# 50 Years of the IEEE Microwave Theory and Techniques Society

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*Invited Paper*

***Abstract*—The early history of the IEEE Microwave Theory and Techniques Society (IEEE MTT-S) is summarized since its founding in 1952, and all administrative committee members and presidents are listed. Some of the more recent changes resulting from growth and multinational participation are described. Publications are discussed with editors listed for this TRANSACTIONS, the IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, the *IEEE Microwave Newsletter*, and *IEEE Microwave Magazine*. The chronological evolution of the IEEE MTT-S's awards is presented, including a listing of all award winners. Distinguished lecturers and microwave symposia sites and chairpersons are also discussed. Early technology trends are described.**

***Index Terms*—Microwave awards, microwave magazine, microwave newsletter, microwave symposia, microwave transactions, MTT history, IEEE MTT-S.**

## I. EARLY HISTORY

IN ORDER TO appreciate the importance of the IEEE Microwave Theory and Techniques Society (IEEE MTT-S), one has to go back to the period between the end of World War II and the formation of the IEEE MTT-S to understand the situation in our profession. Up through World War II, and for several years thereafter, most of the microwave work done was first for the War effort, then for the Defense Department, and, as a result, was classified. The word "microwave" was rarely seen in print until the mid-late 1940s, and although people talked about high frequencies, many had no concept of how high in frequency the microwave range extended. In 1942, a book entitled *Microwave Transmission* by Slater was published by McGraw-Hill. Soon thereafter, the widely used textbook *Fields and Waves in Modern Radio* by Ramo and Whinnery was published by Wiley in 1944. Perhaps the most useful engineering book was *Microwave Transmission Design Data* by Moreno, published by McGraw-Hill in 1948. This book was derived from a classified book with the same title, published by the Sperry Gyroscope Company in 1944.

Shortly after the war ended, a number of microwave publications became available, in particular, the historical Massachusetts Institute of Technology Radiation Laboratory Series, consisting of 27 volumes published by McGraw-Hill from 1947 to 1952. An index volume to this series was published in 1953. Articles on the technology began to appear in the PROCEEDINGS OF THE IRE and also in *Electronics* magazine. There was also an occasional article in the publications of the American Institute of Physics and American Institute of Electrical Engineers (AIEE), but there were really no places where a microwave engineer could search to find articles on his favorite subject. He had to wait for them to appear.

Most of the microwave people knew each other. They were all more or less familiar with the companies that were doing business in the field. In those days, the big event of the year for technical people was the IRE Convention, which was held in the spring in New York, NY, every year. Microwave companies rented booths at the convention to exhibit their microwave components. Early IRE shows were held in the Grand Central Palace Building on Lexington Avenue, next to Grand Central Station. The principal purpose of the IRE Convention at the time was to have technical meetings. The exhibits were an attachment to those technical meetings. Many who were active in microwaves at the time would go to the IRE convention and attend the meetings relative to microwaves. They would also visit the other companies in the exhibit hall. There was usually a cocktail party and sometimes a formal dinner for attendees. This Convention provided an opportunity for microwave people to get together, since most of them were members of the IRE at the time.

In 1948, the IRE recognized the need for forming smaller more compact groups on the basis of professional interest. In March of that year, they adopted the Professional Group principle of operation. In 1951, at the National Convention in New York, Ben Warriner, IV, who was a microwave engineer with General Precision Laboratories, Pleasantville, NY, had a discussion with Larry Cummings, who was the IRE Technical Secretary, on the possibility of promoting a professional group for microwave electronics. Although there was a lack of enthusiasm by the IRE leadership, Warriner circulated a letter dated July 9, 1951 to a group that he addressed as "members of the IRE interested in forming a professional group for microwave electronics." Included with the letter was a petition for the formation of the group. The letter stated a concern for possible conflicts with the group on antennas and a possible conflict with the group on instrumentation. He was able to get a sufficient number of distinguished professionals in the field to sign the petition.

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The original petition stated that the scope of the group, if approved, would "encompass microwave theory, microwave circuitry and techniques, microwave measurements and microwave tubes." The scope would also include "scientific, technical, industrial, and other areas that contribute to the field of interest, or to utilize techniques or products of the field where necessary to advance the art and science of the field, subject, as the art develops, to additions, subtractions, or other modifications directed or approved by the Institute Committee on Professional Groups." There was no problem in getting enough people to sign the original petition, and the Professional Groups Committee of the IRE approved the group on March 7, 1952.

The members of the first administrative committee (AdCom), which had its first meeting on May 1, 1952, included Warriner as Chairman, Andre Clavier as Vice Chairman, and Bill Mumford as Secretary–Treasurer. The other members of the committee included Paul Coleman, Donald King, Harry Marvin, Joe McCann, George Rosselot, Harald Schutz, and George Southworth. The first symposium was held in New York City on November 7, 1952 at the Western Union Auditorium. Attendance at the symposium was 210 people. Ten papers were presented. By January 1953, the group had a total membership of 942, of whom 471 had paid their dues. The annual dues at that time were $2.

## II. Publications

### A. Beginning of this *Transactions*

In the second year, two issues of this TRANSACTIONS were published. The first, in March 1953, consisted of 48 pages and was made up of 14 articles and one abstract. It is important to note that the IEEE MTT-S, which started as a professional group, has gone through a number of name changes. Starting as a professional group, it became a professional technical group as a result of the merger of IRE with AIEE (which IEEE MTT-S opposed); this was later simplified to group, then later to the IEEE MTT-S.

In the beginning, meetings of the group were held at IRE Headquarters, which in those days was in a very handsome mansion on 1 East 79th Street in New York City. This was across from the Metropolitan Museum of Art, where the group would occasionally go for lunch. In those early days, meetings would take perhaps half a day. Normally, they would start at 10:00 a.m. and would finish at lunchtime, but occasionally they would go beyond that and it would conclude back at the mansion.

For a while, it was difficult to get AdCom members to take the whole operation seriously. Although a number of people were named to the committee each year, there was always a small nucleus that carried on most of the activities. This usually consisted in those early days of Dr. Andre Clavier, Bill Mumford, Al Beck, Herb Engelman, Dr. Don King, and Dr. George Southworth. Fortunately, in 1955, five new dynamic members were added to the AdCom, including Seymour Cohn, Art Oliner, Bill Pritchard, Kiyo Tomiyasu, and Harold Wheeler. All five of these people became active AdCom members and contributed to the growth and strength of the committee. Four went on to become AdCom Chairmen. Three became Honorary Life Members. Four won the Microwave CAREER Award.

Both a reason for the existence of the Administrative Committee and a foundation of its success is the publication of this TRANSACTIONS, which above all else has been the pride and mainstay of the IEEE MTT-S. The first AdCom published the first TRANSACTIONS issue in March 1953. For that first issue in 1953, and the following three issues, Al Beck served as the Chairman of the Papers Procurement Committee, with Bill Mumford serving as Publications Chairman. Together they functioned as Editors of the first TRANSACTIONS. After much coercion on a subway ride in Manhattan, Bill Mumford, the new Chairman, convinced Ted Saad to become the editor of this TRANSACTIONS in September 1954. The AdCom provided the editor a budget of $500 per year. Early on, this TRANSACTIONS was converted to letterpress to bring its quality up to that of the PROCEEDINGS OF THE IRE. Photographs and biographies of the contributors were also introduced. To further enhance the quality and attractiveness of the publication, an editorial and biography of a famous microwave person was included in each issue. In January 1957, Kiyo Tomiyasu took over as Editor, and later he was followed by Don King. One of the interesting aspects of being Editor of this TRANSACTIONS is the fact that most of them went on to become Chairmen or, later, Presidents of the AdCom. Don King later became President-elect of the IEEE, but died before he could serve as President.

This TRANSACTIONS started out with two issues the first year, three the second year, and six the third year. It was a quarterly for several years until 1959. Starting in 1960, it was published every other month, and in 1966, monthly publication began. To a certain extent, the content of this TRANSACTIONS was (and still is) influenced by the individual who is Editor at the time. Even more significant is the fact that the quality of the publication has improved steadily since the very beginning. Table I lists this TRANSACTIONS Editors. One of the interesting events that took place relative to this TRANSACTIONS was the time when the IRE allowed this TRANSACTIONS to take advertising. The IEEE MTT-S was one of the few groups at the time that was able to find companies willing to advertise. As it turned out, Tore Anderson was the Advertising Chairman and he was also President of FXR at the time. With the ads that he was able to solicit from FXR and a few other companies, a fairly good surplus was generated to support the publication of this TRANSACTIONS.

