HERMAN SCHWAN

An Interview Conducted by

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Interview: Herman Schwan
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Nebeker: It is the IEEE and the predecessor society's activity that we want to cover mainly today. I know you were a member and a fellow of the IRE before the merger. What do you recall of the early days of interest of the IRE members? It was called Medical Electronics?

Schwan: It was called Medical Electronics. I got in touch with it shortly after transferring to the University of Pennsylvania in 1950. One of the faculty members in the engineering school, Reid Warren, was active in the very early committees. Reid Warren was perhaps influential in getting me elected in the original committees which were active in the field there. As a matter of fact, we had two engineering societies: the American Institute of Electrical Engineering and the Institute of Radio Engineering.

Nebeker: You were a member also of AIEE?

Schwan: I became a member of both groups, yes. At that time, I became aware of the Joint Executive Committee in Medicine and Biology (JECMB), which was a small group of about six people, two appointed of each of three societies: two from the medical electronics group committee of the IRE, two from the AIEE committee on electrical techniques in medicine and biology, and two from the Instrument Society of America. The Joint Executive Committee was primarily responsible for organizing the so-called annual meetings. I want to show you some of the early programs.

Nebeker: From the beginning, was this annual conference something that the three groups collaborated on?

Schwan: Yes. I cannot recall the very first meetings, which took place before I became aware of them. By 1952 I was also a faculty member of the Engineering School, so I had double appointments in the Medical School and Engineering School. In 1952, here is the program of the fourth conference on electronic instrumentation and nucleonic medicine, reflecting how the field was conceived at that time. There was a strong interest in the atom bomb and all related topics, nucleonics and medicine and electronic instrumentation. There were not many papers at the time; here you see five, six, and ten papers. At that meeting there were a total of just eighteen papers.

Nebeker: I see Vladimir Zworykin was one of them.

Schwan: Yes, precisely.

Nebeker: I see you also presented.

Schwan: Yes. Here is Vladimir cited. I remember most of the people, as a matter of fact, quite well.

Nebeker: What did nucleonics in medicine at that time denote?

Schwan: Primarily instrumentation—how to measure ionizing radiation.

Nebeker: Not using radioactive tracers in medicine?

Schwan: Yes.

Nebeker: Also for that?

Schwan: Yes.

Nebeker: Using radiation as cancer therapy, or just the danger of…?

Schwan: There was nothing of the medical aspect as far as treatment is concerned, but there was a good deal about instrumentation. Typically they were engineers from Westinghouse and General Electric. Representatives of industry developing sophisticated x-ray equipment at the time. I am talking about relevant advances from the technical point of view. The emphasis was clearly on instrumentation, not on electronic in general but primarily in the field of nucleonics. The first meeting was just supported by AIEE, the American Institute of Electrical Engineering. Here you see for the first time an electromagnetic and ultrasonic diathermy lecture. I was responsible for that and the emerging interest in nonionizing radiation effects and relevant instrumentation.

Nebeker: What was the difference in the emphasis between the IRE electronics and medicine or medical electronics special interest group and the AIEE group? Do you recall a different emphasis in those two?

Schwan: The very first early meetings were organized just by the AIEE, as you can see.

Nebeker: The sixth one is the three of them.

Schwan: There you see the three of them. There you see probably all three under the same title. Still only seventeen lectures—still very small meetings.

Nebeker: Do you know why it is that EMBS regards 1952 as their founding date? Because they might trace it back to the AIEE group.

Schwan: It always baffled me. I never understood it fully.

Nebeker: The IRE group may have been founded in 1952.

Schwan: The IRE was involved before 1952, but it was not involved in the 1952 meeting yet.

Nebeker: But it probably formed in 1952, and then was involved in the 1953 meeting.

Schwan: I think the AIEE group formed in 1948, if I remember correctly. The IRE group formed later. But it did not have meetings initially. Annual conferences started as early as 1948, i.e. AIEE was involved that early.

Nebeker: What it might be is that the present society structure in IEEE evolved out of the technical committees of the IRE, and the numbers of the societies in IEEE carried over from the IRE numbers. So it may be that although there was an IRE interest in the field, they did not formally organize until 1952. Then because the society of the IRE went into the IEEE society, maybe it is the 1952 date that you are regarding.

