minerals, the hunting of rare species, or the eradication of infectious diseases), or by being admitted to happen as side effects (like the extinction of numerous species of bats and butterflies). Differently from the biologist, the ethicist is mainly interested in anthropogenic irreversibilities because only these can be prevented with a certain effort. The question is: should this effort be made? What are the dimensions of negative value inherent in an irreversibility?

To begin with, a distinction should be made between two dimensions of value inherent in an irreversibility: the positive or negative value attached to an irreversible change because it is in fact not reversed, and the additional positive or negative value attached to it for the reason that it *cannot* be reversed. The first dimension of value is unspecific. It attaches likewise to changes which are in principle reversible but which are never in fact reversed, perhaps from ignorance or thoughtlessness. The second dimension of value, on the other hand, depends on the specific *modality* of irreversibility.

The essential negative component of the value attached to irreversibilities in the first dimension is the utility foregone by later generations. That a thing is irretrievably lost means that it cannot be a source of benefit to future people. The extinction of a biological species means that all future generations are prevented from benefiting from the species in economic, scientific or aesthetic respects. Of course, irreversible changes are not always changes for the worse. Securing the ultimate eradication of a disease does not only mean that all later generations are saved from suffering from it but also that they are saved the necessity to eradicate it by their own efforts. Often, however, primarily positive irreversibilities have negative side effects, and primarily negative irreversibilities positive ones. An irreversibility of a primarily positive nature is, I presume, the intergenerational process of increasing scientific knowledge and increasing technical know-how. This process is not without its ambivalences. One striking exemplification of the "dialectics of enlightenment" is the fact that the expansion of knowledge and rationality leaves people very little chance to adhere to traditional forms of religious belief with the unreservedness of their forefathers. Though western culture is still officially Christian in basic outlook, people who actually believe in the Creed, in a traditional, not yet watered down, sense, tend to be culturally isolated. Energy production by nuclear fission, on the other hand, a technology with irreversible consequences of a primarily negative nature, also involves positive ones. While the longevity of nuclear waste restricts the freedom of later generations to choose their own life forms, availability of this technology for energy production also enlarges their range of choices.

With irreversibilities of a primarily negative kind, evaluation of future costs and opportunity costs will mainly depend on two factors, future *demand* and *substitutability*. These two factors are not independent. With a highly specific demand, the thing irreversibly lost will be less substitutable than with a less specific one. To take the extremes: any ton of phosphorus lost in the Atlantic Ocean is as irretrievably lost as a loved one killed in an accident. Every object has inexhaustibly many properties and aspects of which only a few correspond to an interest on our part. The greater the number of properties interesting us, the less will the thing be replaceable. The extinction of a biological species is no real loss (in value terms) if all its economic, scientific and aesthetic functions are taken over by other species. Even if butterfly B is no adequate substitute for butterfly A as far as its individual configuration of properties is concerned, it may be a sufficient substitute as far as its humanly significant properties are concerned. The aesthetic satisfaction provided by B may be no less than that provided by A. The situation is different, however, if A produces a certain chemical substance for which there will be an urgent need 2000 years hence. The trouble is that we do not know either the future demand nor all the potentially interesting properties of biological species.

All this concerns the first, unspecific dimension of value. The second dimension comes into play when we take into consideration that later generations will not only be objectively prevented from making use of a resource, but may also subjectively react to this fact, both by *knowing* about the irreversibility of the loss or change and by *regretting* it. Knowledge and regret have to be taken separately, for there may be knowledge without regret: If there were a method of irreversibly making a deposit of nuclear waste inaccessible and preventing it from interacting causally with the environment, knowledge of irreversibility would hardly be regretted. On the contrary, this knowledge would rather be a source of comfort, since there would then be no risk that the dangerous inheritance might be put to negligent or criminal use.

These two aspects are not exhaustive, however. There is a further aspect of irreversibility to be taken account of in valuation: the involuntariness of the restriction of freedom imposed by the irreversibility. Slavery or addiction - two forms of unfreedom - are bad enough, but they are easier to bear if incurred voluntarily than involuntarily. The fact that later generations are not free to revoke irreversible changes is not an act of self-imposed asceticism, but it is forced upon them as a *fait accompli*. It is true that earlier generations always impose quite a lot on later generations in leaving them a mixed heritage of goods and bads, chances and risks. But with irreversible bads and irreversible risks the case is worse because later generations are left no choice either to tolerate or to eliminate them.

Once these three dimensions of positive or negative value of irreversibilities are recognized, they can be seen to be in principle commensurable with the positive and negative value attaching to the various aspects of reversible changes. Each dimension points to a certain positive or negative value component the aggregate of which can be compared with the corresponding values of alternatives:

1. the positive or negative value of the state brought about by the irreversible change,

2. the positive or negative value of the subjective feeling of being unfree to revoke the change once it has been introduced,

3. the negative value of having this unfreedom imposed on one by earlier generations.

How significant are the two latter kinds of negative value in the case of primarily negative irreversible losses? Are they in any way comparable to the first, unspecific, kind of negative value?

A plausible assumption is that the regret not to be able to do away with a state of affairs caused by earlier generations depends on two parameters:

1. the difference between the utility level attainable within the limits set by the irreversibility and the utility level that would otherwise be attainable,

2. the absolute level of utility to which a later generation is reduced by the irreversibility.

The greater the *relative loss* (the opportunity costs) suffered by the later generation in consequence of the irreversibility, the more not being free to change it will be regretted. Again, this feeling of regret will be more intense on a low absolute level of welfare than on a high one. A reduction of utility on a high level of utility will only be felt as relative deprivation, whereas on a low level, i.e. subsistence level, it will be felt as an actual harm. For example, the average West European will have great difficulties in finding in his natural environment many or even most of the song birds he finds referred to in the folk songs or in the literature of his cultural heritage. Mostly, their habitats have been irreversibly destroyed by the spreading of residential areas, by the expansion of industry, and by the methods of modern agriculture. This inability will, however, be much less of an existential threat than the inability of the inhabitant of the Sahel zone to make a living in consequence of the irreversible deterioration of his natural environment by desertification. It is easier to cope with not being able to recover a foregone benefit than with not being able to defend oneself against harm. There are many things human beings can get accustomed to, especially when there is no hope that things will get better in the foreseeable future. But adaptation has its limits, and they show up in situations of real hardship.

Moreover, valuation of irreversibilities clearly depends on cognitive factors. The calculation of consequences will yield a different result, for example, if those living in the future will know nothing about the alternatives that were open to earlier generations. The thought that the deterioration in their living conditions may be due not to any purely natural processes but to actual choices made by their forefathers may be completely alien to them. (How many people around the Mediterranean know that deforestation of their landscape is the direct result of - however uninformed - human choice?) In this case a feeling of being restricted in one's options by others will not arise. Though the restrictions are objectively indistinguishable, they tend not to be viewed as such, and the whole range of emotions attached to them will be different. Freedom and unfreedom, in the relevant sense, can be taken to be positive or negative values, however, only if these are actually felt. A dictatorship such as Orwell's Oceania, in which not only the entire documented heritage of music and literature is destroyed in a cultural revolution, but in which threats of draconic punishment successfully prevent the reconstruction of any of it from memory, would produce regret only in the first generation. The feeling of having lost something of importance, acutely felt in the first generation, might well have completely disappeared in the third. The second dimension of negative value has no further role to play. There would, however, remain the essential contribution of the first, unspecific dimension of negative value. Without adequate substitutes, human life would be objectively very much poorer.

Something analogous to this fictional case seems to hold good for the very real process of biological extinction. The disappearance of a species of butterfly from the earth due to the unchecked expansion of human technological civilisation is nothing that seriously afflicts many people. It is rather improbable that, apart from temporary sentimentalities, our grand-grandchildren will seriously miss that particular species. It is by no means idiosyncratic, though, to wish that the opportunity to make acquaintance with living specimens of the species does not become irretrievably lost. The lost opportunity amounts to a very real loss of possible experience even if it is not felt to be such - at least if there are no other possibilites of experience to make good the loss.

There are a number of good reasons, then, to prevent irreversibilities, though these reasons will not always be good enough to warrant a categorical prohibition, irrespective of considerations of costs and benefits. There is no one single principle on which one can rely in deciding whether introducing, or not preventing, irreversible changes in the natural or cultural environment is justified. Each case has to be judged on its own merits. However, since our knowledge about the future is severely restricted (including our knowledge that a change believed to be irreversible is in fact irreversible) and since it is better to err on the safe side, we should at least hold up a presumption against introducing or letting happen irreversible changes which with some probability will either harm later generations or impoverish their lives. (Analogously, there should be a presumption in favour of irreversibly eliminating a source of harm or risks for later generations.) In each case, the presumption can be refuted by good reasons to the contrary, such as prohibitively high costs for people today. It cannot be right that people living now are made to suffer serious hardship for the prevention of some abstract and as yet indeterminate dangers for later generations.

4. Assessing long-term technological risks

The last problem in the moral evaluation of potential long term technological impact I shall discuss is the thorny problem of the standards of risk assessment, the problem of what weight to give to the potentiality of disastrous long-term consequences of modern technology in relation to their short-term benefits.

In practical decision making about the introduction or non-introduction of modern technology elements of *risk* and of *uncertainty* are usually irresolvably intertwined. In theory, however, there are advantages in holding risk and uncertainty apart, because they call for very different treatment. A *pure* risk situation can be characterized by three conditions:

1. All possible consequences ("outcomes") of the decision are known;

2. to any one of these a positive or negative value can be assigned;

3. to any one of them a probability can be assigned.

The "can" in the second and third conditions of this characterization is here understood in a *broad* sense, that is, there is no requirement that the estimates of value and of probability are in some way based on "objective" data. I think, in other words, that the availability of "subjective" estimates of value and "subjective" probabilities is perfectly sufficient for a decision situation to constitute a risk situation, so that decisions involving such subjective estimates should be subsumed under the general decision rules for risks and not under those for uncertainty. Subjective probability estimates should not be overvalued, but they should not be undervalued either. As Howard Raiffa has pointed out, they represent the estimates of an instrument of prognosis, the human brain, the capacity of which for processing information is unrivalled by any explicit analytic procedure. The only alternative, moreover, is singularly unattractive, namely viewing the future as completely uncertain wherever objective probabilities are not available. Intuitively, there is clearly a difference between merely abstract possibilities with probability zero on the one hand, and real possibilities with a positive, but perhaps hazy probability on the other. For use in decision making, subjective probability estimates should meet some criteria of validity, however. They should be sufficiently stable over time, they should be given on careful consideration of all relevant information, and they should react to unforeseen changes in the relevant information.

Let us assume that there are a number of long-term consequences among the consequences the decision maker has to take into account (such as leakage of nuclear waste into the environment or extensive migration of millions of people consequent upon the destruction of vegetation by climatic changes) and that the decision maker is the ideal intergenerational universalist, i.e. is perfectly impartial between his own lifetime and the lifetimes of succeeding generations. While for a decision-maker with a preference for his own life-time (and that of his nearest associates) Keynes's saying holds: "In the long run we are all dead", the intergenerationally impartial decision maker will give adequate attention to the fact that later generations will have essentially the same needs and vulnerabilities as the members of the species living at present and will be similarly affected by environmental and cultural catastrophes.

What is the rational risk strategy for such an intergenerationally impartial decision maker? My suggestion is that in a pure risk situation, i.e. with an exhaustive overview of all possible consequences, such a decision maker will have to be much less risk-averse than a decision maker confronting a less extended time-horizon. With similar risk situations arising again and again in time, the law of great numbers comes into play. Even for technologies with a potential for wreaking very heavy damage, it could be argued that their frequent benefits compensate the infrequent damages done by them. Even if the one particular generation affected by a disastrous accident such as a nuclear failure involving extensive contamination cannot expect full compensation for the harm done to it, the series of generations taken as a whole can, because the accident probability may be so low as to leave most generations unscathed. They reap the benefits for which one generation has to pay the price. Adopting a decision rule expressing neutrality to risk, such as maximizing expected utility, would be fully in line with the decision makers' intention to secure the greatest net benefit for the aggregate of generations, even if he would have to "sacrifice" the welfare of one generation for the welfare of the others.

This result seems paradoxical. For it is contrary to a well-entrenched moral rule for decisions under risk, namely that it is unobjectionable to follow a risk-neutral or even risk-prone strategy whenever the decision affects only oneself, but that a more conservative strategy is called for whenever the decision affects others as well. We do not generally object to someone jeopardizing his own life in pursuit of a highly risky kind of sport or pastime. We do object, however, to someone jeopardizing the life of others in the same pursuit. Nicholas Rescher, for one, has recently endorsed the postulate that decisions the potential negative outcomes of which have to be borne by others ought not follow a risk-neutral rule (such as maximizing the over-all expected value), but a more risk-averse one. According to Rescher, the question the decision-maker has to put to himself is not, how to maximize the value the others can expect from his decision, but the question (in his words): "What is the cautious thing to do - the thing which would least lay me open to reproach and recrimination should matters go wrong?" (Rescher, p. 161)

The contradiction between Rescher's conservative principle for decisions affecting others and the rule of expected value maximization may seem irresolvable, but I do not think that it ultimately is. The solution lies, I think, in taking a broader view of the dimensions of costs and benefits relevant to the issue. Differently from what one may be tempted to think, there are conditions on which a certain amount of risk aversion in decisions affecting others is perfectly compatible with the rule of expected value maximization.

First, let us be clear about the fact that adopting a risk neutral rule of expected value maximization on a *theoretical* level does not imply that it is the best thing to follow this rule *in practice*. Under certain conditions, what the expected value maximization may require one to do is just *not* to apply this rule directly. There is a useful parallel to this seemingly "paradox" state of affairs in utilitarianism: adopting utilitarianism as a general theory of ethics may not require, but even may forbid, the direct application of utilitarian ways of thinking to the solution of practical dilemmas. (Think of Hare's two-level theory of moral discourse). One factor that makes a more conservative rule seem more appropriate in practice is the presence of *insecurity*. The insecurity generated by following a risk neutral decision rule in practice can be a disvalue to such an extent that it is not offset by any of the other advantages of this particular decision rule. A decision rule that is optimal with regard to the possible outcomes of the decisions made, can be far less than optimal if not only the costs of the *outcomes*, but also the costs of the *choice of the decision rule* are taken into account.

This is evident from the case of insurance. The overall utility of insurance is not the same as the sum of the utilities of the potential payments made by the insurance in compensation for damages multiplied with their respective probabilities. An essential part of its overall utility is the security that compensation is paid in case of loss. For someone for whom this safety has a high personal priority it can be rational to buy insurance even if others with a much lower preference for security may hold it to be far too expensive, given the probabilities of the losses to be covered. The utility of subjective security is as much a real utility as the utility of potential outcomes (payments), and in judging the rationality or irrationality of a decision under risk they cannot but be taken seriously.

Empirical data on the prices paid for insurance suggest a rather high preference for security. An intergenerationally impartial decision-maker will have to take this preference into account in deciding on the rules he will follow in practice. If, on the theoretical level, he applies the rule of expected value maximization, he may well find that this rule is followed best by following a more risk-averse rule in practice, whereas a potential direct application of expected value maximization would imply heavy insecurity costs.

Another consideration tends in the same direction. The positive or negative value we assign to the outcomes of risky decisions is not independent of whether these decisions were made by ourselves or by others. Harm flowing from an involuntary risk is usually assigned a far higher disvalue than harm flowing from a voluntary one. Insofar as harms or risks are imposed on later generations by the activities of earlier ones, they are rightly held to be worse than harms or risks flowing from activities of the later generations themselves. Whereas involuntariness usually does not detract from the utility content of a pleasure, involuntariness of an evil makes it far worse than it would otherwise be. Involuntariness is thus a further reason not to expose others to risks one would rationally accept for oneself, though the disvalue associated with it may vary from case to case. An intergenerational decision maker following a theoretical rule of expected value maximization would have to take into account this additional factor, and it would certainly support the tendency to be more risk-averse in practice than in theory.

University of Essen

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INDIVIDUAL AND INSTITUTIONAL RESPONSIBILITY IN TECHNICAL PRACTICE*

Günter Ropohl

1. Introduction

After decades of progressive optimism, technical development, particularly in western countries, has come into a kind of legitimation crisis. Also, there has reemerged the well-known conservative cultural criticism (analyzed e.g. in Wollgast/Banse 1979; Hronszky/Rathmann 1984), it is true, but the hard core of the actual debate on technology has to be seen in the accurate observation of real problems in recent technical development. With a certain justification conscious observers start doubting whether the expected benefits of technization still outbalance the increasing disadvantage. At least, technical change, no longer naively called "progress", has proven to be ambivalent: Although the amazing possibilities of recent innovations still can be seen, a growing number of negative consequences and dangerous side-effects affecting the natural environment and the social conditions of life cannot be neglected any longer. Everybody knows the prominent examples: the case of nuclear power, including the Chernobyl affair; the impacts of microelectronics and new communication media or the dubious perspectives of genetic engineering.

So, the question is posed, who has to answer for those problems and who carries the responsibility for the deficien-

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cies of the so-called technical progress. In analyzing any given case, the careful investigator will find the following statements to be true:

- Not every innovation means social progress as well.
- Innovations are introduced without anybody regarding the ecological and sociopsychological side-effects possible.
- Certain unacceptable side-effects are recognized only when the innovation is already being diffused.
- Afterwards it is difficult to blame an individual person for the negative outcome, because too many people had been involved.

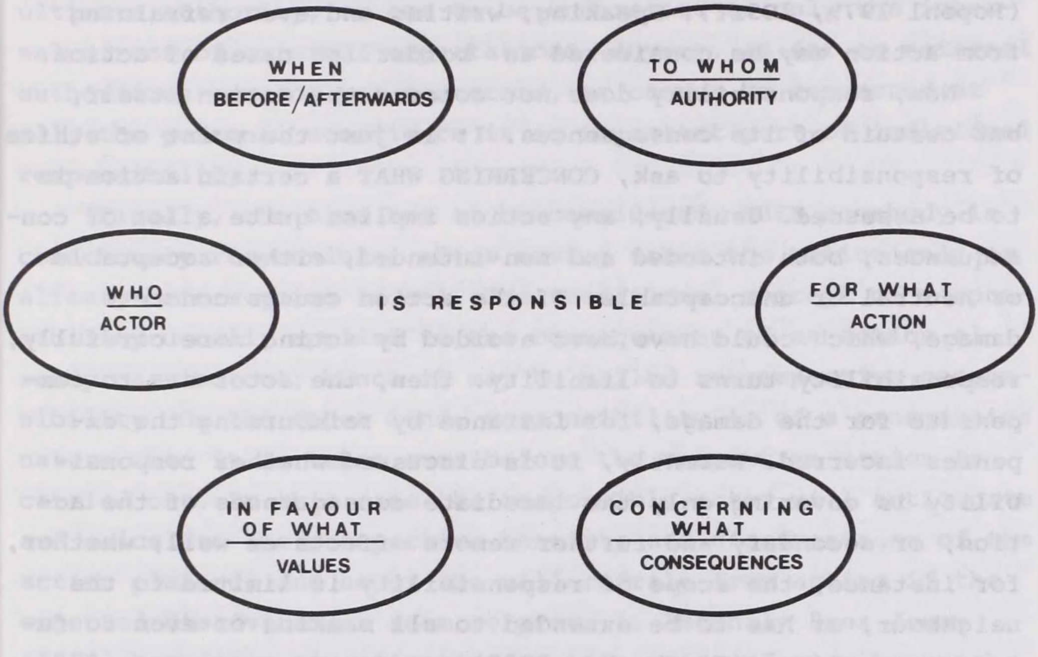
In brief: Technical innovations are being diffused, but nobody takes the responsibility.

The present paper firstly will analyze the concept of responsibility in general. Then, for technical practice two models of responsibility will be outlined and discussed. Individual responsibility, in terms of dialectics, being regarded as the thesis and institutional responsibility being conceived as the antithesis, the last part of this paper will argue for the synthesis of "concerted" technology assessment.

2. *The concept of responsibility*

The original meaning of the word "responsibility" comes from the sphere of law and is known since the times of ancient Romans. To be responsible means to have to respond to the question of the court for what one has done and why one did so. Today, an extended meaning plays an important role in modern ethics, since the concept of duty has been replaced by the concept of responsibility. For instance, the famous German social scientist *Max Weber* (1919) has introduced the distinction between ethics of conviction and ethics of responsibility. While ethics of conviction is bound exclusively to the inherent value of the good and right action, no matter what it could bring about, ethics of responsibility stresses "that we have to pay for the (expectable) consequences of our actions". So, the appeal to responsibility postulates that the actor, in making conscious decisions, is prepared to take the expected consequences of the action upon himself or herself.

On closer examination, the notion of responsibility turns out to be a concept of multiple relations. These relations can be defined on a set of - at least - six elements, which are given in the figure below. Depending on the respective manifestation of the elements and on the kind of relations between those elements, various types of responsibility may be identified. It is not the aim of this paper to develop a general theory of responsibility; but in order to prepare the following considerations, some relevant manifestations of the elements have to be discussed.



ELEMENTS OF RESPONSIBILITY

Figure 1

Obviously, the first question has to be, WHO is responsible. In traditional ethics the individual person only is considered as the subject of responsibility. But, on principle, there is nothing to be said against the suggestion that a collective or institutional actor, such as a group or an organization, may be regarded as a subject of responsibility as well. This view becomes inevitable when a certain action cannot be ascribed to a single individual any more, but turns out to result from the cooperation of several persons, each of them performing nothing but a marginal contribution to the overall action. Next it has to be asked, FOR WHAT the actor is to be responsible. Obviously, he or she is responsible for a certain action, but the concept of an action must be stated more precisely. An action, in the broadest sense, can be defined as a goal-oriented transformation of an initial situation into a final situation; this definition does not apply only to the individual person, but also to an organization and to any other social system, which, thus, may be regarded as an acting system in a non-metaphorical sense (Ropohl 1979, 105ff). Speaking, writing and even refraining from action may be considered as borderline cases of action.

Now, responsibility does not concern the action itself, but certain of its consequences. It is just the point of ethics of responsibility to ask, CONCERNING WHAT a certain action is to be assessed. Usually, any action implies quite a lot of consequences, both intended and non-intended, either acceptable or neutral or unacceptable. If the action causes concrete damage, which could have been avoided by acting more carefully, responsibility turns to liability: then, the actor has to compensate for the damage, for instance by reimbursing the expenses incurred. Recently, it is discussed whether responsibility is covering only the immediate consequences of the action, or secondary and further remote effects as well; whether, for instance, the scope of responsibility is limited to the neighbour, or has to be extended to all mankind or even to future generations (Birnbacher 1988).

Anyway, responsibility can be taken over only if the actor knows, IN FAVOUR OF WHAT he or she is expected to be responsible, to bring about certain consequences and to avoid others. This, however, can only be justified in terms of values. Values may be understood as ideas of normative orientation which mark certain types of actions and consequences as being worth striving for, approving or preferring (VDI 1987, 3). So responsibility, in the end, is not only a formal concept, but it is loaded with content; it would not make any sense without being engaged in moral principles like utility, benevolence and justice (Frankena 1963).

The original meaning of "responsibility" already implies the question, TO WHOM the actor is expected to answer. In the sphere of law, this used to be a legal authority like the court. Other formal authorities might be the employer, the superior or a professional association. An extended concept of responsibility may consider additional, informal authorities, like public opinion, the judgement of colleagues, relatives and friends, or even the actor's own conscience. Certainly, it is disputed, whether the personal conscience can be accepted as a kind of ultimate authority, or has to be understood as only the internal mirror of external expectations. Anyway, as far as external authorities are not yet concerned, or cannot be concerned at all, the personal conscience is an important part of individual responsibility.

Finally, the time has to be considered, WHEN somebody is consciously responsible: after having taken the action only or already before going to act. The traditional concept of responsibility usually applied to the consequences of an action already carried out; hence it may be called retrospective responsibility. On the other hand, responsibility is of a prospective nature when it is taken over before the respective action is carried out. In this case the responsible actor will anticipate and calculate the prospective benefits and disadvantages of the action planned, and he or she will refrain from acting if the expected disadvatanges seem to prevail. Recently *Hans Jonas* (1979) has drawn new attention to this point of view by establishing his "ethics of future-related responsibility". Now, the conceptual framework, outlined before, is to be used in analyzing the related issues in technical practice.

3. *Individual responsibility*

As mentioned above, traditional ethics prefer the idea that only the individual person can take responsibility; and usually they do not take into account any formal, external authority, only the individual conscience of the acting person. This idea of individual responsibility governs the debate on professional ethics in engineering, too. An impressive example may be seen in the so-called codes of ethics, having been established by engineering associations and addressed mainly to the individual engineer (see Lenk/Ropohl 1987, appendix). These codes of ethics, being understood as a counterpart to the Hippocratic oath in medical practice, are expected to determine the engineer to produce on his own nothing but beneficial technology.

A lot of engineers, however, deny this kind of responsibility. They have been brought up with a very narrow understanding of technology being focussed on technical products exclusively and neglecting both the context of development and the context of usage of those products. Obviously, within this understanding there is no place for reflection upon the process of human action and the respective issues of responsibility. An adequate understanding of technics - the word "technics" stressing the aspect of practice, distinguished from "technology" denoting the respective systematic knowledge - may be given by the following extensional definition: Technics consist of (i) the set of useful, concrete, artificial things (artifacts, object system); (ii) the set of human actions and institutions through which artifacts are produced; and (iii) the set of human actions in which artifacts are employed.

Actually, engineers tend to separate those different domains of technics from each other. Even if they admit to be responsible of their producing actions, they pretend the resulting products to be value-free. Regarding the technical means as neutral, producers are not supposed to take any responsibility, because it is up to the user what to do with the technical means. This idea shall be called the user-related understanding of responsibility. A producer-related understanding of responsibility, on the other hand, holds that improper usage is due to the badly designed product, blaming the engineer for any harm which might result from its utilization.

The public debate on technology tends to play these controversial ideas off against each other, engineers shifting the responsibility to the users and the public opinion passing the buck to the engineers again. If these points are made thus generally, the debate does not seem very fruitful. For, in reality, everything is depending on the number of functions incorporated within the technical system. Certainly, there do exist multi-purpose artifacts like the proverbial knife which may be used for cutting bread as well as for killing someone. In modern technology the computer is another example, proving as a multi-purpose system which may be used for better or worse. In cases like that the producer cannot be made responsible for any misuse. But, anyway, even then he or she should be concerned about avoiding any misuse to be expected. This, actually, applies to the knife as well: Christopher Columbus is said to have blunted the points of his crew's knives when, during the crossing of the Atlantic, he was afraid of a rebellion; their shape having been changed, the knives could not be misused as stabbing weapons any longer. On the other hand, there exist specialized artifacts which are good for one purpose only. Then, the producer has determined the way of usage by design, and he or she really is responsible for that kind of usage. For instance, the time-fixed assembly line, which forces the worker to do his or her job with a determined speed, does not allow anything but misuse and thus turns out to be a kind of prefabricated inhumanity.

The distribution of responsibility between producers and users is not the only problem implied by the idea of individual responsibility. Even if the producer-related understanding of responsibility is accepted as far as it really applies, there are certain other difficulties arising. One of these is the limited influence of the single engineer in large organizations. Innovation being rather a social process than an individual performance, the single person takes part in a system of cooperation, based on the division of labour. So, most of the time, the individual is not even able to overview the whole process and all its consequences, to say nothing of controlling it on his or her own. The individual inventor loses control of his or her idea, as soon as it has been published; there is no chance to find a solution when, after having been revised, it turns out to be dangerous, because somebody will exploit the idea anyway. Moreover, in teamwork the contribution of the single collaborator can hardly be demarcated or even identified; frequently, the actor himself or herself is not aware of the actual impact of his or her job. So, the complexity of technical practice makes it nearly impossible to group certain consequences with an individual actor.

Even if an awareness of consequences is possible, individual control and responsibility is restricted by economic and legal dependency. In particular, employed engineers - most engineers being employees, indeed - are bound to the regulations of industrial law; concerning their professional work they are subject to directives and bound to secrecy so that they are not entitled to refuse a tricky job nor even to blow the whistle in public. In the United States of America (Flores/Baum 1980) and in Western Germany (Aktürk et al. 1988) several cases have become known when conscientious engineers and other professionals lost their jobs, and the courts of industrial law which they appealed to decided against them. And certainly there could be found hundreds of less spectacular cases when responsible engineers having the courage to object to the employer did not just lose their job, but had to take serious disadvantages for their career and more. So, the engineer is not very likely to play the moral hero (Alpern 1983), and even if he or she would, that would not change very much, because he or she would be replaced by more submissive colleagues. It would need more detailed investigations to decide, whether, nevertheless, there exist certain leeways for the responsible engineer. Anyway, these considerations exclude individual responsibility as the general antidote against the harm done by technology.

It has to be recognized, however, that ethical conflicts between engineers and their corporations seem to be rather the exception than the rule, and this is due not so much to the moral corruption of engineers, but to their total ignorance regarding the broader context of technology. In their education they never learnt of that, and so they lack any sensibility about the non-technical consequences of technical systems. It is true, the engineer's expertise concerning interdisciplinary impact analysis will necessarily be limited; on principle, a particular engineer cannot be an expert in all the fields which are affected by his work. But if engineers were educated with a careful understanding of their work really affecting natural environment and human life, they would have learnt when to ask the experts of the other fields for advice. Anyway, this is another objection against the idea of individual responsibility that the individual engineer is not at all able to anticipate all the consequences of his or her actions because of the limits of personal cognitive resources.

Moreover, a particular engineer is not entitled to make value decisions on behalf of society unless they have been approved by democratic majorities. Otherwise he or she would run the risk of technocratic presumption, pretending his or her expert values to be valid for everybody. To determine the "real" needs of people is difficult enough within the discourse of social policies (see Moser/Ropohl/Zimmerli 1978); by no means is the engineer legitimated to decide on his or her own, what people really need. If the engineer were to evaluate the consequences of technology exclusively according to personal values, he or she would be likely to behave irresponsibly in a broader sense just doing so.

To conclude this section it can be summarized that there are several difficulties with the idea of individual responsibility in technical practice. Apart from certain small areas of anticipating and controlling opportunity, individual engineers would be overtaxed when being expected to take preventive responsibility for the consequences of technical change; and even in those small areas - which, of course, have to be analyzed in detail - individuals are dependent on institutional support.

4. Institutional responsibility

The consequences of technical practice, actually, cannot be classed clearly with individual persons. Technical developments are increasingly being detached from individual originators; they are, rather, the outcome of a systemic interplay between a multitude of actions than that of individual action. Technical development has to be understood in terms of a social system, and therefore it will now be argued that the normative issues have to be settled on the social level as well. If there is little chance for purely individual responsibility, one has to conceive of institutional responsibility. As this idea is nothing than the other borderline case within the field of possible solutions, an outline of a very extreme model will follow.

Society, being assumed as the actor in technical development, has to take the respective responsibility as well. So, society has to establish a specific institution for this task (Picht 1969, 113). This institution would be something like a National Office of Technology Assessment. It would not perform technical practice, but it would specialize in preventive responsibility. The division of labour between action and responsibility requires, of course, an effective control on technical practice.

It is easy to imagine how this idea would work. Engineers would invent new technical systems as usual. But then, every invention would have to be submitted to that office. In this organization a multidisciplinary team of experts would examine the project, would analyze all the impacts to be expected and would evaluate benefits and harms according to standing values legitimated politically. If some supposed consequences seem to be uncertain, the organization would initiate a pilot project to study the consequences in reality. Then, the National Office would, depending on the overall result, allow or forbid the innovation of the invented system. Only then would engineers take over the project again and would complete their work.

It has to be admitted that the idea of a centralized institution for controlling technical development is the most radical version of so-called technology assessment. Most of its supporters, especially in western countries, prefer more modest versions, according to which the institution, or several of them, would be limited to advisory functions, without being authorized to give directions. Indeed, only then would the institution be able to take on real responsibility. It is to be noted that it was the famous German historian of capitalist economy, *Werner Sombart* (1934, 266), who consistently expressed this prerequisite very early, suggesting a "supreme council of culture" designed to ban "mistaken" inventions and to announce a list of desired inventions. The institution would take on preventive responsibility, because it would test any invention, before it is innovated. It could assume retrospective responsibility as well, even liability, because whatever would happen would be due to the decisions of that central office. Technical development would no longer result from a bewildering mess of partial decisions, but could be controlled by a central agency systematically.

At first glance this idea promises to solve all the problems which burden the individualistic approach:

- Responsibility cannot be shifted any longer from production to usage. Production will be allowed only if the usage seems to be completely harmless.
- The division of labour in development and production will be compensated by an interdisciplinary impact analysis and a holistic assessment.
- If the central agency is as autonomous as a court of justice, there will not occur any dependence on orders and directives.
- The limited expertise of individuals will be compensated by an organized cooperation within an interdisciplinary team.
- Instead of the arbitrary preferences of individuals, the national office will be guided by prevailing values, legitimated by democratic procedures.

That is to say, responsibility in technical practice is to be made effective by a kind of socialization of ethics. Although liberalist thinkers tend to refuse this idea, in some crucial fields of technology it has, indeed, been realized for a long time, in several countries. In Germany, for instance, already in the late nineteenth century associations of technical supervision were established, which originally had been responsible for the safety of steam boilers only, but later they extended their activities to the supervision of elevators, automobiles and other risky systems. It is worth noting that these are associations according to civil law, but they have been given sovereign rights by government; for instance, when they determine a private car not to fulfil the valid standards of safety, they are entitled to forbid further usage. And, also in Germany and also since the end of the last century, there exist building offices in every community, which have to examine and to permit every building project, the small outhouse as well as the skyscraper. So, the suggested national office would be nothing but a gradual extension in competence and scope.