### B. The IEEE Microwave Newsletter and IEEE Microwave Magazine

One of the great concerns that the AdCom had in those early days was providing service to and communicating with the membership. By September of 1954, there were four local IEEE MTT-S chapters in Albuquerque–Los Alamos, Boston, Buffalo–Niagara, and Chicago. (There are now 83 chapters worldwide.) It was the AdCom's concern to somehow arrange for communication with the local membership and to provide the members of the group with some sense of participation. As a consequence, the first *IEEE Microwave Newsletter* published on September 10, 1954 consisted of a report from the retiring Chairman, Dr. Clavier, and a message from the incoming Chairman, Bill Mumford. As this TRANSACTIONS' Editor at the

TABLE I
TRANSACTIONS EDITORS

| | |
|---|---|
| 1953 | BECK, A.C. |
| | MUMFORD, W.W. |
| 1954 | MUMFORD, W.W. |
| 1954-1956 | SAAD, T.S.* |
| 1957-1959 | TOMIYASU, K.* |
| 1959-1962 | KING, D.D. |
| 1963-1965 | BEATTY, R.W. |
| 1966-1968 | OKWIT, S.* |
| 1969-1972 | HADDAD, G.I. * |
| 1972-1975 | ROSENBAUM, F.J. |
| 1975-1977 | PARKER, D.* |
| 1978-1979 | ALLEN, J.L. |
| 1980-1982 | KNERR, R.H.* |
| 1983-1985 | ITOH, T.* |
| 1986-1988 | LEVY, R.* |
| 1989-1990 | TUCKER, R.S. |
| 1990-1991 | MAAS, S.A. |
| 1992-1995 | MASSE, D. |
| 1995-1997 | TREW, R.J.* |
| 1997-2000 | MINK, J.W.* |
| 2001- | RUTLEDGE, D.* |
| | |
| *IEEE Third Millenium Medal | |

TABLE II
NEWSLETTER EDITORS

| | |
|---|---|
| 1954-1956 | SAAD, T.* |
| 1956-1958 | WENGENROTH, R. |
| 1958-1968 | SHAPIRO, G. |
| 1968-1970 | CLAVIN, A. |
| 1971-1972 | HORTON, J. B.* |
| 1972-1974 | RODRIGUE, P.* |
| 1975-1977 | PELNER, N. |
| 1978-1981 | KUNO, J.* |
| 1981-1983 | MARCH, S. |
| 1984-1985 | KAGIWADA, R.* |
| 1986-1989 | STAECKER, P.* |
| 1989-1990 | LERUDE, G. |
| 1990-1995 | WASSEL, J. |
| 1996-1999 | TRUITT, G.A. |
| | |
| *IEEE Third Millenium Medal | |

time, Ted Saad was given the responsibility of preparing the *IEEE Microwave Newsletter*.

Initially, the *IEEE Microwave Newsletter* was published after each AdCom meeting, with a report of the meeting, and included reports from the local chapters. Ted Saad was *IEEE Microwave Newsletter* Editor until May 8, 1956, when Bob Wengenroth took over. Bob's first issue was October 1, 1956. His first issue had six pages, and later the *IEEE Microwave Newsletter* had 13 pages. The *IEEE Microwave Newsletter* in those days was typewritten and then simply duplicated. As time went on, it grew both in content and value to the members.

The next *IEEE Microwave Newsletter* editor was Gus Shapiro, from NBS in Washington. His first issue was December 1958, and it was a bit of a surprise to many people who were used to the solid, but perhaps antiseptic-like editions of the *IEEE Microwave Newsletter* that had appeared up to that time. Gus introduced a number of innovations, one of which was to intersperse jokes and clever sayings throughout the *IEEE Microwave Newsletter*. This had the tendency of inveigling people into reading the entire issue. Gus' technique of interspersing jokes through the *IEEE Microwave Newsletter* created a lot of interest and, in fact, there was one letter of protest, which was discussed at an AdCom meeting. However, the policy was continued through his last issue.

Al Clavin took over in January 1968, and he immediately brought to the *IEEE Microwave Newsletter* a number of significant and professional changes. These changes were not simply mechanical, but they were more from the standpoint of editorial approach. Whereas in prior years the *IEEE Microwave Newsletter* had been strictly a reporting medium, it was Al's intent to include controversial discussions rather than simply straight new items. This has made the *IEEE Microwave Newsletter* a more useful publication. Whereas Gus had included penciled sketches and various types of primitive graphical techniques, Al introduced photography to the *IEEE Microwave Newsletter*. Al continued as *IEEE Microwave Newsletter* editor through October 1970. He was then followed by a succession of excellent editors including Pete Rodrigue, John Horton, Nat Pelner, John Kuno, Steve March, and a series of other IEEE MTT-S individuals, all of whom are listed in Table II. It is interesting to note that the *IEEE Microwave Newsletter* Editor's position has proven to be a stepping-stone to AdCom leadership. In later years, the *IEEE Microwave Newsletter* went to letterpress printing, with a glossy cover. Eventually it was decided to replace the *IEEE Microwave Newsletter* with *IEEE Microwave Magazine*. The last *IEEE Microwave Newsletter* was issued in Fall 1999, and the first issue of *IEEE Microwave Magazine* occurred in March 2000 and is published quarterly. The co-editors of *IEEE Microwave Magazine* are Mike Golio and Robert Trew.

### C. The Letters Publications

In 1991, a new IEEE MTT-S publication was started. This was the IEEE MICROWAVE AND GUIDED WAVE LETTERS, having the purpose of providing fast publication (2–3 months) of significant original contributions and of length limited to about 2-1/2 printed pages. The first editor was Tatsuo Itoh (1991–1994). The second editor was Roberto Sorrentino (1995–May 1998). The third editor was Madhu S. Gupta (June 1998–2000). In January 2001, this publication was renamed the IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS, and Samir M. El-Ghazaly is the Editor-in-Chief.

## III. THE SYMPOSIUM

Perhaps like any other society in the IEEE, the IEEE MTT-S has its own personality. It was one of the few groups of the IRE able to generate advertising to support its expanded publication activities. Another aspect where the IEEE MTT-S was a bit unique was in the matter of having exhibits at its annual symposium. The holding of symposia started very early in the history of the IEEE MTT-S and these would be held alternately between the East and West coasts of the U.S. It has pretty well remained with that tradition, with some deviations. In the mid-