Schwan: I think you will find the answer to that in the publication by Montgomery from Vanderbilt University. He was involved right from the very early beginning of the IRE group. To my recollection, he was the founder of it. I was not immediately involved. Early members were Zworykin and a biophysicist Britton Chance from the University of Pennsylvania.

Nebeker: He was one of the early members?

Schwan: Yes, but only for a short period of time; for only two or three years and then he dropped out since he went more towards biophysics and seemed to have lost interest in this. I think Otto Schmitt was also very early involved. I became a member of that group shortly thereafter, I think about 1954 or 1955. From hereon I tried to find out more about the organization of the Joint Executive Committee and to improve it. Trout from the AIEE was chairman, and Gardner was secretary of the AIEE for many years. Cummings was secretary for the IRE

and then IEEE for a long time. There is some award named after Cummings. He represented the IRE. Julia Herrick, one of the early pioneers of the field from the Mayo Clinic, also represented the IRE. Here you see in my records of early meetings the name Montgomery, who was involved from the start. He published an article about the early history of biomedical engineering, and I think it was published in the IEEE-EMBS magazine. In one of my publications I referred to Montgomery, and Montgomery had missed some important information and I was able to add it. I also have a record of the total membership of the various committees.

Nebeker: Was that also published in the EMBS magazines?

Schwan: Yes, the IRE administrative committee membership (but not including the AIEE and JECMB committees), it was one of the history articles published by me. The meetings continued to be very small. There were no other meetings in the field of what you might call biomedical engineering.

Nebeker: Right. The biophysical society was separate.

Schwan: That came later. The Biophysical Society first came in 1957—significantly later. In the beginning from 1948 until 1957, the AIEE and then IRE committees were all there was in the emerging biomedical engineering field. I feel my records on this should be put in some archive.

Nebeker: I'm sure. It is funny to think today that there are dozens of societies in this area and thousands of researchers.

Schwan: It is amazing.

Nebeker: Did the AIEE group and the IRE group have meetings in the course of the year?

Schwan: No, that was it. Just the annual conference. The committees met two or three times per year to discuss administrative affairs and things like that, and how to get money from their respective parent societies. Individual committees of the two engineering societies and the Joint Executive Committee cooperated well. Representatives from individual societies were appointed to this Joint Executive Committee. The Joint Executive Committee's function was to organize the conferences by appointing a conference chairman and a local chairman and handle the financial affairs and things like that. There was a quantum jump. At the ninth conference there was the usual small number of papers. Attendance was declining. That meeting had only five papers each day, fifteen papers in all. Then came a meeting that Otto Schmitt organized. He was not a member of the Joint Executive Committee. I had suggested to the Joint Executive Committee that we must broaden our perspective, and had suggested that Schmitt be asked to organize the next meeting. Otto organized an annual conference dedicated to computers in medicine and biology. It was attended by about 400 people and was a huge success. That is what I mean by quantum jumping—there was a sudden big jump upwards in number of papers and attendance.

Nebeker: It is still called conference on electrical techniques.

Schwan: Yes, but the heading changed slowly but steadily. We called it a little bit more broadly now Electrical Techniques for several years, we stayed away from the nucleonics image which had been used before without success. The annual meeting still used "electrical techniques" and was still sponsored by three societies, but this was now a big meeting. I organized the next meeting in

Philadelphia, and that was an even larger meeting as you may see from this conference attendance record here. It was the twelfth annual conference on electrical techniques in medicine and biology.

Nebeker: That is very large.

Schwan: Now it gets substantial.

Nebeker: Was part of that jump due to including computers in medicine?

Schwan: No, it was not computers alone. The topics at our Philadelphia meeting had nothing to do with computers, but it had to do with radiation, but not with ionizing radiation. There was a cardiovascular session, an ultraviolet one; a more general one on microwave radiation biological and health effects, one on ultrasonic radiation; and one on infrared radiation. There were several general sessions, a cardiovascular, and various types of non-ionizing radiation. You see in the program that we got now a large number of papers. The attendance at that meeting was even larger than in Minneapolis. Otto Schmitt had attracted around 400 people. The previous conference got something like 50 people. In Philadelphia it was again significantly more; we had around 550 people attending.

Nebeker: How do you account for this sudden growth in 1958 and 1959?

Schwan: Superior publicity and more broadly conceived topical orientation.

Nebeker: So more people were out there working, but they had not learned about this conference.

Schwan: Yes. I can only guess. I think it was partly because of better publicity, and partly a broader concept of biomedical engineering than in existence originally.