Nevertheless, the idea of institutional responsibility, too, shows certain shortcomings. Firstly, this idea would imply notable restrictions to entrepreneurial autonomy, particularly in capitalist countries. Technical development is a constitutive part of corporate strategy, and therefore, innovation projects usually will be kept secret in face of competitors. All this would be strongly modified by a centralized technology assessment. Governmental and administrative directives would control technical development rather than market forces. So, particularly the mixed economies of western countries would be given a much greater part of public intervention. This basic issue of organizing the economic system cannot be discussed in detail here, of course, but, at least, it had to be mentioned.

Furthermore, the idea of institutional responsibility could lead to bureaucratizing the technical development. Just the German examples, mentioned above, show the respective deficiencies: slow and lazy decision making, establishing innovation barriers and maintaining an authoritarian conservatism. So, the usual presumption of offices could kill liberal spirits and the readiness for creativity.

A third difficulty of that centralized solution would be the necessity of doubling the expertise. The central office would have to develop the same quality of expertise, at least, as that existing in industrial practice. Again, the German case of building offices is an instructive example. Although every building project is calculated by a private structural engineer, the building offices employ their own examining engineers to check the structure calculations. Just that way, for every developing field in technology the central agency would have to employ its own specialists. It is rather doubtful if this would be feasible and if society could afford it.

A last argument against institutional responsibility, at least in the centralized way, is the expectation that the institution would rather prevent than promote technical development. Above all, the central office would be focussed on avoiding harmful impacts of technology. Whenever there would appear the smallest risk, the office would intervene, thus slowing down any change. So, what radical ethics would require in a very questionable situation, namely to do nothing in case of doubt (Jonas 1979) might be reinforced by the internal laws of bureaucracy. If, on the other hand, the institution were supposed to foster desirable developments, it would, in the long run, have to invent and to innovate on its own, and this, of course, would be much more than that office is destined to achieve.

In summarizing this section it can be concluded that the approach of institutional responsibility, indeed, would cope with those problems which could not be solved by the individualistic approach, but it would create new problems of a principal nature. So, this idea, at least in its radical manifestation, cannot be recommended either.

5. Concerted Technology Assessment

The two models of responsibility, having been presented in the last sections, ought to be regarded as ideal types, which are useful to understand the principles. But as the discussion of these ideal types has shown, neither is suitable to improve technical practice radically when standing alone. This result has to be stressed firmly, because the philosophical and political debates on technology still tend to neglect that both approaches are dependent on each other. Professional ethics sticks to the individualistic approach without bothering about institutional support; technology assessment, on the other hand, at least in its "first generation", is focussed on formal institutions and procedures at the limits of science and politics without considering the relevance of individual engagement in shaping technical solutions. The point is that these two ideas should be brought together, thus forming a kind of synthesis.

This synthesis shall be called "Concerted Technology Assessment" (in terms of the baroque concerto grosso, of course, not of the solo concert of romanticism!). A synthesis of that kind is expected to give institutional support to the individuals and individual support to existing and new institutions. Obviously, this new idea is too complex to be elaborated on these few pages. So, for the present, the idea is to be illustrated by some examples, two of them rather fictitious as yet and a third one which is already under way.

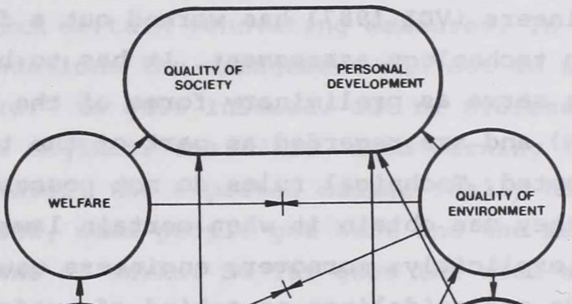
The first example in the beginning, however, is not fictitious at all (Aktürk et al. 1988). A leading engineer, employed by a large corporation, feared that a well-known construction, realized some years ago, would break, unless the corporation undertook certain renovating measures. In spite of his urgent recommendations the management did not do so, but caused the "troublemaker" to quit instead. Out of professional considerations the engineer abstained from warning the public, but some time later, the expected damage really happened: One person was killed, some people got hurt and the material damage ran into millions of Marks. So far goes the real story. And the following is also real insofar as the engineer affected is thinking about it ever since that experience: If there had existed a committee of engineering ethics, he would have been able to appeal to that committee, confidentially, perhaps even anonymously, to discover the case and to protect people from the anticipated danger without risking his own career. So, a committee of engineering ethics turns out to be an indispensable institutional completion of personal engagement. And, of course, the rules of industrial law would have to be changed to enable those committees to work successfully - which obviously means another institutional support.

On the other hand, technology assessment, as carried out usually today, is starting only when a certain innovation is on the run already. And frequently this reactive technology assessment fails to stop a risky innovation because too extensive efforts, both intellectual and financial, have been invested beforehand to give up that development. An innovative technology assessment would do better, which would start with the very beginning of an invention, introducing social values at any moment when decisions have to be made and testing the chances and risks of the new development at all times. But an external office would be unable to do so unless scientists and engineers were ready and willing to give the required information to that institution. This does not apply to a centralized office of technology assessment only, but to a decentralized network of assessing agencies as well. So, the institutional approach, when expected to be successful, on its part relies on the ethical sensibility of the individuals.

In recognizing the indicated interrelationship between professional ethics and technology assessment - this is the last example -, an interdisciplinary working group of the Association of German Engineers (VDI 1987) has worked out a first draft of a guideline to technology assessment. It has to be noted that VDI-guidelines serve as preliminary forms of the national standards (DIN) and are regarded as part of the technical rules generally accepted. Technical rules do not possess legal force as such, but they can obtain it when certain laws or decrees refer to them explicitly; moreover, engineers usually regard those standards and guidelines as a kind of professional authority. So, the proposed guideline to technology assessment will exhibit some institutional force in itself.

The guideline cannot replace a textbook on technology assessment, of course. It rather aims at a general enlightenment of both the engineers and the public involved. So, it explains the basic notions of technology assessment, gives a brief outline of the interrelationship of technology and values, provides a critical review of methods to be applied and recommends a plurality of institutions, including administrative authorities as well as non-governmental organizations such as professional associations, citizens' initiatives and even special working groups in industry, all of them participating in a wide-spread technopolitical discourse. In a central section the guideline supplies a list of values to be recognized in every assessment activity. Figure 2 shows eight main values and some typical relations, both instrumental and conflicting ones, between those values; for each main value, the guideline lists several sub-values to put the general concepts in concrete terms.

The dominant idea of this representation is to make clear that the technical value of performance and the economic value of efficiency basically are subordinate to the quality of life as being expressed by the other values. The guideline does not prescribe - and is not entitled to do so - a definite priority of one value over the other, admitting for instance that there do exist legitimate conflicts between such values as efficiency and the quality of environment - conflicts to be dealt with by political bargaining. There is, however, one prescriptive feature within the argumentation, which says that none of those values must be neglected. Insofar, the guideline contradicts



VALUES IN TECHNICAL PRACTICE

TYPICAL INSTRUMENTAL AND CONFLICTING RELATIONS

Figure 2

the usual practice of technical inventing and industrial innovating, where technical performance and economic efficiency are absolutely prevailing. The guideline cannot define detailed limits to these technical and industrial values, but it makes the point that there do exist certain limits in favour of indispensable requirements of the quality of life.

As a whole, the guideline, when having been ratified, will meet the demands of concerted technology assessment. It will give institutional support to the individuals and encourage individuals to support the appropriate institutions. To foster individual responsibility, the guideline will

- instruct the engineer about the relevance of values in technical practice and help him to overcome the wide-spread technological fix;
- discover that technical and economic values are of instrumental nature only;
- make the engineer sensitive about the relevance of non-technical values;
- give the engineer a list of criteria, with the aid of which he or she can examine his or her technical actions and their consequences;
- communicate to the engineer some basic knowledge on methods and procedures to keep his or her responsibility;
- inform the engineer about appropriate institutions which could help him or her in case of responsibility conflicts;
- represent a kind of safe-conduct for the engineer to refer to when getting in conflict with his or her employer.

To make progress with institutional responsibility, on the other hand, the guideline will

- encourage an improved education of both engineers and non-engineers in favour of the interdisciplinary understanding of technical practice;
- suggest a diversity of analyzing and assessing institutions, including committees of engineering ethics, industrial departments of technology assessment, scientific institutes of interdisciplinary research on technology and, last but not least, governmental authorities to establish the legal frame-

work for controlling technical change and technology courts to watch over the human use of technical power;
- provide working standards for the activities of assessing institutions;
- suggest a normative base to which acts of legislation and of administration may refer when deciding against, or in favour of, certain technical developments.

It remains to be seen whether all these expectations will be really met, but, nevertheless, that guideline seems to be an adequate step towards a novel comprehensive understanding of responsibility in technical practice, combining individual engagement and institutional competence. At last, the ancient Aristotelian idea could come true again in reuniting ethics and politics.

University of Frankfurt
Frankfurt am Main

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ON THE MORAL RESPONSIBILITIES OF ENGINEERS

Éva Gábor

"If a man wants his work to be of service to Mankind, he should not be satisfied with a good knowledge of applied sciences... Care about people should constitute the main aim of all technical endeavour... Human work should be so organized that the result of scientific thinking be a blessing and not a curse for us."

Einstein's words, uttered more than half a century ago in front of students of California Polytechnic State University, are still topical. Professional and lay public opinion is growing more and more impatient and is asking whether the material and human sacrifices demanded by technical progress should necessarily keep growing, or whether, in order to preserve the good name of the profession, the time has not come for the engineers themselves to take energetic measures and bring effective pressure to bear on those engineers who violate ethical norms.

The key figures of our time are engineers whose specific scientific-technical knowledge, skills, vocation and moral attitude enable them to fulfil the requirements of their profession. Should any of these qualities be absent an engineer is hardly capable of fulfilling these requirements. Therefore it is not by chance that we often find engineer training institutions and bodies for safeguarding engineers interests in the forefront of the movement whose main goal is to revise the norms of thinking, behaviour and action expected from the profession and shape them to the requirements of our time.

The richest sources of literature on ethics for engineers are at the disposal of the national and international organizations, associations and societies of engineers* that since the seventies have laid more and more emphasis on training and post-graduate training of engineers in social and human sciences, and in ethics in particular.

After analyzing case studies collected from various countries and regions, FEANI research workers came to the conclusion that in most cases the breakdown or malfunction of technology caused by engineers can be explained not by lack of appropriate professional training but by lack of certain human qualities, capacities and by narrow thinking on the part of engineers, by their insufficient degree of vocation and moral consciousness.

Cases - case studies - case morals

The moral responsibilities of engineers provided the focus of the debates of the symposium** organized in 1983 by VDI, an association which examines the activities of engineers from several points of view and has accumulated considerable experience in this area. The opening lecture was delivered by H. Lenk, professor of the Department of Philosophy of Karlsruhe Technical University. In the light of various case studies he analyzed the situation of the 80s, which he found alarming owing to a gradual decline of ethical standards among engineers. Here we recall some of the cases presented and analyzed by him.

The small car named "Pinto" started causing problems as soon as it appeared on the market. The American firm that produced this car had decided at the beginning of the design phase to undercut its competitors by a radical reduction of produc-

*FEANI - Federation Européenne d'Associations Nationales d'Ingénieurs. - SEFI - Société Européenne pour la Formation des Ingénieurs. - VDI - Verein Deutscher Ingenieure. - CSEP - Center for the Study of Ethics in the Professions, USA. - ASEE - American Society of Engineering Education and others.

**Verantwortung der Ingenieure - J. Lenk - Vortrag in der Sitzung der Bereichsvertung - Technikbewertung am 23. Februar 1987. Mannheim. (Manuskript) tion costs. The planned cost of the bumper suggested by the constructors would have been 11 dollars, but it was replaced by a 5-dollar plastic version. Eleven and a half million cars left the factory with a bumper that was utterly inadequate for its purpose. The "result": an average death toll of 180-200 per year and tremendous material losses.

Public opinion cast the blame on engineers. "Why didn't they protest when they found out about this? Perhaps they were in on the deal..." - grumbled the customers. Later, when the press began to air the question, it turned out that some engineers who at the very beginning had warned the managers about the serious consequences to be expected were dismissed while some others who made remarks shortly after the tragic accidents were demoted. The engineers felt that they had risked as much as could have been expected of them but the association of engineers disagreed.

In no circumstances can engineers act in complicity with those who consciously violate technological norms - was the verdict of the competent body of engineers. It would be better to avoid cases where engineers suffer in these or similar circumstances but if there is no other way to expose such manoeuvres and thus prevent serious tragedies there must be "engineer-victims" ("Helden-Ingenieure"). Naturally, engineers should not then have to defend themselves alone; the organizations which exist to safeguard their interests should definitely take up their cases. In practice especially in constitutional states engineers who enjoy the support of organizations safeguarding their interests win this sort of case.

During the above-mentioned conference of VDI H. Lenk cited another illuminating case. Once again, the scene is the United States. The chief engineer of the factory where DC-10 aircraft were produced noticed during the last checking phase that the safety door did not close perfectly and informed the responsible person that the plane could not be put on the market with such a serious technical fault. The financial managers of the firm decided to disregard his warning, referring to the fact that the terms of delivery had expired, but promised to correct the fault before the testflight. (Of course they did nothing of the sort). Then the chief engineer repeated his protest in written form. The manager of the firm ignored this protest as well. The test flight took place 15 days later. The test pilot was killed over Canada. (This happened in 1972) The factory still left the memorandum of the chief engineer unmentioned. Shortly after this the most terrible air disaster so far took place: the safety door of a DC-10 plane opened at a height of four thousand metres 346 people were killed in the crash.

The investigation proved that the crash was caused directly by a technical malfunction but that this malfunction was the result of human (engineer) negligence. In the indictment the engineers were asked if they had done everything to ensure that only safe planes left of the factory. If they noticed this defect did they warn the management of the factory in time? If they did but their warning was neglected did they do everything to prevent the probable tragedy? The engineers asked in their turn what they could have done apart from definitely warning the management of the factory of the serious technical malfunction?

The court did not accept the engineers' plea and ruled that they could have protested and intervened even at the last minute: they should have made the situation known through the media. No doubt this would have had existential consequences as well but the case would certainly have been won by the engineers. ASEE, the organization safeguarding the interests of engineers made a similar statement.

The following case-study is also worth mentioning. Three engineers of the Bay Area Rapid Transit (BART), a firm producing railway rolling stock noticed that the automatic control system of a null seria locomotive did not work properly. The warning was hushed up by the management of the firm. Then someone (not one of the engineers) published the facts in the press. The three engineers were dismissed at once. Shortly afterwards the first serious accident occured.

According to the ruling of the court the three engineers behaved properly; morally they were blameless and could not be sentenced by law. The firm was obliged to pay damages to all three. The engineering profession also took a stand in this case. Most engineers approved of the sentence and shared the opinion that in cases like this engineers should take such a risk even if it involved - though only temporarily - disadvantageous consequences. A small segment of professional opinion however maintained that an engineer should not be a "martyr"; such sacrifices should not be demanded of him. The association of engineers seconded the opinion of the majority, saying that in the interests of the good name of the profession, engineers should condone only *legally, humanly and morally proper actions*.

The engineering profession - stressed H. Lenk during the VDI symposium - has to take a firm stand in any case where an attempt is made to persuade an engineer to assist in violating technological norms. Engineers who allow themselves to be corrupted should receive even harsher treatment - reads the relevant resolution of the VDI. In certain cases even exlusion from professional practice should be seriously considered. Professional opinion should never remain indifferent when it has to take a stand in questions of engineer ethics.

Nowadays we often find cases where, because of the complex way in which tasks are distributed and shared it is extremely difficult to find out who is responsible personally, legally and morally for an accident in a factory, a manufacturing firm or a nuclear power station, where at some point in the industrial process a serious omission took place. The most characteristic examples of such cases are breakdowns in nuclear power plants, which have become all too numerous in the last two decades.

The ethical committees of engineering associations and societies unanimously maintain that though it is very difficult (and in some extreme and very rare cases impossible) to establish who is personally responsible, this can never mean exemption for the engineers. Every effort must be made to determine the responsibility of *individual* engineers and once this has been done they must be personally called to account. VDI, FEANI, and other organization of engineers have repeatedly laid down that *collective responsibility is nonsense*: each engineer is personally responsible for his actions.

The last of the case-studies is the tragedy of the Challenger space-shuttle, from which new lessons were drawn by CSEP.*

The Challenger tragedy was studied from the point of view of engineering ethics by the director and a leading expert of CSEP.** In their conclusive study the authors state that the tragedy of the space shuttle is a typical syndrome of engineer behaviour and conflict-solving, the professional and moral lessons of which are worthy of attention.

The specific ethical concerns of the relationship between subordinate engineers and management are often neglected. In production, in business and in administration there is a tacit agreement, according to which engineers are generally "subordinate employees" who execute orders and instructions, wherea managers are "directing employees" who give orders and instructions.

The direct cause of the the Challenger tragedy was that the subordinate engineers and the (mostly military) leaders, the majority of whom were also engineers, were in conflict with one another. Shortly before the launch the leaders suggested postponing the countdown by 24 hours because in their opinion another ground check was necessary. However, they did not give any technical reason.

The subordinate engineers considered this excessively cautious, not to say officious and insisted on the original schedule as they saw no serious reasons for postponement. In th ensuing debate the leaders won and postponed the launch. Given this situation the subordinate engineers decided to use the 24 hours at their disposal to check some parts of the vehicle, and got to work. One group of engineers happened to find the hidden fault in what was known as the O-ring. But 24 hours was not

*CSEP was established in 1976 with the intention of working out the curriculum of ethic knowledge indispensable for engineers, researchers, managers and businessmen. Its activities will be discussed later in detail.

**Weil, Vivian - Davis, Michael: Professional Ethics at the Interface of Engineering and Management. In: Perspectives on the Professions. Ethical and Policy Issues, Vol. 7. No. 1. 1987. p.l.

enough to correct it. They reported this to the chief engineer and new they were the ones who suggested indefinite postponement so that they would have time to exchange the ring. The subordinate engineers did not hide the reason for their proposal.

The leaders, however, insisted on carrying out the previous decision. They found the observation regarding the O-ring exaggerated and thought that the subordinated engineers wanted to "get their own back" because their opinion had not been taken into consideration previously. They give the order to start and only minutes later almost the whole world witnessed the tragedy.

The disaster - as was stated later by commitees of experts - was caused directly by a technical malfunction but in the final analysis it was human frailty that led to the catastrophe. It could have been avoided had human vanity and the fear of loss of prestige not been involved. But unfortunately both were deeply involved. Neither subordinate engineers nor leaders could escape from their narrow professional roles; they lacked empathy in the broad sense of the word.

These and similar case studies are of great importance in the training and post-graduate training of engineers, and explain why institutions of higher technical education, professional organizations and associations of engineers insist on creating a broader basis for human and social studies, introducing ethical studies for engineers, and compiling and applying a code of ethics for the profession.

Hopes attached to a code of ethics for engineers

In highly industrialized countries and regions new codes of ethics for engineers or similar collections of rules have appeared one after another. The majority of engineers accept and find obvious the fact that the requirements become stricter and stricter.

At the end of the 70s CSEP made an attempt to compile a new code of ethics for engineers which would take the situation as it was then into consideration. According to P. Torda, professor of the Mechanical Engineering Faculty of IIT,* chairman

*Illinois Institute of Technology (Chicago).

of the commission whose task was to compile the code, the previous codes lacked an unambiguous formulation of priorities. To whom is an engineer accountable in the first place? Prohibitions were not formulated clearly, no appropriate protection was provided for the engineer so that he could make decisions in critical situations with good conscience and the engineer seeking self-justification for improper actions was not condemned unambiguously.

All these considerations have been taken into account in the new version of the code, in the following formulations:

- An engineer is accountable first of all to the *community* (consumers, users) and only in the second place to his employers. (If he can satisfy the public interest only by violating the interests of his firm he cannot be punished for so doing.)
- An engineer must not allow products which are dangerous, being detrimental to health or physical condition to be marketed.
- An engineer is to refuse in all cases when an attempt is made to persuade him to act against the moral requirements of his vocation.
- An engineer is not to exert pressure on anyone else to act immorally.
- Boards of ethics for engineers are not to accept excuses like: "If I do not do it, someone else will" or "I am an engineer and not a moralist" or "I am only a small cog in the mechanism, if I make a mistake, someone else will correct it."*

The draft of a new code of ethics for engineers compiled VDI at the end of the 70s consisted of three main parts. It contained *prohibitions*: things that an engineer should not do because they are incompatible with his profession, *possibilities:* what he can do in a given situation, what sort of action can be expected from him in certain situations and *imper-*

*Report of the Workshops on Ethical Issues in Engineering. (Ed. V. Weil) 1979 p. 15.

atives which he is obliged to follow under any circumstances in a given situation.

An engineer is responsible not only for the safe operation of technical apparatus and the faultless quality of products manufactured in the process directed by him but for the health of the employees working under his supervision and the security of those who use these products. Engineers who act according to ethical principles, thus exposing themselves to attack must be protected by organizations of the engineering profession.

The personal responsibility of an engineer can not be shared. Neglect of duty should be followed by legal and moral calling to account. Even in the lowest position an engineer should behave morally; a higher post merely increases the responsibility. Shifting responsibility onto others is to be considered immoral. The draft takes the Kantian categorical imperative as the basis for moral norms because according to its compilers no other great ethical system could present an acceptable equivalent.

The code of ethics for engineers - states the VDI - cannot give simple and concrete solutions to all the conflicts arising from moral responsibility. It can undertake only the task of keeping alive the sense of responsibility in engineers and of working out training programs for teaching engineering ethics to under- and post-graduate students. The introduction of this subject into engineer training has both supporters and critics.

The operations of the boards of ethics for engineers are considered indispensable because they have a double task: on the one hand they safeguard the interests of engineers in cases when attempts are made to force them to do something incompatible with legal and moral norms or if they are in danger of dismissal because of their adherence to ethic norms. On the other hand they protect the public against engineers who are unworthy of their profession, try to reform those who violate the norms or suggest that those who are unworthy of the profession should leave it.

VDI fights consistently to prevent the boards of engineering ethics from making any concessions. Indeed, if necessary they propose even greater severity so as not to allow any more Bhopals, Chernobyls and Sandozes. An outstanding representative of ethics for engineers, H. Jonas,* also supports greater severity. If today's negative tendencies continue to develop at the present rate there could be a strengthening of anti-technological and anti-engineer atmosphere among the public, which could lead to unforeseen consequences. People would regard technology as a monster threatening their lives and not as a triumph of reason and creativity.

Leaders of VDI (mostly engineers) have repeatedly stated that the strict requirements accepted by the members of the organization are not directed against engineers, but actually serve their interests. VDI fights to preserve the good name or engineers, to make their professional competence unquestionable and to obtain the appreciation of society at large.**

Insight into the workshop of CSEP

The foundations establishing and sponsoring CSEP - National Science Foundation and National Endowment for the Humanities - stated in the foundation document that though the Centre operates through the ITT at a local level, its activities will be extended to the whole of the United States. Since its foundation CSEP has systematically collected and studied literature on ethics for engineers.

From time to time the Centre organizes conferences during which the most topical issues of engineering ethics are discussed.

Philosophers, ethicists, engineers (teachers-engineers), gather round the editorial board of CSEP's periodical "Perspectives on the Professions". There are problems which are discussed by all teams, such as "Responsibilities of engineers today".

*H. Jonas: Warum die Technik ein Gegenstand für die Ethik ist: Fünf Gründe. In Lank, Hans - Ropohl, Günter: Technik und Ethik. op. cit. pp. 81-92.

**It would be worth taking into consideration the rich experience of the VDI even in Hungary, the more so as the coming period of social and economic development will surely raise a number of problems that VDI has already solved or attempted to solve.

CSEP has concentrated its activity on two major issues: 1. The increased moral *responsibility* of engineers, the task of engineer training institutions in creating a sense of responsibility among the technical intelligentsia. 2. The complex program of *teaching* ethics for engineers.

1. It is not difficult to understand why the question of moral responsibility of engineers is the centre of interest. All too often they have failed to observe proper technological discipline, thus bringing discredit upon engineers in general; the good name of the profession was at stake. There again we found that engineers themselves had started to expect greater severity from their associations, and to demand both the exclusion of engineers unworthy of the profession and assistance for those who were ready to satisfy the increased requirements.

CSEP then started a large-scale campaign. It initiated theoretical discussions, had the topical literature on engineer ethics collected and studied, had case studies made, made well-known experts speak on radio and television. A large special committee worked on subjects concerning the moral responsibilities of engineers.

2. CSEP - as we have already mentioned - supported the view that besides general ethics engineering ethics as a legitimate special discipline should take its place in engineer training and postgraduate training. After a short experimental period this discipline entered American engineer training for all. Today in most technical universities and colleges it constitutes an organic part of human/social sciences training and is considered as indispensable as any other subject in this field. Among its instructors may be found philosophers, ethicists and engineers as well.

It was not by chance that CSEP chose as its motto the eye-catching title of the 1982 conference on ethics for engineers: "Beyond Whistleblowing". Several other associations and societies of engineers share with the experts of the Centre the slogan that Hans Sachsse, a renowned West German philosopher of technology, formulated in the early 70's: "The future of mankind will be determined decisively not by technology but by ethics capable of formulating norms for the humane operation of technology."*

*Hans Sachsse: Technik und Verantwortung. Probleme der Ethik im technischen Zeitalter. Freiburg, 1972.

TECHNOCRACY AND HUMAN PURPOSE.

BEYOND TECHNOCRACY?

E.G. Edwards

The purpose of the present document is to contribute to forming a model (paradigm, imaginaire) of the technocratic nature of domination/oppression in the modern world in the interests of those struggling for liberation, and more generally for human and natural survival.[1]

Part 1. THE RISE OF TECHNOCRACY

1.1 What is Technocracy?

Technology is historically the knowledge and praxis of harnessing the forces of nature for the the survival of man. In the modern world the creation, possession and/or control of technology has become the key to all other forms of domination first of non-human nature but then of human nature. Though the formal or constitutional or legal entitlement to decision making may be vested in the rulers of States, (Generals or Political leaders), or the possessors of Capital, (the *formal owners* of the multinational conglomerates), none of these dare to act (or indeed even know how to) in the major matters which affect social or even individual human destiny, without the sanction of the technocrats. Though this form of social domination differs in many ways from its predecessors, it may be regarded as sufficiently pervasive to justify calling it *Technocracy*.

However, the preceding forms of political, economic, social, cultural, or military control are not so much replaced by the rule of the *technologists*, as regrouped in a new paradigm of social domination, in which the pervasive ethos of modern postivistic, amoral, specialised and fragmented scientistic technology has become hegemonic. They are not so much subject to an *external* technocracy as absorbed into it. Like its other branches, they maintain a great deal of autonomy over their specialised functions, precisely by recognizing the equally specialised autonomy, of their constantly proliferating, coexistent technocratic groups of colleagues. Hence the specialised, but fragmented autonomous roles of the separate sectors of the Technocracy though closely interdependent, cannot entail a principle of *general* authority or responsibility. This fundamental dichotomy in the ethos of the modern technocratic managing and controlling classes lies at the heart of the apparent impotence of the innovators and creators of the vast powers of modern technology to prevent its *abuse* or even to avert its threat of total human destruction.[2]

In this paper we will distinguish between this thesis and the positivistic view still prevalent among *progressive* technologists and scientists that technology and its even more protestingly virginal sister, *science*, are essentially neutral and that the menacing, oppressive by-products of their development are solely due to their *abuse* by the controllers of States or the owners of megabillions of capital. Nor would we consider it sufficient to regard them any longer as merely the ideological contribution of the *organic* intellectual servants of the oppressive classes. That excuse was worn out by Robert Oppenheimer; though his scientific successors still protest that the Atom Bomb was no more than a discovery of what was already there, in Nature, waiting for its *inevitable* development.

Of course they still have to pay a similar homage to the wealth, political *power*, legal entitlement or social status of their bourgeois (or even feudal) predecessors as the emerging capitalist classes of the 18th and 19th centuries did to their aristocratic landowning forbears, and similarly, many technocrats are recruited from these older sources. But just as effective social decision making passed from the owners of land to the owners of industrial capital, which ultimately determined the uses to which the land could be put; so it passes in turn to the owners of technological knowledge which determines the uses to which capital can be put.

1.2 The View from the Moor[3]

On the ancient open moorland, just above my house, archaeologists have recently uncovered the site of the earliest "permanent" human settlements. These stone enclosures, probably of the late neolithic period, relatively much larger than the temporary shelters constructed by the previous wandering groups of food gatherers and hunters, and the characteristic pollen counts found in association with them, indicate the beginnings of the first technology, the systematic domestication of non-human nature, but almost certainly also the concurrent invention of human bondage. The newly invented permanent "property" guarded within the larger stone enclosures comprised the privately owned domesticated plants and animals - and of course the first domesticated human animals, the women.

Turning from the contemplation of these ancient origins of human institutions and the first Biotechnologies which preformed them, on the horizon beyond the opposite side of the river valley, one can just see the tops of the glistening metal spheres of one of the world's largest American Nuclear Missile early warning stations (which is also reputed to be capable of listening to all telecommunication in the surrounding British countryside). The inhabitants of the same countryside have, of course, no access to, and no control over this alien institution, though their very survival is subject to its undecipherable messages, to its network of equally unapproachable missile launching bases and to their power to unleash the holocaust, unfettered by any misgivings by the surrounding natives.

These mere natives, who in relation to the impenetrable networks of expert military and ancillary civil technologists who control their destinies, constitute the vast majority of the human population of the planet, may truly be regarded as the domesticated human animals of the present day.

Technology begins with the attempt of human beings to ensure their food supplies in the increasingly severe climates and relative shortages of resources in the millennia preceding the agricultural revolution. Today the extremely sophisticated military electronic technology which dominates the space age is powered and sustained by tensions arising from the failure or uncertainty of adequate food resources to the majority of the world's population.

In the intervening scores of centuries, although technology has diversified and specialised in the human attempt to control, to manipulate all aspects of the non-human environment (and indeed of the human environment external to the controllers) the dynamics of its separate constituents have always been closely interdependent. The separatist ideologies and methodologies of the increasingly isolated groups of specialists have been contradicted by the actual interpenetration of their praxes. To comprehend the element of self-movement of technology we cannot avoid considering it as a totality.

1.3 Technology as Liberation and Bondage

Technology poses two possibilities for human development: Human Liberation and Human Bondage.

Prior to the Agricultural Revolution, although the growth of the technology of hunting and food gathering helped to liberate human groups from the "massive habits of physical nature - its iron laws which determine the scene for the sufferings of men" (Whitehead), it did not necessarily constitute the basis for human bondage. Although different human groups doubtless came into conflict, it was as a consequence of competition for survival. The possibility of domesticating the labour of other human groups could not in general exist until the possibility of labour producing resources over and above those necessary for mere survival had been created. That possibility was created by the domestication on plants and animals.

This exploitation on non-human nature developed unevenly amongst differing human groups. It required time, the protection of permanent enclosures to gather the harvests and tame and breed the herds. It required the invention of the institution of "property" and the new cultural consciousness which reflected it. Hence the birth of the associated concepts of natural superiority, of the right to domination which reflected the control of property. Hence also the possibility of subordination of the unpropertied, from whose depredations property must be defended. From henceforward, Human Liberation was not merely the Promethean struggle for freedom from the constraints of non-human nature, especially physical nature, it was the struggle to escape from human bondage or to exploit it in the interests of the wider freedom of the dominant groups.

The intervening millennia until our own time have hardly changed the basic character of the domestication of the majority of the human race. The basis of human domination has remained the control of property. But the cultural institutions essential to the necessary concurrent taming of the human mind and spirit, though always reflecting the concepts of the natural superiority of the dominant owning groups, have assumed a constantly increasing importance and degree of autonomous development. This results from their other major cultural roles: firstly in transmitting the technology which has both underpinned the power of the dominant owning human groups, but also transformed it and hence transformed the nature of the most dominant forms of property, secondly in cultivating that co-essential and co-existent, general sense of human solidarity, without which stable human society itself could hardly exist.

1.4 Industrial Technology - The Domestication of Humanity by Capital

Modern Industrial Technology has advanced inexorably to its present status as the foundation of world power since its beginnings in the 17th and 18th centuries. But it was only made possible by the remarkable technological advances of the late mediaeval period mainly devoted to agricultural production which laid the bases both for the possibility of release of sufficient labour from the land and for the developments in mechanical techniques and skills necessary to construct the first industrial machines.

But a relatively large accumulation and concentration of money capital was necessary to exploit and accelerate the primitive possibilities of industrial technology and to underpin the power of rising bourgeois class, the future owners of the future dominant form of property - industrial capital.

It was not accidental that this primitive accumulation of industrial capital took place in England, by no means the wealthiest nation in the advanced world of that day. It was largely provided by the most vast and ruthless domestication of the human animal in history up to that time - the triangular slave trade, from Liverpool to Africa with commercial artifacts and guns, from Africa to the Americas with slaves for the plantations (which were to supply the raw materials for the first industrial production of textiles) and from the Americas back to Liverpool with the enormous profits from this trade in human draught animals. For over a century a principal impetus to astronomy, physics and fine instrument technology arose from the consequent demand for more exact navigational instruments and chronometers. Newton's concept of absolute, infinitely extended space, which has been the principal theoretical basis for modern science up to today, was not found from the contemplation of Nature itself - to which it is indeed essentially foreign - but to legitimate and order a new nature offering unlimited possibilities for universal power. And from the beginning of this period of transition to the modern industrial world, all culture began to adapt itself to the potentialities offered by the new technology and to condition the human mind and spirit to its acceptance, to fulfil the vision of Descartes and Bacon of the Arts as the key to the final human mastery of Nature.

