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Science Academies
faced with the problems of the modern world (**)

The theme assigned to this paper makes reference to many aspects of the problems facing us in this age. They are of a social, scientific, technical-economic and, inevitably, also political nature.

At the same time, these problems are so many that it would be hard merely to list them all.

This premise fully justifies, I think, the need for choosing first of all a limited number of problems among the most important ones we are living with and then make a selection of the aspects under which they will be discussed. In this process of choice and selection, I will do my best to follow a line as logical as possible to attenuate the inevitable fragmentation of the discussion, but I must honestly add that I will also have to contend with the need for not straying from the field of my knowledge and experience. This consideration will justify my repeatedly referring to problems I have personally experienced.

Introduction

In this discussion, among the many problems with which mankind is now confronted, attention turns to those connected with the utilisation of some resources essential to the progress of society towards better living conditions.

It is clear that this subject is already so vast, in relation to the time available, that it does not allow any extension, but I do wish to stress that material progress cannot be unconnected with the uplifting of moral values and with intellectual motivations.

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(**) Lecture delivered at the Colloquium on "The Academies of Sciences toward the year 2000" (Rome 20-22 September 1982).

The essential factors of progress are closely connected with the availability and utilisation of the following resources.

— *Raw materials and products*, required among other purposes to improve nutrition and to make the environment healthier and more pleasant.

— *Energy*, required among other purposes:

— to lighten human toil,

— for the extraction of raw materials and their conversion into useable goods, and

— to allow a greater and more efficient mobility of man and materials.

— *Information*, with regard not only to the media for its transmission and processing, but also and above all to the wealth of knowledge and experience.

— *Human efforts* for the best utilization of the above mentioned resources, through the contribution of intelligence, work capability and motivation towards the improvement of living conditions.

I cannot go into the many interconnections and interdependences among the various factors listed above, but it will suffice to mention some significant examples concerning the first three.

a) There is no transformation of matter without energy transfers between the starting materials and the intermediate and final products,

b) a large portion of the energy available to man is obtained from transformations of raw materials (in particular, conventional and nuclear fuels),

c) information is *neither* matter *nor* energy, but its processing, transmission and storage (memorization) requires some material support (equipment, processing and transmission systems, texts, etc.) or energy medium (variable electric currents, electromagnetic or sound waves), etc.

The foregoing represents an initial delimitation of the problems I am going to discuss, and constitutes in a certain sense a frame of reference for the considerations that follow.

The Need for a Systems Approach to the Main Problems

It has been repeatedly stated in these last few years that the progress of technology and the economic and social progress that resulted and will result from it to an even greater extent, have already increased the complexity of the problems which arise in the advance of development to such levels as to suggest that the time is coming in which it could become impossible to maintain a reasonable degree of control over the evolution of the major sectors of human activity, especially in the industrialised countries.

An eminent scholar and at the same time founder and manager of a leading U.S. electronic corporation, Simon Ramo, in a book published some fifteen years ago, warned that in the absence of a preventive "treatment", we would be headed for "chaos". This image appears exaggerated, but perhaps is not so far from the truth. What is the remedy? Simon Ramo claimed that the only cure is the "Systems approach" to the main problems.

In my opinion, there is room for argument about the speed with which the danger evoked is moving closer, but there is no doubt that the problem does exist and that the only remedy is an increasingly extensive application of the Systems Science and Engineering.

Based on this and other considerations, which I cannot go into here, twelve years ago I proposed to the Lincei National Academy to organize a series of seminars aimed at the broadening of knowledge about this branch of applied science, new in so many aspects, but ancient in many others. Six Lincei seminars on this theme, each lasting one full week, were conducted by eminent Italian and foreign experts, and had the constant participation of some 250 professional men and teachers. The proceedings of these seminars are contained in two volumes totaling some 1,700 pages. I trust that in the foregoing I have shown that the Systems Science and Engineering has represented in a certain sense the connecting link between a prestigious Academy and the problems listed in the beginning of this paper.

