

## hte interviews



*Since the interview printed here took place, Art Bergles has not slowed down in his pace of ever-increasing activities. His busy schedule has him working hard on all his projects at Iowa State University, AIChE, and ASME. He is currently planning a trip to China; unfortunately for all his numerous commitments it will be a jet flight rather than the proverbial "slow boat."*

**William Begell:** Art, I believe that this is a very good time to interview you for *Heat Transfer Engineering*. You have just finished your term as Chairman of the Executive Committee of the Heat Transfer Division of ASME, your term as U.S. (AIChE) Representative to the Assembly for International Heat Transfer Conferences, and your term as Chairman of the Department of Mechanical Engineering at Iowa State University. With the experience of having run a department and having been involved with heat transfer administration for a number of years, you have both a perspective backward and I am sure an interesting perspective forward, which we hope to learn more about today.

**Arthur Bergles:** Yes, after 11 years as department chairman and 5 years on executive committee assignments for both societies, it is an interesting time in my life. As far as the ISU administrative responsibilities go, I simply have one fewer full-time job. I am fully confident that other activities will expand to fill the time available. I look forward to putting more effort into research and teaching at the university and devoting more time to other ASME commitments.

### *Professional Short Courses*

**WB:** You have just started your second term as the Vice President for Professional Development of ASME, and I am sure that you have been concerned with heat transfer as well as with other areas of mechanical engineering. Your activities in planning short courses will obviously be directed toward all areas of professional engineering development. I am sure that you will have in mind the interests of the heat transfer community,

even though a job like the vice presidency requires you to be evenhanded.

**AB:** The Heat Transfer Division was an originator of the ASME short courses and has remained a strong participant in the national short course programs since 1976. One of the difficulties we have encountered is with the so-called high technology short courses such as heat transfer. These courses do not attract, on the average, a sufficient number of attendees to make them financially viable. Heat transfer, fluids engineering, and gas turbine courses are, in effect, subsidized by the well-attended programs in codes and standards. Perhaps we must regard the advanced level courses as being primarily in the area of service to the membership and the profession. Certainly, these courses are another way to disseminate technical information.

**WB:** I know that AIChE has a very extensive program of professional development short courses, probably much larger than ASME's. Is AIChE also experiencing the same attendance difficulties these days as is ASME?

**AB:** It is my understanding that the AIChE Today Series has experienced sharply reduced attendance recently and the number of offerings has been reduced accordingly. This is typical of short course programs around the country. Of course, there are some topics that have attracted much interest, for instance, computers, computer-aided manufacturing, and robotics.

**WB:** It seems to me that industries should "take advantage" of lulls in their operating level and support their engineering staff to increase their knowledge during those times so that they can cope with future competition and progress. History has shown that inevitably an upturn will come. A company that plans for the longer term would encourage this practice during the downturn and then would be prepared to face competition in the level of technology when the business cycle improves. I am sure that many chief operating officers of many companies have thought about such ideas long and hard, but that pressures from stockholders and fiscal people are overwhelmingly against such action. Do you agree with me?

**AB:** Most certainly. This is the kind of forward thinking that has to go on so that when the upturn does occur, that particular industry will

be in the lead. We found, however, that there is great resistance to supporting attendance at professional development programs. This is due not only to the time involvement, but also to the increasingly large travel and living expenses associated with a course that is given at a central location. In lieu of that, our most successful programs recently have been so-called in-house programs where the instructor comes to the organization. More employees can attend and the presentation can be tuned to the particular needs of the firm. We see further expansion in this area.

### *Effect of High Technology*

WB: In terms of high technology, specifically its relationship to heat transfer, what do you believe affects our profession most, the computer being the obvious starting point? Is there any new technology that you think will become very important that is looming over on, or on this side of the horizon in terms of instrumentation or techniques or whatever?