Apart from science, their principal cultural invention, the rising capitalist class refashioned religion, and the Arts to emphasise the values, virtues and ethics of the individual freedom whose enjoyment they were to monopolise, but which was also necessary to free European labour from its deep-rooted attachment to the network of feudal dependence and responsibility, for its rootless complete dependence on the chance of employment by industrial capital.

In the succeeding centuries as the new industrial technology multiplied the productivity of labour it was increasingly able to supply its own source of renewal and multiplication of capital and the expansion of the internal markets to replace reliance on the colonial. The expansion of factory labour became more profitable and flexible, less restrictive and freed from any responsibility for the lives, or health of the human cattle, than the ownership of slaves. Moreover the monopolistic practices necessary to sustain the mercantilism of the slave trade became a fetter on the expansion of the free markets demanded by industrial capitalism. Religiously devout leaders of banking and industry in England who had often built their family fortunes a generation or so earlier, on the slave trade, rediscovered their Puritan conscience. They were intellectually reinforced by the leading cultural innovators of the time - the inventors of the latest science: economics - the true high priests of the new prevailing object of worship - "The Wealth of Nations". The slaves had to be freed.

They were replaced in the so-called *advanced* nations by that form of domestication of the human animal which has persisted until this day and remains the basis of their world power - the industrial proletariat.

1.5 Mass Production Technology - the Completion of Domestication of the Human Animal

The supremacy of industrial capital was based on the unprecedentedly rapid advance of mechanical (and later the beginnings of chemical) technology of the 18th and 19th centuries, but its power could only be sustained by harnessing the production of the more primitive parts of the whole world to its needs. The new world empires of the late 19th and early 20th centuries while founded on the newest form of human domestication - the factory system of the metropolitan countries - relied on their domination of simultaneously co-existing older and indeed some ancient, serf based and slave based, regions for their supplies of essential agricultural and mineral raw materials. In the century and a half of this new regime of domestication of virtually the whole human race, the effect on the survival capacity of the less developed regions of the human race has been potentially fatal. Far from advancing beyond it, their basic capacity to feed themselves has been disastrously undermined. The major unsolved world technological problem remains the earliest, the Biotechnology of securing sufficient food resources.

But in the last quarter of the 19th century, science began to display possibilities of application to technology and to industrial production on a vastly new scale. Particularly was this so of the newest technology, that of electrical power, which because of its ease of transmission over much larger distances and because of its potential transformation of the means of communication, laid the basis for enormously increased size of production units. The age of mass production of commodities was born. This fundamentally new technology like those that had preceded it in previous turning points of technological history, profoundly changed the way in which the control of property orders the institutions of human production and of the very nature of the culture which reflects this control.

The mass production technology of the modern "advanced" world required for its exploitation much larger organisations, eventually multinational corporations, and correspondingly extensive complex infrastructures of public and privately owned services. It therefore also called into being a new form of control, that of the managerial, scientific and technological intelligentsia - the technocracy.

Since the inception of this latest period (from about 1870) the exponentially accelerating expansion of this class - up to 100 fold in the economically leading regions - has been the largest single factor trasforming their social and cultural character.

This unprecedented explosive expansion in numbers has been exactly paralleled by that of the major cultural instrument of the 20th century, the institutions of higher education and research, which have been both recruited almost exclusively from the children of this newly dominant class and ideologically transformed for the main purpose of preparing them for future management. Every previous ruling class has been characterised by an ethos, a cluster of "spiritual" values, an image of the goal of human liberation, with which it has both "justified" its domestication of the majority of the human race (as well as the whole of non-human nature) and normally provided even its serfs or slaves with some prospect, however distant, of their own liberation. The main importance of the cultural (especially the religious) institutions and their leaders to the dominant group has, indeed, been their role of transmitting this image of human destiny and giving it a credibility to that large majority who had, in fact, little prospect of ever realising it.

The characteristic supreme "value" of the new technocracy is that "values" in this older sense are irrelevant. Although they have become the actual operational controllers, particularly in the boardrooms of the multinational corporations of the capitalist world but also in the vast collective enterprises of state controlled economies they have bought this commanding position at a certain price; that of their own moral and spiritual sterilisation. The new technological and managerial professions have surrendered any claim to individual ethical or cultural or spiritual autonomy which the older cultural professions claimed for their members and in some significant degree actually maintained, in spite of their orthodox collective role of justifying the existing institutions of human domination. Their modern over-riding ethic is that it is unethical to permit ethics to interfere with efficient management. It is not accidental that this positivistic ethical nihilism became the hall mark of respectability first in the newly pre-eminent scientific and technological departments of 20th century universities but eventually in the older "humanistic" fields of high culture, and began to pervade the newest intelligentsia, the social or *human* scientists almost from their beginnings, and certainly in their most pervasive modern task: that of circumscribing the human mind in a language in which the terms "*Freedom and Dignity*" have no significance.

In its larger, but operationally indivisible modern sense[4] of that systematic creation, fusion and ordering of knowledge of all kinds to harness the powers of nature and human nature to the domination of both by its possessors, Technology is poised for its final stage in the domestication of the human animal - the final taming of the human mind and spirit - or perhaps the penultimate stage to its ultimate destination - that act of complete domination of all living human and non-human nature - the elimination of life from the planet.

1.6 Technology of Knowledge - Bondage or Liberation of the Human Spirit?

Though each successive period of successful technology has bought its ever increasing control of non-human nature with ever more extensive domination of the majority of human beings, each has been largely powered by the apparently opposite purpose - the liberation of the innovators from their own previous relative bondage. And to accumulate the necessary social power to overcome the inevitable resistance to the overthrow of the old order they have been forced to represent, and even design, their own liberation to be (at least in some aspects) a prototype for that of much larger strata of the race - eventually even for the whole of humanity. Each successive phase of human culture has carried simultaneously twin messages: that of the vision of human liberation, and that of the inevitability of human bondage. And each stage of human bondage, though usually more extensive and penetrating than the previous, has usually registered some net gains in liberation, usually from massive constraints of physical nature, of disease, famine and premature death at any rate in the "more advanced" parts of the world - the home bases of the successful innovators. On the other hand the power of human destruction has advanced in practice and potentiality in parallel with that of survival and in the last decades has attained the possibility (perhaps probability) of ending in complete human annihilation.

The leading edge of economic production today passes from that of material commodities to that of Knowledge itself, based on the technology of micro-electronics and that of sub-nuclear particles which provides the vast new power sources at the service of the new knowledge systems and their technocratic controllers. In principle these make possible the supplanting of the human mind itself, as the ultimate director of the domestication of Nature, by artificial intelligence. The increasingly impenetrable closed worlds of the technical experts could close in on themselves. Their only remaining values of accuracy and efficiency in the collection and ordering of dispassionate scientific data could render them redundnat compared with the infinitely more accurate, extensive, reliable and rapidly self-ordering data banks of the future generations of micro-computers. The final generation of human domesticators would finally be domesticated.

But there is another possibility, hinted at throughout this paper, which cannot be the subject of analysis but remains the subject of human vision, as it always has been, and always of sufficient partial attainment, however temporary, to render it more than merely credible. All previous forms of newly prevailing technology have relied on their ownership or control by social groups which could never be more than a minority. But the creation, ownership and control of knowledge itself can now, potentially, be returned to the whole race, though it will need to metamorphose from its present narrow aridly dehumanised language - to reflect the totality and essential interdependence of human consciousness - to do so. So the final domestication - that of the human mind and spirit - could be finally reversed and in its reversal, terminate the age of domestication of the human animal. It is even conceivable that the re-realisation of that essential human interrelationship will propel us to stand in the same relationship not only to all human beings but "to all beings and things which come to meet us in Nature" (Buber).

The termination of the domestication of humanity may end the rape of non-human nature, indeed may be impossible without that end. By contrast, the "nuclear winter" which looms as the inevitable consequence of the deployment of the latest military technology in world conflict must almost certainly complete the subordination of both human and non-human life to universal death. The elimination of this threat becomes the supreme present task commanding all the resources of interdependence and invention which have always sustained the vision and struggle for human liberation.

Part 2. THE ROLE OF HIGHER EDUCATION

2.1 What is Higher Education?

Universities have existed in Europe for over 900 years. For nearly all that period they have dominated the process they largely took over from the monastic orders of the preceding centuries - the production of the intellectual leadership of their societies, the essential cultural aides to the dominant social classes, the legitimators and legislators of the ruling doctrines on the nature of man and civil society, and the relation of both to God. (The first two universities were devoted to medicine and law respectively and the third asserted their claim to theology).

To these they added much later, indeed only in modern industrial times (and after a historic lag of nearly two centuries when they declined and were partly superseded by the academies and scientific societies), the regulation of the doctrines of the nature of nature - science and engineering; and finally the nature of social communication (and of all the arts which serve it). In general, throughout the modern world, Higher Education may be considered as the kind and level of education pursued in Universities. Their world hegemony of this cultural role has only been highlighted by its temporary, partial usurpation by the English Dissenting Academies and Scientific Societies of the 17th and 18th centuries or the French Grandes Ecoles and German Technischen Hochschulen of the 19th or the Polytechnics and the specialised Scientific and Technical Institutes of the 20th. These have not so much substituted a new kind of social cultural role, but, in particular regions and times, piloted new emphases or fields, later to be adopted if selected for their survival value, by the generality of universities.

But this remarkable capacity for survival is a testimony not to some uniquely stable gnoseology, some semi-permanent revelation of the nature of culture, to which they are privy, but rather to the opposite: to their adaptability - their capacity to absorb radical change in their objectives, methods, and even their concepts of the nature of the truth - to serve the changing needs of the dominant social classes of their times - for whom their proper function was to produce the essential cultural mediators, legitimators and consolidators of their powers. This is hardly surprising, since they have always largely been funded and in recent centuries largely populated by the same social classes.

The modern concept of the academic autonomy of the secular university is largely a product of that political liberalism which recognized that in a competitive market economy, the universities could only carry out their general social cultural role of serving capitalist society as a whole, if they were to a large extent protected from the hurley burley struggle between the individual economic masters.

But their necessary degree of autonomy also derived from the (occasionally enlightened but ambivalent) perception by their masters, of their complementary function (there from the beginning but swollen to enormous power in the present century) of nurturing that dynamic of *technology* which is both the source of power of survival of a social system, but also the potential cause of its obsolescence and replacement.

For in its larger, but integral, sense, (Sect. 1.5. ref 4 above), technology must continually develop that critical function which constantly re-appraises the limits of the existing control over natural and human potentialities, in seeking to extend it. But it can hardly perform this role without that degree of social, cultural and ideological enquiry which must make the existing order and its canons themselves the subject of speculation and the legitimacy (or even survival value) of its possessors the subject of critical examination. It is thus, this essential critical function of the dominant intelligentsia which provides the possibility of the nascence of cultural/ideological rebellion within its own ranks.

Higher education is that level appropriate to the dominant social classes of society, (and their essential cultural aides) those who make decisions, give orders, design systems (whether technical, economic, political, social or cultural). In modern society the possession of completed higher education is, broadly speaking, the necessary entry ticket to the technocratic sectors of society. Until the very recent past, although this level of education was an essential resource to the rulers of societies, it was not necessary for them to possess it personally. The services of the highly educated: the clerks, priests, doctors, lawyers, artists, writers, even generals and more recently engineers and scientists and communication specialists could be purchased or patronised. The question of *How Many?* was settled by the demands of the masters of society which in turn were determined by the needs of the prevailing *technology*.

2.2 The 1960s. The Decade of the New Intelligentsia

The decisive breakthrough of the new, technocratic intelligentsia to the centre of the stage of world power may be located in the decade of the 1960s. This may be most generally indicated by the sharp and sudden and remarkably uniform acceleration of the exponential expansion in the numbers of university students throughout the *advanced* world during this decade.

The escalation of University expansion in the *advanced* world of the 1960s was not principally due to any marked extension of the franchise of Higher Education to the lower social classes which had not previously enjoyed it. It was mainly caused by a jump in the participation rate in Higher Education by the leading professional and managerial social class. The steady exponential growth in this class, since the closing decades of the 19th century had been triggered off by a technological revolution giving rise to new, potentially massive changes in industrial productivity and in the size and complexity of productive and social organisations. By 1960 their more than tenfold exponential expansion in proportion of the working population mirrored the parallel exponential expansion of the universities largely populated by their children.

In the 15 years from 1957, the proportion of their sons entering Higher Education soared from a previously stable level of about 25% to as much as 90% in all *advanced* countries. It marked a new transition in the nature of *technology* in the above larger sense - to a *technology* of knowledge itself. The knowledge revolution was already beginning to transform the levers of power and privilege. To stay at the top it was necessary to climb on the Higher Educational bandwagon, and inevitably the most socially alert sections of the growing professional and management hierarchy had first seen the writing on the wall.

Paradoxically, the 60s are claimed (somewhat nostalgically) by the radical left intelligentsia as *their* decade, when the campus became the heart of social revolution, when every tenet of social cultural and political orthodoxy was challenged, when the student revolutionaries became for the time being the masters of the streets of first Paris and later Tokyo; when the mightiest military power in history was forced to retreat not merely by the resistance of the Viet Cong and the North Vietnamese army, but, as much, by the rebellion on its own university campuses.

Yet both the source of the demand and the destination of the large majority of the threefold expanded graduate numbers (including most of the *rebels*), resulting from the escalation from 1957 to 1972, was precisely the new managerial, scientific, technical and communication requirements of just those, Multinational and State conglomerates against whose world domination the student rebellion was directed. Indeed as Alain Touraine pointed out at the time, the primary cause of their anger was precisely the inevitable resistance of the *old* management to the new generation which was destined to take over its place at the controls.

Nevertheless, the student rebellion of the 60s dealt a major ideological blow to that élitism of the universities which the concurrent explosive expansion of student numbers and the underlying demand in the advanced countries for a continually expanding managerial, professional class, had demonstrated to be without any pragmatic foundations.

The idea of *éducation permanente* was born; the implicit goal: Higher Education for Everyone.

(Could this be the clue to the ultimate harnessing of Technology to Human Liberation, to eliminating its historical parallel role of Human Domination, to the fulfilment of a world *Beyond Technocracy?*)

The virtual attainment of this goal in the top echelons of the managerial and professional classes (which was the main operative pressure behind the uniquely rapid escalation of the 60s) was bound to lead to an immediate drop in the pressure for expansion in the early 70s. The economic recession of the subsequent decades and the fact that the cost of Higher Education was now for the first time becoming comparable to and competitive with other major sections of public expenditure, led to a general lag in the supply of Higher Education places below the real (and very much more below the potential) expansion of *qualified* applicants. But this lag was internationally uneven, most in countries least confident of taking a lead in the new knowledge based economies, least in those determined to obtain a major share of these fields. Though the manufacture of Technocrats is not a simple recipe for national political and economic power in the modern world, it is their efficient utilisation which is the most valid index of the redistribution of its possession and of control of the latest forms of neo-colonialism.

2.3 Universal Higher Education: The Concordance of the New Intelligentsia

The modern objective of universal Higher Education was born from the (forced?) marriage of apparently diametrically opposing interests: on the one hand the need for a greatly expanded intellectual elite to sustain the drive to world economic (and hence political social and cultural) domination by the multinational conglomerates (in which they conceive themselves to be in competition for the same objective with a corresponding expansionist, but less developed group of vast State collectives) - and on the other, the need by those equally rapidly expanding, but more diverse social movements, whose objectives share a common vision of *liberation* from one or the other or both versions of *big brother*.

For the latter group, universal higher education is an essential goal to assist in the "conscientisation"of the large majority of the world's people to the possibility of their liberation from domination by the former and to arm them culturally for its attainment.

The *activists* on both sides of this *intentional* divide meet in the modern university and indeed even interchange self images and roles. Moreover they are largely united in their rejection (though for opposing reasons) of the older cultural *élitism* and their search for *applicability* or, more generally, *intentionality*, in their intellectual objectives, rather than the positivistic, *knowledge for its own sake* self-image of their predecessors. Each tend to consider Higher Education as the essential tool to make social revolution (though with opposite connotations of its nature), rather than as the key to the discovery of absolute truth. Each tend to consider the intelligentsia as the new revolutionary class, the prime agent of social change. Each are concerned with the multiplication of their own kind as the key to survival of their corporations or their communities, their national economies or their international networks. But thereafter, their concordance appears to break down.

2.4 *The Dichotomy of Objectives for Expansion of Higher Education*

The future managers of the multinationals must, for the latters' survival, seek to advance and protect just that amoral, instrumentalist, *business is business*, view of *intentionality* in the pursuit of knowledge and the corresponding apotheosis of *efficiency* as the essence of their own role. And their expansionist tendency is bounded by the capacity of their companies to expand and severally or in national or transnational blocs to dominate the external economy. But both the domination of economic giants and the domination within them of an intellectual élite must be, and *is* actually balanced by an equally expanding world of under-development, subject to their domination, and by the ever more rigorous exclusion of its under-educated peoples from the participation in the control of the giant enterprises which determine their own lives.

All other forms of social and international domination give pride of place to the domination by the corporate possessors of new knowledge over those societies which do not and the domination of those who have higher education over those who have not.

On the other hand the intelligentsia of *liberation* are faced with a dilemma. Precisely the possession of that knowl--edge which is the key to domination, but whose critical role can reveal its *illegitimacy* and even obsolescence as an instrument of human survival - can separate them from the *oppressed.* As Paulo Freire put it "But while to say the true word which is work... is to transform the world, saying that word is not the privilege of some few men, but the right of every man... Consequently, no one can say a true word alone, nor can he say it *for* another, in a prescriptive act which robs others of their words.". The implicit goal of the radical élite: the *destruction of their own élitism,* lives uneasily with the modern university curriculum. This is not because the latter is intellectually inaccessible to the majority of the people. There can be no reason to believe that the African, South American or

Chinese people are genetically less intellectually capable than the Japanese. It is because the forms of knowledge it pursues and transmits have developed to serve purposes and systems (*technologies*) of domination which can hardly be applicable to the *liberation* of the whole race and even less to the whole of the living planet.

That cultural revolution in the *nature* of learning, the Great Instauration of the 17th century, embodied the Baconian vision of the domination of man over nature but led inevitably to that determinism which legitimates the domination of man over man, the domestication of the human animal. The scientistic optimists, the 20th century heirs of the Baconian vision may still dream that a mere change of management will suffice to reverse its prospective nihilistic final destination, will suffice to tame the thermonuclear bomb before it annihilates all life. Other leading scientists of our day challenge the axiomaticity of its models of nature and human nature: see its determinism as applicable only to those *closed* (thermodynamic) systems[5] which do not so much reflect nature *as it really is* but are artificial constructs designed (as it were, as cultural cattle enclosures) for the purpose of the domestication of nature (and human nature). The problem for the intelligentsia of *liberation* is whether their own culture (which is predominantly the existing university culture in the *advanced* world) can ultimately serve their purpose, or whether it must undergo a *sea change* at least as cataclysmic as that which gave it birth at the beginning of the modern world. And, if so, can they be the agents of its birth or how are they to give place to *the right of every man* to displace them, to devise the new *true word* for themselves?.

2.5 The Social and International Apartheid in the Possession of Higher Education

While the main pressure for more higher education in the *advanced world* has been the exponential expansion of the managerial and professional classes and in the 60s the dramatic escalation in their participation rate, the latter period marked a significant rise in the minority *proportion* of entrants from the remaining majority of the population. But whereas the former arose from the increased value set on education by the higher social classes themselves, (transmitted through families which already contained highly educated members or were on equal social terms with those who did) - the latter, in the main, did not. It was a secondary consequence of increased educational encouragement from outside the family, especially from schools and devoted teachers. It owed much more than the former to the universalisation of secondary education in the advanced countries and was an important first fruit of the beginnings of comprehensivisation. Such international studies, as were made at the time, concluded that selective systems of secondary education were negative influences, generally inhibiting the social spread of Higher Education.

In the underdeveloped countries, such Higher Education as developed was virtually an exclusive possession of the narrow upper social strata, inevitably either directly obtained from the universities of the *advanced* world or dependent institutions closely modelled on them. It was especially about this neocolonialist culture and its intelligentsia that Freire could issue the warning quoted above.

Education is tested and evolves by its contribution to society to survive. The task of the intelligentsia as a whole, even though most of them serve *immediately* the survival of the existing social systems, involves, for that very reason, the criticism of the latter. It is largely through the exercise of this critical function that the total ethos of a social culture is changed. So it was at the beginning of the modern epoch in the 16th and 17th centuries, when after a period of faltering, the large majority of the intellectuals swung into the creation of the revolutionary new culture of modern western society which was to dominate that of the whole world up to this day.

So it may well be again if a new culture is to be fashioned to serve the imperative needs of a new universal purpose of *liberation and human equality* both within and between all societies; if the race itself is to survive.

Part 3 CONCLUSION: CAN THE OPPRESSED CREATE THEIR OWN TECHNOLOGY, THEIR OWN INTELLIGENTSIA?

The American sociologist Alvin W. Gouldner has observed:

"The Communist Manifesto had held that the history of all hitherto existing society was the history of class struggles: freeman and slave, patrician and plebeian, lord and serf, guild-master and journeyman, and then bourgeois and proletariat. In this series however, there was one unspoken regularity: the slaves did not succeed the masters, the plebeian did not vanquish the patricians, the serfs did not overthrow the lords, and the journeymen did not overcome the guildmasters. *The lowliest class never came to power*. Nor does it seem likely now."

His inference is that that the actual controllers, the exercisers of power in States where capital has been mainly expropriated from private hands are not in fact the people as a whole, in whose name it is now managed, but the new managers themselves, or perhaps to be more precise the political and/or military elite of the new managerial professional and intellectual classes. This question is hardly to be answered merely by ideological protestations of the liberationist purposes for which the political and technocratic elite hold actual power and enjoy actual privileges of an order not dissimilar to many of their counterparts in the capitalist States.

Similar high-minded protestations are the regular stock in trade of the latter who employ their specialist colleagues in the mass media in a way not entirely without analogy in the propaganda departments of the former. And indeed, increasingly wide sections of the most technologically advanced multinational capitalist conglomerates may actually be formally owned in majority part by insurance companies, pension funds and even Trade Union welfare funds formally possessed in their entirety by millions of ordinary people. Indeed the tendency for the latter to become the large majority of funds available for new investment seems to be irreversible as the proportion of the national income devoted to these purposes steadily increases with increased longevity and lower ages of retirement in the so-called *advanced* capitalist world.

Nevertheless, it is likely to be the case that the *legal* ownership of the main means of production and the major sections of social infrastructure by the people as a whole, is a vital instrument for the transformation of technology from its prevalent role of human domination to that of universal liberation. It is not yet apparent, however, that it should *inevitably* result in the achievement of this goal, particularly if it is secured through the critically conscious activity of a mere minority - particularly a minority still largely sharing the ontology and hence the ideological basis of the worldwide technocratic intelligentsia itself. Indeed the very concept of the *inevitable* victory of a social revolution can embody precisely that *determinism* which characterises all ideologies of domination

Marx assumed that all other classes in capitalist society would rapidly diminish in importance leaving the naked confrontation of the owners of capital and their proletarian wage slaves as the only dynamic of further social change. The contradictions inherent in the capitalist mode were assumed to render it more and more unstable. It was assumed that this rendered the takeover of power by the proletariat inevitable (or possibly the only alternative to complete social breakdown).

He did not seem to anticipate that exponentially accelerating multiplication of the managerial and modern technocratic professional classes which we have discussed above. Indeed, the latter only really took off after his death, and remained largely undetected as a major social transformation until its escalation in the 1960s. (In this it resembled the growth of a human cancer undetectable in its constant exponential growth over decades and only recognizable in the final months or weeks of its victim.)

It may be questioned whether this phenomenon really represented the emergence of a separate ruling class in the *Marxist* sense or whether, as we have suggested above, all *leading* sections of the existing ruling classes have become permeated and identified with the ideology of the *Technocracy* and their interests subject to *its* criteria of survival value; so that the question becomes merely *academic*.

To take over power it would (on a *Marxist* model) be necessary for the proletariat to be capable as a class (indeed the only capable social force) of innovating, fostering, and diffusing the highest, i.e. the most productive, most dominant levels of technology. (Indeed Lenin set the seal on this concept in conceiving communism as resulting from Soviet Power *plus electrification*.)

But as technological advance becomes more and more the product of advances in more and more abstract sciences, its specialists distance themselves ever more completely from the comprehension and control not only of the proletariat but even of each other.

We have argued above that in previous societies it was sometimes possible for the dominant social classes to hire or patronise their cultural aides, their intelligentsia, to carry out the task of developing their necessary technology (in the enlarged sense given above). Even so, the creation of *its own* intelligentsia was more critically important for the emerging capitalist bourgeois class than ever before, since they themselves asserted their social and international economic and political supremacy in the 17th and 18th centuries essentially through their capacity to harness an unprecedentedly rapidly changing technology. For this purpose it was insufficient and indeed inapplicable to rely solely on the minority of the disaffected intelligentsia who came over to them for their feudal ruling class predecessors. Nor was it sufficient merely to take possession of the former technology and its parallel cultural institutions.

The bourgeois were forced to create an entirely new intelligentsia largely from their own ranks, an entirely new culture, with its own religion, philosophy, legal superstructure, above all, an entirely new science. For these purposes it was not sufficient to take over the control of the previous major cultural institutions, the churches, the political and legal elites, the universities. They had to create their own reformed churches and their own dissenting academies and scientific and technological societies, their own forms of Government.

Underlying all these cultural (superstructural) forms they had to foster a new ontology, an entirely novel materialist and determinist model of the natural universe (and eventually of the world of human nature) legitimating and ordering their purposes of the universal reification and domination of both. Though the so-called *superstitious* elements (deistic, vitalistic, mystical) in institutional religious and many other social practices survived for centuries and indeed until this day, and indeed have been deliberately encouraged and exploited by the ruling capitalist classes as essential, though minor, cultural instruments of social control, they have been gradually but remorselessly excluded from the cultural models of ultimate control, from the rules of decision making by the Board rooms of the Multinationals or from the War Ministries of Thermo-nuclear Power.

Could a culture of universal *liberation* take over such a world view moulded for the purposes of universal *domination?* To what extent could radical elements in the existing intelligentsia - itself becoming the self-chosen social instrument of ever more pervasive domestication of the human spirit - become the initiators of such a new culture, the initiators of their own replacement by its multigenetic initiators: the oppressed peoples themselves; a culture not devised *for* the latter but *by* them and *of* them, expressing their multitudinous coexisting and co-essential creativity and interdependence; a culture which in all essential respects may incorporate an image of the nature of reality, of the validity of scientific knowledge, at least as contradictory to that of its bourgeois predecessors as was the latter to that of the mediaeval culture they rendered obsolete?

To ask these questions is to realise that there are no historical precedents (unless the Maoist *Cultural Revolution* is regarded as a disastrous false start). At the same time it is impossible to avoid the suspicion that previous intellectual models of universal human liberation which assumed the continuing validity of the precedent bourgeois determinist materialist world view, however elaborated by dialectical concepts of its mechanism, may have been the source of major mistakes in the design of new social systems and major tragedies in the sacrifice of human and natural life and potential.

The weakness of the revolutionary intelligentsia is that it has often not so much expressed the creative critical consciousness of the oppressed (which indeed has still to find a coherent and integrated expression) but, rather, the dissatisfactions of some of those elements of the ruling bourgeois intelligentsia who have been excluded (or even exclude themselves) from participation in its prerogatives of power. Their self-images, their ambitions for their own social and political leadership are usually written in the dominant technocratic language of the hegemonic culture against which they rebel. This is, perhaps inevitably, most likely to be the case when they seek to congeal these fragmented ambitions into a general political programme for taking over the management of precisely the means of social domination against which they rebel, to inherit the role of the preceding *Technocracy*.

On the other hand their potential value to the oppressed arises from that other traditional but contradictory role of the intelligentsia of societies in which it seeks to give new expression to human solidarity and interdependence.

In this role they still have to play an essential and historically unprecedented part: that of the destruction of their own intellectual elitism and its ideology and even ontology. Their task may be nothing less than the fostering of their own replacement by a total human group, the oppressed, which for the first time in history does not, itself, have the economic, political, military or cultural power to destroy the old culture of domination and to *initiate* the new one of its own liberation.

While this task is more credible for a *revolutionary* intelligentsia, especially in States where the ownership and control of all the levers of economic, political, and military power are formally held on behalf of the people as a whole, there are no precedents for taking it for granted. Moreover it may entail not merely the transformation of the essential cultural model of the preceding bourgeois centuries, but to roll back some basic human beliefs of all the millennia since the birth of the first Technology - and the concurrent founding of all subsequent culture as the intellectual modelling of the domination of all other nature and human nature in the interests of its possessors.

Such a prospect would be perhaps unthinkable if epochal historical changes in technology and culture had proceeded linearly through time.

But they have not. The time intervals between revolutionary changes in technology and its concurrent culture have at each stage become a fraction of the time consumed in bringing the previous stage to fruition. The conquest of the world by the technology of the agricultural revolution probably required millennia. Industrial technology exerted its supremacy over all previous systems in a few centuries. Mass production technology pioneered only in the 20th century had become economically supreme within decades. The microelectronic technology of the 1960s established itself at the leading edge of advanced development within a single decade and the revolutions in software development which mark the international economic battles of the *knowledge industry* are won and lost in single years.

And now the universal threat to human survival has become imminent. The shortening time span of confidence in continued human existence matches the shortening time span of revolutionary technological change, whose most advanced sectors are nurtured in the dominant industry of the means of human destruction.

But the need for a totally new social dynamic of *liberation* has also become infinitely more manifest than ever before. This paramount need, forcing itself into human social critical consciousness in an unprecedented and ever wider variety of cultural forms and social groupings begins to manifest itself in revolutionary movements transcending in social and international scope and in their multitudinous and multicultural concerns with peace, liberation and conservation of the total environment, any previous human expressions of solidarity and interdependence.

Though they cannot yet provide a blueprint for a world *Beyond Technocracy* they make credible the struggle for its attainment.

University of Bradford

Notes and References

1 Since the purpose of this paper is to suggest a model rather than prove a thesis, detailed supporting references are not given. However, much of the relevant substance of the first two parts is dealt with more extensively in the following publications of the author where detailed bibliographies are given:

Part 1, E.G. Edwards, "Interdisciplinarity, The Relation between Objective Knowledge, Moral Purpose and Social Practice". *Bulletin of the Inter-University Centre of Post-Graduate Studies*, Dubrovnik; Published by University of Hamburg, Vol 1. 1983, Vol 2 1984.

Part 2, E.G. Edwards, *Higher Education for Everyone*. Spokesman Press, Nottingham 1982. E.G. Edwards and I. Roberts

"British Higher Education; long term trends etc.", *Higher Education Review*, London, Spring 1980. E.G. Edwards "An Analytical View of Trends of Student Enrolment in Western Europe", in: *Higher Education in Europe, UNESCO*, Bucharest, July/Sept 1981.

2 The term '*Technocracy*, meaning a society ruled by technicians has been used by various authors since its invention by W.H. Smyth, a Californian engineer in 1919 (see e.g. W.H.G. Armytage, *The Rise of the Technocrats*, London 1965.) The author uses it in the wider sense given in this paragraph in which Technologists (in the older sense) do not necessarily constitute a *separate* dominant class but, rather, all sections of the ruling classes (including the politicians) tend to congeal into a new block in which the ethos and self image of the most advanced technology becomes hegemonic. C.f. also the wider definition of *Technology* developed in Part 2. e.g. ref. 4.

3 Sections 1.3-1.6. are adapted from a more extensive treatment in E.G. Edwards, "Domestication of the Human Animal", from *Le triomphe des biotechnologies*, I.U.C. of P.G. Studies, Dubrovnik, To be published by Presses Universitaires de Namur, 1987.

4 The wider definition of *Technology* developed below implies that all *other* cultural (i.e. superstructural) social institutions become subject to the hegemony of the ethos and ontology first developed in modern advanced scientific technology. This thesis is developed more extensively in ref. 1. Part 1. E.G. Edwards, *Interdisciplinarity etc.*

5 C.f. especially the works of Ilya Prigogine, e.g. *From Being to Becoming*. pub. W.H. Freeman, San Francisco 1980.

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³ The term Technocracy, meaning a society ruled by technicians has been used by various authors since its invention by W.H. Smyth, a Californian engineer in 1919 (see e.g. W.H.G. Armytage, *The Rise of the Technocrats*, London 1965.) The author uses it in the wider sense given in this paragraph in which Technologists (in the older sense) do not necessarily constitute a separate dominant class but, rather, all sections of the ruling classes (including the politicians) tend to coalesce into a new block in which the ethos and self image of the most advanced technology becomes hegemonic. C.f. also the wider definition of Technology developed in Part 2, e.g. ref. 4.

Sections 1.3-1.6. are adapted from a more extensive treatment E.G. Edwards, "Domestication of the Human Animal", from *Le triomphe des biotechnologies*, I.U.C. of P.G. Studies, Dubrovnik, To be published by Presses Universitaires de Nancy, 1985.

4 The wider definition of Technology developed below implies that all other cultural (i.e. superstructural) social institutions become subject to the hegemony of the ethos and ontology first developed in modern advanced scientific technology. This thesis is developed more extensively in ref. 1. Part 1. E.G. Edwards, Interdisciplinarity etc.

