FUTURE OF ELECTRONICS COMPANIES AT STAKE IN DEVELOPMENT OF NEW TV SYSTEMS

This April an advisory committee to the Federal Communications Commission, the Advisory Committee on Advanced Television Service, will begin to test competing proposals for a new US television system. The committee's mandate is to recommend a new standard to eventually replace or supplement NTSC, the color television system adopted by the National Television Systems Committee back in 1953.

If the FCC's advisory committee does its job successfully, its recommendations will help determine what kind of television services will be available to Americans in the first half of the next century. The committee's recommendations could have a huge impact on the relative competitive positions of the major consumer electronics companies in all the advanced industrial countries, and on the competitive positions of the countries themselves. Perforce, its recommendations also will affect which companies and which countries are best placed in the decades ahead to support all kinds of research, not just research specifically geared to advanced television development.

High-definition television has emerged as a highly charged subject in Washington, with some Democrats positioning themselves to accuse the Bush Administration of "losing the television war." The Administration initially toyed with the idea of adopting an "industrial policy" for HDTV such that the R&D effort would be centrally organized and financed. But the free-market model soon prevailed, and officials in the Commerce and Defense departments who disagreed with the Administration's position were given to understand that they should toe the line or get out. Disagreements over HDTV policy were an important factor, for example, in the resignation last fall of Craig Fields as director of the Defense Advanced Research Projects Agency (see PHYSICS TODAY, November, page 70).

FCC Advisory Committee's Testing Schedule

Tests begin	Television system	Format
12 April 1991	Advanced Compatible Television David Sarnoff Research Center	525/1:1
19 June 1991	Narrow MUSE NHK/Japan Broadcasting Corporation	1125/2:1
3 September 1991	DigiCipher General Instrument Corporation	1050/2:1
31 October 1991	Spectrum-Compatible HDTV Zenith Electronics Corporation–AT&T	787.5/1:1
8 January 1992	Advanced Digital HDTV Sarnoff–NBC–Philips–Thomson	1050/2:1
10 March 1992	GIC–MIT all-digital system American Television Alliance	787.5/1:1

High-definition television will have an aspect ratio—ratio of horizontal to vertical dimensions—of roughly 16:9, as shown here. As displayed in the third column above, the number of lines varies among proposed systems, and scanning may be either interlace or progressive (indicated as 2:1 or 1:1). In interlace, the system used in current television, the electron gun skips lines, and the full screen is scanned twice to compose each full image. In progressive, all lines are scanned consecutively.

Rather than address policy disputes directly, the following report presents an overview of advanced television development efforts. Based on interviews conducted over a one-and-a-half year period in Europe, Japan and the United States, the report is attentive to organizational, political and financial elements, as well as purely technical factors. It appears in two installments, one now and one in April.

In the picture that emerges, the European research effort stands out as especially well integrated and well financed—and as singularly ambitious, in terms of its economic objectives. Japan's effort may in hindsight have gotten off to too *early* a start, but the fact remains that Japan's manufacturers have been the first to produce working prototypes of studio cameras, transmission equipment and receivers for HDTV. While the US lags far behind, it cannot be counted out because of the formidable strengths associated with its university system, its industrial labs and its computer industry.

Defining 'high definition'

Like the camcorder or Sony's Walkman, HDTV is an idea that originated in Japan. A desire for better reproduction of Japanese characters, which cannot be pictured legibly in large quantities on NTSC screens, was an important element in the genesis of the idea. But apparently the Japanese also were the first to appreciate that advances in various technologies would make it not merely possible, but virtually inevitable, that current television would be replaced by something better.

The basic idea of HDTV is simple: Advances in integrated circuitry and

Current TV and HDTV

The first all-electronic television system was demonstrated in 1932 by RCA. It relied on a camera tube called the iconoscope, which was invented and patented by Vladimir K. Zworykin in 1923, and on a cathode-ray tube in the receiver. RCA's all-electronic color television system was selected as the national standard in the United States by the National Television Systems Committee in 1953.

In color TV, creation of the color picture depends on specification of luminance (brightness), hue (color) and saturation (pastel quality versus vividness). Luminance is transmitted on the black-and-white signal, while hue and saturation values are carried by the chrominance signal, in which changes in amplitude correspond to changes in saturation, and changes in phase angle to changes in hue.