AB: I think we are finding that heat transfer is in the forefront of technology in terms of the analytical and experimental tools that we use as well as the products and processes that require the information. It has all happened very quickly. I did my master's thesis at MIT, using the Whirlwind Computer to solve a problem that could now be handled by a modest hand-held calculator. The computer is now routinely used by researchers and the applications personnel who rate and size heat exchangers. We will find that the techniques used in experimental research will increase in sophistication. This comment applies to computational heat transfer as well, since computer experiments must be run to test turbulence models and verify numerical schemes. Physical experimentation, I feel, will remain a very strong part of the research process. It seems that fewer research students are electing, or are offered, experimental studies of heat transfer phenomena. There is a tendency to select a numerical study where there is a greater probability of success in a shorter period of time than the physical experiments where all of Murphy's laws seem to still be in force. In my opinion, Eph Sparrow is an outstanding exception, as he can keep several dozen research students excited about their experiments in heat or mass transfer. We should note, however, that those

entering the experimental arena may not have very sophisticated tools given the deteriorating condition of academic laboratories. Even if the equipment can be purchased, resources may not be available to operate and maintain it.

WB: I detect in what you say, not only a prediction of the future, but also a tinge of nostalgia for the old data acquisition system, which included a pad of paper and pencil, rather than the automatic plotters of today, for writing down to the  $n$ th decimal point the readout of a potentiometer or whatever instrument was available at the time, and K + E graph paper. I was listening to what you said about the analytical versus experimental areas of study. In this respect, I would like to mention a recent issue of *Mechanical Engineering*, which was devoted totally to heat transfer and which was put together under your editorship. It was a wonderful collection of papers that you were able to assemble, particularly in the area of numerical versus analytical methods. Included was a very interesting article by Dick Pletcher and Suhas Patankar. I read this article with great interest, which mentioned some of the things that you were telling me now. Can you comment on trends a little bit more?

### *Teaching Real-World Applications*

AB: Perhaps I can editorialize further, since my good friends Dick and Suhas cannot provide a rejoinder. We will always have the temptation to extend the computer to situations where we have very little experimental evidence, thus running the risk of not having the base points to make sure that the computation scheme is accurate, that there are no bugs in the program, etc. The computer is an enormously powerful tool for extending our understanding and predictive capability, but we must always have some means of checking the calculations. Of course, as the situations that we consider become more complicated, the experiments themselves may be subject to errors. I have encountered numerous situations where the numerical algorithms or simply the program itself contained errors, which were detected by comparison with experimental data.

WB: You seem to be saying that essentially nothing beats hands-on experience. Old-time engineers can design a shell-and-tube heat exchanger and

come out with a certain length of tube or a certain number of tubes or a tube diameter that they know is wrong because it doesn't jibe with what is successfully operating in the field. On the other hand, I hear many engineers today, including young computer-oriented individuals, say that they simply take the answer from the printout and have no feel whether the answer is correct or not. In our field of heat transfer we are faced with the necessity of combining very, very high technology with very basic hands-on experience. This is an irreplaceable combination and I think it is great. But I believe, and I want you to comment on this idea, that it is up to teachers like

security, in part due to all of the digits that are displayed. Eight significant figures are not very useful when the answer is only good to within plus or minus 50% anyway. An order-of-magnitude sense is vital to detect programming and keying errors. We must instill in our students an appreciation of whether the heat transfer coefficient is 1, 10, 100, or 1000 so that they can come up with an intelligent appraisal of a rating or design problem.

WB: That was a nice summary, ending with a list of heat transfer coefficients going from 1 to 1000. Now this increase in heat transfer coeffi-

**"We hope to continue . . . to bring order into this new discipline of heat transfer and reduce some of the entropy generation inherent in heat transfer communications."**

yourself to instill the ability to judge the correctness of an answer in our young engineers who will be running our industry in the years to come.

AB: I fully agree with you, and the place to start, of course, is with the undergraduate heat transfer course. We should certainly introduce the computer, at least in an illustrative sense, for solving certain problems, particularly in conduction. But we should also bring into the classroom the hands-on experience or take the students down into the lab and let them see and touch heat exchangers and really get an appreciation of the real world of hardware. Too often, we spend our lecture time going through boundary layer theory and find that we are too short on hours to discuss applications or to have a laboratory experience. I would hope that we can reverse this trend because we have found that most of our undergraduates are going to be confronted with the hardware problem, one way or another, and the necessity to solve practical problems. Toward that end, I firmly believe that the young engineer's best tool will be the ability to do back-of-the-envelope calculations such that they can get reasonable approximations to heat transfer coefficients and other necessary parameters. Above all, they must be able to recognize the order of magnitude of the answer. The computer and the powerful hand-held calculator, for all of the benefits that they have brought to us, have given almost a whole generation of students a false sense of

coefficients is probably the thing for which Art Bergles is best known—I speak here of heat transfer augmentation. I think it would be amiss not to talk to you about heat transfer augmentation and two-phase heat transfer in this interview. Can you tell me about your plans for pursuing your work in these two areas, now that you have more time available?