TABLE III
INTERNATIONAL MICROWAVE SYMPOSIA

| YEAR | SITE | SYMPOSIUM CHAIR | TECHNICAL CHAIR |
|---|---|---|---|
| 1957 | NEW YORK, NY | ANDERSON, T.R. | WEISBAUM, SAMUEL |
| 1958 | STANFORD, CA | ADEN, ARTHUR L. | TOMIYASU, KIYO* |
| 1959 | CAMBRIDGE, MA | PRITCHARD, W.L. | RIBLET, HENRY |
| 1960 | SAN DIEGO, CA | PROCTOR, D. | MEDVED, D.B. |
| 1961 | WASHINGTON, DC | STONE, ROBERT O. | SHAPIRO, GUSTAVE |
| 1962 | BOULDER, CO | SCHAFER, GEORGE E. | BEATTY, ROBERT W. |
| 1963 | SANTA MONICA, CA | ANDERSON, DEAN B. | KAUFMAN, IRVING |
| 1964 | LONG ISLAND, NY | ROSENTHAL, SAUL W. | SWERN, LEONARD |
| 1965 | CLEARWATER, FL | HENNING, RUDOLPH E. | PIPPIN, JOHN E. |
| 1966 | PALO ALTO, CA | LACY, PETER | YOUNG, LEO* |
| 1967 | BOSTON, MA | MICHELSON, MAX; DAMON, R.W. | SAAD, TED* |
| 1968 | DETROIT, MI | HORTON, M.C.; ROWE, J.E.* | HADDAD, GEORGE I.* |
| 1969 | DALLAS, TX | SADLER, J.C.; HALLFORD, B.R. | HORTON, JOHN B.*; WEBSTER, R.R. |
| 1970 | NEWPORT BEACH, CA | SENSIPER, S. | DUHAMEL, R. H.; KASAI, GEORGE |
| 1971 | WASHINGTON, DC | COOPER, H. WARREN, III* | GARVER, ROBERT. V. |
| 1972 | ARLINGTON HEIGHTS, IL | KNOX, ROBERT M.; HANSEN, L.H. | KNOP, C.M.; TOULIOS, P.P. |
| 1973 | BOULDER, CO | WAIT, DAVID F. | BEATTY, ROBERT W. |
| 1974 | ATLANTA, GA | RODRIGUE, GEORGE P.* | HARRISON, GORDON R. |
| 1975 | PALO ALTO, CA | MATTHEWS, WES | ADAM, STEPHEN F.* |
| 1976 | CHERRY HILL, NJ | DEMARINIS, B. | CAULTON, M. |
| 1977 | SAN DIEGO, CA | RUBIN, DAVID | SCHAFFNER, GERALD; CABAYAN, H. |
| 1978 | OTTAWA, CANADA | VANKOUGHNETT, A.L. | STEENAART, W. |
| 1979 | ORLANDO, FL | HENNING, RUDOLPH E. | ALLEN, LAMAR; WILTSE, JAMES C.* |
| 1980 | WASHINGTON, DC | WHICKER, LAWRENCE F. | VANWAGONER, R. C. |
| 1981 | LOS ANGELES, CA | CLAVIN, ALVIN | PARKER, DON*; KUNO, JOHN* |
| | | | WEGLEIN, ROLF |
| 1982 | DALLAS, TX | MCQUIDDY, DAVID N. | MARCH, S.L.; BUTLER, J.K.* |
| | | | VOGES, R.C.; ITOH, TATSUO* |
| 1983 | BOSTON, MA | HOWE, HARLAN, JR.* | LEVY, RALPH*; RIBLET, GORDON |
| 1984 | SAN FRANCISCO, CA | ADAM, STEPHEN F.* | IVANEK, FERDO* |
| 1985 | ST. LOUIS, MO | ROSENBAUM, FRED J. | HORD, WILLIAM; HONICKMAN, STEPHEN |
| 1986 | BALTIMORE, MD | NIEHENKE, EDWARD C.* | COHN, MARVIN |
| 1987 | LAS VEGAS, NV | MARCH, STEVEN | KAGIWADA, REYNOLD S.* |
| 1988 | NEW YORK, NY | BUNTSCHUH, CHARLES | TAUB, JESSE*; WHELEHAN, JAMES |
| 1989 | LONG BEACH, CA | SWIFT, CHUCK* | KAGIWADA, REYNOLD S.* |
| 1990 | DALLAS, TX | WASSEL, JOHN | ITOH, TATSUO*; LEHMANN, RANDALL |
| 1991 | BOSTON, MA | STAECKER, PETER W.* | THOREN, GLENN R. *; MASSE, DAN |
| 1992 | ALBUQUERQUE, NM | HAUSNER, JERRY | HUTCHINS, ROBERT |
| 1993 | ATLANTA, GA | RODRIGUE, GEORGE P.*; RUCKER, C. | HARRISON, GORDON R. |
| 1994 | SAN DIEGO, CA | PARKER, DON* | EISENHART, ROBERT* |
| 1995 | ORLANDO, FL | HUDDLESTON, KEITH; HENNING, R.E | BROCKMAN, LARRY; DUFFIELD, TERRY |
| 1996 | SAN FRANCISCO, CA | CRESCENZI, E. JAMES* | FIEDZIUSZKO, JERRY*; HORNBUCKLE, D. |
| 1997 | DENVER, CO | WEIL, CLAUDE | GUPTA, K.C.*; POPOVIC, ZOYA |
| 1998 | BALTIMORE, MD | STITZER, STEVE* | NIEHENKE, ED* |
| 1999 | ANAHEIM, CA | EISENHART, ROBERT L.* | KUNO, H. JOHN* |
| 2000 | BOSTON, MA | THOREN, GLENN R. * | STAECKER, PETER W.* |
| 2001 | PHOENIX, AZ | EL-GHAZALY, SAMIR | NAIR, VIJAY |
| 2002 | SEATTLE, WA | HARVEY, DONN | STRID, ERIC |

*IEEE Third Millenium Medal

1960s, when the IEEE MTT-S finances were getting tight, there was some discussion as to the possibility of having paid exhibits at the symposia to help defray expenses. The discussion was carried on at many AdCom meetings, and initially there was great opposition. Some AdCom members were concerned that the symposia would lose some of their flavor, and become industry/sales oriented. Finally, however, the vote was taken to have the exhibits. They started modestly in 1972 in Arlington Heights, outside Chicago, IL. As it turned out, they have proven to be very beneficial for the IEEE MTT-S, but there is no question that it has altered the tone of the symposia. The fact remains, however, that the symposium is the highlight of the society year and, perhaps, with exhibits, the industry year. It is now a major electronics conference, with an attendance usually exceeding 10 000. Table III contains a list of the symposia locations and the names of the chairpersons.

Like any other technical society, ours is always looking to the future for new areas of technology, new opportunities, and new innovations, but coupled with that is the concern for the historical roots of the technology. The Historical Collection and Annual Exhibit began in 1980 and has been growing steadily ever since. The exhibit is brought each year to the International Microwave Symposium. Between symposia, the collection resides at the Historical Electronics Museum, which holds many microwave-related items beside the IEEE MTT-S collection. The Museum is located near the Baltimore–Washington International Airport, MD.

TABLE IV
MICROWAVE LECTURERS

| | |
|---|---|
| | ***NATIONAL LECTURERS*** |
| 1967 | OLINER, ARTHUR A.* |
| 1968 | YOUNG, LEO* |
| 1969 | DAMON, RICHARD W. |
| 1970 | SOBOL, HAROLD* |
| 1971 | BLAKE, CARL |
| 1972 | SAAD, THEODORE S.* |
| 1973 | ALLEN, JOHN L. |
| 1974 | OKWIT, SEYMOUR* |
| 1975 | BEATTY, ROBERT W. |
| 1976 | STERZER, FRED |
| 1977 | OSEPCHUK, JOHN M.* |
| 1978 | LIECHTI, CHARLES A. |
| 1979 | WILTSE, JAMES C.* |
| 1980 | PUCEL, ROBERT A.* |
| 1981 | IVANEK, FERDO* |
| 1982 | GIORDMAINE, JOSEPH A. |
| | |
| | ***DISTINGUISHED LECTURERS*** |
| 1983 | ADAM, STEPHEN F.* |
| 1984 | GREILING, PAUL T. |
| | WEINREB, SANDER |
| 1985 | CARR, KENNETH L. |
| 1986 | BRYANT, JOHN H. |
| | NIEHENKE, EDWARD C.* |
| 1987 | BARTON, DAVID K.* |
| | JANSEN, ROLF H. * |
| 1988/89 | KNERR, REINHARD H.* |
| | SILVER, ARNOLD H. |
| 1990/91 | CURTICE, WALTER R.* |
| | WHINNERY, JOHN R.* |
| 1990/92 | RIZZOLI, VITTORIO |
| 1992/94 | GOLDSMITH, PAUL F. |
| | IVANEK, FERDO* |
| 1993/95 | YONEYAMA, TSUKASA |
| 1994/96 | SCHNEIDER, MARTIN V.* |
| 1995/97 | DIXIT, RAHUL |
| 1996/97 | WAKINO, KIKUO |
| 1997/99 | HERCZFELD, PETER R.* |
| | MENZEL, WOLFGANG S. |
| | RAUSCHER, CHRISTEN |
| | ROSEN, ARYE* |
| 1998/00 | BRAZIL, TOM |
| | BREHM, GAILON |
| | GOLIO, MIKE |
| | TREW, ROBERT* |
| 1999/01 | JENSEN, JOSEPH F. |
| | MARKS, ROGER B. |
| 2000/2 | COMPTON, RICK |
| | LEE, THOMAS H. |
| *IEEE Third Millenium Medal | |

In the early days, there was a constant effort to increase the membership, but although the effort continues to this day, the effort is more slanted toward keeping the membership interested and involved. The AdCom is always seeking ways to provide more services to members of the IEEE MTT-S. Of course, the annual symposium is viewed as fulfilling a service. As another example, we had national lecturers who traveled around the country, and today, we have distinguished lecturers who travel around the world, giving lectures to the local chapters. This gives the chapters an opportunity to hear an eminent microwave individual talk on a topic of current interest. These lecturers are listed in Table IV.