The luminance and chrominance signals are transmitted within overlapping parts of the same band by a process called frequency interlacing. The band has to be at least 6 MHz wide to provide about 4 MHz for transmission of luminance and color information and another 2 MHz for sound, protection against interference and so on. (The picture requires 3–4 MHz because the standard television screen has about 200 000 pixels, which have to be replenished 30 times per second; each cycle carries two bits of information.)

The current European color television systems are essentially identical to NTSC, except that improvements were made to yield better constancy of hue. In PAL, used in Britain and Germany, phase information is reversed in the process of scanning, so that information on hue can be corrected in successive lines. In SECAM, used in France and the USSR, alternate lines carry information on luminance plus red and on luminance plus blue; green is derived in the receiver by subtracting the red and blue information from the luminance signal.

What about HDTV? While all proposed systems differ from NTSC, PAL and SECAM in many respects, the essential difference between HDTV and current TV is simple: HDTV will have twice as many lines and twice as many pixels per line. Taking the wider aspect ratio into consideration, and extra features such as stereophonic sound, HDTV requires transmission of at least five times as much information as current television.

data processing will make it possible for television systems to handle a much larger volume of information to create a larger and finer TV picture. By a general consensus that has developed in the consumer electronics industry in response to the Japanese initiative, the next generation of televisions will have wider, that is to say more rectangular, screens, more closely resembling a conventional movie screen; and they will provide images that are much sharper—indeed, approximately of photographic quality.

Japan tried in the mid-1980s to win world support for a global HDTV standard based on the system it was developing called MUSE (for "multiple sub-Nyquist sampling encoding scheme"), which has 1125 lines, a frame rate of 60 fields per second and an aspect ratio—ratio of width to height—of 16:9. The United States initially supported the Japanese proposal but then reversed its position, partly in response to intense pressure from the Europeans, who regarded the MUSE standard as a Trojan Horse that would enable Japan to penetrate and conquer their market.

At a key meeting of the International Radio Consultative Commission held in Dubrovnik, Yugoslavia, in fall 1986, the Japanese proposal was torpedoed, with the Americans taking the position that any HDTV system for the US would have to be "backward compatible" with NTSC, so that American viewers could watch HDTV programs (in non-HDTV form) on their current sets.

Since Dubrovnik, it has been a foregone conclusion that the HDTV system adopted in Europe will have 1250 lines (double the current number of lines in European systems), and that in the United States HDTV will have some multiple of 525 (the NTSC number).

HDTV development in Japan

Among the countries and groups of countries that have emerged as the major players in the race to develop high-definition television, there are radical differences in the ways in which the corporate research efforts have been organized.

In Japan, which is generally estimated to have spent around $1 billion on advanced television research to date, the scene has been dominated by NHK, the state-owned national broadcasting company. Working in very close collaboration with the Ministry of International Trade and Industry and organizations like the Key Technology Center, a public–private agency founded in 1985 by MITI, and the Ministry of Post and Telecommunications, NHK has divided television R&D and sometimes even concrete production tasks among companies it has selected as subcontractors.

Development of specialized integrated circuits, for example, has been allocated among six companies, with Toshiba responsible for motion compensation chips and Matsushita for audio processing chips. NHK gave the job of developing and producing a 35-inch color picture tube for HDTV to Mitsubishi; in return, Mitsubishi agreed to provide its Japanese competitors with picture tubes off its production line, more or less at cost.

MITI has organized a seven-year, $100-million effort—the Giant Electronics Project—to develop large liquid-crystal displays as a possible alternative to cathode-ray tubes. The project's objective is to produce a 40-inch-diagonal flat-panel display by 1996. "MITI foresees a variety of technological linkages and potential spinoffs to result from this effort," Congress's Office of Technology Assessment said in a report last year. "Participants will have to: produce an alkali-free glass substrate with less than 0.001-inch (20 microns) variation in thickness over the entire 40-inch area; deposit a high-precision thin film on this substrate; develop the manufacturing skills to etch circuitry into this film to a precision of roughly 0.0001 inch (3 microns) over this entire area; develop precision techniques for automatically attaching leads and assembling the display; and invent new technologies to test it."

