Olszewski, Eugeniusz

Periodization of the history of science and technology

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Eugeniusz Olszewski

PERIODIZATION OF THE HISTORY OF SCIENCE AND TECHNOLOGY

The problem of periodization is a problem going deep into the essence itself of historical processes both examined and described by the historians. It is not at all the question of making a formal division of the historical stuff or of merely considering the didactic advantages of its presentation to the reader or listener. The said advantages, indeed, will be obtained only when the periodization corresponds to the internal logic of the process under consideration.

It may be observed in any historical process how a great number of small quantitative changes, agglomerating in a certain period, when infringing the balance established in that period leads to a more rapidly running qualitative change. Just those very changes should constitute the starting points for establishing the historical periodization.

It is both possible and necessary to apply these general lines to researches in the history of science and technology. The qualitative changes are here in principle — as far as their character is concerned — analogous to the changes observed by us in the history of other domains of culture, for instance in the history of literature and of various domains of art. In the political and economic history, however, their character is different. While the qualitative changes as effected here in the form of revolutions, wars, declines and formations of states, at a certain moment obtain as a rule a legal sanction in the form of a constitution, by way of establishing a new regime or a new form of property, by way of concluding a peace treaty — in the history of culture the particular sanction like that does not occur.

None the less the qualitative changes are so much marked in the history of culture that it is quite easy to distinguish them from the quantitative ones.

The regularity of development of the particular scientific disciplines has been approached in a most interesting way, and the dissimilarities of both quantitative and qualitative changes were clearly shown by the professor of history of science at the Californian University, T. S. Kuhn, in his recent book *The Structure of Scientific Revolutions* [1].

The basis of Kuhn's conception is the notion of paradigm introduced by him. He defines paradigms as follows: "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (p. X). The following examples of paradigms may be quoted: Ptolemy's astronomy, Newton's mechanics, wave theory of light. The paradigm is composed of a whole complex of notions embracing the way of approaching the definite phenomena, a general law or a group of scientific laws, the scope of particular problems resolvable on these grounds, the model way of their solution, as well as the general features of the adequate scientific instrumentation.

The formation of a certain paradigm originates a determined phase of the development of the research. Kuhn calls it the phase of normal science. In a given domain, the paradigm then becomes the foundation not only of scientific research, but also of education. In the XIXth and XXth centuries, the codification of paradigms has been dealt with in a series of scientific textbooks, formerly in such works as *Almagest,* Newton's *Principia* or Lavoisier's *Traité de chimie*. Educated in the conviction of an absolute rightfulness of the paradigm, the research workers specialize in the domain where the paradigm is a clue that warrants the solvability of problems. Thus, for instance, on the basis of Newton's paradigm the XVIIIth century mechanics of heavens tried to resolve successively the problems of the motion of planets, their moons and of comets. The accomplishments of this kind are obviously of a quantitative character.

The development of normal science, the continuous refining of research methods and their applying to ever newer phenomena leads, however, sooner or later to the discovery of some anomalies — of phenomena or problems, the explanation or solution of which on the ground of the prevailing paradigm is not realizable, though endeavours are made in order to articulate or to modify it.

In case the number of anomalies augments, the science enters into a state of crisis. It is through a qualitative change, a creation of a new paradigm, that the science is drawn out of it. Thus, for instance, the crisis of Newton's mechanics at the turn of the XIXth and XXth centuries has been surmounted owing to the creation by Einstein of a new paradigm. We have here to do with a qualitative change which finds its testimony if only in the fact that all fundamental notions of mechanics,

[1] Chicago—London 1962.

as time, space, mass, gravitation, have got a new significance, their denominations remaining unchanged.

Owing to the qualitative changes, normal sciences constructed on the base of various consecutive paradigms are logically incommensurable with each other. The change of the paradigm alters the world picture as it is perceived by the science which begins investigating the phenomena, not taken note of before or simply not remarked.

By resolving further and further problems and by refining itself, the new paradigm gains over more and more adherents, especially so when being confirmed by new observations or experiments (thus, for instance, the measurement of light wave deflections in the gravitation field during the eclipse of the sun in 1919 became an important confirmation of Einstein's paradigm). As soon as the new paradigm gets universally recognized as a base for research and education, there begins a new phase of quantitative changes, a phase of normal science.

