

27-1. American Astronautical Soc., mtg., Huntsville, Ala. (S. S. Hu, Northrop Space Labs., P.O. Box 1484, Huntsville)

27-1. Fundamental Cancer Research, 21st annual symp., Houston, Tex. (D. E. Frei, M.D., Anderson Hospital, Univ. of Texas, Houston 77025)

27-1. Sounding Rocket Vehicle Technology, conf., American Inst. of Aeronautics and Astronautics, Williamsburg, Va. (C. A. Sandahl, Mail Shop, 214A, NASA, Langley Station, Hampton, Va. 23365)

27-3. Australian Dental Congr., 18th Melbourne. (J. M. Newton, 53 Martin Pl., Sydney, Australia)

27-3. High Energy Physics and Nuclear Structure, intern. conf., Rehovoth, Israel. (M. Sela, Weizmann Inst. of Science, Rehovoth)

27-3. Membrane Structure and Function, symp., Chemical Inst. of Canada, Ste. Marguerite, P. Q. (K. K. Carroll, Collip Medical Research Lab., Univ. of Western Ontario, London, Ont.)

28-1. Systems Effectiveness, 2nd conf., Los Angeles, Calif. (A. M. Wilson, Engineering Dept., Electronic Industries Assoc., 2001 Eye St., NW, Washington, D.C. 20006)

#### March

1-3. Effect of Malnutrition on Mental Development, Learning and Behavior, intern. conf., Cambridge, Mass. (Dept. of Nutrition and Food Science, Massachusetts Inst. of Technology, Cambridge 02139)

1-3. International Particle Accelerator, conf., Washington, D.C. (Office of Tech-

nical Activities Board, 345 E. 47 St., New York, 10017)

1-3. Particle Accelerator, natl. conf., American Physical Soc., Washington, D.C. (J. A. Martin, Oak Ridge Natl. Lab., P.O. Box X, 4500S, S-103, Oak Ridge, Tenn. 37830)

2-4. Indian Ocean, symp., New Delhi, India. (N. K. Panikkar, Natl. Inst. of Oceanography, CSIR, Rafi Marg, New Delhi)

2-4. Nuclear Magnetic Resonance, conf., Pittsburgh, Pa. (B. L. Shapiro, Dept. of Chemistry, Illinois Inst. of Technology, Chicago, Ill. 60616)

2-10. Radioactive Dating and Methods of Low-Level Counting, symp., Vienna, Austria. (J. H. Kane, Conference Branch, Atomic Energy Commission, Washington, D.C. 20545)

5-9. International Gas Turbine, conf., Houston, Tex. (Meetings Manager, 345 E. 47 St., New York 10017)

6-7. High Speed Testing: The Rheology of Solids, 6th intern. conf., Boston, Mass. (R. H. Supnik, Plas-Tech Equipment Corp., 4 Mercer Rd., Natick, Mass. 01760)

6-10. Analytical Chemistry and Applied Spectroscopy, conf., Pittsburgh, Pa. (G. L. Carlson, Mellon Inst., 4400 Fifth Ave., Pittsburgh 15213)

6-10. WESTEC, 4th Western Metal and Tool Exposition and Conf., Los Angeles, Calif. (Director of Engineering Conf., 20501 Ford Rd., Dearborn, Mich. 48128)

8-10. Viscoelastic Response of Engineering Materials, mtg., Boston, Mass. (R. H. Supnik, 4 Mercer Rd., Natick, Mass. 01760)

8-22. United Nations Regional Cartographic Conf. for Asia and the Far East, Canberra, Australia. (United Nations, New York, N.Y.)

9-11. National Medicolegal Symp., Miami Beach, Fla. (Miss B. Spies, Law Dept., American Medical Assoc., 535 N. Dearborn St., Chicago, Ill. 60610)

10-11. National Conf. on Rural Health, Charlotte, N.C. (B. L. Bible, Secretary, American Medical Assoc., 535 No. Dearborn St., Chicago, Ill. 60610)

10-12. American Assoc. of Pathologists and Bacteriologists, Washington, D.C. (J. Lowell Orbison, School of Medicine and Dentistry, Univ. of Rochester, 260 Crittenden Blvd., Rochester, N.Y.)

13-14. Astronautics, symp., Ottawa, Ont., Canada. (The Secretary, Canadian Aeronautics and Space Inst., 77 Metcalfe St., Ottawa 4, Ont.)