Europe's television effort

Moving energetically to make up for time lost to the Japanese, the Europeans have organized a Europe-wide television research effort under the aegis of EUREKA, the Brussels-based organization founded in 1986 to pool European resources in industry-relevant research (see PHYSICS TODAY, March 1990, page 66). For transmission of HDTV, the Europeans have selected a family of systems known as MAC (as in HD-MAC or D2-MAC), which stands for "multiplexed analog components." In systems such as NTSC, Britain's PAL or France's SECAM, the various signal components for luminance and chrominance are combined by a process called frequency-division multiplexing, in which different information is sent at different frequencies; in the MAC family, the component signals are transmitted in chronological succession, with the information for chrominance on alternating lines. Time-division multiplexing requires compression of both luminance and chrominance signals by factors of 3:2 and 3:1, respectively, and is said to yield higher resolution of both brightness and color, less color noise and none of the disturbing cross-color or cross-luminance common to frequency-multiplexed systems.

Like MUSE (and in contrast to the system requirements set by the FCC), HD-MAC and D2-MAC are intended for direct transmission to home antennas by high-power satellites or hyperband cable. Neither MUSE nor MAC transmissions are receivable by conventional TV sets unless they are equipped with special adapters.

Europe's HDTV project, dubbed EUREKA-95, is a combined effort of many companies and agencies from many of the European countries. Each nation's effort is coordinated by a representative who serves on the project's management committee. By far the most important participants are Holland's Philips, France's Thomson and Finland's Nokia, which are Europe's largest consumer electronics companies. (Nokia joined EUREKA-95 in October 1989, displacing BTS as one of the "big three." BTS, which is co-owned by Bosch and Philips, continues to be an important participant in EUREKA-95 and is responsible for development of the European HDTV studio equipment.)

EUREKA-95 represents a fast-changing picture, but in late 1989, when PHYSICS TODAY sent a reporter to Europe to discuss HDTV with people at Philips, Bosch and Thomson, executives at Thomson said that Philips probably had about 220 researchers working on HDTV per year, Thomson about 190, and Bosch roughly 50. Michel Hareng, the Thomson vice president in charge of the company's advanced television R&D for EUREKA-95, said that the researchers involved in the work were predominantly electrical engineers, optical engineers and physicists. Hareng himself is a physicist–engineer trained at the Ecole Supérieure de Physique de Paris.

The consultative style of decision making in EUREKA-95 seems to be rather different from the way things are done in Japan's top-down research effort and very different from the United States, which has adopted—by acts both of commission and omission—a much more laissez-faire approach.

American Television Alliance

The US research effort is dispersed among a handful of companies and research organizations that are plan-

Zenith–AT&T Advanced Television Development

The major HDTV development effort mounted by US-owned companies is a joint enterprise of Zenith and AT&T, in which Zenith is primarily responsible for system development and transmission technology, and AT&T for provision of VLSI components and video compression. In an interview conducted in Allentown, Pennsylvania, where AT&T maintains a large development laboratory, PHYSICS TODAY staffer Jean Kumagai discussed HDTV with Howard Moscovitz, the head of the advanced systems design department in AT&T's microelectronics division.

PT: What's the key technical problem in HDTV?

Moscovitz: You have a signal that you have to compress—remember the NTSC signal is less than 6 MHz; the HDTV signal is over 30 MHz—and you have to compress that signal without destroying picture quality. The challenge is to work on the algorithms for doing that compression and working on the digital architecture that implements the algorithms.

PT: What kind of work is required?

Moscovitz: A lot of the research has to do with what you throw away, what you keep, how you encode it. And then you have to figure out how to transmit those data in such a way that they can make it through the channel and be reconstructed. So there's a lot of mathematical research on data compression techniques. And there's a lot of research on rf signal transmission and reception, the causes and effects of different types of interference that can cause picture degradation. Then when you get down to actually implementing the system, how do you make it so it's cheap? The whole thing is to make low-cost chips to put in a low-cost set that the FCC will be attracted to. Now how do you make the chips? There's a tremendous amount of physics in that. Most of the engineers working on the IC fabricating technology are physicists or engineers who have physics backgrounds.

PT: The prototypes that Zenith is demonstrating now, do those have AT&T chips?

Moscovitz: Yes, definitely. AT&T's microelectronics division is supplying the integrated circuits for the prototype development. And we're also working on plans for chip sets for a whole production line. So we're working not only on the chips but also on system engineering, helping them with video coding algorithms and other algorithms that are required for data recovery and ghost canceling, which is very important in HDTV.

PT: Are you applying gallium arsenide technology?