Similar, as regards the structure, though obviously different, as regards the material elements, is the run of developing processes in the particular domains of technology. As factors corresponding to paradigms are here to be considered the types of design and technology. In the metallurgy of iron, for instance, the following technologies and corresponding designs of melting plants may be distinguished [2]: ancient primitive kiln, medieval shaft furnace making use of water power, blast furnace based on charcoal and water energy, blast furnace based on coke and steam or electric energy. A new technology arises when the precedent one has attained best technical and economic indices, i.e. when it loses the possibilities of further development. Perfecting itself ever more by way of successive quantitative changes, the new technology at the same time supplants the former one and pushes it out of the production plants, to ultimately come to exhaust its own possibilities, however, this involving the necessity of a new qualitative change.

Both these mutually independent analyses have one characteristic feature, namely that the two kinds of changes, as distinguished in science and technology, are quite different in character, but not in speed. Although the qualitative changes usually run more swiftly than the quantitative ones, this is, however, not their fundamental feature [3].

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[2] Compare: M. Radwan, *Rudy, kuźnice i huty żelaza w Polsce*. Warszawa 1963, p. 10 and p. 256. The diagram drawn from another work of M. Radwan is to be found also in the work: Л. Д. Белькинд, О. Н. Веселовский, И. Я. Конфедератов, Я. А. Шнейберг, *История энергетической техники*. Москва—Ленинград 1960 (L. D. Belkind, O. N. Vesselovsky, I. J. Konfederatov, J. A. Shneyberg, *History of Energetic Technology*), p. 17.

[3] From this point of view, M. Daumas assertion (compare the report for the X International Congress of the History of Science *Le mythe de la révolution technique*, printed in Polish translation in N. 3/1963 of the "Quarterly Journal of the History of Science and Technology") that the changes occurred in the technology of the second half of the XVIIIth century had not the character of a technological revolution by reason of their relative slowness, is a mere misunderstanding.

The relative slowness of the qualitative changes, repeatedly encountered in the history of science and technology, constitutes a considerable difficulty when we try to base the periodization of the said history on this kind of changes. In the political history, indeed, we got accustomed to see the bounds of periodization marked in general so strongly that they can be determined with the exactness not only of a year, but even of a day (for instance November 7, 1917, May 9, 1945). This involves in turn an extrapolation tendency to sharpen all the bounds artificially, to recognize certain dates of a rather symbolic character (for instance July 14, 1789) as sharp periodization bounds. In history of science and technology, however, the determination of any sharp temporal dates of this kind is not possible. Is such a date, for instance, 1687 — i.e. the publishing year of *Principia* — for the development of mechanics and of the whole of physics? Or 1859 — the publishing year of the *Origin of Species* — for biology? After all, both of the paradigms — let us make use of T. S. Kuhn's terminology — have their prehistory which for Newton's paradigm begins with Gilbert's *De magnete*, and for Darwin's paradigm — at least with Buffon's and Erasmus Darwin's works.

The tendency to apply sharp periodical bounds arises to a certain degree from the mechanistic treatment of time as an absolute coordinate, as an absolute scale, by means of which the course of all historical processes can be measured [4]. With existing sharp periodization bounds all the events that occurred prior to a certain moment, are referred to an earlier epoch, and everything that took place after this moment — to a posterior one. The border line between "earlier" and "later" is, of course, the "contemporary". We thus reach the crux of all considerations connected with time — the notion of simultaneousness [5].

In Newton's paradigm the notion of simultaneousness suggests no theoretical doubts — two events are contemporary to each other when both of them are simultaneous with the same moment of absolute time. Einstein — as commonly known — had rejected the physically uncheckable premise of the existence of absolute time; that is what compelled him to analyse thoroughly the notion of simultaneousness and to consequently raise the problem of how to synchronize two clocks connected with two systems in which events subject to checking in the aspect of simultaneousness take place. So, this synchronization can proceed only by means of sending signals, i. e. information (in the cyber-

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[4] "Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything internal". I. Newton, *Principia*, vol. I *The Motion of Bodies*. Berkeley, Los Angeles 1962, p. 6.

[5] "All of our judgments in which time plays its part are always judgments about simultaneous events" — says Einstein (quotation after L. Infeld, *Albert Einstein*, Warszawa 1956, p. 41).

netical sense of this word) — which happens with a certain lesser or greater, but always finite speed.

We take here, of course, no interest in the physical and philosophical consequences of the reasoning starting like that, which had led to the fall of the mechanistic paradigm, and to its replacement by a new one — by the theory of relativity. This reasoning may serve, however, as a pattern for performing an analogous analysis with regard to the notion of historical simultaneousness, and consequently for drawing certain determined conclusions referring to periodization.