Nebeker: I am a little puzzled by all of these papers in these different areas of radiation. Are they looking at biological effects of these different ranges of radiation?

Schwan: Yes. The microwave radiation effects because of growing interest and concern about the biological effects of microwave radiation. It led to research work on whole body effects of microwaves. That was the beginning. At that time already there was a controversy—do microwaves affect people or not—which has been going on ever since.

Nebeker: One might imagine that that concern led to research grants and more people working in that area, and that fed these conferences.

Schwan: In part, no doubt.

Nebeker: Do all these other, the infrared radiation…?

Schwan: Yes. There was a presentation of Julia Herrick, whom I had mentioned before and who came from the Mayo Clinic. One motivation for the microwave interest at the Mayo Clinic was caused by the so-called microwave diathermy. Originators of this modality for therapeutic deep tissue heating used an old and rugged magnetron from the second world war. It had been developed by the Raytheon Company, and could be used to advantage as a diathermy machine. The Mayo Clinic pioneered this use. That was clearly a potentially important medical application, let's face it. Here you see in our meeting program also the beginning of biomedical ultrasound that was also happening at that time.

Nebeker: You say that you were a member of both the AIEE and the IRE. Is it still the case that this annual meeting is by and large what there was of meetings for people in this field?

Schwan: Yes. We were still all alone.

Nebeker: No workshops?

Schwan: There had been a few special topics meetings. For example Mathew Conrad and myself had organized a local workshop meeting in Philadelphia. It was on amplifiers and electrodes for electro-physiological use during the early 1950's. And Bill Greatbatch had organized a meeting in Buffalo, concerned with impedance plethysmography. In 1957 the Biophysical Society had formed. It was more biologically oriented and no strong engineering input. About that time in the late 1950s, there were additional meetings, so-called sectional meetings, primarily due to the initiative of the IRE. About 1963, the IEEE sectional meetings appeared. The first sectional meetings took place in San Diego. I attended them. Then it took several more years and the mountain region started sectional meetings, and that part of the country joined. But that developed slowly. The annual meetings were still the major meetings, and continued growing in size.

Nebeker: Let's stay with these early years. Considering publications, when did IRE or AIEE start publishing in this area?

Schwan: The first regular publication was from the IRE, the Transactions. It was first Transactions for Medical Electronics, but then they changed the name. Particularly, it reflected Otto's and my constant hammering on what was important in the field, and that slowly but steadily changed the name of the Transactions. The earliest Transactions came out somewhere between 1952 and 1955. There was a special issue in 1955 on the biological and health effects of

microwaves. It presented papers which had been presented at a conference that the Mayo Clinic had organized on this topic.

Nebeker: Did you feel that was the best place to publish results in this?

Schwan: Yes. However if you look at my early publications, you will find that I published in quite a spectrum of other journals also.

Nebeker: There are certainly more general engineering journals and physics journals that the papers might be published in.

Schwan: My first publications in this country were in Circulation, which is a cardiovascular journal, and the American Journal of Physiology. The Journal of the American Medical Association published my "Limitations of Ultrasonic in Medicine" paper. I also published a number of papers in the Archives of Physical Medicine. I tried to appeal to the medical profession. So I published in medical journals initially lots of my stuff. I did this since I was at the time primarily affiliated with Penn's Medical School department of Physical Medicine.

Nebeker: I see this transaction article of the AIEE in 1953.

Schwan: Yes. I published a number of papers in the communication & electronics transaction of the AIEE. AIEE never had a journal in biomedical engineering, but they had one Communication & Electronics Transactions, where I published several papers. My first IRE Proceedings paper came out in 1953. Then I had one in the IRE Transaction in medical electronics, Volume III, PGME. In 1955 I had my first IRE Transactions paper published there and probably submitted it in 1954, one year after the first issue came out. That was an interesting paper on electrical properties of biological tissues and impedance plethysmography It was

motivated by a conference which took place and organized by the IRE in Buffalo, New York. It was a memorable meeting. One reason it was memorable is that Wilson Greatbatch organized it.

Nebeker: Was that your first contact with him?

Schwan: That was my first contact with Greatbatch. Then I had a major paper in Nature and another in a book published by the National Academy of Science. So there is a broad spectrum of journals which I used for publication purposes.. At the same time more engineering journals were getting involved with biomedical engineering.