***Heat Transfer Augmentation***

AB: I have been very privileged to work in two of the most exciting areas in heat transfer. I began with two-phase flow and heat transfer when I worked with Joseph Kaye of MIT on the cooling of electronic and electrical equipment. The project I embarked on for my dissertation was the cooling of high-field magnets, an area that was in the late 1950s of particular concern to solid state research at the MIT National Magnet Laboratory. Unfortunately, Professor Kaye passed away early in my doctoral program. I then had the good fortune of becoming associated with Professor Warren Rohsenow who became my mentor in boiling heat transfer. After I spent a year on the research staff of the Magnet Laboratory, Warren gave me the opportunity to return to the mechanical engineering department as a faculty member. Since 1963, I have been associated with the teaching of mechanical engineering with emphasis

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on heat transfer. Now, boiling is a very high heat transfer coefficient situation. Yet, when I first started work in the area, I attempted to obtain the very highest heat fluxes by fair means or foul, in particular, to elevate the critical or burnout heat flux, with immediate application to the high field electromagnets. This naturally led to the consideration of the diverse means whereby the critical heat fluxes might be augmented or enhanced, and expanded into many other situations which do require heat transfer coefficients higher than those obtainable under normal conditions. The work subsequently included enhancement of free convection, that is, some four orders of magnitude lower heat transfer coefficient than in boiling. We could say that from the very beginning, I have been quite sensitized to the problem of the order of magnitude of heat transfer coefficients.

WB: Art, as I said before, you will have more time for active research now that you have given up so many of your administrative duties, not all by any means, but a lot of them. What is your plan for future research and concentration of your interests? Are you still going to continue in the area of boiling and high heat fluxes and enhancement or do you have other areas in mind?

#### *Database Publication*

AB: I will very definitely continue in the area of enhanced heat transfer or second generation heat transfer technology. Since establishing a heat transfer laboratory at Iowa State in 1972, I have had a very extensive ongoing program of work in enhanced heat transfer ranging from free convection to forced convection boiling. In addition to many studies of the phenomena and mechanisms, we have developed a database of literature in this area. We scan the heat transfer literature on enhancement that appears worldwide, classify it, then disseminate the information to the community. That literature has experienced an exponential growth, and we are presently logging in over 300 papers per year. We hope to continue this effort to bring order into this new discipline of heat transfer and reduce some of the entropy generation inherent in heat transfer communications. Along with the research projects, now

about ten, and the documentation, I have returned to a long-standing project to complete a reference book on the subject with my friend and colleague, Ralph Webb. I believe that the necessary time will now be available to finish that project.

WB: That, of course, is music to my ears as the publisher of that book. The database of enhancement literature that you mentioned has been partially published and is available to the community in, I believe, *Previews of Heat Transfer*. I would direct all readers of *Heat Transfer Engineering* to that publication to look up the literature there, which has been cited up to what year?

AB: That collection of literature, which was presented in six installments from 1978 to 1980, included about 1500 references. Our newest edition of this literature search will contain over 3000 references. Needless to say, we have been employing the computer for many years to assist with the task of organizing and retrieving the literature.

WB: Will you or your university make the database printout available to people who are interested or have you considered putting it into a commercial database so people can obtain it for a commercial fee?

AB: The database is readily available through our reports, which for the past 5 years have been sponsored by the Department of Energy. It is not clear whether the sponsorship will continue, but we do hope to continue the project. It would be a shame to stop after having kept up the literature acquisition for 20 years.

WB: I would like to urge our readers of *Heat Transfer Engineering*, especially all those who are interested in enhanced or augmented heat transfer phenomena, to get in touch with Professor Bergles at Iowa State to obtain copies of this latest addition to the literature. Turning to another subject, could you comment on the status of the agreement for scientific exchange with the Soviet Union in the area of heat and mass transfer?

