

Early Organizations of Biomedical Engineering in the U.S.

Much of the history of the origin of the Institute for Radio Engineers Professional Group of Medical Electronics has been reported in the 1959 article by L.H. Montgomery, Jr. This group became today's IEEE Engineering in Medicine and Biology Society in due time. However, the lists of committee members are incomplete, and not much is said about the *Transactions*. The following information is published to supplement the information contained in Montgomery's article. I also provide information about the origin of the Annual Conferences dedicated to engineering in medicine and biology, the Joint Executive Committee on Medicine and Biology and the very early relevant activities of the AIEE Committee on Electrical Techniques in Medicine and Biology. The information is collected from my files. Not included are comments about the development of the International Federation for Medical and Biological Engineering and IEEE representation in the International Union of Pure and Applied Biophysics (IUPAB), the Alliance for Engineering in Medicine and Biology, and more recently, the American Institute of Medical and Biological Engineering.

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Early History of G-EMB AdCom

Table 1 lists the complete membership of the AdCom from 1952 to 1960, including ex officio members and advisors. Originators were L.H. Montgomery, C.M. Ballard and Julia Herrick. Britton Chance, Harry Grundfest and V.K. Zworykin joined the first committee. Britton Chance, well known biophysicist, and Harry Grundfest, eminent physiologist from Columbia, left the committee shortly thereafter. Otto Schmitt, W. Greatbatch and, one year later, Herman Schwan entered the AdCom to serve for many years to come. Figure 1 is a summarizing graph covering the period from 1951 to 1970, not including ex officio members and advisors. Table 2 lists membership for the period 1951 to 1960, indicating the rapid increase typical for the growth of the field.

Early History of the *Transactions*

The *Transactions* started publishing in

1955. The administrative Committee of the IRE Professional Group on Medical Electronics at the time was composed of Chairman V.K. Zworykin, Vice Chair Lee Lusted, Secretary Treasurer Wilson Greatbatch, Members L.E. Flory, J.F. Herrick, J.K. Hilliard, U. Liddel, L.H. Montgomery, Jr., A.J. Morris, O.H. Schmitt, H.P. Schwan, N. Smith, and A.R. Tunturi.

The first issue, *PGME 1*, was dedicated entirely to modern technical developments in the field of electrocardiography. It was organized by E. Franck from the Electromedical Laboratory at the University of Pennsylvania and primarily concerned with the theory of the surface potentials produced by the heart, development of the rotating dipole concept, and lead systems developed by Burger, Franck and Schmitt.

PGME 2 (October 1955) has a panel discussion on medical electronics held on March 24 at the 1955 IRE National Convention. It was organized by O. Schmitt. Addresses were presented by J.W. Buchta, S. Briller, B. Chance, S.R. Gilford, C.C. Johnston, H. Skifter. Others emerging in the field contributed to the discussions.

PGME 3 (November 1955) has papers presented at the Conference on Plethysmography held in December of 1953 at Buffalo, N.Y. and edited by W. Greatbatch and H.P. Schwan. Papers include presentations by J. Nyboer (pioneering impedance plethysmography), H. Kalmus (a pioneer in U.S. flowmeter systems), and Herman P. Schwan (tissue impedances) and several abstracts.

PGME 4 (February 1956) contains papers from a "Symposium on Physiologic and Pathologic effects of Microwaves," held Sept. 23-24 1955 at the Mayo Clinic. Fifteen papers were presented. Sessions included: 1) Problems that are challenging investigators; 2) Field intensities generated by microwave radiating systems; 3) Effects of microwaves on the eye; and 4) General session on biologic effects. This first meeting on microwave bioeffects was attended by about 80 persons and featured a number of important contributions. G.H. Brown, at RCA, attempted to repeat some of the European work on bacterial effects without success.