Nebeker: But in 1953 there was a least one transaction devoted to this topic.

Schwan: Right.

Nebeker: Did you feel a difference between the AIEE group and the IRE group?

Schwan: Not substantially. In the beginning, perhaps yes. Before Otto and myself tried to change the concept of the field, there was an emphasis in the AIEE group on x-rays and ionizing radiation. Most of the representatives were chosen from industry producing X-ray equipment and related things. The IRE was more interested in radio electronics. The microwave diathermy typically was pushed strongly by Julia Herrick at the Mayo Clinic. So there was this difference in orientation. Otto and myself were broadening the horizon. I think that made the difference disappear. Eventually, some years thereafter, came the fusion of the two societies.

Nebeker: It sounds like most of you in the field welcomed that joining of the two?

Schwan: Yes. There were some problems. We had the two committees, and had the same

problems when two companies merge—who is the next CEO? The AIEE committee was headed by Saul Larks, who had pioneered fetal electrocardiograph in this country. He did not want to resign from the job. At that time I served on all the committees: on the Joint Executive Committee, IRE Committee, and the AIEE Committee. They insisted that I resolve the problem and tell Larks to get out and some blamed it on the IRE chairman. It was a most unpleasant job. I will not forget it.

Nebeker: I heard that with a couple of societies that they continued to have two structures for a couple of years before they finally brought about the merger. Do you recall?

Schwan: I do not know details about other societies and groups, but I am aware of the fact mentioned by you.

Nebeker: It was probably easier here because AIEE did not have its own publication specifically in this area. Your annual conference was already a joint conference.

Schwan: It was easier. They continued these annual conferences after the fusion of the two engineering societies. The ISA quietly dropped out, so it became just the IEEE conference.

Nebeker: Why did the Instrumentation Society leave the annual?

Schwan: I do not know. It happened very quietly. They never were very active in this field.

Nebeker: Today, of course, there is an Instrumentation and Measurement Society in IEEE. Are they active in the biomedical realm?

Schwan: To my knowledge; not very much.

Nebeker: Is there a medical instrumentation group outside of IEEE that was the main arena of activity for these people?

Schwan: Yes. There is a good deal of instrumentation going on. There is a more medically oriented American Society of Instrumentation and Medicine, or something like that.

Nebeker: So that is an area that was not emphasized by the IEEE group?

Schwan: It was not strongly emphasized. There always was some instrumentation, and particularly cardiovascular instrumentation. I regret it a little bit because I always felt that instrumentation was an important part of our field. I will talk a bit about this in the opening lecture which I will present at the forthcoming 1999 European Engineering in Medicine and Biology Conference in early November in Vienna.

Nebeker: What do you recall, beyond what you have already said, of the organizational efforts made in the 1950s, these two special interest groups and technical committees and the AIEE and the IRE? You said mainly it was to organize this annual conference and publication. Were there other activities of these groups that you recall?

Schwan: No. The Biophysical Society went its own way and became highly successful. It was not strongly engineering oriented at all. The bioengineering community split a bit. The ultrasonic group became primarily active outside the IRE and IEEE when the American Institute of Ultrasound in Medicine was formed. That was primarily due to the late W. J. Fry at the University of Illinois at Urbana.

Nebeker: I think they recently had their 40th a few years ago.

Schwan: Yes. That makes sense.

Nebeker: Maybe it was 1956 or something like that. I know that there has always been this problem, if you want to see it as a problem, within AIEE, IRE, and IEEE that there is a tendency to fission—for groups to split off and form their own societies. IEEE tries to accommodate that by the special societies and within the societies by these committees that cover certain areas. I'm sure it must be the case that sometimes an area, maybe this ultrasonics, grows so rapidly that the existing structure is inadequate.

Schwan: There was a reason for the development. In the ultrasonic case there was strong participation by medical people. By definition they could not be counted part of the IEEE because to be a member of IEEE you must have a certificate or a degree in engineering, which medical people of course do not have. That led to a severe crisis in 1968, which I have discussed in several of my publications. In 1968 I served two consecutive years as chairman of what was then called the Group of Engineering in Medicine and Biology. At that time I was striving to find ways to achieve recognition of medical doctors who had significantly contributed to this field as full members. That, of course, shook up the IEEE very badly since that would have meant a major change in its total policies. It was debated in many sessions over a period of two years of the IEEE, but it was to no avail. An associate membership was established, but the associate membership never came off very well since it was perceived by the medical profession as a second rate membership. Indeed it did not carry full privilege like a full membership. I remember it was very sad.

