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MR. RICHARD T. NALLE, JR.: If someone could get the people in the lobby there to come in, we will start with the last presentations. We're right on schedule at this moment. As you can see, we're getting set up to have the questions and answers for everybody at the end.

The final presentation of the day and of the convocation will be on the management of R&D, a problem I'm sure many of you have struggled with. I know I have struggled with it and I can never say that I've been very successful at it.

To bring into focus the priorities we must sort out over the next few years, we are fortunate to have Dr. George E. Pake, Group Vice President for Corporate Research from Xerox. He will be followed by Dr. George Heilmeyer. Dr. Heilmeyer is Senior Vice President and Chief Technical Officer at Texas Instruments. Jokingly I was kidding him earlier. His only other claim to fame is that he took all his advanced degrees at Princeton where I went.

(Laughter)

Dr. Pake.

DR. GEORGE E. PAKE: Thank you very much. At the outset with a title like R&D management, let me make the following statement lest there be any doubt. When it comes to R&D, I'm for it. And now I'll try to do some discussion of that.

As other speakers here have doubtless felt in preparing their remarks, I found that attempting to produce thoughts that might be applicable to a forthcoming century was an awesome task. One way to view the problem is to ask what will one have said about my topic in 1884 as the first century begins? And if I could figure out an answer to that question, what meaning might that answer have had in the last few decades of the first century?

These questions pose some difficulty for me, and I feel confident that the phrase R&D management would have drawn puzzled reactions in 1884. First of all, the technical pioneers of those days were probably far less lazy grammatically than we are today. Since the New Deal was 50 years in the offing, the language had not been corrupted by alphabet soup, much less so by acronyms. Fortunately we do not normally attempt to pronounce R&D,

. although I have been told that the Rand Corporation was named as a kind of an acronym for R&D. I don't know whether that's historically accurate or not. But in general, we do not refer to R&D by attempting to pronounce it.

Even if one were to imagine speaking in 1884 of research and development rather than cryptically of R&D, I have serious doubt that the two words were in those days frequently associated. The notion of research as a basis for development of products and services and the concept of a flow from research to development is, I suspect, entirely a 20th century thought pattern. This gives me considerable pause. What will R&D connote in the year 2084?

I'm sure that the word research had full meaning to IEEE members in 1884 though it would not have brought to mind large industrial organizations of professionals such as Drs. David and Gomory and I have responsibility for in our respective corporations. Those did not begin to appear until the very beginning part of the 20th century. Instead research would have had primarily an academic association. I am less sure what meanings

• in a technological context the word development might have had in those days.

My plan for this talk is, following these reflections I've just sketched, to give you my definitions of research and of development so that you will better understand what I'm talking about. But my assigned topic also requires that I introduce and expand upon the management of R&D processes which is surely a 20th century concept.

Research is the active....this is in fact my definition of research. Research is the active, aggressive quest for knowledge or innovative concepts. And if you don't consider it superfluous, I would say for new knowledge.

In the context of the R&D process, people sometimes wish to make distinction between two kinds of research -- basic or fundamental research on the one hand, and applied research on the other. Only occasionally do I find this a useful distinction. It is much dependent on the motivations of the investigators and it is not an intrinsic property of the word nor of the resulting knowledge. Most of the results of so-

called basic research find ultimate utility. Does it then instantaneously transform into applied research?

In fact, this brings to mind an anecdote we heard yesterday about the marvels of NMR, nuclear magnetic resonance, imaging. Now I was a graduate student immediately after World War II at Harvard working with Ed Purcell who doing the pioneering work on nuclear magnetic resonance that would ultimately earn for him a Nobel award. In those days I remember writing a letter to my parents and pointing out that I was learning about the properties of the nucleus and how the nuclear magnet -- that's a kind of a gyroscopic entity inside an atom or a molecule -- was very sensitive to its immediate atomic and molecular environment.

Remember now, this is in the wake of World War II which brought to mind when you did physics and said something nuclear, it brought to mind either nuclear bombs or nuclear energy or maybe my parents might have thought about the practicality of radar and things of that kind. I said, "However, this is just basic knowledge. This will never have any application," which shows how wrong I could be. First of all, that's a warning if I'm

going to project for the second century I guess. But I clearly did not foresee even the applicability of the NMR specter to analytical chemistry.

