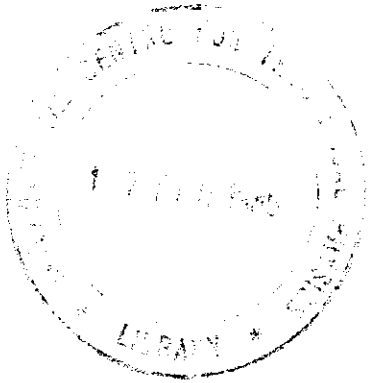

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SOME THOUGHTS ABOUT RESEARCH IN INDUSTRY AND UNIVERSITY AND ABOUT TRAINING OF PHYSICISTS FOR INDUSTRY

presented by

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Some Thoughts about Research in Industry and University and about Training of Physicists for Industry

I am aware of the fact that the complex question of "Training Physicists for an Industrial Society" can not be covered in its completeness in this talk. Furthermore, I can not offer a simple solution for all the problems one faces. All I am able to do, is to formalize in a very general way some of my thoughts. What is research in industry? Are there some typical boundary conditions in which industrial research differs radically from research in universities? What and how should we teach in order to prepare the students for research in an industrial organization? Where should we put the emphasis? These are some of the questions one has to consider before one can make some concrete suggestions.

What is Industrial Research?

There is no real definition simply because there is no typical industrial researcher like there is no typical university researcher; physics can fortunately be done successfully in various ways. In a competent industrial research team various talents are needed. In large organizations one can find long range, medium range and short range projects. Long range research is, by definition, of fundamental nature and should be at the forefront of science. This kind of

research does not differ from good fundamental research at universities. No strict time limits are set for these projects and the results are published in good scientific journals and presented at international conferences. A large fraction of research projects in industry are of medium range nature where some good and useful results are expected within, let us say 2-3 years. Examples are the development of a new material with specific characteristics, a new process, a new approach to solve a practical problem, a new device or a new system. It should be made clear that these findings do usually not signal the end of the project. It often is taken as a feasibility study and is then turned over to a development or a production group for which also physicists are needed. Short term research is to a very large extent typical for smaller industrial organizations. This advanced development work is usually well defined. What is asked for, is a definite solution of a concrete problem in a short time, for example a stability (life time) problem, the design of a better device which can be produced at lower cost, suggestions for a better processing method etc. Furthermore, one finds in an industrial laboratory more than any time before, a considerable number of industrial physicists for analytical tasks like X-ray, electron and neutron diffraction, optical and mass spectroscopy, NMR, EPR, Auger, SIM, LEED etc. not to speak about all the computer work. Their work is not only to be

considered as a service function to be performed for colleague scientists in the laboratory but quite often leads to good research work. Analytical tools and computer work have become so sophisticated that also small research organizations need highly skilled scientists for these tasks.

From all this it can be seen that in a good industrial research laboratory one needs a large variety of talents: Theoreticians and experimentalists; young people who take a new approach and experienced people; scientists with a more fundamental and scientists with a more Edisonian approach; people with analytical talents and inventive people. To have the right mix of talents is of great importance. For this reason the training of young scientists at the university has to be very broad. When I say broad I mean that not only in a technical sense but also in a more social sense as I will discuss later.

Some Industrial Characteristics

Although research at university and industry has more in common than is usually assumed (namely to try to understand a phenomenon and try to solve a scientific problem) I would like to mention here a few points of difference. For medium term programs and obviously for short term programs, industrial research moves, in general, much faster.

A project can be dropped almost immediately if it does not appear to be promising and interesting anymore. This can be in contrast to some projects at universities, for example a thesis, which has to be continued to a certain point although the enthusiasm is not high anymore. Also, a new project can be, often must be, started right away as soon as a new idea, technology or need appears on the horizon. As a consequence of this, one can find in industrial research laboratories experienced researchers with very broad interest. These people have worked over the years in a number of different fields and have thereby gained a broad knowledge and experience in many subjects. Long range projects, on the other hand, are by definition closer to the philosophy of research found in university laboratories. That is, these people are very deeply engaged in a very special field of research, and are at the forefront of science.

Team work undoubtedly is more developed in industry, especially interdisciplinary team work. A normal method to solve and investigate problems is to form task forces which are composed of scientists from different disciplines like theoretical physics, chemistry, technology, electronics, etc. The composition of these teams can change with time depending on progress and need while the work is progressing. Similarly, experienced physicists in an industrial laboratory have to be broad not only on a technical level but also, what I would call, on a social and organizational level.

