1983 Steele Prizes Awarded in Albany

A bequest from the estate of Leroy P. Steele, a graduate of Harvard College in the class of 1923, has provided funds for prizes awarded by the Society each summer in honor of George David Birkhoff, William Fogg Osgood and William Caspar Graustein.

At the Summer Meeting in Albany three prizes, each worth fifteen hundred dollars, were awarded in the following categories:

(1) For a book or substantial expository paper. This award was made to PAUL R. HALMOS for his many graduate texts in mathematics and for his articles on how to write, talk and publish mathematics.

(2) For a paper, whether recent or not, which has proved to be of fundamental importance in its field, or a model of important research. STEPHEN C. KLEENE received this award for three important papers published in 1955 which formed the basis for later developments in generalized recursion theory and descriptive set theory.

(3) For the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students. The 1983 recipient is SHIING-SHEN CHERN.

These prizes were awarded by the Council of the American Mathematical Society, acting on the recommendations of the Committee on Steele Prizes. The members of the Steele Prize Committee were Stuart Antman, H. Jerome Keisler, Martin D. Kruskal, Yiannis N. Moschovakis, Louis Nirenberg, Alex Rosenberg (Chairman), Max M. Schiffer, Edwin H. Spanier and Gail S. Young, Jr.

The text which follows includes, for each of these awards, the Committee's citation, the recipient's response on the presentation of the prize, and a brief biographical sketch of the recipient.

Paul R. Halmos

Citation for Expository Writing. The award for a book or substantial survey or research-expository paper is made to PAUL R. HALMOS for his many graduate texts in mathematics, dealing with finite dimensional vector spaces, measure theory, ergodic theory and Hilbert space. Many of these books were the first systematic presentations of their subjects in English. Their felicitous style and content has had a vast influence on the teaching of mathematics in North America. His articles on how to write, talk and publish mathematics have helped all mathematicians to communicate their ideas and results more effectively.

Response. Not long ago I ran across a reference to a publication titled *A method of taking votes on more than two issues.* Do you know, or could you guess, who the author is? What about an article titled *On automorphisms of compact groups*? Who wrote *that* one? The answer to the first question is C. L. Dodgson, better known as Lewis Carroll, and the answer to the second question is Paul Halmos.

Lewis Carroll and I have in common that we both called ourselves mathematicians, that we both strove to do research, and that we both took very seriously our attempts to enlarge the known body of mathematical truths. To earn his living, Lewis Carroll was a teacher, and, just for fun, because he loved to tell stories, he wrote *Alice's*

Paul R. Halmos

adventures in wonderland. To earn my living, I've been a teacher for almost fifty years, and, just for fun, because I love to organize and clarify, I wrote *Finite dimensional vector spaces.* And what's the outcome? I doubt if as many as a dozen readers of these words have ever looked at either *A method of taking votes ...* or *On automorphisms ...*, but Lewis Carroll is immortal for the Alice stories, and I got the Steele Prize for exposition. I don't know what the Reverend Mr. C. L. Dodgson thought about his fame, but, as for me, I was brought up with the Puritan ethic: if something is fun, then you shouldn't get recognized and rewarded for doing it. As a result, while, to be sure, I am proud and happy, at the same time I can't help feeling just a little worried and guilty.

I enjoy studying, learning, coming to understand, and then explaining, but it doesn't follow that communicating what I know is always easy; it can be devilishly hard. To explain something you must know not only what to put in, but also what to leave out; you must know when to tell the whole truth and when to get the right idea across by telling a little white fib. The difficulty in exposition is not the style, the choice of words—it is the structure, the organization. The words are important, yes, but the arrangement of the material, the indication of the connections of its parts with each other and with other parts of mathematics, the proper emphasis that shows what's easy and what deserves to be treated with caution—these things are much more important.

But there I go again being expository—or should I say meta-expository? Enough of this foolishness; I think I had better stop now and go prove a theorem about automorphisms of compact groups.