From this point of view, let us put, for instance, a question — when was America discovered? We do know, of course, that the ships of Columbus had made landfall at one of the islands connected with the continent of America on October 12, 1492. Was this equivalent, however, to discovering America for the European science and European societies? Would this date have any meaning whatsoever, if for instance all of the ships had perished on their way back? The proper discovery of America in social, economic, political and scientific sense did not start until five months later — on March 6, 1493, when Lisbon had been informed that there was lying in its vicinity the storm-beaten ship of Columbus just arrived straight from "India". That day was for Lisbon, therefore, from this point of view historically (but not physically) simultaneous to the day when Columbus had reached the isle of Guanahani.

This example, while illustrating the problem, is not in itself of any major importance, and at any rate not so for the periodization. It certainly may be said that the historical simultaneousness of events underlying the periodization of political and social history usually is almost identical with the physical simultaneousness, as information about such events spreads in general with the maximum speed available at the given stage of the development of communication technique [6].

The case is quite different with regard to scientific and technological events. The analysis requires here the definition of the historical simultaneousness to be made more precise still. As already said at the outset, the qualitative changes in political and social history swiftly get as a rule a universally valid formal or at least factual sanction. The information about these changes is, then, an information of a controlling character, i.e. it affects the life of the entire population of the country whose history is being considered. In science and in technology the matters stand quite differently. Luther's or Melanchton's having received information on the theory of Copernicus was not of practical importance, as neither their bearing nor convictions were

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[6] In this scope there may occur deflections, however, even in our times as well. Thus, for instance, those Japanese detachments that during the last war went into hiding in the jungles of New Guinea, were unaware of Japan's capitulation for many years and kept living on as if "during the war" long after it was finished.

thereby influenced, and they went on living — like the huge majority of their contemporaries did — in the state of historical simultaneousness with the geocentric paradigm. The metallurgical industry developing on the territory of the so-called Old Polish Basin in the second quarter of the nineteenth century rested on water power and charcoal, and its technology consequently was not historically contemporaneous with that of the English nineteenth century metallurgy making use of steam power and of coke, although the sponsors of the Polish metallurgy of then indubitably were well informed about the contemporary state of the leading technology.

Thus the historical simultaneousness in science and technology is not decided by an ordinary informative signal, corresponding to those Einstein's signals that synchronize two clocks, but by a signal that transmits the controlling information to give now rise to any change or formation of convictions, now to any determined human action.

What conclusions can be drawn from the notion of historical simultaneousness for the periodization of history of science and of history of technology?

The periodization boundaries in these domains never are chronologically sharp, and the tendencies towards defining them by years dates (as for instance *Astronomy of the Period 1517—1727* or *The Production and Distribution of Power since 1832)* lead to purely formal divisions, unless exclusively conventional denominations are meant. The basis for the division of historical material in these domains, consequently, cannot be chronology, but the distinguishing of successive developmental stages of a given branch of science or technology, as e.g. succesive paradigms or successive types of design and technology.

Thus historical, and not physical simultaneousness is to be applied when making division into historical periods in the field of the history of science and technology. According to such an approach to the problems of, for instance, aeronautics history, Leonardo da Vinci's ideas and experiments in design would be historically posterior to the development of balloons and dirigibles — from Montgolfier brothers to the great catastrophes of dirigibles in the thirties of the twentieth century — and historically almost contemporary with the researches and flights of the Lilienthal brothers.

Another distinction is to be made here. When a certain paradigm takes shape on the ground of phenomena constituting an anomaly in the viewpoint of the old paradigm, this development does not influence in its initial stage, or influences but slightly the state of the normal science, that continues holding on to the positions of the old paradigm. Thus, for instance, *De Revolutionibus* of Copernicus, and in particular the previous information about the origin and development of his opinions (*Commentariolus, Narratio prima* by Rheticus), played almost no role in astronomy, which went on chiselling and polishing Ptolemaic epicycles and deferents. At a certain moment, however, when entering a state of crisis, the "normal" science is no longer able to ignore the new paradigm — it has to take the defence against the latter, be it by directly fighting it, be it by efforts to articulate its old paradigm in order to adapt it to solving those problems that are being successfully solved by the new theory. Neither the Holy Office, while condemning Galileo, nor Tycho Brahe were ignoring the works of Copernicus any more — they either tried to stem the spreading of at least some of his ideas, or to build up on the basis of the old scientific system a variant that would have similar values as the new philosophically dangerous paradigm. The defensive attitude is being maintained to the last by the followers of the retreating paradigm. While fighting down the new theory, they cannot help considering it.

