

occurs. The circuits are fabricated as shown in Fig. 1(c). The response of the filter with  $L = (\lambda/8)$  is shown in Fig. 2, while the response of the circuit designed with  $L = (3\lambda/8)$  is shown in Fig. 3. Fig. 4 shows the two filters, with the  $\lambda/8$  filter in the test position in the jig.

As can be seen from the response curves, isolations are quite good for a single sphere device ( $>40$  dB at the design frequency) and can be designed to exhibit fair isolations over a relatively wide tuning range ( $\geq 20$  dB over a 3-GHz tuning range). Insertion losses can be reduced from those shown with improved design and optimized sphere placement (burying the sphere in the substrate, for example). The instantaneous bandwidth is that of a conventional YIG filter ( $\approx 27$  MHz). Input VSWR's are quite reasonable and would probably improve when the connectors and transitions are removed (as would be the case in an integrated circuit). The bias magnets have not been designed into the devices as yet, as data are still being gathered with a laboratory magnet. However, this laboratory has recently learned of a relatively new permanent magnet material, yttrium cobalt 5, developed under the sponsorship of the Air Force

Materials Laboratory, which has an energy product three times that of 74 percent platinum cobalt. It is therefore planned to design the required biasing structures around this material, possibly burying them within the substrate material.

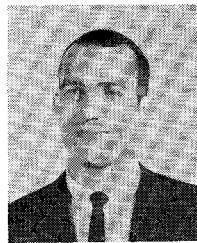
CARL K. GREENE

Air Force Avionics Laboratory  
Wright-Patterson Air Force Base  
Ohio 45433

#### REFERENCES

- [1] H. Skeie, "Nonreciprocal coupling with single-crystal ferrites," *IEEE Trans. Microwave Theory and Techniques*, vol. MTT-12, pp. 587-594, November 1964.
- [2] C. N. Patel, "Magnetically tunable nonreciprocal band-pass filters using ferrimagnetic resonators," *IRE Trans. Microwave Theory and Techniques*, vol. MTT-10, pp. 152-161, May 1962.
- [3] D. Flerl and G. Hanley, "Nonreciprocity in dielectric loaded TEM mode transmission lines," *IRE Trans. Microwave Theory and Techniques*, vol. MTT-7, pp. 23-27, January 1959.
- [4] W. W. Anderson and M. E. Hines, "Wide-band resonance isolator," *IRE Trans. Microwave Theory and Techniques*, vol. MTT-9, pp. 63-67, January 1961.
- [5] D. W. Lambrecht, "Mode conversion methods for strip transmission line nonreciprocal devices," AFIT Master's thesis, GE/EE/67A/5, March 1967.
- [6] B. Lax and K. J. Button, *Microwave Ferrites and Ferrimagnetics*. New York: McGraw-Hill, 1962.

## Contributors



**J. Lamar Allen** (S'57-M'62) was born in Graceville, Fla., on September 25, 1936. He received the B.E.E., M.S.E.E., and Ph.D. degrees in electrical engineering from the Georgia Institute of Technology, Atlanta, in 1959, 1961, and 1966, respectively.

From January, 1959, to June, 1961, he was with the Radar Section of the Georgia Institute of Technology, Engineering Experiment Station, where he worked on high-speed microwave radar scanners. From June, 1961, to September, 1963, he was employed by the Sperry Microwave Electronics Company, a Division of Sperry Rand Corporation, Clearwater, Fla., and worked on ferrimagnetic limiters and microwave filters. He was an Instructor at the School of Electrical Engineering, Georgia Institute of Technology, from September, 1963, to March, 1966. In April, 1966, he returned to the Sperry Microwave Electronics Division, where he is currently engaged in studies related to the design of microwave devices. He is also an Adjunct Professor in Electrical Engineering at the University of South Florida, Tampa.

Dr. Allen is a member of Sigma Xi.