Another major influence at that time which had evolved starting in the early '60s was NIH—providing rapidly increasing amounts of money for research. That counts; you cannot neglect that. NIH became a powerful competitor for the IEEE, influencing the development of biomedical engineering. It was at that time that Sam Talbot took the initiative and obtained a grant from the National Institutes of Health to study the feasibility to set up training of biomedical engineering. No one had talked much about training biomedical engineers. He got the money, and he called representatives from active laboratories, including the Universities of Pennsylvania and Rochester. At Rochester was Edwin Carstensen, one of my early students, collaborator and friend; and the University of Pennsylvania was represented by J. Brainerd, then head of the Moore School of Electrical Engineering and myself. Carstensen is also now a member of the National Academy of Engineering. He is very outstanding in the ultrasound field—one of its pioneers. Edwin Carstensen organized one Biomedical engineering training program at Rochester. Another was considered at Columbia University but it trickled away. There was a strong group headed by Talbot at Johns Hopkins, which has to this day one of the most outstanding departments in this field.

Nebeker: So Talbot organized a committee from these representatives from these universities to talk about an organized program?

Schwan: Right. We met regularly over a period of one and a half or two years and hammered out the details, or should I say the philosophy, for a decent bioengineering training program.

Nebeker: In academia, very often some entrepreneurial professor will set up a program, say in public policy management, and just declare that this is a program. Why did Talbot feel that he wanted agreement with the other universities doing something similar? Did he want to better define the field that would then be recognized more broadly?

Schwan: Frankly, I do not know. I never discussed his motivation. But it came natural to him for several reasons. He knew us very well. We had close contact. As a matter of fact, I met him for the first time in 1950 at a meeting of the Physiological Society. Ever since that time we have been in close contact. That may be one of the reasons. I was impressed by the work that he did at Johns Hopkins. So it was natural to respond to his approaching us. I have forgotten, but I may have been responsible for suggesting Carstensen. I felt in support of the very able people who came from my lab and spread our kind of philosophy. That may be a partial explanation for it.

Nebeker: Also, I can imagine that when one is trying to establish a new field academically or in the engineering world, that it clearly helps to have other people sharing that vision.

Schwan: No doubt.

Nebeker: Were you calling it Biomedical Engineering at that time?

Schwan: We called it Biomedical Engineering, yes indeed. I felt strongly about that name, and it was also pushed by Otto Schmitt strongly. He did not want biomedical engineering limited to its electronics part, but he wanted it more broadly conceived. He was very interested in what he called the biophysical sciences,

plural, of which bioengineering and biophysics represented complimentary parts of a more practical and basic nature, sort of.

Nebeker: Did he wish to include also the same materials people?

Schwan: Yes, absolutely. Yes, he was very broad-minded in that regard. But he was not particularly interested in the training aspect. He did not have a strong program in training at Minnesota. I had developed a training program already at Pennsylvania. We offered a number of specialty courses in the field. My early students got their degree in Electrical Engineering, not yet in bioengineering. With NIH help I established in 1961 our graduate bioengineering program, separate and independent from electrical engineering. As a result of our recommendations, a NIH committee, a study section was established, making funds available. A key role was played by another pioneer, Jack Brown, Associate Director of the National Institute of General Medical Sciences, one of the five major institutes which compose the National Institutes of Health. He pushed bioengineering. He got special funds allocated for training purposes. The first NIH supported training programs were set up at Rochester, Pennsylvania and Johns Hopkins. I obtained significant NIH support for our training program for 25 years. It was a very substantial amount of money. This has helped us to attract so many excellent people in the field, of course.

Nebeker: Was there any involvement of the IRE group in this educational aspect, this training aspect?

Schwan: No. There was no cross-connection between IEEE and NIH. Only to the extent that I served at the same time as a member of several NIH committees and was a

member of the IEEE-PGEMB Administrative Committee and served five years as its Vice Chairman and Chairman.

Nebeker: Since education has long been a strong interest of IEEE, then one might imagine that they might have been involved in establishing it.