We could readily understand from what we were learning about the way in which the immediate environment of the nuclear magnet influenced the resonant spectrum. We could understand that you could learn a great deal about the atomic and molecular environment. But I could not at that time conceive of the data processing capability that would permit the kind of real time analysis that goes on with the NMR tomography of the type you saw illustrated yesterday. So I thought I was doing basic research, but now you can see I discover I was doing applied research.

Now in some respects I find it more useful to distinguish between long-range and short-range research. Although most basic research is long-range in its outlook, the converse is not true.

Development, as a process step following research, is an organized effort to apply the new knowledge gained from research to devising a commercially or socially useful product or service. It, therefore,

• contains a substantial component of engineering. A senior level technical manager in my corporation has made the distinction that in our business context, research aims at expanding the corporation's technical alternatives whereas development seeks to narrow down or focus on a particular alternative in efforts to produce a cost effective and reliable implementation.

Some other comments about distinctions between research and development. Research is more of the province of scientists and development is more of the province of engineers, but each activity has a substantial requirement for the experience and skills of both scientists and engineers.

Another point is that in some elemental sense, development is more expensive than research. The design and construction of implementations requires for hardware the cutting, bending, or molding of metal or other structural materials; and for software, the careful production of reliable, debugged systems and programs, all of which consumes many person hours of work by skilled professionals. And those person hours cost lots of money.

The number of research person hours required to generate and demonstrate at the bench a technology that forms the basis of a new product concept is typically very much smaller than to develop a durable, reliable, and manufacturable implementation of the concept. But it would be wrong to conclude from this last statement that research budgets need be only a tiny fraction of development budgets.

It takes a number of research investments, some of them quite long-term, before we pursue one that succeeds in exhibiting the potential for a new technology which in turn enables a new product or service concept. And once a new technology is launched in the marketplace, a substantial ongoing research effort is mandatory I believe to keep the knowledge base....to build the knowledge base for both sustaining and extending that technology in the field. So as each research success is launched in the marketplace by a successful development effort, an added obligation falls to the research organization to build into its base program a sustaining and extending effort on behalf of the newly succeeding technology. There's no such thing as a technology that

. you suddenly research, understand, and throw into the marketplace and then just forget about it. You can try that, but I think with business risks.

Now my problem is with the notion of managing research. I characterized research as the active quest for new knowledge and concepts. This means looking to the group of researchers for innovation and creativity. How does one manage the creativity of others? In my experience the attempt is quite often ineffective and often counterproductive. I believe that the role of management is to create and maintain an environment supportive of and encouraging to creativity and innovation. In fact, my brief prescription for managing industrial research would be something close to that which is on the first transparency.

The first principle I would lay down is to recruit the best and most creative researchers you can find.

Second, I'd say give them the most supportive environment you can visualize providing. This includes ample amounts of the most advanced instrumentation.

. Holding tight on capital spending is a foolish attempt

. at economy. In fact, it's a false economy when you consider the cost of principle A. If you're going to hire first-rate people and pay their salaries, it's utter folly not to provide them with the very best technical tools.

And third, work the business needs of the corporation (or whatever the entity is) into the program through selective budgetary preferences.

There's little success likely to come from showing researchers to a laboratory, describing in detail a desired technology or process that does not now exist, and then commanding "thou shalt invent." Instead the enterprise seems to go better if some overall goals or needs are generally described and understood and proposals for research projects or areas of investigation are solicited from the creative professionals. Managing the research then consists of adjusting the respective budgets for the projects or programs so as to give selective and therefore sometimes differential encouragement. There are many subjective criteria for this selective support including, of course, the goal or objective of the project in relation to the

. potential needs and especially including the creativity, innovativeness, and productivity of the key researcher or researchers on the team.

This recommendation for the selection process and differential budgetary tuning by the research manager or director of the research organization may seem to some degree to fly in the face of time honored advice of Dr. C. E. K. Meese who was Vice President of Research for Eastman Kodak for quite a period of time. He offered the following lessons that are on the second transparency. Although I think you could read it for yourself, I'll read what his advice was. He said this just about half way through the first century of the IEEE.

"The best person to decide what research work shall be done is the man who's doing the research (I think we should probably say man or woman or person doing the research). And the next best person is the head of the department who knows all about the (Indistinguishable) work. After that, you leave the field of the best people and start on increasingly worse groups, the first of these being the research director who's . probably wrong more than half of the time, and then a

. committee which is wrong most of the time, and finally a committee of vice presidents of the company which is wrong all of the time."