In this connection, however, it is not out of place to recall two significant circumstances, that is:

a) in order to underline the marked interest in the interdisciplinary aspects of the major problems, back in 1971 the Academy set up an "Interdisciplinary Linceo Center".

b) among all branches of science and engineering, the one characterised by the most marked interdisciplinary character is undoubtedly the "Systems Science and Engineering", as extensively shown in the introduction to the Seminars [1] and very succintly put about two years later in the Battelle Institute's monograph "A Unified Systems Engineering Concept" from which I am taking the following statement and chart: "While all of the scientific disciplines may become involved in systems engineering, those that have contributed the most to its academic basis are philosophy, psychology, mathematics, and engineering. Contributions from economics and management science are becoming increasingly significant". Figure 1 shows the contribution of the various sources. I have chosen this quotation not only because of its synthetic quality, but also because it shows that the term

[1] A.M. Angelini: *Lineamenti della scienza ed ingegneria dei sistemi*, Roma, Accademia Nazionale dei Lincei, 1972. Id.: *Scienza ed Ingegneria dei Sistemi* in « Enciclopedia del 900 ». These works stress in particular the relationship between the many problems to which the SSE addresses itself and the methods, techniques and systems that it uses.

MAJOR CONTRIBUTIONS (AVAILABLE OR POTENTIALLY AVAILABLE) / CONTRIBUTORY SOURCES	ATTITUDES AND PERSPECTIVES ON SYSTEMS	UNDERSTANDING NEEDS OF PEOPLE	MANAGEMENT CONSIDERATIONS	ENHANCING CREATIVE OUTPUTS	WORKING TOOLS	PROBLEM-SOLVING METHODOLOGY	CAPACITY FOR PRECISE COMMUNICATION	SPECIALIZED STATE-OF-THE-ART KNOWLEDGE, JUDGMENT, WISDOM	CASE STUDIES, PRACTICAL SIGNIFICANCE OF TOOLS AND METHODOLOGY
PHYSOLOPHY	●								
PSYCHOLOGY		●	●	●					
MATHEMATICS					●		●		
ENGINEERING	●				●	●			
ECONOMICS	●				●				
MANAGEMENT SCIENCE					●	●			
OTHER DISCIPLINES OR PROFESSIONS	●							●	
DEFENSE DEPARTMENT EXPERIENCES									●

Fig. 1 - Contributions to a unified systems engineering approach from various sources.

"Systems *Science* and Engineering" is more fitting than the more limiting "Systems Engineering".

I believe that no more needs to be said to prove the "right of citizenship" of this science in the Scientific Academies, particularly in regard to the problems discussed in this paper.

The Lincei National Academy, through the "Interdisciplinary Linceo Center" is planning a resumption of the project briefly described above, this time for the organization of a series of seminars, each of them addressed to one specific sector. The first will concern *"water management"* and the others will deal with problems of the sectors of *communications, energy, transportation*, etc.

The priority given to the subject of water management derives not only from the fact that this problem, especially in Southern Italy, has assumed alarming proportions and characters, but also from the fact that such an important body as the Centro di Formazione e Studi per il Mezzogiorno — FORMEZ — jointly with the University of Catania and in cooperation with the Colorado State University of Fort Collins, U.S.A., has held in the recent past an experimental course of training and updating for expert operators in this field, based on the systems approach to the problem.

The Lincei project referred to above will be carried out with the participation of FORMEZ and the University of Catania.

The Interdisciplinary Linceo Center will be very glad to consider any possible cooperation in this field with the Foreign Academies so authoritatively represented here.

The Possible Development of the Contribution of Academies to the Solution of the Problems Mentioned

To stay within reasonable time limits, I will have to confine myself to a summary discussion of some of the countless problems included in the frame of reference outlined above and to some considerations of a general nature, when this will seem appropriate.

From Theory to Applications

The evolution we have witnessed in the last few decades has shown not only a growing interdependence between basic research — theoretical and experimental — and applied research, but also an increasingly extensive use of science's most advanced methods and instruments. On the other hand research, above all experimental, is relying on increasingly important contributions from the most advanced achievements of technology.

But there is more, since certain researches conducted even in a distant past, above all in the theoretical field, now constitute the foundation of practical applications of great importance.

Nobody would have even remotely dreamed that when, between 1672 and 1676, Gottfried Wilhelm Leibnitz started developing the first parts of his "diad theory", i.e. the "calculation with zero and one", in the intent of introducing a logical calculus more accurate than the natural languages, he was in effect facing the problem behind the modern computers.

Later, in 1854, British mathematician George Boole introduced the algebra that carries his name, in the framework of a research on the laws of thought, with an approach which went far beyond Leibnitz's.