Schwan: Not much. At that time, Talbot was serving as secretary of the Biophysical Society since 1957. Upon my visiting with him he wrote a letter to the headquarters of the IEEE urging them strongly about their membership problem with medical doctors, unfortunately to no avail. As a consequence of that, Jack Brown from NIH prevailed with the establishment of the Biomedical Engineering Society which had no connection with IEEE. I must say, I was very depressed about this.

At that time I was also heavily involved with the National Institutes of Health. I will have to explain that. The National Institutes of Health had set up so-called program project committees. These program project committees were the ultimate committees as far as funding was concerned because of granting very large funds at that time, more than $100,000 a year, which was a lot of money in the early ‘60s. I became a charter member of the first program project committee, the one set up by the National Institute of General Medical Sciences. I was primarily responsible for interdisciplinary grant applications which dealt with bioengineering and biophysics and served five years. I was torn between what I conceived as feuding entities. It was a difficult job, of course. In addition, NIH set up a special study section aside from the program project committee dealing with smaller grants in biomedical ultrasound and biomedical

engineering, and I served for the first three years also as chairman of that group. So I was very heavily involved with NIH. I very reluctantly endorsed the formation of the Bioengineering Society, even though I did not like it. As a matter of fact, I am one of the four founders of the Bioengineering Society. A year later I resigned from the IEEE administrative committee, having served on it for 17 years continuously, and declined an invitation to run again for membership in the administrative committee. It was a heartbreaking affair for me really, that membership crisis which led to such a split for a long time of biomedical engineering.

Nebeker: Can you explain that a little more fully for me? Was this a result of the problem with people without an engineering degree?

Schwan: Yes, clearly in good part, but not solely so. It started when NIH became involved. Jack Brown was in good part motivated by his different concept of what biomedical engineering should be. Jack Brown was by background a physiologist; he had his degree in physiology. He was also a radio amateur. In his free time he had picked up lots of radio engineering know-how and had combined that with his physiological interests. He probably felt that bioengineering should be a more restricted field, a part of physiology, which Otto and I believed should not be the case. He perceived it also entirely different from the nucleonics and electronics people. He saw it as a tool for physiologists and an amplifier for the biologists, supplying them with instrumentation used for research as formulated by the biologist. However, biomedical engineering was not such a restricted thing. The first president that was elected for the

Biomedical Engineering Society was an able physiology professor from Seattle, Bob Rushmer. A group of excellent physiologists with bioengineering interests from the University of Southern California joined the Bioengineering Society. They influenced it for quite a number of years in that restrictive sense favored by Brown and Rushmer. This resulted in the Society's small annual meetings for many years, leaving the IEEE to continue to run the much larger and successful annual conferences.

Nebeker: Do you recall the year that the Bioengineering Society was formed?

Schwan: 1968 or 1969.

Nebeker: Right at the time that you were finished with your being president of the IEEE group?

Schwan: Yes. Then called chairman.

Nebeker: Chairman, okay. It was the professional group on engineering in medicine and biology?

Schwan: Right.

Nebeker: What more can you tell me about your two years as chairman of that group?

Schwan: I started as member of the AIEE and IRE groups in 1952, and I stopped in 1969. So I served seventeen years on those committees, which I think was enough.

Nebeker: Especially as two years as chairman. Besides what you have already said about this membership problem, which obviously was an important matter, are there other things that stand out in your mind about those two years as chairman? Were there other major concerns?

Schwan: There were many things that happened. I have to say that I benefited from

working together with Otto Schmitt, who became a friend of mine who has visited and stayed here often, with whom I discussed things over the phone and so on. We had similar philosophies about the field and its part in the interdisciplinary sciences and what it should be. We had perfected a technique, where, like ball playing during committee meetings, which worked very effectively.

Nebeker: What do you mean by that?

Schwan: Say that someone introduced a motion, and as he is under attack from the floor, the other one comes to his rescue. Then as he or she gets tired, the first one takes it up again.

Nebeker: You and Otto had your pre-meeting plan.

Schwan: Yes. We did that sort of thing. Like with the organization of the first successful conferences I told you about, the conferences organized in Minneapolis and Philadelphia. I think we were organized and more powerful as a combination. I think we did a lot of good for the development of the field. And we were recognized for this. I still believe that to this day that it was fruitful and quite effective.

Nebeker: In 1969, you decided that you had done the work that you wanted to do administratively?