(Laughter)

Now in spite of my subscription to these principles set forth by Dr. Meese many years ago, I don't wander away and ignore my research groups and their scientists, nor did Dr. Meese. There is a very important role in guiding, challenging, and continually reassessing the selection process at all levels. And it is surely the responsibility of research management to pose problems that are more likely the problem domains that are of business importance to the corporation.

When it comes to selecting projects, the research management is I believe best advised to tune the research program, as I said before, by using the budgetary power to adjust emphases. In some cases that may mean shutting something off completely or occasionally giving birth to a whole new project or activity. But these steps should be taken with continual consultation and discussion up and down the entire hierarchy of research management, which in my corporation is only

. three levels deep in each of the three research centers.

To my mind, this all important process of selecting the research to work and allocating resources to it that is the essence of what we call research management. It draws upon the combination of technical knowledge, business strategies, research experience, understanding the psychological makeup of research scientists, and above all it draws on what I'll call technical taste. The research manager at any level brings all of this to bear in a necessarily subjective way.

Now I've expressed my worry over how to have a vision on R&D management that can retain validity for a good portion of the century. However, in spite of my trepidation, I am willing to make one prediction that parallels a significant event of the first century.

The institute changed its name, and I believe it will do so again in the second century. After being born as the American Institute of Electrical Engineers, the AIEE, as we all know, became the IEEE, the Institute of Electrical and Electronics Engineers. My prediction is that it will become something equivalent . to the IEEEOE, the Institute of Electrical, Electronics,

. and Electro-Optical Engineers. This also tells us something about the nature of the new R&D domains that will be important for the present IEEE.

At the beginning long before AIEE took steps to put the word electronics -- I'm sure that somehow it really should have been adjective electronic -- in its name, people would possibly have had little reason to believe that research on electron processes in vacuum or more recently electron energy bands in purity states and semiconductors would be relevant to electrical engineering. We have now arrived at a point where research on electro-optic materials and optical data transmission is extremely germane to electrical engineering. As we see more and applications of electro-optical phenomena, the name IEEEOE will become especially appropriate.

I have one more thought that I might throw in. We've also seen in the discussions of the last two days that some of the soft sciences, psychology and sociology, are increasingly important to electrical engineering. I'm not going so far as to suggest that some of those names will be thrown into the title of the IEEE, but it's

. worth considering that over the next century those disciplines will have an awful of bearing on the IEEE and its descendant organization will progress. I suppose even if one went back to 1884, the notion that physics would have much to do with electrical engineering as much as it had to do might have been regarded with skepticism with some of the hard-bitten electrical engineers of 1884. They probably thought of physics as a soft science in those days.

So I believe that clearly we have a very exciting century ahead of the IEEE and whatever else it becomes. I suggested IEEEOE.

It's been a pleasure and a privilege to talk to you this afternoon about this topic.

(Applause)

DR. GEORGE H. HEILMEIER: All of the other speakers both yesterday and today began their remarks by saying how honored they were to be here. And I'd like to also say that I am particularly honored to be here as well. But for me, there's another dimension of being here because this is a rather sentimental occasion for me.

I grew up in Philadelphia and did my undergraduate work at the University of Pennsylvania Moore School of Electrical Engineering. And it's been over 30 years since I've been in the Franklin Institute, Dick. I remember very well my dad bringing me here. In those days my favorite exhibit was the train room. I had the opportunity today to browse through the train room once again. And I can still say, Dick, that's still my favorite exhibit.

(Laughter)

This is a sentimental occasion for me for another reason as well because I was able to meet last night a number of my old professors at the Moore School, Dr. Shen, Dr. Salati, Dr. Fegley, and Dr. Weygandt. To you gentlemen I would say that you were my heroes then and you still are.

I'm going to talk about my view of R&D management circa 2000 and beyond. And in particular, I'd like to focus on two questions, namely what things will change in the next century and what things are going to remain the same. So let me begin by addressing the question, what things are likely to change.

I think one of the first things that's going to change in the next century is the coupling to marketing is going to become even tighter. And by marketing, I don't mean sales. Marketing is a separate discipline from sales. What I mean by marketing is the discovery and understanding of the problem to be solved and the implications of solving that problem.

The second thing that I believe is going to change in the next century is that the compensation incentives will be quite different than they are today. They'll be much more entrepreneurial in nature. And straight salary will still be used but it will be augmented by compensation and incentive schemes which are much more characteristic of the venture capital world today than they are of more conventional industrial employment.

