Foreword

DEVICE research and development is being driven by perceived needs for some existing and potential applications. Commercial magnetometer systems based on Josephson devices are in existence. Early work on these systems employed point contacts but it has become clear that more reliable thin-film devices can and must be used. Likewise, the early work on detection of electromagnetic signals depended on the conveniently fabricated point contact; but operating systems demand devices that are rugged and do not need adjustment. Although some clever schemes have been used to make point contacts more satisfactory, it is clear that thin-film devices made with well-controlled properties will be needed for operating systems. Recent studies, reported in this issue, also have shown that non-Josephson thin-film superconductive devices appear to have advantages for detection and mixing. The largest potential application for Josephson junctions is in digital circuits and a large amount of effort is going into research and development on the appropriate types of junction.

The order of the papers in this Special Issue has been chosen to tell the state of development of the applications first so that the desired circuit and device properties will be clarified. The major work on Josephson digital circuits has been done at the IBM Research Laboratories. The current state of development of logic circuits in the IBM project and elsewhere is reviewed by Gheewala. It is seen that circuits with switching speeds of a few tens of picoseconds and on the order of 0.1 fJ speed-power product can be realized. Memory cells for both cache and main memories are the subject of a review by Zappe. In the former, speed is essential and in the latter, density and lower power dissipation. A paper by Beha *et al.* deals with the design of a shift register. One of the proposed schemes for analog-to-digital conversion using Josephson devices is analyzed by Hurrell *et al.* Recent developments in magnetometers based on the Superconducting QUantum Interference Device (SQUID), in which detection sensitivities are approaching the quantum limit, are reviewed by Clarke. Richards and Shen present a summary of the uses of superconductive devices for millimeter-wave detection, mixing, and amplification. The emphasis is on single-particle tunneling for detection and mixing. Again, detection sensitivities approach the quantum limit. A detailed theoretical characterization of mixers based on the Josephson effect is presented by Taur. Levinsen *et al.* review experiments and theory for parametric amplification at 10, 35, and 70 GHz. Finally, Josephson oscillators, in which the Josephson junction is coupled to a resonant circuit, is the subject of an analysis by Stancampiano.

The dynamic behavior of elementary circuits containing Josephson junctions is treated in the next section. The first of these papers is on picosecond applications. McDonald *et al.* consider several aspects of the response of Josephson circuits to pulses and step functions as they explore the potentialities for picosecond circuits. This is followed by a paper by Dhong and Van Duzer which presents numerical and approximate analytic results for the minimum-length control current pulse required to switch single junctions and interferometer circuits. Large junctions can contain an array of flux quanta; the response of this array when current is applied to the junction is the subject of a study by Enpuku *et al.* in the final paper of this section.

The next set of papers deals with the fabrication and physics of Josephson junctions of various types. The first four papers are on tunnel junctions. A fairly extensive amount of effort has gone into the development of a technology employing lead alloys for Josephson junctions. This work has been mainly carried out at the IBM Research Laboratories; the latest developments are reported by Huang *et al.* A related ellipsometric study of the oxide formation on lead-indium alloys is presented by Donaldson and Faghihi-Nejad. Although considerable improvement has been achieved in the cyclability of the lead-alloy junctions and such soft metals are convenient and give good electrical characteristics, the rugged transition metals are an attractive alternative. The state of work on Josephson junctions with niobium-oxide tunneling barriers is reviewed by Broom *et al.* They indicate the remaining problems and note the excellent thermal-cycling properties. Beasley reviews work on tunnel junctions using high-T_c transition-metal compounds and alloys and points out that, although none of these materials are yet suitable for applications, considerable progress has been made. Another approach to the formation of barriers for Josephson junctions is to use semiconductors rather than oxides; Kroger reviews advances that have been made, indicating that both single-crystal and polycrystalline barriers show promise for applications. A new device configuration which employs a semimetal for coupling is reported by Ohta.

Short briefs on Josephson devices comprise the final set of contributions to this Special Issue. Hu *et al.* report the fabrication of tunnel junctions with areas as small as 10^{-10} cm^2. The dependence of the maximum zero-voltage current on noise is reported by Gutmann. Techniques for fabricating metal-connected junctions are described by Gamo *et al.* Finally, a new type of single-flux-quantum logic device is proposed by Tamura *et al.*

There are about three score laborers in the field whose con-

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tributions cannot be recognized individually. They are the reviewers, whose efforts have helped select the papers, remove errors, and sharpen the accuracy and clarity of presentation of the articles which appear in this issue. I would like to extend my thanks for their work and for willing response to requests for speed to meet the schedule.

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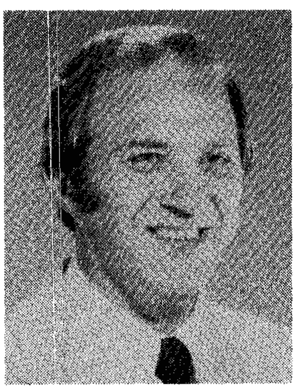
THEODORE VAN DUZER
Guest Editor



Theodore Van Duzer (S'52-A'54-M'60-SM'75-F'77) received the B.S. degree in electrical engineering from Rutgers University, New Brunswick, NJ, in 1954, the M.S. degree in engineering from the University of California, Los Angeles, in 1957, and the Ph.D. degree in electrical engineering from the University of California, Berkeley, in 1960.

He was a Member of the Technical Staff at Hughes Aircraft Company from 1954 to 1957 where his work included radar system studies and development of an electron-trajectory computer. In 1960 he was appointed Acting Assistant Professor of Electrical Engineering at the University of California, Berkeley. During 1960-1961 he was at the Technische Hochschule, Vienna, Austria, as a National Science Foundation Post-Doctoral Fellow. He returned to Berkeley as an Assistant Professor in 1961, and engaged in research in noise and focusing in crossed-field electron-beam amplifiers. During 1965-1966 he taught electromagnetic field theory and initiated a laser research project at the Catholic University of Chile, Santiago, as a part of a Ford Foundation program. He spent 1969-1970 at Rutgers University and Bell Telephone Laboratories in research on superconductivity. He was a Visiting Professor at Kyoto University and University of Paris during 1977-1978. He is currently a Professor of Electrical Engineering and Computer Sciences at Berkeley where he is engaged in teaching and research in solid-state devices and superconductivity. His current research emphasis is on Josephson devices and their applications. He has published numerous papers on electron devices, is co-author (with S. Ramo and J. R. Whinnery) of *Fields and Waves in Communications Electronics*, co-author (with C. W. Turner) of *Principles of Superconductive Devices and Circuits*, and is author and principal of an educational film, "Wave Velocities, Dispersion, and the ω-β Diagram."

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