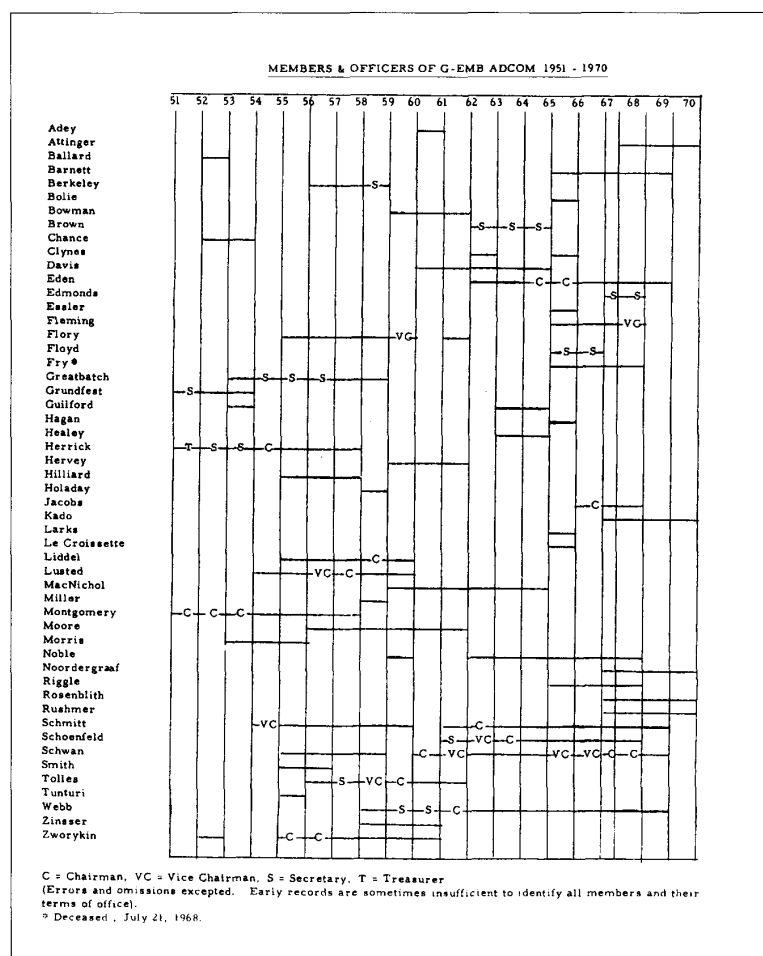


Fig. 1

Williams, et al., presented an excellent piece of work on lens opacities. D.A. Copson was probably primarily responsible for the microtherm food processing technology. Scott Blois is one of the early pioneers of paramagnetic resonance techniques in biophysics. T.S. Ely and D.E. Goldman reported their outstanding early study on animal responses to microwaves. H.P. Schwan and K. Li presented their early dosimetry work and arguments for a 10-mW/cm² standard.

PGME-5 (July 1956, Ed. Lee Lusted) contains papers presented at the 1955 WESCON Medical Electronics Session. Contributors were H.P. Hovnanian and R.B. Holt, W.E. Tolles and R.C. Bostrom, G.N. Webb and V.A. Kusick, A.J. Morris, and J.P. Swanson and an important contributed paper on "Effects of Electric Shock on Man" by C.F. Dalziel.

PGME-6 (October 1956, Ed. Otto Schmitt) was of a more biophysical orientation. The first two papers by O. Schmitt and K.S. Cole summarize modern developments

in axonology. The papers by R.W.G. Wyckoff are about electronmicroscopic and ultracentrifuge studies of viruses and macromolecules, and by E. Pollard on ionizing radiation studies of viruses. All papers demonstrate the usefulness of modern instrumentation and analytical concepts in nerve physiology and emerging biophysics.

PGME-7 (Dec 1956) contained two contributed papers and papers and abstracts presented at three sessions organized by the Professional Group on Medical Electronics at the 1956 WESCON Convention in Los Angeles.