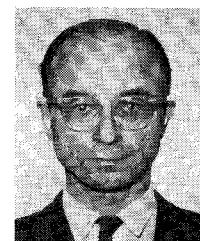
**Arthur Block** was born in Oak Park, Ill., on August 7, 1922. He received the B.Sc. degree from Elmhurst College, Elmhurst, Ill., in 1949. He served in the Air Force from 1942 to 1946, after which he was an Instructor at the DeVry Technical Institute, Chicago, Ill. From 1959 to 1962, he was Division Chief of the Satellite Transmitter Division of Dukane Corporation, St. Charles, Ill. He also worked as an engineer with Delta-f

the Diotron Corporation, where he developed high-speed gallium arsenide switching diodes and solar energy converters. In 1962 he joined Texas Instruments Incorporated as a Project Engineer in the Varactor Diode Development Activity. From 1963 through 1966 he held the position of Senior Engineer and later Applications Engineering Manager with Varian Associates, Bomac Division. While with Varian, he contributed to the development of numerous advanced microwave diode devices. He rejoined Texas Instruments in 1967, where he is responsible for the Advanced Microwave Diode Activity, a group concerned with the development of beam-lead microwave components and microwave integrated circuits. He has published several papers and holds two patents in the microwave diode field.

❖

Incorporated, Geneva, Ill., concerned with improving the stability of crystal controlled oscillators used in probes and satellites. He is currently Head of the Radio Frequency Techniques Section of NASA, Goddard Space Flight Center, Greenbelt, Md.

❖



**P. Bura** received the B.S.E.E. and M.S.E.E. degrees from the University of London, England, in 1949 and 1950, respectively.

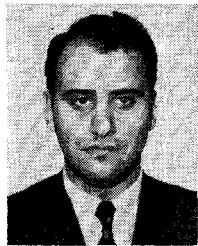
From 1954 to 1957, he was associated with Canadian General Electric and Canadian Westinghouse, where he was involved in the design and development of airborne radar and communications equipment. From 1960 to 1962, he was a Technical Specialist at ITT Laboratories, in charge of advanced development programs. He joined RCA Advanced Communications Laboratory, W. Windsor, N.J., as an Engineering Scientist, in 1962, where he is now conducting research on microwave integrated circuits. He has also worked on solid-state research, superconductivity, and parametric amplifiers.

❖

**T. F. Burke**, photograph and biography not available at time of publication.

**Barry W. Battershall** was born in New York, N. Y., on February 10, 1939. He received the B.S. degree in engineering physics in 1960 from Lehigh University, Bethlehem, Pa.

From 1960 to 1962 he was employed by



**Raymond Camisa** (M'68) received the B.S.E.E. degree in 1965, from the City College of New York, where he is currently working towards the M.S.E.E. degree.

At present, he is a member of the Technical Staff of the Advanced Microelectronics Laboratory of the RCA Advanced Communications Laboratory, W. Windsor, N. J., where he has worked on microwave integrated circuit devices, including parametric amplifiers. He has also worked on conventional varactor techniques, including high-level up-converters, multipliers, and amplifiers. He has published one technical paper.



Princeton, N. J., where he has worked on multivelocity flow problems in electron beams, microwave window problems, and integrated microwave techniques.

Mr. Daly is a member of Sigma Xi.

Since 1959 he has worked for RCA. During the first year he was in Microwave Products at Harrison, N. J. In 1960 he became a member of the Technical Staff of the RCA Laboratories, David Sarnoff Research Center,

volved in magnetometer development using nuclear and electron paramagnetic resonance phenomena. From 1961 to 1964, he was a Project Engineer at the General Electric Company, where he worked on the de-



velopment of array radar components, including phase-shifting devices for beam steering and automatic phase compensation, circulators, limiters, and isolators. He also worked on the development of ECCM devices using electron paramagnetic resonance (spin-echo devices). From 1964 to 1967, he was a Technical Director of Syracuse University Research Corporation, where he administered various projects in the areas of microminiaturization and magnetic integrated micro-circuits. He is currently President of ANAREN Inc., Syracuse, N. Y.