Biographical Sketch

Paul Richard Halmos was born March 3, 1916, in Budapest, Hungary. He received a B.S. in 1934, an M.S. in 1935, and a Ph.D. in 1938, all from the University of Illinois. In 1980 he received an honorary D.Sc. degree from the University of St. Andrews. He was instructor of mathematics at the University of Illinois in 1938-1939. He then went to the Institute for Advanced Study, first as a fellow (1939-1940), then as an assistant (1940–1942). He returned to the University of Illinois as an associate in mathematics for 1942-1943. From 1943 to 1946 he was assistant professor at Syracuse University. In 1946 he became assistant professor at the University of Chicago, advancing to the rank of professor in 1956. From 1961 to 1968 he was a professor at the University of Michigan, then spent the year 1968-1969 as professor and department chairman at the University of Hawaii. In 1969 he became a professor at Indiana University at Bloomington, where, except for a two-year interruption, he has been Distinguished Professor of Mathematics since 1970. The interruption was from 1976 to 1978 when he was professor at the University of California in Santa Barbara. He has held visiting positions for one or more terms at Tulane University (1951), University of Montevideo (1951-1952), University of Washington (1959), University of Miami (1965-1966), University of Edinburgh (1973), and University of Western Australia (1975).

Professor Halmos has been a member of the Council of the Society, off and on, for over thirty years, in a wide variety of positions: as member-at-large of the Council (1950 to 1952, 1957 to 1959, and 1983), as vice president in 1981 and 1982, and as a member of the following editorial committees: *Proceedings* (1958 to 1963), *Mathematical Reviews* (1964 to 1969), *Mathematical Surveys* (1973 to 1975), *Bulletin* (1974 to 1979; Chairman, 1977, 1978). He has been elected to four terms on the Executive Committee of the Council (1959–1960, 1965, 1974, 1983). In addition, he has served on more than a score of AMS committees.

He has also served on the editorial boards of several journals. Currently he is Editor of the *American Mathematical Monthly* and on the board of the *Indiana University Mathematics Journal* and *Journal für die Reine und Angewandte Mathematik* (Crelle's Journal). He has been an editor of *Ergebniße der Mathematik*, and currently he is on the editorial board of Graduate Texts in Mathematics, Undergraduate Texts in Mathematics, and Problem Books in Mathematics.

Professor Halmos has given invited addresses at AMS meetings in Chicago (November 1948) and East Lansing (September 1960). He spoke at Special Sessions on Operator Theory at the Annual Meetings in Atlanta (January 1978) and Biloxi (January 1979), and on C^*-Algebras and Operator Theory at the Annual Meeting in San Antonio (January 1980). He also organized the Special Session on Compact Perturbations of Operators at the Annual Meeting in Dallas (January 1973), and spoke at the Symposium on Lattice Theory in Monterey, California (April 1959).

Professor Halmos held a Guggenheim Memorial Foundation Fellowship at the Institute for Advanced Study in 1947-1948. In 1947 he was awarded the Chauvenet Prize for mathematical exposition by the Mathematical Association of America, and he received the Lester R. Ford Award for mathematical exposition twice, in 1970 and in 1977. He was a member of the staff of the Radiation Laboratory at the Massachusetts Institute of Technology in 1945. He has been the AMS representative to the Division of Physical Sciences of the National Research Council (1958 to 1961), AMS representative on the Conference Board of the Mathematical Sciences (1958 and 1959), and AMS representative to the Conference in Washington on the Gilliland Report (1963). He is a member of the Mathematical Association of America, a fellow of the Royal Society of Edinburgh and a member of the Hungarian Academy of

Science. His major research interests are ergodic theory, algebraic logic, and operators on Hilbert space.

Stephen C. Kleene

Citation for Important Works. The award for a paper, whether recent or not, which has proved to be of fundamental or lasting importance in its field, or a model of important research, is presented to Stephen C. Kleene for the following series of papers:

Arithmetical predicates and function quantifiers, Transactions of the American Mathematical Society **79**(1955), pages 312 to 340.