#### *International Collaboration*

AB: I have always felt that international collaboration is vital if we are to carry forward meaningful heat transfer research and engineering and that

this collaboration should be done on an organized basis with the full agreement of the governments of the participating countries to be fully effective. In 1979, I was appointed by President Carter to head up the U.S. side of a program in heat and mass transfer under the U.S./USSR Agreement in Science and Technology. A major meeting was held in Moscow and Minsk later that year to define the protocol for collaboration as well as the areas of immediate interest for cooperative research. We felt that this meeting laid the groundwork for the formal cooperation between our two countries. Of course, on a person-to-person basis there already existed collaboration in a number of areas. At the end of 1979, world events took over. As a result of the continued intensification of the political situation, when the S & T agreement expired July 7, 1982, it was not renewed. Hence, I no longer hold that chairmanship. But I do hope that the individual collaboration will continue on a meaningful technical and personal basis so that we as engineers can contribute to the lessening of current tensions. When I met my Soviet counterpart in this program, Professor Styrikovich, at the International Heat Transfer Conference in Munich last fall, he and his colleagues made the offer that they would like to continue, on an informal basis, collaboration that would be of mutual benefit to interested parties. It would, of course, be on the traditional receiving-side-pays basis, an arrangement that is much easier for our colleagues in the Soviet Union to carry out than it is for us. Nevertheless, that offer has been made and would be, I think, of interest to a number of the U.S. researchers.

### *Sabbatical in Germany*

WB: Well, politics is probably more unpredictable than any mode of heat transfer. Even though relations between the Soviet Union and the U.S. are currently tense, I certainly hope that an agreement in our area of interest will be reached as soon as the relations get better. In the meantime, the opportunity for individual contacts is continuing at various international forums such as the meetings, seminars, and summer schools of the International Centre for Heat and Mass Transfer in Yugoslavia. This brings me to European travel and the fact that you have recently returned from a sabbatical with Professor Mayinger

in Hannover. Are you looking forward to the next one in about 5 years hence?

AB: Yes, I did go to Germany in 1979-1980 for my first sabbatical ever, joining Franz Mayinger at the Institut für Verfahrenstechnik in Hannover. This renews an acquaintance that began some 21 years earlier at the Technische Hochschule, now Technische Universität, München, when Franz was completing his dissertation for Ernst Schmidt and I was a visiting graduate student of Professor Schmidt's as a holder of a Fulbright. It was a real pleasure to be with Franz Mayinger again, and, as fate would have it, he subsequently returned to Munich to assume the Chair that Grigull, Schmidt, and Nusselt once held.

WB: Your wife and children joined you in your European sabbatical. Are they longing to go back to Europe and urging you to accept another such arrangement when the time comes?

AB: We went at an optimum time in terms of the school years of the boys. As I look at our increasingly diverse schedules now, I think it would be quite difficult, if not impossible, to arrange a similar sabbatical and to derive the same pleasure that we had from that visit. To elaborate, my wife, Penny, has gone back to work. She is a programmer-analyst at the Iowa Department of Transportation, resuming in somewhat different form a vocation that she started in 1960 at the Instrumentation Laboratory, now Draper Laboratory, at MIT where she was working on the Apollo program. Our older boy, Eric, is now heading off to college at Colorado State and our younger son, Dwight, will be a sophomore in high school. Eric is a basketball player and is setting his sights on a career in business. Dwight is a swimmer and bicycle racer with early aspirations to be a marine biologist, a vocation that is not getting too much inspiration from the Iowa prairie.

WB: I know that you travel quite a lot. Every time I telephone, your secretary says, "Professor Bergles is out of town and will not be back until next Monday." With so much traveling, I am sure that you have made many contacts all over the world. I know that you frequently teach short courses with your colleagues from the U.K. and France. Are there any other international connections that you would like to tell us about?

AB: Well, through the years I have had the good fortune to be involved with collaborative programs with a number of countries in addition to the USSR and Germany. These include the long-standing program of NATO Advanced Study Institutes in Turkey, cooperative seminars with Japan, and an arrangement with Portugal. I am presently developing programs in Argentina, India, and the People's Republic of China. Not all of these involvements get me to these countries on a regular basis, but they have been technically significant and very rewarding personally.