Schwan: Yes and no. One of my recommendations had been that the professional group should become a society. That happened indeed a few years later. There were several emerging facts. I took my first sabbatical in 1968/69. I was gone for a year and disappeared from the scene and from the committee meetings, which

were always going on. The second reason was my appointment to the National Advisory Environmental Control Council. The councils are at the top of the study sections and program project committees. Each NIH institute has a so-called council. A council represents a field and contains a mixture of outstanding scientists and great public figures. For example, a famous woman who served on one of the councils was Mary Lasker. Personalities like that had usually a strong influence. I had been appointed to the National Advisory Environmental Control Council, which was deeply involved in radiation such as medical ultrasound, microwaves, ionizing radiation, everything of that sort. It had a broad interdisciplinary character.

I traveled a great deal making site visits for NIH, and I felt when I came back in 1969 that I had done enough for the IEEE professional group. I had also been appointed to several international activities. Zworykin and the International Federation had come about. I became involved in extended discussions how to modify the Federation constitution and served on the advisory board of it institute in Paris. And IEEE appointed me as its representative to serve four years on an National Academy of Sciences biophysics panel representing the USA in the IUPAB.

Nebeker: The IRE from the beginning aspired to be an international organization, but it was mainly people in North America. The AIEE was always a U.S. organization. Was there an effort with the IEEE in the ‘60s to become more international?

Schwan: Yes and no. The only effort that I know of was that the Biophysical Society

tried to become international by becoming a member of the international union of pure and applied sciences. It motivated the formation of the international union of pure and applied biophysics, IUPAB. National biophysical societies became members. The American representation consisted of four or five members appointed by the National Academy of Sciences. The IEEE had to delegate one of those five people. As a matter of fact, I was appointed to serve as the first one for four years on that committee. I worked on a lot of committees at the time. The IEEE was not very effective. We were quite isolated. So were the people representing medical physics and the ionizing radiation field. The people who were effective were molecular biologists. They were also effective with the organization of the IUPAB meetings.

As a consequence the US biophysical society and the IUPAB became increasingly biologically oriented, primarily concerned with the problem of interest to the biologist and not very concerned about environmental issues, radiation effects, ultrasound and all other topics of interest to biomedical engineers as well as medical applications. That IEEE representation at the IUPAB level was one attempt to become international.

The negative attitude of the molecular biologists for biomedical engineering has deep roots, in my opinion. In 1955 I worked during the summer at the famous Cold Spring Harbor laboratories. I moved up electronic equipment to measure the electrical properties of E. coli, together with the old and famous Hugo Fricke. At that meeting I usually had lunch in the cafeteria. I remember my conversations with a famous man whose name was Max Delbrück.

Nebeker: Yes, I know of the physicist-turned-biologist.

Schwan: Yes. Max Delbrück was curious, and he wanted to know what I was doing there with Fricke, so I told him. Then he challenged me in stating that there were all sorts of people such as Fricke and Cole, "What's all that stuff good for, what Cole did?" That was at a time when Cole's work had led to the Nobel Prize for [Alan] Hodgkin and [Andrew Fielding] Huxley. I was amazed at his negative comment. So there was already under the molecular biologists a preconceived negative attitude about electrical measurements of biological material and related things.

Nebeker: Was it called molecular biology back that early?

Schwan: Yes, for the first time in the early '50s.

Nebeker: I did not realize it went back that far. These physicists who took a particular attitude or approach to studying biology at the molecular atomic level, this is very interesting that they kept their distance and were not associated with the biophysics or bioengineers. Is that right?

Schwan: Yes. There was another reason for what happened. To come back to Zworykin, if I may. Zworykin recognized that situation perhaps, and decided to go his own way and not to try IUPAB, but instead to set up a completely separate international organization, which became the Federation of Medical Electronics, then later on it changed its name. But that's a different story in itself.

The Federation was formed in the '50s. The first meetings were all European meetings. Zworykin decided to bypass all the developments in this country, even though he worked here in Princeton, and concentrated on the British and

French. Indeed, the first three meetings were held in Paris and London. The fourth was held in New York. The first meeting was very small. There were only fifty people organizing the Federation. The two following ones were well attended; there were several hundred people. The New York meeting was organized by Les Flory, a coworker of Zworykin and myself. He was conference chairman and I was responsible for the program. I was the program chairman. Once more, I was lucky. There were 36 sessions, and more than 2,500 people attended. There were 300 papers. It was by far the biggest meeting so far in the field. For the Federation, it was a quantum jump

Nebeker: I am, of course, particularly interested in the IEEE story. What has been your involvement since 1969 with the IEEE professional group and then society?