On the forms of the predicates in the theory of constructive ordinals (second paper), American Journal of Mathematics **77**(1955), pages 405 to 428.

Hierarchies of number-theoretic predicates, Bulletin of the American Mathematical Society **61**(1955), pages 193 to 213.

These papers have had a profound influence on mathematical logic for three decades and form the basis for two of the most active areas of current research: generalized recursion theory and descriptive set theory.

Response. When one does work that turns out to be seminal—to lead to far-reaching developments—one has had the fortune to have been working in a context in which such developments were implicit. I was lucky enough to have been at the right place mathematically at the right time.

Stephen C. Kleene

For this I am indebted first of all to Alonzo Church, whose set of postulates for the foundation of logic (1932 and 1933) included as a subsystem the λ-calculus, in terms of which the fertile idea of λ-*definability* was distilled by Church and me. Furthermore, it was he who first had the courage to propose that the λ-definable functions provide an exact characterization of the class of the number-theoretic functions which are "effectively calculable", or in other words for which there are "algorithms" in the somewhat vague sense which has come down through over two thousand years of mathematical history. This became famous as "Church's thesis", first published by him in 1936. Later and independently, Alan Turing (1937) reached the thesis with another characterization, the "Turing computable functions".

Secondly, I am indebted to Kurt Gödel, for introducing me in 1931 to the *primitive recursive functions* (which had been around since Dedekind and Peano) with an exact description of his own, and then to the *general recursive functions* which he defined in 1934 modifying a 1931 suggestion of Jacques Herbrand. Gödel held back from accepting Church's thesis until after Turing's version of it had appeared in 1937. (I showed in 1936 that the general recursive functions are coextensive with the λ-definable functions, and Turing showed in 1937 that the latter are coextensive with his computable functions.) After Gödel's introduction in 1934 of the general recursive functions, I found them to provide a happy format in which to develop the theory of the effectively calculable functions.

Thirdly, I am indebted to L. E. J. Brouwer. His intuitionism (extending perceptions of Kronecker and Poincaré) constituted a different and older manifestation of constructivism than the theory of general recursive (or λ-definable or Turing computable) functions. Actually, it was in my 1950 International Congress paper, *Recursive functions and intuitionistic mathematics*, written in pursuit of my continuing project (begun in 1941) for relating these two manifestations of constructivism, that I took the step of generalizing recursiveness to allow type-1 variables, which forms the subject of the first of the papers cited now. In both the second and third of those papers (though they are quite classical, in contrast to intuitionistic), I used a construction that I mined from Brouwer's work. Indeed, one speaks now of "the Brouwer-Kleene ordering".

You will perhaps be amused by some recollections of mine from the time of writing the three papers.

The paper cited second has the words "(*second paper*)" concluding its title. What was the first

paper under that title? It was a 1944 paper perpetrating a mammoth mathematical mistake, I think the only such in my career. (Of course, I have also made some flea-sized mistakes.) That mistake has been compared to a mistake of Lebesgue, who in his classic paper of 1905 on the theory of definability obtained a noteworthy result by an argument which has since been described as "simple, short but false". The wrong step in his proof was hidden in a lemma taken as trivial. Ten years later, the error was spotted by Suslin, then a student of Lusin at Moscow.

My chagrin at having made a fundamental mistake was diminished by my having been the one to recognize it as a mistake half a dozen years later. As Yiannis Moschovakis said on page 444 of his 1980 book *Descriptive set theory* (from page 2 of which I have taken my information about Lebesgue's mistake), "Kleene was his own Suslin." Thus my first paper *On the forms of the predicates in the theory of constructive ordinals* had got by the American Journal's referee. I could name several prominent American logicians who had heard me present my result in seminars, and one who had made it the subject of a seminar talk of his own, without perceiving any error. Andrzej Mostowski in his 1947 paper had developed independently of my 1943 paper the arithmetical hierarchy, into which my 1944 paper proposed to fit the predicates in question. After I informed him that the result I had claimed to have in 1944 was not proved, he wrote me from Warsaw on Christmas day in 1952, "I was very astonished to learn that there is a flaw in your paper on the form of the predicates in the theory of constructive ordinals. I have read the paper very carefully /as it then seemed to me/ and did not remark anything suspicious. ... It seems to me that problems treated in your paper in question may be of vital importance ... for certain plans of scientific work which I hope to start ... soon ... ."