WB: Switching to another subject, I know that one of your very, very deep interests is the background of heat transfer and where heat transfer came from, the historical aspects of heat transfer. It has been said that "today will be history tomorrow." Can you tell us more about your work and interest in the area of the history of heat transfer?

AB: The "roots" of heat transfer are more an avocation than an area in which I have done serious work, but I have prepared a few articles on the subject. I think it is very important, regardless of the scientific or technical specialty in which we work, to have a sense of history because past is indeed prologue. This is a particularly auspicious time for heat transfer as many significant anniversaries are appearing. We have passed just recently the 100th anniversary of Nusselt's birth. One

hundred years ago Reynolds published his pioneer study and we are approaching the 100th anniversary of Graetz's work on laminar flow. It is enlightening to go back in time and see how perceptive the early workers really were. The papers of 50-100 years ago often contain valuable "new" information in terms of ideas and insight into the various processes. I hope to bring a sense of this history to the heat transfer community in a modest way through the "Heat in History" column of this magazine. It seems to be increasingly important to do this since the burgeoning literature keeps all of us from having even a modest control over our own specialty literature that is appearing in real time. I believe that if we have this sense of history and if we do try through reviews and critical surveys to digest the current literature, we will much better control our destiny and future as to areas that we work on and the means whereby we explore the subject areas. All in all, I feel that there are enormous "existential pleasures" to be derived from heat transfer research, engineering, and education.

WB: In closing, I would like to say that I hope your professional and personal life and existential pleasures will be not only augmented, but also enhanced, every step of the way. Thank you very much for coming to talk to us today.



## 13 Years Later: An Interview with Art Bergles

The editors of this Festschrift for Art Bergles have approached me to conduct a follow-up interview with our honoree. The original interview was printed in *Heat Transfer Engineering* in 1983.

I caught up with Art in Houston, in August 1996, during the National Heat Transfer Conference and the interview below is the result of this meeting.

It is a great privilege and honor for me personally and for my publishing house to be involved in the presentation of this festive volume. I have been associated with Art Bergles for many many years and hold him and his family in great professional and personal esteem. I wish him many more years of fruitful and effortless endeavors and great success.

Bill Begell

**William Begell:** Art, the last interview with you was published in *Heat Transfer Engineering* 13 years ago. During this period there have been many accomplishments in your career. You served as President of ASME, you moved to Rensselaer Polytechnic Institute, you were the Dean of Engineering there. Please tell me about your professional happenings since 1983. I may have missed some.

**Art Bergles:** The past 13 years have indeed been a time of great change for me. Looking at the gainful employment first, I was able to relax a bit at Iowa State, as Anson Marston Distinguished Professor of Engineering and Professor-in-Charge of the Heat Transfer Laboratory. In 1986, however, we moved to Troy, New York, where I became the Clark and Crossan Professor of Engineering at Rensselaer Polytechnic Institute. This move was based on personal considerations as well as the outstanding professional opportunity of the endowed chair. My father died in 1985, and we were now only 70 miles away from the family property, in Rhinebeck, New York, where my mother lived alone. Also, our boys were away at college: Eric, finishing up at Colorado State, and Dwight, just starting at Boston University. In 1989 I became Dean of Engineering, serving in this capacity until 1992, when an emergency

hospitalization and operation nearly led to an end of my involvement in everything. Fortunately, I recovered motor functions to some extent, and have been able to engage in many of the old activities these past four years. Perhaps the foremost of these is the RPI Heat Transfer Laboratory, which I established in 1986, and which I have been the director. In the volunteer department, I was elected two times to the Board of Governors of ASME (1985–89) and was the 1990–91 President of ASME. The latter is a three-year commitment, as president nominee/elect, president, and past president. Needless to say, it was an extraordinary busy time.

I have done a few other things, too: Chair of the NSF Advisory Committee for Chemical, Biochemical, and Thermal Engineering; member of the NSF Advisory Committee for Engineering; and now Chair of the Executive Committee of the International Center for Heat and Mass Transfer. I'm on the editorial advisory boards of 17 international thermal science journals, some of which require a fair amount of work.