It is analogically that the relations between the old types of design and technology, and the new ones are developing. At first, the new idea is taking shape without exerting its influence on the developmental processes of the older one, later on, however, the impending competition involves either a downright struggle against the new technology (it was, for instance, only after prolonged opposition that the House of Commons allowed the first railway lines to be built, for it was already known that they would infringe the interests of waterway owners and toll tenants) or such a perfecting of the old technology as to enable it to compete economically and technically with the new one (of such a character was, for instance, the short-lived development of the steam buses in England in the twenties and thirties of the XIXth century).

It is here that clearly appears the transition period between the two development stages of science and of technology. It seems, besides, that it is the moment when the new paradigm became so much developed as to begin influencing the old ideas, i.e. as to start being fought and simultaneously becoming the starting point for the efforts to save the old ideas by means of their articulating, that is to be taken, to same extent conventionally, as the moment of transition from one paradigm to another, from one technology to another. This phase of mutual influencing of these two ideas is to be reckoned in the history of the new paradigm or new technology, the historical simultaneity of both of them corresponding at that time with physical simultaneity.

In the heretofore considerations, the geographical factor had not been taken into account. In former epochs this one played a very essential role, as in various areas, remote from each other, science and technology were developing to a high degree independently from their state in other areas at that time. It is here, besides, not so much a question of the fact that the historical simultaneity considerably differed for distant areas from the physical simultaneity, as the question of discrepancies of scientific and technological ideas in their very contents. So, for instance, the Chinese scientific paradigms were up to the modern times different from those of Europe, and the technology was preoccupied with partly different problems.

It may be admitted that there might have occurred any uncoupled and independent developmental processes which are, of course, to be investigated comparatively, but to establish a common periodization for them would be an operation nearly as much formalistic as the imposition of a terrestrial periodization when analysing the development of science and technology in one of the civilizations existing, may be, in the cosmos and not yet known to us.

As regards, however, some determined area — and this being the whole of our globe nowadays — the analysis of geographic factors amounts to the analysis of the historical simultaneity. The said analysis is not of essential complexion for the universal history of science, since the delay in the development of science and penetration of scientific ideas into some countries (for instance the retard in Russia lasting up to the XVIIIth century, the cultural regression in Poland in the XVIIth century and in the first half of the XVIIIth century) did not visibly influence the evolutional process of those ideas — which evidently does not mean that such a retardation might not be of great importance for the development of culture and at the same time for that of the social and economic situation of a given country.

It is different in the field of technology where disturbances in the physical simultaneousness cause discrepancies in development processes. Thus, for instance, the swift transfer of other countries technological achievements into mid-nineteenth-century Germany or in the thirties of the XXth century into the Soviet Union both acted on the contents of old achievements applied in the new conditions, and stimulated further development of old ideas and creation of new ones.

Was chemistry, taught and developed in Wilno by Jędrzej Śniadecki, indeed — as he is said to have told to Napoleon in 1812 — *la chimie qu'on enseigne à Paris,* the German technological revolution of mid-nineteenth century was not to the full extent historically simultaneous to England's technological revolution of mid-eighteenth century. It was not only that its course was different, but it led to the rise of new technological contents, as for instance to the creation of the chemical technology, qualitatively different from the old ones — this becoming one of the foundations of imperial Germany's industrial power.

This does not mean — in spite of what Professor Daumas states [7] — that the notion of technological revolution is useless. While it is possible

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[7] In work cited in footnote 3.

to thus define the qualitative changes that occurred in England and in Germany, the English and the German revolutions were yet not equal in their process, as the non-technological factors, and in particular the development of science and the discrepancy of economic and social conditions, infringed to a considerable extent upon their historical simultaneousness. In a similar way, the difference in the social system is the cause of the fact that the process of technological development in the Soviet Union is different from that in the capitalist countries, and so, to some extent, they are historically not contemporary, even if their physical simultaneousness be preserved. The circumstances of this kind considerably complicate the periodization of the history of particular branches of technology, the successive transition stages of their development being, due to the aforesaid circumstances, sometimes remarkably extended.