The situation was subtler than I had supposed in 1944; and in the second paper under the same title (1955) a deeper and more interesting result—shall I say a seminal result—was substituted for the result claimed in the first paper.

I will tell you that, when I submitted that second paper to the American Journal, its referee gave me a very rough time. Here was a complicated paper by an author who was admitting that his previous paper in the Journal was wrong—not *all* wrong (as much of the work in it was still used), but wrong in one crucial step and in its main result, based on that step. It seemed to me the referee was determined that this second paper should not get into print. But he couldn't quite pin down a mistake in the new paper, try as he would—nor has anyone since.

What keeps a mathematician working at problems until, if he is lucky, he solves them? I had worked unsuccessfully off and on for a year on the problem whose solution forms the key result of the third paper cited now for my Steele Prize. As I remember it, one Monday I said to myself, "If I don't solve the problem this week, I won't waste any more time on it." Whether I would have lived with this resolve I don't know. But as it turned out, it was just before supper on the last day of the week that I had an idea, which, when I tried it out after supper and in the next few days, provided the solution.

I will conclude with reminiscences about a very uninhibited and outspoken graduate student I had in those years. When he arrived in Madison, I put him to work reading the first printer's proof of my book *Introduction to metamathematics*. He absolutely gloated when he found something wrong in it. I feigned humility, figuring that the more pleasure it gave him to correct me, the harder he would search for other errors. At that time, I had not been very productive of research papers, as the book had been taking up my time. One day he said to me, "Kleene, you know (don't you?) that there is such a thing as a mathematical menopause!" In the next couple of years I put in his hands, for reading, the manuscripts of the three papers now being cited for this Steele Prize. Thank you very much!

Biographical Sketch

Stephen Cole Kleene was born January 5, 1909, in Hartford, Connecticut. He received an A.B. from Amherst College in 1930 and a Ph.D. from Princeton University in 1934 for a thesis written under the direction of Alonzo Church. He received an honorary Sc.D. degree from Amherst College in 1970. After spending the spring semester of 1933-1934 and the year 1934-1935 as a research assistant in mathematics at Princeton University, Professor Kleene went to the University of Wisconsin, Madison, first as an instructor and then as an assistant professor. From 1941 to 1942 he was an associate professor at Amherst College. After service in the U.S. Navy (which included directing an applied mathematics group at the Naval Research Laboratory, 1943–1945), he returned to the University of Wisconsin in 1946 as associate professor of mathematics, becoming professor in 1948. He served as chairman of the department (1957-1958, 1960–1962), as chairman of the Department of Numerical Analysis (1962-1963), and as acting director of the Mathematics Research Center (1966-1967). In 1964 he was named Cyrus Colton MacDuffee Professor of Mathematics; in 1974 "and Computer Sciences" was added to this title. During this time he also served as dean of the College of Letters and Science (1969–1974). Since 1979 he has been Emeritus Professor of Mathematics and Computer Science and Emeritus Dean of Letters and Science at the University of Wisconsin, Madison.

Professor Kleene gave invited addresses at AMS meetings in Chicago (April-May 1954), the published text of which is the third of the papers cited for this Steele Prize, and at Kenosha,

Wisconsin (October 1980). He also gave a 60-minute talk at the 1958 International Congress of Mathematicians in Edinburgh. Between 1948 and 1983, he gave a dozen invited addresses at international meetings of logicians, philosophers and computer scientists.