Only two issues were published in 1957. A Symposium issue was dedicated to heart sounds (Organizer University of Buffalo). Three issues appeared in 1958. In 1959 four issues appeared. Three of them contained conference papers about artificial organs, computers in medicine and biology and blood flow. The Conference on Computers in Medicine and Biology (11th Annual Con-

ference on Electrical Techniques in Medicine and Biology, Chairman Otto Schmitt) was the first such conference to attract a really large attendance and submission of many papers.

In 1960, four issues appeared. One of them was dedicated to Stuart McKay, a pioneer in telemetry. Another includes papers from the 12th Annual Conference on Electrical Techniques in Medicine and Biology, organized by H.P. Schwan in Philadelphia. This conference was also very well attended. The central topic was dedicated to nonionizing radiations and their bioeffects.

The first issues were almost entirely composed of papers which had been presented at meetings dedicated to special topics, and participants were usually invited. I participated in many of these early meetings and remember them with nostalgia. Attendance was not large, and discussions lively and often productive. Contributed papers came in slowly at first, but since 1960 with increasing frequency. By then, the *Transactions* had become well established, adding greatly to the visibility of the emerging field of medical electronics. Furthermore, the 1958 and 1959 Annual Conferences were the first ones to attract large attendance. Thereafter, the field was broadened as the *Transactions* title was changed replacing "Medical Electronics" with "Medical and Biological Engineering." The development of the *Transactions* also benefited greatly from the dedication of a number of able, hardworking editors including Julia Herrick, Lee Lusted, Ted McNichol Jr., R.L. Schoenfeld, Dave Geselowitz, H. Sun, and the recently deceased Theo Pilkington.

Annual Conferences and JECMB Membership

The annual conferences on engineering in medicine and biology began after World War II, apparently in 1949 (my records only go back to 1952). They started about four years before the IRE Professional Group on Medical Electronics formed. Initial sponsorship was solely by the American Institute for Electrical Engineering (AIEE). The Institute for Radio Engineers (IRE) and Instrument Society of America (ISA) joined in 1953, and shortly thereafter the Joint Executive Committee on Medicine and Biology (JECMB) formed. A document, "Organization and Functions of the Joint Executive Committee on Medicine and Biology," was formulated and adopted by the committee at its organizational meeting in Chicago on Nov. 11, 1954. It stated that the committee structure should consist of two members plus the secretary of each of the three sponsoring societies and the past chairman of the preced-