❖

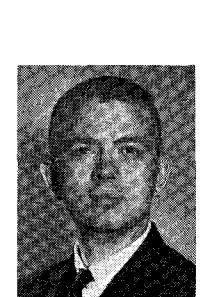


**Martin Caulton** (M'61-SM'65) was born in the Bronx, N. Y., on August 28, 1925. He received the B.S., M.S., and Ph.D. degrees in physics from the Rensselaer Polytechnic Institute, Troy, N. Y., in 1950, 1952, and 1954,



**W. F. Hoffman** (M'66) was born in Albany, N. Y., on May 3, 1936. He received the B.S. degree in physics from Arlington State College, Arlington, Texas, in 1964.

From 1964 to 1966 he was employed by Microwave Physics Corporation as a Design Engineer concerned with varactor diode measurements and parametric amplifiers. In 1966 he joined Texas Instruments Incorporated, Dallas, as a member of the Technical Staff, where he is presently involved in the design of microwave integrated circuits for the MERA module.



**Kenneth M. Johnson** (M'61) was born in Detroit, Mich., on October 13, 1935. He received the B.S. degree in physics from Wayne State University, Detroit, in 1957, and did graduate work in physics at the University of

California, Los Angeles, and at San Diego State College, San Diego, Calif., from 1957 to 1960.

At Hughes Aircraft Company, he assisted in the development of the first production-type S-band parametric amplifier. From 1960 to 1965, he was with Texas Instruments Incorporated, Dallas, Tex., doing extensive research in the field of solid-state modulation and demodulation of light. This work led to the discovery and development of the microwave avalanche photodiode, and to the receipt of the 1966 Browder J. Thompson IEEE Memorial Prize Award for his paper on the subject. From 1965 to 1966 he was

respectively.

From 1950 to 1953 he was an Instructor in physics at Rensselaer Polytechnic Institute. From 1953 to 1954 he was Research Associate, and simultaneously did part of his doctoral work in high-energy nuclear physics, at the Brookhaven National Laboratories, Upton, N. Y. From 1954 to 1955 he was a Fulbright Scholar at the Imperial College of Science and Technology in London. From 1955 to 1958 he was a member of the Technical Staff at Bell Telephone Laboratories, Inc., working in research and development on low-noise microwave tubes. In 1958 he became Assistant Professor of Physics at Union College, Schenectady, N. Y. Since joining RCA Laboratories, David Sarnoff Research Center, Princeton, N. J., in 1960, he has been engaged in work on microwave power tubes, multivelocity flow problems in electron beams, and microwave solid-state devices. He is a co-author of a textbook on physical electronics and is also Adjunct Professor of Electrical Engineering at Drexel Institute of Technology, Philadelphia, Pa.

Dr. Caulton is a member of the American Physical Society, American Association of Physics Teachers, and Sigma Xi.

❖



**V. G. Gelnovatch** (S'61-M'64), photograph and biography not available at time of publication.

❖

**Hugh A. Hair** was born in Prestwick, Scotland, on December 20, 1934. He received the B.S. degree in 1959 from the University of Glasgow, Glasgow, Scotland, where he is currently a candidate for the Ph.D. degree.

From 1959 to 1960, as a Ph.D. research student, he undertook, under contract to the Admiralty, a theoretical study of ferromagnetic microwave amplifiers. As a Research Engineer, from 1960 to 1961, at Bruce Peebles, Edinburgh, Scotland, he was in-

❖

**Daniel A. Daly** (M'68) was born in Doylestown, Ohio, on March 11, 1937. He received the B.S. degree in electrical engineering from Case Institute of Technology, Cleveland, Ohio, in 1959, and the M.S. degree in electrical engineering from Rutgers University, New Brunswick, N. J., in 1961.

with the Sylvania Electric Company, engaged in the development of a 5-watt micro-electronic S-band transmitter and varactor-tuned transistor oscillators. Since 1966 he has been with Texas Instruments Incorporated, working in the field of integrated microwave circuits, including the design of varactor frequency multipliers, image terminated mixers, and filters, and studying Gunn and avalanche diode effects for use with integrated microwave circuits.