Professor Kleene held a Guggenheim Memorial Foundation Fellowship in 1949-1950, residing at Amsterdam during the spring semester. He was a member of the Institute for Advanced Study (1939-1940, 1965-1966), a visiting professor at Princeton University (1956-1957), and held a National Science Foundation Grant at the University of Marburg in 1958-1959. He was a member of the Mathematics Division of the National Research Council (1957-1958) and was chairman designate of its Division of Mathematical Sciences (1969–1972), continuing one more year as a member (1972-1973).

He was vice president of the Association for Symbolic Logic (1942, 1947–1949) and president (1956–1958), and consulting editor of the Journal of Symbolic Logic (1936–1942, 1946–1949) and editor (1950–1962).

He was president both of the International Union of History and Philosophy of Science (1961) and of its Division of Logic, Methodology and Philosophy of Science (1960–1962).

Professor Kleene was elected to the National Academy of Sciences (1969), and to the American Academy of Arts and Sciences (1980).

His major research interest is recursive functions, but he has also contributed to proof theory and to the theory of finite automata.

Shiing-Shen Chern

Career Citation. The award for cumulative influence of the total mathematical work of the recipient is made to Shiing-Shen Chern who, for half a century, has been a leader in the field of differential geometry. His work is both deep and elegant, a typical example being his intrinsic proof of the Gauss-Bonnet Theorem. Professor Chern has extremely broad interests and has made very important contributions to such diverse areas as web geometry, integral geometry, complex manifolds, minimal submanifolds and characteristic classes.

He is also an outstanding teacher. He has directed about fifty doctoral theses, first in China, then at the University of Chicago and, from the early sixties to the present, at the University of California, Berkeley. Many of his students have gone on to become famous in their own right.

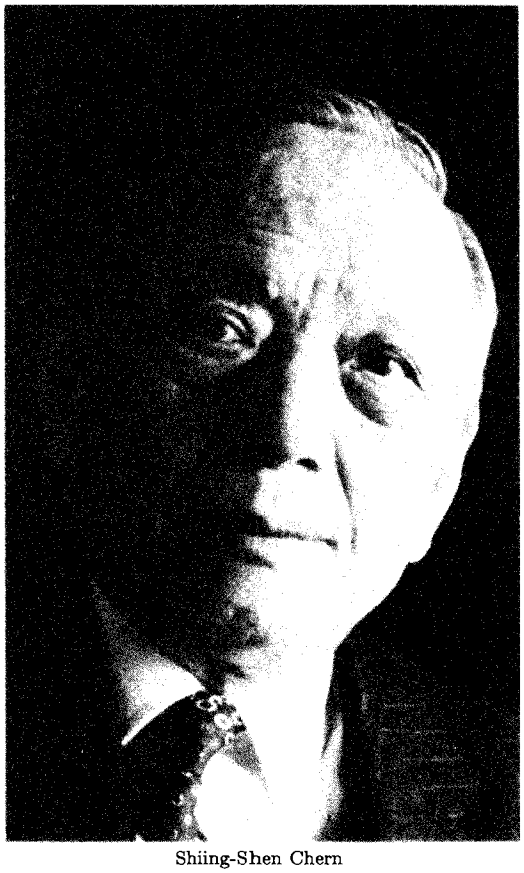
His research and teaching have exerted a deep and lasting influence on mathematics.

Response. I am very grateful to be awarded a Steele Prize for my cumulative work. Such a prize is by definition given to an old mathematician. I think it appropriate because old mathematicians need encouragement.

My appreciation of the prize goes further. Looking at the distinguished list of past recipients, I wonder whether it makes sense for the Society to publish a book on the Steele Prizes. It could include, among other materials, the autobiographies or biographies of the recipients who receive the prizes for their cumulative works and articles on the developments initiated by the seminal papers for which the prizes are given. I believe such a book will be of both mathematical and historical interest.