What I mean is that often they are asked to work closely with people in development and/or production. This form of team work requires considerable adaptation in attitude and work philosophy simply because people engaged in production approach problems differently. In a less dramatic form this can be accomplished by consulting with people from other divisions in the company. Consulting, transfer of technology and knowledge to other groups is very important and not always easy. For this reason an open attitude is asked for.

New projects are most of the time not initiated by one man only, "the boss", but by a group of people including scientists and management. The driving force behind it is either a new scientific discovery or a new need for the company. It is of prime importance that in the decision making not only the management is engaged but also technical people both experienced and qualified scientists with a broad knowledge but also young people with lively, fresh and sometimes not conventional ideas. Again, a balanced team work is of prime importance.

To summarize: Research in industry is spread across many disciplines, both technical and functional. Depending on talents and interests one can find many challenging opportunities. Accomplishments are therefore not just measured by the number of publications and presentations

at international meetings but also by patents, concrete suggestions, general consulting with people from other disciplines and parts of the organization, transfer of knowledge and technology, from research to development and production. Whatever approach and career a scientist takes, success and satisfaction is given by enthusiasm, motivation and, of course, hard work.

University-Industry-Training of Scientists

Let me now turn to the question of training young physicists and to the question of coupling between university and industry. Often the question is asked whether university should teach special courses for physicists who want to join an industrial laboratory. In my opinion, no special training is required for industrial research for two reasons. First, as I discussed before there is no basic difference between good research in industry and university and second, most students while taking courses do not know whether they eventually will end up in an industrial position. What is needed is a solid education in physics and related fields - broad and fundamental! As I mentioned before it happens quite often that a researcher in industry is asked to change his project and get involved in a different field of physics. Of course, some time is needed to get acquainted with the problems in a new field. However, it is quite clear, if the person has had a

very deep, broad and fundamental training in physics at the university he has a much better chance to become familiar with his new assignment in a relatively short time. Special courses are, of course, welcome but they do not have to have an industrial flavor. Again - basic and fundamental knowledge is what should be given to the young scientists. For the same reason, in my opinion, the topic of a thesis is not critical. I think it does not matter in which field it is except if the company is looking for a very specialized man for a very specialized assignment. The purpose of a thesis is still to give a young physicist the opportunity to show that he is able to tackle a problem on his own, i.e. study the literature, work out a program, perform experimental or theoretical studies, discuss the results, put down the results in a report and make recommendations for future work.

There is one aspect I would like to have encouraged in the training of young physicists. This is to develop more inventiveness, creativity and imagination. It may be, these talents can not be developed, a person has them or not. However, I feel an effort should be made by all means. Learning many facts is one thing; to come up with new ideas, even if sometimes not realistic, is another thing. Imagination is for both, fundamental thinking and practical solutions of great value. I have the feeling that at universities learning is much more emphasized than encouraging young people to come

up with their own ideas, even if they may be wrong or not convincing. Let me give an example: When interviewing candidates I usually ask them at the end of a discussion what kind of a project they would like to tackle in our organization given complete freedom to chose. Of course, since these people do not know our organization I can not expect an answer which would be exactly along the lines of our thinking. However, from the answers I can learn much about the interests of the candidates. Some young physicists have no other suggestions than to continue more or less along the lines of their thesis. Others propose completely new things, things I never have thought of. Needless to say that I prefer the latter. Although these proposals may be unrealistic and far fetched the candidate shows imagination. This is what we need; thus it should be encouraged at the universities by having free discussion in "brain storming" sessions.

The problem of better coupling between university and industry is in my opinion solely a question of attitude. Both sides have to respect the problems and approaches of the other. There is no principal barrier between research in industry and university. Quality of research is determined primarily by the people involved and not so much by the organization although the approach may be different. Mutual visits and discussions should be encouraged. Both sides can learn from each other. Industry can profit from new dis-

coveries and knowledge acquired at university laboratories; universities can profit from technical developments acquired at industry and from interdisciplinary team work. Again - it is a question of attitude and mutual respect and understanding.

Let me conclude: One should not make an issue about industrial and university research. Although some boundary conditions may be different, one finds in both types of organizations good or mediocre people, and projects. All of us want to see good and interesting research in physics and related fields independent of emphasis and approach. It is the quality of people, their knowledge, their enthusiasm, their creativity and their attitude which counts.