Moscovitz: We're investigating use of gallium arsenide chips for front-end applications, like mixers. Gallium arsenide has very high linearity and extremely low noise. The main question [with gallium arsenide] is getting a low cost in high volume; performance is not an issue. For receivers [television sets], we're using bipolar silicon circuits, submicron CMOS [complementary metal–oxide silicon].

PT: What do you think of the Japanese work on HDTV?

Moscovitz: I have a lot of respect for what they've done. But their satellite broadcast system was developed ten years before what we're working on now, and it's actually more complex in the hardware to decode the HDTV signal, even though their spectrum is wider. It's an earlier system and may be economically unattractive compared with something that comes out of the United States.

PT: What is the goal for introducing HDTV to the market?

Moscovitz: I don't see why you couldn't make a good HDTV receiver, equivalent to today's 27-inch receiver, for between \$1000 and \$2000, starting in 1994. Most people figure that HDTV is only going to mean the big wide-screen projection sets. But Zenith has shown that even on televisions as small as 19 inches, when you put the HDTV pictures on, it really looks significantly better than current-generation television.

Zenith is the last American television manufacturer. They've been focusing on low cost from the very beginning. When there's a choice between two options and one is a lower-cost solution, they go with it.

PT: Does your agreement with Zenith exclude you from supplying chips to any other company?

Moscovitz: No, it's not exclusive. We would hope to have a chip set that we could sell to anybody.

PT: What are your ties to foreign electronics companies?

Moscovitz: All the players are international—Japan vs the United States vs Europe. We talk to Japanese companies and European companies, and the human interactions are as interesting as the technical problems. The television business is amazing because by nature you often do business with your worst competitor.

ning to compete in the FCC's testing program. Disregarding Japan, which seems to be making a surprisingly low-key effort in the United States, the contest is shaping up as a competition between three major R&D consortia: one made up of AT&T and Zenith, the only surviving US-owned television manufacturer; an alliance between General Instrument Corporation and a group at MIT; and one that includes NBC, the David Sarnoff Research Laboratory in Princeton, North American Philips and France's Thomson.

The American Television Alliance, as the GIC–MIT consortium is called, is the most recent of the three to be formed: It was announced on 30 January. The previous June, GIC surprised almost everybody in the television business with the claim that it had devised an all-digital system for producing, transmitting and receiving HDTV. The claim met with considerable skepticism in the industry, and questions were raised as to whether GIC would be able actually to present a working system in time for the FCC trials.

Prior to last June GIC was a relatively obscure player in HDTV. Headquartered in New York City, the company manufactures cable components like amplifiers and settop converters as well as things such as scrambling systems for satellite transmission of video material.

The HDTV team at MIT consists of just Jae Lim, an electrical engineer, and a dozen or so graduate students. But MIT also is home to the Media Lab, which has advocated an approach to HDTV that emphasizes development of "open systems" that would be fully compatible with other equipment such as PCs, workstations, and telephone accoutrements.

One important difference between GIC's and MIT's proposals, prior to their alliance, was that General Instrument's relied on interlace—the current system in which alternate television lines are scanned 30 times per second—while MIT's was progressive. Progressive scanning, in which all lines are scanned consecutively, is essential if television pictures are to be manipulated in real time, and therefore also is essential to any approach that stresses full compatibility with computers.

By entering into an alliance with MIT, GIC has in effect bought itself a second slot in the test schedule and six extra months to refine its system (see the box on page 57). This puts GIC–MIT on a roughly equal basis with the NBC–Sarnoff–Philips–Thomson consortium, which also has two shots: this April, in Sarnoff's slot, and in January 1992, in the slot originally allocated to Philips.

RCA–Thomson consortium

Thomson has been the largest single manufacturer of televisions in the United States ever since December 1987, when it exchanged its medical technology assets in Europe for General Electric's consumer electronics business in North America (which GE had acquired when it bought RCA the year before). Sarnoff, formerly RCA's corporate research laboratory, now works primarily on contract for Thomson, even though it is owned by SRI International in Menlo Park, California (see PHYSICS TODAY, June 1989, page 63).

The technical basis for the systems proposed by the NBC group has been developed mainly at Sarnoff, which has the distinction of having been the principal inventor of NTSC, the first working color television system compatible with the black-and-white standard. Sarnoff originally designed two advanced-compatible systems for HDTV: ACTV I would produce an enhanced but not fully high-definition signal using the standard NTSC 6-MHz channel; ACTV II would provide added details on a second 6-MHz channel, and information from the two channels would be combined to yield a fully high-definition picture.