TABLE V
HONORARY LIFE MEMBERS

| | |
|---|---|
| 1960 | SOUTHWORTH, GEORGE C. |
| 1961 | CLAVIER, ANDRE G. |
| 1965 | MUMFORD, WILLIAM W. |
| 1967 | BECK, ALFRED C. |
| 1973 | KING, DONALD D. |
| 1973 | SAAD, THEODORE S.* |
| 1973 | TOMIYASU, KIYO* |
| 1978 | COHN, SEYMOUR B.* |
| 1978 | OLINER, ARTHUR A.* |
| 1982 | YOUNG, LEO* |
| 1994 | ITOH, TATSUO* |
| *IEEE Third Millenium Medal | |

## IV. MEMBER RECOGNITION

### A. Prizes and Awards

Over the years, the IEEE MTT-S has established ways to recognize member contributions. In 1956, the first of these, the Microwave Prize, was established for the best microwave paper published in the preceding calendar year. The recipients are listed in Table VI(h). This recognition is given annually. In 1960, the grade of Honorary Life Member was created. A selectee must be an individual of national and international prominence who has performed outstanding service to the profession and the IEEE MTT-S, whose contributions, technical or otherwise, must have made an important impact in the field, who has been an elected member of the AdCom, an IEEE MTT-S member for at least ten years, and has been elected Fellow. To date, only 11 persons have been selected for this honor (four of these are deceased). They are listed in Table V.

The Microwave CAREER Award and the Application Award were initiated in 1973 and presented at the Awards Banquet during the 1974 Symposium. That particular symposium was unusual because it was a joint meeting with the IEEE 1974 International Symposium on Antennas and Propagation. The Microwave CAREER award, which includes a significant cash prize, is made to an individual IEEE member for an outstanding career of achievement in the microwave field, and is the IEEE MTT-S's most prestigious award. The Microwave Application Award, which also includes a monetary prize, recognizes the most outstanding application of microwave theory and techniques by an individual or a team. Prior to 1982, these awards were dated by the year of the election. Beginning in 1982, they were dated by the year of presentation. Winners of these awards are listed in TableVI(a) and (b). Awards created later are described below as they evolved chronologically.

The Distinguished Service Award was initiated in 1983. It recognizes significant contributions and outstanding service to the IEEE MTT-S and the microwave profession. Winners of this award are listed in Table VI(c). The Certificate of Meritorious Service was given from 1985 to 1994 and the awardees are listed in Table VI(d). The N. Walter Cox Award recognizes an individual who has given exemplary service to the IEEE MTT-S in a spirit of selfless dedication. It was initiated in 1989 in memory of Dr. Walter Cox, a member of the AdCom, after his untimely death due to leukemia. Winners of this award are listed in Table VI(e).

TABLE VI
MICROWAVE CAREER AWARD

| | |
|---|---|
| 1973 | MUMFORD, WILLIAM W. |
| 1974 | WHEELER, HAROLD A. |
| 1975 | RIBLET, HENRY J. |
| 1976 | WHINNERY, JOHN R.* |
| 1977 | WEBER, ERNST |
| 1978 | FOX, A. GARDNER |
| 1979 | COHN, SEYMOUR B.* |
| | KLEEN, WERNER J. |
| 1980 | TOMIYASU, KIYO* |
| **1982 | MATSUMOTO, AKIO |
| | OLINER, ARTHUR A.* |
| 1983 | HINES, MARION E. |
| 1984 | PIERCE, JOHN R. * |
| 1985 | BARLOW, HAROLD M. |
| | MARCUVITZ, NATHAN |
| 1986 | MATTHAEI, GEORGE L. * |
| 1987 | BEATTY, ROBERT W. |
| 1988 | YOUNG, LEO* |
| 1989 | COOKE, HARRY F. |
| | CULLEN, ALEX |
| 1990 | PUCEL, ROBERT * |
| 1991 | OKAMURA, SOGO* |
| 1992 | SAAD, THEODORE S. * |
| 1993 | DORING, HERBERT |
| | LEWIN, LEONARD |
| 1994 | KONISHI, YOSHIHIRO |
| 1995 | GETSINGER, WILLIAM J. |
| 1996 | BRYANT, JOHN H. |
| 1997 | LEVY, RALPH* |
| 1998 | SOBOL, HAROLD * |
| 1999 | BROWN, WILLIAM C. |
| 2000 | WILTSE, JAMES C. * |
| 2001 | *NO AWARD* |

*IEEE Third Millenium Medal
**DATES OF AWARD CHANGED IN 1982

(a)

TABLE VI *(Continued.)*
MICROWAVE APPLICATION

| | |
|---|---|
| 1973 | CRISTAL, EDWARD G. |
| 1974 | PETERSON, DEAN F. |
| | SMITH, PHILLIP H. |
| 1975 | WHITE, JOSEPH F. |
| 1976 | WALKER, MARTIN G. |
| 1977 | LONG, STEPHEN I. |
| 1978 | CLAXTON, DALE H. |
| 1979 | BELOHOUBEK, ERWIN F. |
| 1980 | LANGE, JULIUS |
| **1982 | BOYD, CHARLES R., JR.* |
| 1983 | BESSER, LES* |
| 1984 | MEIER, PAUL |
| 1985 | CHEAL, JAMES |
| 1986 | SWAN, C. BURKE |
| 1987 | *NO AWARD* |
| 1988 | FUKUTA, MASUMI |
| | NAPOLI, LOUIS S. |
| 1989 | CARR, KENNETH L. |
| 1990 | PODELL, ALLEN F. |
| 1991 | GLEASON, K. REED |
| | STRID, ERIC W. |
| 1992 | HERSHENOV, BERNARD |
| 1993 | CARTER, JOHN L. |
| | REINGOLD, IRVING |
| 1994 | SCHNEIDER, MARTIN V.* |
| 1995 | WEN, CHENG P. |
| 1996 | WAKINO, KIKUO |
| 1997 | *NO AWARD* |
| 1998 | HESTON, DAVID D. |
| | LEHMANN, RANDALL E. |
| 1999 | RAUSCHER, CHRISTEN |
| 2000 | ROSEN, ARYE* |
| 2001 | RAUTIO, JAMES C. |

*IEEE Third Millenium Medal
** PRIOR TO 1982 AWARD WAS DATED BY YEAR OF ELECTION

(b)

The Microwave Pioneer Award was first offered in 1990 in recognition of a major lasting contribution in the microwave field reported at least 20 years prior to the year of the award, to an individual or a team of up to three persons. Awardees are listed in Table VI(f). The most recently awarded recognition is for a Distinguished Educator, which was commenced in 1993. The award, which includes an honorarium, is given to an educator in the field of microwave engineering and science who exemplifies the special human qualities of the late Professor Fred J. Rosenbaum, known for his regard for teaching as a high calling and for his dedicated service to the IEEE MTT-S. Table VI(g) gives a list of these winners. As mentioned above, the Microwave Prize Award winners are given in Table VI(h).

In summary, since the founding of the IEEE MTT-S, over 200 members have received the awards listed above. A new award has just been approved by the AdCom and will be offered in the future. This is the Outstanding Young Engineer Award, which will be given to an engineer 38 years of age or younger and an IEEE MTT-S member when nominated who has distinguished himself/herself through a sequence of technical and/or service achievements. An honorarium accompanies the award. More information on the various awards, including the bases for judging, is given in *IEEE Microwave Magazine* [1], [2]. In addition to these IEEE MTT-S awards, many IEEE MTT-S members have received the IEEE Third Millennium Medal for outstanding contributions in their respective areas of activity. Approximately 3000 IEEE members were selected by IEEE societies, sections, regions, or major boards and may be identified by accessing the IEEE web page at http://www.ieee.org/about/awards/Millennium.htm. Members listed in this paper's tables who have won the medal are identified by asterisks.