No one, even in a science-fiction vein, would have imagined that the work of these two famous mathematicians would have made possible the development of a discipline and technique which under various aspects characterise our present age.

But there are many more cases in which the time elapsed between the achievement of theoretical results and practical applications is much shorter, as we shall see further on.

I shall mention here only one significant example, which concerns the use in practical applications of an advanced mathematical method introduced by Levi Civita and Ricci Curbastro, extensively used by Einstein in the development of the theory of relativity. This is the *tensorial calculus* which, after having been extensively used in the theory of elasticity (among others by Leon Brillowin), through the work of Gabriel Kron, has found extensive applications in the calculation of electric power networks and has made possible the formulation of a unified theory of electrical machines and, later, the formulation of a theory of a very general nature which Gabriel Kron himself developed under the name of "Universal Engineering" in a paper published in 1963 by Mac Donald Publishing

House in London (²). Although it did not attract the attention it would have deserved, outside of the electric power sector, this work constitutes a fundamental theoretical contribution to Systems Science and Engineering. In any event, it led to the formation of the Tensor Society of Great Britain, founded by Sir Austen Stigant.

I believe there are no doubts about the fact that the subjects I have just mentioned constitute a very fitting area for any Scientific Academy.

The following examples originate from the problems mentioned at the beginning of this paper.

Raw Materials and Products

In the field of energy, a distinction is made between renewable sources (e.g. hydraulic energy) and non-renewable ones (e.g. fossil fuels).

This distinction also applies to raw materials, with the difference that almost all of them are non-renewable. There is, however, an important selection based on the foreseeable duration of mineral resources and, as it is logical, attention is called in particular to the raw materials which are becoming more rapidly depleted.

The problems involved concern among other things:

— the estimates of reserves,

— the evolution of methods and costs of extraction, the processing of ores, refining, etc.

— the conversion of the ores into the basic raw material, etc.

One problem of a general nature, and all the more urgent and important the more limited are the remaining resources, is that of replacing these raw materials with others whose depletion is farther in time.

There is then the process of conversion of the raw materials into useable products, affecting the whole chemical industry, which raises innumerable problems into which I could not go, both because of time limitations and because they fall outside my field of knowledge.

I will therefore confine myself to mentioning the fact that the most advanced of the theories of the structure of matter — the theory of quanta — is finding more and more extensive applications not only in the field of basic research, but also in that of applied research.

In this connection, I believe it fitting to quote a passage from a recent paper titled "L'Europe vis à vis du défi technologique des années 80" (³), in which Prof. Umberto Colombo, Chairman of the "Comité Européen de Recherche et Développement", makes the following statement:

(²) Gabriel Kron, *Diakoptics - the Piecewise Solution of Large-Scale Systems.*

(³) A paper read at the Colloquium on "Innovation et Société" held in Paris on November 19-21, 1981, on the initiative of the "Academie Européenne des Sciences, des Arts et des Lettres".

"Today, the complex of scientific knowledge tends to become unified into a homogeneous branch of knowledge: it is more important to know about the interactions between matter, forces and phenomena than to study them thoroughly but separately. This tendency is perfectly illustrated by the awarding of this year's (1981) Nobel Prizes. They were given for the study of the forming of molecules through the mechanics of quanta and for electronic and laser spectrometrics, which are essential elements in the determination of chemical structures".

It is not necessary to recall here the very fast evolution of the research — based on the most advanced knowledge of the intimate structure of matter — into the properties of the materials now in use and of new materials intended to meet increasingly strict and sophisticated requirements.

In this succession, though rapid and fragmentary, of exemplifications, we cannot leave out a mention of biotechnologies and of "Genetic Engineering", which are taking on an exceptional relevance in the field of basic and applied research in the most advanced aspects. It goes without saying that this area is forming the object of intensive activity by all Scientific Academies everywhere.

In this connection, I would like to recall that genetic engineering is one of the subjects of closest study in the U.S.A. by the National Academy of Engineering, whose President, Dr. C.D. Perkins, in presenting the Proceedings of a symposium organised by the NAE on the theme of "Genetic Engineering and the Engineer" (*), after recalling the fast evolution of genetic engineering in the last 20 years, stressed the need for a close liaison and exchange of information between researches, engineers, academies, industries and governments.

Genetic engineering is also one of the leading subjects in the prestigious magazine, *Science*, the official organ of the American Association for the Advancement of Sciences (AAAS).