The Sarnoff proposal suffered a reverse early last year when the FCC issued a "finding" that it would strongly favor simulcast over augmentation systems. In simulcast, all the information needed to create an HDTV picture would be transmitted in an unused channel—one of the so-called taboo channels currently left empty to prevent interference among allocated channels. The FCC finding forced Sarnoff to transform its proposal for ACTV II into a purely simulcast system, in a hurry.

Putting the best possible face on a decision that required Sarnoff to substantially recast its plans, James Carnes, the president of the lab, takes the position that truly satisfactory HDTV will take longer to develop than was initially assumed in the industry. For one thing, he says, it will require a bigger screen, and devising a satisfactory technology for bigger screens will take seven to ten years. Also, he argues that solving channel distribution (interference) problems will not be easy.

As originally proposed, Sarnoff's ACTV II simulcast system was mixed analog–digital, but last November the consortium announced that it would demonstrate a fully digital simulcast system in its second shot at the FCC trials, in January 1992. The lab now refers to ACTV I simply as ACTV, and has dropped the name ACTV II in favor of Advanced Digital HDTV—it too will be a simulcast system, consistent with the FCC's finding.

Executives at Zenith and AT&T, the principal beneficiaries of the FCC finding, argue in contrast to Carnes that a satisfactory and surprisingly inexpensive HDTV system can be designed and marketed quite soon (see the interview with AT&T's Howard Moscowitz on page 59). Zenith and AT&T originally proposed a mixed analog–digital system in which power-hungry low-frequency components would be transmitted analog, while high-frequency video components below 200 kHz, sync elements (which keep receivers synchronized with transmitters) and sound would be digitized.

Last December, Zenith and AT&T announced that they now would be submitting an all-digital HDTV system to the FCC's advisory committee for testing. Their system calls for 787.5 lines (1.5 x 525) with progressive scanning. In a chart they issued as part of their press release on 17 December, they showed that this format is equivalent to 1575 lines per 30th of a second and that the closest current competitor in the FCC trials offers only 1050 lines per thirtieth of a second.

Regulatory prospects

In light of what is at stake in the FCC trials, it is hardly surprising that the FCC's advisory committee is headed by a politically well-connected lawyer who has a lot of experience in telecommunications policy. Appointed to the chairmanship of the committee by the head of the FCC in 1987, Richard E. Wiley was himself a previous FCC chairman, and his law firm served as counsel to the Bush–Quayle Presidential campaign in 1988.

A seemingly modest and unassuming man upon casual encounter, Wiley is a formidable presence when seated behind his large wood desk in his law offices at 1776 K Street in Washington, DC. Facing the visitor on the front of Wiley's desk is a large bronze plaque reading, "For workaholics: Thank God it's Monday." Wiley doesn't like to waste time. When PHYSICS TODAY visited him last June and asked how he got to be so extremely expert in telecommunications policy, he pointed out that he first was general counsel to the FCC, then an FCC commissioner and finally the FCC chairman. "So I had all the best jobs at the FCC," he told us matter-of-factly. Having had all the best jobs, he left the FCC in 1977, founded a law firm, brought several of the best people from the FCC over to his firm and proceeded for the next 14 years to provide legal counsel to many of the world's top telecommunications companies.

Wiley, who describes himself as a Republican stalwart, made it clear at the outset of our interview that he had no intention of saying anything about HDTV that would be at variance with the stated policies of the Bush Administration. Asked what he had learned from the experience of being FCC chairman at a time when television was being radically altered by cable, he said, "Simple: Competition is good." He declined to be more specific about what that lesson might mean for HDTV, except to say, "What's at stake here is the future of television service in this country and the US role in high technology." With that remark, he conceded that he faces a daunting assignment.

—William Sweet

LITTLE CHANGE IN JOB MARKET FACING 1989 PHYSICS GRADUATES

Each winter the statistics division of the American Institute of Physics conducts a survey to determine how well the previous summer's degree recipients in physics and astronomy fared in finding full-time employment. The findings of the latest survey, which covers graduates from the 1988–89 academic year, have just been published. The general results were essentially similar to those of other recent years—many recipients of bachelor's, master's and doctoral degrees had found jobs within a couple of months of graduation, and at least 90% in each category had found jobs by the end of six months.