5 C.f. especially the works of Ilya Prigogine, e.g. *From Being to Becoming*, pub. W.H. Freeman, San Francisco 1980.

TOWARDS A NEW NOTION OF RATIONALITY FOR TECHNOLOGY POLICY

László Molnár

It is widely known that in Hungary, the problem of technological innovation is unsolved. This can be regarded as a fundamental problem of technology policy.

In the 1960s and 1970s in Hungary there were conflicting views concerning a technology policy separated from economic policy. There were some who denied the necessity of such a technology policy. Others considered it as part of the economic policy of enterprises. But neither the economic policy of the state nor that of enterprises can provide us an appropriate technology policy, because this would be too great a task for them to carry out adequately. On the one hand it would be beyond the competence of enterprises and on the other hand, the economic policy of the state is determined by short-term requirements and the need for equilibrium. Technology policy aims at creating a new, different environment in the long run. According to Tibor Vámos, this policy "... goes beyond the installation of new products, new technological methods... it comprehends the whole of producing - or at least helping the production - of new *conditions*, the totality of assessment and of consideration of effects."[1]

These conditions are: human and social factors, financial means, general material conditions, and the action aiming at technological development.[2] For me the value-system determining technology policy also merits analysis, because this system plays an important part in shaping technology, too. In this case the notion "technology" is of great significance, and its meaning can clarify the formative factors of technology policy.

I. The technocratic-minded view

Neglecting the social factors of technology and regarding it as socially neutral, means to accept the view known as "technological determinism". According to Jacques Ellul, a famous representative of this view, "Technical progress today is no longer conditioned by anything other than its own calculus of efficiency."[3] This technical determinisn is based on an unproved and false assumption, i.e. that it is always possible to find "the one best way" for technological decisions. The person who accepts this has no reason to reject its consequences.

I."'The one best way' so runs the formula to which our technique corresponds. When everything has been measured and calculated mathematically so that the method which has been decided upon is satisfactory from the rational point of view, from the practical point of view, the method is manifestly the most efficient of all those hitherto employed or those in competition with it, then the technical movement becomes self-directing. I call the process automatism."[4]

II. "If a desired result is stipulated, there is no choice possible between technical means based on imagination, individual qualities, or tradition. Nothing can compete with technical means. The choice is made a priori. It is not in the power of the individual or of the groups to decide to follow some method other than the technical. The individual is in a dilemma: either he decides to safeguard his freedom of choice, chooses to use traditional, personal, moral, or empirical means, thereby entering into competion with a power against which there is no efficacious defense and before which he must suffer defeat; or he decides to accept technical necessity, in which case he will himself be the victor, but only by submitting irreparably to technical slavery. In effect he has no freedom of choice."[5]

III. "... a new characteristic of economic technique: it is inevitably antidemocratic."[6] "Technique is a boundary of democracy. What technique wins, democracy loses. If we had engineers who were popular with the workers, they would be ignorant of machinery. In our time, technique is a court of last appeal.

The worker is master neither of his factory nor of his bosses."[7]

IV. "With the introduction of technical development into the life of the state, the situation becomes completely different: doctrine is merely explicative and justifying. It no longer represents the end; the end is defined by the autonomous operation of techniques. It is no longer the criterion of action; the sole criterion of action consists in knowing whether or not technique has been correctly used, and no political theory can tell us that."[8]

The crucial point of this argumentation is the "one best way" formula concerning technological decisions. This formula is expressed in the slogan of the Chicago World Fair of 1933, that science discovers, genius invents, industry introduces the new things and we adapt ourselves to them and are formed by them.[9]

Technical determinism describes the technical development as a linear progression. But this description rests on an arbitrary handling of facts, and on the disregarding of the possibility of alternative outcomes at the turning points.
This view has a common assumption with the Taylorian "Scientific Management" theory. Namely, both assume the possibility of finding "the one best way" of decisions by seeking the maximization of profit. But in reality economic organizations are often satisfied not by the best but by merely satisfactory solutions.[10]

János Kornai has pointed out that "the one best way of" of decision making is not a fact, it is only an inexecutable postulate."[11] Michel Crozier regards this sort of rationality as an "improverished one", which is "totalitarian" as well.[12] In Crozier's opinion this ideology of industrialization was used for the following reason: the notion gave absolute power to the management defining and elaborating *this* rational solution and through this the management was able to break the habits, attitudes and privileges of other groups participating in production.[13] In my opinion this "absolute power" is not necessary for the functioning of modern technology: there are non-

Taylorian forms of organization of work in successful American firms.[14]

To sum up: the substantial common features of technological determinism and Taylorism are the following:

1. the false hypothesis of the "one best way" of technological decision and development,

2. the neglect of the human problems (e.g. special interests, values and informal relations) of the workers participating in production,

3. the preference for authoritarian and totalitarian ways to solution of the problems of production,

4. the myth of the autonomy of technology,

5. the suppression of human autonomy and

6. the input-output analysis which takes into account only the internal costs of a product and neglects the social and external costs (environmental pollution, alienation etc.).

This "impoverished rationality" can represent a threat to society and to mankind at high levels of technology. Accordingly we must urgently enrich the content and the dimensions of "rationality" in order to be able to cope with the threat.

II. Toward a new type of rationality

To establish a new type of rationality it is necessary to use a more encompassing meaning of "technology". This wider meaning must have, in Pacey's view, three aspects: 1. *the cultural* (goals, values and ethical codes, belief in progress, awareness and creativity;) 2. *the organizational* (economic and industrial activity, professional activity, users and consumers, trade unions) and 3. *the technical* (knowledge, skill and technique, tools, machines, chemicals, livestock, resources, products and waste). The technical aspect of the wider meaning is equivalent to the "restricted meaning" of technology.[15]

From this it follows that we have to take into account not only the expert opinion but lay (user) views as well when assessing technological developments. The main problem is "that experts see the goals of programmes in much more specific <ways>

than the public, and ... <their> basic values differ."[16] Therefore we have to arrange an "innovative dialogue"[17] between promoters and users.

Arnold Pacey has worked out a matrix for assessing different points of view concerning any new technological development. This matrix gives us a possibility to compare the different views, those of the experts and those of the users, along the following lines: 1. practical benefits and costs, 2. status and political advantage, 3. basic values.[18] Pacey says that this matrix "... is also useful in illustrating how dialogue is curtailed. When new highways, chemical works or power plants are proposed, many very detailed questions about benefits, costs, and risks are asked in technology assessment exercises and environmental impact assessments. These questions cover some of the same ground as the top half of the table but those who ask them tend to assume that objective answers can be given. There is little recognition of the way in which promoters must usually answer the question differently from the lay public. Yet even to present the lay public as a single entity may be over-simple, for consumers, employees of the projects and local residents whose amenity is disturbed will have quite different points of view. A more significant way in which discussion is curtailed, however, is that questions in the bottom half of the table may never be asked at all."[19]

If we complete the Taylorian concept of rationality with the above mentioned factors, then we can arrive at an enriched form of rationality. This also changes the character of technological development: the monologue of the promoters becomes a dialogue between promoters and users. We have to develop it into a democratic dialogue, because "we are to have a democratic control over technological development, we need public inquiry and technology assessment procedures that are able to strip off the various disguises which allow fundamental conflicts of basic values and political interests to hide behind utilitarian arguments about benefits and costs. But many technology assessments and most major British inquiries have served mainly to cloak issues with technical detail that is often

Table from Arnold Pacey, *The Culture of Technology*, Basil Blackwell, Oxford, 1983. p.155

Matrix for assessing different points of view on any new technological development (e.g. a public health project). The columns representing expert and lay (or user) views are initially blank and are filled in by promoters of the project as a means of testing its appropriateness in the community concerned. The matrix is here shown partially completed; in practice, both questions and answers will usually need to be more detailed.

Queries	Expert views	User views
Practical benefits and costs		
What benefits are sought?	Very specific benefits (e.g. control of a particular disease)	Better living standards in general, including health, amenity, housing, jobs
What costs, what risks, and what environmental impacts are perceived?	Cost of implementation; risks as a statistic to be weighed against benefits	Costs in time, cash, amenity, organization, risk, seen in personal and family terms
Who gains which benefits? Who loses?		Lowest income groups cannot afford the cash costs
Status and political advantage		
What is the impact of the project in terms of status and prestige?	Visible progress, good for national prestige. Professional advancement for the experts concerned	Status associated with possession of new household amenity
Whor gains or loses status, power or influence?	Some strengthening of central government authority	Some loss of control over life-style, fear of bureaucratic power
Basic values		
What is the cultural context?	Scientific/technical; the expert sphere	Domestic/traditional; the user sphere
What are the dominant values?	Technical interest and virtuosity; economic values	Need or user values, family welfare

barely relevant. Commenting on one such inquiry, a writer in the science journal *Nature* observed that: 'Technical decisions as complex as these have a political content, and that content must be isolated and recognized for what it is'. (Robert Walgate, Mr. Justice Parker and technical fact. in: *Nature* (London), 273/23 March 1978, pp. 300-301.) This had not been done."[20]

But, you may ask, what do you intend to say by way of explanation of this problem? Everyone knows that there is no technology assessment in Hungary! My answer is that just because of this we should be careful before institutionalizing it and so, perhaps, we will have a chance to derive advantage from our disadvantage: to organize technology assessment institutions *and* to assess these as well.

According to the abovementioned we have to distinguish three levels of technological rationality:

I. The Taylorian and Ellulian level with the notion of the "impoverished rationality".

II. The level of technology assessment and that of the environmental impact.

III. The assessment of the second level.

On this level the critical assessment tends to establish a democratic control over technology development and lay (user) views would be taken into account by the promoters. But this process can be carried out only as democratic communication between experts and laymen. This rationality renders it meaningless to separate the Weberian type purposive rational (*zweckrational*) and value-rational (*wertrational*) action: purposive rational development has to take into account the means correctly chosen to obtain ends, but "correctly chosen means" have to be in accord with conscious value standards of laymen and experts as well.

If we take this version of rationality as a merely utopian one, then we have to pay the social and environmental price of technological development proceeding as though it were a natural force.

Technical University, Budapest

Notes

1. Tibor Vámos, "A müszaki fejlesztési politikáról" (On technical development policy), in: *Hazánk és a müszaki haladás* (Hungary and technological progress), (Budapest: Magvető, 1984), pp. 67-68.
2. *Ibid.*, pp. 68-69.
3. Jacques Ellul, *The Technological Society* (New York: Vintage Books, 1964), p. 74.
4. *Ibid.*, p. 80.
5. *Ibid.*, p. 84.
6. *Ibid.*, p. 209.
7. *Ibid.*, pp. 281-282.
8. This slogan is cited by Arnold Pacey, *The Culture of Technology*. (Oxford: Basil Blackwell, 1983), p. 25.
9. See this fact concerning the development of the steam-engine in: A. Pacey, *Op. cit.* p. 17.
10. See J.G. March - H.A. Simon, *Organizations*. (New York: Wiley, 1958 and Michel Crozier, *Le phénomène bureaucratique* (Paris: Éditions du Seuil, 1963), p. 214.
11. János Kornai, *Anti-Equilibrium* (Budapest: Közgazdasági és Jogi Könyvkiadó, 1971), chapters 10 and 11.
12. M. Crozier, *Op. cit.* p. 211.
13. *Ibid.*, p. 212.
14. See T.J. Peters - R.E. Waterman Jr., *In Search of Excellence. Lessons from America's Best-Run Companies*. (New York: Harper and Row, 1982).
15. A. Pacey, *Op. cit.* p. 6.
16. *Ibid.*, p. 156.
17. Cf. *ibid.*, Ch. 8.
18. *Ibid.*, p. 155.
19. *Ibid.*, p. 156.
20. *Ibid.*, p. 157.

RECENT METHODOLOGICAL ORIENTATIONS IN SCIENTIFIC AND ENGINEERING DISCIPLINES

V.G. Gorokhov

The sphere of scientific-engineering disciplines, which today are developing intensively along with natural scientific, mathematical and socio-humanistic disciplines, includes diverse fields of research and many types of engineering and design. These disciplines have a well-shaped disciplinary organisation (a specific publication file and a distinctive research community) and occupy a prominent place in modern science. Besides, by the second half of the 20th century most scientific-engineering disciplines could shape their own theoretical research known as engineering theory (or technical theory), which ought to become a principal subject of methodological analysis.

The main feature of scientific-engineering disciplines is that they emerge at the junction of scientific and engineering activity and must function precisely in the conditions ensuring such interconnection. This determines the specific features of their structure and formation.

In the structure of a natural-science and engineering theory conceptual and mathematical apparatus and theoretical (ontological) schemes are usually singled out. (See V.S. Stepin. 1976.)

Theoretical schemes represent a combination of abstract objects oriented, on the one hand, on the use of the corresponding mathematical apparatus, and, on the other, on the "mental" experiment, i.e. the design of possible experimental situations. The mathematical apparatus is primarily used to calculate experimental situations. In a developed theory it performs the displaying function, i.e. the function of transformating abstract objects by deductive inference. This enables one to obtain new knowledge without needing to turn to experiment and observation. For the mathematisation of a scientific discipline the parallel elaboration of adequate conceptual apparatus is needed.

In principle, engineering science has the same mathematized theory as natural science. An engineering theory also has abstract objects assembled from a fixed set of elements according to definite rules of assembly. Capacities, inductances and resistances correspond to them in electrical engineering; generators, filters and amplifiers in theoretical radio engineering, and various types of kinematic pairs, links, circuits, etc. in the theory of mechanisms. These ideal elements correspond adequately to standardized structural elements listed in engineering catalogues. In other words, abstract objects of engineering sciences should exactly correspond to the structure of engineering objects.

Three main levels in the theoretical (ontological) schemes of an engineering theory can be discerned (see Fig. 1) *The*

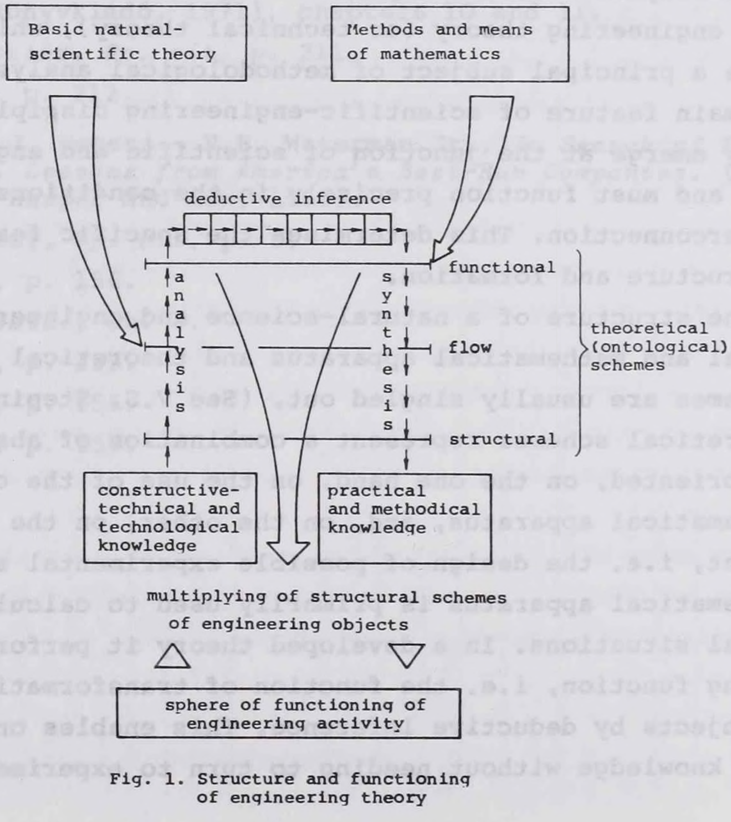

Fig. 1. Structure and functioning of engineering theory

functional scheme is oriented on the mathematical description and fixes the general idea about the engineering object, irrespective of the method of its realization. The units of this scheme reflect only the functional properties of the elements of the engineering object for the sake of which they are included in it to attain the general objective and reflect certain mathematical relations. *Flow schemes*, or schemes of performance, describe natural, for instance, physical processes taking place in the engineering object and connecting its elements into a single whole. The units of such schemes reflect various operations performed in the natural process by the elements of the engineering object while it is functioning. These are based on natural-scientific concepts. Finally, *structural schemes* reflect the structural arrangement of elements and linkages in the given engineering object and presuppose its possible realization. The elements of the latter are regarded in them as having not only functional properties, but also properties of the second order, i.e. those undesirable properties which are added by a definitely realized element, for instance, non-linear distortions of the amplified signal in the amplifier. These schemes represent constructive-technical and technological parameters, i.e. they reflect specific problems cropping up in engineering practice.

The functioning of engineering theory is realized by the iteration method. At first a special engineering problem is formulated. Then it is represented in the form of the structural scheme of the engineering object which is transformed into the idea about the natural process reflecting its performance. To calculate and mathematically model this process a functional scheme is constructed. Consequently, the engineering problem is reformulated into a scientific one and then into a mathematical problem solved by the deductive method. This path from the bottom to the top represents *the analysis of schemes*.

The way in the opposite direction - *the synthesis of schemes* - makes it possible to synthesize the ideal model of a new engineering object from idealized structural elements according to the appropriate rules of deductive transformation, to calculate the main parameters of the ideal model and to simulate the performance. The solution obtained in the functional scheme is gradually transformed to the engineering activity level, where engineering parameters which are secondary from the point of view of the ideal model are taken into account, for instance, the size and weight of parts, their screening from electromagnetic side effects, the optimum structural layout, etc., and additional calculations (corrections of theoretical results) are carried out.

Functional, flow and structural theoretical (ontological) schemes reflect different methods of representing an engineering object and levels of the solution of a mathematical problem, a scientific problem and an engineering problem. Using the procedures of analysis and synthesis of schemes based on the construction of some equivalent schemes which replace the engineering object at each of these levels, these three levels are mutually correlated and the theoretical solution of the problems advanced by engineering practice found. As a result of the functioning of engineering theory new structural schemes of hypothetical (potentially possible) engineering objects of the given type are worked out. They serve as the initial point for the design. Herein lies the main contribution of engineering theory to the solution of practical engineering problems.

This to a great extent explains the specific feature of engineering theory: the class of hypothetical engineering objects which are not yet designed must correspond to its abstract objects. Therefore, what matters in engineering science is not so much the explanation of the existing facts and the forecast of the course of natural processes, but the design of possible situations (and of the means for their attainment), not only the analysis, but also the synthesis of the theoretical schemes of engineering objects. For this reason, the empirical basis of engineering theory contains necessarily not only some constructive-technical and technological knowledge, oriented on the generalization of experience in engineer's work, but also some practical and methodological knowledge representing practical recommendations for application in engineering practice.

Ontological (theoretical) schemes of scientific disciplines provide a specific "vision of the world", that is, the universe of the objects studied in the given theory and of the methods of their theoretical representation. In natural sciences this specific vision of the world is expressed in "special scientific world pictures" (the physical, biological, mechanical, elektrodynamic and other pictures). In engineering sciences there are also analogues of this vision of the world, but somewhat different principles of ontologization are developed in them. They are associated with the rigorous orientation on engineering activity. Let us call it a "universal" ontological scheme with respect to a "family" of scientific-engineering disciplines. Within the framework of every individual discipline in such a "family" this scheme is concretized in the form of the generalized ontological one which, in its turn, generalizes a number of specific ontological schemes developed in various fields of studies or lines of research of the given discipline.

The genesis of the "universal" ontological scheme in scientific-engineering disciplines is determined, on the one hand, by the basic natural-scientific discipline, and, on the other, by engineering ideas and tasks. This is why its formation takes place along two opposite lines: firstly, due to ever greater concretization and utilisation of the "universal" ontological scheme borrowed from the appropriate natural science, and, secondly, by generalizing specific theoretical models developed in the given engineering science. In the first case emphasis is placed on the flow scheme, in the second case on the structural scheme. Thus, the "universal" ontological scheme of a scientific-engineering discipline is obtained as a result of the intersection and superposition of two layers of ontological schemes.

Unlike the case in natural-scientific disciplines, in scientific-engineering disciplines the layer of structural schemes determines their becoming and development. (Flow and functional schemes perform auxiliary functions within the framework of theory.) They constantly develop and improve through direct contact with practical engineering activity. The scientific-engineering discipline can be considered as formed when a mathematized engineering theory is constructed in it. It should also clearly give the procedures of the transition from structural schemes to flow and functional schemes (schemes of analysis) and vice versa (schemes of synthesis). Only when an engineering science has worked out the means of the theoretical synthesis of engineering systems which make it possible to extrapolate the theoretical results obtained for the class of hypothetical engineering objects (with the orientation on practical and methodological knowledge) can its generalized ontological scheme be considered universal in relation to the given class of objects.

In developed engineering science new scientific-engineering disciplines can be constructed after the pattern of a basic engineering (and not natural-scientific) theory (for instance, radiolocation after the pattern of theoretical radio engineering) within the framework of the "universal" ontological scheme common for the given "family" of disciplines. In this case their formation follows the "research line - research field - scientific discipline" scheme.

So, one can speak about two basic methods of forming classical engineering science: in the first place, out of new applied lines of a natural-scientific theory, and, secondly, as branches of the corresponding basic engineering theory within the framework of the "family" of homogeneous scientific-engineering disciplines grouped around it.

Engineering sciences have traditionally been regarded only as spheres of the application of natural-scientific knowledge. However, recently we have seen the emergence of a number of scientific-engineering disciplines oriented on using not only natural-scientific knowledge but also socio-humanistic knowledge in engineering practice and design. The range of design problems has been expanded and includes now socio-economic and engineering-psychological systems and other problems.

Two main types of scientific-engineering disciplines can be discerned - classical and nonclassical. The former are oriented on a certain type of engineering object (a mechanism, a machine, a radio or radar device, an electric circuit, etc.) which is under study or design. The latter are oriented on different classes of comprehensive scientific-engineering problems, although their subject of study and design can coincide, for instance, the man-machine system in ergonomics and systems engineering. Such scientific-engineering disciplines can be called modern comprehensive (nonclassical) scientific-engineering disciplines. Theoretical studies for these two types of disciplines essentially differ, but are comparable to an extent.

In classical scientific-engineering disciplines of the theory of mechanism and machinery, theoretical radio engineering, circuit analysis, etc. type, the engineering theory was shaped to a large extent in conformity with the norms and ideals of organising scientific knowledge, which were borrowed from a basic natural-scientific theory (theoretical mechanics, theory of electricity, electrodynamics, etc.). However, having branched out of basic natural science or mathematics, engineering theory gradually shaped its own specific ideals and norms of organizing scientific theoretical knowledge. These ideals and norms are determined by the necessity of strict orientation on the corresponding field of engineering practice.

Present-day comprehensive (nonclassical) scientific-engineering disciplines are already oriented not on a single basic (natural-scientific, socio-humanitarian or engineering) theory, but on the whole complex of scientific knowledge and disciplines. This is why they shape another epistemological ideal of theoretical research - comprehensive theoretical research. Systems engineering is the most typical in this respect.

Systems engineering develops the nonclassical way. As a rule, at first there evolve some rather general concrete-methodological approach enjoying "universal" application. Then this is gradually adjusted to a definite problem area (complex scientific and engineering problems). Behind the phenomenon is a broad scientific movement which may result in a new scientific discipline.

The uniqueness of the nonclassical way is that a solution of integrated scientific and engineering problems may, in principle, be found on the basis of any scientific disciplines, theories, knowledge, and methods (and not only on the basic theory) which in the future are synthesized on a general methodological foundation into an integral theoretical system of a scientific and engineering discipline. Of course, they are adequately processed and revised. Finally, new specific methods and theoretical tools of research are developed, making it possible to accomplish most effectively the tasks faced by the given scientific-engineering disciplines. Though at first glance the main task here is a synthesis of heterogeneous knowledge, theoretical notions and methods, it implies coordination, alignment, management, and organisation of different activities aimed at the solution of a certain integrated scientific-engineering problem. Hence, the objects of the disciplines of this type carry out studies into specific "activities". Systems engineering belongs precisely to such disciplines.

There are two basic ways of theoretical research organisation in modern science: monodisciplinary and interdisciplinary. Monodisciplinary research realised within classical engineering sciences has already been considered. Interdisciplinary theoretical research may be integrated and complex. The former results from generalization and subsequent integration of particular theoretical schemes of different scientific-engineering disciplines, i.e. different lines of research into a certain type of engineering object conducted on a general mathematical basis and from a certain standpoint (e.g. stability and quality of automatic control systems). The latter are both multiple aspect and multifaceted. They remain complex at all stages of research into the complicated engineering objects, whereas their unity and integrity are provided for methodologically. The automatic control theory is a clear illustration of integrated interdisciplinary research. Let us now consider the organization of comprehensive theoretical research with systems engineering as an example.

The nonclassical, specific evolution of systems engineering is stipulated by the necessity of solving complex engineering problems. Though integrating a complex collection of different types of knowledge and methods, and encountering a variety of disciplines, it uses them for handling specific problems that cannot be solved by any of these disciplines separately. Hence, the formulation of systems engineering theory starts directly with the development of a generalized ontological scheme. It is worth noting that such a scheme cannot be borrowed from any of the existing scientific disciplines. This requires a certain methodology. The most adequate concrete methodological basis for the comprehensive theoretical research in systems engineering is provided by systems approach. The use and development of the latter determine its status as a comprehensive scientific-engineering discipline. It is worth nothing that methodological knowledge constitutes an integral part of the systems engineering theory.

A specific feature of modern scientific-engineering disciplines, in particular systems engineering, is that they are systems oriented. In other words, all of them (systems engineering, ergonomics, engineering cybernetics, systems analysis, etc.) operate according to a certain "universal" ontological scheme represented by different versions of the general systems theory, and methods and means of systems approach. This "universal" ontological scheme provides a basis for an ideal model, for specific viewing of the object under study and design, the reality which the systems engineer faces and in which it operates, the only reality permitting a synthesis of "particular" theoretical concepts.

The research methods and means are selected from different scientific disciplines or developed specially as applied to each concrete problem. A comprehensive piece of theoretical research should take account of all the particular concepts (representations) and specific ontological schemes. These must be generalized and reformulated into a sort of partial systems theories while their abstract objects, ontological schemes, are represented as special systems. These special systems may be further synthesized into different (depending on the problem being solved) complex models of a complicated engineering object. It is a collection of all possible (including hypothetical) comprehensive systems models that makes up a generalized ontological scheme of systems engineering which, on the one hand, is generalization of specific particular ontological schemes, of the theories used therein and, on the other, specification of the "universal" ontological scheme.

In systems engineering the "universal" ontological scheme (or systems ontology) serves as a methodological guide in choosing the theoretical methods and means for solving complex scientific and engineering problems, and makes it possible to adopt them from the related disciplines or methodological field. It also determines the methodological principle of "designing" complex abstract objects of systems engineering - complex systems models, their subsequent simulation and interpretation, i.e. makes it possible to extrapolate the experience accumulated in systems engineering to future design situations. Complex systems models of a complicated engineering object, developed at a theoretical level, may be used as a basis for designing new systems.

In practical systems engineering activity, the task of creating a new system consists in a combination of different scientific and engineering concepts without reducing them to a unified theoretical representation. This enables a researcher or developer, while solving a special systems engineering problem, to build the dissimilar schemes of complex engineering objects. And it is impossible to reproduce the procedure of their construction (it is within the sphere of the designer's intuition). Such schemes actually constitute a "syncretic" combination of different theory representations (elements of electric circuits and mechanical diagrams, algorithmic, skeleton, and block diagrams of automatic control theory and other disciplines) and the representations of the object in engineering activities: elements of different schemes of production, development, functioning, etc. Thus, a common structural ontological scheme contains the components of gearing diagrams, electronic circuits, and block and wiring diagrams that underlie the design and assembly of mechanical, electric and other blocks.

An essential shortcoming of the representation of a complicated engineering object this way is the qualitative inhomogeneity of the obtained ontological scheme which makes it possible to simulate the functioning of a system as a whole, and complicates the design and development of technology, adjustment, etc. The "syncretic" schemes actually do not solve the problem of an integral theoretical description of a complicated engineering object.

To solve this problem, it is necessary to represent the given "syncretic" scheme as a system of honogeneous descriptions. Automatic control theory arises as a result of the integration of different engineering sciences (theory of mechanisms and machinery, theoretical electrical engineering and radio engineering, engineering hydraulics and pneumatics) which deal with specific engineering problems (servomechanism). The theoretical synthesis of scientific-engineering knowledge is based here on a single mathematical scheme. The comprehensive theoretical research is also oriented towards a synthesis of the theories employed, though from somewhat different positions as compared to integrated interdisciplinary research.

Thus, the main problem facing theoretical systems engineering is the transition from the syncretic description of a complex engineering problem by theoretical means and notions of different scientific disciplines to the homogeneous abstract ontological scheme. It is necessary, first of all, to be able to use the appropriate mathematical apparatus in systems engineering. For this purpose the method of a uniform description of qualitatively heterogeneous elements must be chosen. That is why in theoretical systems engineering the structural and flow ontological schemes are formed in principle as maximaly abstract. (In classical engineering science they are much more specialized and particular).

Functional schemes in systems engineering can be of two types (Fig. 2). The schemes of the first type are developed in so-called structural analysis and are aimed at investigating the structure of large-scale systems. They correspond to abstract structural schemes of systems engineering and generalize various structural schemes - automatic control theories, network theories, switching circuit network theories and computer logics, etc. The second type is represented by functional schemes elaborated in theoretical programming which are adequate to generalized flow (algorithmic) schemes. They have been generalized in cybernetics and are considered on the plane of the transformation of substance, energy and information. They actually are idealized representations of the functioning of any system and the initial point of computer programming. In systems engineering these two types of ontological schemes are combined at a single level of abstraction but on different planes.

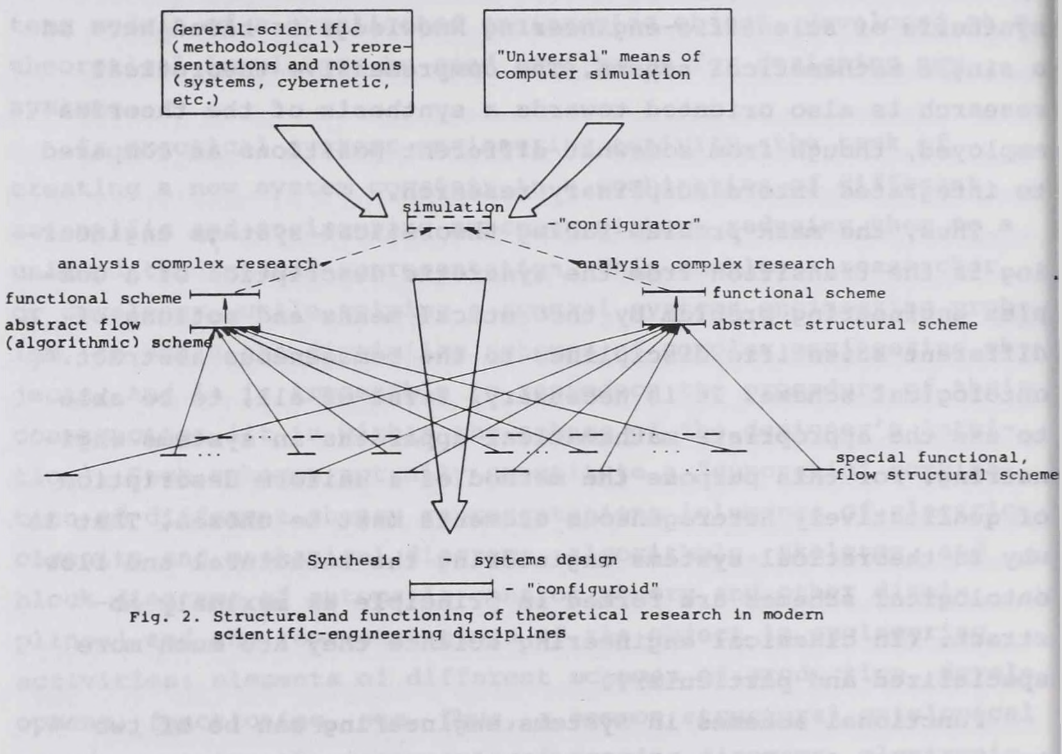

Fig. 2. Structureland functioning of theoretical research in modern scientific-engineering disciplines

Algorithmic schemes in systems engineering are used for describing and organizing activity aimed at creating a large-scale system. The ensuring of the functioning of the designed system also belongs to it. The algorithm of the functioning of the system merges with the algorithm of this activity, especially during the creation of automated management systems. The algorithms of their functioning describe automated managerial activity. It is not fortuitous that most works on systems engineering contain two basic parts: the description of the structure of the system and the description of the process of its creation. It is essential, therefore, to combine both descriptions in a single theoretical model. This, for instance, takes place in algorithmic languages of computer simulation in which the flow (algorithmic) scheme is superimposed on the structural (static) scheme of the system which is being simulated. The rules of transforming structural and flow schemes into functional schemes are formalized, and this transformation is carried out automatically on a computer.

Systems engineering solves comprehensive engineering problems of a qualitatively new class. These problems are associated with the mutual co-ordination of particular, local solutions, with their systems representation in the form of a single whole. Here arises the problem of "configuring", reducing the multi-aspect description recorded in different flow and structural ontological schemes into a single systems model - a "configuroid" - obtained as a result of simulation. So, the configurator is a device for synthesizing theoretical schemes, a generator of the simulation models of the system while the configuroid is a comprehensive (structural-flow) model of the system.