Table 1. Professional Group on Biomedical Electronics Officers and Administrative Committee Members 1952-60						
Year	Chairman	Vice-Chairman	Secretary-Treasurer	Committee Members	Advisory Members	Ex-Officio
1952	L.H. Montgomery	C.M. Ballard	J.F. Herrick	Britton Chance Harry Grundfest V.K. Zworykin		
1953	L.H. Montgomery	Britton Chance	J. F. Herrick	S.R. Gifford W. Greatbatch A.J. Morris		
1954	J.F. Herrick	O.H. Schmitt	W. Greatbatch	L.B. Lusted L.H. Montgomery A.J. Morris		
1955	V.W. Zworykin	L.B. Lusted	W. Greatbatch	L.E. Flory J.F. Herrick J.K. Hilliard Umer Liddel L.H. Montgomery A.J. Morris O.H. Schmitt H.P. Schwan Newbern Smith A.R. Tunturi		
1956	V.K. Zworykin	L.B. Lusted	W. Greatbatch	Carl Berkley Matthew Conrad L.E. Flory J.F. Herrick J.K. Hilliard E. Levinthal Umer Liddel L.H. Montgomery O.H. Schmitt H.P. Schwan Newbern Smith W.E. Tolles	Otto Glaser	
1957	L.B. Lusted	Umer Liddel	W.E. Tolles	Carl Berkley Matthew Conrad L.E. Flory W. Greatbatch J.F. Herrick J.K. Hilliard E.C. Levinthal L.H. Montgomery J.W. Moore O.H. Schmitt H.P. Schwan V.K. Zworykin	G.E. Burch L.M. Hellman C.F. Kay J.P. Sampson DeWitt Stetten S.F. Thomas	T.H. Ham
1958	U. Liddel	W.E. Tolles	Carl Berkley	Matthew Conrad L.E. Flory W. Greatbatch J.K. Hilliard L.B. Lusted J.W. Moore O.H. Schmitt H.H. Zinsser V.K. Zworykin	G.E. Burch L.M. Hellman C.F. Kay J.P. Sampson DeWitt Stetten S.F. Thomas	G.F. Buranich J.F. Herrick T.H. Ham
1959	W.E. Tolles	L.E. Flory	G.N. Webb	R. Bowman Saul Gifford J.P. Hervey U. Liddel L.B. Lusted E.F. MacNichol J.W. Moore O.H. Schmitt H.H. Zinsser V.K. Zworykin	G.E. Burch Duncan Holaday Ogelsby Paul J.P. Sampson DeWitt Stetten	Carl Berkley M. Conrad W. Greatbatch T.H. Ham J.F. Herrick J.E. Jacobs R.S. Mackay W.J. Poch J.M. Reid J.W. Woodbury
1960	H.P. Schwan	R.S. Mackay	G.N. Webb	W.R. Adey R.L. Bowman J.F. Davis Saul Gifford J.P. Hervey E.F. MacNichol J.W. Moore W.E. Tolles H.H. Zinsser V.K. Zworykin	G.E. Burch Duncan Holaday Ogelsby Paul J.P. Sampson DeWitt Stetten	Carl Berkley M. Conrad L.E. Flory W. Greatbatch F.F. Herrick J.E. Jacobs U. Liddel L.B. Lusted J.M. Reid O.H. Schmitt R.G. Stranix

ing Medicine and Biology Conference.¹ This committee was responsible for the organization of the annual meetings by choice of meeting site and appointing conference and program chairs. It also dealt with the cooperation of interested societies. Later, the committee dealt with other matters of interest.² The committee changed its name from General Committee to Joint Committee when IRE and ISA joined. The name Joint Executive Committee on Medicine and Biology appears first in the program of the 9th Annual Conference and was to last until the committee was replaced by the Alliance for Engineering in Medicine and Biology 14 years later. The early conferences were dedicated to electronic instrumentation and nucleonics in medicine and attendance was limited. The sixth conference chairman's (S.R. Gilford) final report lists sessions on diagnostic devices, X-ray, blood measurements and electrophysiology. It also expresses "...some concern for the future of this conference, since the attendance records showed a gradually decreasing attendance... This had been... attributed to the shift in emphasis... The first three conferences reached an attendance peak of... 650 in 1948 to 1950. There was a sharp drop at the fourth conference to about 230 and a further drop to 196 at the fifth conference." S.R. Gilford and Harold J. Morowitz subsequently published a fine editorial, "Electronic Instrumentation and Nucleonics in Medicine" in *Science*.

A significant change took place starting with the 11th Annual Meeting. The number of papers increased about fourfold as a different membership of the JECMB had emerged. The table lists the meetings until 1961, when the combined annual meeting and the International Federation on Medical Electronics meeting in New York attracted more than 2,000 attendees. In July 1962, the JECMB acted on a recommendation by H.P. Schwan: "Dr. Schwan moved that Dr. Schmitt be authorized to form an ad hoc committee whose responsibility will be to prepare recommendations—after a re-examination of the scientific and technical interests of the JECMB—for expanded activities which may include cooperation with other societies having related interests. (Minutes of JECMB meeting July 18, 1962)." The motion carried. But another half a decade passed before the alliance was formed.