**Stan Jones** was born in Rhyl, North Wales, on November 20, 1941. He received the B.Sc. degree in electrical engineering and the Ph.D. degree from the University College of North Wales, Bangor, in 1963 and

1967, respectively.

In January, 1967, he joined Texas Instruments Limited, Bedford, England, where he worked on the development of high-power VHF transistors. He was transferred to the Semiconductor Research and Development Laboratory of Texas Instruments Incorporated, Dallas, Tex., in June, 1967. He is currently assigned to advanced circuit development in the Microwave Diode and Millimeter-wave IC Section of the Microwave Research and Development branch, where he is working on design and measurement techniques for millimeter-wave monolithic and hybrid circuitry.

Dr. Jones is an associate member of IEE.



**Frank Z. Keister** was born in Harrisburg, Pa., on April 19, 1928. He received B.S. degrees in mechanical engineering and in engineering science from the University of Miami, Coral Gables, Fla., in 1952, and the M.S. degree from the University of Pennsylvania, Philadelphia, in 1958. He has done post-graduate work at the University of California, Los Angeles.

Since 1958, he has been with Hughes Aircraft Company, Culver City, Calif., where he is presently Supervisor of the Research and Development Group in the Microcircuit Facility. He has responsibility for microwave microcircuits, thin-film and thick-film materials evaluation and deposition methods, interconnections, and hybrid microcircuit packaging development. Prior to this he was Head of the Advanced Packaging Processes Group, where he worked on multilayer etched circuitry, welding and soldering evaluations, vacuum deposition techniques, and microelectronic packaging designs. Before joining Hughes, he was with Western Electric Company,

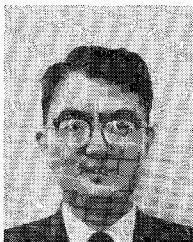
Winston-Salem, N. C., for six years, as a Development Engineer, where he engaged in studies on printed circuitry, mass soldering, fluxes, and encapsulation. He holds 3 patents and has published 25 technical papers, primarily in the areas of hybrid microcircuits and interconnections.



**Stanley P. Knight** was born in Bradford, Pa., on May 26, 1939. He received the B.S.E.E. degree from the University of Kentucky, Lexington, in 1961, and is studying for the M.S.E.E. degree at Newark College of Engineering, Newark, N. J.

Since 1961 he has been employed by RCA Astro-Electronics Division, Hightstown, N. J., where he has designed various spacecraft communication subsystems, ranging from telemetry equipment to command receivers and transmitters. He is currently in the Astro-Electronics Division Microwave Group and is a member of the RCA Corporate-wide Blue Chip Team. At present, he is on loan to RCA Laboratories, Princeton, N. J.

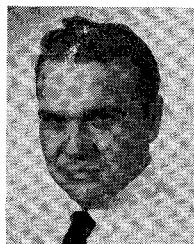
Mr. Knight is a member of Eta Kappa Nu and Tau Beta Pi.



**Shing Mao** (S'59-M'63) was born in Kiangsi, China, on May 21, 1935. He received the B.Sc. degree in electrical engineering from National Taiwan University, Taipei, Taiwan, in 1957, the M.Sc. degree in solid-state electronics from Carnegie Institute of Technology, Pittsburgh, Pa., in 1959, and the Ph.D. degree in microwave electronics from Stanford University, Stanford, Calif., in 1963.

In 1958, he worked with the Institute of Fluid Dynamics and Applied Mathematics, College Park, Md. From September, 1958, to June, 1959, he was a Buhl Fellow at Carnegie Institute of Technology. During the summer of 1959, he worked on junction field effect transistors at Westinghouse Semiconductor, Youngwood, Pa. From 1959 to 1962, he was a Research Assistant and C. T. Loo Fellow at Stanford University, studying cyclotron microwave interactions. In 1962, he joined the Research Division of Raytheon Company, Waltham, Mass., as a Senior Research Scientist, working on solid-state microwave devices. In 1966, he joined the Semiconductor Research and Development Laboratory of Texas Instruments Incorporated, Dallas, Tex., where he is presently Manager of research and development of microwave diodes and millimeter-wave integrated circuits.