Energy

There is really no need to stress the importance assumed by the energy problem, a subject for concern by the Governments, by the scientific and technical organisations and by public opinion of all countries, as well as by the leading international bodies, such as the UN, the OECD and the European Community, especially after the oil crisis which broke out with the Kippur War.

Its many scientific, technical, economic and social aspects have been discussed on repeated occasions by all Academies of the world, so that it is hard to talk about them without repeating things that have already been said and written, and therefore I shall limit myself to some considerations.

As a whole, the energy supplies offered by Nature are unlimited: the basic

(*) *Genetic Engineering and the Engineer*. A Symposium at the Seventeenth Annual Meeting - November 3, 1981, Washington D.C. - The National Academy of Engineering. National Academy Press, Washington D.C., 1982.

problem is that of drawing from these supplies the energy useable in the most varied applications under the most economical and reliable conditions as regards the meeting of requirements and the safety of workers and populations.

If there is one sector in which applied research and applications have followed without delays the achievements of basic research, it is that of energy. It will suffice to think of the evolution that has led to the use of nuclear fission reactions for the generation of large quantities of energy and of the close connection between basic and applied research in this field. It was just forty years ago that Enrico Fermi and his coworkers produced, at the University of Chicago, the first controlled nuclear reaction for the production of energy for peaceful purposes that has led to the present great nuclear power plants and to developments which, in a relatively short time, will lead to the breeder reactors, which will extract a quantity of energy from uranium equal to sixty to seventy times that producible by the existing reactors. And this is not a purely theoretical forecast, since a 1,200 MWe plant is being completed, which is the greatest in the world of this type, while not only experimental but also demonstration power breeder reactors have been operating for many years.

The construction of this plant is the product of an international cooperation within the European Community, whose origin and developments are discussed in the papers cited in the footnote [5].

Farther in the future is the construction of "fusion reactors" which will again multiply to a very substantial extent the potential energy reserves useable by man. An intensive experimental work in this field is in progress in the U.S.A., the USSR and in the European Community. As in the sector of breeder reactors, the latter has achieved a concurrence of efforts by combining the efforts of scientists and engineers and financial resources, towards the attainment of goals upon which the future of the countries of the Community largely depends.

I have discussed in the first place those research programs which, on the one hand, offer the prospect of a substantial contribution, not very far in the future, to the meeting of steadily increasing energy requirements, and at the same time make it possible and will make it possible to an increasing extent, to progressively displace conventional fossil fuels, and in particular oil and natural gas from use in thermal power plants, releasing them for uses in which they are irreplaceable.

This does not at all mean that other energy sources, mainly renewable ones, such as the hydraulic, solar radiation, wind, the tides, etc., are not attracting the same attention.

Thus, every effort will have to be made to limit energy consumption through the greatest economies in use and adopting all possible measures for the conservation of non-renewable sources.

I have thus sought to describe the fields in which more significant work is

[5] A.M. Angelini: *Il presente ed il futuro dell'energia nucleare con particolare riguardo ai surrigeneratori* - UNIPEDE - Community Joint Study Group on Breeder Reactors. *Il ruolo dei reattori autofertilizzanti nella Comunità Europea*, «L'Elettrotecnica» No. 7, July 1982.

being done by scientists and experts, and therefore by the Academies to which they belong.

This does not mean that careful consideration should not be given to the development of research in more traditional fields towards the improvement of the efficiency of the current means of energy production, but this is essentially a matter of applied research.

Before moving on to another subject, I would like to dwell on the significant contribution that the Systems Science and Engineering can make to the solving of energy problems.

The entire energy sector, from all primary sources through the phases of conversion and down to the end uses of energy, constitutes a generalized system comprising sectors, each of which is to be considered separately, before being viewed as part of the overall energy system. To make the following considerations more concrete, I shall take up the electric power sector, also because I am more familiar with it, with regard to one problem in which I have been very much involved, and to the solution of which nothing could more effectively contribute than the systems approach, and therefore the use of the methods of Systems Science and Engineering.

The problem arose in Italy in 1963 when, following the nationalisation of the electric power industry, some 1200 utility companies, large, medium and small and organized in different ways, had to be merged (and not merely thrown together) into a single structure and organization, achieving among others the following objectives:

— raising productivity as much as possible,

— reducing to a minimum the "mean energy path",

— raising the overall efficiency of thermal power generation and, as a consequence of the foregoing,

— reducing in real terms the cost of energy.