**WB:** If I recall correctly, the ASME Presidency was held by more members of the Heat Transfer Division than any other Division in the Society. Recall for us the Heat Transfer Division Presidents and explain this phenomenon. Are the heat transfer engineers most active, most able, most ambitious?

**AB:** Of the 115 ASME presidents, many have made heat transfer their technical specialty. Among the current groups of 20 ASME past presidents, Ernest L. Daman, Nancy D. Fitzroy, Leroy S. Fletcher, Richard J. Goldstein, Serge Gratch, Charles E. Jones, S. Peter Kezios, and myself are identified with heat transfer. This is probably more than our fair share, considering that there are now 37 boards or groups in the five ASME councils. While there are plenty of challenges in heat transfer, heat transfer specialists, in either academia or industry, have been unusually willing to work for professional societies. With persistence, and luck, some have made it to the top of ASME.

**WB:** Last time we spoke, we touched upon the computational aspects of heat transfer research ver-

sus the experimental techniques. With the help of hindsight, can you comment on what has transpired in our profession over the last decade and a half in terms of computing and experimentation.

**AB:** This is truly the age of the computer, in heat transfer as well as in engineering and science generally. Some conservation principle must be at work, for as computer technology has been adopted everywhere, there has been a widespread decline in laboratory work. This loss in classical experimental capability is especially detrimental to enhance heat transfer, my main field of endeavor. Even if computer simulations were effective for more than several of the 14 enhancement techniques, the actual experiments would be necessary to bench-mark the computer codes. Experimentation, as we have known it, appears to be a dying art. The concerns that I voiced in 1983 have been realized. Now, if you will excuse me while I get out my laptop to check the e-mail...

**WB:** What about the teaching of heat transfer today as compared with the early 1980s? Are heat transfer courses finding their way into non-mechanical, non-chemical, non-nuclear engineering courses like electrical, civil, etc?

**AB:** The teaching of heat transfer has eroded. It is a required course in fewer curricula, especially where heat transfer or unit operations is not central to the discipline. Due to the explosion of knowledge, disciplinary courses have pushed aside the thermal-fluid engineering sciences. One need only observe that heat transfer is no longer a required course in the undergraduate mechanical engineering program at M.I.T.! Heat transfer textbooks have grown larger, and the number of problems has increased. A complete solutions manual and computer disks appear to be necessary for a successful undergraduate textbook. In my recent experience, the student wants to be entertained and the instructor wishes to have as easy a time of it as possible. There seems to be less of the practical; heat exchange technology and design are not usually frequently covered in the basic course.

**WB:** Have you kept up your activities in heat transfer augmentation? How about two-phase flow?

**AB:** With the assistance of colleagues, and the aid of some excellent graduate students, I have kept up my activities in heat transfer augmentation or enhancement. This work is intertwined with two-phase flow and heat transfer. Major projects were carried out on single-phase heat transfer from internally finned ceramic tubes; single-phase flow in tubes with

twisted-tapes; boiling with enhanced tube bundles (flow through), critical heat flux in subcooled flow boiling – plain or enhanced with twisted tapes or additives to the water; boiling from enhanced, simulated microelectronic chips; and enhancement of refrigerant evaporators by micro-fin and deep-spirally-fluted tubes. I am closing out my research activities with studies of enhancement of power transformer oil coolers by addition of water spray, the effect of a micro-fin tube on heat transfer to an alternative refrigerant, enhanced heat transfer to the interior of simulated gas-turbine blades (rotating), and active enhancement in single-phase duct flow. For these studies, some of the largest and most complex experimental rigs I have worked with were constructed.

**WB:** You spoke about data-base publishing back in 1983. Now, with the advent of Internet, in particular, and electronic publishing, in general, we are facing a brave new world. How does heat transfer fare in cyberspace and in the information superhighway?