The third thing that's likely to change in my view is the capitalization per professional, and that's going to be higher. Computation aplenty of course means more capability for more people, and it means lower cost per unit. But that won't necessarily keep pace with the demand for ever increasing capability and a more perva-

. sive fan-out of that capability.

The fourth thing that's likely to change in my view is the work place because I think we're going to see much more extensive use of what I'll call the extended work place. This means more work at home in addition to more work in the office. It means prime time work at home. And that is all made possible by the pervasiveness of networking capability.

The fifth thing that's likely to change in my view is industry/university relationships. I think they're going to be much closer. Some may say that this is a shotgun marriage, but I believe it's inevitable for both economic and professional reasons. But as the poet Yubron once said about marriage, and I think it applies here as well, "The pillars of the temple should be close but not too close."

Finally, I think we're going to see a much more extensive use of internal education. The reason for this is that the pace of technological change makes this inevitable. In our profession, as in many other professions, one must either learn and grow or die.

. The technology can bring us the best lecturers into our

. facilities on our terms at times of our choosing. And this is sort of paraphrasing what Raj Reddy said earlier this afternoon, I see the formation of the microuniversity or the virtual university in our plants and facilities.

Now I'd like to turn to the things that I think will remain the same.

I believe that blocking and tackling in our business means people, ideas, and the management of change. To me that's what R&D management is all about. And no matter how much we push and shove and tug, that's not going to change.

Secondly, I believe that personal and professional pride is going to remain unchanged. You know, no matter what we as managers do, we're really only in the final analysis coaches, chaplains, and patrons of our professional people who for reasons of personal and professional pride drive themselves far harder than we could ever dream of driving them.

Third, we've all heard the question, what have you done for us lately? That's not going to change.

. I guess what I'd like to do is to paraphrase the words

. of Geraldine Ferraro, the Democratic vice presidential nominee, who said in the context of another discussion, "Those of you who have CEOs who are concerned about next year's earnings, you know what it's like."

In the fourth instance, I believe that R&D productivity measures will still be elusive. We'll keep trying to measure R&D productivity in quantitative terms, but I don't think we'll be very successful in doing much about it. It's still, after all, a business that puts a premium on insight and vision and those are not very quantifiable quantities.

Fifth, I think that there's another aspect of all this that's not going to change, and that's how you communicate to your people. And in my view, policy statements, speeches, and things of that nature may be the popular mode of communicating to your people but in the final analysis the action that speaks the loudest about what you really stand for is the kind of people that you promote, and that's not going to change.

Finally, the characteristics of innovative organizations aren't going to change very much.

If I may have the next and final slide, Rog.

We tend to look at innovation and too often we focus on innovation as a synonym for invention. Innovation really has another dimension, and that's execution. You can't have an innovation without execution, and that's not going to change.

And the characteristics of organizations that are innovative organizations aren't going to change. Let me just run through these very, very quickly in closing.

Innovative organizations spend less time debating the obvious than the other kind of organization. They have close contact with the customer at all levels. They have very low NIH, or not invented here. They have a minimum of formal communication mechanisms and a maximum of ad hoc communication schemes. They have a strong personal incentive system, and they're not afraid of failure. They try more things and they risk failure or embarrassment without an animosity or without score keeping. Finally, they have leaders that know the business. Unfortunately, there are a number of people who think that because one has an M.B.A. degree that he or she can run any business. I don't subscribe to that

. theory at all.

I looked for an appropriate quote with which to end my brief look at the next century, and I find that I'm not sure just what side of this quote I'd like to be on. But I think Lord Melbourne said it best when he observed, "What all the wise men promised has not happened, and what all the damned fools said would happen has come to pass."

Thank you very much.

(Applause)

MR. NALLE: Thank you very much, Drs. Pake and Heilmeier. They were very interesting comments. I was particularly interested in your comment about the professional managers. That same comment was made at lunch to me by another IEEE member that this theory that professional managers can manage anything has been overworked.

We're a little bit ahead of schedule which I'm pleased to report will give us time to have a good question and answer period. As you can see, we got set up for all six of the people to be here. I would like • Dr. Kobayashi to come up please and Dr. Reddy, Dr.

. Linvill, Dr. Slaughter, and Dr. Pake. Dr. Pake is here and Dr. Heilmeyer. If you've got your name tag, your name cards....good, we have them there. We can put them out.