Schwan: I never served in the IEEE administrative committee again until I accepted to serve as its Historian for three years recently. However, I published a number of papers in the IEEE journals, and I maintained close contact with many IEEE members.

Nebeker: You remained a member yourself?

Schwan: Oh yes, absolutely. You probably know from my bibliography that I was recognized by the IEEE repeatedly at the local, national and international level.

Nebeker: I know you received the Edison medal.

Schwan: Yes. In 1957 I got the Morlock Award, with a strong citation, if you care to read it.

Nebeker: This is the 1967 William Morlock Award.

Schwan: Yes. That is the same thing that we call these days Achievement Award.

Nebeker: That is right, that became the Career Achievement Award.

Schwan: I think I was the third one to get it. The IEEE recognized me twice in Philadelphia with the Philadelphia Achievement Award. I am one of two people in the Philadelphia area who got it twice. Then the Edison Medal. And I became a Fellow 40 years ago and Life member a few years ago and received a Centennial Medal.

Nebeker: Yes, the Edison is one of the very top awards. As a person very active early on and then a continuing member, when you look at this development over the '60s, '70s and '80s, do you see lost opportunities or missteps for IEEE's involvement in the field?

Schwan: Not too much. Clearly, the IEEE has played a dominant role in the creation of the new discipline of biomedical engineering. Its annual conferences have grown far above anything anticipated originally. I regretted the membership issue. Another basic regret that I have about the field is that it is split too much. We have many biomedical engineering organizations now, including the International Federation, the American Institute of Medical and Biological Engineering, the Biomedical Engineering Society, and the IEEE Engineering in Medicine and Biology Society. But the cooperation between the various societies is not quite clear. A powerful Washington DC-based group at this time is the American Institute of Medical and Biological Engineering. It serves as a roof organization for the three societies mentioned, but does not include a number of others such as the American Institute of Medical Ultrasound and the Bioelectromagnetics Society. Nor does it have any connection with the

Biophysical Society. Some are of the opinion that the electric oriented part of bioengineering is passé and out, and believe in the material sciences and in genetic engineering and more clinically related endeavors. This orientation is not shared by IEEE and should be taken seriously. It could be a return to a more restricted point of view in my personal opinion, which reflects the limited capability of all various bioengineering groups to come together. That is a major regret that I have, and it was shared with the late Otto Schmitt, who died last year.

Nebeker: It seems a little easier to demarcate the field of biophysics. Biomedical engineering seems to involve such a range of techniques and applications that one might argue it is less natural to have a single society representing those people.

Schwan: I do not share that point of view. One might represent the activities as follows. On a two-dimensional diagram, one may place all engineering disciplines on one axis, and on the other axis the biological- medical disciplines. I see a similar subdivision on both axes: the more practical oriented engineering disciplines and the more basic physical disciplines, and on the other axis the more basic biology and the more applied medical. Then you find at each intersection a potential field of interdisciplinary activity. And there are comparable numbers of subspecialties in biophysics and in bioengineering.

Nebeker: You think that there was some kind of failure of leadership or of diplomacy that could have better organized this field?

Schwan: It was a great problem for an existing engineering society to deal with the

problem of inter-science activities. The biophysicists have tried at the beginning to make a decision to be neither affiliated with the Federation of Biological Societies or with the American Institute of Physics. But they decided to go on their own as an interdisciplinary science.

Nebeker: One could have a physics degree or a biology degree and be a full-fledged member?

Schwan: Right. That was possible. Their chosen position of independence from existing organizations paid off. Originally it was said that they would not succeed at all. But they were wrong. The biophysicists took some sub disciplines away from the biochemists. They were extremely successful. There are thousands of people every year at the biophysics annual meetings. - These meetings are huge.

Nebeker: I am particularly interested in the history of the society. In recent years I know that the society has become somewhat more international—travel is easier, and meetings are sometimes held overseas.

Schwan: Yes. There is still some conflict. Some will not go to the Vienna meeting since they were opposed to this meeting taking place. The conference in Vienna was regarded to be in competition with the Atlanta meeting and indeed they were practically adjacent to each other in time, which is regrettable.

Nebeker: Yes, so there could have been some better coordination.

Schwan: No doubt, quite.

Nebeker: Thank you very much.