AIEE Committee on Electrical Techniques in Medicine and Biology

My files on the AIEE Committee on Electrical Techniques in Medicine and Biology are less complete. AIEE activities in the field began rather early, about 1948, some four years before I became active and at-

Table 2. Professional Group on Biomedical Electronics Membership (1952-1960)

Year	Total Membership	Affiliates
1952	539	
1953	1000	
1954	1181	
1955	1389	
1956	1542	
1957	1661	47
1958	1711	104
1959	2134	167
1960	2344	205

tended meetings rather frequently, giving papers and joining committees. The AIEE Committee on Electrical Techniques in Medicine and Biology was part of the Science and Electronics Division of the AIEE. Its main contribution to the field was the organization of the annual conferences.

The committee also organized several special sessions at the large general AIEE meetings which took place twice each year. For example, T.H. Rogers presided over a February 1956 session with six papers given by A.L. Albin and H.M. Sachs (Armour Research Fdt.), Saul Aarawow (Mass. Gen. Hosp.), H.P. Schwan and Kam Li (Univ. of Pa.), M.E. Hayes (Westinghouse), J.E. Jacobs and H. Berger (GE), and E.H. Wood (Mayo Clinic).

The minutes of a January 1955 committee meeting list E.D. Trout as Chairman, T.H. Rodgers as Vice Chairman, and H.P. Schwan as Secretary. On Dec. 26, 1956 a "Report of AIEE Ad Hoc Subcommittee on AIEE, IRE, ISA Cooperation" (chairman, H.P. Schwan) was submitted.³ It recommended that AIEE cooperate with IRE and ISA to establish common sponsorship of the annual conferences. This set in motion negotiations leading to common sponsorship with IRE and ISA (as apparent in the joint 1957 conference and all others to follow). In 1956 T.H. Rodgers served as chairman and H.P. Schwan as vice chairman.

The minutes of the JECMB meeting from Oct. 25, 1957 in New York report, for the first time, representation by IRE (C. Berkley, L.G. Cumming and H.P. Schwan [also representing AIEE]) and ISA (D.A. Holaday, R.H. Tripp). The meeting was chaired by T.H. Rogers. AIEE representatives included Rogers, R.S. Gardner, W.S. Lusby, and Schwan. "The desirability and feasibility of continuing the Annual Conferences with full participation and sponsorship by the present three sponsoring societies" was

stated and "organization of proper machinery, under JECMB, to effectively carry on the necessary work involved" decided. At the same meeting, H.P. Schwan recommended on behalf of IRE that Minneapolis be chosen as the site for the 1958 conference and submitted the name of O.H. Schmitt as Conference Chairman. Both suggestions were accepted after due study. With the Minneapolis and subsequent Philadelphia meetings, organized by Schmitt and Schwan respectively, a new spirit and interpretation of the BME field had began, replacing the previous small attended meetings by large scale and more broadly conceived conferences. A few years later, the name Medical Electronics was replaced by Engineering in Medicine and Biology in order to attract a broader representation of all engineers with pertinent interests.

Common sponsorship of the annual conferences prevented the occurrence of many small meetings between the competing societies. From then on there was only one large BME annual conference for many years to come. In addition, regional meetings developed, first in San Diego, then the Rocky Mountain conferences were added. Other regional meetings followed in due time. These regional conferences proved sufficiently successful to last to this day.



Herman P. Schwan has received three doctoral degrees: Ph.D., Frankfurt, 1941; Dr.habil. Frankfurt, 1946; Honorary D.Sc., University of Pennsylvania, 1986. He has been with the University of Pennsylvania since 1950, where he headed biomedical engineering activities from 1952 to 1973. He is currently the Alfred Fittler Moore Professor Emeritus in biomedical engineering. He has also been a University Lecturer at Drexel University since 1983. He has received the 1974 B. Rajewsky Price Award for Biophysics; the 1983 IEEE Edison Medal; the AIEE Kendall Award, 1983; 1984 Centennial Medal; and the first d'Arsonval Medal, Bioelectromagnetic Society, 1985. Dr. Schwan has served on many interdisciplinary committees for IEEE, the Biophysical Society, the Biomedical Engineering Society, and the NIH.