### *B. The AdCom*

The first AdCom consisted of ten members. Over a period of time, the number has grown slowly in concert with the membership growth of the IEEE MTT-S as a whole. For many years, members were elected by the AdCom from a slate of candidates proposed by a nominating committee. In 1999, the AdCom decided to expand from 18 by adding one member selected by the IEEE MTT-S membership at large. Beginning in 2000, a general membership election is held each year for one new member for a three-year term. Thus, by 2002, the third new member will be added for a term beginning in 2003, when the AdCom membership will reach 21. Initially, of course, all members were from

TABLE VI *(Continued.)*
DISTINGUISHED SERVICE AWARD

| | |
|---|---|
| 1983 | SAAD, THEODORE S.* |
| 1984 | CLAVIN, ALVIN |
| 1985 | RODRIGUE, GEORGE P.* |
| 1986 | SOBOL, HAROLD * |
| 1987 | TOMIYASU, KIYO* |
| 1988 | ROSENBAUM, FRED J. |
| 1989 | PARKER, DON* |
| 1990 | OLTMAN, H. GEORGE, JR.* |
| 1991 | RUCKER, CHARLES T. |
| 1992 | SPARKS, RICHARD A.* |
| 1993 | ADAM, STEPHEN F.* |
| 1994 | HORTON, JOHN B.* |
| 1995 | KNERR, REINHARD H.* |
| 1996 | HENNING, RUDOLF E. |
| 1997 | GELNOVATCH, VLADIMIR G.* |
| 1998 | SCHNEIDER, MARTIN V.* |
| 1999 | COOPER, H. WARREN, III* |
| 2000 | YAMASHITA, EIKICHI |
| 2001 | KAGIWADA, REYNOLD S.* |
| *IEEE Third Millenium Medal | |

(c)

| | |
|---|---|
| 1985 | ADAM, STEPHEN F.* |
| | ROSENBAUM, FRED J. |
| 1986 | SPARKS, RICHARD A.* |
| 1987 | PARKER, DON* |
| 1988 | OLTMAN, H. GEORGE, JR.* |
| 1989 | SCHNEIDER, MARTIN V. * |
| 1990 | SWIFT, CHARLES W.* |
| 1991 | *NO AWARD* |
| 1992 | ELLOWITZ, HOWARD I. |
| | HORTON, JOHN* |
| | MOORE, ROBERT A. |
| 1993 | BRYANT, JOHN H. |
| | MEDGYESI-MITSCHANG. L. |
| | NIEHENKE, EDWARD C. * |
| | SORRENTINO, ROBERTO* |
| 1994 | DIETRICH, NORMAN R. |
| | STITZER, STEVEN N. * |
| *IEEE Third Millenium Medal | |

(d)

| | |
|---|---|
| 1989 | SPARKS, RICHARD A. * |
| 1990 | STAECKER, PETER W. * |
| 1991 | SCHRANK, HELMUT E. * |
| 1992 | SPIELMAN, BARRY E. * |
| 1993 | DEGENFORD, JAMES E., JR |
| 1994 | SWIFT, CHARLES W.* |
| 1995 | AGARWAL, KRISHNA K.* |
| 1996 | *NO AWARD* |
| 1997 | KAGIWADA, REYNOLD S.* |
| 1998 | KAUL, ROGER |
| 1999 | MASSE, DANIEL |
| 2000 | *NO AWARD* |
| 2001 | WASSEL, JOHN W. |
| *IEEE Third Millenium Medal | |

(e)

TABLE VI *(Continued.)*
MICROWAVE PIONEER AWARD

| | |
|---|---|
| 1990 | FUKUI, HATSUAKI |
| 1991 | DICKE, ROBERT H. |
| 1992 | BARRETT, ROBERT M. |
| 1993 | CLEETON, CLAUDE E. |
| | HOGAN, C. LESTER |
| 1994 | UENOHARA, MICHIYUKI* |
| 1995 | BROWN, WILLIAM C. |
| 1996 | KUROKAWA, KANEYUKI* |
| 1997 | ATIA, ALI E. |
| | WILLIAMS, ALBERT E. |
| 1998 | KILGORE, G. ROSS* |
| 1999 | EISENHART, ROBERT L. |
| | KAHN, PETER |
| 2000 | KULESHOV, Y.M. |
| 2001 | GANDHI, OM P. |
| *IEEE Third Millenium Medal | |

(f)

| | AWARD |
|---|---|
| 1993 | OLINER, ARTHUR A.* |
| 1994 | COLEMAN, PAUL D. |
| 1995 | RODRIGUE, GEORGE P.* |
| 1996 | HADDAD, GEORGE* |
| 1997 | RUTLEDGE, DAVID B.* |
| 1998 | TREW, ROBERT J.* |
| 1999 | HERCZFELD, PETER R.* |
| 2000 | ITOH, TATSUO* |
| 2001 | GUPTA, KULDIP C.* |
| *IEEE Third Millenium Medal | |

(g)

the U.S. As time went by and engineers from other countries joined the IEEE MTT-S, the makeup of the AdCom gradually changed to include members from outside the U.S. The demographics are such that, although a majority of members are from the U.S., the number of members from other countries is approaching 50%, and there have now been numerous members of the AdCom (and one president) from non-U.S. membership. The AdCom normally meets three times each year, the first in January in conjunction with the Technical Program Committee meeting, the second in May or June at the time of the International Microwave Symposium, and lastly in September. In the past, the meetings had all been held in the U.S., but in September 2001, the AdCom met in London, U.K., contiguous in time to the European Microwave Conference. After 50 years, there have been about 170 members of the AdCom and four dozen chairman/presidents. The AdCom leader was referred to as "chairman" initially, but in 1972, the title was changed to "president." The business of the IEEE MTT-S has grown into a substantial operation, which includes nearly two dozen technical conferences, publication of two refereed journals and a magazine, sponsoring graduate fellowships and undergraduate scholarships, producing numerous products, and has an appreciable net worth. The IEEE MTT-S has also established a web site, which can be accessed at http://www.mtt.org. TableVII(a) and (b) contains a list of all AdCom members and chairmen/presidents.

TABLE VI *(Continued.)*
MICROWAVE PRIZE

| VI-H | | | | | |
|---|---|---|---|---|---|
| DATE | WINNER | DATE | WINNER | DATE | WINNER |
| 1956 | CHAIT, HERMAN | 1981 | FUKUI, HATSUAKI | 1994 | CHOMA, JOHN, JR.* |
| | SAKIOTIS, NICHOLAS G. | 1982 | KOBAYASHI, KUNIKATSU | | GROSSMAN, P. CHRIS |
| 1957 | PRIMICH, ROBIN I. | | NEMOTO, YOSHIAKI | 1995 | BLOMME, KRIST |
| 1958 | SEIDEL, HAROLD | | SATO, RISABURO* | | OLYSLAGER, FRANK |
| 1959 | GOLDSTEIN, LADISLAS | 1983 | HONJO, KAZUHIKO | | ZUTTER, DANIEL DE |
| 1960 | AULD, BERT A. | | TAKAYAMA, YOICHIRO | 1996 | CHENG, H.J. |
| 1961 | HARVEY, A.F. | 1984 | HOFFMAN, REINMUT K. | | KATEHI, L.P.B.* |
| 1962 | MATTHAEI, GEORGE L. * | | SIEGEL, JOHANN | | WELLER, T. M. |
| 1963 | LEWIN, LEONARD | 1985 | NICLAS, KARL B. | | WHITAKER, J. F. |
| 1964 | YOUNG, LEO* | | TUCKER, BRETT A. | 1997 | ALLEN, SCOTT T. |
| 1965 | COHN, SEYMOUR B.* | 1986 | AYASLI, YALCIN | | CASE, MICHAEL |
| 1966 | BOSMA, HENDRIK | | REYNOLDS, LEONARD D. | | PUSL, JOE |
| 1967 | OLINER, ARTHUR A.* | | VORHAUS, JAMES L. | | REDDY, MADHUKAR |
| 1968 | WENZEL, ROBERT | 1987 | RAUSCHER, CHRISTIAN | | RODWELL, MARK J. |
| 1969 | GABRIEL, WILLLIAM | 1988 | HONJO, KAZUHIKO | | YU, RUAI Y. |
| 1970 | RHODES, JOHN D.* | | MADIHIAN, MOHAMMAD | 1998 | NARHI, TAPANI |
| 1971 | EVANS, WILLLIAM J. | 1989 | MAAS, STEPHEN A. | 1999 | SNOWDEN, CHRISTOPHER |
| 1972 | HINES, MARION E. | 1990 | HIKITA, MITSUTAKA | 2000 | BARKER, N. SCOTT |
| 1973 | ROWE, HARRISON E. | | ISHIDA, YOSHIKATSU | | REBEIZ, GABRIEL M. |
| | YOUNG, DALE T. | | KUROSAWA, KAZUHITO | 2001 | AHLANDER, MATS |
| 1974 | GERARD, HENRY M. | | TABUCHI, TOYOJI | | ANDERSON, DAN |
| | JONES, WILLIAM R. | 1991 | AIKAWA, MASAYOSHI | | JORDAN, ULG |
| | SMITH, W. RICHARD | | HARA, SHINJI | | LISAK, MITEK |
| 1975 | LIECHTI, CHARLES | | TOKUMITSU, TSUNEO | | OLSSON, TORBJORN |
| | TILLMAN, ROBERT L. | 1992 | BANDY, STEVE G. | | |
| 1976 | MECKLENBRAUKER, W. | | GLENN, MICHAEL | *IEEE Third Millenium Medal | |
| | ROZZI, TULLIO E. | | MAJIDI-AHY, REZA | | |
| 1977 | BERA, RICHARD F. | | NISHIMOTO, CLIFFORD K. | | |
| | MASSE, DANIEL | | PAO, YI-CHING | | |
| | PUCEL, ROBERT* | | RIAZIAT, MAJID | | |
| 1978 | HINES, MARION E. | | SILVERMAN, S. | | |
| | POSNER, RONALD S. | | TAN, ZOILO Z.H. | | |
| | SWEET, ALLEN A. | | WENG, SHANG-LIN | | |
| 1979 | HELD, DANIEL N. | | ZDASIUK, GEORGE A. | | |
| | KERR, ANTHONY R. | 1993 | KIM, MOONIL | | |
| 1980 | CARLSON, ERIC R. | | POPOVIC, ZOYA B. | | |
| | MCMASTER, THOMAS F. | | RUTLEDGE, DAVID B. * | | |
| | SCHNEIDER, MARTIN V.* | | WEIKLE, ROBERT M. II | | |