**AB:** We are indeed facing a “brave new world” in communicating heat transfer results. The internet will make available more data than any other technology in history — if we can access it. There is clearly an information overload, that is not alleviated by the computer. We recently assembled another citation data base on enhanced heat transfer (through mid-1995). In hard-copy form, it takes a 11/over 2-in.-thick report to document the 5676 citations. Of course, this information is nicely covered on two disks. A great deal of manual searching was necessary, because the existing search programs and alert journals do not sweep up all the literature. Manual searching was particularly relied upon when doing early versions of the report, especially since the first reference was published in 1861.

We are faced with a break in knowledge, newer research students will rely only on computerized data bases, and if a reference has not been entered into such a data base, it will not be cited or used. As a result, Santayana's prophecy is being borne out: “those who ignore history are condemned to repeat it.”

Of course, we can do some wonderful things now with desktop publishing. What concerns me is the quality of the dialog. People are concentrating more on how it is written rather than on what is said. Then, too, there is nearly instant communication, via fax, e-mail, and voice mail. Prompt communications are so ubiquitous that there is a tendency to clutter up cyberspace and overcrowd the electronic highway with unnecessary communications. In my view, we



are in danger of becoming roadkill on the electronic highway.

**WB:** Too many events happened on the international scene to be squeezed into the few columns of this conversation. The demise of the USSR, the falling apart of Yugoslavia, and the ensuing move of the International Center of Heat and Mass Transfer from Belgrade and Dubrovnik to Turkey. The adding of the word International to ASME. I am sure your thoughts and comments will be of great interest to us all.

**AB:** Fragmentation of nations and globalization is everywhere. As the world is broken into smaller pieces, there is a tendency for heat transfer to be splintered also. More truly international meetings are vital to the transport of information and furtherance of the art and science of heat transfer.

There must be help to restore the excellent capability for thermal research in the nations of the former Soviet Union and in the former Yugoslavia. The situation is particularly desperate in Bosnia-Herzegovina and Croatia. The difficulty, of course, is that Western institutions are being "reengineered," and funds for collaborations are in very short supply.

The competition has intensified, as thermal design and production of heat-exchange components can be done far away. This requires modern communications, but it does take advantage of lower-price technical labor. Survival is a real issue in many cases, and it is leading to cut throat practices in some areas of heat transfer. The place where I notice this most is in reviewing of papers. There is simply no time available for researchers to do the important volunteer work of paper reviewing, which, in essence, is the quality control for our publications.

**WB:** We started our 1983 interview speaking about the woes facing professional development resources. What has happened there? Now the problems we face are severest in the library budget area. Please tell us more.

**AB:** It seems that short courses are picking up, after a rather long downturn. Thermal sciences courses are again attracting interest; but "general interest" courses in manufacturing, mechatronics, etc., are "in" right now. There is much emphasis on "tools," such as finite-element analysis, and multimedia presentations. With the rapid downsizing of corporations, much experience and expertise is lost. Short courses, particularly if they are given "in-house," offer the chance to re-establish that knowledge in current employees.

Library budgets are under severe pressure, probably around the world. Books (any sort: textbooks, reference books, conference proceedings) are not being purchased, and journal subscriptions are being cut. Having located a reference, it may be difficult to obtain it — even through interlibrary loan. Electronic journals are touted as the solution, but there is a cost issue there, too. It is very frustrating for researchers to publish papers that are unavailable locally.

**WB:** Your children must now be all grownup. Tell us about your family and your plans for the future. What about travel?

**AB:** The boys left the "nest" some time ago. Eric graduated from Colorado State, and is market research specialist in Mountain View, California. Dwight graduated from Boston University and Stanford, and is doing a post-doctoral stint at the Vollum Institute, Oregon Health Sciences University. He and his wife, a lawyer, live in Portland, Oregon. We see them only several times a year.

Time has marched on, and I will retire in June 1997. This academic year, I am on "terminal" sabbatical, much of the time in Europe. For three months, I will be at the Technical University of Munich working with Franz Mayinger, with whom I had my only previous sabbatical at the University of Hanover. This is fitting, as I studied in Munich during 1958–59. Other visits are planned for Denmark, Italy, Poland, Portugal, Slovenia, and Switzerland.

Penny and I already have a retirement house in Centerville, Massachusetts, on Cape Cod. We'll do some traveling, of course, but there I can spend the time worrying about the heat transfer problems of fish and clams. Now there's an interesting problem: what keeps them from freezing during the winter?