I would be departing too far from the subject of this paper if I dwelt on the results achieved, which have been largely satisfactory, but I would like to call attention to that structure of the system which decisively contributed to the attainment of those results.

This is a central control system, now being progressively automated, which achieves in real time the economically optimal pattern of generation and primary transmission of electric energy over the entire national territory, achieving in particular that load distribution among generating units and that regulation of energy flow in the power lines which minimize losses in the entire system.

But the "integration" of the national production complex has involved several other problems, on which I reported in the General Report to the "Power Systems Computation Conference", which not by chance was held in Rome in 1969 (*).

(*) A.M. Angelini: *The Role of Systems Engineering and Analysis in the Production, Transmission and Distribution of Electric Power.* - June 1969.

One participant was the late Philip Sporn, one of the leading experts in the field of energy generation and pioneer of the electric power industry in the USA, with whom I had later a number of meetings at the National Academy of Engineering (of which he was an authoritative national member and I a foreign member).

In 1971, Philip Sporn gave to the wide-circulation magazine, "Electrical World", an interview in which he drew a picture of the avalanche of problems the electric power industry was going to face. This interview was published prominently under a particularly significant title, dictated by Sporn himself "For Utilities, the Future is a Systems Problems" (7).

The above considerations serve to make clearer what I said earlier about Systems Science and Engineering.

Information

I do not believe it necessary to go into the merit of the many problems concerning data transmission and processing, also because there would be no space to develop them and, furthermore, this subject has been discussed at length on many occasions.

I will instead take up some matters of a different nature and of no small importance.

First of all, I will deal with a subject developing from the information problems concerning the utilization of energy resources.

I do not believe there can be any doubt about the fact that one of the roles of the Academies is to contribute to the establishment and the respect of truth. Many authoritative statements could be cited in this sense from speeches and papers of eminent scientists and philosophers, but this will be unnecessary.

All of us have had occasions to observe that in the very field of energy production, public opinion is troubled by the spreading of information which very often has little or no connection with the truth. Mostly, these are claims voiced by incompetents who, however, are very well versed in the art of capturing the attention of readers or listeners by clamoring about dangers which are either inexistent or blown up out of all proportion and by projecting images of the facts which are entirely fantastic or even ridiculous for those who have some idea of the truth.

By way of example, I am referring to the image of a hypothetical nuclear power plant accident, which has been circulated very widely (also through a movie shown around the world), and which created in some strata of public opinion the so-called "China Syndrome", widely exploited following the Three Mile Island accident. What is presented is a succession of events which not only are largely impossible, but even contradict the most elementary principle of physics.

(7) Philip Sporn: *For Utilities, the Future is a Systems Problem* in « Electrical World », January 1971.

And what should we say about the "classification" of energies as "soft" and "hard", which is meaningless but generally used to fight that concentration of production facilities often dictated by Nature in the hydroelectrical field, and which, in any case, results in the highest efficiencies and economies of scale? For some time, public opinion was convinced that a nuclear power plant could explode like an atom bomb, but this image is now declining.

Leaving aside these images, and many others of the same kind, it would seem appropriate for Academies to carry out an action intended to contain — if a total elimination is impossible — a "pollution" of information which causes enormous damage, as I have had occasion to stress at different times, in particular at the World Energy Conference (8).

Let me add that sometimes we find, with great regret, that well-educated people, widely known in different fields, speak out about things they do not know, with consequences whose seriousness is readily apparent.

This is a matter which is worth discussing. Personally, I have long believed that action for a wider and more correct information about certain problems should be conducted at all levels of education, from the elementary to the highest. Some ten years ago I proposed a program in this direction to the then Minister of Public Education, and an action was started and is now developing, but results take time in coming.

On the matter of education, I would like to call attention to another problem: in setting up teaching curricula, it would be productive of significant benefits to include in the programs for the various specializations the teaching of Systems Science and Engineering, but not only as a separate subject. The methods, techniques and instruments of this typically interdisciplinary branch of science and engineering should find space above all in preparatory courses.

The objective is to broaden the student's horizons and to largely offset the negative consequences of specialization, however necessary.

I cannot devote any more time to this subject, except to refer those who might be interested in it to a paper I wrote some twenty years ago and published in the Proceedings of the Lincei Academy (9).