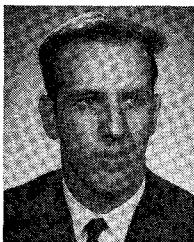
Dr. Mao is a member of Sigma Xi.



**Edward W. Mehal** was born in Detroit, Mich., on December 9, 1931. He received the B.S. degree in 1954 from Wayne State University, Detroit, and the M.S. degree in chemistry from the University of Michigan, Ann Arbor, in 1956.

Since joining Texas Instruments Incorporated, Dallas, Tex., in 1957, he has done research on refractory metals and compound semiconductor materials. This included work on materials for sensors, light emitters, and microwave devices. Presently he is Head of the Compound Semiconductor Materials Section in the Semiconductor Research and Development Laboratory.

Mr. Mehal is a member of the American Chemical Society and the Electrochemical Society.



**Francis L. Opp** was born in Litchfield, Ill., on October 28, 1931. He received the B.S. degree in electrical engineering from the University of Michigan, Ann Arbor, in 1959.

Upon graduation he joined the Engineering Staff of Texas Instruments Incorporated, Dallas, where he has worked in the general area of semiconductor applications. This work has covered the application of discrete devices to integrated circuits from dc to microwaves. At present he is a Project Engineer in the Microwave Products Branch engaged in the design and manufacture of microwave thin-film circuitry.

Mr. Opp is a member of Eta Kappa Nu and the Stoic Society of Eastern Michigan University.

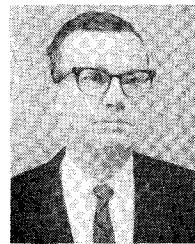


**Wen Y. Pan** (A'41-SM'46-F'58) received the B.S.E.E. degree from Chiao-Tung University in 1935, and the M.S.E.E. and Ph.D. degrees from Stanford University, Stanford, Calif., in 1939 and 1940, respectively.

He was a Research Scientist with the Radio Research Laboratory, Cambridge, Mass., where he worked with radar jamming and anti-jamming techniques. He then joined RCA where he was Manager of Advanced Development with the Home Instrument Division, and also served as Advisor to many activities, including the FCC UHF-TV Project, the Advisory Committee on Telecommunications of the United Nations, and

International Civil Aviation Conferences. From 1963 to 1966, he was in charge of the Thin Film Laboratory, RCA Defense Microelectronics, Somerville, N. J. He is currently Manager of Advanced Solid-State Techniques at the RCA Advanced Communications Laboratory, W. Windsor, N. J., where he is responsible for research and development of microwave techniques and concepts. He has published and presented over fifty papers, and holds thirty U. S. patents.

Dr. Pan is a Fellow of the American Association for the Advancement of Science.



**Gerard T. Roome** (S'59-M'61) was born in New York, N. Y., on September 20, 1932. He received the B.E.E. degree in 1960 and the M.S.E.E. degree in 1965 from Syracuse, N. Y.

From 1954 to 1956, he served as Signal Corps Instructor at the Electronics School, Fort Gordon, Ga. From 1961 to 1965, he was an engineer in the Electronics Laboratory of the General Electric Company and worked on the development of helical, stripline, and waveguide digital ferrite phase shifters and other microwave components, such as a miniature ferrite circulator, high-speed antenna switches, and a traveling-wave optical modulator. Since 1965, he has been with Syracuse University Research Corporation, Syracuse, N. Y., where he has been Project Engineer for the development of thin ferrite devices. In this work, sponsored by Wright-Patterson AFB, he led the development of a technique for producing phase shifters that utilize the remanent characteristics of dimensionally thin magnetic materials. He currently heads the Microwave Devices and Materials Group of the Special Projects Laboratory.