In modern engineering theory the place of the analysis of schemes is taken by a comprehensive study, while the place of the synthesis is taken by systems design. Not only the theoretical schemes of different engineering, natural, mathematical and social scientific disciplines are made comprehensive, but also the engineering requirements and limitations represented in a theoretical form (special structural schemes). Modern engineering theory, unlike classical theory, is oriented on general scientific (methodological) notions (systems, cybernetics, etc.) and on universal means of computer simulation. Therefore, the process of its construction is inevitably accelerated. It is associated with the adaptation of these already developed universal notions and schemes.

Let us sum up the basic features of the structure and functioning of theoretical studies in modern scientific engineering disciplines.

1. The structural and flow schemes of modern engineering theory are more general and are shaped, on the one hand, as the concretization of a universal ontological scheme, for instance, systems ontology whose principles of construction are developed in a wide methodological sphere, and, on the other, as a generalization of appropriate ontological schemes of classical engineering theories.

2. The generalized structural scheme of modern engineering theory represents a maximally abstract image of the static structure of a complex engineering object abstracted from the qualitative definiteness of structural elements. It is used to analyze the configuration of the system and the degree of the interrelationship and reliability of its elements, irrespective of their specific content.

3. The generalized flow scheme of modern engineering theory is a generalized algorithmic description of the functioning of the system, i.e., of the sequence of transforming the flow of substance, energy or information, irrespective of its realization. It is the result of abstracting from the qualitative definiteness of the natural (in particular, physical) process which is passing through the system and which is being transformed by it.

4. Each of these generalized ontological schemes (structural and flow schemes) has its specific methods of mathematical descriptions. In other words, in modern engineering theory (where the mathematical description depends primarily on the flow scheme) functional schemes develop. They are oriented, in the first place, on structural schemes and, secondly, on flow

ontological schemes. Besides, modern engineering theory uses, as a rule, several standard (functional) schemes adapted for solving different classes of engineering problems.

5. This gives rise to differences in functioning. In classical engineering theory (for instance, in theory of electrical circuits) at first a structural scheme of a device is built which then, according to certain rules of correspondence, is transformed into a flow scheme and then into a functional scheme equivalent to it, for instance, an operator scheme. On the basis of the latter, sets of equations are formed into which specific values of parameters under study can be substituted. The solution of these sets of equations makes it possible to determine either unknown parameters of some structural elements (of the electrical circuit) with known characteristics of the natural process passing through them (e.g., the electrical current passing through the circuit), or unknown characteristics of the electric current with known parameters of elements.

In modern engineering theory the complexity of engineering objects conditions the necessity of the theoretical study and the mathematical description of not only the process of their functioning but also of their structural schemes. Therefore, mathematical problems of two types are solved in it: firstly, the determination of the rank, connectedness, reliability, etc. of the elements and the structure of the system, and, secondly, the calculation of the parameters of its functioning.

6. Since modern engineering theory deals with the qualitatively new object of research and design, the problem of its systems representation, of creating special systems ontology, emerges. Within the framework of each theory this finds its expression in the necessity of comparing the generalized structural and flow schemes of the same object, of its syncretic structural-flow description. For example, in many algorithmic languages of computer simulation the static structure of the system is combined with the algorithm of its functioning (on a single block diagram). This algorithm is regarded as a consequence of operations carried out by the elements of the static structure.

7. Finally, owing to the comprehensive character of theoretical study in modern scientific disciplines, their functioning consists not only in revealing different aspects and modes of the operation of the system under study (design), which are subject to the generalized description and calculation, but also in collecting all the results obtained in a single multi-aspect simulation model. This task has not been set within the framework of classical engineering theory.

Moscow, USSR

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KNOWLEDGE AND VALUE ORIENTATION IN SYSTEM DESIGNING

Ladislaw Tondl

Abstract

The term "knowledge and value orientation" in technology presupposes that any technological system is a materialization of a certain amount of knowledge and a certain set of values. Discussions concerned with the explanation of technological changes have pointed at the role of value orientation and at the importance of decision-making processes influenced by accepted value structures. Changes in knowledge orientation have accentuated primarily an interdisciplinary approach; analyses of dynamic behaviour; the sphere of impacts in time and space; and considerations of prognostic dimensions in the preparation, planning and designing of technological changes. New accents in value orientation presuppose a synthesis of technical and humanitarian rationalities, respecting those aspects which are expressed in terms of "human dimensions", "controllability", "manageability", "acceptability", "solving ecological and ergonomical problems".

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1. The terms "knowledge orientation" and "value orientation" in technological systems

Recent Soviet discussions concerned with outlooks of technical disciplines - with system designing and designing culture, which have also reflected certain generalized experience with recent technological accidents and the increase of potential hazards or the danger of negative impacts of some technological solutions - have focused attention on two important areas which tend to be expressed in terms of "knowledge orientation" and "value orientation" in technology and technologico-engineering thinking. These terms represent a certain generalization or modification of those concepts which were stimulated by the pioneering work of Thomas Kuhn, which deals with the role of paradigms in the development of science and technology. According to these concepts, any scientific/technological artifact, i.e. any new work resulting from rational cognitive or creative activities, is characterized by certain knowledge and certain value structures being projected into its creation. In this respect, any new step in science and technology is characterized by what is expressed in terms of "knowledge-ladenness", or "theory-ladenness" and "value-ladenness".

Naturally, the increasing complexity of envisaged, planned or designed technological systems also results in an increased amount of knowledge being applied in the course of the design process, and in the realization or implementation of complex technological systems. The very synthesis, aggregation or integration of these knowledge prerequisites (which are, as a rule, of a different nature and origin, resulting from many scientific and technical disciplines, and which include not only the knowledge of what can be realized but also the knowledge of how it can be realized, the knowledge of realization conditions and limits) requires a certain systems approach, a systems analysis. Consequently, one cannot wonder that the designing of large technical systems involves well-managed and organized work of teams composed of specialists in different professions, not only in technical and natural scientific disciplines, but frequently in economics, some biological and medical disciplines and, principally, ecology.

While the knowledge orientation and knowledge prerequisites of the conceptual and design preparation of a piece of technical work may seem obvious - this is also corroborated by the fact that the conceptual and design preparation is always carried out by specialists and specialized teams - the situation is different as far as value orientation is concerned. And yet the origin of any technical work inevitably results also from certain decisions and evaluations, starting with the assessment of existing, justified and accepted needs, requirements or obligations, and ending with the selection of a technical solution for a given problem situation. These decision-making and evaluating processes always employ certain value structures, certain criteria, certain priorities etc. This essential characteristic of the genesis of technical works holds true, even when these value structures may be concealed, and need not be explicitly expressed or formulated; this is also because decision-making and evaluating processes reflect certain interests or requirements on the part of those who are engaged in the realization of a required technical work.

The value orientation of envisaged, planned or designed pieces of technical work may sometimes be prone to a certain contradiction, as shown in recent works by Soviet authors dealing with the system designing of new technology. On the one hand, a team of specialists is correctly required to submit an optimized solution which would satisfy all-society demands and comply with up-to date trends in scientific and technical development, using the highest level of knowledge. On the other hand, the technical solution submitted is required to comply with interests and needs of the customer, which may be biased by narrow or limited knowledge or value horizons, resulting from outdated ideas and concepts, or from a unilateral approach to a potential technical solution, which is biased by partial interests. It can be assumed that the contradiction is partly responsible for some still-existing deficiencies in the investment process, for the continuing accentuation of technical development within existing or rather outdated technical paradigms, i.e. for the mere dissemination and distribution of so far accepted models, standards, designs, methods and technologies, for the increasing technical delay in many technical areas, or, in other words, for giving inadequate attention to the importance and role of some new technical directions.

2. Problem of the explanation of technical changes

In the past, analyses of technical trends and technological developments operated mainly with the term "innovation", introduced by Schumpeter. Their attention was focused principally on the analysis of the influence and role of technical innovations in the economic development, on the typology of technical innovations, analyses of so-called innovation cycles or innovation rhythms etc. Concurrently with analyses of this type, analyses of so-called technical delay, technological transfer, and importance of so-called innovation clusters, i.e. centres of scientific and technical creativity, were carried out in Western Europe and in the OECD member countries. These works resulted in many valuable incentives, mainly for the orientation of scientific and technical policies and the programming and planning of promising technical trends. (This holds true despite the fact that analyses of this kind were considerably underestimated or, in other words, following certain promising initial works, discontinued completely in our country.)

Recently, analyses of additional problem spheres - apart from those mentioned above - have been initiated, which represent a certain expansion of the original ones. While the earlier efforts focused mainly on scientific and technical innovations, their genesis, informational, technical and social prerequisites of their fruitful development, problems related to a more general term, namely to that of "technical change", have recently been analyzed and discussed more frequently. An essential difference from concepts and analyses which use the term "innovation" can be briefly characterized as follows: while the term "technical innovation" includes desirable, required and currently prepared technical changes which are assumed in advance to be generally beneficial or, to be exact, to be leading to a reduction of entropy in processes of man-controlled, -managed and -utilized material, energy or information changes, the term "technical change" also denotes undesirable changes, changes related to negative (mainly environmental) impacts, changes involving increased risks, increased possibilities of accidents etc. Obviously, this is not to say that the ratio between positive and negative impacts of technological changes is stable, or that it cannot be modified to follow a desired direction using a series of appropriate measures, i.e. additional technological changes.

The issue of technological changes can be examined from various viewpoints and in different consequences. These include principal directions and trends of technical changes, their potential or assumed trajectories (which are usually tree structures), directions of these changes projected into chronological and spatial dimensions (i.e. a certain expansion and generalization of the earlier analyses of the so-called "transfer of technology"). In this respect, it is necessary to mention an important problem sphere which has recently been in the focus of keen attention and which tends to be denoted as the "explanation of technological change".

The explanation of technological change includes mainly analyses of the origin and course of technical change, i.e. usually the reconstruction of causal concatenations leading to a technological change of a certain type; in these analyses, attention is paid chiefly to general relationships and dependencies, i.e. dependencies which have a repeatable character and which can lead - assuming identical or analogous conditions - to a repeated occurrence of an identical or analogous technological change. Consequently, the problem sphere is sometimes characterized as "technological diagnostics". (Formally, explanation or diagnostic models have a suitable or analogous structure, being represented by sets of procedures operating with general data, i.e. scientific laws, hypotheses or other generalizations, singular factographic data and certain inference rules. For these reasons, the term "technological diagnostics" has the same or analogous meaning as the "explanation of technological change".)

The explanation of technological changes, or the use of the term in the sense corresponding to the technological diagnostics, is important for analyzing changes which have already taken place, especially those changes which can be characterized as undesirable, unwanted or unexpected and which have resulted in negative impacts, deteriorations of the overall situation, or increased risks or dangers characterized in any other way. The fact that we are capable of explaining such changes, that we know the sequence of processes leading to a technological change of a certain type (the sequence is, as a rule, a tree structure where analyses proceed from its branches and ramifications downward to the root) is very important for selecting measures which can prevent an undesirable change occurring, or at least reduce the probability of its taking place, as well as for selecting measures which could reduce negative impacts of some situations. Essentially, the function of explanation procedures in this case is the same as that of diagnostic procedures: a diagnosis is reliable and efficient enough if it is capable of initiating an efficient therapy.

However, the explanation of technological change is by no means limited to changes which have already taken place, or even to their negative impacts. It is also concerned with envisaged, prepared, planned or designed changes. As every technical work is a result of human technical activities which usually constitute a complex, sequentially and hierarchically organized structure of different activities, mainly cognitive, evaluating, decisionmaking, proposing and materializing (manufacturing) ones, which are interrelated and interlinked, the explanation of technological changes includes findings which render our knowledge concerning the structure of these activities more detailed. Unlike the explanation of phenomena, occurrences or situations which originate or which are manifested without any interference on the part of man and which are, to a substantial degree, represented by general relationships and causal concatenations, the explanation of technological changes must also take into account the fact that these changes are always a result of a purpose-oriented, organized and man-controlled set of activities into which elements of a very broad sphere of subjective phenomena enter. Apart from other constituents, the sphere includes elements which tend to be expressed as needs, requirements, demands, motivations etc. At the same time, elements of what are usually termed "knowledge orientation" and "value orientation" are always projected into and reflected in this sphere. To summarize the role of these subjective elements in the explanation of technological changes, it is possible to conclude that:

- every technological change can be regarded and analysed as a result of a conscientious, organized and target-oriented set of activities which are capable of desirable transformations of some material, energy and information processes,
- every technological change represents a "second nature" element, i.e. conditions, processes or occurrences produced by practical human activities,
- every planned, required or designed technological change must be - before it takes place - prepared in the form of an "ideal model", an "informational model", i.e. in the form of a project of what is to be changed, how the change is to take place and what its future use will be. (This is to stress the indispensability of a design preparation stage in every planned and required technological change.)

3. *Changes in knowledge orientation of designing*

Changes in the conceptual knowledge orientation, i.e. mainly in the research, development and design preparation of technical works, are stimulated chiefly by the necessity of a system-conceived approach to the preparation, realization and use of these works. For this reason, the term "system designing" is often used. (Although the interpretation of this term need not necessarily be unambiguous, it may either denote the use of system principles and system-engineering methods in designing technical works, or denote the designing of works explicitly characterized as systems - there is no clearly delineated boundary between the two interpretations. In the following parts of the present article, the first interpretation will be adhered to.)

Principal changes in the knowledge orientation of engineering designing, which are being enforced step by step and which have to be taken into account in all spheres of engineering-technical activities, can be summarized as follows:

- provisions for an interdisciplinary snythesis and interdisciplinary cooperation,
- an accentuated system approach to the preparation, realization and operation of technical works,
- thorough application of prognostic criteria.

The interdisciplinary synthesis has already built up a relatively good and developed tradition in some technical fields. Practically all important works in the field of engineering, power generation, construction industries and other technical branches cannot dispense with purposefully controlled and orga ized cooperation of specialists in a number of different technical disciplines, especially engineering disciplines, disciplines related to materials and control processes, electrotechnical disciplines related to microelectronics, and many others. Lately, these problem spheres have been supplemented by information sciences and a number of disciplines of theoretical and technical cybernetics, including the use of automated algorithmizable activities, databases and, possibly, knowledge bases and other elements of artificial intelligence.

Many technical jobs and technical solutions of acknowledged problem situations require the interdisciplinary synthesis to include ergonomic information, i.e. information concerned with man-technical system relationships, ecological and medicinal knowledge etc. The solution of many technical tasks cannot be comprehensive and versatile, if it does not take into account knowledge of some non-technical disciplines which include not only engineering psychology, but many others. It may be of some interest to mention certain new tasks in linguistics, theory of language and graphic communication and other humanities, which have emerged in relation to the programming of more advanced generations of computers.

The accentuated system attitude and system approach are manifest mainly in that every important technological work (such as large manufacturing systems, new power sources, transportation systems, urban schemes etc.) must be conceived as a subsystem of a broader system (technico-economic, socio-economic, or characterized in another way), which presupposes complex interrelationships and interactions of individual subsystems, usually in time and space, as early as the conceptual and predesigning preparatory stages. A system concept must include analyses of the dynamic behaviour of a subsystem under consideration, and potential or assumed changes in the interactions of the individual subsystems. The analyses of dynamic behaviour usually include the behaviour in extreme situations as well, i.e. in conflict situations, situations characterized by an increased measure of risk etc. These analyses must pay utmost attention to problems of a whole broad range of potential or expected impacts, including impacts in extreme situations. Considering the range of potential impacts, our attention will naturally be focused on ecological/environmental impacts, potential microclimatic changes and potential dangers to living environment and biosphere. For these reasons, the most advanced designing establishments include in their interdisciplinary teams specialists or groups of specialists in engineering ecology, that is why models or simulations of potential or expected environmental impacts are, in their view, an indispensable part of any project.

The application of prognostic criteria must be an indispensable part of the system designing orientation as far as projects of larger technological systems are concerned. The opinion that project/designing documentation should contain only a model of a future technical work at the time of its being put into operation must be regarded as outdated and quite unsatisfactory. The system designing must include assumed impacts of a project's operation, of its assumed dynamic behaviour in time and space, cycles and rhythms of accomplished functions etc.

The incorporation of chronological parameters must not be limited only to the traditional concept of a sequence of chronological instants, but must also include such concepts as tend to be characterized by the term "time direction". The term denotes the direction and speed of the increasing of the entropy level of a given system. Consequently, such chronological parameters include those related to moral ageing, a decrease of the measure of reliability of a given system, useful life intervals etc.

As complex technological systems are usually composed of a number of subsystems or elements the typical feature of which are differential characteristics of the time direction and differential chronological parameters determining typical intervals and cycles in general, an important part of the system designing is what may be conclusively termed as the "flow chart coordination". The flow chart coordination is very important for assessing linkages and relations of a technical system being designed to its surroundings, as well as for assessing interrelationships of individual subsystems of a broader system into which the technical system being designed is to be incorporated.

System designing which incorporates chronological parameters and time direction measures and variables into an image of a technical work being prepared, cannot dispense (mainly as far as building investment projects are concerned) with an extensive problem sphere of potential modernizations, updating or other modifications of the created technical system, with problems of so-called secondary and tertiary uses, and - last but not least - with problems of its future liquidation. One should never succumb to a carefree and naive faith that all these problems will fall on future generations and need not concern us at all. Even now, it is well known that problems of this kind concern some power-generating facilities, e.g. nuclear power-generating plants, and - albeit in a somewhat different way - some construction projects, such as large housing schemes built of precast elements etc.

Problems related to chronological parameters cannot always be exactly determined and exactly quantified using current knowledge. Nowadays, the technological prediction also accounts for such situations as require the use of prognostic methods based on viewpoints, opinions and recommendations of teams of experts or *ad hoc* task groups.

4. Changes in value orientation

The value orientation of the conceptual, research, development and design preparation of large technical works can also draw on certain positive traditions, and on many developed methods and procedures employed in technological decisionmaking processes. In this respect, one should never forget methods, criteria and criterional systems developed for analyses of economic efficiency of investment projects and cost-benefit analyses, for concepts of so-called "utility functions", multicriterional decision-making processes etc. Starting with the classic works of Pareto from the beginning of this century, a relatively rich pool of methods and methodologies is available, which has also found a good application in the sphere of technical and technico-economic decision-making processes.

Hence, the methods listed above have in no way lost their importance for solutions concerned with those problem spheres which are related to the value orientation of system designing. They have been rather expanded or generalized in some ways. The expansion of the problem sphere can also be attributed to one of the trends of the present technical thinking, usually denoted by the term "technology assessment", for which the author recommends the term "system conceived assessment of technological innovations and investment projects". On this occasion, I shall attempt to show in brief how the system-conceived assessment expands the existing methods and means in the value orientation, i.e. which trends it promotes and what it accentuates. Certain changes or some new accents in the value orientation of system designing can be summarized as follows:

- generalization of the traditional concept of efficiency or the concept of utility functions,
- synthesis of technical and non-technical rationalities,
- accentuated "controllability", "manageability" and "human dimensions" of new technology.

The generalization of the traditional concept of efficiency consists mainly in that the technical work to be assessed is purposefully conceived as a subsystem of a broader system, that its dynamic behaviour, expected or extreme situations impacts in time and space are taken into account. As efficiency methods presuppose analyses of inputs, and outputs of a given technological system, and of functions the system is capable of performing, to be undertaken, the generalization of the traditional efficiency concept requires a synthesis of analogous viewpoints of the whole broader system. At the same time, the concept of "functions" must not be limited only to immediate users of a given system, but must include universal criteria in a long-term view.

The synthesis of the technical and the non-technical rationalities denotes mainly the expansion of the so far applied sets of technico-economic criteria by those criteria which are concerned with the preservation and protection of a healthy living environment, with medical, biological, psychological and social viewpoints, with cultural and aesthetic values, with universal and moral responsibility problems which cannot be limited only to the responsibility for existing state-of-the-art of technology, but must also include potential future situations and impacts of technological systems. These problems are highly complicated and, at the same time, very sensitive, as exemplified by discussions on the moral and human responsibility for proposals, recommendations and decisions carried through by computer systems, automated systems containing artificial intelligence elements, expert systems etc. As far as system designing is concerned, the synthesis of the technical and the non-technical rationalities assumes that the designing process and its results should also include solutions to all ergonomical problems related to the use of a technological system, to relationships between its human user and technology. These relationships also comprise a broad group of problems concerned with communication processes, control, management and monitoring of a technological system, possibilities of dialogue, cross-checking or other forms of interaction. It may seem that these problems have become especially topical and sensitive in the sphere of modern computer technology or in that of the use of automated systems provided with elements of artificial intelligence. In fact, experience with solving ergonomical problems in the spheres mentioned above can have a more general meaning and may come in handy in other spheres of manipulations with and sophisticated uses of modern technology. This applies especially to solving problems of the so-called technical alienation, to humanitarian solutions of problems arising in such situations when man becomes in a certain way dependent on or even subordinate to a technological system.

The synthesis of the technical and the non-technical rationalities is closely related to those systems of assessment criteria which are expressed in terms of "controllability", "manageability" of technological systems, or "human dimensions" of new technology. These expressions truthfully denote certain changes which have taken place in value structures employed in technical thinking and decision-making processes. On the basis of these changes, system designing should not leave aside problems of certain guarantees in situations when a technological system becomes uncontrollable and unmanageable. The recent technological development has proven beyond doubt that these problems, for years and years known only from works of science fiction writers, need not necessarily be just a fiction.

5. *Decision-making bases and theoretical support of technical solutions*

The scheme of the explanation of required, planned or designed technical changes presented above presupposes that such a technical change always results from a decision-making process. These processes always employ what has been defined as knowledge orientation and value orientation. In relation to the role of knowledge orientation and value orientation in proposing a final technical solution, terms which are to a certain extent analogous to those used in determinations and assessments of informational prerequisites and initial solutions in systematization-type procedures (such as explanation, diagnosis, prediction and other procedures operating with knowledge and factual data), i.e. the "decision-making base" and "theoretical support" can be employed for determining and assessing informational prerequisities and initial solutions. (As far as the term "theoretical support" is concerned, it corresponds to that of "conditional credibility" introduced by the author for assessing scientific results.)

The term "decision-making base" denotes a set of informational prerequisites necessary for solving a given task, the solution of which makes use of certain knowledge. In scientific procedures, the decision-making base consists of an arranged pair of a general data set (scientific laws, hypotheses, empirical generalizations) and a factual data set. The resulting solution can be derived from the decision-making base. The decision-making base of designing processes is usually far more extensive and includes:

- characteristics of a given problem situation, including specifications of needs, requirements, demands and objectives of an assumed technical solution,
- a sufficiently detailed description of the initial *state of the art* including a description of the initial situation, surroundings of the system (such as the geosphere and anthroposphere around the proposed technical system), i.e. sets

of factual empirical data,

- sets of knowledge necessary for potential solutions of a given problem situation, i.e. generally scientific and technical knowledge,
- a set of all additional conditions necessary for potential solutions, which include feasibility conditions regarding employable resources, capacities and other technical prerequisites, and standardized conditions for all potential solutions,
- a set of all criteria, values and priorities (i.e. a set characterizing the value orientation) usable in selecting the optimum alternative.

The term "support" (or the analogous term "conditional credibility") denotes how and to what extent the resulting solution corresponds to all informational prerequisites available for a given solution. For these reasons, the term has become very important for evaluating results obtained in all systems which allow for their derivation using a decision-making base and appropriate inference procedures, i.e. in cognitive systems, expert systems, consulting systems and systems characterized in any other way and containing elements of artificial intelligence. Similarly, it is very important, when assessing results of a designing process, to know how the designer or the designers' team made use of the informational background which was available, mainly of the information falling within the "knowledge orientation" and "value orientation" categories.

Hence, the assessment of the theoretical support of different project alternatives is a very important part of tasks concerned with the system evaluation of designing activities or project alternatives. Obviously, the interdisciplinary team of specialists appointed to solve the evaluation/assessment task must have all informational prerequisites of the technical solution, including the set of usable knowledge, at its disposal. Here, too, the importance of what has been characterized as the "knowledge orientation" and "value orientation" of all technical solutions under consideration is clearly seen.

Design Institute PUDIS

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NEW PARADIGMS OF DESIGNING AND THE FUNCTION OF CAD

Ladislaw Tondl

1. Introduction

The present paper does not aim at submitting a survey of various design automation systems. Fairly good surveys of design automation systems, basic principles of their construction, and their architecture are provided, for example, in monographs [1] and [2], various other conceptual studies and publications, the journal CAD etc. The paper is rather meant to outline some consequences and new functions of CAD, as well as CAD relations to what is going to be characterized as "new paradigms of designing".

2. CAD and Traditional Engineering Design

Computer-aided design (CAD) is conceived as the use of cybernetic means in a set of activities and information bonds among these activities, the ultimate result of which is an information model of what is to be realized and how to realize it on the basis of available means, sources, capacities, knowledge or prerequisites characterized in some other way. At the same time, designing in a general sense is conceived as a (conceptual) preparation of a change required by man and achievable by human working activity [3]. The use of cybernetic means may assume various forms, starting with scientific-technical calculations, mass data processing, automated drawing or other kinds of graphic presentation of intermediate or ultimate results of design activities, and ending with retrievals from databases, dialogue or interactive forms, simulations of potential behaviour or impacts of a designed technical work. The introduction of these or additional analogous automated procedures into the process of designing is usually stimulated by the necessity of improving the designing process quality, in particular through expanding the resources and capacities needed to solve a given design problem, reducing human labour, substituting routine, repeated and algorithmizable human activities (especially those bottlenecking the process of designing), activities with high time and capacity requirements (such as searching through and processing extensive data files, preparation of design documentation drawings etc.) by automated procedures implementable on computer technology. Consequently, the introduction of automation into designing concerns both the automation of certain activities constituting an indispensable component of the entire designing process, and the automation of information prerequisites, information inputs and outputs.

The characteristics presented above show that automation can concern different components of the designing process. To be able to specify automation requirements and needs in a detailed manner, it is advisable to perform a system analysis of a given designing process, or, in other words, to construct a system model of this process, to specify its constituents, their information prerequisites, functions, inputs and outputs, organizational forms of these elements, their information bonds etc., thus rendering it possible to determine what should be automated and what not (creative, management, decision-making, assessing activities) in the sphere of designing. Obviously, this presupposes a certain coordination of, and a conceptual approach towards, automated and non-automated components of the designing process, which are an indispensable prerequisite for the introduction of higher, i.e. system-conceived forms of automation.

The emphasized fact, namely that design automation can include various elements and linkages of the designing process, should also be understood in the following manner: Design automation can be introduced gradually and in a modular way, accomplished on various levels and in different stages. From a system point of view, the following design automation stages can be distinguished [4], [5]:

a) fragmentary automation of individual partial components of the designing process,

b) system-conceived automation of the designing process, which makes use of a system approach and system models of the designing process, in particular purposeful organization of different algorithmized components and related programs, e.g. organizing differents programs into automated lines,

c) system-conceived automation which, in addition, makes use of various purpose-oriented information systems and which allows for a multi-purpose utilization of databases in various tasks and in different stages of the designing process.

Higher, i.e. system-conceived stages of design automation mainly allow for a multi-purpose utilization of automated components in various tasks, such as a multi-purpose use of program elements in various automated lines (the term "automated line" denoting a target-oriented sequence of programs with all necessary instructions needed to run it specified in its beginning by the user), multi-purpose utilization of data files and databases. As designing can also be analyzed as an information process the inputs (including the determination of objectives, specifications, requirements, criteria, standards and other information prerequisites) and outputs of which have an informational character, suitable cooperation and coordination of different information sources and informational prerequisites is essential for higher levels of design automation. In terms of a traditional classification of information systems, designing cannot dispense with the use of diverse and multiple information sources, such as systems of socio-economic, scientific-technical and technico-economic information, various factual systems, e.g. land information systems, catalog systems, different systems of standards, value or criterional systems etc. For these reasons, the integration of various information sources and prerequisites for designing belongs to comparatively demanding tasks of design automation.

The CAD concepts listed above, or, in other words, the concept of design automation stages, does not essentially have to change what can be characterized as paradigms of designing. The term "paradigm" was first introduced into the analysis of scientific and technological development by T.S. Kuhn [6] who used the Greek word for denoting a basic initial model, a pattern, or a scheme determining the explanation and interpretation of the entire area of interest. In this sense, Ptolemy's (geocentric) concept is a paradigm, while the heliocentric concept of Copernicus represents its revolutionary change and, hence, a new paradigm. Analogously, as shown in a number of other works, technical paradigms can be considered. E.W. Constant [7], for example, characterizes a technical paradigm as an accepted manner of a technical activity, as an accepted set of means to accomplish a certain technical task. In this respect, paradigms of designing could also be considered. The concept of paradigms then makes it possible to distinguish two basic types of scientific and technological changes; either those in the framework of existing paradigms, characterized as "normal development" by T.S. Kuhn, or changes of scientific and technical paradigms characterized as "scientific" or "technical revolutions". The basic paradigms of a traditional engineering designing process are then as follows:

- Designing is a *component of* an organized system of activities which, as a whole, constitute the *investment process*. The system comprises a sequence of linked-up blocks, starting with the formulation of a design problem, i.e. with the appearance, recognition, justification and acceptance of certain needs which can be satisfied only through carrying out a certain technical change, followed by the acceptance of a concept of approach toward the problem, resulting in the formulation of an investment project or the specification proper of the project task, preparation of related documentation, and ending with the realization proper and use of the required technical change. The system includes extensive sets of diverse and interdependent activities, such as decision-making, evaluating, cognitive and proposal-formulating ones.

- Designing, which results in the preparation of project documentation, is fully *subject to the accepted solution concept*, to the accepted task specifications. Consequently, the designer's initiative is limited by the scope of the accepted task specification.

- Results of the designing process contained in project documentation are evaluated mainly with regard to *how they satisfy the task specification,* or objectives and requirements formulated in the task specification.

- The traditional engineering designing is focused on what can be characterized by a question "*how to realize*" rather than "*what to realize*", with the latter (except for technical details) formulated outside the design process proper.

- In the process of designing, efforts aimed at the *optimization of the solution* of a given problem, manifested mainly in attempts to minimize costs and to maximize efficiency of the proposed solution to the given problem, are very important.

Naturally, these and some other paradigms of the traditional engineering designing are only partly set forth in appropriate standards, regulations or other forms of organizational, normative and value frameworks of designing. Undoubtedly, these paradigms have proved useful in practice as an efficient normative and value scheme which incorporates designing into the entire cycle of the investment activity. However, this is not to say that the existing set of paradigms should not be, regarding present needs and problems, modified, expanded or supplemented in some ways.

3. *Motives for Some Changes of Traditional Designing Paradigms*

Recently, significantly increased importance has been attributed to certain situations which require changes of traditional schemes of the investment process and, consequently, also of what has been characterized as paradigms of designing. Such situations may include the following facts, or, in other words, awareness of the following facts:

a) There has been significantly increasing criticism of the *lack of coordination* of some investment projects, not only in terms of their chronological scheduling, but also from the viewpoints of their spatial arrangement, provision of materials and energy, relations between suppliers and customers, building up of research, development and organizational prerequisites and tools etc. (Undoubteldy, examples of such a lack of coordination are plentiful, no matter which viewpoint is chosen, as well as those of its negative technico-economic, social, esthetic, ecological and other impacts which continue to persist and which are overcome at a cost of considerable efforts.)

b) Some investment projects may result in *unexpected negative impacts* after a certain period of operation or use, particularly in increased hazards, danger of accidents, uncontrollable situations or situations which can be coped with only at a cost of immense efforts, needs of additional investment funds, initially not accounted for, etc. At the same time, these impacts do not include only apparent, unique power-generating plants, accidents of some means of transport, leakages of noxious chemical substances into the atmosphere or streams, but also long-term changes of the entire environment, sometimes utterly irreversible.

c) The importance of so-called *limit problems* has also increased. This applies in particular to limits of materials, power resources and human capabilities, to so-called "limits to growth", which have been pointed to in works of the Club of Rome etc. Their scope is fairly broad and diverse, while awareness of them has increased gradually. Some problems, such as those brought by the energy crisis of the seventies, have shifted the awareness of these problems from narrow groups of specialists to minds and opinions of the broad public. The same applies to problems related to the controllability of certain technical systems, or, in other words, to hazards associated with these systems. These facts also explain the popularity of some slogans, such as "human dimensions of new technology", "small is beautiful" [8] etc.

d) Lately, increased attention has been paid to what can be generally characterized as *problems of ecological impacts* of all technical changes, innovations or investments. The problems of environmental protection and formation have justly become primary factors influencing planning and investment policies [9]. This is an indisputable contribution of different ecological movements (the so-called "green" movements) and similar citizens' initiatives, despite the fact that some of these movements use rather simple slogans and emotionally laden proclamations, while investment policy needs can never dispense with multifaceted analyses carried out on an expert level.

These and some additional circumstances stimulate the introduction of some new accents into existing designing paradigms, or of new paradigms; this phenomenon by no means concerns only the sphere of designing, but is extended to the whole investment process, including its conceptual, research and development preparation. Generally, the new accentuation (or new paradigms) can hardly be achieved without automating some of the related activities, without using extensive, interdisciplinary knowledge, without processing large data files and databases, without having at one's disposal the possibility of presenting or simulating the assumed behaviour of technological systems and their potential impacts in time and space, that is, without making use of the capabilities offered by the existing and developed state-of-the-art of CAD.

The following can be assumed to represent new designing paradigms which partly change the content of the existing ones:

1. Every engineering technical work, no matter whether in the stage of preparation, planned, or being designed, should be considered to represent a *subsystem of a broader technological, technico-economic or socio-economic system* which is always characterized by a certain dynamic behaviour, probabilities of risks, conflicting situations etc. Consequently, the designing process should always take into account linkages to broader systems, its functioning and maintenance within a higher-level system, or the liquidation of a technical work in the stage of preparation in the framework of a broader system.