With regard to the questions, again would the questioner identify who he is and identify to whom he is directing his question. Could I have the first question please.

MR. BEDE LIU: I understand in Japan, a lot of the....

MR. NALLE: Could you identify who you are, sir.

MR. LIU: Bede Liu, Princeton University. The question is directed to Dr. Kobayashi. I understand in Japan a lot of the continuing education is done by the industry itself. Could you comment on this.

MR. NALLE: I must say I didn't hear the question clearly myself. Did you hear it clearly? Okay.

DR. KOJI KOBAYASHI: Many companies, almost all the companies in Japan are putting pretty much importance on the education in the company, after they enter the company. So we have a many fold educational system

. -- education for engineers, education for middle management, education for the (Indistinguishable). So many layers.

So the most important matter is that in promoting from this level to this level, they need to receive the examination. They need to go to such educational course. They study about this educational course. When the time is coming that he is to be promoted, he needs to receive the examination. Every year we have such examination. So most of the employees pass this examination but a few are dropped out and he is forced to study one year more, like that. So we have a complete educational system in the company, not only like that but we have an educational system for the employees for....we have many customers overseas. So we are having an educational system. Who is picked to work in the business overseas, they are to receive this course.

MR. NALLE: Thank you, Dr. Kobayashi.

DR. KOBAYASHI: And also we have an educational training system for the customers. Usually we are receiving 1,000 people from outside. We have a hotel for them. The poorer countries cannot afford to stay in a big hotel

. so we have a hotel. If you would like to study it, I'll prepare some documents and send them to you.

MR. NALLE: Thank you very much, Dr. Kobayashi.
Yes, sir.

MR. EDWARD E. DAVID, JR.: I'm Ed David from Exxon Research. I think Dr. Kobayashi's provocative theme of virtual factories can be coupled with a number of other virtuals such as virtual cities, virtual communities of interest of all kinds. And it brings us back to John Pierce's comment some years ago that people would travel for pleasure and communicate to work, which seems to be coming to pass.

What I'm concerned about and interested in is whether some of you would speculate on how fast that's going to come and the effect that it will have on energy consumption.

MR. NALLE: Who wants to volunteer?

DR. KOBAYASHI: I can't say when. But 20 years ago I started to completely reorganize the whole company to meet the future of the company. Our organization is a pyramid. I completely changed this organization to a flat horizontal organization.

Furthermore, we need to think of the working in the foreign countries so that this (Indistinguishable) organization means that we have almost 60....it's divided into 60 companies besides the parent company. We have 60 companies. We have 20 factories outside of Japan and 30 companies inside Japan and 10 independent subsidiaries. Independent subsidiary means that they are provided with everything. They're just a complete company, independent company, but we have the (Indistinguishable).

Then I asked them, you should compete with the parent company. Beat the parent company. We will fight together. But such companies, I have 10.

The remaining 50 companies are the subsidiary company. But that subsidiary company is subsidiary but they are independent. So they have the chairman, president, executive past president. Therefore, I have more than 100 presidents. They wish to become the president.

MR. NALLE: Great.

(Laughter)

MR. KOBAYASHI: It's natural. So I made the organization very (Indistinguishable). On the other hand, this has become education training. So if he is

. very capable, then we pick them up to come back to the parent company to become the director of our company, the parent company. So the organization is very (Indistinguishable)

MR. NALLE: Thank you, doctor.

DR. KOBAYAH: So this is one way.

MR. NALLE: Thank you. I think, Dr. Reddy, you had a thought.

MR. D. RAJ REDDY: I think you can divide who will communicate and who will travel to work into two groups. What you might call knowledge workers will communicate. That includes all the people producing knowledge products. And all the government servants and all of us who use our head for the job will probably communicate. But people like hospital workers or builders or people in service industries, like if you travel for pleasure, somebody has to be there to serve you. A bunch of people of that character will probably have to travel to work.

So it's going to be interesting to see what the shift will be, namely when the knowledge workers will increase, will be the majority, and the service

. workers, if you will, will become a minority.

DR. KOBAYASHI: Well, Raj, we just have one plant now for testing, just for testing, just inside Tokyo city, one. I think that when we use such a system could take some time, but I have one now, under study now.

MR. NALLE: Does anybody else from the panel want to take a crack? Yes, Dr. Pake.