On various occasions, however, I have called for a revision of university curriculums, especially in Engineering schools, on the basis of a systems approach which, I am convinced, would serve to eliminate certain limitations which often hamper the careers of future engineers.

Finally, one consideration which I believe concerns many Academies, afflicted by a sort of isolation which causes them to be regarded by public opinion, by industrial circles and by those responsible for the political guidance of the country as "ivory towers" inhabited by people who understand each other (and that not

(8) A.M. Angelini: *The Cost of Delays in Building Large Electric Power Plants due to Obstacles to their Construction - The Italian Situation.*

(9) A.M. Angelini: *Contribution to the Study for the Restructuring of the Engineering Curriculums in Relation to the Field of "Energetics"* - October 1971.

always) and who have little or no contact with the external world and with the country's economic and social realities.

This was one of the reasons — perhaps the main one — which led the late Prof. Beniamino Segre, past President of the Class of Physical and Mathematical Sciences and then President of the Academy, to establish the Linceo Interdisciplinary Center I have mentioned earlier. The result was a positive one, as proved by the fact that in 1976 the Italian Office of the Prime Minister commissioned the Lincei Academy to carry out an investigation on the development of Italian society, which involved the study of some subjects of national interest, including "Italian Labor Forces in 1986", "Violence and Crime", "The Health Aspects of Italian Society in the Coming Decade", "The Energy Problem" and others of comparable importance.

The reports prepared and published were much praised, but the project was not followed up as desired because of the frequent changes in the government of Italy.

To conclude the above considerations in summary form, I will say that for various Academies the problem is not that of "savoir faire" but rather that of "faire savoir"; it is my personal belief that this problem deserves more attention.

Human Resources

This is the last subject of my report, but certainly not the least important. To back up this conviction, I would like to mention one personal experience.

When, in 1976, at the end of one of the triennial Congresses of the International Union of Producers and Distributors of Electrical Energy (UNIPEDE), I was asked to draw the conclusions of a rather busy week, I decided not to make a quick review of the various papers, but instead to call attention to the only resource which had not been discussed as being "immaterial": the human resource, which I had no hesitation in rating as more important than all the others put together.

Indeed, what would be the use of plant and equipment — even though they form a patrimony worth many billions — if they were not operated by men guided by the knowledge and experience gained through much work and sometimes suffering?

Towards the best and most satisfactory use of the human resource, also from the social standpoint, a predominant role is played by a structure also of the immaterial type (I was about to say of the "software" type), and namely *organization*. This resource is decisive towards the results of plant operation and management. Here again, the Systems Science and Engineering finds its full application, since the organizational fabric can only be woven after that of the complex of planning forming the object of management.

This is all I can say here about this matter, referring those who wish to know more about it to the paper cited in the footnote ([10]).

If I have mentioned the problems connected with the organizational structure of a certain type of enterprise taken as an example, it is because through this structure the human resource makes its contribution, which depends to an appreciable degree on its articulation.

And let me dwell here for an instant on an increasingly frequent error committed by those who believe that they can make even the most important decisions on organization without knowing, or knowing only superficially, about the "functioning" besides the articulation of the structure to be managed. The management of the human resource constitutes for those concerned with the fate of an enterprise a task the more delicate the more complex and sophisticated the enterprise.

This consideration applies fully to industrial enterprises, especially those involving advanced techniques; it applies particularly to research organizations.

I would like to mention one more reason to stress the importance of the subject which concludes this report: the errors made in the field of organization mostly do not have immediate consequences. Their very serious effects develop gradually, but when they do make themselves felt, the situation has in most cases become irreversible.

And, finally, the organization of teaching at all levels assumes an importance which it would be hard to overestimate. I have already stressed in this connection the contribution which the Systems Science can make to the solution of these problems. I wish to call your attention to a UN manual which constitutes a sound "guide for educators in developing countries" ([11]).

([10]) A.M. ANGELINI: *The Electric Power Industry's Growth and Organizational Problems* in « L'Elettrotecnica », No. 5, May 1974.

([11]) *A Systems Approach to Teaching and Learning Procedures: a Guide for Educators* in « *Developing Countries* ». UNESCO Press, Paris 1975.