2. Present-day engineering designing should always produce *alternative solutions*. One of them may even be the preservation of the existing state, i.e. dropping or shelving a given problem to be solved. The alternatives, which should be described in sufficient detail, should undergo a system-conceived, i.e. comprehensive and multicriterional evaluation (technology assessment tasks). The system evaluation of alternative solutions should by no means be limited solely to the quality of the

technical solution of a given task, but also include the sphere of broader linkages to its neighbourhood, a comparative analysis regarding the current state-of-the-art in the world, the sphere of potential impacts in time and space, problems of "direction of time" (the term denoting the direction of the maximum increase of the entropy of an evaluated technological system), of so-called "time horizons" etc.

3. The current designing represents an important intermediate link in the cycle of

Research - development - designing - realization - use.

As important links in this cycle have an informational character, it is necessary to solve a number of problems related to informational links, such as those of noise minimization in these links, of a sufficient absorption capacity of some blocks in these cycles (i.e. the ability of such blocks to recognize in time and to interpret competently enough what is taken over from other blocks), of potential delays in the cycle etc. The same ring also includes what can be characterized as respecting problems of *feasibility,* i.e. the feasibility of a given technical solution regarding given conditions, available resources and capacities, and disposable assets of the realization sphere.

4. The current designing must also include solutions of problems related to *man (user)- technical work* bonds and linkages. It is a fairly broad and diverse group of problems (which are generally characterized as ergonomical problems) which, for different technical jobs, are connected with many diverse and varying aspects. The group includes particularly the following ones:

- problems of manageability and controllability of a designed solution (including manageability and controllability in limit emergency situations),
- potential for secondary uses of an accepted technical solution, including possibility for its external use in different conditions (the so-called spin-off), or, in other words, in situations not yet defined.

5. The modern concept of designing technical work must also take into account tendencies in the present technological

and investment policies which may be characterized as efforts for "*participation democracy*" in investment policy, "public participation" in urban development and land-use planning, and elements of "direct democracy" in construction planning and management. Essentially, these efforts are focused upon increasing the direct participation of citizens in management and decision-making in the spheres of land-use planning, investment policy and urban development, i.e. upon combining direct and representative democracies in all areas directly or indirectly concerned with the life, work and leasure of citizens. As far as the designer's work and the basic alternatives of the solution of a given design problem of greater importance are concerned with an entire region and its population, they should be, if possible in a sufficiently illustrative and understandable form, submitted for public discussion. (Switzerland has already gained considerable experience with combining direct and representative democracies in investment policy. In some countries, such as in Denmark [10] or in Great Britain [11], direct democracy is law-enforced. The applicable Danish law, passed in the seventies, charges all regional administration bodies with the duty of providing land-use plans and important investment projects in several alternatives, of organizing public discussion on the given topic for a period not shorter than 6 months; only then is it possible to decide which alternative will be selected. The selected alternative must next be submitted to the Ministry of Environmental Affairs for a final approval and authorization.) The provision of participation democracy in investment policy, or, in other words, the coordination of concepts, proposal and evaluating judgments of competent experts and the public, is obviously a very complex and not always feasible affair, not only because public opinions can be easily manipulated and unilaterally influenced, but also because these opinions are not homogeneous; conflicts of different concepts have to be solved, as well as those of different interests or analogous conflict situations.

Although the problems related to this area predominantly lie outside the spheres proper of designing or designing automation, it is necessary to take account of some of the important aspects even in the designing process proper. These generally include aspects of technical solutions considered and evaluated which are usually expressed in terms of "acceptability", "desirability" etc., or in their quantitative measures.

4. CAD Tasks in Relation to the Paradigms Given Above

Undoubtedly, the introduction of the paradigms mentioned above into the process of designing, or the modification of traditional paradigms in accordance with the trends mentioned earlier, result in a considerable increase in the demand for knowledge, information and capacity prerequisities of the designing process proper, and also in its importance as an indispensable link of the research - development - design - realization - use cycle. The very increase in the number of alternatives in designing, the increased importance of management, decision-making and evaluating activities, the need to simulate broader links with the surrounding environment, the expected dynamic behaviour and potential impacts of proposed solutions, the need to process extensive data files of variable nature and origin - these all necessarily promote requirements for automating all such activities and information processes as are algorithmizable and, hence, implementable through using appropriate tools, as well as requirements for expanding the scope and room for proposal, management, decision-making and evaluating activities and, in fact, for everything which tends to be characterized as creative technical activities.

Understandably, the fragmentary concept of the automation of individual tasks, characterized earlier, does not and cannot satisfy these requirements, no matter what their linkages to other tasks may be. If it is declared that the system concept of automation is indispensable, then the "system" attribute represents no a priori guarantee of overcoming the fragmentary concept limitations. Consequently, it is necessary and advisable to formulate principles of the system concept of design automation, which can be, of course, implemented gradually and to a varying extent.

Leaving aside hardware prerequisites (which include, in articular, a hierarchically organized computer network with a ystem of distributed intelligence, a system of intelligent erminals and means allowing for dialogue and interactive modes f work, a system providing for a purpose-oriented parallelism f digital and graphic outputs, and other facilities of com-unicating with hardware means at all levels and in every stage f the designing process), the main principles of the system-onceived automation of the process of designing can be char-cterized as follows:

1. Automated components of the designing process must be urposefully incorporated into the entire process of designing nd providing for guaranteeing necessary linkages and bonds. 'or these reasons, the introduction of automation satisfying hese requirements presupposes a *system analysis* and *system decomposition* of the entire process, including the determina-tion of its sequential and hierarchical structure. (In the literature on CAD, the results of such analyses are generally characterized as a "*network model of the designing process*" [1].) The system analysis and decomposition of the designing process is also important regarding that CAD should satisfy general and specific objectives of designing, and at that, more efficiently, in higher quality, faster, with reduced human labour requirements and, in comparison with traditional de-signing, a lower demand for other indispensable capacities. (The note conerning general and specific objectives is also important because the system of objectives, too, is hierarchi-cally structured, with the aims of specific (lower level) ac-tivities being subordinated to more general (higher level) ob-jectives. An example of general objectives, which are usually yet far from the designing proper, is the well-known statement by J.F. Kennedy, made on May 25th, 1961, that it is necessary to provide for a safe landing of man on the Moon and for his safe return to the Earth by 1970, or a proclamation that the housing shortage in City Y should be solved by the year X, while specific objectives are represented, for example, by a static calculation for a given type of a block of apartments etc.)

2. The system-conceived automation of designing presupposes a *multi-purpose* utilization of all developed methods, means, algorithms and programs in different tasks, a multi-purpose use of data files and databases on different levels and in various stages of the designing process (as well as, naturally, the use of the data - and of data produced during the designing, implementation and post-implementation stages - for operation, maintenance and, perhaps liquidation purposes). The multi-purpose utilization of individual programs also implies that they can be arranged into various automated lines directed by a single instruction (command) or query, the use of organized sequences of subroutines and programs arranged into so-called menus etc. The multi-purpose use of all means developed is important regarding the increase of the number of alternative solutions offered by the designing process, for modelling the dynamic character of the items of technical work considered and their assumed impacts.

3. The system-conceived automation of designing must provide for guaranteeing not only *reliable linkages and forms of communication* among automated constituents, but also among automated and non-automated components of the designing process, i.e. individual activities and their informational linkages. Requirements of this type are by no means limited to ensuring compatibility and transferability of data among various levels and components of computer networks, but are also concerned with various forms of communication between the user-designer and automated components of the process of designing. The requirement for these forms of communication to be sufficiently reliable and efficient emphasizes the role of graphic forms as highly illustrative and fairly comprehensive ways to present extensive data files, the role of interactive graphic systems and dialogue systems using linkages and mutual transformations of digital and graphic forms of presentation.

4. The system-conceived automation of designing cannot leave unheeded new trends and new tendencies related to higher-generation computers. In particular, the new trends include especially what may be generally characterized as the *introduc-*

ion of artificial intelligence elements into systems of tasks being solved and, most of all, into information systems being made use of in such tasks. The elements of artificial intelligence, which seem promising for the automated designing development, include, in particular, knowledge systems or knowledge bases. These are automated systems which operate with precisely determined inference mechanisms and certain knowledge, i.e. certain proven or valid generalizations applicable to an entire area of interest. When building up informational prerequisites for designing (in the form of managed databases), it will undoubtedly be useful to design some of such databases as knowledge bases. This especially concerns normative systems, axiological systems (i.e. systems of criteria and criterional functions assuming a certain synthesis of a large number of criteria having a varying degree of relevancy) allowing for evaluating alternative solutions under consideration, or, in other words, their arrangement into a suitable system of priorities.

5. A very important principle of the system-conceived automation of designing is what may generally be characterized as a *principle of modularity*. The principle of modularity presupposes a possibility of expanding the designing process in a modular, step-by-step way, through adding new automated components, of a broader use of automated components already developed in new tasks and in new circumstances, or of a suitable adaptation, modification or updating of these components in new contexts. Naturally, the principle of modularity should not be interpreted in an oversimplified way, claiming that all CAD systems being developed or developed so far can simply be expanded by the addition of new elements without having to reconstruct them dramatically or to abandon them altogether. Its aim is rather to point out the necessity of taking into account the gradual expansion and supplementation of newly developed systems.

Design Institute PUDIS

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HUMANISTISCHE ASPEKTE DER WISSENSCHAFTLICH-TECHNOLOGISCHEN ENTWICKLUNG

G. BELKINA

Was ist im 20. Jahrhundert geschehen, welchen Stellenwert haben in ihm Wissenschaft, Technik und Technologie, was verheißen sie den Völkern für die Zukunft und womit bedrohen sie sie? Diese konkreten und praktischen Fragen, die unvermeidlich einen politischen und ideologischen Klang bekommen, werden heute von den Exponenten verschiedener sozialer Kräfte und Bewegungen gestellt.

Noch zu Beginn unseres Jahrhunderts hatte die Menschheit derartige Probleme und Dilemmas nicht gekannt. Und dies nicht nur deshalb, weil die sozialen Voraussetzungen für ihr Dasein andere gewesen sind. Die Wissenschaft selbst und die auf ihr basierenden technischen und technologischen Neuentwicklungen hatten dazu keinen zwingenden Anlaß gegeben. Es hatte den Anschein, als gebe es nur in utopischen Romanen Platz für die künftige Erhabenheit und die "Dämonie" der Wissenschaft und Technik. Gegen Mitte des 20. Jahrhunderts geschah jedoch etwas, was ihren Platz und Rolle bei der Entwicklung der Gesellschaft von Grund auf veränderte. Die Wissenschaft begann zu einer unmittelbaren produktiven und sozialen Kraft zu werden, wobei sie zugleich auch zu einem gewichtigen Faktor in der internationalen Politik wurde.

In der neuen Etappe des wissenschaftlich-technischen Fortschritts, der die Zukunft der Menschheit in einem sehr starken Maße bestimmt, fanden vor allem Veränderungen bei der Entwicklung und Verwendung der Mikroelektronik, der Informatik und der Biotechnologie, hinsichtlich der Beherrschung der Atomenergie sowie bei der Erschließung des Weltraums statt. Diese Richtungen in der Forschung bildeten von Anfang an den Inhalt der modernen wissenschaftlich-technischen Revolution.

Heute aber sind sie durch solche revolutionäre Umgestaltungen gekennzeichnet, die die Produktionstechnologie und viele Seiten im Leben des Menschen von Grund auf verändern. Die Sphäre der Technologie wird zu einem entscheidenden Faktor.

Welche Folgen wird dies für den einzelnen Menschen und für die Gesellschaft, in der er lebt, haben, und welche reale soziale und menschliche Probleme, die einer dringenden Lösung bedürfen, treten in diesem Zusammenhang bereits heute auf? Diese Fragen sind neben den Problemen der Effektivität, der Produktivität der neuen Technologie, der neuen Prinzipien der Organisation und Leitung der Produktion im Zusammenhang damit, daß diese immer mehr von Mikroelektronik, Informatik und Biotechnologie durchdrungen wird, von überaus großer Bedeutung. Denn neue Technik und neue Technologie existieren ja nicht in einem sozialen und menschlichen "Vakuum" und sie bestimmen auch nicht an und für sich das gesamte Spektrum des menschlichen Daseins, das seinen Ausdruck in dem einen oder dem anderen Typ der Zivilisation, der Menschheitskultur findet. Mehr noch, sie hängen in ihrer Entwicklung wesentlich von den sozialen und menschlichen Faktoren ab, obgleich sie relative Selbständigkeit besitzen, die, wie wir sehen, zuweilen in technokratischen Konzeptionen verschiedener Art absolutisiert werden. Aus diesem Grunde ist denn auch die Untersuchung der sozialen Probleme von so großer Bedeutung, die in der neuen Phase der wissenschaftlich-technischen Revolution auftreten und unter anderen mit der Entwicklung der neuen Technologie zusammenhängen.

Wollten wir den Versuch unternehmen, auf die gestellten Fragen eine kurze Antwort zu finden und damit das wichtigste soziale Problem dieser Phase zu bestimmen, die mit den Erfordernissen der neuen, der, wie sie bezeichnet wird, "hohen" Technologie unmittelbar zusammenhängt, so würde die Antwort etwa wie folgt lauten: "hohe Kontaktebene". Diese, dem Sprachgabrauch der Computertechnologie entliehene Terminologie gewinnt somit einen umfassenderen Sinn: je höher das technologische Niveau der Produktion und der gesamten menschlichen Aktivitäten sind, desto höher müssen auch die Entwicklungsstufe der Gesellschaft und des Menschen selbst in ihrer Wechselbeziehung mit der Natur, die neue Zivilisation und die neue humanistische Kultur sein, die davon ausgeht, daß der Mensch der "eigentliche Zweck" der gesellschaftlichen Entwicklung ist.

Die marxistische Theorie, die die starke Wechselbeziehung und gegenseitige Beeinflußung der Entwicklung von Wissenschaft und Technik einerseits und der sozialen Umgestaltungen sowie der Entwicklung des Menschen und seiner Kultur, einschließlich seiner Einstellung zur Natur, andererseits, ermittelte, hat diesen Schluß bereits von langem gezogen. Was ist eigentlich das Neue, was die neue Etappe der wissenschaftlich-technischen Revolution hierbei mit sich bringt? Sie spitzt die hier aufgetretenen Probleme äußerst zu, wobei sie nämlich "eine hohe Kontaktebene" von neuer Technologie, Gesellschaft, Mensch und Natur verlangt, wobei zu bemerken ist, daß dies nicht mehr einfach lebensnotwending, sondern auch zur unerläßlichen Voraussetzung sowohl für eine Effektive Anwendung dieser Technologie als auch für die Existenz der Gesellschaft, des Menschen und der Natur selbst wird. Heute wird die Gefahr immer realer, daß der Mensch jeden Sinn für sein Dasein in der Welt von Robotern verliert, die ihn aus der Produktion immer mehr verdrängen, ihn nich nur von den routinemäßigen und ermüdenden Operationen, sondern auch von solchen befreien, die die Maschine einfach besser als der Mensch erledigt.

Im Westen wird dieser Umstand nicht selten zum Gegenstand von sozial-philosophischen Experimenten verschiedener Art, von denen sogar die Phantasie des Schöpfers des Begriffes "Roboter", Karel Čapek, verblaßt, die in einer so prägnanten und glänzenden Form im seinem Drama "Rossum's Universal Robots" zum Ausdruck kommt. Zu einer der Formen der Erkenntnis, daß sich der technische Fortschritt von seiner menschlichen, personenbezogenen Dominante losgelöst hat, wurde die in der 60er Jahren dieses Jahrhunderts im Westen aufgetretene Theorie vom "menschlichen Kapital". Nach Auffassung ihrer Adepten ist diese Theorie mitunter geeignet, unter anderem das wirtschaftliche Denken umzuorientieren. "Das menschliche Kapital", so der US-amerikanische Wirtschaftswissenschaftler L. Thurow, "sind die schöpferischen Fähigkeiten, die Begabung und das Wissen des Individuums." Das

Investieren in den Menschen gilt deshalb als eines der wichtigen Probleme der Entwicklung neuer Technologie. Diese Einstellung, durch die die politisch-ökonomischen Probleme durch ideologischen ersetzt werden, darf wohl kaum als konstruktiv betrachtet werden. Sie macht jedoch auf einige nichtökonomische Faktoren aufmerksam, deren Bedeutung im "Zeitalter der Roboter" zunimmt. Heute gelangen Wissenschaftler immer mehr zu der Ansicht, daß die Verbreitung der Roboter für die Werktätigen ein weiteres fundamentales humanitäres Problem, das Problem der Reproduktion menschlicher Funktionen außerhalb des Produktionsprozesses, entstehen läßt[1]

Das ist aber kein technologisches Problem mehr, sondern ein soziales, das Lösungen erfordert, die sich aus einer neuen humanistischen Sicht ergeben.

Die neuen Technologien, etwa die auf Mikroprozessoren beruhenden, enthalten umfassende Möglichkeiten für ihre verschiedene Anwendung. Ob sie zur Entwicklung humanistischer Werte oder zur geistigen und häufig auch zum physischen Unterdrückung und sogar zur Vernichtung des Menschen genutzt werden, hängt vom Charakter der sozialen Ordnung ab.

Unter den Verhältnissen des Kapitalismus "findet eine Ausbeutung der Wissenschaft, des theoretischen Fortschritts der Menschheit statt"[2]. Eine äußere Form hat diese Ausbeutung der Wissenschaft in unseren Tagen vor allem in ihrer Militarisierung gefunden[3]. Bekanntlich ist heute ein beträchtlicher Teil von Forschungskräften im Rüstungsbereich beschäftigt, der bis zu 40 Prozent aller Ausgaben für Forschung und Entwicklung verschlingt.

Außerordentlich gefährlich für die Menschheit und kostspielig sind die Arbeiten im Zusammenhang mit der Vorbereitung der "Sternenkriege".

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Die Pläne für das Übertragen des Rüstungswettlaufs in den Weltraum sind ein schreiendes Beispiel für die Entstellung von Sinn und Inhalt der wissenschaftlich-technischen Entwicklung, ihre Unterordnung unter die Ziele und Motive des Militarismus, die in der Ausbeutungsordnung selbst wurzeln.

Militarismus, Militarisierung der Wissenschaft und Technik verfälschen nicht nur deren humanistisches Wesen und Sinn. Sie kompromittieren sie auch in den Augen der breiten Volksmassen, die dann nicht selten die Tatsache der militaristischen Anwendung der Ergebnisse des wissenschaftlich-technischen Fortschritts auf die Charakteristik ihrer Bedeutung als Sozialer Kraft übertragen, die die Menschheit und ihre Zukunft bedroht.

Ob die neue Technik "humane Züge" gewinnt, ob sie neue geistige und materielle Reichtümer mit sich bringt, oder ob sie zur Ursache und zum Quell von unsagbarer Not wird, wird in einem immer stärkeren Maße von konkreten Menschen und von denjenigen abhängen, die diese neue Technik und Hochtechnologie entwickeln, in die Praxis überleiten und benutzen. Damit stellt sich das Problem der Wahl und Ausbildung von Fachleuten, der Gewährleistung ihres garantiert hohen professionellen und kulturellen Niveaus. Garantierten deshalb, weil die Menschheit nicht das Recht hat, Fehler unter Verhältnissen zuzulassen, da die neue Technik den "Preis" eines jeden solchen Fehlers auf das Millionenfache steigert. Ein prägnantes Beispiel dafür war die Havarie im Kernkraftwerk Tschernobyl, wo mangelndes Verantwortungsbewußtsein und Fahrlässigkeit von nur wenigen Menschen zur größten Tragödie für tausende und zehntausende Menschen geworden sind. Gerade deshalb besteht denn auch eine der wichtigsten Besonderheiten bei der Entwicklung der modernen Wissenschaft und bei ihrer Realisierung in der modernen Technologie in der außerordentlich gewachsenen Rolle der moralischen und ethischen Aspekten der Anwendung des einen oder des anderen technologischen Ergebnisses sowie der Forschung selbst.

Daß sich die ethischen, die humanistischen Probleme der Wissenschaft und Technik in einer so zugespitzten Form darbieten, ist wohl auf die eventuelle praktische Anwendung der Erkenntnisse der Genetik, vor allem der Genetik des Menschen, zurückzuführen.

Die Entstehung und Entwicklung der Kibernetik hatte seinerzeit die Aufmerksamkeit auf das Problem der Steuerung, unter anderem auf den Umstand gelenkt, daß sich in den Prozessen der Steuerung mit Hilfe von, ihrer Leistung nach schwachen, Signalen energetische Veränderungen von ungeheurer Stärke regeln und kontrollieren lassen. Mit etwa dergleichen Problematik hat auch die Genetik zu tun, die Strukturen und Mechanismen untersucht, mit denen Prozesse der Steuerung des Wachstums und der Entwicklung biologischer Organismen verwirklicht werden. Der Mensch gewinnt somit eine Macht, mit der er mit äußerster Vorsicht umgehen sollte. Gerade damit wird denn auch letzten Endes der sozial-ethische und humanistische Inhalt der Forschungen in der Gentechnologie, geschweige denn ihrer Anwendung, bestimmt

Mehrere angesehene Wissenschaftler im Westen, die sich früher zu den ethischen Aspekten der Gentechnologie leidenschaftlich äußerten, sprechen heute davon, daß solche Erörterungen überflüssig und sogar schädlich sind, und behaupten, daß die Gefahr dieser Forschungen von den Massenmedien übertrieben worden war, und daß Verbote und Einschränkungen den wissenschaftlichen Fortschritt auf diesem wichtigen Wissensgebiet nur hemmen könnten. Diese Haltung dürfte weder vom wissenschaftlichen noch vom ethischen Standpunkt aus gerechtfertigt sein. Die Gentechnologie lenkte vielleicht nachdrücklicher und anschaulicher als irgendwann und irgend was in der Vergangenheit (einschließlich der Diskussion über die Gefahr der Forschungen in der Kernphysik) die Aufmerksamkeit der Menschheit auf die Notwendingkeit einer öffentlichen Kontrolle (sozialer und ethischer) darüber, was in der Wissenschaft und Technologie geschieht und was für den Menschen unmittelbar gefährlich werden könnte. Bisher beschränkte sich alles lediglich auf das "Drama der Ideen" und in einem noch höheren Grad auf das Wortgeplänkel. Aber es steht noch alles bevor, sowohl Gutes, denn die Gentechnologie verspricht uns für die Zukunft wahre Wunder in der Landwirtschaft und in der Medizin, wie auch, leider wahrscheinlich auch weniger Gutes.

"Die wichtigste Frage, die die Menschen beunruhigt, lautet, wer darüber entscheiden soll und wird, welche Gene falsch funkionieren", stellt der US-amerikanische Biochemiker, der Nobelpreisträger D. Baltimore, fest. Die Angst, daß diese Entscheidungen von Diktatoren getroffen werden könnten, um ihre Macht zu festigen, ließ die Gentechnologie zu einem Symbol von moralischen Problemen, die die moderne Biologie erzeugen könnte, zu einem Symbol der Abschreckung der modernen Technik als Ganzes werden.

Die Diskussionen über die Ethik der genetischen Kontrolle sind in folgender Hinsicht bezeichnend. In ihnen werden nicht selten zeitlich recht fernliegende und manchmal auch einfach utopische Möglichkeiten erörtert, die mit der Entwicklung der Gentechnologie eröffnet werden könnten. Und vielleicht lassen sich die Aktualität und die Leidenschaft dieser Diskussionen nicht so sehr damit erklären, wie real diese Möglichkeiten sind, als vielmehr damit, daß sie uns veranlassen, auf solche ewige Probleme, wie die des Menschen, seiner Freiheit, seiner Möglichkeit und seiner Bestimmung, auf eine neue Weise oder empfindlicher zu reagieren. Die fernen Perspektiven, die die Gentechnik (sowie die Mikroelektronik und andere fortgeschrittene Zweige der Wissenschaft, die den technologischen Fortschritt bestimmen) bieten, haben auf uns bereits heute eine Wirkung und lassen uns etwa darüber nachdenken, ob wir eine klonale Vermehrung des Menschen wünschen und wünschen sollten. Und wir sehen uns veranlaßt, uns, wie wir heute sind, etwas genauer anzuschauen, um zu verstehen, was wir wollen, was wir anstreben und was wir ablehnen.

Somit geht es hier nicht nur um die Zukunft, eine fernere oder auch eine nähere, sondern auch um Dinge, die sehr gegenwärtig sind. Und hierbei wird die Anwendung von Mitteln der philosophischen Analyse, der im Laufe von Jahrhunderten gesammelten Erfahrungen aus einer philosophischen Untersuchung dieser Probleme nicht nur wünschenswert, sondern vom sozialen Standpunkt aus betrachtet geradezu unentbehrlich. Die Leistungen und Erkentnisse der modernen Wissenschaft stellen die Menschen immer wieder vor die Aufgabe einer Selbstbestimmung, einer Neubewertung ihrer Werte. Ohne Benutzung der gesammelten philosophischen Erfahrungen, würde der Mensch dieser Aufgabe gegenüber ungewappnet, ohne Richtschnur da stehen.

Die sozialistische Gesellschaft ist sich der revolutionären Möglichkeiten und der sozialen Folgen der Anwendung der neuen Technologien, die die Mikroelektronik, die Informatik und die Biotechnik bieten, voll und ganz bewußt. Sie schafft für diese Anwendung breiten Raum und entspricht schon ihrem Wesen nach im höchsten Grade dieser neuen Technologie, die erforderlich macht, daß außerordentlich umfangreiche gesellschaftliche Fonds (und zwar auf planmäßiger Grundlage) und nicht Privatkapital in Bewegung gesetzt werden, wenngleich dieses Privatkapital die materiellen Ressourcen des Sozialismus in einem bestimmten historischen Zeitabschnitt auch übertrifft. Die gesellschaftliche Struktur des Sozialismus gestattet es, das Hauptpotential der neuen Technologie, deren arbeitssparenden Charakter maximal zu nutzen, wobei dies keine Arbeitslosigkeit zur Folge hat, die im Kapitalismus unvermeidlich ist.

Darin bestehen die wichtigsten Vorzüge des Sozialismus und die fundamentale Grundlage der "hohen Kontaktebene" von Sozialismus und neuer Technologie.

Ein Vorzug des Sozialismus besteht auch noch darin, daß er eine umfassende Kooperation von vielen Ländern gewährleistet, die sich auf verschiedenen Ebenen der wissenschaftlich-technischen Entwicklung, der Produktion und Einführung neuer Technologien befinden. Wenn in der kapitalistischen Welt eine immer stärker werdende Konkurrenz, etwa zwischen den japanischen Monopolen einerseits, die sich mit der Produktion neuer Technologie befassen, und den USA-Monopolen sowie den Monopolen des "Vereinten" Westeuropas anderseits zu verzeichnen ist, so sind in der sozialistischen Staatengemeinschaft enges Zusammenwirken und gegenseitige Unterstützung bei der Verwirklichung des wissenschaftlich-technischen Fortschritts und der Einführung seiner Ergebnisse in die gesellschaftliche Produktion festzustellen. Davon war auf dem 27. Parteitag der KPdSU die Rede und das findet konsequente Verwirklichung im Komplexprogramm des wissenschaftlich-technischen Fortschritts der Mitgliedsländer des RGW bis zum Jahre 2000.

Die "hohe Kontaktebene" der neuen Technologie setzt ein hohes Niveau von Kultur, Schöpfertum des Menschen in seiner Gesamtheit, in seiner harmonischen Entwicklung voraus. Und schließlich ist es unerläßlich, daß sie in die neue "Wertskala" aufgenommen wird, die auf einer neuen Auffassung vom Sinn des Menschenlebens und der Bewertung all dessen, einschließlich der modernsten Technologie in Übereinstimmung damit basiert, daß der Mensch und seine Entwicklung das "Maß aller Dinge" und der "Selbstzweck" der Geschichte sind.

Die "menschliche Ebene von Berührung" der neuen Technologie, ihre humanistische Bewertung, ausgehend von den Möglichkeiten, die sie für eine harmonische Entfaltung des Menschen, für seine Entwicklung als Persönlichkeit und als Schöpfer eröffnet, stimmt maximal mit der wichtigsten Wertorientierung der neuen Gesellschaft, mit der Sorge für den Menschen, mit seinen wachsenden geistigen Bedürfnissen überein.

Dem kommt eine ganz besondere Bedeutung zu einer Zeit zu, da die Zivilisation in das Zeitalter der Mikroelektronik, Informatik und Biotechnologie tritt.

Heute werden sowohl klassische Antiutopien wie auch modernste Mythen benutzt, die berufen sind, den Menschen, der verwirrt ist, sich der Gesellschaft entfremdet hat und unter anderem den Sinn und die Bedeutung der neuen Technologie nicht begreift, entweder einzuschüchtern oder maßlose Hoffnungen und Illusionen bei ihm zu erwecken, wobei diese lediglich auf die Sphäre der Konsumtion beschränkt werden soll. So wird, den Prophezeihungen des kanadischen Soziologen M. McLuhan folgend, vom "Untergang des Humanismus" gesprochen, wobei die Massenmedien ("Media") als solche betrachtet werden, die tiefgreifende Veränderungen in der menschlichen Natur verursachen. Die "Media" und die Technologie werden als physische, vergegenständlichte Realität und die Ideologie lediglich als so etwas wie Ausschmückung, als "offizielle Uniform" betrachtet, die sich die "Media" anlegen. Es wird die Möglichkeit erörtert, mit Hilfe von "Media" sogar die menschliche Physiologie, ihre organische Realität zu verändern. In neuen Formen und unter Ausnutzung der noch nie dagewesenen Möglichkeiten der Mikroelektronik und der Biotechnologie, so etwa der Gentechnologie, werden die neuen genetischen Ideen von einem "fabrizierten Menschen" (Homo sapientissimus) und sogar vom "Biokiborg" (Machina Sapiens) wiederbelebt.

Zugleich setzt sich immer mehr das Bewußtsein, häufig in einer abstrakt-utopischen Form, von der Notwendigkeit einer "hohen Ebene der Berührung" der neuen Technologie mit dem Menschen und den humanistischen Werten neuen Typs, nämlich solchen durch, die der alte Gesellschaftsordnung nicht bietet und auch gar nicht bieten kann, die jedoch die Grundlage der neuen Zivilisation ausmachen. So wird etwa die Bedeutung der sozialpsychologischen sowie der kulturellen und moralisch-sittlichen Probleme unterstrichen, die mit dem Prozeß der Robotisierung zusammenhängen. Obgleich hierbei der Begriff "hohe Berührungsebene" in seiner engeren Auslegung gerade das Zusammenwirken von Mensch und Maschine charakterisiert, bei dem der Computer als "delikate" Maschine dem Menschen viel, einschließlich des Verzichts auf mehrere Gewohnheiten (wie etwa das Rauchen u.dgl. m.), abverlangt, geht es häufig auch um solche notwendigen Dinge wie Hebung (Erhöhung) des professionellen Wissens, der allgemeinen Kultur des Menschen, seiner moralischen Qualitäten.

Nur tiefgreifende soziale Umgestaltungen der gegenwärtigen Gesellschaft in Richtigung einer, nach Marx, "wahrhaft menschlichen" Gesellschaft können die humanistischen Probleme lösen, die sich im Zusammenhang mit der umfassenden Einführung neuer Technologie in die Produktion noch weiter zuspitzen.

Der Mensch in neuer Gesellschaft tritt in das "menschliche Zeitalter" ein, und er wird aus der Produktion nicht als ein für diese Produktion überflüssiges Element verdrängt, um das Heer der Erwerbslosen weiter zu vergrößern, sondern er bekommt immer umfassendere Möglichkeiten, schöpferisch in sie einzusteigen und sie im wahrsten Sinne des Wortes seinen materiellen und geistigen Bedürfnissen anzupassen, seine Fähigkeiten, auch außerhalb der Produktion zu entfalten, die ja immer mehr den Maschinen anvertraut wird. Dieses schöpferische Wirken einer ganzen Persönlichkeit, eines harmonisch entwickelnten Menschen, gestatten es ihm, auch die "hohe Ebene der Berührung" mit jeder neuen bzw. mit der modernsten Technologie und folglich auf dieser Grundlage auch mit der natürlichen Umwelt vollständiger wahrzunehmen.

[illegible] und sogar vom "Biokiborg" [illegible] derbeiet.

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J.C. NYIRI

*Some Marxian Themes in the Age of Information**

The radical conceptual and social changes related to recent developments in technology - aptly summed up under the term 'computer revolution' - give new interest to certain basic tenets of Marx. But these tenets are at the same time moved into a perspective hardly envisaged by Marx himself.

There is, to begin with, one fundamental Marxian thesis which can definitely be said to have *gained in plausibility*. This is the thesis of *technological determinism* - relativized already by Engels[1], contested by scholars of such different persuasions as Max Weber[2] or Georg Lukács[3], but no doubt very strongly adhered to by Marx himself. Recall the well-known passage in *The Poverty of Philosophy:*

> In acquiring new productive forces men change their mode of production; and in changing their mode of production,

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* I am indebted to the Alexander von Humboldt Stiftung under whose auspices, in 1986-87, most of the research embodied in the present paper was conducted.

[1] Cf. his letter of Aug. 5, 1890, to Conrad Schmidt - "wenn die materielle Daseinsweise das primum agens ist, [schließt] das nicht aus, daß die ideellen Gebiete eine reagierende, aber sekundäre Einwirkung auf sie hinwiederum ausüben" - or, e.g., his letter of Sept. 21/22 of the same year to Joseph Bloch: "Wir machen unsere Geschichte selbst, aber ... unter sehr bestimmten Voraussetzungen und Bedingungen. Darunter sind die ökonomischen die schließlich entscheidenden. Aber auch die politischen usw., ja selbst die in den Köpfen der Menschen spukende Tradition, spielen eine Rolle..."