DR. PAKE: Ed, I do much traveling across the country to my corporate headquarters usually to try to get money for R&D. And I would love to be able to substitute something for my high standing in the airline mileage clubs. But I think that in certain circumstances, you feel that to conduct some kinds of negotiations or business interactions, you almost have to see the whites of their eyes and they want to see the whites of your eyes.

However, I agree with what Raj says about knowledge workers. We had one very important and very well defined technical problem in my corporation which was worked upon by a team, several of whom are on the east coast and several of whom are up and down the west

. coast. It was, as I say, a well defined technical problem. They solved that problem without ever convening as a team, except that when the problem was solved, we were so happy about it we brought them all together for a dinner. That's the first time they ever...

(Laughter)

And so there are many, many types of knowledge tasks that can be clearly handled. These people were all using work stations on local nets which were connected to one another through gateways and high data area phone lines.

MR. NALLE: Dr. Dees.

DR. BOWEN C. DEES: I'd like to address this question to Dr. Linvill and perhaps other members of the panel. What role if any does the federal government have in your view in the question of science and engineering education, pre-engineering education as well?

DR. JOHN G. LINVILL: Well, it's a very strong role. I would not at all project that the support, particularly of graduate education and research by the federal government would disappear. The overall task is going to increase in significance and I believe a larger

. fraction of it will come from the private sector.

The federal government....oh, and one other point with respect to that. One other projection I would make is that there should be two couples. The university should be coupled to government and the university should be coupled to industry. Three body problems are unnecessarily complicated, though good relationships between one couple facilitates the relationship in the other one as well.

So I think that the role of the government is really very, very significant, not only the federal government but occasionally state governments make particularly important initiatives. The most recent example of that that I can mention to you is the setup, of course, of the North Carolina Microelectronics Center which was an activity promoted really by the government of the state in thorough league with his assembly. So it was very nicely done from that perspective.

MR. NALLE: Thank you. Dr. Herman. Oh, excuse me.

DR. KOBAYASHI: (Indistinguishable) but in the recent two or three years, we built many software com-

.panies in the local city -- 100, 200 people. So it's easy to come to the company because it is built in the local city. So this software company is connected to the headquarters....the parent company by the online so they can use the computer easily. So they're working locally.

MR. NALLE: I see.

MR. KOBAYASHI: (Indistinguishable) but it's a company.

MR. NALLE: Thank you. Dr. Herman.

DR. TED HERMAN: My question is to Dr. Pake, well two questions actually. You mentioned electro-optics. Does that include acousto- and magneto-optics? And my second question is what market will pull that technology?

DR. PAKE: I didn't get that last question.

DR. HERMAN: What market will pull EO?

DR. PAKE: Well, I suppose one could include acoustic and other technologies. I had in mind specifically electro-optics simply because I see so many potential applications in devices as well as, of course, transmission as was discussed in some detail by Dr.

. Lucky. I think the communications market will pull it. He pointed out the need for a better switching, and I think that will clearly be electro-optical devices. And I believe that the communication demands will pull that market.

MR. NALLE: Yes, sir, in the middle there.

DR. KENNETH A FEGLEY: Ken Fegley, University of Pennsylvania. A question for Dr. Linvill. You point to the master's degree as a most important degree for technical change. Where do you place a Ph.D. in this scheme of things?

DR. LINVILL: I think the Ph.D. being connected with research operations primarily is utterly vital to the development of our scientific base. No doubt of that at all. It's also vital for the production of educators. It's vital for the research enterprise on all levels.

Except for the fact that the numbers involved there are so much smaller by about an order of magnitude, not quite that but approximately that, in the United States, so I wouldn't say that this select 10 percent which invests more and in who more is invested is not to be looked aside from. It is very important. But the

.major mass is really in the master's level.

MR. NALLE: I have a question I want to ask Dr. Heilmeyer. I think you said on one of your slides that one of the ingredients for successful R&D management was a strong personal incentive system. Is that literally what it means? Is it a monetary compensation system? And if so, how do you set the goals that you reward on?

DR. HEILMEIER: I'm not sure that the best researchers that I've known have really had monetary compensation as the prime motivational factor. I think personal and professional motivation plays much more of a role than any compensation scheme that involves dollar signs.

MR. NALLE: Thank you. Yes, sir.

AUDIENCE: (Indistinguishable)

DR. HEILMEIER: I have some goals to fill. I'm not sure that I would put them in the form of...

AUDIENCE: Repeat the question.