This problem becomes even more complicated when switching over from the research concerning periodization of particular branches of science and of technology to the periodization of the whole of scientific and technological progress (both of these fields becoming so tightly tied with each other, though, that they are to have a joint periodization in the future). Although it is possible, with regard to the particular scientific and technological fields, to point out qualitative changes specific for each of them by applying the aforesaid criteria that will be decisive for their periodization the distinguishing of qualitative changes characterizing the whole of science and of technology is far more difficult.

The question is here of such changes as would occur in an analogous form with regard to a considerable part of scientific and technological branches. Although those changes are not bound to show a physical simultaneousness, it would be difficult, however, to talk about their historical simultaneousness, if the differences in time were to reach thousands of years. Mathematization, for instance, might be considered as such a qualitative change, but it cannot be used as a basis for periodization in the general history of science, as in astronomy it dates back to Babylonian times, in physics — to Galileo and Stevin, in chemistry — to the end of the XVIIIth century, in economics — to Petty, and in linguistics to the middle of our century.

The overcoming of difficulties may be sought in two directions. Firstly, one can proceed along the inductive way by comparing periodization intervals in the particular branches of science or technology as well as in those factors tied with the development of science and technology as ways of organizing scientific research, social influence of scientific results obtained, social situation of scientific and technological workers. Periods in which condensation of qualitative changes in many fields and in many aspects occurs may be regarded as general periodization intervals [8]. The character of changes in some fields of science or technology may be, however, different in a given period from that in others. Thus, for instance, one certainly may remark the condensation of qualitative changes in the science of the mid-seventeenth century, but for some branches of science it will mean the arising of the first paradigm while for others — a replacing of one by another [9].

The other way may be defined as deductive. The starting point will be in this case the determination of the character of the qualitative changes, that can be recognized as the important ones for the whole development of science or technology.

Thus, for instance, it is changes in the ways of obtaining scientific achievements, as changes in the social position of scientific workers, in their working conditions, in the organization of scientific research, that are by A. Kauffeldt considered as decisive factors for the periodization of the history of science [10]. An extraordinarily interesting effort in pointing out fundamental stages of scientific cognition within the range of natural science — observational, analytical, and synthetical — is being presented at this Symposium by Professor Kedrov [11]. There were also

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[8] Compare the contribution of E. Rosen to the present Symposium and И. Я. Конфедератов, *К вопросу о периодизации истории техники*. „Вопросы Истории Естествознания и Техники", т. 4, 1957 (I. J. Konfederatov, *To the Problem of Periodization of History of Technology*. "Problems of History of Science and Technology", v. 4, 1957).

[9] Compare: E. Olszewski, *Les problèmes de périodisation dans l'histoire de la science et de la technique. Actes du IX Congrès International d'Histoire des Sciences*. Barcelona—Paris 1960, pp. 678—683, and "Archives Internationales d'Histoire des Sciences", N. 50—51/1960.

[10] Compare: A. Kauffeldt, *Zur Periodisierung der Geschichte der Naturwissenschaften, Teil I*. "Wissenschaftliche Zeitschrift der Technischen Hochschule Dresden", N. 1, Annale 1957—1958.

[11] His paper is extremely stimulating both for discussion and further research. The scheme presented by him is very attractive for its simplicity, there arise however some questions and doubts:

1) The scheme does not take account of social sciences, and this may be misleading because the interaction between social and natural sciences has become strong and manifest since the XIXth century (for instance, the great synthesis of Darwin has its roots in the erroneous ideas of Malthus).

2) The scheme overlooks the Renaissance which is to be regarded as a transition period between the 2nd period — it itself being a transitional period — and the 3rd period.

3) The notion of leading science for different periods is not sufficiently developed.

4) It is easy to show in the history of science a lot of deviations from B. M. Kedrov's scheme. The observational period lasted in some branches of science for a much longer time than in others. Some of them (e.g. astrophysics) entered at the very moment of their creation into the analytical period. Some others passed from the observational period directly to the synthetical one. Thus, for instance, the microbiology created by Leeuwenhoek in 1674, i.e. in the analytical period of science, was at that time — as it happens to sciences worked out by amateurs — typically observational and after nearly two hundred years of stagnation it advanced directly to the synthetical period — in the second half of the XIXth century the great synthesis of Pasteur was created.

All these remarks, however, are not at all directed against the very attractive periodization of B. M. Kedrov, they only show some topics for further discussion.

not infrequent efforts towards joining the periodization of history of science with the periodization of the whole of cultural phenomena [12]; in many of them however, those connections were accepted without more profound argument, the problem thus getting formalised.