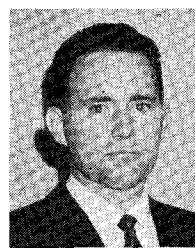
Mr. Roome is a member of Eta Kappa Nu.



**Harold E. Stinehelfer** (S'46-M'52-SM'59) was born in Bucyrus, Ohio, on April 22, 1924. He received the B.E.E. and M.E.E. degrees from Polytechnic Institute of Brooklyn, N. Y., in 1948 and 1951, respectively.

From 1948-1953, he was with the Radio Research Division of Western Union Telegraph Co. From 1953-1955, he was Chief Engineer of Frequency Standards, Inc., and from 1955-1966, he was a member of the Technical Staff of Bell Telephone Laboratories. In August 1966 he joined the Semiconductor Division of Microwave Associates, Inc., Burlington, Mass., as a Senior Engineer.

Mr. Stinehelfer is a member of Eta Kappa Nu, and a licensed Professional Engineer.



**Donald R. Taft** was born in Mendon, Mass., on October 1, 1928. He received the B.A. degree in physics from the University of New Hampshire, Durham, in 1957, and has done graduate work at the Polytechnic Institute

of Brooklyn, Brooklyn, N. Y., and the University of Florida, Gainesville.

In 1957 he joined the Sperry Microwave Electronics Division, Sperry Rand Corporation, Clearwater, Fla., where he has worked on the design and development of microwave ferrite devices. He is presently a Senior Member of the Research Staff.

various GaAs devices. These include Gunn devices and varactor and mixer diodes, both in discrete form and in monolithic integrated circuits, transistors and MOS structures, and light-emitting diodes. He is presently engaged in research on the latter as a member of the Optoelectronics Group.

Mr. Wacker is a member of Tau Beta Pi, Eta Kappa Nu, and Pi Mu Epsilon.



**William M. Webster** (A'48-SM'54-F'60) was born in Warsaw, N. Y., on June 13, 1925. He received the B.S. degree in physics from Union College, Schenectady, N. Y., in 1945, and the Ph.D. degree from Princeton University,

Princeton, N. J., in 1951.

He joined RCA Laboratories in 1946 as a specialist in vacuum and solid-state electronics. From 1954 to 1959, he was Manager of Advanced Development for the RCA Semiconductor and Materials Division. He returned to RCA Laboratories as Director of the Electronic Research Laboratory in August, 1959, and was appointed Staff Vice President, Materials and Device Research, in 1966. He holds a number of patents, mostly relating to semiconductor devices.

Dr. Webster is a member of Sigma Xi.



**Shui Yuan** received the B.S.E.E. degree from the University of California in 1952, and the M.S.E.E. degree from Columbia University, New York, in 1956.

From 1956 to 1963, he was a Senior Research Engineer at the Electronics Research Laboratory of Columbia University. He joined RCA in 1963, where he has worked as a Senior Member of the Technical Staff of the Solid-State RF Techniques Group and as a Staff Scientist with the Advanced Solid-State Group, engaged in research and development of frequency multipliers, balanced mixers, modulators, and similar circuits utilizing solid-state techniques. He is currently Leader of the Advanced Microelectronics Laboratory of RCA Communications Systems Division, Advanced Communications Laboratory, directing projects involving microelectronic microwave circuits, microelectronic VHF/UHF circuits, and microelectronic switching circuits. He is the author of ten technical papers.



Mr. Vendelin is a member of Tau Beta Pi.



**Robert W. Wacker** (S'61-M'66) was born in Milwaukee, Wis., on April 3, 1942. He received the B.S. degree in electrical engineering from Marquette University, Milwaukee, in 1964, and will receive the M.S. degree in electrical engineering from Marquette this year.

Since joining the Semiconductor Research and Development Laboratory of Texas Instruments Incorporated, Dallas, Tex., in 1965, he has worked primarily on