[2] The relevant classic essay being, of course, his "Die protestantische Ethik und der 'Geist' des Kapitalismus", *Archiv für Sozialwissenschaft und Sozialpolitik* XX-XXI (1903-1904).

[3] I am referring to his fateful early notion of *class consciousness*, cf. esp. the essay "Klassenbewußtsein" in his *Geschichte und Klassenbewußtsein* (1923).

> in changing the way of earning their living, they change all their social relations. The hand-mill gives you society with the feudal lord: the steam-mill, society with the industrial capitalist.[4]

And recall also the famous preface to the *Critique of Political Economy*, where Marx affirms that the way men produce their means of subsistence conditions their whole social, political and intellectual life.[5] That developments in microelectronics have deep implications for society and politics in the United States, in Western Europe, and in the Far East, is by now of course obvious. But it is obvious, too, that these implications are not independent of the social and political frameworks within which they emerge. There is one part of the world, however, namely Eastern Europe and the Soviet Union, with regard to which the political and social effects of the new technology are absolutely determining in the sense that they led to changes to which the dominant political forces have been rigidly opposed; to changes for which the inherited and existing political cultures in the countries in question - with no democratic traditions whatsoever in the Soviet Union, and with a bare minimum of such traditions in Eastern Europe - did not provide a framework, and did not herald any promise.

Has not recent history amply demonstrated that the dream of drawing closer to the West - characteristically not indulged in by Russians - could at any time be turned into a nightmare in Eastern Europe? But then came the *chip*, and a very different

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[4] Moscow: n.d., p.122.

[5] "Die Produktionsweise des materiellen Lebens bedingt den sozialen, politischen und geistigen Lebensprozess überhaupt", *Zur Kritik der politischen Ökonomie*, Marx - Engels, *Werke*, vol. 13, Berlin: Dietz, 1971, pp.8f.

icture emerged. The centralized economies of the so-called so-ialist countries proved to be unable to keep up with Western evelopments in microelectronics. As a consequence, the faith n the continuing military supremacy of the Soviet Union over he West wavered. Eastern European products became, for reasons f quality and price, increasingly difficult to export. Attempts at a decentralization of economy with no democratization f the political system failed. Liberalization at home and a ew *détente* in foreign policy were the result. It would require great deal of naivety not to see that in this instance, once ore, a deeply Marxian idea has been confirmed: namely the idea hat instead of the personal traits of political leaders forming their policies, it is, much rather, the exigencies of political realities that become reflected in the personal make-up of politicians.

Seen from a Marxist perspective, however, this state of affairs possesses a truly strange feature. For the economy providing a suitable framework for technological progress thus turns out to be not that of central planning, but that of the free market. Indeed the situation, as in particular the Japanese experience shows, is even more peculiar: the presence of some old-fashioned traditions in the texture of a liberal society does *not* seem to be an obstacle to the development of successful free enterprises, and, by implication, to advances in technology. And the joint values of the free market on the one hand and of traditionalism on the other add up to just about everything Marx *detested* - and to just about everything Marx's arch-liberal adversary F.A. von Hayek stands for.[6]

Some central Marxian themes are, to be sure, only seemingly affected by the emergence of the new technologies. Thus for instance the labour theory of value, with all its implications, strikes one today, at a time when knowledge has become the supreme commodity, as utterly implausible; but this theory had never been a logically acceptable one, and was, precisely with reference to the effects of science, withdrawn by Marx himself. The plausibility of the labour theory of value has radically decreased because the element of labour *time* has lost its relevance as a source of added value.[7] The substance of value, Marx

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[6] Recall the view succintly expressed by Hayek in his 1945 talk "Individualism: True and False", where he spoke about "true individualism" affirming the value of the family, the local community, and of "common conventions and traditions" (Hayek, *Individualism and Economic Order* [1949], London: Routledge & Kegan Paul, 1976, p.23). Hayek called into question "whether a free or individualistic society can be worked successfully if people are too 'individualistic' in the false sense, if they are too unwilling voluntarily to conform to traditions and conventions". (*Ibid.*, p.26) Or, as Eisenstadt has put it: "the implicit assumption in many studies (and the one most closely related to the dichotomous conception of traditional versus modern societies) that the less 'traditional' a society is, the more capable it is of sustained growth was proven incorrect. It became clear that the mere destruction of traditional forms did not necessarily assure the development of a new, viable, modern society... In addition ... it was realized that in some countries, such as Japan or England, modernization had been successfully undertaken under the aegis of traditional symbols and even traditional elites... ...a growing array of evidence has shown that many forms of extended-family and/or kinship relations may indeed not only be compatible with industrialization but even reinforce it." (S.N. Eisenstadt, *Tradition, Change, and Modernity*, New York: Wiley, 1973, pp.98f. and 108.)

[7] The adjective *added* has to be stressed by anyone who does not subscribe to an *objective* theory of value. The question one then addresses is: given the subjective economic value preferences of a society, what are the elements or processes which satisfy those preferences, i.e. act towards conferring value upon this or that commodity?

eld, is labour; its *measure* is time.[8] As exchange values, all ommodities are but certain amounts of congealed labour time.[9] oday however it is obviously *knowledge*[10], not labour time, hat is primarily embodied in the added value of any commodiy.[11] Incidentally, this was already the case, even if to a esser degree, in Marx's days - a state of affairs he fully ealized[12], but to which he gave a strangely twisted inter-

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[8] "Wir kennen jetzt die *Substanz* des Werts. Es ist die *Areit*. Wir kennen sein *Größenmaß*. Es ist die *Arbeitszeit*." *Das apital*, vol.1, Berlin: Dietz, 1969, p.55.

[9] "Als Tauschwert sind alle Waren nur bestimmte Maße *festeronnener Arbeitszeit*", *Zur Kritik der Politischen Ökonomie*, .18.

[10] "Knowledge" and "information" are of course not idential; but they are closely related. As Fred I. Dretske puts it n his *Knowledge and the Flow of Information*, Oxford: Basil lackwell, 1981, p.44: "Roughly speaking, information is that ommodity capable of yielding knowledge, and what information a ignal carries is what we can learn from it." - "By informaion", writes Daniel Bell, "I mean data processing in the roadest sense; the storage, retrieval, and processing of data ecomes the essential resource for all economic and social exhanges. ... By knowledge, I mean an organized set of stateents of facts or ideas, presenting a reasoned judgment or an xperimental result, which is transmitted to others through ome communication medium in some systematic form." ("The Soial Framework of the Information Society", in M. L. Dertouzos nd Joel Moses, eds., *The Computer Age: A Twenty-Year View*, ambridge, Mass.: MIT Press, 1979, p.168.)

[11] "[W]ith the shortening of labor time and the diminution f the production worker ... it becomes clear that knowledge nd its applications replace labor as the source of 'added vale' in the national product. In that sense, just as capital and labor have been the central variables of industrial society, so information and knowledge are the crucial variables of postinlustrial society", Bell, *loc. cit.*, p.168.

[12] In his 1857-58 manuscripts, later published as *Grundrisse der Kritik der Politischen Ökonomie*, he wrote: "to the legree that large industry develops, the creation of real vealth comes to depend less on labour time and on the amount of labour employed than on the power of the agencies set in motion luring labour time, whose 'powerful effectiveness' is itself in urn out of all proportions to the direct labour time spent on their production, but depends rather on the general state of

pretation. As Marx saw it, the labour theory of value would cease to be valid once the capitalist mode of production had been superseded; and the signs that the theory *was* in fact becoming increasingly implausible he understood as heralding the imminent doom of capitalism. In this sense the labour theory of value was not susceptible to scientific refutation[13]; only the historical deed of establishing communism could prove it false - by rendering it obsolete. And it is indeed a piece of irony that the attempt at that historical deed led to an entirely different result: to the perfect realization of the labour theory of value, in the form of the Soviet *labour camp*. There, certainly, all work was reduced to uniform, simple labour, measurable in units of men and time.

Then there are other Marxian convictions, for instance some of those having to do with the idea of the concentration of capital, which, for a long time, seemed convincing, but appear antiquated in the light of today´s high-tech economy, in particular in the light of developments in software engineer-

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science and on the progress of technology... As soon as labour in the direct form has ceased to be the great well-spring of wealth, labour time ceases and must cease to be its measure", *Foundations of the Critique of Political Economy*, transl. by Martin Nicolaus, Penguin Books, 1973, pp.704f.

[13] Cf. David McLellan, *Karl Marx: His Life and Thought*, London: Macmillan, 1973, p.299. - In another sense this theory is irrefutable since it is from the start *circular*. Consider Marx´s central introductory argument: "Um die Tauschwerte der Waren an der in ihnen enthaltenen Arbeitszeit zu messen, müssen die verschiedenen Arbeiten selbst reduziert sein auf unterschiedslose, gleichförmige, einfache Arbeit, kurz auf Arbeit, die qualitativ dieselbe ist und sich daher nur quantitativ unterscheidet. - Diese Reduktion erscheint als eine Abstraktion, aber es ist eine Abstraktion, die in dem gesellschaftlichen Produktionsprozeß täglich vollzogen wird", *Zur Kritik der Politischen Ökonomie*, p.18.

ng. Although huge enterprises obviously do play an important, sometimes dominant, role in the electronics industry, and although with the increasing tendency of programs to be written by large teams the costs of software production are, on the whole, rising, it is still the case that small firms in these areas continue to have relatively good chances of success, and that the software industry still offers entrepreneurial possibilities for programmers with practically no capital to invest. The success stories of bright teenager "hackers" - virtuoso programmers - in the United States and in Western Europe are a familiar theme. And it is significant that software development is practically the only economic domain where a backward country like Hungary, with no funds to mobilize, seems to be able to co-operate effectively, and in places to compete, with Western firms.

On the other hand the romantic-eschatological aspect in Marx - notoriously a cause of embarrassment to bureaucratic Marxism - is today acquiring an air of reasonableness. Certainly the overthrow of liberal institutions and the elimination of free competition by a revolutionary proletariat no longer has, for those who tried the Marxist experiment, the ring of promise it apparently possessed earlier. Yet the emerging technologies for handling information do indeed seem to herald a new age of community, of the *vergesellschafteter Mensch* - of participatory democracy, of a new craftsmanship, of non-alienated cultural patterns. Discussing the historical role of a mode of production based on exchange values, Marx writes:

> The universal nature of this production with its generality creates an estrangement of the individual from himself

> and others, but also for the first time the general and universal nature of his relationships and capacities. At early stages of development the single individual appears to be more complete, since he has not yet elaborated the wealth of his relationships, and has not yet established them as powers and autonomous social relationships, that are opposed to himself. It is as ridiculous to wish to return to that primitive abundance as it is to believe in the necessity of its complete depletion.[14]

Clearly, Marx's vision of a non-alienated past does indeed play a part in his dream of a non-alienated future.[15] And when depicting that future he strikes a utopian, almost millenial note. The historical mission of capitalism is fulfilled and a new age begins when the productive forces of labour have reached a stage at which general affluence is maintained by a minimum of labour essentially *scientific*, indeed by an activity which is really the free development of rich personalities.[16]

Now the specialist whose work is most deeply embedded in,

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[14] Cf. *Foundations*, p.162. I am here quoting after the English translation as cited by McLellan, *op. cit.*, p.297.

[15] In a telling passage in one of his earliest writings he regards it as a "correct idea" that early, primitive conditions in a way foreshadow the genuine conditions under which man ought to live, "daβ die *rohen* Zustände naive niederländische Gemälde der *wahren* Zustände sind". "Das philosophische Manifest der historischen Rechtsschule" (1842), Marx - Engels, *Werke*, vol.1, Berlin: Dietz, 1964, p.78.

[16] Cf. *Foundations*, pp.325 and 611: "the development of the productive powers of labour" makes it possible that "the possession and preservation of general wealth require a lesser labour time of society as a whole, and ... the labouring society relates scientifically to the process of its progressive reproduction, its reproduction in a constantly greater abundance; hence where labour in which a human being does what a thing could do has ceased." Here, then, emerge "the material elements for the development of the rich individuality which is as all-sided in its production as in its consumption, and whose labour ... therefore appears no longer as labour, but as the full development of activity itself, in which natural necessity in its direct form has disappeared...". It is at this stage that labour truly becomes *travail attractif*, "self-realization, objectification of the subject, hence real freedom, whose action is, precisely, labour...".

d is perhaps most revealing of, the age of information, is e professional programmer. Thus in assessing the claim that e tendencies emerging in this age in a sense vindicate the rxian utopia, it seems reasonable to begin by analyzing the y the members of this profession labour and live. First im-essions are, certainly, discouraging. As Sherry Turkle ites,

> In the course of the last decade programmers have watched their opportunities to exercise their expertise in a spontaneous way being taken away. Those who are old enough remember the time when things were different as a kind of golden age, an age when a programmer was a skilled artisan who was given a problem and asked to conceive of and craft a solution. ... Today, programs are written on a kind of assembly line. ... Thus programmers are particularly sensitive to the fragmentation of knowledge and the lack of a feeling of wholeness in work to which so many of us are subject.[17]

ut this is not the only possible perspective. As David Bolter uts it:

> The computer shows that even teamwork need not thoroughly subsume and homogenize the special contribution of each member. The best organization for many computer projects is modular: each member of the group is given a separate part of the larger program or machine design. This is not the stultifying specialization of the assembly line, where one worker performs one operation repeatedly for hours. Instead, each module may be a self-contained program or portion of hardware, with challenges and difficulties all its own.[18]

Another way to point to the non-alienating aspects of the

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[17] *The Second Self: Computers and the Human Spirit*, London: Granada, 1984, p.173. "*Structured programming*", the programming mode or style which is sufficiently constrained to permit smooth team co-operation, is "good for business, death for the joy of work", as one programmer interviewed by Turkle expressed the matter (*ibid.*). For a more detailed discussion of structured programming, in the spirit of Adam Smith, cf. David Levy, "Constraining the Choice Set: Lessons from the Software Revolution", *Reason Papers*, Spring 1985, pp.77-88.

[18] *Turing's Man: Western Culture in the Computer Age*, Chapel Hill: The Univ. of North Carolina Press, 1984, pp.231f.

computer is to highlight its *tool-like* character. "The computer is", writes Bolter,

> in some ways a grand machine in the Western mechanical-dynamic tradition and in other ways a tool-in-hand from the ancient craft tradition. The best way to encourage the humane use of computers is to emphasize, where possible, the second heritage over the first, the tool over the machine. - A machine is characterized by sustained, autonomous action. It is set up by human hands and then is more or less set loose from human control. ... A tool, unlike a machine, is not self-sufficient or autonomous in action. It requires the skill of a craftsman...[18]

Now Turkle, too, exploits - with reference to Marx[20] - the tool--machine distinction. "Tools are extensions of their users; machines", she writes, "impose their own rhythm, their rules, on the people who work with them, to the point where it is no longer clear who or what is being used."[21] At work - in the office, at the lab - the computer has become a machine; but *at home* - this is the aspect Turkle stresses - it can play the compensatory role of a tool. When people in the electronics industry, or professional programmers, speak of the way they approach problems on their home computers - in their free time, as a hobby - they convey "a sense of power" that comes from "having full knowledge of the system", from working in a "safe environment" of their "own creation".[22] Building up from ma-

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[18] *Ibid.*, pp.232f.

[20] The text she directly bases her analyses on seems to be ch.13 of *Das Kapital*: "Maschinerie und große Industrie". But, here again, the *Foundations* is worth quoting too: "The science which compels the inanimate limbs of the machinery, by their construction, to act purposefully, as an automaton, does not exist in the worker's consciousness, but rather acts upon him through the machine as an alien power, as the power of the machine itself" (p.693).

[21] *Op. cit.*, p.172.

[22] *Ibid.*, pp.172f.

ine code to finished project, becoming directly involved, as it were, with the workings of the CPU - the central processing unit - itself, turns the computer virtually into a physical tool.

> The CPU's primary activity is moving something that is conceptually almost a physical object (a byte of information) in and out of something (a register) that is conceptually almost a physical place. The metaphor is spatial, concrete. One can imagine finding the bytes, examining them, doing something very simple to them, and passing them on. ... People are able to identify physically with what is happening inside the machine. It makes the machine feel like a part of oneself. It encourages appropriation of the machine as a tool in Marx's sense - as an extension of the user.[23]

The idea that it is the worker's *free time* which constitutes the true domain of non-alienated activity is of course again a very Marxian one, one belonging to the less romantic layers of his thinking.[24] But it appears that it is precisely the romantic-utopian vision of the *Grundrisse* which today is becoming increasingly plausible. The emergence of the *homo otiosus*, the human being enjoying the leisure of his free time, will, so it seems, coincide with developments which lead to a blurring of the boundaries between working hours and the hours

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[23] *Ibid.*, pp.186f.

[24] Freedom within the sphere of material production, Marx writes in volume three of *Das Kapital*, "kann nur darin bestehn, daß der vergesellschaftete Mensch, die assoziierten Produzenten ... ihren Stoffwechsel mit der Natur rationell regeln, unter ihre gemeinschaftliche Kontrolle bringen.. .. Aber es bleibt dies", *viz.* the sphere of production, "immer ein Reich der Notwendigkeit. Jenseits derselben beginnt die menschliche Kraftentwicklung, die sich als Selbstzweck gilt, das wahre Reich der Freiheit, das aber nur auf jenem Reich der Notwendigkeit als seiner Basis aufblühen kann. Die Verkürzung des Arbeitstags ist die Grundbedingung", Berlin: Dietz, 1969, p.828.

spent off work.[25] The main new element here is *the possibility of working at home*, the "return to cottage industry on a new, higher, electronic basis, and with it a new emphasis on the home as the center of society"[26]. Economically this might imply, as Toffler puts it, that

> if individuals came to own their own electronic terminals and equipment, ... they would become, in effect, independent entrepreneurs rather than classical employees - meaning, as it were, increased ownership of the "means of production" by the worker[27].

The possible sociological implications are no less significant:

> If employees can perform some or all of their work tasks at home, they do not have to move every time they change jobs, as many are compelled to do today. They can simply plug into a different computer. - This implies less forced mobility, less stress on the individual, fewer transient

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[25] Cf. Klaus Haefner, *Die neue Bildungskrise: Lernen im Computerzeitalter*, Reinbek bei Hamburg: Rowohlt, 1985, pp.197 and 245f. - Haefner registers a certain similarity between what he calls the "humanely computerized society" of the future on the one hand, and ancient Greece on the other. "Bei den Griechen", he writes, "gelang es, Demokratie, Künste und Kultur auf der Basis intensiver Nutzung der Sklaven zu entwickeln; manuelle und kognitive Routinearbeit konnten vergeben werden, dem freien Griechen blieb das ´reine Denken´ (und das Kriegshandwerk). Die human computerisierte Gesellschaft nutzt die ´intelligente´ Informationstechnik in der Kombination mit dem hohen Stand von Agrar-, Konsumgüter- und Energietechnik zur Lösung vieler ´Sklavenprobleme´ im täglichen Leben...", *ibid.*, p.240. Comparing computers to slaves is, incidentally, not lacking a certain epistemological and ethical interest. I have touched on this issue in my paper "Wittgenstein and the Problem of Machine Consciousness", *Grazer Philosophische Studien* 1989, forthcoming.

[26] Alwin Toffler, *The Third Wave*, New York: Bantam Books, 1980, p.194.

[27] *Ibid.*, p.205. Indeed Toffler speaks of "a new civilization" which "begins to heal the historical breach between producer and consumer, giving rise to the ´prosumer´ economics of tomorrow. For this reason, among many, it could ... turn out to be the first truly humane civilization in recorded history", *ibid.*, p.11. - Another aspect of "prosumer" economy is what Michael L. Dertouzos calls "individualized automation", the technological possibility of producing, at home, with the help of intelligent tools, commodities for one´s own use, cf. Dertouzos - Moses, eds., *The Computer Age*, pp.38ff.

human relationships, and greater participation in community life. ... The electronic cottage could mean more of what sociologists, with their love of German jargon, call *gemeinschaft*.[28]

It is not by their indirect effects on the local level however, but by their direct impact on a nationwide or even a global one, that computer networks contribute most significantly to the forming and maintaining of new communities. Discussing the introduction of personal computers in the late 1970s, Sherry Turkle points out that

> they came on the scene at a time of dashed hopes for making politics open and participatory. Personal computers were small, individually owned, and when linked through networks over telephone lines they could be used to bring people together. ... The computer clubs that sprang up all over the country were imbued with excitement not only about the computers themselves, but about new kinds of social relationships people believed would follow in their wake. ... Personal computers became symbols of hope for a new populism in which citizens would band together to run information resources and local government.[29]

Such hopes might have been premature at the time; but they were certainly not delusive in principle. For computer networks can in fact become instrumental in overcoming the information gap separating the knowledge any individual has from the knowledge society at large possesses.[30] This information gap is, indeed,

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28 *Ibid.*, p.204.

29 Turkle, *op. cit.*, pp.174f.

30 Applied to the field of politics this is tantamount to saying that participatory democracy can be deepened by making use of computer networks - not so much in order to count votes, as rather to disseminate relevant knowledge. "The genius of democratic government is not arithmetic", writes Herbert A. Simon, "it is informed consensus. ... The computer enters as a tool that permits policy alternatives to be examined with a sophistication and explicitness that would otherwise be impossible" (Simon, "The Consequences of Computers for Centralization and Decentralization", in Dertouzos - Moses, eds., *The Computer Age*, pp.224f.).

a real source of alienation in the modern world. In closed, pre-literate societies the knowledge conveyed by oral traditions was partly knowledge in the common realm; partly knowledge available to the initiated only, but to them in fact directly accessible. With the rise of literacy - a fundamental change in the technology of communication, information storage and retrieval[31] - knowledge became embodied in written texts. And the first early libraries contained in principle *all* there was to read: the information they provided was a global one. Even a hundred years ago it was still possible for someone to assume that he was acquainted with all the essential documents that were of importance for his private and professional life. Modern man however has lost control over his informational environment[32]. Computer networks - representing a second fundamental change in the technology of communication - are a possible means to regain that control.

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[31] Cf. the pioneering early essay of the Hungarian historian István Hajnal, "Le rôle social de l'écriture et l'évolution européenne", *Revue de l'Institut de Sociologie* (Bruxelles), 1934.

[32] Man is today, as Haefner puts it, "hineingestellt in eine mit seinem Gehirn allein *nicht mehr überschaubare informationelle Umwelt*. Die Informationsexplosion ... hat den einzelnen Menschen in eine relativ willkürliche Ecke seiner informationellen Umwelt geschleudert...", *op. cit.*, pp.31f.

*INDETERMINISM IN QUANTUM MECHANICS**

Péter Szegedi

There has been much illuminating discussion over the last 5 years concerning the motives and conditions of the appear-nce of quantum mechanical indeterminism. It was initiated by aul Forman, who earlier took part in the project "Sources for istory of Quantum Physics", organized by Thomas Kuhn. Forman ublished a long paper[1] on the relations between the Weimar ultural milieu, causality and quantum theory. His thoughts and he publications disputing his theses will be the starting oint of this paper.

Forman's first thesis is that Weimar culture constituted a ostile intellectual environment for causality, physics, and athematics. After Germany's defeat in 1918, ideas such as ir-rationalism, mysticism, *Lebensphilosophie*, wholism (neovitalism n biology, Gestaltism in psychology) began to spread. For the erman middle classes the Weimar period was a period of perma-ent political, economical, moral, intellectual, cultural, and scientific crisis and was also perceived as such. According to Forman, the characteristic representative of this climate was "The Decline of the West" by Oswald Spengler. In this work causality is presented as a Western, Baroque phenomenon.

Secondly, Forman states that the German physicists and mathematicians accomodated themselves to the Weimar intellectual environment. Mainly through Wien's popular lectures he tries to prove that these physicists within a short space of time turned from (Machist) positivism to *Lebensphilosophie*. Forman has de-

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tected explicit references to Spengler in the works of Born, Einstein, Exner, Frank, Jordan, von Mises, Weyl, and Wien. In the papers of some physicists and mathematicians he met with a decided capitulation to Spenglerism. For instance, R. von Mises in a lecture at the Technische Hochschule Dresden - delivered in February 1920 - told the students that the age of technology was on its way out and that it was being replaced by "culture consciousness". Progress "is not a question of new facts of any sort, nor of new theoretical propositions, nor even of new methods of research, but if I may say it - thinking of this word in its philosophical sense - of new intuitions (Anschauungen) of the world". In this "numerical harmonies, even numerical mysteries play a role, reminding one no less of the ideas of the Pythagoreans than of some of the cabbalists". At the same time, concerning the development of spectral analysis (Balmer, Rydberg, and Ritz) A. Sommerfeld saw the orientation of new physics in Pythagorean number mysticism. "If only Kepler could have experienced today's quantum theory! He would have seen the most daring dreams of his youth realized..." Besides the acceptance of Spengler and mysticism, a large number of physicists' papers and lectures, which refer to the crisis in their science, also comes into this category.

Forman's third thesis is that, as a result of the outlined external forces, there was an acausal tendency established in physics. The first to convert to acausality were Exner and Weyl. (The latter had fallen under the influence of Husserlian philosophy as well, and he was not the only one to do so.) Exner and Weyl were followed by von Mises, Schottky, Nernst, and others. Later Schrödinger and Reichenbach joined them. Naturally, some theoretical physicists continued to adhere to causality (e.g. Planck and Einstein).

As the third thesis is the consequence of the first two, the last proposition can also be deduced from the previous ones: the negation of quantum mechanical causality is due to the abovementioned external influences. Speaking of this Forman refers to the Bohr-Kramers-Slater paper, and tries to establish a connection between *Lebensphilosophie* and Heisenberg on the basis on his earlier membership of the German *Jugendbewegung*.

Our aim is to establish the truth concerning all this. As for his first thesis, Forman's valuation of the Weimar cultural climate rings true when compared to the picture drawn by historians. From the point of view of the general intellectual milieu he rightly puts Spengler's work in the centre (of course within philosophy, Husserl's influence was more important).

On the other hand some problems occur with Forman's second thesis. In connection with the dimensions of the social-intellectual pressure on scientists and, accordingly, with the manner of their accomodation to it historians have taken a different point of view. According to J. Hendry "while there were indeed many attacks upon mathematics and physics from outside these disciplines, there were in all cases attacks upon their *value* rather than upon their *content*. ... physicists and mathematicians were to some extent *isolated from* , rather than *attacked by* the forces of the milieu".[2] The historian Walter Laqueur - without naming Forman - writes that "There was a German literature, a German theatre, German schools in the visual arts, even in history and philosophy. But only a fool or a fanatic would talk about German mathematics or German physics".[3]

One also can draw the lesson from Laqueur's book that we have to form a much more refined notion of the mutual interaction of religious, political, and philosophical groupings in the physics community than Forman did.[4] However, in my opinion there can be no denying that there existed certain external forces. I shall try to analyse these forces in our particular case, but here I might also mention Heisenberg's opinion, according to which science is entirely inseparable from more general problems.[5]

As concerns Forman's third thesis, it is hardly disputable that there existed an acausal tendency in physics at this time.

But this was by no means a clear-cut consequence of Weimar's irrationalistic intellectual climate or Spengler's philosophy. For instance S. Brush emphasizes "the continuity of the stream of thought running from Fourier to Kelvin to Maxwell to Boltzmann to Planck to Einstein to Born and Heisenberg".[6] From the point of view of physics he traces acausality through statistical method back to the problem of irreversibility. As regards its philosophical foundations, he differs from Forman, too. He clearly links the transition from determinism to indeterminism with the positivistic-pragmatic-operationalist-instrumentalist-phenomenalist attitude that many physicists adopted in the early twentieth century, partly under the influence of Ernst Mach and other critics of nineteenth-century mechanicism, partly as a result of the difficulty of fitting the new phenomena of atomic physics into any consistent theoretical scheme.

P. Hanle makes a similar statement. Investigating indeterminacy in the case of Exner and Schrödinger Hanle finds an early account of Exner's positivistic attitude in the latter's first book on electricity published in 1888, which recalls Mach's positivist conception.[7] On Exner's anti-causal attitude Hanle writes that "it would be incorrect to ascribe Weimar cultural influences to ideas that originated before 1908".[8] The roots of these ideas, in Hanle's opinion, also lay in statistical mechanics. Schrödinger accepted the likelihood of an acausal physics towards the end of World War I, adopted Exner's ideas almost verbatim in 1922, supported them in a research paper in 1924, but after 1922 explicitly rejected (Machist) positivism as inadequate and insufficient for motivating physics research.

According to M. Jammer "certain philosophical ideas of the late nineteenth century (namely the questioning of the strict validity of the causality principle - P. Sz.) not only prepared the intellectual climate for, but contributed decisively to, the formation of the new conceptions of the modern quantum theory".[9] He then writes about Poincaré's book published in 1904, It is clear that Poincaré's question whether differential equations are still the appropriate instrument for the mathematical formulation of physical laws was but a mathematician's way f expressing his doubts in the validity of the causality principle. For, obviously, the positing of a differential equation resupposes a continuous change or a continuous chain of events s implied in the conception of causality." Moreover, in 1910 .H. Jeans proved that continuous motion - i.e. a differential quation - could not lead to the Planck law.[10] C.G. Darwin, ollowing Poincaré in 1919, already writes, in an unpublished aper, about electrons exhibiting free will.

We can add, with Hendry, to the abovementioned facts that Weyl's conception, for instance, was not related explicitly to these problems and that the primary external influence upon the latter's ideas on physics appears to have been an intuitionist philosphy. Furthermore, although von Mises expressed his conclusions in a Spenglerian framework, and Schottky's presentation also had a strongly existentialist tone, there were important internal factors as well - for instance the reopening of the wave-particle issue (by M. de Broglie[11]).

Concerning the origin of quantum mechanical acausality - Forman's fourth thesis - we shall take a look at the famous paper by Bohr, Kramers, and Slater,[12] because among the direct preliminaries to Heisenberg's matrix mechanics it contains the first explicit possibility of indeterminism. In the section entitled "Principles of the quantum theory" they write that "great difficulties have been involved in the problem of the time-interval in which emission of radiation connected with the transition takes place. In fact, together with other well-known paradoxes of the quantum theory, the latter difficulty has strengthened the doubt, expressed from various sides+, whether the detailed interpretation of the interaction between matter and radiation can be given at all in terms of a causal description in space and time of the kind hitherto used for the interpretation of natural phenomena". Here they refer (at +) to

O.W. Richardson's *The Electron Theory of Matter* (2nd ed. Cambridge, 1916) and to Bohr's paper in *Zs. f. Phys. 13* (1923), although they could have referred to Darwin mentioned above, too, because he and Bohr were in correspondence and A.H. Compton informs us that in 1923 "The conviction of the truth of the spherical wave hypothesis produced by ... interference experiments led Darwin and Bohr in conversation with me to choose ... the abandonment of the conservation principles."[13]

After this introduction they abandon "any attempt at a causal connexion between the transitions in distant atoms, and expecially a direct application of the principles of conservation of energy and momentum". The authors assume "an independence of the individual transition processes, which stands in striking contrast to the classical claim of conservation of energy and momentum. Thus we assume that an induced transition in an atom is not directly caused by a transition in a distant atom for which the energy difference between the initial and the final stationary state is the same. ... This independence reduces not only conservation of energy to a statistical law, but also conservation of momentum." The basic technical idea originated with Slater, but the idea of the independence of emission and absorption came from Kramers, and the statistical character of conservation laws got into the paper against Slater's better judgement, too. Therefore we should give further attention to Kramers and Bohr.

It is highly improbable that the Danish Bohr's opinion was determined by the Weimar milieu. His acausal views were founded on a deep adherence to the principle of correspondence introduced by himself, and because he had been reluctant to accept light quanta[14]. In the formation of his *Weltanschauung* not the Spenglerian *Lebensphilosophie*, but - as is demonstrable in his later conceptions - in different indirect and direct ways, certain elements of Kierkegaard's philosophy[15] and (probably through Hevesy) Machist positivism played an important role.

The Dutchman Kramers had been living in Copenhagen for a long time, and although he was acquainted with Spengler, his "romantic" ideas had established themselves before the Weimar period started,[16] under the influences of the existentialist theologian Karl Barth. In his mind, elements of Machist-like positivism were present too.

The acausality of their paper was interpreted in a spirit of pure positivism by the authors, and by those who were concerned with the matter (like Heisenberg, the most important person for us from the point of view of further development). Kramers's next paper on dispersion theory used only Slater's idea, not the statistical assumptions. But this work suited an important requirement of positivism, namely that only the observables of atomic transitions (frequencies and intensities of spectrum lines) appeared in it. Then Kramers collaborated with Heisenberg, and so this tradition found its way into Heisenberg's paper founding the matrix mechanics.

Another strong positivistic influence reached Heisenberg through W. Pauli. Probably a major factor in Pauli's intellectual development was the philosophy of his godfather, E. Mach. Pauli's opinion as early as 1919 was already that "in physics only quantities which are observable in principle should be introduced"; later he very much objected to the concept of electron orbits.[17] His judgement had an effect on Heisenberg's views, who was a fellow student and constant correspondent. They believed that the principle of observables was the basis of Einstein's succesful relativity theory. So this principle of positivism got into the first paper on matrix mechanics. "It is well known that the formal rules which are used in quantum theory for calculating observable quantities (such as the energy of the hydrogen atom) may be seriously criticized on the grounds that they contain, as an essential element, relationships between quantities that are apparently unobservable in principle (such as position, period of revolution of the electron, etc.); that these rules lack an evident physical foundation, unless one still retains the hope that the hitherto unobservable quantities may perhaps later become accessible to experimental determination."[18] So Heisenberg intended to treat only observable quantities, and according to Born's recollections just this philosophical principle solved the problems.[19] Otherwise here the indeterminism - so characteristic of Machism - had not been emphasized so far. Its turn came only later in the treatment of interpretational problems and in the discovery of uncertainty relations.