Various were, besides, the endeavours toward choosing factors, decisive for the periodization of the history of technology. In view of the connections — considerably tighter than in the case of science — between the development of technology and of economics, there were often trends toward replacing periodization, peculiar to the history of technology, by general historical periodization. Besides even the Marxist scientists did not draw the proper conclusions out of the fundamental thesis of historical materialism that the development of production tools, and thus the technological progress, precedes changes in economic and social relations, the former being the main factor to provoke those changes [13].

Out of the periodizations based on the analysis of certain general factors of the development of technology there is to be mentioned the periodization originating from the formulation by Marx (in his *Poverty of Philosophy* on the margin of his discussion with Proudhon about the role of machines for the division of labour) of the successive stages of the development of machines out of the simple tools [14]. Thus, by this periodization the development of tools and working machines is considered as the main development factor of technology.

Another trend of mind regards the qualitative changes in utilizing natural energy resources by man as the decisive factor for the periodization of the history of technology. It is suggested by K. I. Ators to take into account as well — as a secondary factor — the qualitative changes in the assortment of materials utilized in the technology [15]. R. Brittain, at last, considers the problems of energy in connection with the whole of man's relations to the natural resources, following here to some extent L. Mumford's ideas [16].

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[12] Compare: e.g. J. Mayerhofer, *Der Begriff der Epoche in der Geschichte der Naturwissenschaften. Actes du IX Congrès...",* pp. 674—677; and J. Mayerhofer. *Die Perioden in der Geschichte der Naturwissenschaften...* "Veröffentlichungen der Internationalen Gesellschaft für Geschichte der Pharmazie", Neue Folge, Band 20. Stuttgart 1962.

[13] Attention is drawn to this matter a.o. by С. В. Шухардин, *Основы истории техники.* Москва 1961 (S. W. Schoukhardine, *The Foundations of the History of Technology*), pp. 108—109 (comp. also the German translation: S. W. Schuchardin, *Grundlagen der Geschichte der Technik.* Leipzig 1963, p. 56); application of general historical periodization is recommended by him in spite of this, however.

[14] Compare for instance the Schoukhardine's book, p. 109 or its German translation, p. 56.

[15] K. I. Ators, *Periodization of the History of Technology,* report for the X International Congress of the History of Science.

[16] R. Brittain, *River Technology and Historical Development,* report for the same Congress (Polish translation in "Kwartalnik Historii Nauki i Techniki" — "Quarterly Journal of the History of Science and Technology", N. 3/1963). L. Mumford, *Technics and Civilisation,* (e.g.) London 1946.

Neither a detailed analysis of these and other conclusions concerning the periodization of the general history of science and the general history of technology, nor promoting the author's own conclusions in this respect are the purpose of the present report. After all, the history of science and the history of technology seem to be still very young branches of knowledge and owing to that, not yet mature enough up to this moment for forming a paradigm of their own, comprising the periodization problems as well (with the assumption — this being a matter for discussion — that the scheme suggested by T. S. Kuhn is obligatory for social sciences, too, and that science will be developing also in future in accordance with that scheme).

It is right and just what Professor Kedrov has said in his statement at the present Symposium that while periodizing the history of natural science the inner logic of the cognition process as well as its links with practice and its dependence on economic and social relations, and on the ideology corresponding to them, are to be taken into account. The same — although the importance of the particular factors will be different — can be said of the history of social science, and by exchanging ties with practice for ties with science — likewise of the history of technology or history of medical art.

This multiplicity of links makes it difficult to fix the leading factors, and — as it seems — there do not yet exist, so far, all the premises for resolving this problem. It is to be stressed once more, however, that the discussion on periodization of history of science and technology is to be considered as an integral part of a more general discussion about factors of decisive value for the development of science and technology, when separated, it will easily slip down to formal discussion plane.

The ultimate criterion of the advantages and drawbacks of some assumed periodization can only be an elaboration of a general history of science or of technology making use of the periodization in question. Among the existing, but not too numerous synthetic elaborations there is hardly any one that might be recognized as satisfactory in this respect, the majority of them applying a formal chronological periodization (as for instance by centuries) [17] or a general historical one.

This proves that the history of science and the history of technology have not yet reached their synthetical stage of development, the third and ultimate one among those pointed out by Professor Kedrov.

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[17] Compare e.g. the assemblage of periodization in several history manuals in the author's article cited in footnote 9.