Among those earning PhDs, a somewhat higher proportion accepted postdocs and a slightly lower proportion full-time employment than was true the year before: 65% took postdocs and 34% full-time jobs in 1989, while in 1988, 61% accepted postdocs and 38% found full-time jobs. Among foreign students earning PhDs in theoretical fields, the proportion taking full-time jobs dropped sharply, from 29% to 5%, and the proportion accepting postdocs increased correspondingly, from 65% to 92%.

Among master's degree recipients, the survey found that service industries employed the largest proportion of women, and that the military attracted the largest proportion of new masters under the age of 25 (though military jobs made little or no use of the physics training they had received). Among bachelor's recipients, the survey found further evidence of a persistent decline in use of physics training by initial employers. "Since 1985," the report states, "the proportion of physics bachelors who felt that their initial employment did not utilize their physics training at all rose steadily from 14% to 23%."

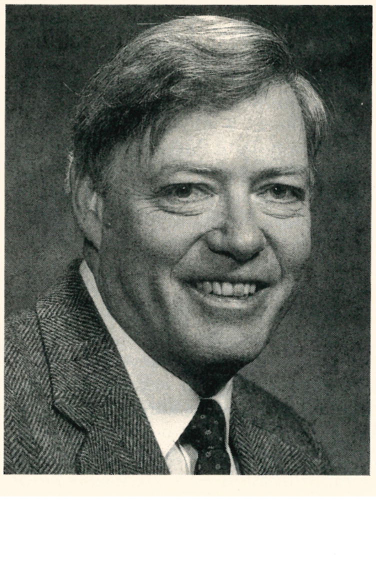
The report on the 1989 employment survey is available from its authors, Susanne D. Ellis and Patrick J. Mulvey, Education and Employment Statistics Division, AIP, 335 East 45 Street, New York NY 10017.

WATENPAUGH IS NEW VICE PRESIDENT OF CRYSTALLOGRAPHERS

The American Crystallographic Association has a new vice president: Keith D. Watenpaugh of the Upjohn Company. He succeeds Judith L. Flippen-Anderson of the Naval Research Laboratory, who is president for 1991.

Watenpaugh received a BS from the University of Idaho in 1962 and a PhD in chemistry from Montana State University in 1967. He joined the department of biological structure at the University of Washington in 1966. In 1984 he became a senior scientist in the physical and analytical chemistry research division at Upjohn. Watenpaugh's research interests include macromolecular structure determination, structure refinement and accuracy, protein–drug interactions, synchrotron radiation and computing software development. He currently serves on the users' steering committee of the Advanced Photon Source under construction at Argonne National Laboratory and is chair of the Structural Biology Synchrotron Users Organization.

Keith D. Watenpaugh



In addition to electing Watenpaugh, ACA members reelected Vivian Cody, a senior research scientist at the Medical Foundation of Buffalo, New York, to a three-year term as secretary.

NEW AGU AWARD RECOGNIZES RESEARCH MANAGERS

The American Geophysical Union has established a new award to recognize people who contribute to the advancement of scientific research through their roles as facilitators or coordinators of research programs.

The award, which will be presented annually, is named for the late Edward A. Flinn III, an expert in seismology and space geodesy who was widely known in the geophysics community for his managerial work with NASA. As chief of NASA's geodynamics program, Flinn directed a global research effort using laser ranging to satellites and to the Moon, together with radiation from quasars, to detect the motion and deformation of the Earth's crust.

Flinn received a BS in geoscience in 1953 from MIT and a PhD in geophysics and mathematics from Caltech in 1960. In 1960 he joined United Electrodynamics (later part of Teledyne Geotech), where he worked on detection of underground nuclear tests. In 1975 he became director of the lunar program of NASA's division of space sciences, and from 1977 until his death in 1989 he was chief scientist of the geodynamics program.

The first Flinn Award, which has been funded by Flinn's family and friends, will be presented in May at the 1991 AGU spring meeting in Baltimore.

AIP CHILDREN'S WRITING AWARD GOES TO MAURER

Richard Maurer, a free-lance writer, is this year's winner of the American Institute of Physics's award for science writing for children. The award is being given to Maurer for his book *Airborne* (Simon and Schuster, New York, 1990), which traces the discovery of the principles of