13-15. 32nd North American Wildlife and Natural Resources Conf., San Francisco, Calif. (Wildlife Management Inst., 709 Wire Building, Washington, D.C. 20005)

13-17. International Laboratory Apparatus and Materials Exhibition, London, England. (U.T.P. Exhibitions Ltd., 3 Racquet Ct., Fleet St., London E.C.4)

13-17. Use of Plutonium as a Reactor Fuel, intern. symp., Brussels, Belgium. (J. H. Kane, Div. of Technical Information, U.S. Atomic Energy Commission, Washington, D.C. 20545)

14-15. American Astronautical Soc. 5th Goddard Memorial Symp., "The Voyage to the Planets," Washington, D.C. (M. B. Lees, General Electric Co., Defense Programs Div., 777 14th St., NW, Washington, D.C. 20005)

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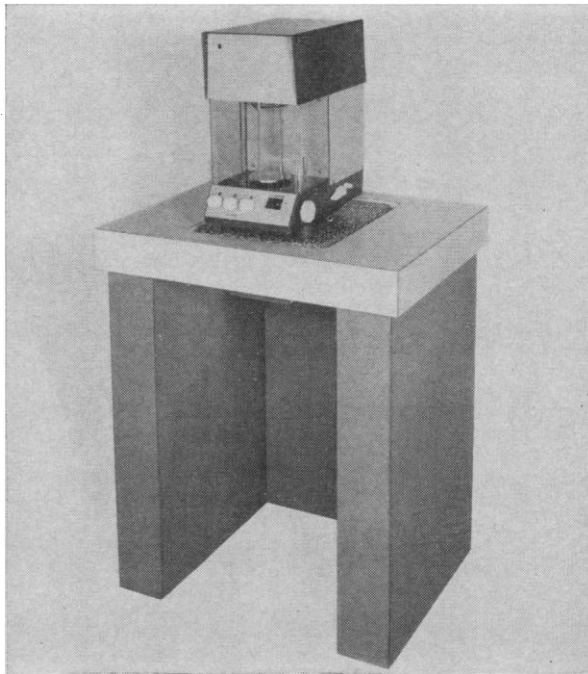
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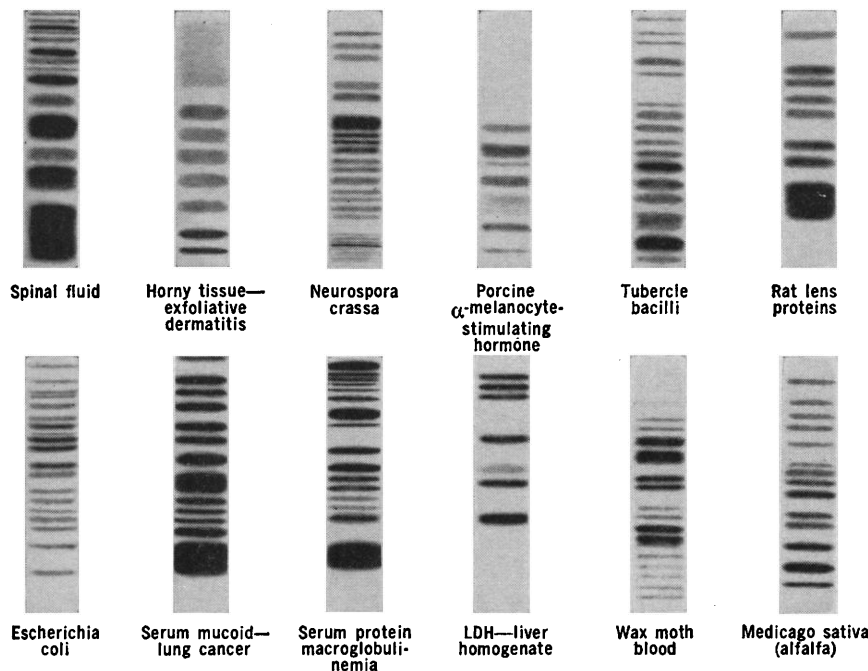
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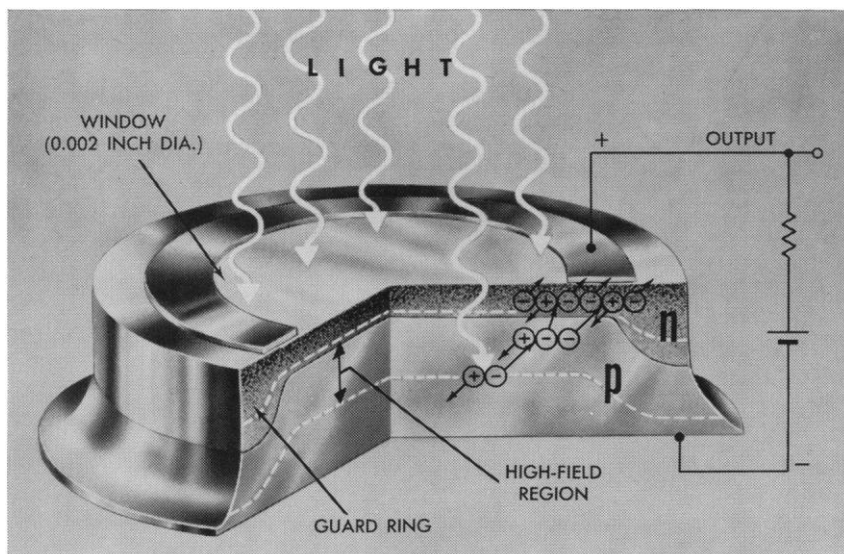
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# Photodiodes with gain