DISCUSSION

TANNENBERGER

I fully agree with the very fascinating talk by Professor Angelini and I fully agree that the problems of the management of energy problems in our world are very important, but I would like to draw your attention to some other problems which I would like to call challenges of our modum world. First of all the problem of peace in our world is one of the main tasks of the Academies of Sciences. Second: I would like to draw your attention to some problems in medical science. I am totally engaged in medical science, particularly in cancer research, and I believe that we should never forget that the problems of medical science are playing an important role, and a growing role, in our modern world. I feel that for example problems such as mental diseases or cancer get more and more important. If I compare for example the importance of the cancer problem and the role which the cancer problem is playing in the United States, with some developed countries, I see that cancer and mental disease are top problems in our society and I think the academies of sciences have a high responsibility also for such problems. This is the first point I would like to mention, and I think we have to focus the problem that now every fifth person is dying of cancer and we can expect that in the year 2000, maybe every second or third, person will die of cancer. This is a very, very hard point and it has to be focussed by the scientific role and particularly by the academies of sciences.

I would like to mention in this connection one problem which we see in our country. We have for example an institute, a comprehensive cancer center, in the frame of the Academy of Science, and so far we are already attracting very much attention in the Academy of Science to the cancer problem. But there is one point which is maybe a point for discussion. It is the question of how much attention an academy of science should give to a problem such as cancer. We have a lot of discussions on that. Some people say, "Well, the Academy of Science should have responsibility for such a problem but only in the sense of the basic research, nothing more". Other people say, "It is not enough to do only basic research on that. We have a much greater responsibility, and we have also responsibility for the management of cancer control in the country. This is the real point of discussion: how far should we extend the responsibility of the Academy of Science in such a problem? Shall we limit our activities to basic research, or shall we take the responsibility also for very hard problems for society, like cancer control in the country? We take the position that the Academy of Science should do not only basic research — we believe that it is very stimulating if the Academy of Science is doing both basic research and applied research, and I think the stand of Professor Angelini that an academy of science should not be isolated from the society will support me in this and

I believe it is a direct answer to Professor Angelini if I would like to support a very wide involvement of academies of sciences in such fields, not only limited to basic research. This is exactly the idea which was at the beginning of our Academy of Sciences in the German Democratic Republic and in the spirit of the German Academy of Sciences and of its founder Wilhelm Leibnitz which was: *Theoria cum praxis*. This is what we realize in cancer research and I think this is what we have to realize also in some other fields.

Angelini

I thank Professor Tannenberger for this comment. I believe that, more than a discussion of the items I have proposed, it constitutes an original and important contribution. I should like here to mention the fact that the National Academy of Engineering of the United States (a sister Academy of the National Academy of Sciences) has a particular interest in medical research. I mentioned the interest in genetic engineering, and I would like to emphasize the fact that almost half of the activity of the National Academy of Engineering is devoted to medical problems and other problems brought up so far.

Peters

I think we should probably confess that one of the problems that we have in the Academies of Sciences is that we do not even understand the colleagues when they are speaking in related fields. I think that the academies have failed in finding a common language between different people in different fields. Now as an objection to what our colleague from Germany said, I do not think we should widen the field of our concerns in the Academies of Sciences or we will end up not understanding anything about anything any more. So I would make a pledge for future action to stress the importance of developing mutual understanding between different terminology in the different fields of sciences. Let us not forget that the Academy of France, l'Académie Française, was founded in order to get a common language and a common terminology. We failed in that. And a second point, I am sorry, is the age of our colleagues. Although we are very grateful that they still participate in our work, we must consider that science today, and especially technology, is practiced by people below 50. Now, when we look into the age of our Academy, we see that it is really a block to any influence they can have in modern society where civil servants have a limit of age at 65. I think that a formula should be found for emeritus members as exists in other academies, so that the famous scientists still take a full part in the academic work but letting younger people give also their important contribution. And I hope something like that can be one of the conclusions of our present meeting.

Angelini

I thank professor Peters for his comments and I fully agree with him

Marini-Bettòlo

I thank Professor Angelini for his important report on these questions and I want to call attention also to the importance of the aspect of information in the function of the Academies. This is especially important for developing countries. We all know the difficulties of creating new libraries in any new research center. This is even more difficult in developing countries, where a certain tendency is evolving to eliminate in part the reference libraries and to join instead the international net of scientific information in the various fields. This makes it necessary — and here the Academy may have a role to play — to develop training and the formation of personnel. I believe that in this regard too there is something that the Academies can do to provide them with the scientific data available to the international scientific community, as well as the training of personnel to use this information, so that they can build their own future.