In 1926 Schrödinger published his papers introducing a totally different mathematical apparatus for the quantum theoretical problems with an interpretation and philosophical presuppositions different from the Bohr-Heisenberg conception. The Schrödinger picture caught Max Born's attention, and he tried to use it in his work. Concerning the interpretation he also wanted to adopt a middle stand. The motion of particles follows probability laws, but the probability itself propagates in harmony with the causality principle.[20] In Born's view, causality can be found in quantum mechanics, but not in all of its fields: individual events are not causally determined. However, in Born's theory of collision processes the individual particles have position and velocity, and their motions are determined. In contrast to Born, positivism is most obvious in Heisenberg's article in which the latter describes the uncertainty relation: "When one wants to be clear about what is to be understood by the words 'position of the object', ... then one must specify definite experiments with whose help one plans to measure the 'position of the electron'; otherwise this term has no meaning."[21] The author describes such a possible measurement with an otherwise rather classical character in which "At the instant when position is determined ... the electron undergoes a discontinuous change in momentum. ... At the instant at which the position of the electron is known, its momentum therefore can be known up to magnitudes which correspond to that discontinuous change. Thus the more precisely the position is determined, the less precisely the momentum is known, and conversely. ... Let q_1 be the precision with which the value q is known ... p_1 be the precision with which the value p is determinable ... Then ... p_1 and q_1 stand in the relation

$$p_1 q_1 = h \text{ .} \qquad (1)"$$

This is the first form of the uncertainty relation. The principal conclusion of its interpretation is that "what is wrong in the sharp formulation of the law of causality" is that "'When we know the present precisely, we can predict the future' is not the conclusion but the assumption. Even in principle we cannot know the present in all its details. ... one might be led to the presumption that behind the perceived statistical world there still hides a 'real' world in which causality holds. But such speculations seem to us, to put it explicitly, fruitless and senseless. Physics ought to describe only the correlation of observations. One can express the true state of affairs better in this way: because all experiments are subject to the laws of quantum mechanics, and therefore to equation (1), it follows that quantum mechanics establishes the final failure of causality."

The rejection of causality later became closely connected with the principle of complementarity which in some respects could be interpreted as the generalization of uncertainty relations. Concerning the emergence of Bohr's notion of complementarity one cannot neglect certain of the young Bohr's abovementioned philosophical sympathies. At the university he studied Kierkegaard, and while preparing his dissertation for a Ph.D. degree he also found time to read and annotate a copy of Kierkegaard's "*Stages of Life's Journey*"[22]. Bohr recommended this in a letter to his borther, Harald, as one of the most delightful things he had ever read.[23] Perhaps he did not identify totally himself with Kierkegaard's philosophy, but in Bohr's writings the philosopher's ideas are to be found.

The title - "Either-or" - of Kierkegaard's first mature work can already be associated with the problem of complementarity. The essence of the matter is that while in Hegel's conception the poles form a unity, and they are transmittable, on Kierkegaard's view there is no interposition in the contradiction. In my opinion Bohr's complementarity is the scientific equivalent of Kierkegaard's moral-social "either-or".

But from the young Bohr let us turn our attention to Bohr the Nobel-prize winner, who in his lecture delivered on the occasion of the Volta celebration (Como, 1927) explained that the quantum postulate - by which there are discontinuities in the atomic processes - "implies a renunciation as regards the causal space-time co-ordination of atomic processes. ... any observation of atomic phenomena will involve an interaction with the agency of observation not to be neglected. ... The very nature of the quantum theory thus forces us to regard the space-time co-ordination and the claim of causality, the union of which characterizes the classical theories, as complementary but exclusive features of the description, symbolizing the idealization of observation and definition respectively."[24] According to Bohr these exclusive features are also complementary to each other, that is the reality may be approached through these counterpoles - similarly to Kierkegaard's "either-or".

Heisenberg's initial idea was crystallized into a theory by Bohr. In the centre of Machist positivism there was the sensation, while the main concept of Bohr's Copenhagen School is measurement. "... just the impossibility of neglecting the interaction with the agency of measurement means that every observation introduces a new uncontrollable element. ... the measurement of the positional co-ordinates of a particle is accompanied not only by a finite change in dynamical variables, but also the fixation of its position means a complete rupture in the causal description of its dynamical behaviour, while the determination of its momentum always implies a gap in the knowledge of its spatial propagation."

Of course in the beginning there were objections to Bohr's complementarity principle. One of the most long-lived analoes was described in a 1927 lecture by H.S. Allen. Allen oted that the wave and particle theories constitute two seprate edifices, and "Up to the present no one has bridged the ılf between these two buildings. Many attempts have been made build a bridge, but the keystone of the arch has not been itted. Physicists are obliged to live sometimes in one buildng, sometimes in the other. ... Bohr's latest work may be egarded as an attempt to dig an underground passage between he two (buildings), but the tunnel is dark and gloomy, and the tmosphere scarcely fit for human respiration." Or, "We may iken the 'complementary' theory of Bohr to a see-saw on which om Particle and Mary Wave are so evenly balanced that a touch ill send one end of the plank up or down. If we attempt to ix one end to mother earth, the other is suspended in midir."[25]

In the course of the further development of quantum mechanics ew mathematical methods were introduced the success of which nvolved principally unobservable elements. But in this way eisenberg's original requirements could not be realized. In rder to overcome this and some other shortcomings Neumann anted to put quantum mechanics on an exact mathematical basis.[26] He demonstrated that quantum mechanics reveals processes which correspond to strict causality just as much as processes which are incompatible with it.

Thus positivism and indeterminism infiltrating into physics seemed to strengthen and continued to spread. A number of persons wished to extend them to fields outside physics, too. The indeterministic conclusions have also found their way into popular scientific literature.

Finally, what kind of conclusions can be drawn with respect to the particular case (and therefore to some extent to the general development of science) from Forman's theses and from discussions formed around them? First of all the roots of quantum mechanical indeterminism must be searched for within physics also and such roots can be found. Thus we must mention statistical physics, which introduced the averages of mass phenomena, and the theory of probability, which ignores the causal description of individual processes (by necessity or spontaneously). In this way possibilities were created for the acausal theories. To explain the realization of these possibilities we must draw other factors into the analysis - for instance, the inner factors of physics, such as the contradictions between stationary states and classical electrodynamics, or between waves and particles. To some extent we must agree with Forman (and Kuhn) that mainly (but not exclusively) the feeling of crisis arising from these contradictions forces scientists to choose among the different apparent, but as yet unknown, ways and possibilities. And although the physicist (and the scientist generally at least from the time of Aristotle) considers it his duty to explore the relations, determinations, and causes in his particular research area, it seems that he is also ready to give up the causality principle, if its use is hopelessly difficult, in the expectation of any other (functional or structural) relation.

Of course the answers to the questions of what is hopeless and what are the possibilities of solving the problems are partly subjective ones. We cannot discuss here the psychology of research workers, but this evidently plays role in their decisions. Psychological factors have a very close relation to the so-called "external" social milieu. But between "external" and "internal" there is no sharp borderline, their usage has only a relative meaning. For instance, the abovementioned physical cores of indeterminism (such as statistical physics) also had a social background, and in this case these causes are not pure inner causes. And we cannot distinguish between the external and internal effects on the knowledge, sympathies, and other mental states in the physicists' minds. Naturally Forman is right when he says that the social milieu has a considerable effect on scientific development. However this effect may be very complex, and its consequences complex as well.

our case for instance physicists as intellectuals do not rm a homogeneous group from a political, ideological or even om a scientific point of view. Correspondingly we can find eat differences in their reactions to the situation in the 20s. For this reason Forman's statements are sweeping generizations. I think that it is demonstrable that in the rise orthodox interpretation, for example, positivism has played greater role than Spenglerian *Lebensphilosophie*, if we speak ly about the "external" factors.

In every case it must be said to Forman's credit that bedes showing the Weimar cultural climate to be among the posble factors in the formation of quantum mechanical acausality, has called the attention of historians and others, in a wellritten and well-documented paper, to the importance of external nfluences. This is not negligible, since every history of hysics is uncritical when it disregards the social basis. Nevrtheless we have to take into consideration that this social asis only last of all, through transmissions, and in a comlicated manner determines the former, and rather in its main utlines than in every particular instance. Forman's work can nspire further research, since the question already seems to e raised as to how the world physics community could accept causal quantum mechanics, for instance in the opinion of two talian physicists "Through a *programmatic reduction* of the riteria of knowledge and control of natural phenomena (implicit in the 'philosophy of observables'), they produced an epistemological shift in the concept of 'scientific explanation', limiting it only to a sort of search for statistical correlations between subsequent measurements carried out on the physical system as a whole. The new style of conceiving (and practising) physics was better suited to the transformations of society which took place in both the cultural sphere and the industrial world during the '20s and '30s, first in Weimar Germany and then in the USA. Because of its adaptability, the 'orthodox' approach did work better than any other in the emerging sectors of scientific and industrial research. ... The 'realistic' approach, since it was the expression of a more *complete* and *unitary* project regarding the knowledge of natural phenomena, appeared to be more *rigid*, less manageable, and thus it was simply rejected by the majority of younger researchers engaged in the new scientific sectors. ... With the transformation of science into a *direct productive force* the new physics played a central role in the production of technological innovations in the most diverse sectors, from chemical industries to electronics. Thus the 'orthodox' QM 'purged and relieved' of all epistemological questions became 'the basis of all practical applications'..."[27]. And after this we must ask the questions why the Copenhagen interpretation is the prevailing interpretation even now, and why attempts at reinterpretation still continue.

Loránd Eötvös University
Budapest

Notes

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2. *J. Hendry*, "Weimar Culture and Quantum Causality", *History of Science 18* (1980) pp. 157-158.
3. *W. Laqueur*, *Weimar, A Cultural History 1918-1922* (Weidenfeld and Nicholson, London 1974), p. 217.
4. See also *H. Kragh*, "The fine structure of hydrogen and the gross structure of the physics community, 1916-1926", *Hist. Stud. Phys. Sci. 15* (2) pp. 108-109.
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8. *Op. cit.* p. 246.

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14. *M.J. Klein*, "The First Phase of the Bohr-Einstein Dialogue", *Hist. Stud. Phys. Sci. 2* (1970), pp. 1-34.

15. See *B. Holton*, "The Roots of Complementarity", *Daedalus*, Fall 1970, pp. 1015-1055., reprinted in his book *Thematic Origins of Scientific Thought. Kepler to Einstein* (Harvard, Cambridge 1973), pp. 115-161.

16. *H. Radder*, "Kramers and the Forman Theses", *Hist Sci. 21* (1983), p. 171.

17. On Pauli's views see *C.P. Enz*, "W. Pauli's Scientific Work", in *J. Mehra* (ed.): *The Physicist's Conception of Nature* (Reidel, Dordrecht 1973), pp. 766-768.;
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K.V. Laurikainen's lecture at the 7th International Congress of Logic, Methodology and Philosophy of Science, Salzburg, Austria, July 11th-16th 1983, *4* Abstracts of Sections 8 and 9. pp. 122-123.

18. *Zeitschrift für Physik 33* (1925) p. 679.

19. *Born's* Nobel lecture in 1954.

20. *Zs. f. Phys. 38* (1926) p. 803.

21. *Zs. f. Phys. 43* (1927) p. 172.

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26. *J. Neumann*, "Mathematische Grundlagen der Quantenmechanik", *Göttinger Nachrichten*, Math.-Phys. Klasse, 1927. p. 1.

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MARX, MARXISTS AND THE PROBLEM OF ECOLOGY

Imre Hronszky

There are two typical one-sided interpretations of Marx. One reconstructs Marx as a *technicistic* thinker who made a fetish of the development of the "objective productive forces", mainly that of technology. The other reconstructs Marx as a thinker who *morally* committed himself to the realization of the "real human essence". Interpretations usually move between these two polarities.

Commitment to technological development at any price - this is one typical reconstruction. "This" Marx saw history as the scene of necessary technological development which should never be interrupted, and defined the development of the "objective productive forces", especially technology, as an independent variable of history, part of the destiny of mankind. Because he interpreted the advancement of technology as the "objective revolutionizing force", he even subordinated his moral indignation over the state of the working-class in the capitalism of his time to the constraint of the "objective-course" of history as he perceived it. He not only interpreted history as an "objective course of events" but as moving towards a definite goal, and he was convinced that the "objective functioning" of contemporary capitalism was nothing but its role as a social vehicle of development of the productive forces into those needed for future communism - so the accusation. Hence the working-class of his time was simply the victim of the "objective and necessary" course of history. This victim role even had a "positive" effect in revolutionizing the working-class, by providing the "subjective" element of social action. In this light, Marx appears as a rather cynical commentator on the "objective course" of history who saw Nature, and natural resources, as just another victim of, in capitalistic production, just as the working-class was.

It is no small wonder for a novice in the literature on Marx that the other typical one-sided view of Marx reconstructed Marx's thinking as if he had *morally* committed himself to the realization of the "real human essence", discarding all ideas of an "objective history" that only concerned man.

These interpretations see Marx as a secular prophet who, on the basis of his firm moral conviction, rejected the whole of history so far as being nothing but a long period of *alienation*, a prehistory of mankind, and called for social resistance. Some scholars working on this type of representation have tried to reconcile the idea of alienation with the fatalistic interpretation of history. According to them, alienation was a necessary phase in human history for Marx; a sort of transcendental punishment, but having reached its full development, it would necessarily lead to its own abolishment. At this point, alienation had to become conscious, and once conscious, it was to be superseded through human action. The prophecy about the future did not only have the function of justifying a future communism, the latter being none other than the full abolition of alienation by definition, but assured that a growing consciousness would really lead in this direction.* The abolition of alienation by a new, conscious mankind includes a new non-exploitive relationship with Nature, too; a friendly harmony based on a "non-possessive" orientation towards Nature.

The first type of Marx reconstruction made him into a cold "scientist" who revealed the "objective course" of history, a course directed by laws like the course of Nature, and presented him as a commentator on history who measured its progress by technological development. The second type turned his ideas into a secularized eschatology.

*We lack space here to analyze the Hegelian characteristics of this sort of argumentation. History has been working behind mankind as the "cunning of reason" and the objective course of history has the task of realizing the morally justified future- expectation.

Both types of interpretation have had many advocates over e last century. The debate between them reached its highest int in the sixties.* A kind of "productive-force fetishistic" rx interpretation became official throughout the socialist untries. In it the emphasis was on a positive promise of the *alth of goods* made available by advancing technology. This rt of Marx interpretation got its backing from "bureaucratic gmatic" Marxists in the "official" Marxism of socialist coun- ies. With the help of the thesis of what was known as the rimacy of the development of objective productive forces" Marx s applied to the needs of the ideology of state socialism dified in the early thirties, at the beginning of the Stalinist eriod. The need for a new ideology had became acute by the xties. In response to growing dissatisfaction with the socialist ates' policies on living standards, a moderate but steady rise the standard of living became a political goal. By this very oderate goal, the gap between the Marxian idea of man steadily eveloping himself and his needs and capacities, and the misera- le reality, was filled by the promise of richer consumption and asier work in the near future.** *Technology* became the panacea hat promised to solve all the problems.

The idea of scientific-technological revolution (STR) first under the name of the material-technological basis of ommunism) came into prominence as the means.*** The outcome of his revolution was seen as the automation of the production rocess (predicted in the near future), itself liberating the orkers from subordination to machines in the ordinary type of actory work. Marx and his ideas about the automation of the abour process were adjusted to suit ideological needs. But the ew interest in Marx's writings brought with it a real theoretic-

*The scope of this paper does not permit us to go into detail here.

**Small wonder that communism became the wonderland of richness in consumption (!) in the speeches of politicians such as Khrushchev, too. In direct contrast to Marx, communism received a petit-bourgeois definition.

***As one function of the idea of STR, this ideology offered a re-evaluation of the role of scientists and engineers in socialism. Another function was to assure people of the "advantages" of socialist state-directed planning in a new type of large-scale technological revolution.

al profit as well. Scholars began to analyze more deeply than before what Marx wrote about *the typical historical evolution of the working process*. As Marx reconstructed it, the relationship between the worker and his productive tools developed from the original immediate unity of craftsmen and their tools, through the new relationship between workers and machines in which the former became subordinated to the latter (to the material basis, "stoffliche Grundlage" of capitalistic production), into full automation of the labour process, liberating the labourer from subordination, and making him a free user of his capacities.

The *practical background* of the theoretical interest directed the focus of attention to the evolution of productive tools. To put it the other way round, the relationship of man with Nature became only marginally interesting as the possible appropriation of natural processes in transforming them into technologies, and not as the ecological problem of the relationship between mankind (technology) and the *reproduction* of Nature.

It is enough to point out that even György Márkus, a writer who surely cannot be accused of vulgarizing Marx, concentrated in his very important book on that side of Marx's thinking, claiming that for Marx there was a continuous historical process of ever-more universal appropriation of Nature by mankind, in the form of technology, and this process of appropriation was seen by Marx as the basis and part of the advancing social development of mankind, the basis of the improvement of man's own social essence.* In other, words, even Márkus failed to explicitly consider the relationship between man and Nature as a *social ecological* problem.

Scholars in some Western countries began to emphasize in the early sixties that the ecological crisis, accompanying the accelerating technological growth, had begun to assume global and acute features. At that time this crisis had not affected the socialist countries to the same extent as e.g. some parts of the USA. Certain political and ideological mechanisms were

*Márkus György: Marxizmus és "antropológia". Bp. Akadémiai Kiadó, 1966.

ill able to prevent the growing ecological problems from ecoming conscious. Nevertheless, by the end of the sixties cological problems had not only become more and more acute in he different socialist countries, but people began to be increasingly aware of them as well.

It is only a minor simplification to say that the vulgar arxist ideological guardsmen of socialism first of all worked ut ideological buffer mechanisms against the literature of the cological crisis instead of a thorough social-scientific analysis. Applying the much-used reflex, typical writings interpreted the problem in the following way: the productive forces technology - are *per se* neutral, but they can be used socially in opposite ways. The ever growing threat of the contamination of Nature that accompanies industrial growth is due to he capitalistic use of technology, and once property relations ave changed, this misuse will be abolished. Even the technology nherited from capitalism has been continuously modified - so he integration. Another standard argument was that the ecological risks were simply unavoidable side-effects of the necessary growth of industrial production. This argument was based on the idea of the inevitable character of the growth of technology and on the consensus that accompanied industrial growth in the hope of increased individual consumption. To my mind, this sort of argument did not reach the level of real philosophical articulation, although it presented itself as such. For instance, it eliminated the basic level of argument of Marxian thinking, that of the welfare of mankind, in the interests of the immediate future.

In the seventies a powerful ecological movement and a vast literature of philosophical, economic and sociological ecology emerged in the Western countries: a literature ranging from the social background of alternative energy models through different ideas of alternative economy to possible alternatives to our entire way of life. Some of these even reached practical reality either in groups looking for alternative ways of living or as part of state political and economic conceptions. Let me only pick out a few characteristic features of the theoretical writings. They extended from the most fundamental subsistence ideas to those alternative concepts that tried to explore a possible harmony between technological advancement (in the form of some "artful" continuous growth), the widening of consumer needs and ecological requirements. The truly philosophical literature made progress in analyzing different sides of the social aspect of the ecological problem. Some dug into the categorical foundations of the modern age laid down at the turn of the 18th century.* In my opinion, these writings expressed justified criticism, but in questionable ways. Fr. Capra, e.g., demanding the overthrow of the "Newtonian paradigm", attacked the whole causal attitude of thought, M. Bermann argued for a new "enchantment" of the world, cybernetic relations were given an easy teleological interpretation, etc. It seems that in many cases the search for an appropriate categorial foundation for ecological thinking advanced in a cheap and easy form of reteleologization, even revitalization, of the world-picture.**

Another important topic of the ecologically oriented philosophical literature was a reappraisal of the problem of human needs; the question being whether it was wise to think of human needs without taking into consideration the reproduction of the potential of Nature as a basic need of mankind.

Other philosophically oriented social-theoretical writings tried to point out that the nature of technology, or at least a particular rate of industrial growth, was the ultimate cause of the possible global ecological disaster.

Yet another type of literature concentrated on the social values internalized and realized by the different technologies: they analyzed the value-creating, mediating role of the development and introduction of new technologies, too.

*Due to growing ecological awareness it was realized more widely than before that the triumph of mechanical materialism the doctrine itself comprised in the definition of matter as deprived of its sensuous qualities, allowed for an attitude to Nature in which Nature was reduced to a repository of raw materials.

**Compare this evaluation with the suggestions that Nature, the Earth (Gaia), the biological species have their own goals and hence their "right" to have these goals acknowledged by mankind.

Editorial policies in the socialist countries have so far adly neglected these writings or confined themselves (as in the DR) to mere "rejection".

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No textbook of Marx's writings relevant to the ecological roblem has been published in Hungary until now. That is why his edition is of such importance. It should help us see clear-y whether Marx had a definite ecological standpoint (as a basic nd coherent philosophical, economic and sociological orienta-ion to this problem), or, what is much more important in pract-cal terms, whether Marx actually left something in his theo-etical heritage to assist our understanding of the *recent* e-ological crisis.

The textbook collected and edited by H. Parsons tries to ulfil the task of giving a good overview of Marx's conception. ut the extensive introduction does "much more": it gives a ummary of the *application of vulgar Marxism to ecology,* too. his textbook has the merit of surveying Marx's conception though Parsons' choice leaves its mark on the texts) and the "merit" (?) that the reader can immediately confront Marx's ideas with their misuse. I should like to clarify this point in some detail.

Marx developed a definite philosophical anthropological stand-point with regard to the ecological question. Parsons for-mally shares the same opinion. But he thinks, unlike us, that a general dialectic character of the thinking of Marx (and Engels) should be seen as the philosophical foundation of their ecolog-ical sensibility. To my mind, it is not a "general dialectic" in their thinking but Marx's definite philosophical-antropo-logical stnad-point that gives a coherent and vitally important starting point. This starting point allows us to discard the extremes which are so fashionable nowadays when ecological questions come under discussion.

Marx based his anthropology on the analysis of the *labour process* as the basic dialectical relationship of mankind with Nature. This dialectical relationship – the continuous process of objectification and appropriation mediated by each other - necessarily connects the historical development of the human essence, the process of self-creation of the historical-social essence of mankind, to the ever fuller material and intellectual, sensuous-emotive appropriation of Nature. In Marx's interpretation, mankind develops itself into a set of *universal natural beings*. It does so in the sense that throughout its whole history, moulded by the special structure of the labour process mankind learns to behave itself appropriately to Nature, to broader and broader fields of Nature, converting then into its own *inorganic body*.* A continuously growing part of its capacities, knowledge and needs comes into being through mutual, man-directed interaction with this ever growing "inorganic body". I is not only a process whose goal is none other than the use of Nature for human needs - themselves defined in relation to thei use of Nature -, but Marx sees Nature as the source of *human* capacities and hence as a necessary reservoir for mankind. The devastation of Nature is at the same time the devastation of mankind, too. For it restricts the evolution of the manifold nature of human beings, too. (In Marx's interpretation, the human being is the only creature that works out its historical essence by appropriating the essence of everything that exists. Its existence is a truly historical process of partly bringing into being its own essence by appropriation.**) Labour is not only the development of the freedom of mankind in relation to Nature, by its appropriation, but the freedom of man as a socia being as well. For the growing "inorganic body" which is the basis of his life in its different functions such as technolog or the setting of aesthetic pleasures, allows mankind to evolv its purely social characteristics, too.

It is important to emphasize, as Márkus points out with polemic intent, that this historical process of appropriation

*I repeat here the reconstruction of Marx's thought by Gy. Márkus in the above-mentioned book.

**According to Marx every living being measures its environmen by its partial measure fixed in its essence. Only man elaborates and changes his essence, partly by incorporating in hi behaviour and intellect the essence of other beings in a historical process.

s not restricted to a purely instrumentalist relationship with
ature.

This position is an adequate starting point from which to onceive of the expansion of man's needs and his awareness of cology in unity. In this way, it does away with the futile ntinomy which says that either man must be subordinated to the interests" of Nature, or vice versa.

The advocates of the *Romantic* stance would like to see *thical* constraints imposed on man to bridle his crudely selfish, ature-devastating behaviour, his "exploitation" of Nature. The rounds for doing so usually involve assigning some "eigenvalue" o Nature that exists independently of man. The next practical tep dictated to the followers of this conception by the "eigen-alue" of Nature, in order to preserve the unlimited character f Nature, is to proclaim the necessity of the ethical limita-ion of human needs. Thus, the alternatives are: the unrestrain-ed economic, industrial exploitation of Nature disregarding the uture needs of the economic process for reproduction, or the omantically naturalistic, contemplative relationship based on an's self-restraint. Which begs the question of how effective ethical self-restraint may actually be in a social mechanism!)

Marx seems to offer philosophical bases for a way out of both impasses by his theoretical, philosophical-antropological starting point. He helps to distinguish between the needs to be restrained and those to be developed in relation to Nature with reference to the real human essence, this self-creating historical -social process. In his anthropology a sort of *en-larged reproduction* becomes the natural starting point; man's course is represented as gradually passing on from the stage of gathering, drawing the natural goods into his sphere of activity, to the stage of reproducing the bases of his existence. Man has condemned himself either to reproducing, even improving his own natural existential foundation, or to limiting his own develop-ment.

In the course of improving his many-sided being, man has become a more and more comprehensively acting agent of Nature; Nature, in turn, is increasingly *transmitted* through human ac-tivity even when it is a question of the conservation of "intact" Nature e.g. in late 20th century national parks. Man cannot free himself from being *homo mensura* in relation to Nature, either; by coming into existence, man became a *normative* factor in the evolution of Nature. And since Nature is to an ever-increasing extent reproduced via man's interference, man deliberately puts an end to certain processes harmful to mankind; ever since man came into being, he has *directed the evolution of Nature in view of his own evolution,* at first unconsciously and later more and more consciously (cf. e.g. the development of agriculture via improved species). *Homo mensura* denotes a permanent relationship in the case of any ecological behaviour, including sheer subsistence.

At the same time, in today's industrialization we necessarily force Nature into a *self-destructive* reproduction. By reducing man to a "short-term consumer" in his basic tendency, the different formations in history have turned him into an actor working contrary to the human essence (in the Marxian sense) which should be realized in his work (in this regard the only difference between "existing socialism" and capitalism is that in the former a productive mechanism consumes at a high rate and not the individuals). Therefore, Marx can help us conceive of ecological awareness as part of man as a *whole* whose reproduction also implies the development of his aesthetic dimensions and his senses refined by the richness of Nature, as against a crudely reductive production-centered thinking which ignores both the reproduction of the very conditions of production and the reproduction of man as a whole including e.g. his aesthetic dimensions.

This ecological thinking is anthropocentric. However, this anthropocentrism, which claims that man's essence cannot develop unless an ever-expanding circle of natural relationship are incorporated into his activity, depends on Nature's man-transmitted evolution, its enlarged reproduction. Besides, man in the Marxian sense is a conscious being capable of recognizing his own world-historical needs and seeking ways to abandon activities that counteract the evolution of his human essence as a universal being.

Obviously, Marx spoke for the idea of *homo faber* (he always rote enthusiastically of the Promethean symbol). Accordingly, e also regarded the principle of "production for production's ake" first emerging with capitalist industry, as an achievement f historic significance. Yet at the same time he criticized ost fiercely the social formation of his time, namely capitalsm, which spurred production to "excesses", making it an end n itself, subjected to profit. He warned that the blind growth f production would gradually eat up *its own* preconditions. hat he proposed in its place was a communism in which the moral onsequence of the unity between mature humanism and naturalism ould become necessary through human action. This, in today's erminology, presupposes a conscious ecology in man's relationhip with Nature.

The next layer of Marx' theory concerns his view on *social ormations*. His position is lucidly outlined in claiming that he relationship between man and Nature changes with the hisorically changing social formations, and the primary question o be looked at when tackling the problem of ecology is what ype of global social reproduction is at work. As the textbook learly reveals, Marx himself exposed the fundamental features of the relationship of the capitalism of *his time* with Nature. In the capitalism of his time, economy functioned through constantly depriving work of some of its preconditions and increasing the individual capitalists' profit directly by extensively exploiting the labour force and/or exteriorizing the harmful side-processes of production, shifting the burden onto others. (Exteriorization assumed the spectacular form of smokestacks in the case of chemical works.) In this context he stressed that for the capitalist the problem of wages and, to use a modern term, of ecology both belonged to the costs of production which reduced his profit, and for an individual capitalist the working of the system was a compulsion from which he could not free himself.*

*The average reader is well aware that in capitalist England in the early 1840's the government was forced to issue bans to check the waste of labour and the rapidly growing mortality rate. However, he is far less aware that in the form of the "alkali act" something similar was ruled concerning damage to Nature.

There are two essential tasks facing Marxist theory today. One is to explore how the capitalist system woke to the recognition, via a global ecological crisis, that it was crucially important to make widespread efforts to stop the devastation of Nature, the basis of its own reproduction. The first major steps were taken in the early seventies by announcing and gradually effecting the replacement of the "technology of force" by the "technology of the intelligence".*

That is the very point at which Parsons' preface can be regarded as mistaken both at the time of writing and even more 10-12 years later. Parsons uses Marx in a peculiar way. For him the cause of the ecological problem is "parasitic capital" and what guarantees the elimination of the ecological problem is the abolition of capitalist society. He tries to present the necessary insensitivity of the "capitalist" to ecological problems as a deceptively simple alternative. On the horn of the dilemma of profit vs pollution, the capitalist, he says, will choose profit.

Thus, in Parsons' view, the way to solve the ecological problem is to do away with capitalism. What we have here is the ecological application of the hackneyed stereotype: under the appropriate social conditions, the working of productive forces will not have harmful effects. The latter derive from the capitalistic mode of using these forces, whereas the transformation of property relations will result in the right use of the productive forces. The critical attitude of the petit-bourgeoisie and dreams of paradise replace the Marxian imperative that the current reality must be put under scrutiny as a type of overall socio-economic reproduction. The way in which Parsons analyses contemporary capitalism reminds one strongly of Veblen's turn-of-the-century "petit-bourgeois" spectacles even in its terminology. Capital is anything but "parasitic". Parsons confronts

*Lack of space prevents us here from discussing the point that the rapid acceleration of the ecological crisis in the "Third World" is largely the consequence of their dependence on the advanced capitalist world for their development. This means that their ecological crisis is generated by globally active capital intent on "exteriorization".

e Marxian analysis of the capitalism of his time, of which
day's capitalism is a variant taken to the extreme, he says,
th the ideal of a communist society. He compares existing
pitalism, more precisely, one of its aspects comprising the
gative features, to ideal communism, instead of existing
cialism, and in the meantime he makes a short detour praising
e ecological attitude of existing socialism. Now, when we
ve been taught by sad experience that the "elimination of the
pitalistic form" is not tantamount to the liberation of the
oductive forces, Parsons' description is dangereously simplist-
c and jeopardizes the recovery of the dwingling credit of Marx-
sm. The problem is that it is not only capital that is slow to
earn from the rapidly multiplying symptoms of global ecological
risis; workers' movements in the capitalist countries and the
tate administration of the countries of "existing socialism"
ave proved particularly conservative as well. When a strategic
ecision had to be made between increasing of the volume of
onsumer goods and preventing of the deterioration of produc-
ion's natural preconditions, the raising of wages or produc-
ion was given priority. Therefore, the realistic context for
n examination of the contemporary ecological problem is *not* a
omparison between Marx's analysis of classical capitalism -
lthough such a comparison may have significance for the phil-
sophy of history - but a comparison of today's two existing
ocial systems as overall reproductive mechanisms. In other
ords, the problem of ecology must be evaluated with reference
o the specific mechanisms of reproduction in the two world
ystems. The Marxian methodology (whose importance can hardly
e overemphasized) requires that the reproductive mechanisms of
oth modern capitalism and existing socialism be examined from
a Marxist viewpoint devoid of ideological prejudices. These
inquiries might show, for example, that it is a minimal social
condition of ecology that forced industrialization with the
suppression of individual consumption has made us insensitive
to the introduction of agricultural technologies based on cruel
soil contamination just to boost the productivity of agriculture.
To mention an even more effective element, we should also ex-
plore the fact that a huge insensitive political apparatus (and

a bureaucracy consisting of selected experts) can put through as political will - highly questionable global investment projects causing immense ecological damage (suppressing first with brutal and later with increasingly refined means that public opinion which is an integral part of a well-run democratic political mechanism and ranges from ordinary people in the street to academicians). One of the tasks would be the unbiassed critical analysis on a Marxian basis of the social reproductive mechanism of "existing socialism" in order to clarify the fundamental peculiarities of the socialist version of the ecological crisis in the hope of overcoming it.

Therefore, the reader is kindly referred to Marx's original texts in search of a better understanding of his ideas about ecology.

* * *

This foreword was written to the Hungarian edition of H. Parson's Marx, Engels on Ecology (Englewood, 1977), to be published in 1989 by Kossuth. The aim of the English version of this paper was to give an insight into Marxist positions on ecology in Hungary.

nuscripts and inquiries should be addressed to

"Doxa", Neumer Katalin
Institute of Philosophy of the Hungarian Academy of Sciences,
P.O. Box 594.
H - 1398 Budapest

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