(h)

## V. TECHNOLOGY TRENDS

The microwave technology of the early 1950s as reported in the initial issue of this TRANSACTIONS has seen dramatic changes in comparison to today's technology. This is partly due to concerted efforts to advance the theory, evolve new concepts, optimize the hardware, and employ new manufacturing techniques. In addition, outside factors also contributed. An example is the development of earth satellites and, in particular, communication satellites, where microwave technology is used extensively. Another example, engendered by the competition between the U.S. and the then Soviet Union, is ballistic missile defense, leading to the development of advanced microwave radar and phased arrays, and missile guidance, leading to the development of guidance radars, and microwave communication systems. Such major programs provided large amounts of funding and the pressure to improve microwave technology.

At the time of the beginning of the IEEE MTT-S group in 1952, microwave technology, as stated earlier, had largely evolved from the extensive developments during World War II. Optimization of components and standardization of transmission lines and connectors were important topics [3]. In addition, new technology was appearing; for example, this TRANSACTIONS' first issues in 1953 contained an abstract and an article dealing with ferrite devices at microwaves. Development of ferrite isolators, circulators, and phase shifters continued for many years. Today, we take such devices for granted as catalog items. The types of technology activities that were being reported in early issues of this TRANSACTIONS have been summarized in a 1980 article [4] by the respective editors, who covered the period from March 1953 to December 1977. In addition, in 1984, the Special Centennial Issue of this TRANSACTIONS (hardbound) contained 28 full papers describing the history and status of microwave technology up to that time [5]. These stories of early development are quite fascinating. A brief summary of some of the early activities is given below.

TABLE VII
IEEE MTT-S ADCOM ROSTER

| ADCOM MEMBERS | TERM | CHAIRMAN/ PRESIDENT | ADCOM MEMBERS | TERM | CHAIRMAN/ PRESIDENT |
|---|---|---|---|---|---|
| AARON, BURT D. | 1961-1964 | | GUY, A. WILLIAM | 1974-1976 | |
| ADAM, STEPHEN F.* | 1974-1980 | 1980 | HADDAD, GEORGE I.* | 1968-1976 | |
| AGARWAL, KRISHNA K.* | 1986-1992 | | HANSEN, ROBERT C.* | 1959-1968 | |
| ALTSCHULER, HELMUT | 1960-1967 | 1964/65 | HARRIS, MIKE | 2001-2003 | |
| ANDERSON, DEAN B. | 1975-1976 | | HENNING, RUDOLPH E. | 1965-1968 | 1968 |
| ANDERSON, R. W. | 1969 | | HICKS, ROBERT B. | 1978-1984 | |
| ANDERSON, TORE N. | 1957-1963 | 1961/62 | HONJO, KAZUHIKO | 1998-2002 | |
| ARAMS, FRANK R. | 1966-1973 | | HORNBUCKLE, DERRY | 1993-1995 | |
| AUCKLAND, JERRY C. | 1977-1982 | | HORTON, JOHN B.* | 1969-1973 | 1973 |
| BARLOW, HAROLD M. | 1964-1967 | | | 1977-1979 | |
| BARR, JOHN T., IV | 1994-2002 | | HORTON, M. C. | 1969-1971 | |
| BASAWAPATNA, G.R. | 1980-1982 | | HOWE, HARLAN, JR. * | 1976-1985 | 1985 |
| BEAM, ROBERT E. | 1954-1961 | | HUDDLESTON, KEITH G. | 1995 | |
| BEATTY, ROBERT W. | 1961-1975 | | ITOH, TATSUO* | 1982-1990 | 1990 |
| BECK, ALFRED C. | 1953-1966 | 1955/56 | IVANEK, FERDO* | 1983-1991 | 1991 |
| BERSON, BERT | 1979-1982 | | JACKSON, CHARLES* | 1996-2002 | 2001 |
| BIERIG, ROBERT W. | 1995 | | JANSEN, ROLFE H.* | 1989-1997 | |
| BRYAN, RICHARD E. | 1991-1998 | 1997 | JASIK, HENRY | 1953-1956 | |
| BRYANT, JOHN H. | 1965-1970 | 1970 | JERINIC, GEORGE | 1982-1985 | |
| BUTTON, KENNETH J. | 1975-1980 | | JOCANOVIC, BRANKA | 1991 | |
| CHANDLER, CHARLES W. | 1953-1956 | | KAGIWADA, REYNOLD S | 1984-1992 | 1992 |
| CLARRICOATS, PETER J.* | 1968-1970 | | KAUFMAN, IRVING | 1964-1967 | |
| CLAVIER, ANDRE G. | 1952-1960 | 1953/54 | KEMMERLEY, R. "TIM" | 1995-2002 | |
| CLAVIN, ALVIN | 1969-1972 | 1972 | KENNEY, J. STEVE | 1998-2003 | |
| COHEN, ELIOT D.* | 1991-1996 | 1995 | KING, DONALD D. | 1952-1957 | |
| COHN, MARVIN | 1964-1966 | | | 1959-1964 | 1963/64 |
| COHN, SEYMOUR B.* | 1955-1964 | 1962/63 | | 1965-1967 | |
| | 1965-1969 | | | 1969-1970 | |
| COLEMAN, PAUL D. | 1952-1954 | | KNERR, REINHARD H.* | 1978-1986 | 1986 |
| COOPER, H. WARREN, III* | 1969-1975 | 1975 | KNOX, ROBERT M. | 1973-1975 | |
| COX, N. WALTER | 1983-1988 | | KOMAREK, ERNEST L. | 1977-1979 | |
| CRESCENZI, E. JAMES JR* | 1987-1995 | 1994 | KONISHI, Y. | 1983 | |
| CURTIS, C. W. | 1956-1959 | | KUNO, H. JOHN* | 1976-1986 | |
| DEGENFORD, JAMES E., J | 1975-1984 | | LEESON, DAVID B. | 1970-1972 | |
| DE LISIO, MICHAEL | 2000-2002 | | LEHMANN, R.E. | 1996 | |
| EL-GHAZALY, SAMIR | 2001-2003 | | LERUDE, D. GARY | 1987-1990 | |
| ENGELMANN, HERBERT | 1953-1961 | 1956/57 | LEVY, RALPH* | 1985-1988 | |
| ESTES, ALBERT L. | 1989-1991 | | LIPETZ, NAT | 1970-1974 | |
| FIEDZIUSZKO, S. JERRY* | 1995-2001 | | MAAS, STEPHEN A. | 1990-1993 | |
| GALANI, ZVI | 1990-1992 | | MAGNUSKI, HENRY | 1952-1954 | |
| GARVER, ROBERT V. | 1971-1973 | | MARCH, STEVEN L. | 1979-1987 | |
| GELNOVATCH, VLADIMI | 1980-1989 | 1989 | MARKS, ROGER B. | 1999-2001 | |
| GOLIO, J. MIKE | 1994-1996 | | MARVIN, HENRY B. | 1952-1954 | |
| GREILING, PAUL T. | 1979-1988 | | MATTHAEI, GEORGE L.* | 1962-1965 | |
| GUPTA, K.C.* | 1997-2002 | | MAURY, MARIO A., JR. | 1986-1995 | |

