

FOREWORD

Alfred Tarski has been known to four generations of logicians and students as a scholar of extraordinary breadth and depth. His influence on the development of foundational studies in logic, mathematics, and the philosophy of science is due not only to his own investigations and numerous writings, but also to his influence as a teacher and a source of energy and organization in the international scientific community during the past half century. It was only natural, therefore, that as his 70th birthday approached the idea should have arisen in many quarters to utilize the occasion for an international symposium, not only to render public acknowledgement of Tarski's immense contribution, but to assess the impact and present status of the many domains to which he put his hand.

The symposium was held at the University of California, Berkeley, during June 23-30, 1971. The University joined with two international organizations in sponsoring the event: The Association for Symbolic Logic, and the International Union for the History and Philosophy of Science—Division of Logic, Methodology, and the Philosophy of Science. The major source of support was the National Science Foundation.

Robert Vaught, a colleague and former student of Tarski's, served as the Chairman of the Organizing Committee. When he arose at the opening session of the Symposium he spoke of the enthusiasm evinced by all who had been asked to help in preparing for the event. There was an almost tangible feeling of admiration and friendship for Tarski which bound together the 300 or so registered participants, a feeling that informed the meetings with a sense of liveliness impossible to convey in this volume which sets forth the principal scientific contributions of the invited speakers.

The Symposium Organizing Committee consisted of the following: J. W. Addison, Rudolf Carnap, C. C. Chang, Alonzo Church, Paul Cohen, William Craig, Solomon Feferman, Kurt Gödel, Leon Henkin, Bjarni Jónsson, H. Jerome Keisler, Stephen C. Kleene, Roger C. Lyndon, Richard Montague, Andrzej Mostowski, W. V. Quine, Abraham Robinson, Julia Robinson, Dana Scott,

Robert Vaught.¹ This group set up the policies within which the symposium was developed, and delegated the working out of details to a Symposium Executive Committee consisting of Addison, Chang, Craig, Henkin, Scott, and Vaught (Chairman).

From the beginning, the main problem of the Executive Committee was to cope with the wealth of ideas to which Tarski had given impetus, and somehow to encompass these in a coherent meeting of one week's duration. An early list drawn up by the Committee of the principal areas in which Tarski had worked, read as follows: general theory of algebras, foundations of geometry, algebraic logic, theory of models, metamathematical applications to algebra, decision methods, undecidable theories, classical set theory, foundational investigations in the theory of sets, philosophy and methodology of deductive sciences, measure theory, nonclassical logic, infinitary logic, definability. Realizing that this list was still not comprehensive—where, for example, would we fit in Tarski's work in sentential logic, or in the algebra of topology?—the Committee nevertheless looked at its list in awe, and wondered whether to seek to expand the Symposium from a week to a month.

In the end, practical considerations constrained the meeting to eight days. A good number of scholars who clearly should have been present could not be accommodated, or in some cases were unable to attend. Altogether 35 papers were presented in response to invitations from the Executive Committee to speak in specified areas, and another 25 papers were presented in sessions open for contributed work by participants. The programs of these two series of papers, as presented, are given immediately following this Foreword. Several of the invited addresses, at the express request of the Organizing Committee, took the form (at least in part) of a survey—either of the current literature, or of the historical development—of some area of foundational studies. In particular, the papers of the following speakers encompassed surveys of the indicated fields: Rabin (decidability), Julia Robinson (undecidability), Mostowski (set theory), Chang/Vaught (model theory), and Jónsson (general algebra). A portion of the papers of Henkin/Monk and of Hanf were devoted to surveys of the algebras of logic, and of Boolean algebra, respectively. The last five invited papers on the program, presented on the afternoon of June 30, were given (at the invitation of the Executive Committee) within a Symposium on Truth in Natural and Formal Languages.

In addition to the invited addresses and the contributed papers, a great many informal meetings and conversations contributed to the total scientific impact of the symposium. Students, professors, and other research workers from Canada, France, Israel, Poland, England, Hungary, Germany, China, India, Sweden, Egypt, and Japan, as well as from all parts of the United States, attended the symposium and took part in the many discussions. An invited speaker from the

¹Regretfully, Carnap and Montague did not live to see the symposium to whose organization they contributed.