MR. NALLE: As I gathered, he asked Dr. Heilmeyer -- I think I have this correctly -- what changes did he foresee in R&D. And the second question was....

AUDIENCE: In industry.

MR. NALLE: In industry.

AUDIENCE: And government/industry combinations.

MR. NALLE: The second one was government and industry? Industry/industry, and the second one was government/industry.

DR. HEILMEIER: Phil, I hope to see much more cooperation among the industrial partners in basic research. But I personally am against the socialization of development. I don't think that's a constructive trend.

With regard to government/industry relationships, I think the government has a strong role to play in the support of basic research. I'm a little concerned about the call by many to put the government into the business of prioritizing basic research. So I would hope that we would continue to see strong governmental support for basic research. I would hope that see little change on the part of the government to dictate or prioritize basic research.

MR. NALLE: I have an announcement that Mr. Goldberg's cab is here. Is there a Mr. Goldberg who has

. a cab coming? Fine.

The next question please. Yes, sir.

MR. OSCAR GARCIA. I'm Oscar Garcia, University of South Florida. We have a tendency of paying attention to the urgent rather than to the important. The title of this session was priorities for the next century. I'd like to go quickly and very briefly and ask each one of the panelists what do they think is the most important item from the point of view of the IEEE and the profession we should tackle in the second century. One item.

MR. NALLE: The question, in case you didn't hear it, was urgency versus importance. And he's asked to go across the panel and ask each member what he thinks the most important item is -- the one most important item is for the profession.

Are you ready to start, George?

MR. HEILMEIER: Only one, Oscar. I guess I would place the highest priority in increasing the quality of our source material, namely our students. If we get good people, as George Pake says, if we get good people and continue the supply of good people, I

. think our profession and our society will have performed perhaps its greatest service.

MR. NALLE: Dr. Linvill.

DR. LINVILL: I would say that a creative, really, use of not only finding the people but then harnessing them is a key thing. I believe the quality of excellence is something that's much on our agenda these days, and that's well placed. It's in excellent people, excellent performance.

MR. NALLE: Dr. Reddy.

DR. REDDY: One word -- training. If we can develop technologies in the IEEE for a sharing of knowledge, know-how, and literacy, all of which spell training as far as I'm concerned, we will have done a great job.

MR. NALLE: Did Dr. Kobayashi understand the question?

DR. KOBAYASHI: (Speaking Japanese)

MR. KIYOSHI EMI: I have been working for the company for the past 55 years, and I think that the excellent people are also important. But we should provide the environment so that those excellent people can

. perform to their maximum extent. I'd like to create such circumstances for those excellent people. (Translation of Dr. Kobayashi's statement)

MR. NALLE: Thank you. Dr. Pake.

DR. PAKE: I think I would second what George Heilmeier said. I think I would put a specific emphasis on it. I believe that it's very important to motivate our young people in the primary and secondary part of the educational system toward first rate careers in science and technology as well as to provide at that level a fairly broad general education in science and technology for those students. I think the quality of material that is provided to the universities is something I believe needs most urgently to be improved, and I believe that IEEE could do some things about that.

MR. NALLE: I think that's probably a very good question to end on. I want to thank this panel for their wonderful presentations. I want to apologize to everybody for having to ramrod the thing through like I did, but we got off to a bad start on the time.

I also want to express to IEEE the tremendous . honor that the Franklin Institute has with your having

. selected us to host this hundredth anniversary. It really was a great thing for us.

Now we wind up this very stimulating session with Charles Eldon who's the President Elect of the IEEE, taking Dick Gowen's place who's a little bit under the weather, for the closing remarks.

MR. CHARLES A. ELTON: Ladies and gentlemen, I'm in the awkward position of feeling I just got my marching orders for next year -- what the IEEE should do, what the priorities are. On such short notice, I'm not going to try to answer them. I came here with the good news for you that I have no prepared remarks. The hour is late. The day is long.

I did want to say again, as Dick Gowen said at noon, on behalf of the IEEE generally and ourselves specifically, how grateful we are, how rewarded we are for the opportunity we had to work with Franklin Institute and for the contributions of our speakers this afternoon, this morning, and yesterday, and so on. I want to thank you also as attendees of this conference.

Instead of saying that we should adjourn, . suppose we just agree that we will go away on the basis

. that we are going to be getting together continuously.
And I hope that all of you can be here a next hundred
years.

Thank you.

(Applause)

MR. NALLE: Thank you very much.