He served as the first chairman of ANSI's C96 committee on electromagnetic radiation hazards. He chaired three of the annual biomedical engineering conferences, one for the Biophysical Society, and many conference sessions. Dr. Schwan has published about 300 articles, edited two books, and presented some 360 lectures at national and international meetings and universities. He is a member of the National Academy of Engineering. His major research areas include electrical and acoustic properties of biomatter, dielectric-spectroscopy, electrode properties, electromagnetic field interactions with biological matter, and electromagnetic safety standards.

Dr. Schwan can be reached at the University of Pennsylvania, Department of Bioengineering, Philadelphia, PA 19104.

End Notes

1. This was increased to three representatives of each society in 1960.
2. For example, an inquiry was received in 1959 from Sen. Hubert H. Humphrey, chairman of a subcommittee on reorganization and international organizations, acting on behalf of the United States Senate, International Health Study. The inquiry concerned a forthcoming committee on "The Federal Government and Medical Electronics." The JECMB submitted a 10-page statement.

Sen. Humphrey responded, "Dear Dr. Schwan: It is a delight to have your splendid report on behalf of the JECMB. It contains precisely the type insight which will prove invaluable for our subcommittee....We will be making ample reference to it and look forward to being in constant close touch with you. AIEE, IRE, ISA are all to be congratulated for their fine leadership—through your own able chairmanship. With best wishes, sincerely, Hubert Humphrey." Sen. Humphrey, in a 1961 memorandum, proposed expansion of federal support, including \$8.4 million per year for medical electronics and NIH grants of nearly \$1 million for special resource centers for expanded computer technology in medical science, indicating further action. One House resolution re-

quested \$1.5 million for two regional centers for biomedical electronics.

3. H.P. Schwan was the only one to serve for a number of years on all three administrative committees (IRE AdCom, AIEE-EMB committee and JECMB). This enabled him to introduce a variety of suggestions beneficial to the development of the field. His initiative with regard to the three-society sponsorship of the annual conferences and the choice of Minneapolis and Philadelphia (11th and 12th annual conferences) are examples. Another somewhat delicate task had to be confronted when AIEE and IRE committees had to be replaced by a single committee.

Annual Conferences and Membership

The following list records the early conferences from 1952 until 1963, their changing titles and the JECMB membership.

4th Conference on Electronic Instrumentation and Nucleonics in Medicine: AIEE; New York, January 1952; 18 papers presented.

5th Conference on Electronic Instrumentation and Nucleonics in Medicine: AIEE; New York, November 1952; 17 papers. General Committee: S.R. Warren, Jr. (Chair), R.S. Gardner (secretary), L.F. Ehrke, W.A. Gilbert, S.R. Gifford, G.H. Hupman, J.D. Luntz, L.H. Montgomery, G.A. Morton, G.C.B. Rowe, J.S. Smith, J.D. Tabo, R.E. Watson.

6th Conference on Electronic Instrumentation and Nucleonics in Medicine: AIEE, IRE, ISA; New York, November 1953; 17 papers. General Committee: S.R. Gifford (chairman), T.H. Rogers (secretary), R.L. Bowman, R.H. Chamberlain, L.G. Cumming, L.F. Ehrke, R.S. Gardner, R.W. Gilbert, Wilson Greatbatch, J.F. Herrick, G.H. Hupman, R.W. Johnson, J.D. Luntz, L.H. Montgomery, H.J. Morowitz, B.R. Shepard, E. Dale Trout, W.J. Tuttenham, S.R. Warren, Jr., J.F. Zauner.

7th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Chicago, November 1954; 14 papers. General Committee: E.D. Trout (chairman), R.S. Gardner, G.A. Pillmore, J.P. Kelley, E. Mittelmann, G.A. Morton, T.H. Rogers, T. Fields, J.E.C. Askin, J.J. Gershon, D.E. Hasse, H.R. Heckendorn, L.H. Montgomery.