USSR regretfully had to withdraw at the last moment. Among the formal events listed in the symposium program were a reception tendered by the University of California to participants, a two-day excursion to the Monterey Peninsula, and a banquet on the last evening. At the banquet gifts were presented to Professor Tarski, Mrs. Tarski, Mrs. Dale Ogar, Secretary of the Symposium, and Mrs. Roselyn Witherspoon, Assistant Secretary.

The list of papers in this volume differs in several respects from the program as presented at the symposium itself. The papers of Bernays, Birkhoff/Lipson, Cohen, Eršov, Karp, Schwabhäuser/Szczerba, Jan Tarski, and Woodger were included in this volume by invitation of the Organizing Committee, although not presented at the symposium itself. The symposium papers of Chang/Vaught and of Adams/Suppes were separated and each appears here as two distinct contributions. The papers of Erdős and of McKenzie were enriched through the collaboration of Hajnal and Shelah, respectively. The following symposium speakers chose a different title for their published contributions: Erdős/Hajnal, Feferman, Fraïssé, Gaifman, Keisler, Levy, McKenzie/Shelah, Mostowski, Shelah, Szmielew. Regretfully, the authors of several excellent talks delivered at the symposium are not represented by papers in this volume: Ax, Davidson, Jensen, Kaplan, Rabin, and Julia Robinson.

Special mention should be made of the role of Alfred Tarski in connection with these PROCEEDINGS. As an invited speaker, he was of course asked to contribute a paper to the volume. He agreed to do so, but elected to write on a subject different from the foundations of geometry, on which his symposium talk was based. In fact, the title he chose for his paper was *A formalization of set theory without variables*. Although this title suggests a rather specialized study, the material of the paper as Tarski developed it ranged widely over the foundations of mathematics. Appropriate to its scope, the length of the paper grew beyond what could be accommodated in this volume. Accordingly, the Editors recommended that it be published not as a part of the symposium proceedings, but as a separate companion volume to appear also in the American Mathematical Society series *PROCEEDINGS OF SYMPOSIA IN PURE MATHEMATICS*. Author and publisher agreed, and the two volumes will inaugurate a subseries of the AMS series to be co-sponsored by the Association for Symbolic Logic.

The arrangement of papers within this volume may be described roughly as an ordering which moves from algebraic to set-theoretical aspects of the foundations of mathematics, then proceeds to philosophical questions, and finally arrives at deductive aspects of empirical sciences. A more detailed description now follows.

We begin with Jónsson's survey of recent work in the general theory of algebraic structures. Gaifman next deals metamathematically with general operations on algebraic structures. The Birkhoff/Lipson paper deals with structures having several domains of elements, there follow papers by McKenzie/Shelah, Hanf, Craig, and Henkin/Monk, dealing with special classes of algebraic structures, and

then come papers by Szmielew and Schwabhäuser/Szczerba on geometric structures. A re-examination of the decision problem for elementary algebra and geometry, by A. Robinson, then follows.

Several papers on model theory are introduced by an historical survey, split at the year 1945 between the papers of Vaught and Chang. Shelah's paper deals with a problem of first-order model theory, while Feferman's is concerned with a variety of languages and those of Karp, Morley, and Fraïssé are involved in part or in whole with models of infinitary languages. Eršov deals with models of equational logic, and Ehrenfeucht deals with highly nonclassical logics arising from the ultra-intuitionistic studies of Essenin-Volpin.

The first of a series of papers on set theory is a survey of problems and results by Erdős/Hajnal. Then come axiomatic studies by Bernays, Church, and Levy, followed by examinations of models of set theories by Cohen, Keisler, Mostowski, Silver, and Solovay.

Philosophical papers by Quine, Mates, and Popper are focused on Tarski's theory of truth, Scott gives a reinterpretation of many-valued logic, and then Adams, Jan Tarski, and Suppes deal with the employment of the methodology of deductive sciences in empirical theories. The last paper is a personal tribute to Tarski by Woodger, to whom all readers of this volume are grateful for his translation of Tarski's early papers as well as for his own foundational research.

The volume closes with a list of Tarski's doctoral students, and a bibliography of his published work to date.

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