Biographical Sketch

Shiing-Shen Chern was born October 26, 1911, in Kashing, China. He received a B.S. degree from Nankai University in 1930, an M.S. from Tsing Hua University in 1934, and a D.Sc. from the University of Hamburg in 1936. His honorary degrees include LL.D. from the Chinese University of Hong Kong (1969), D.Sc. from the University of Chicago (1969), D.Sc. from the University of Hamburg (1971) and D.Math. from the Eidgenossische Technische Hochschule in Zürich (1982). From 1937 to 1943, he was professor of mathematics at Tsing Hua University in China. He served as professor of mathematics at the Academia Sinica from 1946 to 1948, then at the University of Chicago from 1949 to 1959. In 1960 he became professor at the University of



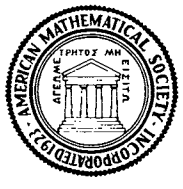
Shiing-Shen Chern

California, Berkeley, where he served until 1980. He is now Professor Emeritus at Berkeley. Since 1982 he has been Director of the Mathematical Sciences Research Institute in Berkeley.

Professor Chern served the American Mathematical Society as vice president in 1963 and 1964. In addition he has been active on many AMS committees, including the Committee on Summer Institutes (1953–1956; 1975–1976); the *Proceedings* Editorial Committee (1956–1958); the *Transactions* and *Memoirs* Editorial Committee (1957–1959); the Selection Committee for Expository Articles in the *Bulletin* (1962–1966); the Invitations and Organizing Committee for the Summer Institute (1962 and 1963); the Committee to Select Hour Speakers for Annual and Summer Meetings (1963 and 1964); the Committee to Award the Veblen Prize (Chairman, 1966; 1976); the Organizing Committee on the 1968 Summer Institute on Global Analysis; the Committee on Steele Prizes (1970–1972); the *Colloquium* Editorial Committee, 1972–1977 (Chairman, 1974); the Organizing Committee for the 1973 Summer Research Institute (Chairman); the Committee on Summer Institutes (1976); and the AMS Subcommittee of the AMS-IMS Committee on Translations from Russian and Other Foreign Languages (1979–1981).

Professor Chern gave invited hour addresses at the Summer Meeting in New Brunswick, New Jersey (September 1945) and at the Annual Meeting in Houston (December 1955). He gave one-hour talks at two International Congresses: in Cambridge, Massachusetts in 1950 and in Nice in 1970, and a thirty-minute talk in the Congress at Edinburgh in 1958. He spoke at the Summer Institute on Entire Functions and Related Parts of Analysis (San Diego, June 1966) and at the Special Session on Entire Functions and Related Parts of Analysis (Annual Meeting, Houston, January 1967). He also delivered the Colloquium Lectures at the Summer Meeting of the Society in East Lansing in September 1960.

Professor Chern held Guggenheim Memorial Foundation Fellowships in 1954-1955 and in 1967 and was an AMS representative to the Editorial Board of the *Duke Mathematical Journal* (1953–1955). He was awarded the Chauvenet Prize of the Mathematical Association of America in 1970 and the National Medal of Science in 1976. He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the Mathematical Association of America, and the Academia Sinica. The areas of his major research interest include differential geometry, integral geometry, and topology.



OPERATOR ALGEBRAS AND *K*-THEORY

edited by *Ronald G. Douglas* and *Claude Schochet*

In the last twenty years there has been more and more interplay between functional analysis and algebraic topology, and, more specifically, between operator algebras and *K*-theory. This interplay has led already to the index theorem for elliptic operators, the classification of essentially normal operators, the index theorem for foliations, as well as a host of other related results.

A Special Session in Operator Algebras and *K*-Theory was held at the annual AMS meeting in San Francisco on January 7-8, 1981. The present volume represents nearly all of the talks given, one extra paper by an honorary participant, and a list of problems edited by Edward G. Effros.

The book is intended for mathematicians and graduate students. Several of the articles are partially or totally expository in nature, requiring a very modest background. Others are research articles for the specialist. These papers delineate a new field of study and describe various directions of new research. They should make it possible for others to enter the field.

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