8th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Washington, DC, November 1955; 15 papers. Joint Committee: E.D. Trout (chairman), T.H. Rogers (AIEE), R.S. Gardner (AIEE), L.G. Cumming (IRE), H.J. Horowitz (ISA), J.F. Herrick (IRE), W.H. Kushnick (ISA), Delmas C. Little (ISA), L.H. Montgomery (IRE), T.H. Rogers, L.B. Lusted, R. Jonnard, Walter Lusby.

9th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; New York, November 1956; 18 papers. Joint Executive Committee on Medicine and Biology (JECMB): T.H. Rogers (AIEE), R.S. Gardner (AIEE), L.G. Cumming (IRE), L.B. Lusted (IRE), W.H. Kushnick (ISA), R. Jonnard (ISA). (Partial, since taken from attendance record.)

10th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; New York, November 1957;

* No records are available for the first three conferences, or for General Committee membership for the 4th conference.

unrecorded number of papers. JECMB: T.H. Rogers (AIEE) chairman, C. Berkley (IRE), L.G. Cumming (IRE), R.S. Gardner (AIEE), D.A. Holaday (ISA), W.S. Lusby (AIEE), H.P. Schwan (AIEE, IRE), R.H. Tripp (ISA).

11th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Minneapolis, November 1958; 69 papers. JECMB: O.H. Schmitt, IRE (chairman, and conference chairman), H.P. Schwan, IRE, AIEE (vice chairman), L.G. Cumming (IRE), L.E. Flory (IRE), W. Greatbatch (IRE), R.S. Gardner (AIEE), G.C. Riggie (AIEE), D.A. Holaday (ISA), H.S. Kindler (ISA), R.H. Tripp (ISA).

12th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Philadelphia, November 1959; 54 papers. JECMB: H.P. Schwan (chairman, and conference chairman), R.L. Bowman (vice chairman), D.A. Holaday, ISA (secretary), O.H. Schmitt (IRE), C. Berkeley (IRE), R.S. Gardner (AIEE), L.E. Flory (IRE), L.G. Cumming (IRE), G.C. Riggie (AIEE), H.S. Kindler (ISA).

13th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Washington, DC, November 1960; 53 papers. JECMB: R.L. Bowman, ISA (chairman, and conference chairman), H.P. Schwan, AIEE, IRE (ex officio chairman), G.C. Riggie, AIEE (secretary), O.H. Schmitt (IRE), L.E. Flory (IRE), L.G. Cumming (IRE), R.S. Gardner (AIEE), H.S. Kindler (ISA), P. Frommer (ISA).

14th Annual Conference on Electrical Techniques in Medicine and Biology (With 4th International Conference on Medical Electronics): AIEE, IRE, ISA; New York, July 1961; 36 sessions, each with six to eight papers. This successful meeting was attended by more than 2000 people. L.E. Flory was conference chairman and H.P. Schwan program chairman.

JECMB: R.L. Bowman, chairman; IRE: L.G. Cumming, O.H. Schmitt, H.P. Schwan, G.N. Webb; AIEE: J. Beckett, H. Beenken, R.S. Gardner, G.C. Riggie; ISA: R.L. Bowman, P.L. Frommer, D. Holaday, H.S. Kindler.

15th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Chicago, November 1962.

JECMB: G.N. Webb, chairman, R.L. Bowman, chairman, ex officio; IRE: G.N. Webb, H. Beenken, H.P. Schwan; AIEE: J.E. Jacobs, G.C. Riggie, O.H. Schmitt; ISA: R.L. Bowman, P.W. Frommer, D.A. Holaday.

16th Annual Conference on Electrical Techniques in Medicine and Biology: AIEE, IRE, ISA; Baltimore, November 1963.

JECMB: R.N. Schoenfeld (chairman), H.G. Beenken (secretary); ISA: F. Alt, P. Frommer, D. Holaday; IEEE: V.W. Bolie, S.D. Larks, H.P. Schwan, G.N. Webb.