(a)

### A. Low-Noise Concepts

An area that received extensive activity was that of noise reduction and low-noise amplification. Crystal mixer design was studied in detail [6], but part of the superheterodyne mixer problem was local-oscillator noise. Balanced mixers were used for noise cancellation and were suitable for narrow-band cases, but balancing the RF and IF circuits over a wide band was extremely difficult. Wide-band radiometers and pulse-compression radars needed bandwidths of 1 GHz or more. For higher frequencies, where low-noise preamplification had not been available, the answer to this situation was to use single-ended mixers with microwave IF amplifiers [7]. This technique has been used for decades in radio astronomy receivers and sensitive radiometers (including NASA satellite imaging receivers) to improve sensitivity.

A significant development coming out of the field of microwave spectroscopy was that of the maser (an acronym for "microwave amplification by stimulated emission of radiation"), an extremely low-noise amplifier. This was a very important advance because its noise performance was so exceptional and it also was the precursor to the laser. It involved complicated hardware setups and cryogenic cooling. It was not practical for everyday low-cost installations, but it did represent

TABLE VII *(Continued.)*
IEEE MTT-S ADCOM ROSTER

| ADCOM MEMBERS | TERM | CHAIRMAN/ PRESIDENT | ADCOM MEMBERS | TERM | CHAIRMAN/ PRESIDENT |
|---|---|---|---|---|---|
| MCANN, JOSEPH G. | 1952-1954 | | SMULLIN, LOUIS D. | 1953-1956 | |
| MCKINNEY, J. K. | 1997-1999 | | SOBOL, HAROLD* | 1972-1978 | 1978 |
| MCQUIDDY, DAVID N., JR | 1983-1987 | 1987 | SORRENTINO, ROBERTO* | 1998-2003 | |
| MEDGYESI-MITSCHANG, | 1988-1989 | | SOUTHWORTH, GEORGE | 1952-1960 | |
| MODELSKI, JOSEF* | 1999-2001 | | SPARKS, RICHARD A.* | 1974-1984 | 1982 |
| MOORE, ROBERT A. | 1988-1993 | | SPIELMAN, BARRY E.* | 1977-1988 | 1988 |
| MORENO, THEODORE | 1963-1966 | | STAECKER, PETER W.* | 1985-1993 | 1993 |
| MUMFORD, WILLIAM W. | 1952-1964 | 1954/55 | STEER, MICHAEL B. | 1998-2000 | |
| NIEHENKE, EDWARD C.* | 1981-1989 | | STINEHELFER, H.E., JR. | 1974-1977 | |
| OKWIT, SEYMOUR* | 1966-1971 | 1971 | STRUM, PETER D. | 1958-1961 | |
| OLINER, ARTHUR A.* | 1955-1965 | 1959/60 | SUDBURY, ROGER W.* | 1993-2002 | 2000 |
| | 1966-1969 | | SULLIVAN, FRANK J. | 1999-2002 | |
| OLTMAN, H. GEORGE, JR. | 1973-1984 | 1984 | SWANSON, DANIEL G. | 1992-1997 | |
| OSEPCHUCK, JOHN M. | 1970-1972 | | TAUB, JESSE J.* | 1973-1974 | |
| PARKER, DON* | 1972-1979 | 1979 | TEMPLE, STEVEN J. | 1985-1992 | |
| PERLMAN, BARRY S.* | 1989-1994 | | THOMPSON, M.C. | 1959-1962 | |
| PIPPIN, JOHN E. | 1963-1965 | | THOREN, GLENN A.* | 1993-1998 | |
| POLLARD, ROGER D.* | 1993-1998 | 1998 | | 2001-2003 | |
| POND, JEFFREY | 2001-2003 | | TOMIYASU, KIYO* | 1955-1968 | 1960/61 |
| PRITCHARD, WILBUR L. | 1955-1961 | 1957/58 | TORGOW, EUGENE N. | 1962-1967 | 1965/66 |
| RA, JUNG-WOONG | 1996-1998 | | | 1971-1972 | |
| RAUE, JORG E. | 1984-1993 | | TREW, ROBERT J.* | 1996-2001 | |
| REZEK,ED | 1993-2001 | 1999 | TUCKER, RODNEY S. | 1989-1990 | |
| RIVERS, ROBERT A. | 1961-1972 | 1974 | VARIAN, KARL | 1997-2002 | |
| RIZZI, PETER A. | 1965-1969 | | WAIT, DAVID F. | 1973-1975 | |
| ROBERTSON, SLOAN D. | 1956-1959 | | WANTUCH, ERNEST | 1956-1959 | |
| RODRIGUE, GEORGE P.* | 1970-1976 | 1976 | WARREN, F.G.R. | 1964-1970 | |
| ROE, JAMES M. | 1981-1984 | | WARRINER, BEN | 1952-1955 | 1952/53 |
| ROSENBAUM, FRED J. | 1971-1981 | 1981 | WASSEL, JOHN W. | 1992-1997 | 1996 |
| ROSENTHAL, SAUL W. | 1959-1967 | 1966/67 | WEBB, DENIS | 1994-1996 | |
| | 1971-1974 | | WENGENROTH, ROBERT | 1957-1964 | |
| ROSSELET, G. | 1952-1955 | | WETENKAMP, SCOTT F. | 1999-2001 | |
| RUCKER, CHARLES T. | 1976-1983 | 1983 | WEXLER, A. | 1971-1972 | |
| SAAD, THEODORE S.* | 1953-1969 | 1958/59 | WHEELER, HAROLD A. | 1955-1958 | |
| SCHAFER, GEORGE E. | 1964-1965 | | WICKER, LAWRENCE F. | 1972-1977 | 1977 |
| SCHINDLER, MANFRED J. | 1994-2002 | | WHINNERY, JOHN R.* | 1954-1957 | |
| SCHNEIDER, MARTIN V.* | 1985-1990 | | WILTSE, JAMES C.* | 1965-1966 | |
| SCHRANK, HELMUT E.* | 1976-1978 | | | 1990-1992 | |
| SCHUTZ, HARALD | 1952-1957 | | WIND, MOE | 1961-1962 | |
| SCHWARTZ, RICHARD F. | 1956-1962 | | YAMASHITA, EIKICHI | 1992-1997 | |
| SHAPIRO, GUSTAVE | 1958-1968 | | YEN, J.L. | 1962-1963 | |
| SHIROMA, WAYNE | 2001 | | YOUNG, LEO* | 1965-1969 | 1969 |
| SINCLAIR, GEORGE | 1957-1962 | | *IEEE Third Millenium Medal | | |

(b)

an impressive breakthrough for specialized applications. The maser-laser research by C. H. Townes in the U.S. and N. G. Basov and A. M. Prokhorov in the then Soviet Union resulted in their sharing the Nobel Prize in 1964. The maser has been used in radio astronomy and the evolution of atomic clocks. As Okwit said [6], "The maser had a flashy, exciting career that fizzled out after about eight years, except for the most stringent radio astronomy and deep-space requirements." However, in one famous case, A. A. Penzias and R. W. Wilson used a low-noise maser receiver, built in the early 1960s at Bell Laboratories for satellite communications, in radio astronomy research. The maser was tuned to 7-cm wavelength (4.1 GHz), and they used it in 1965 to measure the cosmic background radiation, which they discovered was higher than expected. For this research and their interpretation of the "big bang" theory of the creation of the universe, Penzias and Wilson received the 1978 Nobel Prize in physics. The theory of the "big bang" effect was developed by R. H. Dicke and his associates at Princeton University.