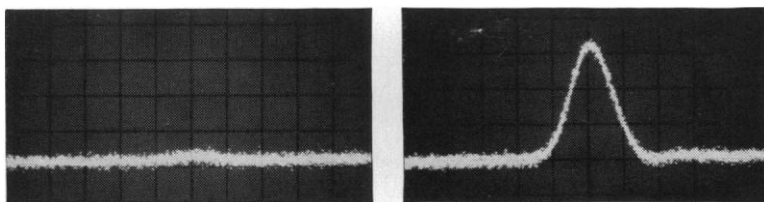


Cross-section of one form of the new photodiode. For the avalanche effect, positive voltage is applied to the n region and negative to the p (i.e., against the direction of easy current flow).

A photon, in being absorbed, creates an electron-hole pair. Electrons, formed in this way within the high-electric-field region of the junction, move toward the n-side. In so doing, they pick up energy, strike other atoms and create more pairs of electrons and holes. (A similar but opposite process occurs for the holes.) This "chain reaction"—the avalanche effect—produces relatively large currents and gives the diode its gain.

It is important that the avalanche multiplication factor be uniform over the entire window area... that no small area exhibit a particularly high multiplication factor. To achieve this, we start with homogeneous germanium and create a "guard ring" in which the density of charge-carrying impurities is relatively low. This low density results in a reduced electric field where the p-n junction meets the circumference... where breakdown currents would otherwise occur.

Because the time required for avalanche is very short, the diode responds to modulation frequencies as high as 60 GHz.

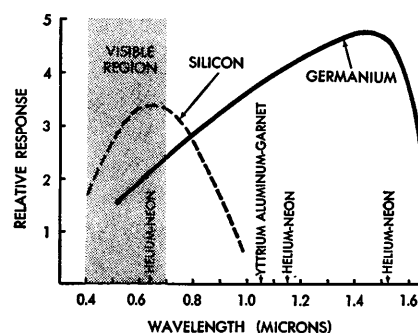


Performance of Bell Laboratories' germanium avalanche photodiode (right) compared with that of an otherwise identical non-avalanche type. Under a weak light signal (40  $\mu$ W) the output of the ordinary diode is lost in noise. High gain of the new avalanche type, however, permits the signal pulse to be clearly seen.

In a typical photodiode, a negative and a positive charge carrier—called an electron-hole pair—are created for each photon that penetrates the diode's surface. Now, Bell Laboratories scientists W. T. Lynch and H. Melchior have made experimental germanium photodiodes that have gain, developing up to 250 such electron-hole pairs per photon. And the new photodiodes respond to light of wavelengths from the visible region well into the infrared... to 1.6 microns.

The gain in these diodes stems from the "avalanche" effect (left). This requires carefully selected germanium and a special construction feature—a "guard ring"—developed here some years ago.

PHOTODIODE RESPONSE CURVES



In opto-electronic systems using infrared light from helium-neon or yttrium-aluminum-garnet lasers, for instance, the response of the new diode (above right) could be used in detecting modulation signals, and its high output would permit omission of some stages of amplification. (The "avalanche effect" was discovered at Bell Laboratories; the first avalanche photodiodes were of silicon and cut off below 1 micron in the "near" infrared.)

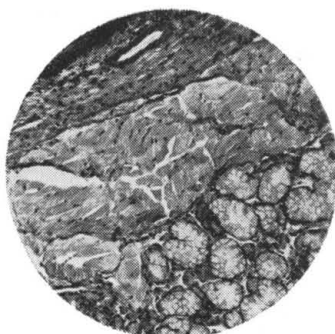


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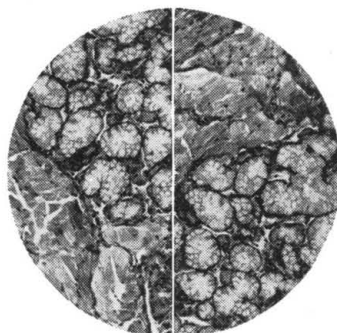
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