A semiconductor device that had some moderate commercial success for about 12 years in the 1960s and early 1970s was the tunnel diode amplifier. This was based on a heavily doped p-n junction diode (sometimes referred to as an Esaki diode), which exhibits negative resistance when forward biased. Its noise characteristics were good for the period, but much poorer than the maser. Its relatively poor dynamic range was another limiting

factor. Still, it was simple, inexpensive, small in size, and met some intermediate needs. For his invention of the tunnel diode, Dr. L. Esaki shared the 1973 Nobel Prize in Physics with I. Giaever and B. Josephson for their work in superconducting junctions.

The parametric amplifier also appeared on the scene in the 1950s and 1960s. At first, it had limitations on noise temperature and gain-bandwidth product, but improved circuitry and high-quality GaAs varactors, plus cryogenic cooling, eventually made it the workhorse receiver that has been used for decades in most of the satellite communications ground stations [6]. The paramp requires a pump signal at twice the frequency being amplified. At high microwave or millimeter-wave frequencies, such a pump signal is not always available.

Subsequently, the low-noise GaAs field-effect transistor (FET) appeared in the picture for use in low-noise systems. Constant improvements over a period of years, plus low cost and simplicity, have made it a strong participant in today's systems. More recently, the pseudomorphic high electron-mobility transistor (pHEMT) has also produced excellent low-noise characteristics, especially at higher microwave frequencies all the way to 95 GHz. The heterojunction bipolar transistor (HBT) is also a contender in some applications.

### *B. Sources*

The sources developed during World War II were the klystron, cavity magnetron (pulsed), and the lighthouse tube (useful at low microwave frequencies). The klystron and cavity magnetron had been invented just before the war and were reported in the literature in 1939 [8]–[10]. The only solid-state source was the harmonic generator, which used a crystal diode and produced low power. The transistor was invented in 1948 and began to see use at radio frequencies in the 1950s, but was not available at microwaves. Shockley, Brattain, and Bardeen received the Nobel Prize in 1956 for their invention of the transistor. The 1950s saw the development of the traveling-wave tube (TWT) and the backward-wave oscillator (BWO), both of which had wide-band capabilities. The continuous wave (CW) magnetron also was developed and saw use in microwave ovens starting in the mid-1950s. All of these sources have seen improvement over the years: higher power, better efficiency, wider bandwidth, lower noise figure for BWOs, longer lifetime, and/or extension to higher frequencies. Wong [11] authored a good discussion of tube advances.

Many of the breakthroughs, however, were in the solid-state source area. The 1960s saw the invention of the Gunn (transferred electron device) and impact ionization avalanche transit time (IMPATT) diodes, both of which have seen extensive use to this date. The GaAs Gunn diode gives a low-power signal having a clean spectrum, often used in local oscillators at frequencies as high as 100 GHz or higher [12]. The InP Gunn version offers advantages of going to higher millimeter-wave frequencies and of giving higher power [13], typically 200 mW or less. The IMPATT can provide an order of magnitude more power than the Gunn diode (and even to higher frequencies), but has a poor spectrum unless control techniques are employed [14]. When pulsed with a short pulse (e.g., 50 ns), thermal tuning of the diode junction can produce a frequency change of hundreds of megahertz. Both Gunn diodes and IMPATTs have been used in power combiners to increase the outputs. Transistors have seen steady improvement in power output, efficiency, noise-level, and frequency range.

A typical solid-state source provides milliwatts to watts of peak and average power. For really high powers, say, kilowatts to megawatts peak, one must resort to tube sources. In the 1960s, major conferences were held to concentrate on megavolt electronics and exotic proposed techniques for high-power sources. Out of the activity came the beginnings of work on gyrotron-type sources, which has continued in Russia since that time. In the last dozen years, many other countries, including the U.S., have mounted major research projects on gyrotron-related sources, and the field is now mature [11]. Gyrotrons provide the highest average and peak powers available (peak powers as high as 1 MW), except for burst-mode devices and, in addition, are more efficient than most other sources.

### *C. Passive Components and Devices*

In the 1950s, a great emphasis was placed on investigating various waveguiding concepts. Enclosed hollow-metal waveguide had been investigated in the 1930s at Bell Laboratories and MIT. Schelkunoff at Bell had shown theoretically that, in circular metal waveguide, there was a field configuration, the $\mathrm{TE}_{01}$ mode, which exhibited an attenuation that decreased monotonically with increasing frequency. The $\mathrm{TE}_{01}$ mode is a higher order mode, difficult to maintain, and one that is converted to lower order modes at nonuniformities, discontinuities, and bends. Nonetheless, it held promise for low-loss long-distance communications, and a significant effort was put into development of components [15]. The interest in low-loss transmission spurred investigation of other waveguiding structures, particularly surface waveguides. These included dielectric waveguides, especially the dielectric image line [16], and coated or uncoated metal wires supporting the Goubau [17] or Sommerfeld [18] modes, all of which held promise for low-loss transmission at millimeter wavelengths. Goubau and Schwering invented the beam waveguide, and there was much research on quasi-optical transmission methods [19], [20]. A great deal of activity was concentrated on directional couplers and filter design. Reference [21] and the book by Matthaei *et al.* [22] was widely used and is referred to as a "classic." Development began on microwave acoustic devices, with application particularly to analog signal processing. Work on ferrite devices such as isolators, circulators, switches, and phase shifters continued, driven strongly by application on phased arrays, which began to be built in large sizes during the 1960s [23], [24]. The advent of phased arrays produced emphasis on small size and low cost of components. The development of transmit/receive modules at each element of phased arrays was a major thrust for many years under U.S. government programs. The first of these, in 1964, was a program to construct a feasibility model of a solid-state phased-array airborne radar employing integrated circuit transmit/receive modules [15], [25].

### *D. Microwave Integrated Circuits*

The development of microwave integrated circuits began as early as 1957 [15], [26], [27], and these involved components,

devices, planar transmission lines, sources, antennas, and material considerations (e.g., silicon versus gallium arsenide). Jack Kilby, an engineer at Texas Instruments Incorporated, who later shared the 2000 Nobel Prize in physics, initiated much of the early integrated circuits work. Of course, over the years, an enormous amount of funding and effort have gone into the work on microwave integrated circuits, culminating in the U.S. in major Department of Defense focused projects, such as the microwave and millimeter-wave monolithic integrated circuit (MIMIC) program and others.

### *E. Millimeter-Wave Technology*

Research in coherent millimeter and submillimeter-wave technology began shortly after World War II [10] and has continued to this day. As with microwave integrated circuits, a huge amount of effort has been applied in this field. Major conferences have been conducted, almost on an annual basis, for three decades. Major journals have regularly concentrated on such material, and thousands of articles have been written on these subjects. Investigations have included radar, communications, radiometry, missile guidance, spectroscopy, atmospheric sensing, and satellite imagery; however, applications are relatively scarce compared with the enthusiasm of investigators. One of the most fertile areas has been radio astronomy [28], [29], where important fundamental discoveries have been made.

## VI. Summary

This article has covered the early history of the IEEE MTT-S, the development of its awards program, recent changes due to growth of the organization and multinational participation, and a brief discussion of the early technology trends. Tables have been included, which list all of the AdCom members and presidents/chairmen, this TRANSACTIONS' editors, *IEEE Microwave Newsletter* editors, awards recipients, distinguished lecturers, and International Microwave Symposium sites and chairpersons. The authors were limited by editorial policy for this Special Issue to a total of ten pages, and of these, the tables occupy over one-half of those allowed. Thus, the actual historical description has, of necessity, been limited. However, the references offer opportunity to obtain additional details; in particular, the paper by Sobol and Tomiyasu [15] gives a chronicle of microwave history over approximately 100 years, up to 1980. The tutorial articles in the PROCEEDINGS OF THE IEEE are also an excellent historical resource. Within the page limitations of this TRANSACTIONS, it is hoped that serious omissions have been avoided, but if there are any, the authors wish to apologize in advance for them.

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